# IMPACT OF SUPPLEMENTATION OF VALUE ADDED PRODUCTS USING PARTIALLY DEFATTED PEANUT CAKE FLOUR ON THE NUTRITIONAL STATUS OF MALNOURISHED CHILDREN

**Dissertation**

**Submitted to the Punjab Agricultural University**
**in partial fulfillment of the requirements**
**for the degree of**

**DOCTOR OF PHILOSOPHY**
**in**
**FOOD AND NUTRITION**
**(Minor Subject : Food Science and Technology)**

**By**

**T. Bindhya Dhanesh**
**(L-2012-H.Sc.-89-D)**

**Department of Food and Nutrition**
**College of Home Science**
**©PUNJAB AGRICULTURAL UNIVERSITY**
**LUDHIANA-141004**

**2016**

## CERTIFICATE I

This is to certify that the dissertation entitled, **"Impact of supplementation of value added products using partially defatted peanut cake flour on the nutritional status of malnourished children"** submitted for the degree of **Ph.D.,** in the subject of **Food and Nutrition** (Minor subject: **Food Science and Technology**) of the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by **T. Bindhya Dhanesh (L-2012-HSc-89-D)** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.


**(Dr. (Mrs.) Anita Kochhar)**
**Major Advisor**
Professor and Head
Department of Food and Nutrition
Punjab Agricultural University
Ludhiana- 141004

## CERTIFICATE II

This is to certify that the thesis entitled, **"Impact of supplementation of value added products using partially defatted peanut cake flour on the nutritional status of malnourished children"** submitted by **T. Bindhya Dhanesh** (Admn No. **L-2012-HSc-89-D)** to the Punjab Agricultural University, Ludhiana, in partial fulfillment of the requirements for the degree of Ph.D, in the subject of **Food and Nutrition** (Minor subject: **Food Science and Technology**) has been approved by the Student's Advisory Committee after an oral examination on the same.

**(Dr. (Mrs.) Anita Kochhar)**
**Major Advisor**

**(Dr. S. K. Mann)**
**External Examiner**
**Former Dean**
**College of Home Science**
**Punjab Agricultural University**
**Ludhiana-141 004**

**(Dr. (Mrs.) Anita Kochhar)**
**Head of the Department**

**(Dr. (Mrs.) Neelam Grewal)**
**Dean Postgraduate Studies**

# ACKNOWLEDGEMENT

*I bow to the lotus feet of Almighty whose grace had endowed me the inner strength and confidence and blessed me with a helping hand at each step of my life.*

*I wish to place on record my profound sense of gratitude to my revered Major Advisor Dr.(Mrs.)Anita Kochhar, Professor and Head, Department of Food and Nutrition, Punjab Agricultural University for her exceptional guidance, persistent encouragement, valuable suggestions and ever willing help rendered at all stages of this endeavor. Always looking for perfection, she corrected me several times but with understanding, love and forbearance. She has strongly supported me not only with untiring efforts during the preparation of my manuscript but also as guardian in my endeavors whenever I needed.*

*I thankfully acknowledge the respected members of my advisory committee Dr. (Mrs.)Kiran Grover, Senior Extension Specialist and Dr. (Mrs.) Jaswinder Brar, Professor, Department of Food and Nutrition for their whole hearted cooperation, help and valuable suggestions during various stages of study. I deeply express my gratitude to Dr. (Mrs.) Savita Sharma, Senior Dough Rheologist, Department of Food Science and Technology for her timely help, precious suggestions and generous support during my entire study and successful completion of this work. I extend my gratitude to Dr. M. Javed, Professor, Department of Maths, Statistics and Physics for his timely help, valuable suggestions and critical scrutiny of statistical analysis.*

*Words can never truly portrait the love, affection, care, constant encouragement, patience, unflinching support and advice of my friends Dipti, Gopika, San san, Manpreet and Sreepriya. My heartfelt gratitude cannot be captured in words for the support and valuable advices of my classmates, juniors and seniors friends. I wish to express my sincere gratitude to my friends from other departments and colleges for their whole hearted help and support.*

*I sincerely thank the office staff and lab attendants of the department for their timely help, cooperation and support.*

*I sincerely acknowledge the gracious help extended to me by Rakesh Bhaiya of rakesh computers.*

*I am forever indebted to my beloved mother Smt. Girija Dhanesh, my loving brothers Ani and Anshu for their support, increasing encouragement, boundless affection, deep concern, prayers and personal sacrifices which helped me to overcome many hurdles experienced during the course of time.*

*Last but never the least this dissertation is dedicated to my father late Sri. T. R. Dhanesh whose words of inspiration and encouragement in pursuit of excellence will still linger on.*

**Date :**

**Place: Ludhiana** **(T. Bindhya Dhanesh)**

| | | |
|---|---|---|
| Title of the thesis | : | Impact of supplementation of value added products using partially defatted peanut cake flour on the nutritional status of malnourished children |
| Name of the Student<br>and Admission No. | :<br>: | T. Bindhya Dhanesh<br>L-2012-HSc-89-D |
| Major subject | : | Food and Nutrition |
| Minor subject | : | Food Science and Technology |
| Name and Designation<br>of Major Advisor | : | Dr. (Mrs.) Anita Kochhar<br>Professor and Head |
| Degree to be awarded | : | Ph.D. |
| Year of award of Degree | : | 2016 |
| Total pages in thesis | : | 156+Appendices+Vita |
| Name of the University | : | Punjab Agricultural University, Ludhiana – 141004, Punjab, India |


**Abstract**

Five nutritious value added products namely *matthi*, *seviyan*, *pinni*, *panjiri* and biscuits were developed using cereal-pulse flour (3:1), partially defatted peanut cake flour and green leafy vegetable powder for malnourished children. The products were first standardized with partially defatted peanut cake flour followed by fenugreek leaf powder in *matthi* and *seviyan* and spinach leaf powder in *pinni*, *panjiri* and biscuits. *Matthi*, *seviyan* and biscuits were acceptable at 10 per cent level while *pinni* and *panjiri* were acceptable with 15 per cent of peanut flour. Addition of fenugreek leaf powder was acceptable at 1 per cent in *matthi* and *seviyan* while spinach leaf powder was acceptable at 2 per cent in *pinni* and *panjiri* and 1.5 per cent in biscuits. Mean overall acceptability scores of developed products were significantly different ($p < 0.01$). The products were analyzed for nutritional composition. A significant ($p < 0.01$) difference was observed in terms of proximate composition among the developed products. Among the value added products, highest energy value was found as 492.85 kcal for *pinni*. Lysine and methionine content was observed highest in *seviyan*. *In vitro* protein digestibility was in the range of 60.22 to 80.13 per cent. The tannin content of the products decreased significantly. The developed products were stored in three different packaging material i.e. glass container, aluminium zip lock pouch+glass container and plastic zip pouch+glass container 90 days to check their shelf life and were found acceptable after sensory evaluation. To study the impact of supplementation of developed products on nutritional status of malnourished preschool children, a total of 110 children were selected from four ICDS centers of Ludhiana city. Out of total subjects, a sample of 60 preschool children in the age group of 3 to 5 years was selected for feeding trial on the basis of z scores. The subjects were divided into two groups i.e. experimental and control with 30 subjects in each group. The subjects of experimental group were supplemented with 120-150 g of the developed product for 120 days. A significant ($p < 0.05$), ($p < 0.01$) increase in intake of all food groups except for milk and milk products as well as all macro and micronutrients. An increase in weight (14.12%), BMI (14.64%), MUAC (1.64%), chest circumference (0.14%) and in biochemical parameters like blood albumin (17.35%), blood protein (9.28%) and haemoglobin (8.59%) was observed in the subjects of experimental group after supplementation. The developed products could be recommended for malnourished children under supplementary feeding programmes in the country.



**Key words**: malnutrition, nutritional composition, partially defatted peanut cake flour, sensory evaluation, shelf life, supplementation, value added products


**Signature of Major Advisor** **Signature of the Student**

| | | |
|---|---|---|
| ਖੋਜ ਗ੍ਰੰਥ ਦਾ ਸਿਰਲੇਖ | : | ਕੁਪੋਸ਼ਣ ਦੇ ਸ਼ਿਕਾਰ ਬੱਚਿਆਂ ਦੇ ਪੌਸ਼ਟਿਕ ਪੱਧਰ ਉਪਰ ਅਰਧ ਤੇਲ ਕੱਢੀ ਮੂੰਗਫਲੀ ਦੇ ਆਟੇ ਦੀ ਵਰਤੋਂ ਨਾਲ ਤਿਆਰ ਕੀਤੇ ਭੋਜਨ ਪਦਾਰਥਾਂ ਦਾ ਪ੍ਰਭਾਵ |
| ਵਿਦਿਆਰਥੀ ਦਾ ਨਾਮ ਅਤੇ ਦਾਖਲਾ ਨੰ. | : | ਟੀ. ਬਿੰਦੀਆ ਧਨੇਸ਼ (ਐਲ-2012-ਐਚ ਐਸ ਸੀ-89-ਡੀ) |
| ਪ੍ਰਮੁੱਖ ਵਿਸ਼ਾ | : | ਖੁਰਾਕ ਅਤੇ ਪੋਸ਼ਣ |
| ਸਹਿਯੋਗੀ ਵਿਸ਼ਾ | : | ਫੂਡ ਸਾਇੰਸ ਅਤੇ ਤਕਨੋਲੋਜੀ |
| ਪ੍ਰਮੁੱਖ ਸਲਾਹਕਾਰ ਦਾ ਨਾਮ ਅਤੇ ਅਹੁਦਾ | : | ਡਾ. ਅਨੀਤਾ ਕੋਛੜ ਪ੍ਰੋਫੈਸਰ ਅਤੇ ਹੈਡ |
| ਡਿਗਰੀ | : | ਪੀ.ਐਚ.ਡੀ. |
| ਡਿਗਰੀ ਮਿਲਣ ਦਾ ਸਾਲ | : | 2016 |
| ਖੋਜ ਪੱਤਰ ਵਿੱਚ ਕੁੱਲ ਪੰਨੇ | : | 156+ਅੰਤਿਕਾਵਾਂ+ਵੀਟਾ |
| ਯੂਨੀਵਰਸਿਟੀ ਦਾ ਨਾਮ | : | ਪੰਜਾਬ ਖੇਤੀਬਾੜੀ ਯੂਨੀਵਰਸਿਟੀ, ਲੁਧਿਆਣਾ-141004, ਪੰਜਾਬ, ਭਾਰਤ |


**ਸਾਰ**

ਮੌਜੂਦਾ ਅਧਿਐਨ ਦੌਰਾਨ ਕੁਪੋਸ਼ਣ ਦੇ ਸ਼ਿਕਾਰ ਬੱਚਿਆਂ ਲਈ ਅਨਾਜ-ਦਾਲ ਦਾ ਆਟਾ (3:1), ਅਰਧ ਤੇਲ ਕੱਢੀ ਮੂੰਗਫਲੀ ਦੇ ਆਟੇ ਅਤੇ ਹਰੀਆਂ ਪੱਤੇਦਾਰ ਸਬਜ਼ੀਆਂ ਦੇ ਪਾਊਡਰ ਦੀ ਵਰਤੋਂ ਕਰਕੇ ਮੱਠੀ, ਸੇਵੀਆਂ, ਪਿੰਨੀ, ਪੰਜੀਰੀ ਅਤੇ ਬਿਸਕੁਟ ਨਾਮਕ ਪੰਜ ਪੌਸ਼ਟਿਕ ਪਦਾਰਥ ਤਿਆਰ ਕੀਤੇ ਗਏ। ਤਿਆਰ ਕੀਤੇ ਗਏ ਪਦਾਰਥਾਂ ਦਾ ਪਹਿਲਾਂ ਅਰਧ ਤੇਲ ਕੱਢੀ ਮੂੰਗਫਲੀ ਦੇ ਆਟੇ ਨਾਲ ਅਤੇ ਇਸ ਉਪਰੰਤ ਮੱਠੀ ਅਤੇ ਸੇਵੀਂਆਂ ਵਿੱਚ ਮੈਥੀ ਦੇ ਪੱਤਿਆਂ ਅਤੇ ਪਿੰਨੀ, ਪੰਜੀਰੀ ਅਤੇ ਬਿਸਕੁਟਾਂ ਵਿੱਚ ਪਾਲਕ ਦੇ ਪੱਤਿਆਂ ਨਾਲ ਮਿਆਰੀਕਰਨ ਕੀਤਾ ਗਿਆ। ਮੂੰਗਫਲੀ ਦੇ ਆਟੇ ਦੇ 10 ਪ੍ਰਤੀਸ਼ਤ ਪੱਧਰ ਨਾਲ ਤਿਆਰ ਕੀਤੀਆਂ ਮੱਠੀ, ਸੇਵੀਂਆਂ ਅਤੇ ਬਿਸਕੁੱਟ ਅਤੇ 15 ਪ੍ਰਤੀਸ਼ਤ ਪੱਧਰ ਨਾਲ ਤਿਆਰ ਕੀਤੀ ਪਿੰਨੀ ਅਤੇ ਪੰਜੀਰੀ ਸਵਿਕਾਰਤ ਸਨ। ਮੈਥੀ ਦੇ ਪੱਤਿਆਂ ਦੇ ਪਾਊਡਰ ਦੇ 1 ਪ੍ਰਤੀਸ਼ਤ ਪੱਧਰ ਨਾਲ ਤਿਆਰ ਕੀਤੀਆਂ ਮੱਠੀਆਂ ਅਤੇ ਸੇਵੀਂਆਂ ਜਦੋਂਕਿ ਪਾਲਕ ਦੇ ਪੱਤਿਆਂ ਦੇ ਪਾਊਡਰ ਦੀ 2 ਪ੍ਰਤੀਸ਼ਤ ਪੱਧਰ ਨਾਲ ਤਿਆਰ ਕੀਤੀਆਂ ਪਿੰਨੀਆਂ ਅਤੇ ਪੰਜੀਰੀ ਅਤੇ 1.5 ਪ੍ਰਤੀਸ਼ਤ ਪੱਧਰ ਨਾਲ ਤਿਆਰ ਕੀਤੇ ਬਿਸਕੁਟ ਸਵਿਕਾਰਤ ਸਨ। ਤਿਆਰ ਕੀਤੇ ਪਦਾਰਥਾਂ ਦੇ ਔਸਤਨ ਕੁੱਲ ਸਵਿਕਾਰਤਤਾ ਅੰਕ ਵਿੱਚ ਅਰਥਪੂਰਨ ਵਿਭਿੰਨਤਾ ($p < 0.01$) ਦਰਜ ਕੀਤੀ ਗਈ। ਪੌਸ਼ਟਿਕ ਬਣਤਰ ਲਈ ਪਦਾਰਥਾਂ ਦਾ ਮੁਲਾਂਕਣ ਕੀਤਾ ਗਿਆ। ਪ੍ਰੋਗਜ਼ੀਮੇਟ ਬਣਤਰ ਦੇ ਲਿਹਾਜ਼ ਨਾਲ ਤਿਆਰ ਕੀਤੇ ਪਦਾਰਥਾਂ ਵਿੱਚ ਅਰਥਪੂਰਨ ($p < 0.01$) ਵਿਭਿੰਨਤਾ ਪਾਈ ਗਈ। ਊਰਜਾ ਦੀ ਮਿਕਦਾਰ ਸਭ ਤੋਂ ਵਧੇਰੇ ਪਿੰਨੀ ਲਈ ਦਰਜ ਕੀਤੀ ਗਈ ਜੋਕਿ 492.85 kcal ਸੀ। ਲਾਈਸਿਨ ਅਤੇ ਮਿਥੀਓਨਿਨ ਦੀ ਸਭ ਤੋਂ ਵਧੇਰੇ ਮਿਕਦਾਰ ਸੇਵੀਂਆਂ ਵਿੱਚ ਪਾਈ ਗਈ। *ਇੰਨ-ਵਿਟਰੋ* ਪ੍ਰੋਟੀਨ ਪਾਚਣਤਾ 60.22 ਤੋਂ 80.13 ਪ੍ਰਤੀਸ਼ਤ ਤੱਕ ਸੀ।ਪਦਾਰਥਾਂ ਵਿੱਚ ਟੈਨਿਨ ਦੀ ਮਿਕਦਾਰ ਵਿੱਚ ਅਰਥਪੂਰਨ ਕਮੀ ਆਈ। ਤਿਆਰ ਕੀਤੇ ਪਦਾਰਥਾਂ ਦੀ ਮਿਆਦ ਦੀ ਜਾਂਚ ਕਰਨ ਲਈ ਇਹਨਾਂ ਨੂੰ ਤਿੰਨ ਵੱਖੋ-ਵੱਖਰੀਥਾਂ ਭੰਡਾਰਨ ਸਮੱਗਰੀ ਭਾਵ ਕੰਚ ਦੇ ਮਰਤਬਾਨ, ਐਲੂਮੀਨੀਅਮ ਜ਼ਿਪ ਵਾਲੇ ਲਿਫਾਫੇ + ਕੰਚ ਦੇ ਮਰਤਬਾਨ ਅਤੇ ਪਲਾਸਟਿਕ ਦੇ ਜ਼ਿਪ ਵਾਲੇ ਲਿਫਾਫੇ + ਕੰਚ ਦੇ ਮਰਤਬਾਨ ਵਿੱਚ 90 ਦਿਨਾਂ ਤੱਕ ਭੰਡਾਰ ਕਰਕੇ ਰੱਖਿਆ ਗਿਆ ਅਤੇ ਮਿਆਰੀਕਰਨ ਉਪਰੰਤ ਦੇਖਿਆ ਗਿਆ ਕਿ ਭੰਡਾਰਨ ਦੇ 90 ਦਿਨਾਂ ਮਗਰੋਂ ਇਹ ਉਤਪਾਦ ਖਾਣਯੋਗ ਸਨ। ਸਕੂਲ ਨਾ ਜਾਣ ਵਾਲੇ ਕੁਪੋਸ਼ਣ ਦੇ ਸ਼ਿਕਾਰ ਛੋਟੇ ਬੱਚਿਆਂ ਉਪਰ ਇਹਨਾਂ ਪਦਾਰਥਾਂ ਦੇ ਪ੍ਰਭਾਵ ਦਾ ਅਧਿਐਨ ਕਰਨ ਲਈ ਲੁਧਿਆਣਾ ਸ਼ਹਿਰ ਦੇ ਚਾਰ ਆਈ.ਸੀ.ਡੀ.ਐਸ. ਕੇਂਦਰਾਂ ਤੋਂ 110 ਬੱਚਿਆਂ ਦੀ ਚੋਣ ਕੀਤੀ ਗਈ। ਜ਼ੈਡ ਸੰਖਿਆ ਦੇ ਅਧਾਰ ਤੇ ਕੁੱਲ ਬੱਚਿਆਂ ਵਿੱਚੋਂ, 3 ਤੋਂ 5 ਸਾਲ ਦੇ ਸਕੂਲ ਨਾ ਜਾਣ ਵਾਲੇ 60 ਬੱਚਿਆਂ ਨੂੰ ਚੁਣਿਆ ਗਿਆ। ਇਹਨਾਂ ਬੱਚਿਆਂ ਨੂੰ ਤਜ਼ਰਬਾ ਅਤੇ ਕੰਟਰੋਲ ਦੋ ਸ਼੍ਰੇਣੀਆਂ ਵਿੱਚ ਵੰਡਿਆ ਗਿਆ ਅਤੇ ਹਰੇਕ ਸ਼੍ਰੇਣੀ ਵਿੱਚ 30 ਬੱਚਿਆਂ ਨੂੰ ਰੱਖਿਆ ਗਿਆ। ਤਜ਼ਰਬਾ ਸ਼੍ਰੇਣੀ ਦੇ ਬੱਚਿਆਂ ਨੂੰ ਤਿਆਰ ਕੀਤੇ ਉਤਪਾਦ 120 ਦਿਨਾਂ ਤੱਕ 120-150 ਗ੍ਰਾਮ ਰੋਜ਼ਾਨਾ ਖਾਣ ਲਈ ਦਿੱਤੇ ਗਏ। ਦੁੱਧ ਅਤੇ ਦੁੱਧ ਪਦਾਰਥਾਂ ਦੇ ਨਾਲ-ਨਾਲ ਸਾਰੇ ਮਾਈਕ੍ਰੋ ਅਤੇ ਮੈਕ੍ਰੋ ਨਿਊਟ੍ਰੀਐਂਟਸ ਤੋਂ ਇਲਾਵਾ ਬਾਕੀ ਸਾਰੇ ਭੋਜਨ ਪਦਾਰਥਾਂ ਦੀ ਖਪਤ ਵਿੱਚ ਅਰਥਪੂਰਨ ($p < 0.05$), ($p < 0.01$) ਵਾਧਾ ਹੋਇਆ। ਤਜ਼ਰਬਾ ਸ਼੍ਰੇਣੀ ਦੇ ਬੱਚਿਆਂ ਨੂੰ ਭੋਜਨ ਪਦਾਰਥ ਖੁਆਉਣ ਉਪਰੰਤ ਉਹਨਾਂ ਦੇ ਭਾਰ (14.12%), ਬੀ.ਐਮ.ਆਈ. (14.64%), ਐਮ.ਯੂ.ਏ.ਸੀ. (1.64%), ਛਾਤੀ ਦੇ ਘੇਰੇ (0.14%) ਅਤੇ ਜੀਵ-ਰਸਾਇਣਕ ਮਾਪਦੰਡਾਂ ਜਿਵੇਂ ਕਿ ਖੂਨ ਵਿੱਚ ਐਲਬਿਊਮਿਨ (17.35%), ਪ੍ਰੋਟੀਨ (9.28%) ਅਤੇ ਹੀਮੋਗਲੋਬਿਨ (8.59%) ਵਿੱਚ ਵਾਧਾ ਦਰਜ ਕੀਤਾ ਗਿਆ। ਅਧਿਐਨ ਦੌਰਾਨ ਤਿਆਰ ਕੀਤੇ ਗਏ ਸਸਤੇ ਅਤੇ ਪੌਸ਼ਟਿਕ ਭੋਜਨ ਪਦਾਰਥ, ਦੇਸ਼ ਵਿੱਚ ਸਪਲੀਮੈਂਟਰੀ ਫੀਡਿੰਗ ਪ੍ਰੋਗਰਾਮਾਂ ਅਧੀਨ ਕੁਪੋਸ਼ਣ ਦੇ ਸ਼ਿਕਾਰ ਬੱਚਿਆਂ ਨੂੰ ਖੁਆਉਣ ਦੀ ਸਿਫਾਰਿਸ਼ ਕੀਤੀ ਜਾਂਦੀ ਹੈ।



**ਮੁੱਖ ਸ਼ਬਦ:** ਕੁਪੋਸ਼ਣ, ਪੌਸ਼ਟਿਕ ਬਣਤਰ, ਅਰਥ ਤੇਲ ਕੱਢੀ ਮੂੰਗਫਲੀ ਦਾ ਆਟਾ, ਮਿਆਰੀਕਰਨ, ਮਿਆਦ, ਪੌਸ਼ਟਿਕ ਭੋਜਨ


**ਪ੍ਰਮੁੱਖ ਸਲਾਹਕਾਰ ਦੇ ਹਸਤਾਖਰ** **ਵਿਦਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ**

## CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF PLATES

## ABBREVIATIONS

| | |
|---|---|
| µg | Micro gram |
| µm | Micro meter |
| AF | Aflatoxin |
| APS | Atmospheric packaging |
| ARF | Amylase rich flour |
| BCG | Bacillus Calmiti Guerin |
| BMI | Body Mass Index |
| CF | Combination films |
| cfu | Colony forming unit |
| cm | centimeter |
| dL | deci liter |
| DNP | Dinitrophenyl derivative of polypeptide |
| DPF | Partially defatted peanut cake flour |
| DPMF | Partially deoiled peanut meal flour |
| DW | dry weight |
| EDTA | Ethylene diamine tetraacetic acid |
| FAO | Food and Agriculture Organisation |
| FFPF | Fat free peanut flour |
| FS | Fortified spread |
| fL | femtolitres |
| g | gram |
| GLV | Green leafy vegetables |
| HDL-C | High density lipoprotein cholesterol |
| HDPE | High density polyethylene |
| ICDS | Integrated Child Development Scheme |
| ICMR | Indian Council of Medical Research |
| IPS | Inter Press Services |
| Kcal | Kilo calories |
| Kg | Kilo gram |

| | |
|---|---|
| KJ | Kilo joule |
| LDL | Low density lipoprotein |
| LDPE | Low density polyethylene |
| MAM | Moderate acute malnutrition |
| ml | milliliter |
| mm | millimeter |
| mmol | millimol |
| MP | Metallised polyester |
| MUAC | Mid upper arm circumference |
| nm | nanometer |
| PET | Polyethylene terephthalate |
| PP | Polypropylene |
| ppm | parts per million |
| Psi | pounds per square inch |
| RDA | Recommended dietary intake |
| rpm | rotation per minute |
| RTUF | Ready-to-use food |
| SD | Standard deviation |
| SDI | Suggested dietary intake |
| SE | Standard Error |
| SUN | Scale Up Nutrition |
| TF | Therapeutic foods |
| TPC | Total plate count |
| UNICEF | United Nations International Child Emergency Fund |
| WHO | World Health Organisation |

**CHAPTER I**

# INTRODUCTION

Severe acute malnutrition (SAM) remains a major killer of children as mortality rates in children with severe wasting - a widespread form of SAM - are nine times higher than those in well-nourished children (Black *et al* 2008). Malnutrition is an underlying cause of death of 2.6 million children each year-one-third of the global total of children's deaths (UN 2011). Globally, an estimated 52 million children under-five years of age, or 8 per cent, were wasted (weight-for-height below-2SD) in 2011 - 11 per cent decrease from an estimated 58 million in 1990. Seventy percent of the world's wasted children live in Asia, most in South-Central Asia (UNICEF-WHO-The World Bank 2012). These children are at substantial increased risk of severe acute malnutrition and death. According to 2012 figures compiled by the U.N., nearly half of children under five in Southern Asia and 39 percent of the same age group in Sub-Saharan Africa are stunted – that is, too short for their age due to poor nutrition. With more than 60 million stunted children, India is among the most hard-hit countries, as is Nigeria, with nearly 11 million stunted children (IPS 2014). The prevalence of undernutrition in under 5 children in India is among the highest in the world, and is nearly double that of Sub-Saharan Africa (World Bank 2014).

Malnutrition in young children is attributed to various factors including female illiteracy, ignorance about nutritional needs of infants and young children and poor access to health care. Protein Energy Malnutrition is a primary concern of nutrition particularly among children, expectant and nursing mothers. Fifty percent of children under five are underweight and stunted. Global progress on stunting has been extremely slow. The proportion of children who are stunted fell from 40 per cent in 1990 to 27 per cent in 2010 – an average of just 0.6 percentage points per year (Onis *et al* 2011). Forty three percent of India's children below the age of three years are malnourished. Approximately 40 per cent of Indian children are underweight, 44.9 per cent of Indian children are stunted and 22.9 per cent of Indian children are wasted. The global community has a target of halving the prevalence of underweight children by 2015 as a key indicator of progress towards the Millenium Development Goal of eradicating extreme poverty and hunger (WHO 2011).

Nutrition is at the top of the global development agenda and political commitments to scale up programmes aimed at reducing the scourge of child malnutrition have been made. The Scale Up Nutrition (SUN) movement, launched in 2010, calls for intensive efforts to improve global nutrition in the period leading up to 2015. The SUN movement Lead Group was established in 2012 by the United Nations Secretary-General to improve coherence, provide strategic oversight, improve resource mobilization and ensure collective accountability. The movement has brought together government authorities from countries with a high burden of malnutrition, and a global coalition of partners committed to working together to mobilize resources, provide technical support, perform high level advocacy and develop innovative partnerships (UNICEF-WHO-The World Bank 2012). In May 2012, the World Health Assembly, the decision-making body of the World Health Organization (WHO), agreed on a new target: reducing the number of stunted children under the age of 5 by 40 per cent by 2025. The United Nations Secretary-General has included elimination of stunting as a goal in his Zero Hunger Challenge, launched in June 2012. This emphasis on stunting has led to a review of national programmes and strategies to increase the focus on prevention and integrated programmes (UNICEF 2013).

Nutrition of infants and young children is critical for their survival, cognitive development and growth not only during the childhood but for their whole life span. The treatment of malnutrition, as well as its prevention, among under five children requires consumption of nutritious food, including exclusive breastfeeding for the first 6 months of life and in combination with complementary foods thereafter till at least 24 months of age, a hygienic environment (clean drinking water, sanitary facilities), access to preventive (immunization, vitamin A supplementation etc) as well as curative health services and good prenatal care (Pee and Bloem 2008). Adequate and regular complementary feeding of infants with home based foods from the age of six months, while continuing breast feeding is crucial for their healthy growth and development.

Reducing child malnutrition requires nutritious food, breastfeeding, improved hygiene, health services and prenatal care. Poverty and food insecurity seriously constrain accessibility of nutritious diets, including high protein quality, adequate micronutrient content and bioavailability, macro-minerals and essential fatty acids, low anti-nutrient content, and high nutrient density (Pee and Bloem 2008). Hence, popularization of low cost nutritious food particularly for vulnerable groups like infants, young children and adolescent girls is the main concern. Instant food mixes are important as the child needs to be fed 5-6 times a day.

Vegetable proteins have been used in infant feeding on an unscientific basis for centuries. Animal protein is getting beyond the reach of many people in developing countries. So, peanuts being cheaper source of protein are an alternative that can serve the purpose up to a great extent. Peanut meal, a by-product left after oil extraction is a rich source of protein. Peanut meal can be dried and ground in a flour form that can be added to various daily consumed foods (Zhao *et al* 2012).

Peanut (*Arachis hypogaea* L.) is one of the major oilseed crop of the world. India is one of the major contributors of peanuts produce to the world as India is the second world's largest producer after China. India accounts for nearly 30 per cent of total world peanut production and China accounts for 38 per cent of world peanut production. In India, 80 per cent of total peanut production is used for oil extraction and 20 per cent for snacks.

Peanuts are an important source of food protein. Peanuts have a desirable fatty acid profile and are rich in vitamins, minerals and bioactive materials. They contain several known heart healthy nutrients including monounsaturated and polyunsaturated fatty acids, potassium, magnesium, copper, niacin, arginine, fiber, $\alpha$-tocopherol, folates, phytosterols, and flavonoids. Peanuts have gained much attention as a functional food due to the presence of considerable amount of phenolic and other health promoting compounds (Win *et al* 2011).

Peanut flour formed after partial extraction of oil is popular with chefs because its high protein content makes it suitable as a flavor enhancer. Peanut flour is used as a gluten-free solution. Peanuts are a significant source of Resveratrol (an antioxidant), a chemical associated with reduction in risk of cardiovascular disease and cancer. The average amount of resveratrol in one ounce of commonly eaten peanuts (15 whole peanut kernels) is 73 μg. Peanuts are a good source of niacin, and thus contribute to brain health and blood flow. Peanuts themselves contain about 25per cent protein; peanut flour has about 50 per cent. Because the process of mechanically removing fatty oil from roasted peanuts enriches the levels of the remaining peanut components. The resulting flour is naturally low in fat, high in protein and relatively low in carbohydrates. Peanut flour has been used to replace animal proteins in a variety of products. Peanut flour blends well with cereal flour to yield products with excellent flavour, texture and colour. Compared to peanut butter, the lower fat level in peanut flour helps improve the shelf life of products (NPB 2009).

Defatted peanut cake flour has been widely used in the formulation of different kind of products. It has been used in the diets of cardio vascular disease, celiac disease and in the diets of malnourished. It is now gaining its importance as a vital ingredient in different products so as to meet the nutritional requirements. The defatted peanut flour has been used as an additive to increase the protein content of foods such as bread and other baked goods, macaroni, pancakes and puddings; an extender in meat products such as meat loaf and frankfurters; and as an aid in preparing skim and full fat milk, milk-like drinks and ice creams. Phytochemicals like resveratrol is also reported in peanut flour which has been ground along with the skin which is reported to exhibit several physiological activities including anticancer and anti-inflammatory activities *in-vitro* and in experimental animal models, as well as in humans (Udenigwe *et al* 2008)

Peanut flour being lower in fat than peanut butter is popular because its high protein content which makes it suitable as a flavour enhancer. As mentioned earlier, it is also used in the diets of celiac disease and in weight watch diets due the lower fat content. Peanut flour which is most commonly used for fortification contains protein ranging in between 47-55 per cent which contributes to a good amount of protein. Peanut flour has also been used to replace animal protein in a variety of products. The cake contains 45-60 per cent protein, 22-30 per cent of carbohydrates, 3.8-7.5 per cent crude fiber and 4-6 per cent minerals (Desai *et al*

1999). Defatted groundnut flour produced from cake blends easily and enhances or enriches the nutritive value of wheat flour and other flours (Purohit and Rajyalakshmi 2011). The defatted groundnut flour is an underutilized by-product of groundnut processing that has potentials to be used in food system as low fat groundnut concentrate to be used extenders in meat processing, in production of beverages, fermented products, composite flours and protein supplements of bakery products and weaning formulation.

The unique functional properties of defatted groundnut flour such as whipping properties, emulsification, bulk density, viscosity, water and oil absorption has made it important in food processing and in food product formulations (Yu *et al* 2007) but functional properties of DPF are rarely studied. Therefore, groundnut processors are seeking ways to add value to this by-product through novel utilization. The development of groundnut flour from defatted groundnut cake can also provide the food industry with a new cost-effective and high-protein food ingredient for product formulations. This is critically needed in many developing countries where protein-energy malnutrition remains a major health hazard, especially among children.

Peanut flour is made from crushed, partly defatted peanuts and is very low in saturated fat and cholesterol. It is also a good source of dietary fiber, thiamin, folate, potassium and zinc, and a very good source of protein, niacin, magnesium, phosphorus, copper and manganese (Fekria *et al* 2012). Food processing has become important to prevent its post harvest and storage losses and provide better shelf life and nutrient quality. Processing also helps to preserve peanut even for the off season consumption. Roasting of peanut kernels was found to be rich in antioxidants due to the formation of maillard reaction (Zhou *et al* 2013). Processed foods include convenient foods like instant mixes, packed foods and dehydrated foods. Among the processed foods, nutrient mixes have better shelf life and are easily acceptable by all age groups. Several value added products have been developed from different combinations of peanut flour with other cereal, pulse and green leafy vegetable.

Partially defatted peanut meal flour, either convenient or organic, is derived from high oleic peanut roasted to various degrees to deliver everything from bland to bold peanut flavour (Purohit and Rajyalakshmi 2011). Peanut flour being lower in fat than peanut butter is popular with chefs because of its high protein content making it suitable as a flavour enhancer. They are defatted via a mechanical, solvent free process to fat levels of 12-28 per cent. Moisture content of the flours is typically less than two per cent. Fat levels play major role in the degree of flavor, with 28 per cent fat flour delivering a more pronounced peanut flavour. The 12 per cent fat flour is best for high protein, low fat applications like nutritious bars and snack bars where peanut flavour can be masked off notes in highly fortified foods, as well as low fat baked products (Yadav *et al* 2013).

Defatted peanut cake flour can replace peanut butter in formulations where one wants to control fat migration of peanut-butter filled items (Fekria *et al* 2012). Thus, partially defatted peanut flour being an excellent source of protein and other essential nutrients will surely make a solution in prevention and control of many health problems as well as protein-energy malnutrition which is one of world's biggest challenges faced today.

In recent years, the increased interest in health foods has made consumers demand foods with health benefits with desirable sensory qualities especially for infants and children. Many convenient foods enriched with antioxidants and phytonutrients are made available in the market for consumers as they have busy schedule and lack of time for preparation. Currently there is a good deal of interest in carbohydrate and protein rich foods because of their specific nutritional importance in controlling chronic diseases in the dietaries of population. Hence, food processing industries can play an important role in helping the consumer to eat wisely by offering foods with variety and most importantly with the best quality and prolonged shelf life.

Keeping in view the prevalence of malnutrition among vulnerable group as well as the importance of partially defatted peanut cake flour, it's nutritional and health potentials and most importantly the present status of malnutrition, the present study was planned with following objectives:

i. To develop value added products from a combination of cereal, pulse, green leafy vegetables and partially defatted peanut cake flour.
ii. To evaluate the nutritional composition of developed products before and after storage period.
iii. To study the shelf life of the developed products in different packaging materials.
iv. To study the impact of supplementation of the developed products on the nutritional status of malnourished children.

**CHAPTER II**

# REVIEW OF LITERATURE

The present study entitled "Impact of supplementation of value added products using partially defatted peanut cake flour on the nutritional status of malnourished children" was undertaken to develop five protein rich value added products using partially defatted peanut cake flour as well as powdered dehydrated green leafy vegetables and to study their impact on the nutritional status of malnourished children on supplementation. The relevant literature related to the study was reviewed under the following sub headings.

2.1 Present scenario of malnutrition among children

2.2 Nutritional composition of peanuts and defatted peanut cake flour

2.3 Development and quality evaluation of value added products using defatted peanut cake flour

2.4 Effect of supplementation of value added products using defatted peanut cake flour

2.5 Effect of storage on the acceptability and quality of peanuts and defatted peanut flour based products

## 2.1 Present scenario of malnutrition among children

Malnutrition has been the most serious global challenge since the early 70's whose prevention appears to be problematic from then to this century even after the introduction of several nutritional intervention programmes in the various parts of the globe. Undernutrion contributes to more than one-third of all deaths in children under the age of five. In 2011, it was reported that globally, 165 million children were stunted, 101 million underweight and 52 million wasted, all belonging to the under five category (UNICEF-WHO-The World Bank 2012).

Stunting and emaciation, major forms of undernutrition reduce a child's chance of survival, while also hindering optimal health and growth. In May 2012, The World Health Assembly, the decision making body of World Health Organisation (WHO), agreed on a new target: reducing the number of stunted children under the age of five by 40 per cent by 2015 (UNICEF 2012). The United Nations Secretary-General has included elimination of stunting as a goal in his Zero Hunger Challenge, launched in June 2012 (UNICEF 2012). This emphasis on stunting has led to a review of national programmes and strategies to increase the focus on prevention and integrated programmes.

Almost 870 million people, or 12.5 percent of the world's population, were undernourished in 2010-2012; the majority of them (852 million) live in developing countries. Stunting rates also exceeded 40 percent in South and South East Asia during the same period, with peaks in India, the Lao People's Democratic Republic, Nepal and Timor-Leste. African countries show the highest rates of underweight prevalence. During 2005-2011, 16 African countries showed underweight rates of at least 20 percent, with the highest levels recorded in Africa (Quisumbing and Haddad 1999, FAO 2013).

Globally an approximate of 165 million children (26%) under the age of five was stunted in 2011. But this burden is not equally distributed around the world. Sub-African (40%) and South Asia (39%) are home to three fourth of the World's stunted children. Eighty percent of the world's stunted children live in 14 countries. According to the highest malnourished population the countries are ranked first and they are India (36% of global burden and 48% of stunting prevalence) followed by Nigeria, Pakistan, China, Indonesia, Bangladesh, Ethiopia, Congo, Philippines, Tanzania, Egypt, Kenya, Uganda and Sudan (UNICEF 2012). The global prevalence of stunting children under the age of 5 has declined by 36 per cent over the past two decades- from an estimated 40 per cent in 1990 to 26 per cent in 2011. An annual reduction of 2.1 per cent per year was observed. The greatest declines in stunting prevalence occurred in East Asia and the Pacific. This region experienced about a 70 per cent reduction in prevalence – from 42 per cent in 1990 to 12 per cent in 2011. The prevalence of stunting in China decreased from more than 30 per cent in 1990 to 10 per cent in 2010. The South Asia and Middle East and North Africa regions have both achieved more than a one-third reduction in stunting prevalence since 1990. However, progress in reducing stunting prevalence in sub-Saharan Africa was limited to 16 per cent, from 47 per cent in 1990 to 40 per cent in 2011 (FAO 2013).

Globally an estimated 101 million children under the age 5 years (16% of child population under age 5) were underweight in 2011. Underweight prevalence is highest in South Asia, which has a rate of 33 per cent, followed by Sub-Saharan Africa, at 21 per cent. South Asia has 59 million underweight children, while Sub-Saharan Africa has 30 million. Globally, underweight prevalence has declined, from 25 per cent in 1990 to 16 per cent today – a 37 per cent reduction. The greatest reductions have been achieved in Central and Eastern Europe and the Commonwealth of Independent States, where prevalence has declined by 87 per cent, and in East Asia and the Pacific, where it fell 73 per cent (largely by the reductions made in China) (UNICEF 2012).

Moderate and severe wasting represents an acute form of undernutrition, and children who suffer from it face a markedly increased risk of death. Globally in 2011, 52 million children under 5 years of age were moderately or severely wasted, an 11 per cent decrease from the estimated figure of 58 million in 1990. More than 29 million children under 5, an estimated 5 per cent, suffered from severe wasting. The highest wasting prevalence is in South Asia, where approximately one in six children (16 per cent) is moderately or severely wasted. The burden of wasting is highest in India, which has more than 25 million wasted children. This exceeds the combined burden of the next nine high-burden countries. In Sub-Saharan Africa, nearly 1 in 10 children under the age of 5 (9 per cent) were wasted in 2011, a prevalence that has decreased about 10 per cent since 1990. The number of wasted children in sub-Saharan Africa as a proportion of the world's total has increased over the same period of time. Countries like South Sudan, India, Timor-Leste, Sudan, Bangladesh and Chad have a very high prevalence of wasting – above 15 per cent. The ten most affect countries are India (Highest burden estimate of 20%) followed by Nigeria, Pakistan, Indonesia, Bangladesh, China, Ethiopia, Congo, Sudan and Philippines. Worldwide, of the 80 countries with available data, 23 countries have levels of wasting greater than 10 per cent (UNICEF 2012 and Global Nutrition Report 2014).

Malnutrition among under-five children is a one the prevalent major public health issue India faces today. The prevalence of undernutrition in under 5 children in India is among the highest in the world, and is nearly double that of Sub-Saharan Africa (World Bank 2014). Every year about 2.3 million deaths among 6-60 months aged children in developing countries are linked with malnutrition, which is about 41 per cent of the total deaths in this age group (Bhagowalia *et al* 2014). A study conducted by the authors among children aged between 3 months and 3 years of age belonging to 130 districts through Demographic and Health Surveys in 53 countries over a period from 1986 to 2006 found that mild malnutrition was more prevalent than severe under-weight. The study concluded that the prevalence of mild undernutrition requires greater attention for health care and nutrition intervention programmes among preschool children in developing countries. Hence, it is necessary for various governmental and non-governmental organizations to detect malnutrition at an early stage for planning and implementing timely interventions at the community level.

According to the data from the survey conducted in 2010 showed that the figures for prevalence of undernutrition for children 0 - 59 months has hardly changed in since the previous surveys. Based on the survey of nearly 1,09,000 children in 112 districts (100 of them are backward districts) of 9 selected states, it found that 42 per cent of children under five years are underweight and 59 per cent were stunted. Of all the children suffering from stunting, about half of them were severely stunted. In the best district in each of these states (12 out of 112), the rates of child underweight and stunting are significantly lower – 33 per cent and 43 per cent respectively, but still these are unacceptable high figures in relation to any developed country (HUNGaMa 2011). The interesting aspect of this study was all these children were attending anganwadis and had access to supplementary nutrition programme for the preschool children. As per the records of the Integrated Child Development Scheme (ICDS) till March 2014, 27.6 per cent of children of age 0-6 years attending the ICDS centers were underweight (Mishra 2015).

As per a 2014 UNICEF report, 34 per cent of urban and 47 per cent of rural children of age less than five years were underweight, and risk of being underweight is 1.4 times more for rural children than their urban counterparts. Poverty has a strong impact on nutritional status of children in India. The report also states that the children from poorest 20 per cent households are 3 times more likely to be underweight. Even in urban areas, children from households living in poor neighbourhoods experience higher risk of different forms of undernutrition. A recent case study from a Kolkata slums based on 120 children of age 5-11 years found 44 per cent of these children were underweight, 40 per cent were stunted and 48 per cent showed thinness (Mandal *et al* 2015). In some cases, the seasonal cycle also matters in determining the nutritional status, as found by a study in Odisha based on 1951 preschool children from tribal regions. The study shows that prevalence of undernutrition was significantly higher ($p < .01$) during monsoon as compared with winter season (Meshram *et al* 2014).

Bharati and co workers (2008) observed that the lowest percentages of under-weight children according to the z-score were found in the states of Goa, Kerala and Punjab which are the three most developed states in India through nutritional assessment of preschool children. While in the North-Eastern states of India too, the prevalence of undernutrition was low were women are well-educated. Hence it was concluded that the overall development, enhancement of level of education and low gender inequality are the key factors for improvement in the health status of Indian children.

In India, the risk of infection is associated with lower BMI (Body Mass Index) for age and wasting among the preschool children which indicates a deficiency in calorie intake compared to other indicators like weight for age and height for age (Mittal *et al* 2007). Other than the dietary deficiency, maternal age, weight and anaemia during adolescent age and pregnancy in mother significantly affects child's nutritional status (Mittal *et al* 2007 and Ganesh *et al* 2010). In an intervention study by Schmid *et al* (2007) compared dietary intake and nutrient sources among Dalit mothers for their children aged 6-39 months living in villages based on improved access to the traditional Dalit food system. They observed that there was no significant difference in children's food intake between the intervention and control villages. Socioeconomic inequality such as poverty, illiteracy, lack of awareness regarding the quality of food items, large family and poor sanitary environment are the key factors associated with malnutrition (Van *et al* 2008).

Nutrition-specific interventions are actions that have a direct impact on the prevention and treatment of undernutrition, in particular during the 1000 days covering pregnancy and the child's first two years. These interventions should be complemented by broader, nutrition-sensitive approaches that have an indirect impact on nutrition status. Equity considerations in nutrition programming are particularly important, as stunting and other forms of undernutrition afflict the most vulnerable populations (DeOnis *et al* 2006 and Victoria and Cesar 2010).

UNICEF reports of 2014 states that the global agricultural system is currently producing enough food to feed the world, but access to adequate, affordable, nutritious food is more challenging. Improving dietary diversity by increasing production of nutritious foods is achievable, particularly in rural populations. It is done by producing nutrient-dense foods, such as fruits and vegetables, fish, livestock, milk and eggs; increasing the nutritional content of foods through crop biofortification and post-harvest fortification; improving storage and preservation of foods to cover 'lean' seasons; and educating people about nutrition and diet. In several settings these types of interventions have been shown to improve dietary patterns and intake of specific micronutrients, either directly or by increasing household income. However, the impact on stunting, wasting and micronutrient deficiencies is less clear. Thus, more effort is needed to align the pursuit of food security with nutrition security and improved nutritional outcomes (Global Nutrition Report 2014).

**2.2 Nutritional composition of peanuts and defatted peanut cake flour**

Peanuts are usually processed for oil and residue cake is used either as animal feed or as a fertilizer. Many researchers have also demonstrated that oil extraction produces a protein-rich co-product which may be used for human consumption, if processed from edible-grade peanut seed by commercially accepted food processors (Cherry 1990). Generally, this material is available as cake, flakes or grits and may be further processed to partially defatted peanut cake flour (DPF). DPF, a protein-rich, inexpensive and underutilized product that offers the same health and dietary benefits of peanut has less fat content making its wide applications in the weight watch diets (Liu *et al* 1996).

Tharanathan and his co workers (1975) estimated the proximate composition of defatted edible groundnut flour. They found that the flour had 38 per cent carbohydrates of which oligosaccharides account for 18 per cent, starch 12.5 per cent, fiber 4.5 per cent, sucrose 13.9 per cent and raffinose 0.92 per cent. A similar study by Bansal (2013) also studied the proximate composition of partially defatted peanut cake flour. The author reported that DPF contains 2.55 per cent of moisture, 52.75 per cent of protein, 14.39 per cent fat, 11.02 per cent fiber, 5.2 per cent ash, 14 per cent carbohydrates, 396.91 per cent energy. It is also a source of calcium (74%) and iron (2.6%), thus making it a highly nutritious food ingredient.

Peanut flour is used as gluten free solution and can be used in the diets of patients suffering from celiac disease until and unless it is contaminated with the wheat flour while milling. Peanut contain about 25 per cent protein while peanut flour has about 50 per cent protein available because the process if mechanically removing fatty oil from roasted peanuts enriches the levels of the remaining peanut components. The resulting flour is naturally low in fat, high in protein and relatively low in carbohydrates making it most suitable for weight watch diets (Venkataraghavan 1998).

Cold and heat pressed peanut cake meal cakes were milled, defatted and ground into fine powder and evaluated for proximate composition and functional properties. Flours contained over 50 per cent protein as compared with 25-45 per cent of protein in peanut cake meal. The commercial cake produced during expeller pressing of peanuts was extracted with n-hexane and 80 per cent ethanol followed by sieving through 80 mesh to remove residual oil, pigments, bitter taste and fibrous material. The processed cake exhibited low methionine content and *in-vitro* protein digestibility as compared to its flour (Juliana and Zhengxing 2008).

Peanut flour being lower in fat than peanut butter is popular because its high protein content which makes it suitable as a flavour enhancer. Peanut flour which is most commonly used for fortification contains protein ranging in between 47-55 per cent which contributes to a good amount of protein. Peanut flour has also been used to replace animal protein in a variety of products. The cake contains 45-60 per cent protein, 22-30 per cent of carbohydrates, 3.8-7.5 per cent crude fiber and 4-6 per cent minerals (Desai *et al* 1999). Defatted groundnut flour produced from cake blends easily and enhances or enriches the nutritive value of wheat flour and other flour (Purohit and Rajyalakshmi 2011). The defatted groundnut flour, an underutilized by-product of groundnut processing, has potentials to be used in food system as low fat groundnut concentrate to be used extenders in meat processing, in production of beverages, fermented products, composite flours and protein supplements of bakery products and weaning formulation (Tate *et al* 1990 and Venkataraghavan 1998).

**2.3 Development and quality evaluation of value added products using defatted peanut cake flour**

The unique functional properties of defatted groundnut flour such as whipping properties, emulsification, bulk density, viscosity, water and oil absorption has made it important in food processing and in food product formulations but functional properties of DPF are rarely studied. Therefore, groundnut processors are seeking ways to add value to this by-product through novel utilization. Peanut flour is made from crushed, partly defatted peanuts and is very low in saturated fat and cholesterol (Fekria *et al* 2012).

Groundnut is widely used to improve the quality of many cereal based food products in India, Kenya, Malawi, Nigeria, Senegal and Zimbabwe (Devi *et al* 2013). The partially defatted flour is used to improve the nutritional quality of various cereal-based products such as *gonfa,* millet (*Pennisetum glaucum*) based products and *epo-ogi*, a corn (*Zea mays*) based gruel. *Uji* is a food product commonly prepared from maize or sorghum in Tanzania. Groundnut cake after oil extraction is exported for the preparation of *Kisra*, a sorghum based food of Sudan. Acceptable and nutritionally superior quality *kisra* is prepared from sorghum flour fortified with defatted groundnut flour (Beuchat *et al* 1992). The addition of defatted groundnut flour improves baking quality, colour and texture of the final product.

Fortification with groundnut flour and subsequent fermentation improves the *in-vitro* digestibility of sorghum flour (Juliana and Zhengxing 2008). In developing countries where sorghum is a staple food there is a need to have a nutritional improvement programme on sorghum with peanut flour. Acceptable *gari*, a commonly used cassava-based Nigerian food, can be prepared with 15 per cent defatted groundnut flour. There was a four-fold increase in the amount of protein at this level of fortification and a remarkable increase in the concentration of all amino acids was also observed.

Fortified milk systems were prepared by blending pasteurized standardized whole milk with three ingredients- dried skim milk, groundnut flour or groundnut protein isolate to increase the total solids to 15, 18, 20 or 23 percent. This was followed by processing at 60 or 80°C for 30 minutes and storage at 4°C for 24 hours. Curds were prepared by Lactic acid bacteria culturing of the processed milk system. Curd obtained from the fortified milk processed at 80°C showed increased yield stress along with curd strength with enlarged concentration of added protein (Rama Rao *et al* 2000). *Oncom* is a popular dish of Indonesia and can be prepared by pressing the kernels to remove oil. The procedure involves soaking the cake in water for 24 hours, drain and then adds high starch material such as a cassava or residue from soybean milk. The material is then steamed, incubated with fungus *Neurospora intermedia* or *Rhizopus oligosporus* and fermented for 1-2 days at 25 to 30°C after wrapping in banana leaf. It may be fried in oil or margarine and consumed.

Defatted peanut flour is also being used to formulate weaning foods as they are an excellent source of protein. This is one effective way of fighting malnutrition in infants and preschool children. Low cost weaning formulations can be made in the traditional ways. Appropriate process characteristics and blend formulations were developed for the preparation of a high protein-energy weaning food (Mosha and Vincent 2004). The product was based on a blend of dissi-oule rice flour (70%), Philippine peanut flour (20%), skim milk powder (10%), maltodextrin (1.97%), lecithin (0.17%) and hydrogenated peanut oil (0.5%). These ingredients were mixed, blended and fortified by dry mixing with vitamins and minerals. Weaning food made from dissi-oule rice and Philippine peanut had superior nutritional quality.

Bansal (2013) conducted a study on the preparation of fifteen Indian highly acceptable products like soup, *matti, tikki, vada*, pancakes, biscuits, *kheer, halwa, dhokla, seviyan, idli, burfi, vadiya, papad and panjeeri* with the incorporation of defatted peanut meal flour. Incorporation or the peanut flour in common recipes at a level of 5-50 per cent was highly acceptable and can be recommended to improve the nutritive value of the diets. The acceptable percentage of peanut flour was 10 per cent for *vada*, 15 per cent for *halwa, dhokla,* 20 per cent for i*dli,* and 50 per cent for *panjeeri* and overall acceptability score was 8 for *vada*, 8.3 for *halwa*, 8.04 for *dhokla* , 8.13 for *idli* and 8.04 for *panjeeri*. The developed products were found to be highly nutritious as *vada* provided 424.58 Kcal of energy, 25.34per cent protein, 140.85 mg calcium and 3.42mg of iron per 100 g. *Halwa* provided 630.78 Kcal, 15.4 per cent of protein, 49.00mg of calcium and 4.34mg of iron per 100 g. *Dhokla* provided

408.85 Kcal of energy, 28.90 per cent of protein, calcium 187.50 mg and iron 3.86mg per100g. *Idli* provided 393.95 Kcal of energy, 19.50 per cent of protein, 137.08 mg of calcium and 1.50 mg/100g. *Panjeeri* provides 482.50 Kcal of energy, 31.00 g of protein, 57.62 mg of calcium and 3.70 mg of iron per 100 g.

Granato and Ellerdensen (2009) developed gluten free cookies using peanut flour and almond flour separately. The sensory parameters of the developed cookies were compared and it was found that gluten free cookies prepared from peanut flour were liked very much compared to the almond cookies. Chemical composition of the cookies revealed that the protein content for both the cookies were higher than normal cereal cookies i.e. 12.21 percent in peanut cookies and 11.87 in almond cookies. Fat and energy content of almond cookies (27.53 and 513.54 per cent respectively) were higher than peanut cookies (22.41 and 488.12 per cent respectively). Both peanut and almond cookies presented a high degree of sensory acceptance, considerable content of proteins and lipids, and are sources of iron. The data suggested a possible commercial exploration of the produced cookies, so the number of these types of products could increase in the market, offering new nourishing options of consumption for gluten-intolerants.

In a study conducted by Adenuga (2010), the nutritional and sensory properties of infant weaning food developed using sweet potato, cowpea and peanut flour were investigated. The flours were combined in specific ratios (Sweet potato: 60, 65, 70%; Cowpea: 15, 20, 25% and Peanut: 15, 20, 25%) to produce three weaning formulations which were then compared to a commercially available weaning food. The results showed that there was a significant increase of crude protein, ash, fat, fiber and carbohydrate content. The addition of cowpea and peanut flour increased the protein content of weaning food. Fortification with less than 25 per cent cowpea and 15 per cent peanut flour was found to be the most acceptable with regard to sensory evaluation.

Five different products incorporating defatted groundnut cake flour (DGCF) was developed by Purohit and Rajalakshmi (2011). Defatted groundnut cake flour (DGCF) was incorporated at 15–100 per cent levels in laddoo, chutney powder, fryums (deep fried crisp and crunchy item), biscuits, noodles and extruded snacks. The products were studied for sensory and nutritional quality. Housewives and children liked all DGCF incorporated products. Overall acceptability scores by housewives showed that the fryums were highly acceptable followed by chutney powder, extruded snacks, noodles, biscuits and *laddoo*. All the DGCF products were liked extremely by 74 to 98 per cent and 1 to 26 per cent housewives said to like it moderately. In case of children the taste of DGCF biscuits was highly acceptable followed by *laddoo*, extruded snacks, fryums, noodles and chutney powder. The acceptable proportion of DGCF in Biscuits and noodles were 30 per cent, *laddoo* 50 per cent, fryums 15 per cent, extruded products 40 per cent and in chutney powder it was found to be acceptable at 100 per cent. With respect to the nutritional quality, the authors found out that all the DGCF products had a better profile compared to its control. Protein content for noodles, fryums, extruded products, biscuits, chutney powder and *laddoo* was found to be 16.4, 5.9, 17.8, 17.8, 50.1 and 20.4 per cent respectively and their energy values ranged between 344 to 549 Kcal/100g. Lower fat content for noodles, fryums, extruded products, biscuits, chutney powder and *laddoo* was found to be 2.1, 0.82, 2.8, 40.4, 6.5 and 2.7 per cent respectively.

Weaning foods were formulated by Adebayo-Oyetoro and his coworkers (2011) in Nigeria using ground nut flour. Ofada rice and bambara groundnut were processed into flour and mixed in three ratios mainly 90:10, 80:20 and 70:30 respectively to produce a well balanced weaning formulation. Their chemical, functional, rheological and sensory properties were evaluated and the authors indicated an increasing level of proximate composition namely protein, fat and ash which were found to be 19.64-21.10 per cent, 4.78-6.1 per cent and 1.78-2 per cent respectively. The carbohydrate content decreased on increasing levels of substitution with the groundnut flour (64.5 to 58.7 per cent). Apart from adding value and varieties to meal, due to textural improvement, fortifying ofada rice with groundnut flour at 20 per cent level would produce a more nutritionally balanced and acceptable product which will reduce the problem of food security and malnutrition among children in Nigeria.

Muffins prepared with peanut flour contained twice the amount of protein when compared to those prepared with wheat flour alone (Gregory *et al* 2012). Thus it was observed that substitution of wheat flour with peanut flour can increase the protein intake and improve overall health of general produce.

Yadav and his co workers (2012a) studied the effect of partially deoiled peanut meal flour (DPMF) on the nutritional, textural, organoleptic and physic-chemical properties of biscuits. Partially DPMF was blended with wheat flour at 5, 10, 15 and 20 per cent for making biscuits. Chemical analysis of DPMF showed that it contained 30.26 per cent crude protein, 10.11 per cent crude fat and 43.65 per cent carbohydrates. The protein content increased nearly 1.5 times in biscuits as a result of incorporation of DPMF. With regard to sensory evaluation, the results demonstrated that biscuits made up by 15 per cent DPMF exhibited all the scores within an acceptable range.

A ready-to-drink peanut based therapeutic food (TF) was formulated by Nabumma and his co workers (2013) that matched the nutrient profile of F100 milk formulation. Three inexpensive formulations namely A, B and C were designed using computer formulation software with peanuts, beans, sesame, cowpea and grain amaranth as ingredients. A 100g portion of the TF provided 101-111 Kcal, 5g protein and 5.3-6.5g fat. Consumer acceptability hedonic tests showed that the products were liked extremely and moderately by 62-65 per cent of mothers.

A study was conducted in the preparation of bread incorporating deoiled peanut meal flour (DPMF). Bread was prepared by incorporating DPMF with refined wheat flour at 0-20 per cent level and was evaluated for their physical, chemical, textural, colour and sensory attributes. The bread prepared with 10 per cent addition of DPMF had about 1.5 times higher protein content as compared to control. Sensory evaluation revealed that the sample containing 15 per cent DPMF scored the highest in most of the attributes including overall acceptability. Incorporation of DPMF had significant effect on the colour values of bread. The study revealed that incorporation of 15 per cent deoiled peanut flour gave desirable results in terms of nutritional, sensory and textural attributes (Yadav *et al* 2013)

**2.4 Effect of supplementation of value added products using defatted peanut cake flour**

Pelkman and co workers (2004) proved through their investigation that peanut consumption can reduce or control weight. In their study, participants were fed a moderate-fat weight loss diet that provided 33 per cent of energy from fat and purposefully included peanuts or a low-fat weight loss diet that provided 16 per cent of energy from fat without peanuts. Both diets were designed to elicit approximately 1 kg/week of weight loss. After 6 weeks of weight loss, participants were fed the same diet designed to maintain body weight for 4 weeks. As designed, similar weight loss was achieved with the 2 diets (7.2 kg for the moderate-fat group and 6.5 kg for the low-fat group at the end of the weight loss phase and approximately 8 kg for both groups at the end of the maintenance phase). Both diets reduced total and LDL cholesterol, but the low-fat diet decreased HDL cholesterol and increased triglycerides after maintenance of weight loss, unlike the moderate-fat diet. Thus, the moderate-fat weight loss diet that contained peanuts was preferable in terms of the effects on lipid cardiovascular disease risk factors.

Low cost weaning formulations can be prepared in many traditional and new methods. Weaning food made from dissi-oule rice and Philippine peanut had superior nutritional quality. The protein content was 18 per cent with 10 per cent fat and 67 per cent carbohydrates. Calcium, iron and phosphorus levels were also high. The blend can therefore be used as an ideal weaning food hence can improve the nutritional status of infants and can help solve problems associated with malnutrition (Mosha and Vincent 2004). Similar study reported that the preparation of ten types of composite weaning diets based on peanut flour was assayed for their proximate composition, energy, mineral density and tannin content. They found that the concentration of protein, fat, ash, calcium, iron, zinc and copper were significantly increased when plain maize and sorghum gruels were enriched with rojo beans, peanut paste and ground sardines. The maize and sorghum based composite products therefore have a potential to be used as a weaning and’or supplementary foods for older infants and young children (Toure *et al* 2007).

Stephen and his co workers (2010) studied the cardiovascular effects of the nonlipid portion of peanuts through the evaluation of peanut fractions that contain arginine, flavanoids, folates and other compounds that have been linked to cardiovascular health. The objective of their study was to evaluate the effects of fat free peanut flour (FFPF), peanuts and peanut oil on cardiovascular disease risk factors and the development of atherosclerosis in male Syrian golden hamsters. Each experimental diet group was fed a high fat, high cholesterol diet with various peanut components (FFPF, peanut oil or peanuts) substituted for similar metabolic components in the control diet. Tissues were collected at week 0, 12, 18 and 24. Peanuts, peanut oil and FFPF diet groups had significantly lower non-HDL-C than the control group beginning at about 12 week and continuing through the 24 week study. HDL-C was not significantly different among the diet groups. Thus, peanut and peanut component diets retarded an increase in total cholesterol (TC) and cholesterol ester (CE). Because CE is an indicator of the development of atherosclerosis, this study demonstrated that peanuts, peanut oil and FFPF retarded the development of artherosclerosis in animals consuming an atherosclerosis inducing diet.

Phuka and his co worker (2013) carried out an intervention among malnourished infants to improve their nutritional status. There were three intervention schemes. Infants in the control group were provided with an average of 71 g / day of micronutrient fortified maize and soy flour (Likuni Phala, LP). Participants in the other two groups received on average either 50 g / day or 25 g / day of micronutrient fortified spread (FS50 or FS25). The supplements were home-delivered at three-weekly intervals (at each food delivery, either three 500 g bags of LP, four 262 g jars of FS50, or two 262 g jars of FS25 were given). Fortified spread was produced at a Malawian non-governmental organization, Project Peanut Butter prepared from peanut paste, milk powder, vegetable oil, sugar, and premade micronutrient mixture. All supplements were fortified with micronutrients, but the level of fortification varied between the products. The difference between the FS50 and FS25 supplementation was in the amount of food base given (50 vs. 25 g / day). Infants receiving FS50 or FS25 for one year gained on average slightly more weight and length than those receiving an approximately iso-energetic portion of maize and soy flour (LP). In contrast to the mean gains, their study demonstrated a marked and statistically significant difference in the incidence of severe stunting between the FS50 and LP groups. Also, a stratified analysis suggested an interaction between initial height and the intervention group, as demonstrated by bigger between-group differences in both length and weight gain among infants with at least mild stunting at enrolment.

### 2.5 Effect of storage on the acceptability and quality of peanuts and defatted peanut flour based products

Different products incorporating Defatted groundnut cake flour (DGCF) was developed by Purohit and Rajalakshmi (2011) at 15–100 per cent levels in *laddoo,* chutney powder, f*ryums*, biscuits, noodles and extruded snacks. These products were subjected to quality evaluation fresh and after a storage period of 90 days. There was a gradual increase ($p$<0.05) in the moisture content of all the products except *fryums* during the storage period. Both control and DGCF *fryums* recorded a gradual decrease ($p$≤0.05) in moisture content during storage period. There was an increase ($p$<0.05) in FFA of all the products during storage. Microbiological quality in biscuits, *fryums* noodles and extruded snacks, the total viable bacterial count slightly decreased up to 60 days of storage and slightly increased up to 90 days. The increase after 60 days was significant ($p$< 0.05) in biscuits and not significant in *fryums*, noodles and extruded snacks. Chutney powder was an exception as in chutney powder there was a decrease in total bacterial count at each monthly interval from 0 to 90 days, however the decrease was not significant ($p$<0.05) during storage. Total bacterial count of all the products in the present study was less than the specified limit. Initially in all the food products no coliforms were found but they found that there was an increase in total coliform count in all the food products at the end of storage period. A significant increase in total yeast and mold count was observed for *fryum*s (DGCF), noodles (DGCF), chutney powder (control and DGCF) and biscuits (control and DGCF) during the storage period. In *laddoo* after 30 days of storage there was visible mold growth on the surface of *laddoo* which was not acceptable. Significant ($p$<0.05) reduction in sensory scores was found for texture and taste (biscuit), taste (*fryums*), texture (noodles and extruded snacks). However, no significant decrease in the scores was observed for appearance, flavour and overall acceptability in all the products.

The detection of spoilage fungi and mycotoxins contamination in peanut cake product, popularly called ‘‘*kulikuli*’’ was investigated by Adjou and his co workers (2012). Forty five major markets were sampled and peanut cake products were analyzed for aflatoxins and ochratoxin A contaminations, and associated mycoflora. Total coliform count ranged between $1.6 \times 10^1$ and $14.0 \times 10^2$ cfu/g, while the fungal count was between 1.0 to $8.1 \times 10^2$ cfu/g. Bacteria isolated from peanut cake product were *Eschericha coli*, *Klebsiella spp.* and *Clostridium spp.* The fungal isolates include *Aspergillus flavus*, *Aspergillus parasiticus*, *Aspergillus* spp., *Fusarium* spp., and *Penicillium* spp. being the dominant microflora in decreasing frequency of occurrence. High concentrations of aflatoxins were detected. They were between 25.54 to 455.22 μg/kg for AFB1, 33.94 to 491.20 μg/kg for AFB2, 0.41 to 100.33 μg/kg for AFG1 and 22.04 to 87.73 μg/kg for AFG2. Ochratoxin A concentrations ranged between 0.3 and 2 μg/kg.

Nyirahakizimana and his coworkers (2013) studied the occurrence of aflatoxin contamination in raw as well as roasted peanuts in formal and informal markets of two town in Kenya namely, Eldoret and Kericho. The study revealed that the incidence of aflatoxin producing fungi in different peanut products analyzed was high (up to 76%), and the levels of aflatoxin differed in peanuts sampled from formal and informal markets. The highest population of aflatoxin-producing fungi was recorded in raw peanuts sampled from informal market outlets. The high incidence of aflatoxin producing fungi in peanuts and peanut products implies poor quality of peanuts marketed in Eldoret and Kericho towns, and cones- quently, a high risk of aflatoxin contamination and health risk to consumers of peanut products. The significantly higher aflatoxin contamination of raw peanuts compared to roasted de-coated peanuts implies that processing combining roasting and de-coating potentially reduces the incidence of aflatoxin producing fungi and aflatoxin production in pea nuts.

Two flavoured extruded products were developed by Oluwole and his co workers (2013) by co-extruding yam grits (750 µm) obtained from white yam *(Dio-scorea rotundata)* and bambara groundnut flour (250 µm) in 160:40 respectively obtained from white bambara ground-nut with added flavouring agents of salt (1% - 3%) and sugar (4% - 6%). The extruded products were packaged in low density polyethylene bag (0.02 µm gauge size) and stored at room temperature (28°C ± 2°C) and at refrigeration temperature (9°C ± 2°C) for a period of twenty weeks. After the storage period, microbiological changes in the extruded products as determined by the total plate under both storage conditions showed that maximum total plate counts were $0.5 \times 10^4$ and $5.4 \times 10^4$ cfu/g at 9°C ± 2°C and 28°C ± 2°C respectively. Nutritional evaluation studies of extrudates were comparable ($p \geq 0.05$) with standard casein diet with minimum crude protein content of 13.51per cent providing 1707.2 KJ energy per 100g of diet and supported weight gain and growth of laboratory animals.

An investigation was conducted by Aly and his co workers (2013) to include defatted peanut cake flour (DPF) in chicken burger and to evaluate the organoleptic, physiochemical and microbial characteristics of the end product. The authors found out that chicken burger supplemented with 20 per cent roasted defatted peanut flour (R-DPF) showed the taste was the most affected parameter of cooked samples followed by texture, colour and flavour. These samples registered a remarkable increase in fat (8.87%) and protein (32.56%) contents as well as water holding capacity accompanied with a decrease in cooking loss (19.0%) leading to improvement of the final product. *Escherichia coli* and *Staphylococcus aureus* counts were detected in the control samples (5.00 and 6.20 log10 cfu/g respectively); however, only *E coli* count decreased significantly in burger supplemented with 10 per cent unroasted DPF and 20 per cent R- DPF. The total fungal count was only decreased in burger supplemented with 10 per cent R-DPF. A decrease was observed in both total bacterial and fungal counts after storage at 20ºC for 60 days. Supplementation with 20 per cent DPF to low fat chicken burger exhibited good quality attributes and was the most acceptable. Thus the use of DPF could be considered a good source of protein which could increase nutritional value, minimize the product cost and microbiological contamination.

The effect of ambient storage on the quality attributes of aerobically packaged fish curls incorporated with optimum levels of different flours was studied by Raja *et al* (2014). The curls were developed by extrusion technology using fish meat (Catla catla). The fish curls containing optimum levels of different flours viz. 20 percent corn flour, 10 percent black gram flour and 10 percent peanut flour were compared with the control snacks containing 30 percent rice flour and assessed for storage quality and shelf life at ambient temperature. The curls were aerobically packaged in LDPE (low density polyethylene) pouches and evaluated for various physicochemical, microbiological and sensory parameters. Mean values of pH of all the curls showed significantly ($p < 0.05$) decreasing trend with increasing days of storage. Total plate count (log cfu/g) and yeast and mould count (log cfu/g) for the control as well as treatment samples showed significantly ($p < 0.05$) increasing trend with storage. Coliform counts (log cfu/g) were not detected until day 28 in all the products. The mean scores of sensory parameters i.e. appearance and colour, flavour, crispiness, texture and overall acceptability for control as well as treatment samples showed significantly ($p < 0.05$) decreasing trend with storage period. The decrease was significantly ($p < 0.05$) highest on 21st and 28th day of storage. The mean values for all the quality and storage parameters up to the day 21 of the storage were within the acceptable limits. Thus, based on various physicochemical and sensory parameters, the curls incorporated with optimum level of different flours were acceptable up to 21 days of ambient storage in the LDPE pouches.

The literature was reviewed regarding the prevalence of protein energy malnutrition, nutritional composition of peanuts and defatted peanut cake flour, development and quality evaluation of value added products using defatted peanut cake flour, their supplementary effects and effect of storage on the acceptability as well as quality of the peanut and peanut flour based products to analyse the quantum of work done under above mentioned areas.

**CHAPTER III**

# MATERIALS AND METHODS

The present investigation was carried out on the development, nutritional and shelf life evaluation of value added cereal - pulse based products using partially defatted peanut cake flour and powdered green leafy vegetables. The impact of supplementation of the developed products on the nutritional status of the malnourished children was also studied. The materials and methods selected for the study have been discussed under the following sub headings.

3.1 Procurement and processing of raw materials

3.2 Formulation, standardization and development of value added products using peanut flour and green leafy vegetables

3.3 Sensory evaluation of the developed value added products

3.4 Nutritional evaluation of developed value added products

- 3.4.1 Proximate composition
- 3.4.2 Total minerals
- 3.4.3 Vitamins
- 3.4.4 Amino acids- lysine, methionine and tryptophan
- 3.4.5 *In-vitro* protein digestibility
- 3.4.6 Anti nutritional factors

3.5 Effect of storage on the quality of the value added products in different packaging materials

- 3.5.1 Sensory evaluation
- 3.5.2 Nutritional evaluation
- 3.5.3 Microbiological evaluation

3.6 Supplementation of the developed products

- 3.6.1 Location of study
- 3.6.2 Selection of subjects
- 3.6.3 Development and pre-testing of interview schedule
- 3.6.4 Collection of data
  - 3.6.4.1 General information
  - 3.6.4.2 Dietary survey
  - 3.6.4.3 Anthropometric measurements
  - 3.6.4.4 z-score classification
  - 3.6.4.5 Supplementation of the developed value added products
  - 3.6.4.6 Assessment of blood profile

3.7 Statistical Analysis

### 3.1 Procurement and processing of raw material

Different ingredients for the development of value added products like wheat flour, refined wheat flour, chick pea flour, raw peanuts , seasonal green leafy vegetable i.e. spinach and fenugreek leaf as well as other ingredients like oil, ghee, salt, powdered sugar were procured from the local market of Ludhiana in a single lot.

#### 3.1.1 Processing of peanuts

Peanuts of the variety SG-99 were purchased and checked for any infestation or damage. Peanuts free from damage were then roasted, de-skinned. Oil was extracted by using oil extraction machine at the local market in Ludhiana. The residual cake containing 8.96 per cent of fat was then collected and further dried in the oven at 85 ºC for half an hour. Dried cake was ground to fine powder.

#### 3.1.2 Processing of green leafy vegetables

Green leafy vegetable like spinach and fenugreek leaf were procured from local market in a single lot. They were sorted separately and thoroughly washed in running water to remove adhering dirt. The washed vegetables were blanched and spread as a single layer on separate aluminum trays and dried in a tray drier at 60°C for 5-6 hours (constant weight was achieved in this time). The dried spinach and fenugreek leaf was ground to fine powder in a stainless steel electric grinder and sieved by using thin mesh of pore size 1mm. They were then stored in separate airtight containers.

### 3.2 Formulation, standardization and development of value added products using peanut flour and green leafy vegetables

The value added products were developed in such a way keeping the basic ingredient a cereal-pulse mix. Cereal flour and pulse flour was taken in the proportion of 3:1 ratio. The products were developed from different combinations and percentage of wheat and chick pea flour and peanut flour. The product with acceptable level of peanut flour was then modified with different percentages of powdered green leafy vegetables along other ingredients for better acceptability and nutritional composition. The ingredient mixes of the products were developed to provide calorie dense, protein rich products packed with essential amino acids, minerals and vitamins.

#### 3.2.1 Development and standardization of value added products using specific ingredient mix

Five wholesome value added products namely *panjiri*, *matthi*, *seviyan*, biscuits and *pinni* were developed and standardized using different combinations of wheat flour, chick pea flour, partially defatted peanut cake flour and green leafy powder at different levels. The value added products were prepared in the Food Laboratory of Department of Food and Nutrition, Punjab Agricultural University, Ludhiana. The five value added products were first standardized with different levels (5%, 10% and 15%) of peanut flour. Products like *matthi*, *seviyan* and biscuits were acceptable at 10 per cent incorporation of peanut flour while *pinni* and *panjiri* at 15 per cent. Different levels of incorporation of fenugreek leaf powder in *matthi* and *seviyan*; spinach leaf powder in *pinni*, *panjiri* and biscuits were further done along with the acceptable proportion of peanut flour.

**i) First trial of standardization of value added products with partially defatted peanut flour**

**Sample I (Control):** value added products prepared with wheat and chick pea flour alone in 3:1 proportions using standardized recipes

**Sample II:** Same as I + 5% partially defatted peanut cake flour

**Sample III:** Same as I + 10% partially defatted peanut cake flour

**Sample IV:** Same as I + 15% partially defatted peanut cake flour

*Matthi* and *seviyan* were acceptable at 10 per cent incorporation of partially defatted peanut cake flour while *pinni* and *panjiri* were found to be acceptable at 15 per cent addition of peanut cake flour.

**ii) Second trial of standardization of value added products with green leafy vegetable powder**

For *Matthi* and *Seviyan*, the sample trials were as follows:

**Sample I (Control):** value added products prepared with wheat and chick pea flour with accepted proportion of partially defatted peanut cake flour (10%)

**Sample II:** Same as I + 0.5% of fenugreek leaf powder

**Sample III:** Same as I + 1 % of fenugreek leaf powder

**Sample IV:** Same as I + 1.5 % of fenugreek leaf powder

For Biscuits, *Pinni* and *Panjiri* the sample trials are as follows:

**Sample I (Control):** value added foods prepared with wheat and chick pea flour with accepted proportion of partially defatted peanut cake flour (10% for biscuits and 15% for *pinni* and *panjiri*)

**Sample II:** Same as I + 1% of spinach leaf powder

**Sample III:** Same as I + 1.5 % of spinach leaf powder

**Sample IV:** Same as I + 2 % of spinach leaf powder

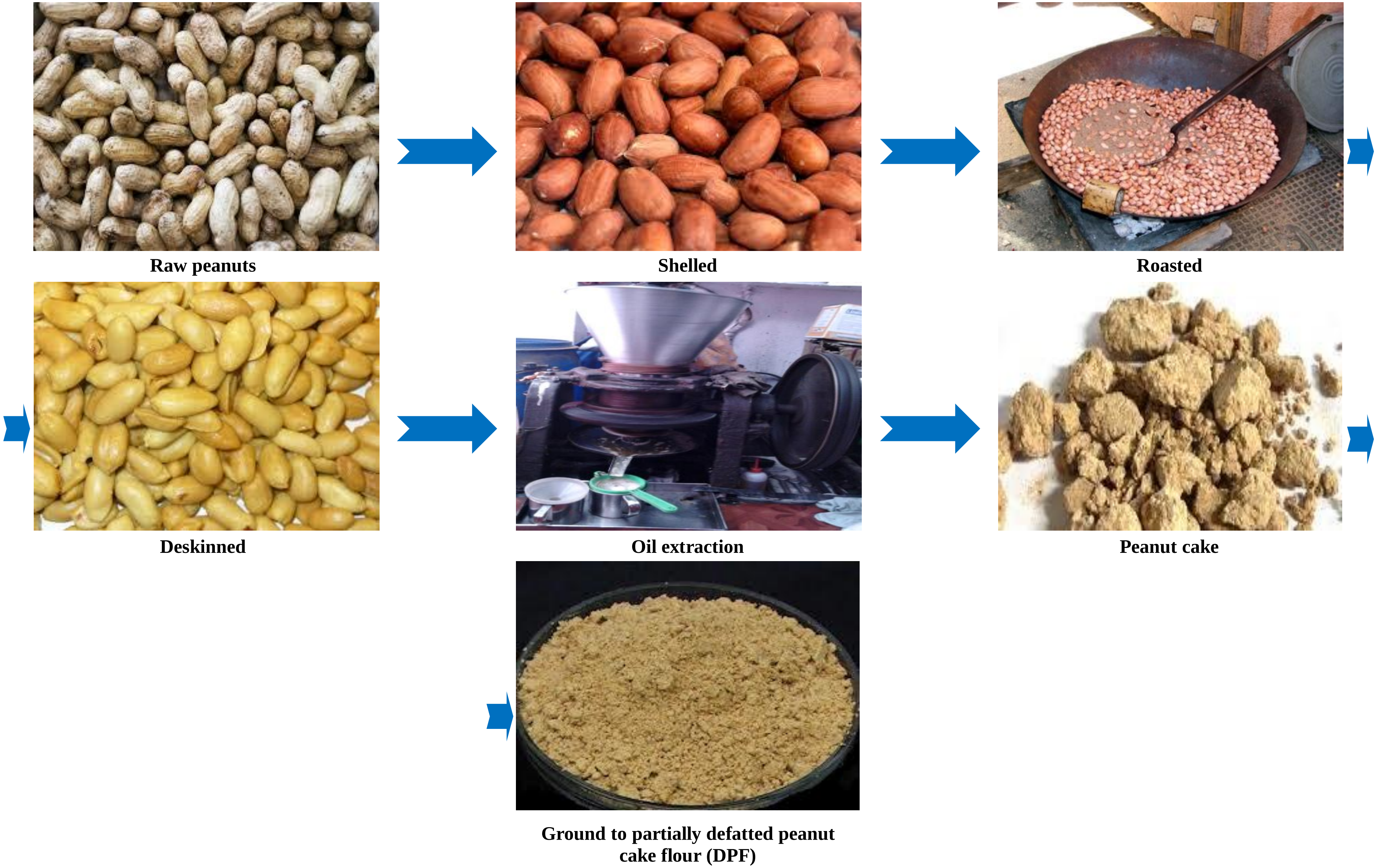


**Plate 1: Preparation of partially defatted peanut cake flour**

**Standardized recipes of developed products**

***MATTHI***

**Ingredients:**

| | |
|---|---|
| Refined Wheat flour | 66.5g |
| Chick pea flour | 22.5g |
| Partially defatted peanut flour | 10g |
| Fenugreek leaf powder | 1g |
| Fat | 15 g |
| Salt | 3 g |
| Carom seeds (*Ajwain)* | 3 g |
| Water for kneading | 10 ml |

**Method:**

1. Add chick pea flour, peanut flour, salt and carom seeds to the refined wheat flour.
2. Add fat to the flour as shortening and mix thoroughly.
3. Knead it into stiff dough.
4. Divide the dough into small balls.
5. Roll the balls into the shape of *matthi.*
6. Prick the rolled *matthi* with knife so that it remains flat even after frying.
7. Deep fry *the matthi* till golden brown colour.

***SEVIYAN***

**Ingredients:**

| | |
|---|---|
| Wheat flour | 22.5g |
| Chick pea flour | 66.5g |
| Partially defatted peanut flour | 10g |
| Fenugreek leaf powder | 1g |
| Salt | 3 g |
| Mustard Oil | 5g |
| Water for kneading | 50 ml |

**Method:**

1. Mix all the flours, 5g of oil and salt thoroughly.
2. Add water and mix well.
3. Fill the mixture in *seviyan* making machine.
4. Heat the oil; rotate the machine over the oil and fry the *seviyan* till brown colour.

## *PINNI*

**Ingredients**

| | |
|---|---|
| Wheat flour | 61.5g |
| Chick pea flour | 21.5g |
| Partially defatted peanut flour | 15g |
| Spinach leaf powder | 2g |
| Powdered sugar | 70 g |
| Saturated fat | 60 g |

**Method**

1. Add saturated fat in a thick pan, add wheat and chick pea flour and cook on slow fire till light brown colour.
2. Add peanut flour in it, mix thoroughly and cook for few minutes.
3. Remove from fire, add powder sugar and mix well.
4. Grease a tray and spread the mixture over it.
5. Roll out small balls called *pinni* of desired sizes when warm.

## *PANJIRI*

**Ingredients**

| | |
|---|---|
| Wheat flour | 61.5g |
| Chick pea flour | 21.5g |
| Partially defatted peanut flour | 15g |
| Spinach leaf powder | 2g |
| Powdered sugar | 70g |
| Saturated fat | 50g |

**Method**

1. Heat fat in thick pan and roast wheat flour and chickpea flour on slow fire.
2. Add peanut flour, mix well and roast for 2 minutes.
3. Add powder sugar and mix it, cook for 2-3 minutes.

## BISCUITS

**Ingredients**

| | |
|---|---|
| Wheat flour | 66g |
| Chick pea flour | 22.5g |
| Partially defatted peanut flour | 10g |
| Spinach leaf powder | 1.5g |
| Saturated fat | 34 g |
| Sugar | 52 g |
| Milk | 10 ml |

**Method**

1. Cream the fat on clean surface
2. Add sugar little by little till both fat and sugar creams well.
3. Add baking powder to the flour mixture and sieve 2-3 time.
4. Add the flour mix slowly and mix well with the cream
5. Knead the mixture evenly with milk till smooth dough.
6. Roll the dough and cut them into desired shapes
7. Bake at 150°C for 15-20 minutes.

### 3.3 Sensory evaluation of the developed value added products

The sensory evaluation of the developed value added products was carried out to select the most acceptable level of peanut flour from the first trial as well as the acceptable level of green leafy vegetable powder in the development of products in the second trial. In the second trial, the acceptable products of first trial were used as the control sample. The sensory evaluation of the developed products was carried out by ten trained panelists including faculty of department of Food and Nutrition of Punjab Agricultural University with approximate age between 45 to 55 years. The panel was provided 9 point hedonic scale for attributes like appearance, colour, texture, aroma, taste and overall acceptability (Larmond 1970) (Appendix-I). Different sample codes were given to different levels of products and exact composition of the levels were not revealed to the panelists to get their exact judgment of the samples. The mean scores for each product were then calculated. The sensory evaluation was performed in controlled environmental conditions with minimum distractions to reduce the effect of physical conditions on panelist judgment. The highly acceptable products from the second trial containing both peanut flour and powdered green leafy vegetable along with their corresponding control (with no supplemented flour or green leafy vegetable) were weighed, homogenized and oven dried at $60^0$C. Dried samples were stored in air tight plastic bags for further analysis.

### 3.4 Nutritional evaluation of developed value added products

#### 3.4.1 Estimation of proximate composition

##### 3.4.1.1 Moisture (AOAC 2000)

Weighed sample (5g) was dried in the china crucible in hot air oven for 8 hours at $105°^{\circ}$C. China crucible with dried material was immediately transferred to a desiccator, cooled and weighed. The loss in weight represented the moisture content of sample.

$$\% \text{ Moisture} = \frac{\text{Loss in weight (g)}}{\text{Weight of sample (g)}} \times 100$$

##### 3.4.1.2 Crude protein (AOAC 2000)

The kjeldahl method was used for determination of nitrogen. The factor 6.25 was used to convert nitrogen to crude protein.

**Reagents**

1. Conc. Sulphuric acid.
2. Digestion mixture: Copper Sulphate and Potassium Sulphate in the ratio of (1:9).
3. 4 % Boric acid
4. 40% Sodium hydroxide.
5. Mixed indicator: 0.1g methyl red and 0.5g bromocresol green were dissolved in 100ml of 95% ethanol.
6. 0.1 N Sulphuric acid.

**Procedure**

Weighed sample (0.5g) was digested in a digester (PELICAN) with conc. sulphuric acid (25 ml) and digestion mixture (10g) in a kjeldahl digestion flask. The digestion was carried out until the solution was of clear blue color. The volume of digested solution was made to 250ml with water. Took 50ml of this solution in a distillation flask, added 200ml water and 100ml of 40% sodium hydroxide to neutralize the acid and create strong alkaline pH. The distillation flask was immediately fixed to a condenser having a 250ml flask containing 20 ml of 4% boric acid with mixed indicator, marked the flask at 100ml. Collected about 100ml of distillate. The ammonium borate formed was titrated against standard 0.1 N $H_2SO_4$.

$$\% \text{ Nitrogen} = \frac{\text{Vol. of } 0.1\text{N } H_2SO_4 \text{ used} \times 0.0014 \times 100}{\text{Weight of sample}}$$

% Crude protein = % Nitrogen × 6.25

**3.4.1.3 Crude Fat (AOAC 2000)**

**Reagents**

Petroleum ether (40 - 60°C)

**Procedure**

Thimbles were prepared from Whatman No.1filter paper sheet with the help of 2cm diameter test tube and thread. Five gram of moisture free sample was transferred to the thimble and was plugged with cotton. The thimble was placed in the beakers of Soxhlet Assembly and petroleum ether (40 - 60°C) was put in the flask to 1.5 times capacity of Soxhlet Assembly and the apparatus was fitted with condenser to a water tap for cold water circulation. The apparatus was started by fixing at 60°C and was run for 18 hours taking care of the tap water and the ether in the flask. Fatty constituents dissolved in the ether were transferred in the beaker.

At the end, ether was evaporated and the fat left in the beakers was weighed.

$$\text{Crude fat \%} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

**3.4.1.4 Crude Fibre (AOAC 2000)**

**Reagents**

1. 1.25 % Sulphuric acid
2. 1.25% Sodium hydroxide

**Procedure**

5g of moisture free sample was taken in 500ml beaker and 200ml of 1.25 % sulphuric acid was added to it. It was refluxed for 30 minutes and filtered through muslin cloth using Buchner funnel. The residue was washed with hot water till it was acid free and then transferred to beaker. Added 200ml of 1.25 % sodium hydroxide to beaker and again refluxed for 30 minutes. Again filtered through muslin cloth and washed with hot water. Transferred the residue to a pre-weighed crucible and dried to a constant weight at 130°C for 2 hours in a hot air oven. Residue was ignited in muffle furnace and loss in weight was recorded.

$$\text{Crude fibre \%} = \frac{\text{Weight of residue - weight of ash after ignition}}{\text{Weight of sample taken}} \times 100$$

**3.4.1.5 Crude Ash (AOAC 2000)**

5 g of sample was weighed in previously weighed crucible. It was ignited and placed in a muffle furnace at 550°C for 4 hours. After cooling the residue left in the crucible was weighed.

$$\text{\% Ash} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

**3.4.1.6. Carbohydrates**

Available carbohydrates were calculated by adding proximate composition and subtracting from 100.

**3.4.1.7. Energy**

The energy content was calculated by factorial method.

Energy (Kcal) = (4 x protein) + (9 x fat) + (4 x carbohydrates)

**3.4.2. Estimation of total minerals**

Elements namely iron, calcium, zinc and phosphorus were estimated using atomic absorption spectrophotometer (AAS, Varian model) after wet digestion (Piper 1950).

**Principle**

The sample is vaporized into its atomic state usually by a flame and irradiated by the light from a source whose emission lines are those of the element being sought. The absorption of the light by the vaporized sample is related to the concentration of the element in it.

**Decontamination of the equipment**

All the glassware and plastic bottles required for mineral estimation were cleaned, washed and were soaked overnight in 10 percent commercial hydrochloric acid followed by thorough rinsing with deionised water followed by drying and labeling.

**Reagents**

Diacid mixture was used for digesting the food sample consisting of nitric acid (AR) and perchloric acid in the ratio 5:1 respectively. Always use freshly prepared diacid mixture.

**Procedure**

Weighed sample (0.5g) was digested with 25 ml of diacid mixture in a conical flask (100 - 250 ml). The contents were kept overnight for slow digestion and then heated at a low temperature on a hot plate till about 1 ml clear, colorless liquid was left. Then contents were allowed to cool and then transferred with deionised water into a 50 ml volumetric flask after repeated washings and the volume made to the mark. The digests were filtered through Whatman No. 42 filter paper and stored in the decontaminated, dried, labelled and air tight polythene bottles for mineral determination by atomic absorption spectrophotometer. For blank, 25 ml of diacid mixture was digested as in case of sample and volume was made to 50 ml with deionized water.

**Standard Curve**

Standards were used to prepare the standard solutions of iron, calcium, zinc and phosphorus. The solutions of 100 ppm concentration of each mineral were prepared. These were diluted to various concentrations with distilled water, 1 ml of concentrated sulphuric acid was added and volume was made to 50 ml. The absorbance of the standards was recorded in the form of standard curve by the automated recorder in the atomic absorption spectrophotometer. The concentration of the samples was also recorded automatically.

$$\text{Mineral content} = \text{Conc. of sample (ppm)} \times \text{dilution factor}$$

### 3.4.3 Vitamins

#### 3.4.3.1 Estimation of Ascorbic Acid (AOAC 2000)

**Principle**

The blue colour produced by the reduction of 2, 6-dichlorophenolindophenol dye by ascorbic acid is estimated spectrophotometrically.

**Reagents**

1. Acetate buffer, pH 4.0: Dissolved 300 g of anhydrous sodium acetate in 700 ml of water and added 100 ml of glacial acetic acid.
2. 2,6-dichlorophenolindophenol dye solution : Dissolved 25 mg of the sodium salt of 2,6-dichlorophenolindophenol in distilled water and maked upto 200 ml.
3. Metaphosphoric acid (HPO3) 6%: Dissolved 6 g metaphosphoric acid in 1000 ml distilled water.

4. Ascorbic acid standard (1 mg/ml): Dissolved 100 mg of pure ascorbic acid in 100 ml of 6 % metaphosphoric acid.
5. Xylene

**Procedure**

For estimation of vitamin C, 2-5 g of the fresh sample was weighted and placed in a mortar and pestle. 20 ml of 6 % metaphosphoric acid was added slowly and the food sample was ground to slurry. The slurry was filtered through Whatman no. 1 filter paper. 30 ml metaphosphoric acid was added to residue and filtered again. Three separating funnel (50 ml) were set and labeled as A, B and C - A for sample, B for dye and C for standard. 5 ml of filterate was pipetted into a separating funnel A, 0.1 ml of standard ascorbic acid solution into funnel C. 5 ml acetate buffer was added to all three funnels followed by 2 ml the dye solution. 10 ml of xylene solution was quickly added and the contents were shaked for 5 to 10 seconds. The contents were allowed to separate into two layers. The bottom layer was discarded. The xylene layer was transferred into a test tube and the optical density was read in a spectrophotometer at 500 nm.

**Calculation**

$$X \text{ mg} = 0.1 (b-a) / (b-c)$$

Where b = OD of blank

a = OD of sample

c = OD of standard

**3.4.3.2 Beta Carotene (Rangana 1995)**

Beta carotene was estimated by column chromatography.

**Reagents**

1. Acetone
2. Petroleum ether (BP 40-60°C)
3. Aluminium oxide (neutral)
4. Standard carotene: 5 mg of beta carotene was dissolved in 250 ml of 3% acetone in petroleum ether.

**Extraction and Procedure**

The sample (5 g) was taken and carotenoid pigments was extracted 4-6 times with 3% acetone in petroleum ether. Acetone was completely removed from the extract by washing with water 3 times and the extract was concentrated to 5 ml. Beta carotene was separated from the extracted pigments by column chromatography of dimension of 10 cm in length and 0.5 cm in diameter. Aluminium oxide was used as absorbent. Acetone (3%) was used as elutent. The first eluted pigment was beta carotene which was made upto 5 ml volume and its absorbance was read at 450 nm in spectrophotometer. Acetone (3%) in petroleum ether was used as a blank. The results were expressed as μg beta carotene / 100g.

$$\text{Beta carotene } (\mu g/100g) = \frac{\text{Total Vol. made x Y}}{\text{Weight of sample taken}} \times 100$$

Y= Total volume charged x Avg. OD/ml x 4

Note : 1 OD = 4µg/ml of beta carotene

**3.4.4 Estimation of amino acids**

**3.4.4.1 Available lysine (Carpenter 1960) as modified by Booth (1971)**

**Reagents**

1. 8% Sodium bicarbonate
2. Ethyl alcohol
3. 1-Fluoro-2,4-Dinitrobenzene (FDNB) (2.5%) (v/v) solution in ethanol
4. 1N HCl
5. 8.1 N HCl
6. Conc. HCl
7. Ethyl ether
8. 2 N NaOH
9. Buffer pH 8.5 (19 parts of 8% $NaHCO_3$ and 1 part of 8% $Na_2CO_3$)
10. Methoxy carbonyl chloride
11. Standard Lysine solution -100 µg of lysine per ml of distilled water.

**Procedure**

Stage I – In 8 ml of 8% $NaHCO_3$ 0.5g of sample was added in a conical flask. Further 12 ml of ethyl alcohol containing 0.3 ml of FDNB was added in the conical flask. The samples were shaken for 1 hr in a water bath cum shaker at $50^0$C. Afterwards the ethanol was evaporated in a hot water bath and then 24ml of 8.1 N HCl was added to the flask. The contents were refluxed gently for 16 hours. The volume was then made to 100 ml and filtered.

Stage II – 2 ml of filtrate was taken in 3 tubes A, B and C marked at 10 ml. The contents of A and B were extracted with approximately 5 ml of ether twice and ether layers were discarded. The tubes were immersed in hot water to remove residual ether. The volume was made to 10 ml with 1 N HCl.

Stage III- To tube C one drop of phenolphathalein was added as an indicator and the contents were titrated against 2N NaOH. The same amount of alkali was added to tube B. Then 2 ml of buffer acetate (pH 8.5) was added. Any precipitates formed were dissolved by adding 0.5 ml of methoxy carbonyl chloride with vigorous shaking for 10 minutes and 0.75 ml of conc. HCl was added drop wise. Then contents were extracted with ethyl ether twice. The ether layers were discarded. The excess ether was removed by placing the test tube in hot water bath and the volume was made to 10ml with 1N HCl after cooling the tube.

Stage IV – The extinction coefficients of the contents of tubes A and B were measured at 435 nm. Reading A and reading B was taken as the extinction due to E-NDP lysine, and was compared with the corresponding values obtained with standard lysine solution passed through the procedure from stage 2 onwards, with omission only of the ether washing in stage 2.

The equivalent amount of lysine from the test sample that has reacted with FDNB is calculated, with a suitable correction for losses due to hydrolysis where necessary.

**Calculations**

$$\text{Available lysine / 100 g protein} = \frac{0.85 \times 0.4862 \times \text{dilution factor} \times 100 \times 100 \times \text{conc. of E-DNP lysine HCl.}H_2O}{\text{Weight of sample taken} \times \text{percent protein}}$$

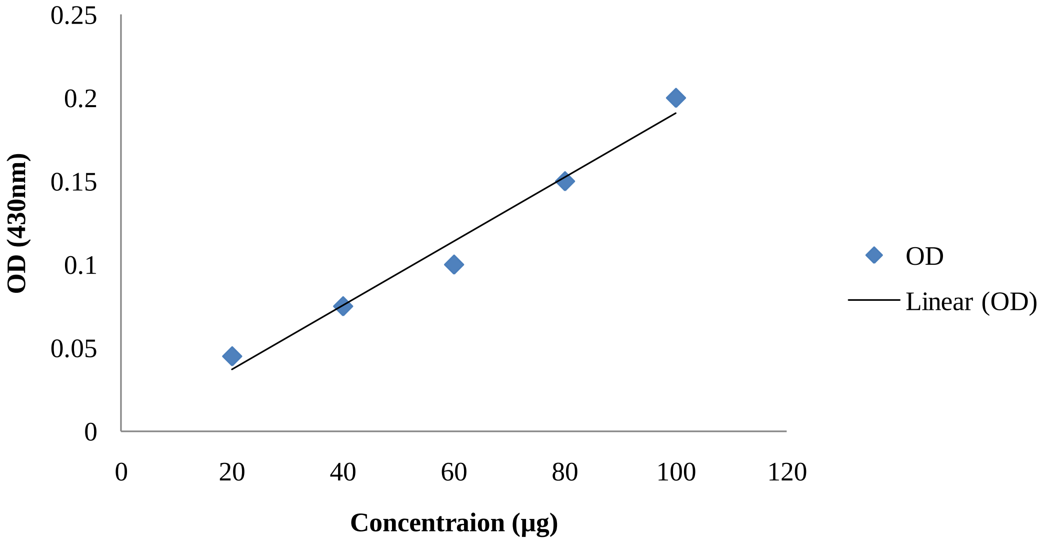


**Fig. 3.1 Standard curve for lysine**

**3.4.4.2 Methionine (Horn *et al* 1946)**

**Hydrolysis of sample for determination of methionine in food sample**

2g fat and moisture free sample was weighed and 25ml of 2.5N HCL was added in the conical flask. The flask was plugged with cotton and kept in the autoclave for 6 hours and 15 lbs pressure. After hydrolysis the volume was made to 25 ml, treated with a pinch of activated charcoal and contents are filtrated. The aliquot thus obtained was used for the determination of methionine in the food sample.

**Reagents**

1. 5N Sodium hydroxide
2. 10% Sodium nitroprusside

3. 3 % Glycine

4. 85 % Orthophosphoric acid

5. Standard methionine solution: 500mg of methionine was dissolved in 2.5N HCL and volume was made to 100 ml.

**Procedure**

Three ml of distilled water, 1 ml of 5 N NaOH and 0.1 ml of freshly prepared 10 % sodium nitroprusside was added to 2 ml of the protein hydrosylate filterate in a test tube. The mixture was shaken for 10 minutes. After that 2 ml of 3% glycine solution was added, slowly drop by drop with constant shaking. The absorbance was measured in spectronic-20 spectrophotometer at 540 nm after 10 minutes. Standard and blank were also run similarly. Standard curve was drawn using 200 to 1000 µg/ml of methionine.

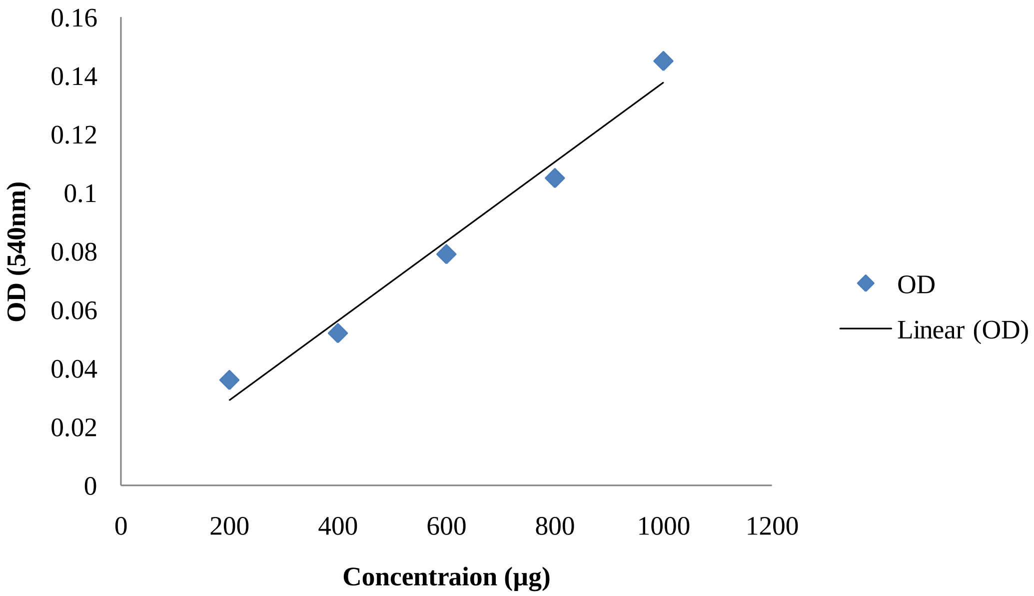


**Fig. 3.2 Standard curve for methionine**

### 3.4.4.3 Tryptophan (Concon 1975)

**Reagents**

1. Acetic acid-$FeCl_3$ solution: Dissolve 0.54 g $FeCl_3$ in 1 ml water containing few drops of acetic acid to prevent formation of insoluble ferrous hydroxide. To 0.5 ml of this solution add glacial acetic acid containing 2 percent acetic anhydride and make the volume to 1 litre.

2. 25.8 N $H_2SO_4$

3. 0.075 N NaOH

**Procedure**

Weigh 100 mg of defatted sample in a test tube and add 10 ml of 0.075 N NaOH. Shake the test tubes in a mechanical shaker for 1 hour. Centrifuge the contents at 12000 rpm for 15 minutes and decant the supernatant. Determine the protein in the supernatant using micro-kjeldahl method. For estimation of tryptophan take 1 ml of protein extract in a test tube and add 3 ml of glacial acetic acid -$FeCl_3$ solution. Then add 2 ml of 25.8 N $H_2SO_4$ rapidly and mix well. Stabilize the colour by incubating the sample at $60^0$C for 45 minutes. Cool to room temperature in ice water bath and read absorbance at 545 nm against reagent blank. Prepare standard curve using 40-200 µg of tryptophan and determine the concentration in unknown from the standard curve.

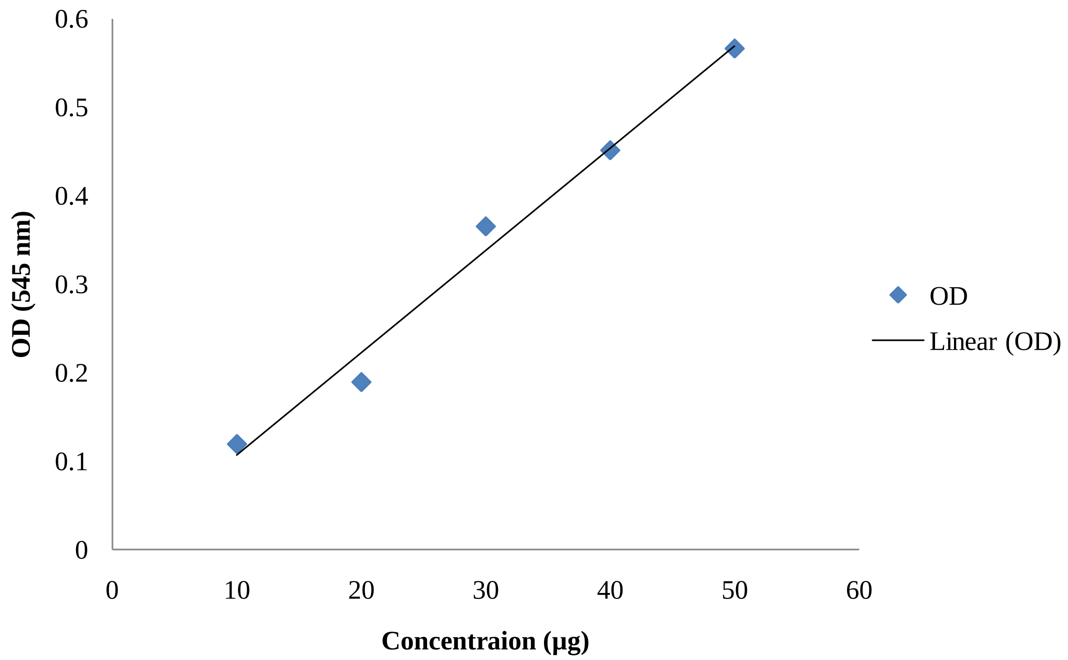


**Fig. 3.3 Standard curve for tryptophan**

### 3.4.5. Estimation of *in vitro* protein digestibility (Akeson and Stachman 1964)

**Reagents**

1. Pepsin: Dissolved 5g of pepsin in 1 litre of 0.01N HCl.
2. Pancreatin solution: 4g of pancreatin dissolved in 1 litre phosphate buffer.
3. 0.2N Sodium hydroxide.
4. 0.1N HCl
5. 0.2M Acid potassium phosphate: Dissolved 27.32g potassium phosphate in distilled water and made the volume 1 litre.
6. Phosphate buffer (pH- 8): To 50 ml of 0.2M acid potassium phosphate added 46.80 ml of 0.2N NaOH and diluted to 200ml.
7. Toulene.

**Procedure**

0.5g of dried sample in 250ml conical flask was taken. Added 50 ml of pepsin solution and incubated at $37^0$C for 24 hours. After that it was neutralized with 30ml of 0.2N NaOH. Then added 50 ml of pancreatin solution and incubated again at $37^0$C for 24 hours. Enzyme blank was run under the described conditions with the protein sample omitted. A few drops of toluene were added to maintain the aseptic environment in the system. The contents of the flask were centrifuged under high speed and filtered residue was analyzed for nitrogen content by macro kjeldahl method. The digestibility co-efficient of the protein was determined by subtracting the residual protein from the initial protein on the basis of 100g of the sample.

**3.4.6 Estimation of anti nutritional factors**

**3.4.6.1 Phytin phosphorous (Haug and Lantzsch 1983)**

**Reagents**

1. Phytate reference solution: Stock solutions are prepared by adding 0.15g sodium phytate in 100ml distilled water. The reference solution used for deriving the standard curve is made by diluting 1 ml of stock solution to 25 ml of 0.2N HCl. Standard curve is obtained by using concentration of phytate phosphorous ranged from 6µg to 30 µg.
2. Ferric solution: Dissolved 0.2g ammonium ferric sulphate in 100ml of 2N HCl and volume was further made to 1 litre with distilled water.
3. 2, 2 Bipyridine solution: Dissolved 10 g of 2,2 bipyridine and 10 ml of thioglycollic acid in distilled water and make the volume to 1 litre.

**Procedure**

One gram of sample was added to 20 ml of 0.2 N HCl and extraction was done by keeping the solution for 3 hrs in shaker. Filter the solution. Pipette 0.5 ml of this extract into tube fitted with a ground glass stopper. Added 1 ml of ferric solution, covered the test tube with stopper and heated the tube in a boiling water bath for 30 minutes, taking care for the first 5 minutes that the tube remained well stoppered. The tubes were cooled in ice water for 15 minutes, allowed to adjust at room temperature. Added 2 ml of bipyridine solution after it reaches the room temperature. The contents were mixed after adding 2 ml of water in each tube. The absorbance was read at 519 nm spectronic 20 after a defined time (0.5 to 1 minutes.). For the blank, 0.5 ml of distilled water was taken and proceeded in the same way as the sample.

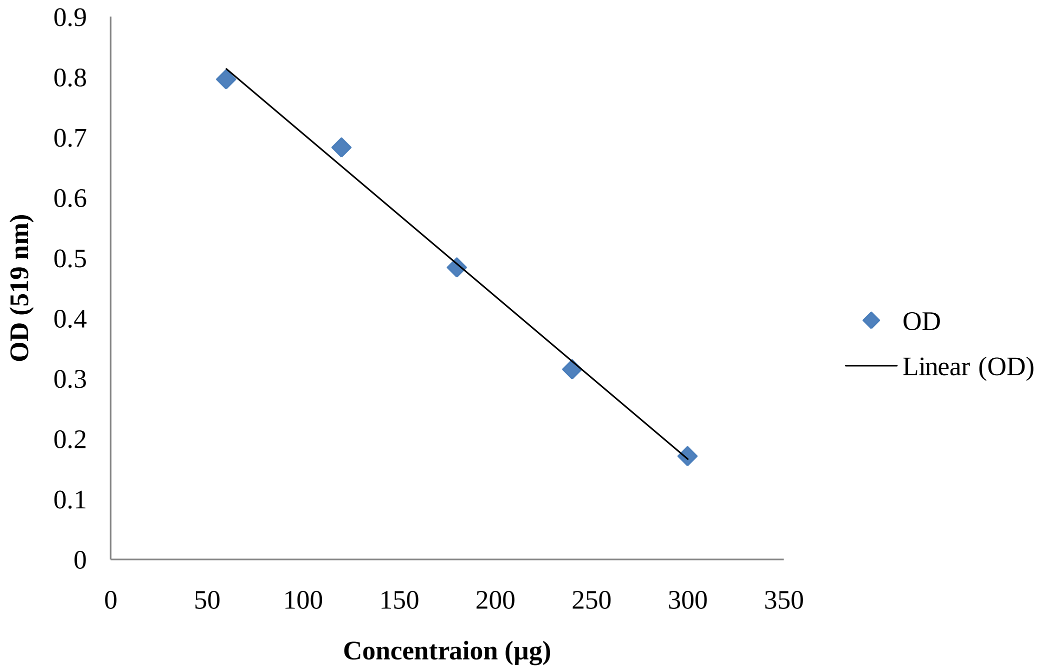


**Fig. 3.4 Standard curve for phytin phosphorus**

### 3.4.6.2 Total phenols (AOAC 2000)

**Reagents**

1. Folin Denis reagents: To 750 ml distilled water added 100g sodium tungstate, 20g phosphomolybdic acid and 50ml orthophosphoric acid. Refluxed for 2 hours, cooled and diluted to 1 litre.
2. Sodium carbonate solution: Sodium carbonate (35 g AR) was added to 100 ml distilled water at 70-80$^0$C, cooled, kept overnight and filtered.
3. Standard solution: Dissolved 100 mg tannic acid in 100ml distilled water. For working standard, pipette 50 ml stock solution in 500 ml volumetric flask and made the volume. Took 0.5, 1.0, 1.5, 2.0 and 2.5 ml standard aliquots in different tube in duplicate and color was developed.

**Procedure**

One gram finely ground sample was taken into a stoppered conical flask and added 25 ml of methanol: water (20:5 v/v) mixture. The contents were refluxed for 2 hrs and then filtered. Evaporated the methanol contents and made the volume of remaining water extract to 15 ml. Taken 2.6 ml of extract in a test tube and made the volume to 7 ml. After 3 minutes, added 1.0 ml of standard $Na_2CO_3$ solution and mixture is made upto 10 ml with proper shaking. After keeping for 1 hour, the absorbance was read using spectronic 20 at 725 nm against a reagent blank.

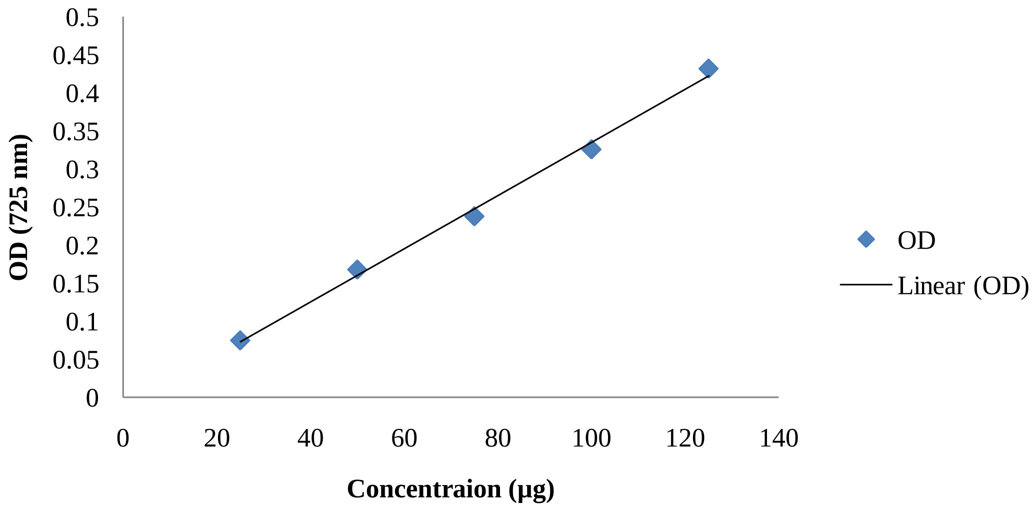


**Fig. 3.5 Standard curve for total phenol**

**3.4.6.3. Tannin (Ranganna 2001)**

**Principle**

Tannin like compounds reduce phosphotungstic molybdic acid in alkaline solution to produce a highly coloured blue solution, the intensity of which is propotional to the amount of tannins. The intensity is measured in a spectrophotometer at 700nm.

**Materials**

1. Folin-Denis Reagent

   Dissolved 100g sodium tungstate and 20 g phosphomolybdic acid in 750ml distilled water in a suitable flask and added 50 ml phosphoric acid. Refluxed the mixture for 2 hours and was made upto 1litre with water. The reagent was kept away from the light.

2. Sodium carbonate solution

   Dissolve 350g sodium carbonate in 1litre of water at 70-80°C. It was then filtered through glass wool after allowing it to stand overnight.

3. Standard tannic acid

   Dissolve 100g tannic acid in 100 ml distilled water.

4. Working standard

   Dilute 5ml stock standard to 100ml with distilled water. (1ml contains 50 µg tannic acid).

**Procedure**

Extraction of tannin- Weighed 0.5g of powdered material and transferred to 250ml conical flask. Seventy five milliliters of water was added to it and heated the flask gently and boiled for 30 minutes. It was then centrifuged at 2000rpm for 20 minutes and collected the supernatant in 100ml volumetric flask and made up the volume. Transferred 1ml of the sample extract to a 100ml volumetric flask containing 75ml water and added 5ml Folin-Denis reagent and 10 ml sodium carbonate solution and diluted to 100 ml with water. The solution was shaken well and read the absorbance at 700nm after 30 minuites. Blank was also run with water instead of sample. A standard graph was also prepared by using 0-100µg of tannic acid.

**Calculation**

Tannin content of the samples were calculated from the tannic acid equivalent from the standard graph

**3.4.6.4. Total Aflatoxin**

**3.4.6.4.1 Preparation of samples**

For minimizing the sub-sampling error in aflatoxin analysis, all the samples were grinded and collected in a plastic bag. Finally, 10 g of test portion from the ground samples was taken for analysis.

Chemical methods were employed for extraction of the aflatoxins from the samples and the detection of the toxins was done by employing a rapid method using pressure mini column as described in Fig. (Sashidhar *et al* 1989)

**Preparation of Mini Column**

Five millilitre glass syringe was packed with the following adsorbents: a disc of filter paper (Whatman No. 1) at the bottom, finely powdered anhydrous sodium sulphate (3mm), silica gel (60-120 mesh, 5mm), florisil (1mm), a filter paper disc at the top. Each layer was tightly packed using a plunger. The column was activated at 100°C for 1-2 hours before use.

**3.4.6.4.2 Extraction**

Aflatoxins from the samples were extracted by using the method of Barabalok *et al* (1974). Food sample (10 gm) was shaken with 50ml of acetone water (85:15 v/v) for 30 min. The extract was filtered through Whatman No. 1 filter paper and the filterate (10ml) was taken in a test tube to which 10ml of 20% lead acetate solution (w/v) was added. This was mixed vigorously for 3-4 min and filtered through Whatman No. 1 filter paper. Benzene (2ml) was added to the filterate in separating funnel and mixed thoroughly to extract aflatoxins in to benzene layer, which was further collected in a test tube containing 400mg of neutral alumina. The contents were mixed and allowed to stand for 2 min.

**Charging and detection**

For further detection 1ml of this clear benzene layer was slowly loaded on to the activated pressure mini column. The layer was allowed to enter the column by gravity, followed by 3ml of clearing solvent. The solvent was rapidly drained by applying pressure with the plunger. The column was observed under long wave UV light (365nm) for the presence of a compact blue fluorescent band at the interface of florisil and silica gel. The fluorescence was compared with the standard aflatoxin by visual comparison.

**Standard Pressure Minicolumn**

Standard columns were prepared by dissolving standard $AFB_1$ and $AFB_2$ (obtained from Sigma Co., USA) in 1ml of chloroform in quantity of 0.1µg, 0.2µg, 0.5µg and 1µg. These columns were used as standard while quantitation of aflatoxins was done by comparing the intensity of fluorescence.

**Blank Pressure Minicolumn**

Blank column was prepared by using the extract of non-contaminated samples and was used for comparing the negative samples.

**3.4.6.4. 3. Quantitation of aflatoxins by PMC method (Sashidhar *et al* 1989)**

By comparing the intensity of the fluorescent band of sample with that of the standard, a semi-quantitation of aflatoxins can be achieved using the following equation:

$$S_2\ (\mu g/ml) = \frac{S_1 \times V_1}{V_2}$$

Where,

$S_1$ = Standard aflatoxin concentration matched with fluorescence of the sample.

$S_2$ = Concentration of sample fluorescence matched with standard aflatoxin fluorescence.

$V_1$ = Volume of standard aflatoxin loaded on to the column (ml).

$V_2$ = Volume of sample extract loaded on to the column (ml).

**PRESSURE MINICOLUMN- (**for detection of aflatoxins)

Feed sample (10gm) + 50ml Acetone water*
(in flask)

↓ Shaking for ½ hr

Filtration through Whatman No 1

↓

10ml Filterate + 10ml 20% Lead Acetate
(in test tube)

↓ Mixed vigorously for 3-4 min.

Filtration through Whatman No 1

↓

Filterate + 2ml benzene

↓ Mixed thoroughly

Upper benzene layer collected in a test tube containing 400mg neutral alumina

↓ Mixed and allowed to stand for 2 min

Load the activated column with 1ml of this benzene layer + 3ml of clearing solvent**

↓ Apply pressure with piston of glass syringe to drain solvent

Observe the loaded column under UV light in the UV chamber at 365nm for the presence of compact blue fluorescence band at the interface of florisil and silica gel

*Acetone water
Acetone = 85ml
Water = 15ml

**Clearing solvent
Hexane = 70ml
Chloroform = 20ml
Tetrahydrafuran = 10ml

**Fig.3.6: Flow sheet of Pressure Minicolumn method**

### 3.5 Effect of storage on the quality of the value added products in different packaging materials

All the five developed ready-to-eat supplementary foods were packed in three different types of packaging material namely glass container, aluminium zip lock pouch+ glass container and plastic zip lock pouch + glass container. They were stored at room temperature ($30\pm2^{0}$C) for three months. The packed products were subjected to microbial evaluation by standard methods every fortnightly for storage period of three months and nutritional evaluation after three months of storage. Sensory evaluation of the products was conducted during each month of storage based on the results of microbial evaluation of the products with regard to the safe period of consumption of the products.

#### 3.5.1 Sensory evaluation of the developed products during storage

The products stored in different packaging materials were organoleptically evaluated after each month of storage. The sensory evaluation of the products was conducted as mentioned under the section 3.3 of this chapter.

#### 3.5.2 Nutritional evaluation of the developed products after storage period

The products stored in different packaging materials were analysed for their nutritional composition after a period of three months storage using standard procedures as mentioned in the section 3.4 of this chapter.

#### 3.5.3 Microbial evaluation of the developed products (David and Frankhausar 2010)

The developed products were analysed for their microbial quality when stored in different packaging materials for three months. The products were analysed for different microorganisms using specific medias has mentioned in Table 3.1:

**Table 3.1. Microbial tests and medias used**

| Test performed for | Media Used |
|---|---|
| Aerobic Plate Count /Total Plate count (TPC) | Nutrient Agar |
| Yeast & Mold count | Glucose Yeast Extract Agar |
| Total coliforms | Urinary Tract Infections Media |
| *Staphylococcus aureus* | Urinary Tract Infections Media |
| *Escherichia coli* | Urinary Tract Infections Media |

The specific colour of the colonies differentiates the Total coliforms, *Staphylococcus aureus and Escherichia coli* on the Urinary tract infection media.

##### 3.5.3.1 Total bacterial count

Total bacterial count was determined by cutting 1 g of sample with sterilized forcep and adding it to 9 ml dilution blank, shaken thoroughly thus making the dilution $10^{-1}$, the dilutions were made till $10^{-3}$ and $10^{-5}$. Plating was done using pour plating technique on nutrient agar media. The plates were incubated at 37°C for 24-48 hrs and the total bacterial count (cfu/ g sample) was recorded.

**Composition of nutrient agar (NA)**

| Ingredients | g/l |
|---|---|
| Beef extract | 3 |
| Peptone | 5 |
| Sodium chloride | 5 |
| Agar agar | 20 |
| pH | 6.8-7.2 |

The medium was sterilized at 15 psi (121°C) for 20 minutes before use.

**3.5.3.2. Yeast and mold Count**

Total yeast count was determined by cutting 1 g of sample with a sterilized forcep and adding it to 9 ml dilution blank, shaken thoroughly thus making the dilution $10^{-1}$, the dilutions were made till $10^{-3}$ and $10^{-5}$ . Plating was done using pour plating technique on Glucose yeast extract agar media. The plates were incubated at 25°C for 5-7 days and the total yeast count (cfu/ g sample) was recorded.

**Composition of glucose yeast extract agar (GYE)**

| Ingredients | g/l |
|---|---|
| Yeast extract | 5 |
| Peptone | 5 |
| Glucose | 5 |
| Agar agar | 15 |
| pH | 6.8 |

**Counting micobial colonies**

1. After an appropriate incubation period examine the plates for colonial growth.
2. Colonies will form on the top of the media as well as in the media. Those on top of the media will be larger but all colonies must be counted.
3. Record the data. Calculate cfu/g.

   cfu/ g = cfu/plate x dilution factor x 1/aliquot

**3.6 Supplementation of the developed products**

**3.6.1 Location of study**

The present study was conducted in the Ludhiana city of Punjab state for convenience of the research.

**3.6.2 Selection of subjects**

Four ICDS centers situated in Ludhiana city of Punjab were selected by purposive sampling method for the sample selection. A total of 110 preschool children i.e.32 from ICDS center I, 28 from ICDS center II, 23 from ICDS center III and 27 from ICDS center IV belonged to the age group of 2 – 5 years were selected for the preliminary survey. On the basis of preliminary survey a sub sample of 60 moderately malnourished preschool children in the age group of 3 to 5 years were selected from two ICDS centers for further supplementation study. The subjects underwent a physical examination before enrollment in the study. The subjects had no evidence of any chronic illness. The research was approved by the ethical committee of Punjab Agricultural University, Ludhiana (No. DR 12505-14/16-4-2014) and an informed written consent (Appendix II) was obtained from the parents of all the subjects who participated in the trial and they were explained in detail the study protocol.

To evaluate the effectiveness of the developed value added products, the selected 60 preschool children were divided into two groups- Group A (Control) and Group B (Experimental) containing 30 subjects each, out of 30 there were 15 girls and 15 boys in each group. The feeding trials was conducted for a period of four months and during the entire study period, the feeding and both the experimental and control groups were supervised and well monitored. The ICDS center members were also briefed about the study and were selected to monitor the feeding trial.

**3.6.3 Development and pretesting of interview schedule**

An interview schedule (Appendix III) was developed to elicit information from mothers or family members of preschool children pertaining to general information regarding age, religion, educational qualification, family type and occupation, family income, food habits, dietary intake, clinical parameters, anthropometric measurements of the subjects. Biochemical parameters were estimated for those 60 preschool children who were selected for further feeding trial of developed products on the basis of their dietary survey and anthropometric parameters.

The reliability and feasibility of the interview schedule was worked out by pre-testing on 10 non-sampled subjects. Based on the response received during pre-testing, certain necessary changes were incorporated in the schedules. Hence the pre-tested and reconstructed interview schedule was used to collect the data for the present study.

**3.6.4 Collection of data**

The data were collected through personal interview technique using pretested interview schedule.

**3.6.4.1 General information**

The detailed background information regarding age and sex of the preschool children and mother, education, religion, family type, family size and family composition was collected. Socioeconomic status was assessed on the basis of occupation of family members and monthly family income of the selected subjects.

**3.6.4.2 Dietary survey**

Dietary intake of subjects was recorded by “24 hour recall method” to assess the food intakes of the subjects. The 24-hour recall method is widely used standard method at national and international level to provide information on foods consumed by the individual over the previous 24 hours. The 24-hour recall method was repeated for three consecutive days. Sunday was included to cover the variation in the diet. The recall was collected by doing home visit or visit at ICDS center. The dates and times of these recalls were unannounced (unscheduled) so that participants do not change their normal eating pattern. The 24 -hour recall questionnaire was pre tested on twenty participants so as to test the validity and suitability of the questionnaire. These twenty participants were not included in the study. Thereafter, necessary modifications were incorporated. The modified questionnaire was structured by meals (early morning, breakfast, mid morning, lunch, evening snack, dinner, and bed time). The data collected indicated recording of daily consumption of cereal grains and products, pulses and legumes, fats and edible oils, milk and milk products, meat and poultry, vegetables, fruits, and sugar. The selected food categories reflect the composition of the diet pattern in this population as well as representing the source of nutrients of interest. The food intake of participants was assessed in terms of cooked food with the help of standardised cups measures appropriate for the local conditions. These cups were used to help the respondent to easily recall the quantities of food consumed by each member. These cups were standardised on a volume by volume basis representing the sizes of vessels used in the household. For each preparation, all the ingredients were first listed. The mother was then asked to give the actual weights of each of the food ingredient used in each preparation so as to get the information regarding total quantity of raw food used for the family. Later, she was asked to indicate in terms of the standardised cups the total volume of each preparation after cooking to get the information regarding total cooked quantities for each food item. Then the respondent was asked the amounts of cooked food consumed by each individual intake of cooked food. This was repeated for each meal for each preparation. The individual cooked intake was converted into raw amounts of each food item using a formula:

$$\text{Individual Raw Intake} = \frac{\text{Total raw amount for each food ingredient (g)} \times \text{Individual cooked intake (volume)}}{\text{Total cooked amount of the preparation (volume)}}$$

From the raw amounts**,** the average daily intake of nutrients was calculated using the Indian Nutrition Software (Diet Soft). The average nutrient intake (3 days) was compared with the recommended dietary allowances given by ICMR (2010).

**Nutrient Adequacy Ratio (NAR)**

Nutrient adequacy ratio (NAR) was calculated for each nutrient. For, a value of 100 percent is the ideal since it shows the intake is equivalent to the suggested requirement (Torheim *et al* 2004). The NAR percent were calculated using following formula:

$$\text{NAR \%} = (\text{Intake of nutrient / Recommended intake of nutrient}) \times 100$$

**Table 3.2 Categorization of NAR % (using a classification given by Jood *et al* 1999)**

| | |
|---|---|
| Adequate | 100 % and above |
| Marginally adequate | 75 % and above |
| Marginally inadequate | 50 to 74.9 % |
| Inadequate | Below 50 % |

**3.6.4.3 Anthropometric measurements**

Height, weight, mid upper arm circumference, chest circumference and head circumference were measured using standard methods (Jelliffe 1966).

**3.6.4.3.1 Height**

A vertical anthropometric rod attached to the platform was used to measure the height of the subjects. The subjects were made to stand barefoot on the platform with feet parallel, heels, buttocks, shoulders and back touching the scale. The head was held comfortably erect, head piece was lowered, crushing the hair making contact with top of the head and height was recorded in centimeters (cm) up to 0.5cm accuracy.

**3.6.4.3.2 Weight**

A lever balance was used for weighing the subjects. The subjects were weighed without shoes and making them stand straight at the center of the platform. The weight was recorded in Kilograms (Kg), up to 0.2 Kg accuracy.

**3.6.4.3.3 Mid upper arm circumference**

A narrow flexible, non stretch fibre glass tape was used to take the measurements. Tape was placed gently and firmly around the left upper arm, mid way between acromial and olecraeon according to the compression of soft tissues and measurements were taken.

**3.6.4.3.4 Chest circumference**

The chest circumference was measured by flexible, non stretch fibre glass tape at nipple line and the mid inspiration.

**3.6.4.3.5 Head circumference**

Head circumference was measured by flexible, non stretch fibre glass tape at the frontal bones just superior to the supra-orbital ridges passing it round the head at the same level on each side and laying it over the maximum occipital prominence at the back.

**3.6.4.4 z-score classification**

To evaluate the nutritional status of the selected preschool children, the data on weight and height was classified according to z-scores. The z-scores for different indices like weight for age (WAZ), height for age (HAZ), body mass index for age, MUAC for age, head circumference for age were calculated using ‘WHO Anthro plus software’ (Zuguo and Laurence 2007). The prevalence of malnutrition was calculated on the basis of z-score cut off level WHO (2006) given below:

**Table 3.3 Prevalence of malnutrition using standard z-score classification (WHO 2006)**

| z-score cut off level | Grade of malnutrition |
|---|---|
| > +2.0 SD | Overweight |
| -2.0 SD to +2.0 SD | Normal |
| <-2.0 SD | Moderately malnourished |
| <-3.0 SD | Severely malnourished |

### 3.6.4.5. Supplementation of the developed value added products

From the total number of subjects, 30 preschool children of age group 3-5 years were selected as the control group. This group was not provided any supplementary foods. Another 30 subjects of the same age group were selected as the experimental group who were provided with the value added products for a period of four months. The products provided 353-400 Kcal of energy and 11.4-13g of protein which would meet one-third of their daily nutrient requirements. The quantity of each product provided is depicted in Table 3.4.

**Table 3.4.Amount and nutrients provided by the value added products**

| Products | Quantity (g) | Calories (Kcal) | Protein (g) |
|---|---|---|---|
| *Matthi* | 120 | 400.55 | 11.4 |
| *Seviyan* | 140 | 353.28 | 13 |
| *Pinni* | 140 | 370.50 | 13 |
| *Panjiri* | 140 | 378.56 | 12.6 |
| Biscuits | 140 | 376.44 | 12.6 |

The subjects of both the control and experimental groups were subjected to anthropometric measurements as well as for biochemical parameters before and after supplementation. Survey regarding their food as well nutrient intake was also conducted as mentioned above before and after supplementation of the value added products.

### 3.6.4.6 Assessment of blood profile

Blood samples of all the selected subjects were collected in an EDTA vacuum container by trained personnel under aseptic conditions before and after supplementation trial. The blood sample was analyzed for total blood count (TBC). In TBC following blood components were estimated:

#### 3.6.4.6.1 Haemoglobin Estimation (Hb)

Haemoglobin level was estimated by Cynomethaemoglobin method (Dacie and Lewis 1975). All the subjects selected for supplementation trial were involved in haemoglobin estimation.

**Principle:** In solution the ferrous ions (Fe++) of the haemoglobin are oxidized to the ferric state (Fe+++) by potassium ferric cyanide to form methemoglobin. In turn, methemoglobin reacts with the cyanide ions ($CN^-$) provided by potassium cyanide to form a coloured complex cyanmethemoglobin, which has absorbance of 540nm. Hemoglobin is calculated from the standard provided in the kit. NIN (1986) classification was used to assess the prevalence of anemia among selected preschool children.

**Table 3.5: Classification of anaemia (NIN 1986)**

| Severity of anaemia based on haemoglobin | Haemoglobin level (g/dl) |
|---|---|
| Non – anaemic | > 11.5 |
| Anaemic | < 11.5 |
| Mild | 10 – 11.5 |
| Moderate | 7 – 10 |
| Severe | < 7 |

**3.6.4.6.2 Packed cell volume (PCV)**

Packed cell volume or haematocrit is determined using whole blood (anticoagulant added) in capillary tubes (75×1 mm) and microhaematocrit centrifuge by the method of Hunter and Bonford (1968).

**Procedure**

The uncoagulated blood was sucked in a capillary tube filling it half to three fourth of its length and sealed on the opposite end using sealing wax. The tubes were transferred to haematocrit centrifuge grooves with open ends of the tubes towards centre. The centrifuge was run for 5 minutes at 11000 rpm. The haematocrit values were read on calibrated scale as volume percent.

**Mean corpuscular haemoglobin concentration (MCHC)**

MCHC indicates defective haemoglobin production due to iron deficiency. It is the quantity of haemoglobin expressed as percent of packed cell volume.

MCHC % (g/dL cells) = [Hb (g/dL) / PCV (ml/dL)] × 100

**3.6.4.6.3 Red blood cells (RBC)**

**Principle**

It involves accurate dilution of measured quantity of blood with an isotonic fluid that prevents blood coagulation. Diluted blood is placed in a counting chamber and number of cells in a circumscribed volume is enumerated under a microscope by the method of Raghuramulu *et al* (1983).

**Procedure**

The blood was drawn by mouth suction upto 0.5 mark, the tip of the red cell pipette was wiped clean and the diluting drawn in until the solution fills the pipette and reaches '101' mark. The pipette was shaken by holding loosely in one hand after removing the attached rubber tubing between the thumb and the forefingers at least for 3 min before loading it in chamber. Alternately 20 ml of blood can be diluted in 4 ml of the diluting fluid in a test tube. The coverslip was put on the counting chamber. A few large drops of mixed solution were discarded from the pipette and then a small quantity of diluted blood was put between the coverslip and the ruled platform of the counting chamber. The chamber should not overflow and there should not be any air bubble in the chamber. The solution was allowed to settle for a couple of minutes and then the counting was done under high power of microscope. In the Neubauer ruling, small squares in the central large 1 mm square are used for the enumeration of erythrocytes. The number of cells in the 4 corner groups of 16 squares are counted and also one central group including those cells which lie within the area on the dividing lines to the left or above 0.5 mark. The total number of cells found in the 5 groups of 16 squares was multiplied by 10,000 in order to give the number of cells in million per $mm^3$ of blood

**Red cell indices**

**Mean corpuscular volume (MCV)**

MCV in femto litres (fl) = (PCV / RBC count ) × 10

**Mean corpuscular haemoglobin (MCH)**

MCH in pg = (Hb / RBC count) × 10

**3.6.4.6.4 Total proteins (Biuret Method by Robinson and Hogden 1940)**

**Principle**

Copper in alkaline solution reacts with the peptide bonds (-CONH groups) in proteins, producing a violet color which is proportional to the amount of proteins present.

**Reagents**

1. **Biuret reagent**: Dissolve 4.25g of potassium sodium tartarate ($KNaO_4$ .H4O6.4H2O), 1.5g CuSO4.5H2O and 2.5g of potassium iodide in about 500 ml of distilled water. Add 4g NaOH to the solution and make the volume to one litre.

**Standard**

0.5g bovine albumin fraction V is dissolved in saline (0.9% NaCl) and diluted to 100ml (5 mg/ml). Few drops of NaOH are added to facilitate dissolution before making final volume.

**Procedure**

0.1ml of serum was taken in a test tube. To this, 0.9 ml of saline was added to make the volume 1 ml. 1ml of saline was taken as blank to set the reading 1st at zero. 5 ml of biuret reagent was added to each test tube. Then they were mixed well and kept for 30 minutes. Finally, absorbance was read against blank at 540 nm.

**Standard curve**

Aliquots of standard (0.5-3mg) as prepared above were taken and saline was added to make the volume 1ml and preceded as for sample. Standard curve was prepared by plotting absorbance against concentration of protein and the same was calculated from the standard curve.

**Calculation**

$$\text{Protein (g/ml)} = \frac{\text{Sample A}}{\text{Test A}} \times \frac{\text{Conc. of standard}}{1000} \times \text{dilution factor}$$

Using this formula, protein in serum samples was estimated. Serum protein concentration was compared against standard concentration 7.5 g/ml (Harper 1981).

**3.6.4.6.5 BCG method for Albumins (Doumas *et al* 1971)**

BCG method is used for *in vitro* quantitative determination of albumin in serum or plasma.

**Principle**

Albumin in a buffered solution reacts with the anionic bromocresol green (BCG) with a dye binding reaction to give a proportionate green colour which is measured at 628 nm (600-650 nm). The final colour is stable for 10 minutes.

**Reagents**

1. Succinic Acid 94 mmol/L
2. Sodium Hydroxide 10.2 mmol/L
3. BCG 0.149 mmol/L
4. Standard (Albumin 5g/dL) BSA- 50g/L

**Procedure**

The samples and reagents were brought to room temperature prior to use. Test tubes were labeled for each blank, standard, control and test. 5.0 ml bromocresol green reagent was added to all tubes.0.020 ml sodium hydroxide was added to the blank tube. 0.020 ml standard, control and test solution were added to all test tubes. All test tubes were mixed by complete inversion and kept for 10 minutes at room temperature. Absorbance of each reaction tube was read at 630nm, using the blank to zero/100%T the spectrophotometer.

**Calculation**

$$\frac{\text{Absorbance Unknown}}{\text{Absorbance Standard}} \times \text{Conc. of standard (g/dl)} = \text{Conc. of unknown albumin (g/dl)}$$

### 3.7 Statistical analysis

Mean and standard error for different parameters were computed. Kruskal Wallis test was used for selecting the best formulations through sensory evaluation as well as for the acceptability of the products after a storage period of three months in different packaging materials. Paired t-test was applied to compare the nutritional parameters between the control and the value added products while Tukey's test was applied to compare the nutritional parameters of the developed products stored in different packaging materials after a storage period of three months. Paired t-test was employed to assess the impact of supplementation on the nutritional and blood profile of selected subjects in the experiment as well as control group ($p<0.05$, $p<0.01$). The data were analyzed using appropriate statistical tools.

# CHAPTER IV

## RESULTS AND DISCUSSION

Good nutrition is the first line of defense against numerous childhood diseases, which can leave their mark on a child for life. The effect of undernutrition on young children (ages 0-8) can be devastating and enduring. It can impede behavioral and cognitive development, educability, and reproductive health, thereby undermining future work productivity. The present study was undertaken with an aim to develop value added products incorporating partially defatted peanut cake flour and powdered dehydrated green leafy vegetables making them rich in calories, protein as well as micronutrients and further to find their impact on the nutritional status of malnourished children. The results of the study are presented and discussed under the following subheadings:

4.1 Development and sensory evaluation of value added products
- 4.1.1 Development and standardisation of value added products with partially defatted peanut cake flour
- 4.1.2 Development and standardisation of value added products with partially defatted peanut cake flour and powdered green leafy vegetables

4.2 Nutritional composition of developed products
- 4.2.1 Proximate composition of raw ingredients and developed products
- 4.2.2 Amino acids content of developed products
- 4.2.3 Mineral and vitamin content of developed products
- 4.2.4 *In-vitro* digestibility of developed products

4.3 Antinutritional composition of the developed products

4.4 Impact of storage of developed products in different packaging material
- 4.4.1 Sensory evaluation of the developed products
- 4.4.2 Nutritional Composition of the developed products
- 4.4.3 Aflatoxin in the developed products
- 4.4.4 Microbial evaluation of the developed products

4.5 General information of preschool children and their mothers

4.6 Ecological profile of the preschool children

4.7 General health and hygiene status of preschool children

4.8 Assessment of nutritional status of preschool children
- 4.8.1 Food intake of preschool children
- 4.8.2 Nutrient intake of preschool children
- 4.8.3 Anthropometric profile of preschool children
- 4.8.4 z-scores of preschool children

4.9 Impact of supplementation of developed products on nutritional status of selected malnourished preschool children

4.9.1 Impact of supplementation on food intake

4.9.2 Impact of supplementation on nutrient intake

4.9.3 Impact of supplementation on anthropometric profile

4.9.4 Impact of supplementation on z-score

4.9.5 Impact of supplementation on blood profile

**4.1 Development and sensory evaluation of value added products**

Five value added products namely *matthi, seviyan, panjiri, pinni* and biscuits were developed from different combinations and percentage of cereal flour like whole wheat flour and refined wheat flour along with pulse flour like chick pea flour, partially defatted peanut cake flour and powdered green leafy vegetables like spinach and fenugreek leaf powder.

Four samples of all the products were prepared using basic ingredient i.e. wheat flour and chick pea flour for control in the ratio of 3:1 (75g of wheat flour and 25 g of chick pea flour except for *seviyan*). The development of the products was carried out in two standardizations. First standardization was carried out to develop value added products with acceptable proportion of partially defatted peanut cake flour. Second standardization was carried out to develop value added products with acceptable proportion of powdered green leafy vegetables keeping the acceptable product of first standardization as control. Each of the five developed value added products for malnourished children has been compared treatment wise by ten trained panelists including faculty of department of Food and Nutrition of Punjab Agricultural University in the age range of 45 to 55 years using 9 point hedonic scale for different parameters such as appearance, colour, texture, aroma, taste and overall acceptability (Larmond 1970) (Appendix-I) in controlled environment. The developed value added products were stored for 90 days (3 months) and overall acceptability of the products was checked every fifteen days up to the storage period of 90 days.

**4.1.1. Development and standardisation of value added products with partially defatted peanut cake flour (DPF)**

Five value added products were developed incorporating partially defatted peanut cake flour (DPF). The sensory evaluation of these products was then carried out to select the acceptable proportion of DPF in all the products. The percentages of different ingredients used in development and standardization of five value added products using DPF are presented in Table 4.1.

**Table 4.1: Composition of the value added products with partially defatted peanut cake flour (DPF)**

| Treatments | Ingredients for the value added products with Partially defatted peanut flour (DPF) (g) | | |
|---|---|---|---|
| | **Wheat flour (Refined for *matthi*)** | **Chick pea flour** | **DPF** |
| **S1 (Control)** | 75 | 25 | - |
| **S2 (5%)** | 71.25 | 23.75 | 5 |
| **S3 (10%)** | 67.50 | 22.50 | 10 |
| **S4 (15%)** | 63.75 | 21.25 | 15 |
| ***For *Seviyan*: Chickpea flour was taken as the basic ingredient instead of wheat flour** | | | |

**Sensory Evaluation of the Developed Value Added Products**

The various sensory scores obtained for the different value added products prepared incorporating partially defatted peanut cake flour is presented in Table 4.2 to Table 4.6.

***MATTHI***

*Matthi* was developed at four different levels. Control (S1) sample was prepared using refined wheat flour and chick pea flour. Five, 10 and 20 per cent of partially defatted peanut cake flour was added to develop other three levels of *matthi*. The most acceptable level of peanut flour in *matthi* was taken as control for further development and standardization of *matthi* with fortification of fenugreek leaf powder. The scores statistically revealed that all the treatments were significantly different with regard to parameters like appearance, colour, texture, flavor, taste and overall acceptability as presented in Table 4.2 and Fig 4.1.

The highest score obtained was for S1 (Control) which did not have any partially defatted peanut flour incorporation in it. Among the other treatments which were incorporated with the peanut flour, S3 (10%) scored the highest with respect to appearance, colour and aroma. Statistically insignificant difference in the scores for taste (7.60) was observed between S2 and S3. But the highest score for overall acceptability of 7.58 was obtained by the S3 treatment with a 10 per cent incorporation of peanut cake flour. Hence, S3 (10% DPF) was taken as the control for the second standardization with fenugreek leaf powder. Similar study conducted by Bansal (2013) also reported that traditional Indian snack *matthi* was prepared with peanut flour at 10, 20 and 30 per cent level of incorporation. Peanut flour at the level of incorporation of 10 per cent in *matthi* was found to be acceptable. *Matthi* developed with the incorporation of defatted soy flour at 20 per cent level was found to be highly acceptable and obtained highest scores compared to the higher levels of incorporation (Shah 2005). Agarwal and Sharma (2013) also found that control sample of *matthis* scored the highest for sensory attributes followed by those prepared incorporating five per cent garden cress seed flour.

**Table 4.2: Mean sensory scores for *matthi* incorporated with partially defatted peanut cake flour**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | **Appearance** | **Colour** | **Texture** | **Aroma** | **Taste** | **Overall Acceptability** |
| S1 | 7.80 | 8.00 | 7.70 | 7.40 | 7.50 | 7.67 |
| S2 | 7.20 | 7.20 | 7.60 | 7.50 | 7.60 | 7.48 |
| S3 | 7.60 | 7.70 | 7.40 | 7.60 | 7.60 | 7.58 |
| S4 | 5.90 | 5.90 | 6.10 | 6.20 | 6.20 | 6.06 |
| **$\chi 2$ value** | 23.57** | 27.53** | 17.34** | 18.40** | 15.39** | 21.66** |

** Significant at 1% level of significance ($p$<0.01)
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

***SEVIYAN***

Different levels of *seviyan* were developed and standardized incorporating partially defatted peanut flour. Control (S1) sample was prepared using chick pea and wheat flour at the ratio of 75:25. Other three levels were prepared with an addition of 5, 10and 15 per cent of peanut flour. The most acceptable level of incorporation of peanut flour in *seviyan* was selected for the second standardization as control. Further development and standardization of *seviyan was* done with fortification of fenugreek leaf. The mean scores of acceptability trials of *seviyan* with level of peanut flour are presented in Table 4.3 and Fig 4.2.

**Table 4.3: Mean sensory scores for *seviyan* incorporated with partially defatted peanut cake flour**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | **Appearance** | **Colour** | **Texture** | **Aroma** | **Taste** | **Overall Acceptability** |
| S1 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| S2 | 7.60 | 7.00 | 8.00 | 7.00 | 8.00 | 7.52 |
| S3 | 7.60 | 7.00 | 8.00 | 7.30 | 8.00 | 7.52 |
| S4 | 6.30 | 6.30 | 7.60 | 6.00 | 6.00 | 6.24 |
| **$\chi 2$ value** | 25.63** | 34.62** | 20.65** | 30.50** | 38.07** | 34.73** |

** Significant at 1% level of significance ($p$<0.01)
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

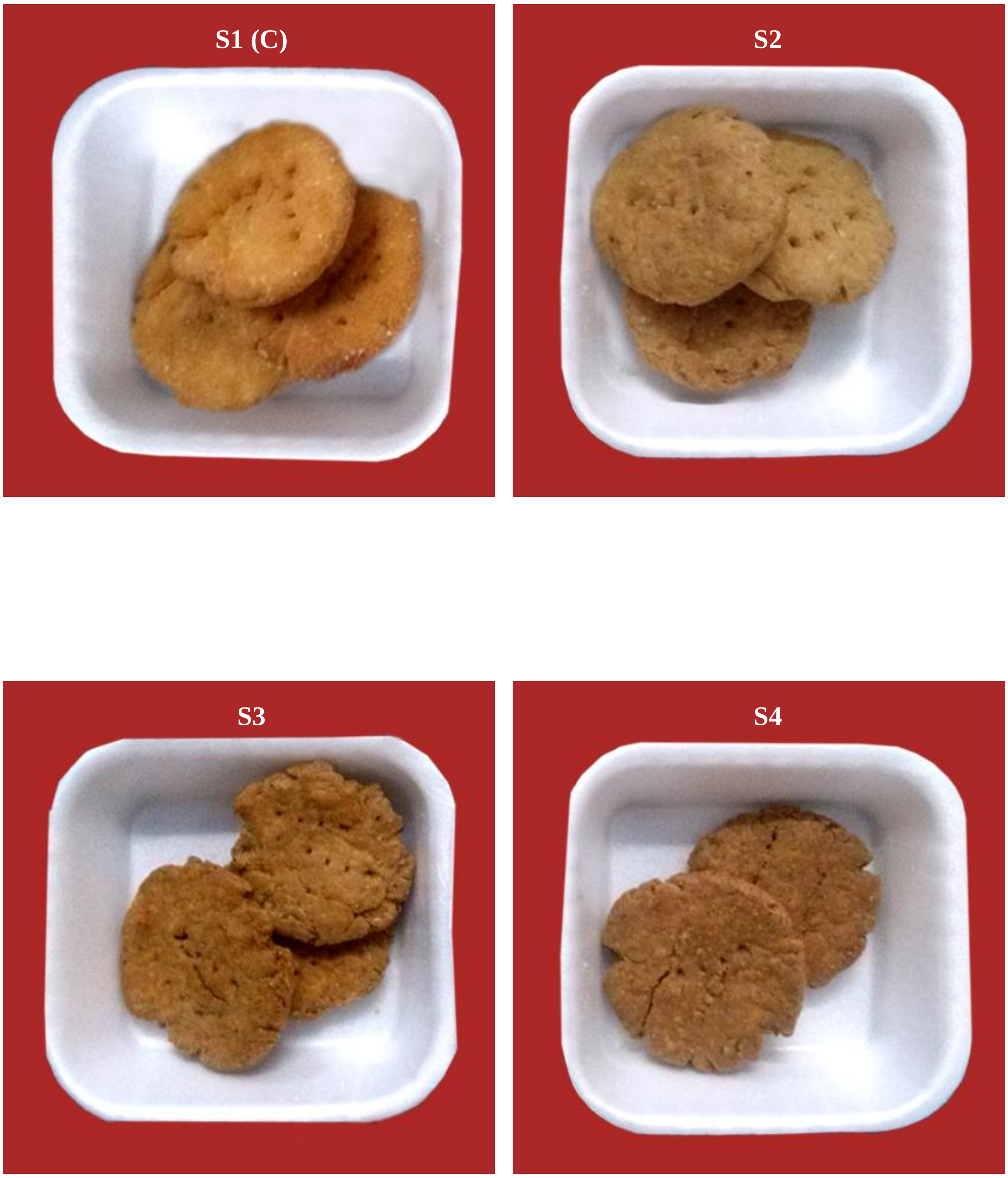


**Plate 2: Development of *matthi* with partially defatted peanut cake flour**

**Sample 1 (Control):** Wheat flour + Chick pea flour
**Sample 2:** Same as 1 + 5 % of partially defatted peanut cake flour
**Sample 3:** Same as 1 + 10 % partially defatted peanut cake flour
**Sample 4:** Same as 1 + 15 % partially defatted peanut cake flour

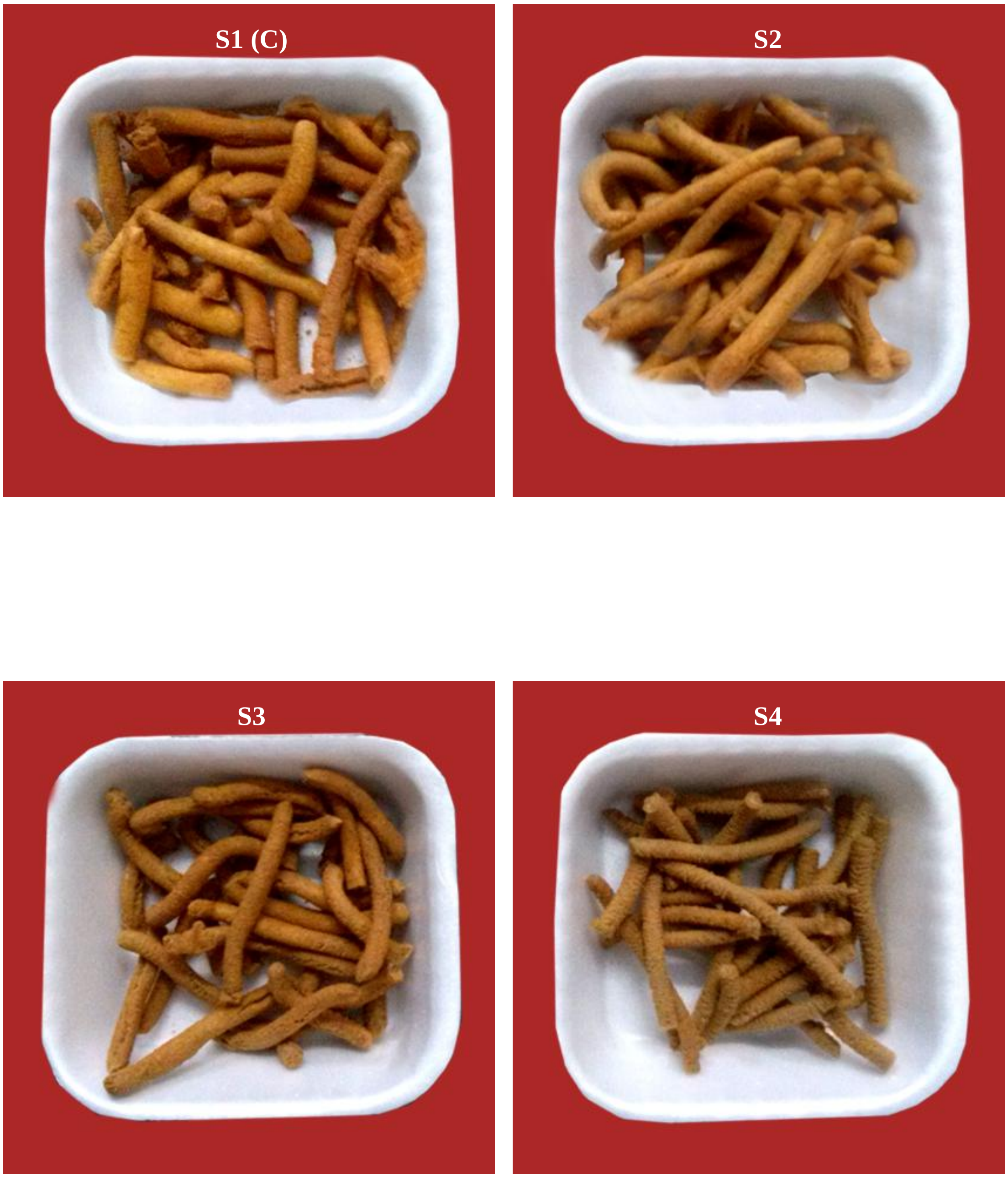


**Plate 3: Development of *seviyan* with partially defatted peanut cake flour**

**Sample 1 (Control):** Wheat flour + Chick pea flour
**Sample 2:** Same as 1 + 5 % of partially defatted peanut cake flour
**Sample 3:** Same as 1 + 10 % partially defatted peanut cake flour
**Sample 4:** Same as 1 + 15 % partially defatted peanut cake flour

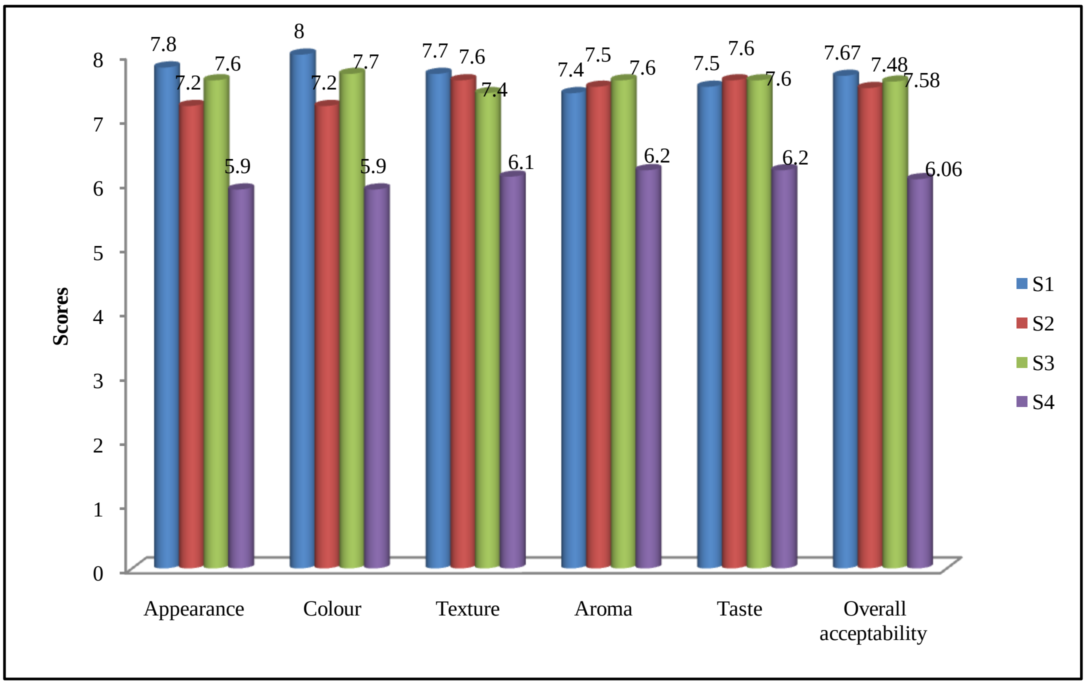


**Fig 4.1: Mean sensory scores for *matthi* incorporated with partially defatted peanut cake flour**

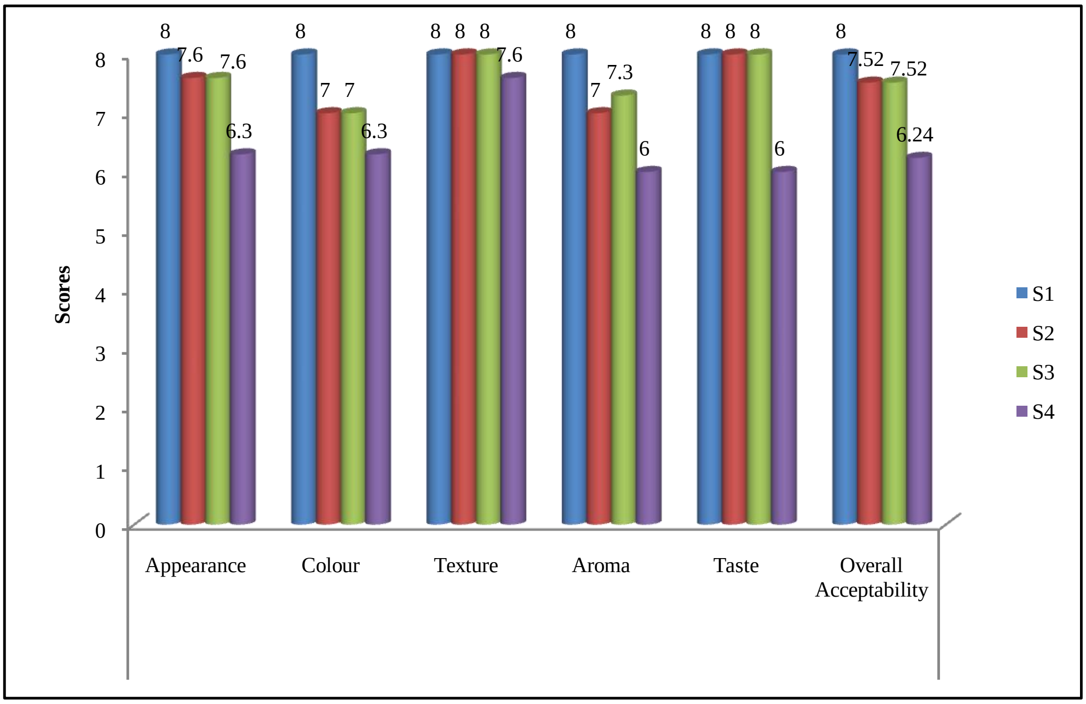


**Fig 4.2: Mean sensory scores for *seviyan* incorporated with partially defatted peanut cake flour**

The difference in scores was found to be statistically significant with regard to all the sensory parameters except between S2 (5% DPF) and S3 (10% DPF). The highest mean scores for different sensory parameters of *seviyan* were observed for control (S1) followed by S2 and S3 treatments. The S2 and S3 treatments were comparable to control (S1) treatment for sensory parameters such as appearance, texture, aroma, taste and overall acceptability. The S2 and S3 treatment was significantly different from S4 treatment in terms of texture, aroma, taste and overall acceptability. The overall acceptability scores for the control S1 (8.00) followed by S2 and S3 (7.52) and then S4 with a score of 6.24. However, among the treatments with added peanut flour, S3 (10% DPF) was selected as control for the standardization of *seviyan* prepared with different proportions of powered fenugreek leaf. Bansal (2013) also reported a higher level of incorporation of peanut flour (20%) in seviyan was found to be acceptable by the panelists. Rajawat *et al* (2002) reported that extruded *sev* from faba bean mixed with cereal flour at 20 per cent level was found to be well accepted by panelists. Similarly, *seviyan* standardized with 30 per cent defatted soy flour was found highly acceptable (Shah 2005). Seviyan fortified with germinated wheat flour and soybean flour at a level of 20 per cent was also reported to be highly acceptable from the sensory point of view (Sadana *et al* 2008).

***PINNI***

Four different treatments of *Pinni* were prepared incorporating different levels of partially defatted peanut cake flour. Control (S1) was prepared by using wheat flour and chickpea flour at the ratio 75:25. Peanut flour was added to the rest of the treatments at 5, 10 and 15 per cent. Like all the other products, the best acceptable level of peanut flour in *pinni* was taken as the control for the second standardization using spinach leaf powder. The sensory scores obtained for the four treatments are presented in Table 4.4 and Fig 4.3.

**Table 4.4: Mean sensory scores for *pinni* incorporated with partially defatted peanut cake flour**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Texture | Aroma | Taste | Overall Acceptability |
| S1 | 8.00 | 8.00 | 7.90 | 7.60 | 8.00 | 8.00 |
| S2 | 7.70 | 6.70 | 7.30 | 7.30 | 7.60 | 7.56 |
| S3 | 7.30 | 7.40 | 7.30 | 7.30 | 7.60 | 7.42 |
| S4 | 7.70 | 7.40 | 7.30 | 7.00 | 7.60 | 7.62 |
| **$\chi 2$ value** | 11.00* | 21.69** | 10.64* | 8.36* | $5.57^{NS}$ | 18.68** |

** Significant at 1% level of significance ($p$<0.01)
*Significant at 5% level of significance ($p$<0.05)  NS- Non significant
S- Sample where S1 to S4 stands for Sample 1 to Sample 4


**Plate 4: Development of *pinni* with partially defatted peanut cake flour**

**Sample 1 (Control):** Wheat flour + Chick pea flour
**Sample 2:** Same as 1 + 5 % of partially defatted peanut cake flour
**Sample 3:** Same as 1 + 10 % partially defatted peanut cake flour
**Sample 4:** Same as 1 + 15 % partially defatted peanut cake flour

The statistical analysis revealed that the sensory scores for all the sensory parameters namely appearance, colour, texture, aroma and overall acceptability were significantly different for *pinni* incorporated with different levels of peanut flour. Control (S1) scored the highest scores for all the sensory parameters with a highest overall acceptability score of 8.00. It was followed by S4 (15% DPF) with the highest score for appearance (7.70), colour (7.40) and overall acceptability (7.62). The scores for colour and taste were at par between S4 and S3 (10% DPF). With respect to texture, the scores were significantly different from control (S1) but between the treatments, the scores were at par. The sensory scores for taste were found to be statistically insignificant between the treatments S2 to S4 (7.60) and Control (8.00). Ghatge (2012) observed high sensory acceptability scores for soya *laddos* prepared from soybean and Bengal gram. *Pinni* prepared with different combination of cereal and pulse flours were studied for sensory and nutritional parameters by Talwar and Brar (2015). The authors found that Control (wheat flour) *pinni* scored the highest scores for sensory attributes followed by *pinni* prepared using wheat flour and *suji* followed by those prepared using wheat flour and chickpea flour.

***PANJIRI***

*Panjiri* was prepared in four different treatments. S1 was control which was prepared using wheat flour and chickpea flour only. Three treatments S2, S3 and S4 were prepared using defatted peanut cake flour at 5, 10 and 15 per cent levels respectively. The treatment S4 (15% DPF) scored the highest score for the sensory attributes after the Control (S1) and was then selected as control for the second standardization of *panjiri* with spinach leaf powder. The scores for the sensory parameters of different treatments given to *panjiri* are presented in Table 4.5 and Fig 4.4.

**Table 4.5: Mean sensory scores for *panjiri* incorporated with partially defatted peanut cake flour**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Texture | Aroma | Taste | Overall Acceptability |
| S1 | 8.00 | 8.00 | 7.80 | 7.80 | 8.00 | 8.00 |
| S2 | 7.70 | 7.30 | 7.20 | 7.30 | 7.50 | 7.54 |
| S3 | 7.70 | 6.70 | 7.20 | 7.00 | 7.50 | 7.16 |
| S4 | 7.30 | 7.30 | 7.20 | 7.30 | 7.50 | 7.54 |
| **$\chi$2 value** | 11.00* | 22.91** | 11.57** | 14.14** | 10.64* | 18.63** |

** Significant at 1% level of significance ($p$<0.01)
*Significant at 5% level of significance ($p$<0.05)
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

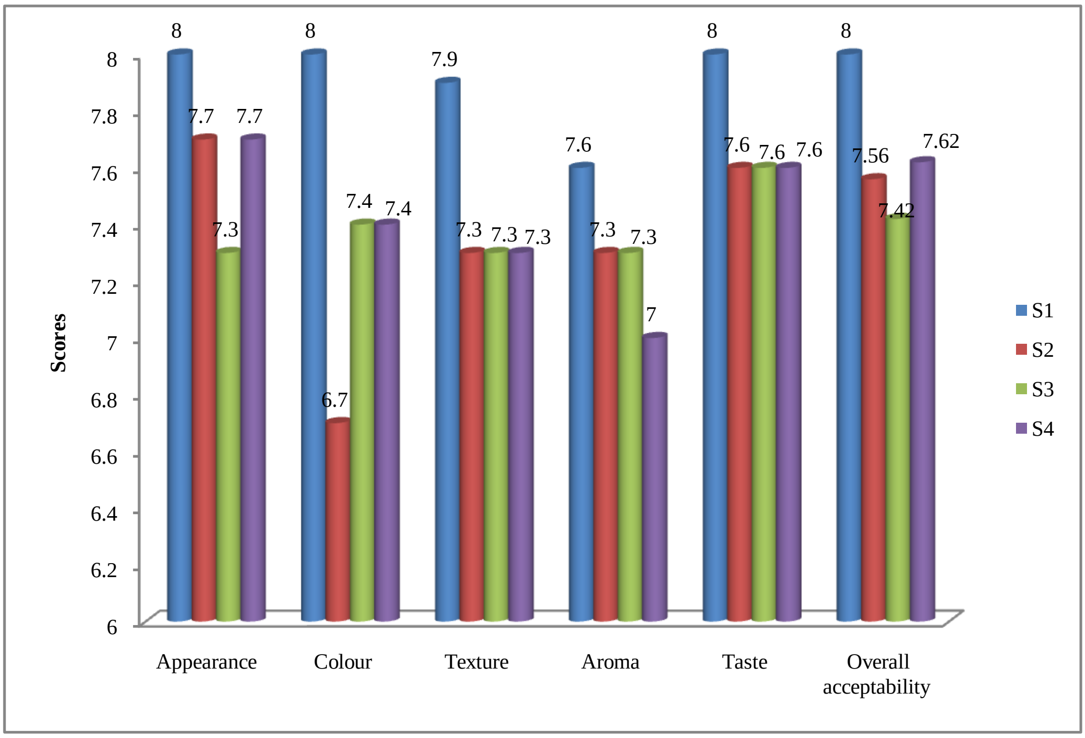


**Fig 4.3 Mean sensory scores for *pinni* incorporated with partially defatted peanut cake flour**

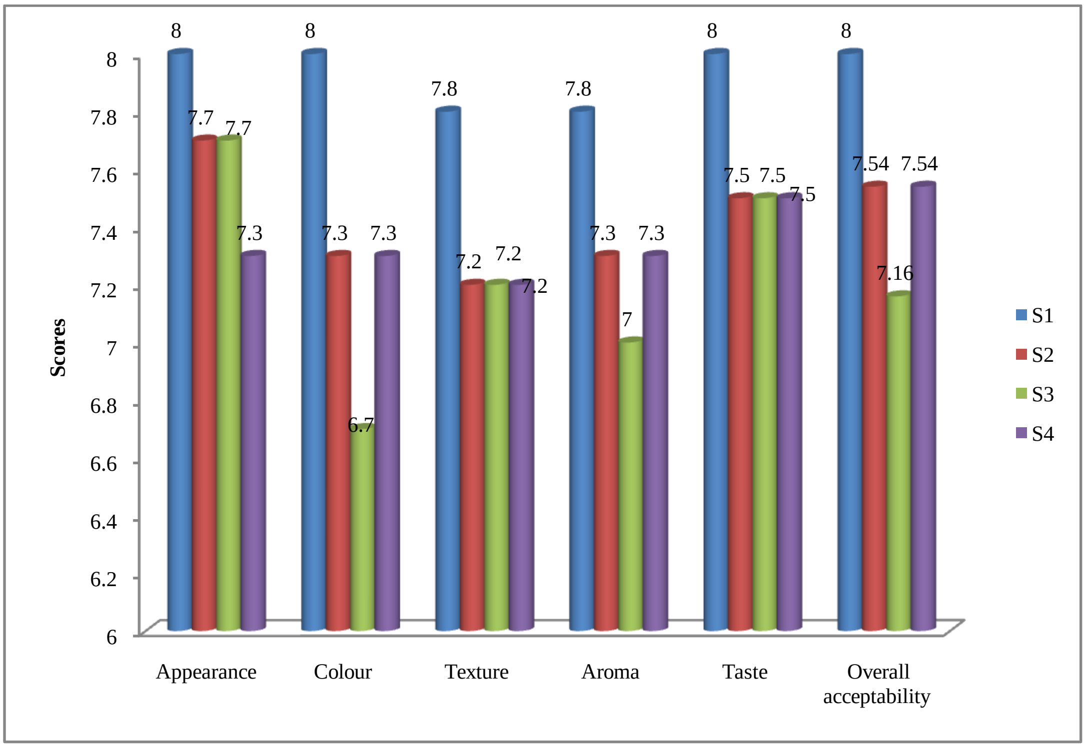


**Fig 4.4: Mean sensory scores for *panjiri* incorporated with partially defatted peanut cake flour**

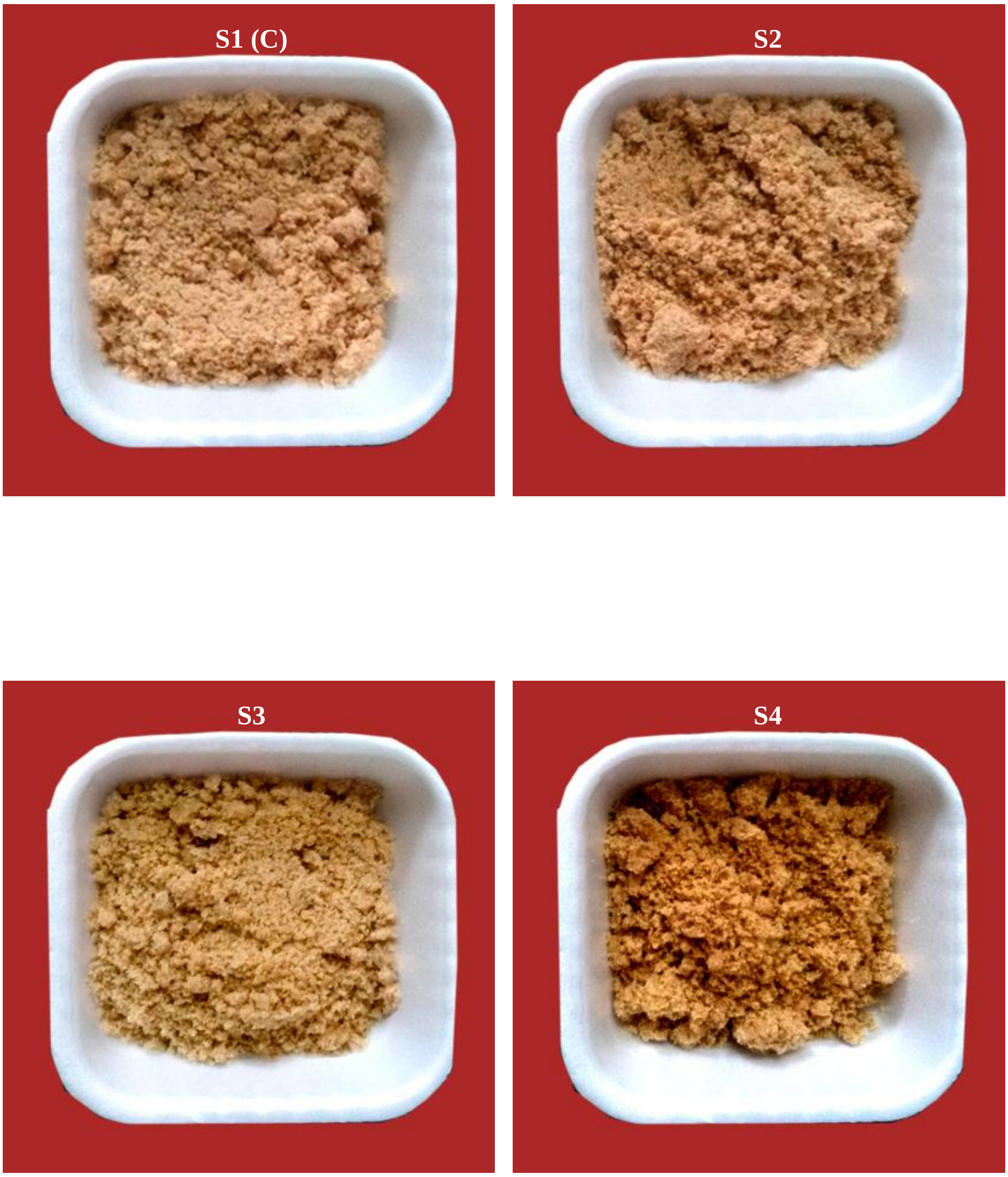


**Plate 5: Development of *panjiri* with partially defatted peanut cake flour**

**Sample 1 (Control):** Wheat flour + Chick pea flour
**Sample 2:** Same as 1 + 5 % of partially defatted peanut cake flour
**Sample 3:** Same as 1 + 10 % partially defatted peanut cake flour
**Sample 4:** Same as 1 + 15 % partially defatted peanut cake flour

The highest scores were obtained for S1 (Control) with respect to all the sensory parameters. It received an overall acceptability score of 8.00. The highest acceptability score was obtained for S1 followed by S2 (5% DPF) and S4 (15% DPF) which received an overall acceptability score of 7.54. With regard to texture and taste, the scores were not significant among the treatments S2 to S4. Colour and aroma scores were at par for both S2 and S4.

Similar study by Bansal (2013) also revealed that increasing incorporation of peanut flour till 50 per cent enhanced the sensory parameters of *panjiri* and was highly acceptable by the panelists. Salve *et al* (2011) reported that *panjiri* fortified with roasted wheat, soybean and chickpea flour with 10 per cent skimmed milk powder was not only nutritionally superior but also was highly acceptable to the panelists. *Panjiri* and sweet porridge prepared with 20 per cent wheat, 15 per cent *bajra* and 65 per cent *moong* flour scored the highest scores for all the sensory parameters compared to the products prepared with only wheat flour (Srivastava *et al* 2015).

**BISCUITS**

Different treatments of biscuits were prepared using partially defatted peanut cake flour (DPF). S1 was taken as control which was prepared using wheat flour and chickpea flour. Treatments S2 to S4 were prepared using defatted peanut flour at levels 5, 10 and 15 per cent respectively. Different scores were obtained for the different treatments as presented in Table 4.6 and Fig 4.5. As the other products, S1 (Control) scored the highest for all the sensory parameters with an overall acceptability score of 7.84. Among the treatments with added peanut flour, S3 (10% DPF) scored the highest and was then selected as the control for the second standardization of biscuits with spinach leaf powder.

**Table 4.6: Mean sensory scores for biscuits incorporated with partially defatted peanut cake flour**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Texture | Aroma | Taste | Overall Acceptability |
| S1 | 8.00 | 8.00 | 7.70 | 7.50 | 7.80 | 7.84 |
| S2 | 7.50 | 7.30 | 7.20 | 7.00 | 7.40 | 7.28 |
| S3 | 7.50 | 7.70 | 7.50 | 7.20 | 7.50 | 7.38 |
| S4 | 6.60 | 7.20 | 6.90 | 5.60 | 6.20 | 6.25 |
| **$\chi 2$ value** | 14.37** | 24.63** | 9.06* | 24.23** | 23.10** | 28.39** |

** Significant at 1% level of significance ($p<0.01$)
*Significant at 5% level of significance ($p<0.05$)
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

The difference in scores was found to be statistically significant with regard to all the sensory parameters for all the treatments. The highest mean scores for different sensory parameters of biscuits were observed for control (S1) followed by S3 treatment .With respect to appearance alone, the score of 7.50 was at par for treatments S2 (5% DPF) and S3 (10%DPF). Among the treatments prepared using peanut flour, S4 (15% DPF) received the least scores for all the parameters with an overall acceptability of 6.25. Yadav and his co workers (2012a) have reported that incorporation of deoiled peanut flour in biscuits was most acceptable at 5 per cent (8.60) and was acceptable upto 15 per cent but more amounts had a negative effect. Similar results have been reported by Bansal (2013), biscuits were highly acceptable with an incorporation of 10 per cent DPF with good nutritional profile. Cookies incorporated with moong bean and chickpea flour at 10-20 percent level were found to be highly acceptable by panelists of all age groups (Aziah *et al* 2012). Cookies were developed incorporating full fat soy flour at different levels with wheat flour by Ndife and his co workers (2014). The authors found out that the cookies were highly acceptable at 30 and 50 per cent levels of addition of soy flour to wheat flour.

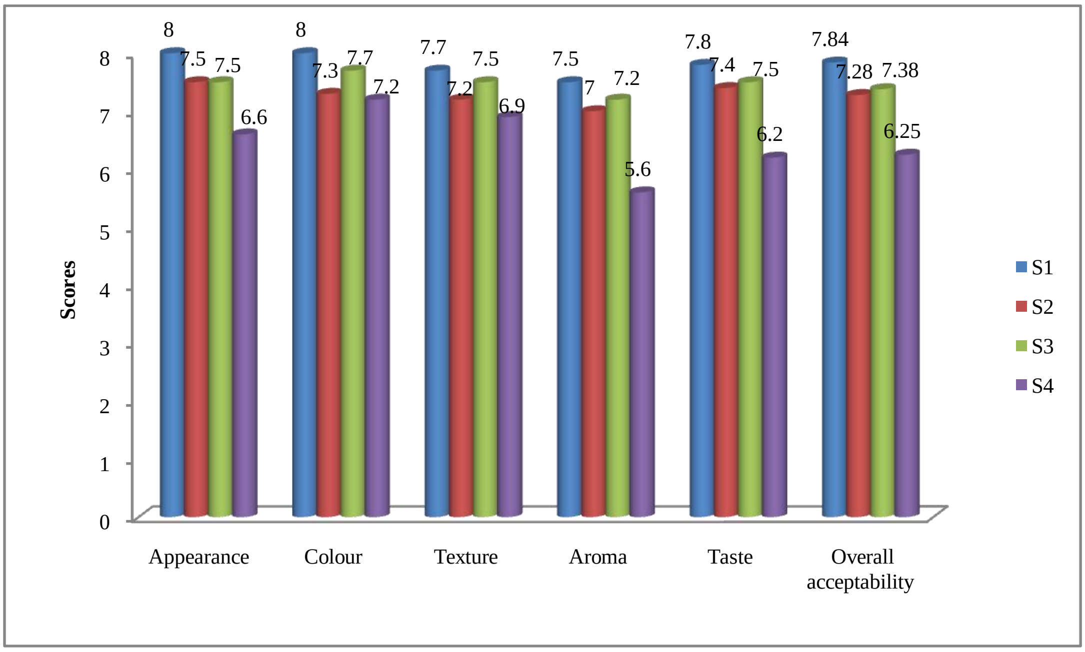


**Fig 4.5: Mean sensory scores for biscuits incorporated with partially defatted peanut cake flour**

**4.1.2 Development and standardisation of value added products with partially defatted peanut cake flour (DPF) and powdered green leafy vegetables (GLV)**

Five value added products were developed incorporating powdered green leafy vegetables in the acceptable products of the first standardization (with peanut flour) to further improve the micronutrient content of the products. Seasonal green leafy vegetables like fenugreek leaf was selected for products like *matthi* as well as *seviyan* and spinach leaf for sweet products like biscuits, *pinni* and *panjiri*.


**Plate 6: Development of biscuits with partially defatted peanut cake flour**

**Sample 1 (Control):** Wheat flour + Chick pea flour
**Sample 2:** Same as 1 + 5 % of partially defatted peanut cake flour
**Sample 3:** Same as 1 + 10 % partially defatted peanut cake flour
**Sample 4:** Same as 1 + 15 % partially defatted peanut cake flour

**Table 4.7 Composition of value added products with partially defatted peanut cake flour and powdered green leafy vegetables**

| Products | Ingredients | | | |
|---|---|---|---|---|
| ***1. Matthi*** | | | | |
| Variations | Refined Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 67.50 | 22.50 | 10 | - |
| S2 | 67.00 | 22.50 | 10 | 0.5 |
| S3 | 66.50 | 22.50 | 10 | 1.00 |
| S4 | 66.00 | 22.50 | 10 | 1.50 |
| ***2. Seviyan*** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 22.50 | 67.50 | 10 | - |
| S2 | 22.50 | 67.00 | 10 | 0.50 |
| S3 | 22.50 | 66.50 | 10 | 1.00 |
| S4 | 22.50 | 66.00 | 10 | 1.50 |
| ***3. Pinni*** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 62.50 | 22.50 | 15 | - |
| S2 | 61.50 | 22.50 | 15 | 1.00 |
| S3 | 61.00 | 22.50 | 15 | 1.50 |
| S4 | 60.50 | 22.50 | 15 | 2.00 |
| ***4. Panjiri*** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 62.50 | 22.50 | 15 | - |
| S2 | 61.50 | 22.50 | 15 | 1.00 |
| S3 | 61.00 | 22.50 | 15 | 1.50 |
| S4 | 60.50 | 22.50 | 15 | 2.00 |
| **5. Biscuits** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 67.50 | 22.50 | 10 | - |
| S2 | 66.50 | 22.50 | 10 | 1.00 |
| S3 | 66.00 | 22.50 | 10 | 1.50 |
| S4 | 65.50 | 22.50 | 10 | 2.00 |

DPF - Partially defatted peanut cake flour

GLV – Fenugreek leaf powder was used in *matthi as well as seviyan*

Spinach leaf powder was used in *pinni, panjiri and biscuits*

The sensory evaluation of these products was then carried out to select the acceptable proportion of DPF along with GLV in all the products. The products thus obtained are the final valued added products fortified with partially defatted peanut cake flour and powdered green leafy vegetables. The composition of the value added products with GLV are given in Table 4.7.

**Sensory Evaluation of the Developed Value Added Products**

The various sensory scores obtained for the different value added products prepared incorporating powdered green leafy vegetables along with partially defatted peanut cake flour is presented in Table 4.8 to Table 4.12.

***MATTHI***

*Matthi* was developed at four different levels using powdered fenugreek leaf powder. Control (S1) sample was prepared using refined wheat flour, chick pea flour and 10 per cent peanut flour. The three levels at which the fenugreek leaf powder was added were 0.50, 1.00 and 1.50 per cent and were coded as S2, S3 and S4 respectively. The scores statistically revealed that all the treatments were significantly different with regard to parameters like appearance, aroma and overall acceptability as presented in Table 4.9 and Fig 4.6.

**Table 4.8: Mean sensory scores for *matthi* incorporated with partially defatted peanut cake flour and fenugreek leaf powder**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | **Appearance** | **Colour** | **Texture** | **Aroma** | **Taste** | **Overall Acceptability** |
| S1 | 7.30 | 7.30 | 7.60 | 7.5 | 7.40 | 7.42 |
| S2 | 7.10 | 7.20 | 7.50 | 7.1 | 7.40 | 7.16 |
| S3 | 7.00 | 7.20 | 7.50 | 7.20 | 7.40 | 7.18 |
| S4 | 5.70 | 5.90 | 6.10 | 5.70 | 6.40 | 5.86 |
| **$\chi 2$ value** | 27.13** | 24.34** | 19.08** | 28.50** | 15.78** | 24.97** |

** Significant at 1% level of significance ($p<0.01$)
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

The highest score obtained was for S1 (Control) which did not have any fenugreek leaf powder incorporation in it. S2 (0.5% fenugreek leaf powder) and S3 (1% fenugreek leaf powder) scores were at par with respect to colour, texture and taste. Statistically insignificant difference in the scores for taste (7.40) was observed between S2 (0.5% fenugreek leaf powder) and S3 (1% fenugreek leaf powder). But S3 (1% fenugreek leaf powder) received the highest overall acceptability score of 7.18 after control (S1). It was seen that on increasing the addition of leaf powder colour was significantly affected and therefore S4 (1.50% fenugreek leaf powder) received the lowest score for overall acceptability (5.86).

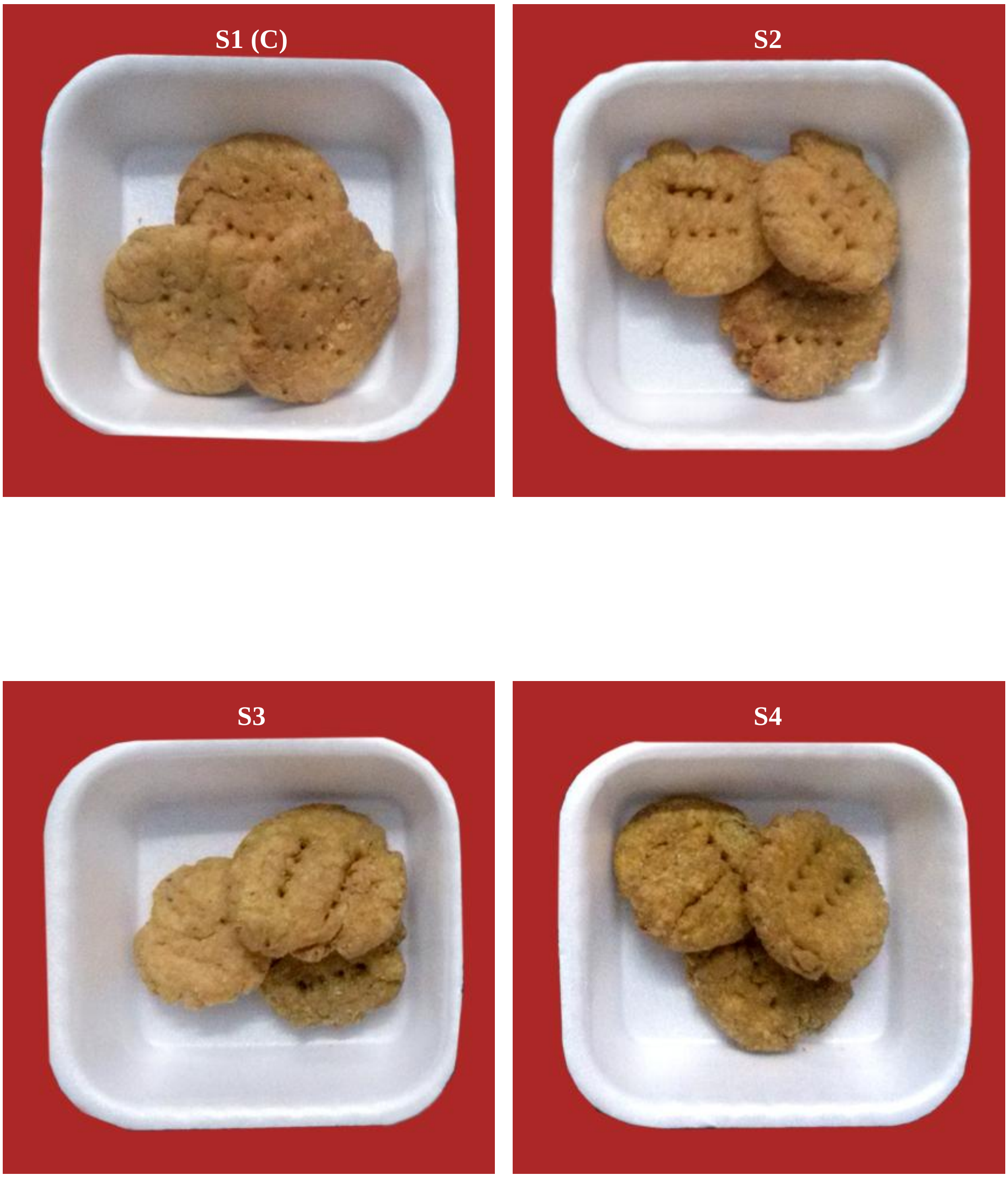


**Plate 7: Development of *matthi* with partially defatted peanut cake flour and fenugreek leaf powder**

**Sample 1 (Control):** Wheat flour + Chick pea flour+10 % partially defatted peanut cake flour
**Sample 2:** Same as 1 + 0.5 % of fenugreek leaf powder
**Sample 3:** Same as 1 + 1 % fenugreek leaf powder
**Sample 4:** Same as 1 + 1.5 % fenugreek leaf powder

Hence, S3 (1% fenugreek leaf powder) was taken as the final value added product for further analysis. Gupta and Prakash (2011) reported that an incorporation of '*Keerae*' (*Amaranthus paniculatus*) upto 4 per cent level in products like *Mathri* and *Thalipeeth* was acceptable. *Matthi* prepared incorporating dehydrated *palak* (*Beta vulgaricus* L.) was reported acceptable at 4 per cent level (Kaur *et al* 2015).

***SEVIYAN***

*Seviyan* with different levels of fenugreek leaf powder were developed and standardized along with addition of peanut flour from the first standardization. Control (S1) sample was the acceptable treatment from the first standardization, prepared using chick pea and wheat flour at the ratio of 75:25 and 10 per cent peanut flour. Other three levels were prepared with addition of 0.50, 1.00 and 1.50 per cent of fenugreek leaf powder. They were then subjected to sensory evaluation to select the acceptable level of fenugreek leaf powder in *seviyan*. The mean scores of acceptability trials of *seviyan* with different levels of fenugreek leaf powder is presented in Table 4.9 and Fig 4.7.

**Table 4.9. Mean sensory scores for *seviyan* incorporated with partially defatted peanut cake flour and fenugreek leaf powder**

| **Proportions** | **Parameters** | | | | | |
|---|---|---|---|---|---|---|
| | **Appearance** | **Colour** | **Texture** | **Aroma** | **Taste** | **Overall Acceptability** |
| S1 | 7.70 | 7.00 | 8.00 | 7.70 | 8.00 | 7.68 |
| S2 | 7.70 | 7.00 | 7.70 | 7.00 | 7.20 | 7.40 |
| S3 | 7.00 | 7.00 | 8.00 | 7.00 | 7.30 | 7.48 |
| S4 | 6.30 | 5.30 | 7.40 | 5.40 | 5.00 | 5.84 |
| **$\chi 2$ value** | 30.72** | 38.33** | 30.60** | 34.13** | 29.16** | 30.89** |

** Significant at 1% level of significance ($p$<0.01)

S- Sample where S1 to S4 stands for Sample 1 to Sample 4

The treatment S1 (Control) obtained the highest score with regard to all the sensory parameters. The highest mean scores for different sensory parameters like texture, taste and overall acceptability of *seviyan* among the treatments with fenugreek leaf powder were observed for S3 (1% fenugreek leaf powder). With respect to appearance, S2 (0.5% fenugreek leaf powder) scored higher compared to S3 (1% fenugreek leaf powder) while for all the parameters except colour treatment S3 was superior to S2 (0.5% fenugreek leaf powder). The overall acceptability scores for the control S1 (7.68) followed by S3 (7.48) and then S2 with a score of 7.40. In the case of *seviyan* too, increase in the concentration of fenugreek leaf powder in the treatments reduced the score with regard to all the parameters especially colour, aroma and taste. Hence S4 (1.5% GLV) received the lowest acceptability score of 5.84.

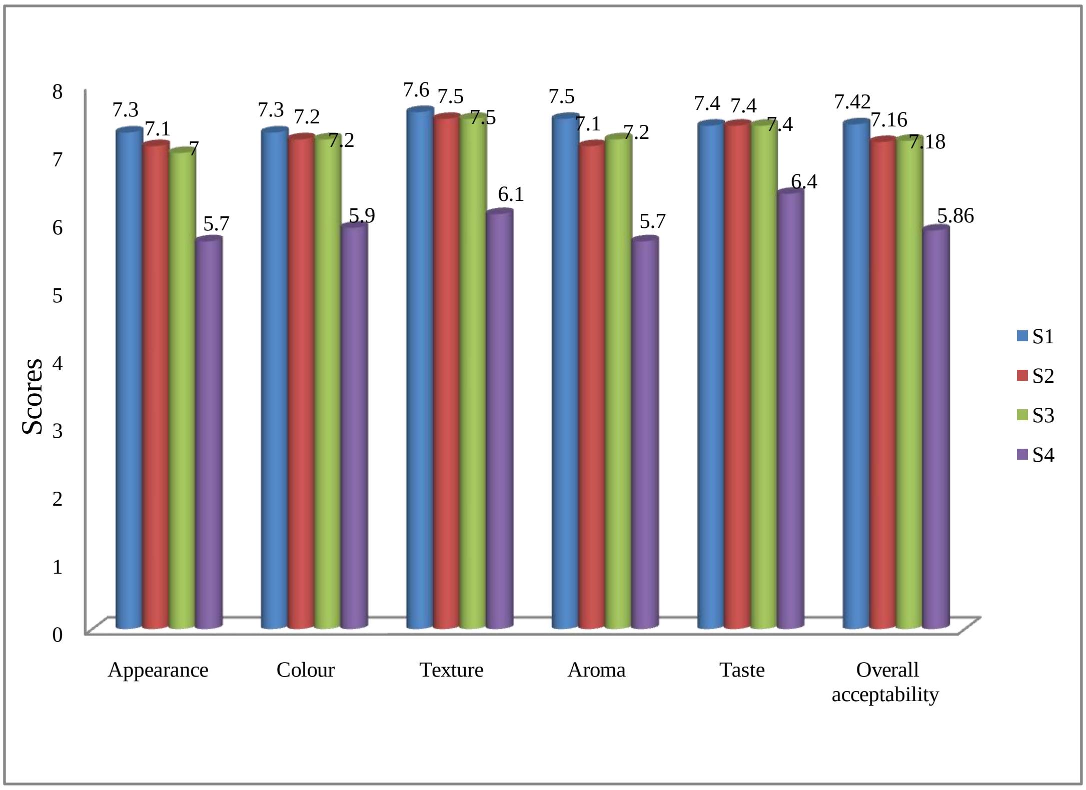


**Fig 4.6: Mean sensory scores for *matthi* incorporated with partially defatted peanut cake flour and fenugreek leaf powder**

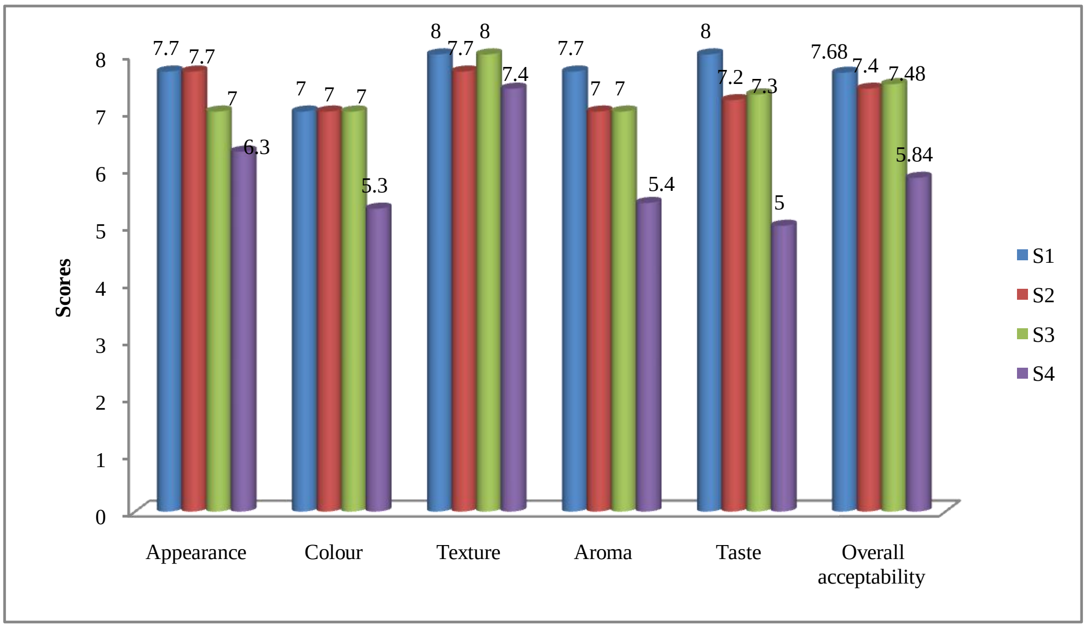


**Fig 4.7: Mean sensory scores for *seviyan* incorporated with partially defatted peanut cake flour and fenugreek leaf powder**

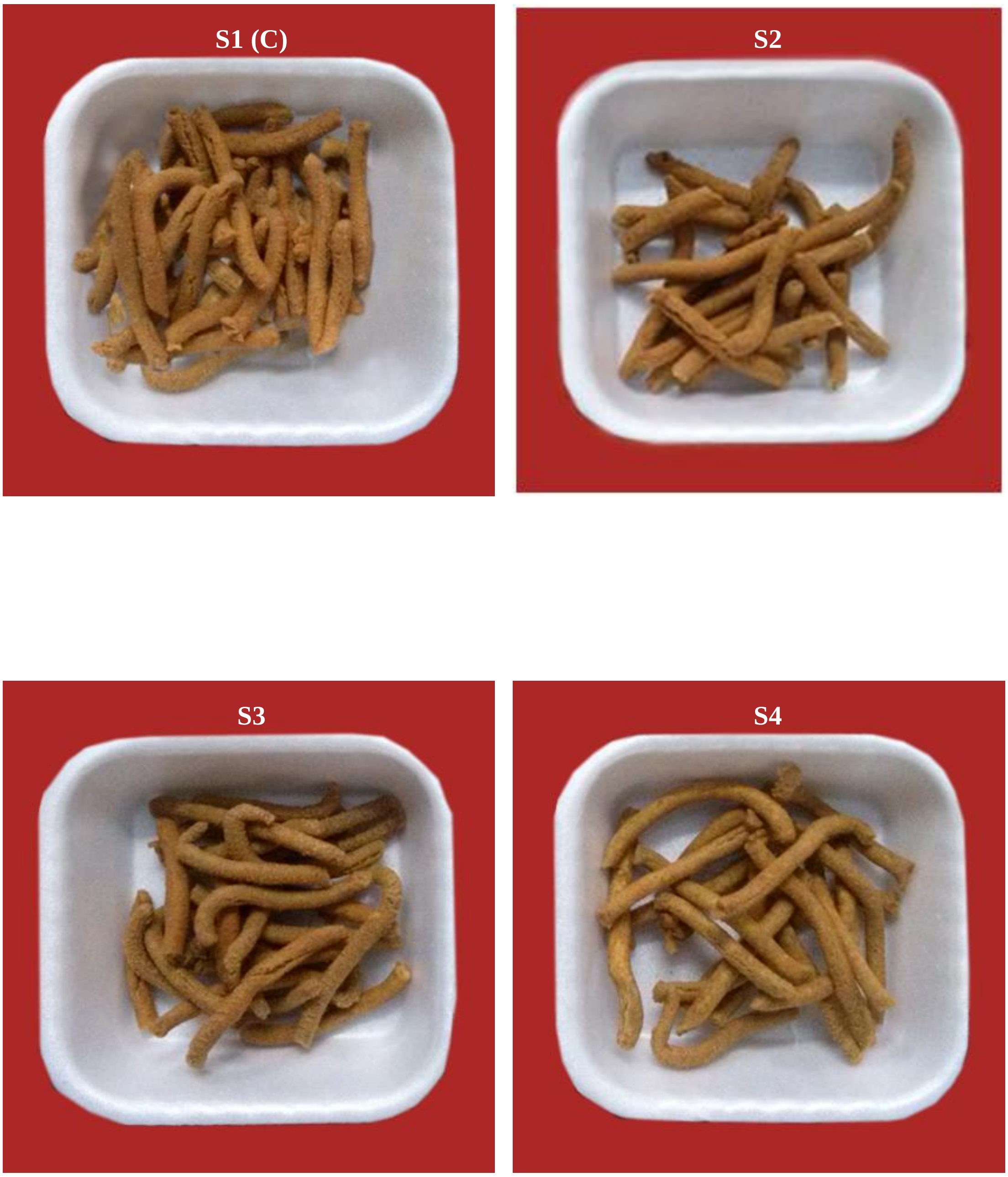


**Plate 8: Development of *seviyan* with partially defatted peanut cake flour and fenugreek leaf powder**

**Sample 1 (Control):** Wheat flour + Chick pea flour+10 % partially defatted peanut cake flour
**Sample 2:** Same as 1 + 0.5 % of fenugreek leaf powder
**Sample 3:** Same as 1 + 1 % fenugreek leaf powder
**Sample 4:** Same as 1 + 1.5 % fenugreek leaf powder

Extruded chickpea based products were developed fortified with fenugreek leave powder at 2, 5 and 10 per cent by Gamlath and Ganesharanee (2008). The authors too reported that due to the distinct bitter taste, inclusion of fenugreek flour was not acceptable at levels more than 2 per cent in extruded chickpea based products.

***PINNI***

Four different treatments of *pinni* were prepared incorporating different levels of spinach leaf powder along with partially defatted peanut cake flour. The sensory scores obtained for the four treatments are presented in Table 4.10 and Fig 4.8.

**Table 4.10: Mean sensory scores for *pinni* incorporated with partially defatted peanut cake flour and spinach leaf powder**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | **Appearance** | **Colour** | **Texture** | **Aroma** | **Taste** | **Overall Acceptability** |
| S1 | 7.80 | 7.80 | 7.80 | 7.60 | 7.80 | 7.80 |
| S2 | 7.50 | 6.90 | 7.60 | 7.00 | 7.60 | 7.44 |
| S3 | 7.50 | 6.90 | 7.60 | 7.00 | 7.60 | 7.50 |
| S4 | 7.30 | 6.00 | 7.50 | 7.00 | 7.30 | 7.62 |
| **$\chi 2$ value** | $7.49^{NS}$ | 24.41** | $5.09^{NS}$ | 20.65** | $5.69^{NS}$ | 13.55** |

** Significant at 1% level of significance ($p$<0.01) NS- Non significant
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

The acceptable *pinni* incorporated with 15 per cent peanut flour from the first standardization was taken as the Control (S1). Further, spinach powder was added to the rest of the treatments at 1.00, 1.50 and 2.00 per cent and was coded as S2, S3 and S4 treatments respectively. The scores for all the sensory parameters like appearance, colour, texture, aroma and taste were the highest for control (S1) with an overall acceptability score of 7.80. The analysis revealed that the sensory scores for appearance, texture and taste were not significantly different for the treatments of *pinni* incorporated with different levels of spinach leaf powder. But with respect to the overall acceptability, S4 (2% spinach leaf powder) scored the highest of 7.62 which was statistically significant when compared to the other treatments. It was followed by S3 (1.5% spinach leaf powder) and S2 (1.00% spinach leaf powder). *Laddos* prepared by fortifying underutilized greens like leaf of beet root (*B. vulgaris*), carrot (*D. carota*), cauliflower (*B. oleracea*) and turnip (*B. rapa*) was carried out by Joshi and Mathur (2010) and concluded that the leaf powder incorporation was only acceptable from 5 to 10 per cent.

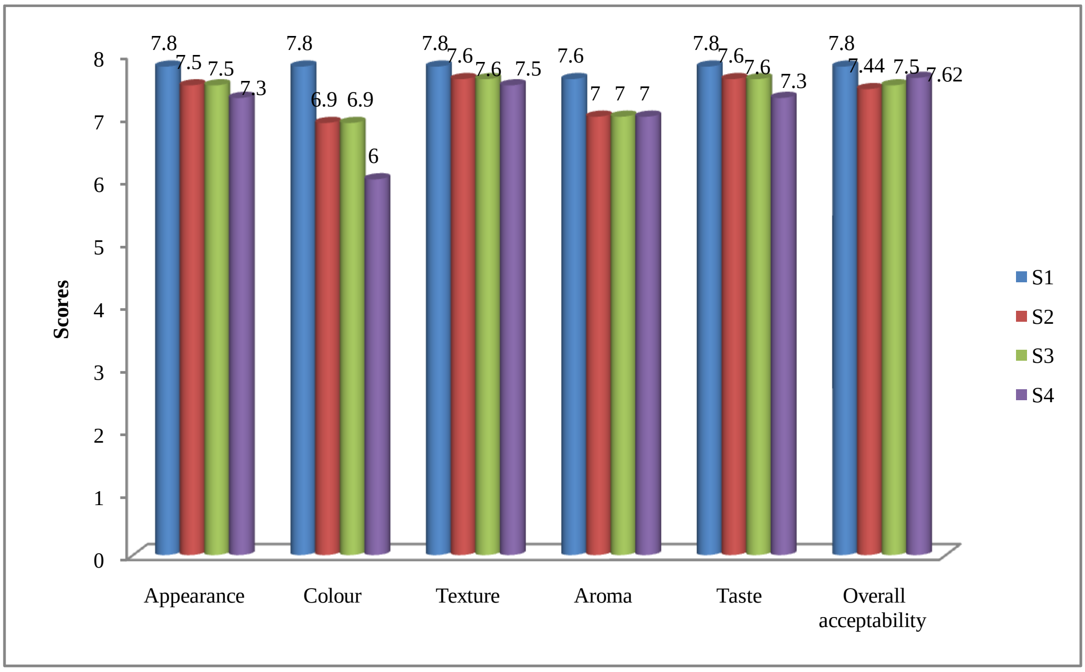


**Fig 4.8: Mean sensory scores for *pinni* incorporated with partially defatted peanut cake flour and spinach leaf powder**

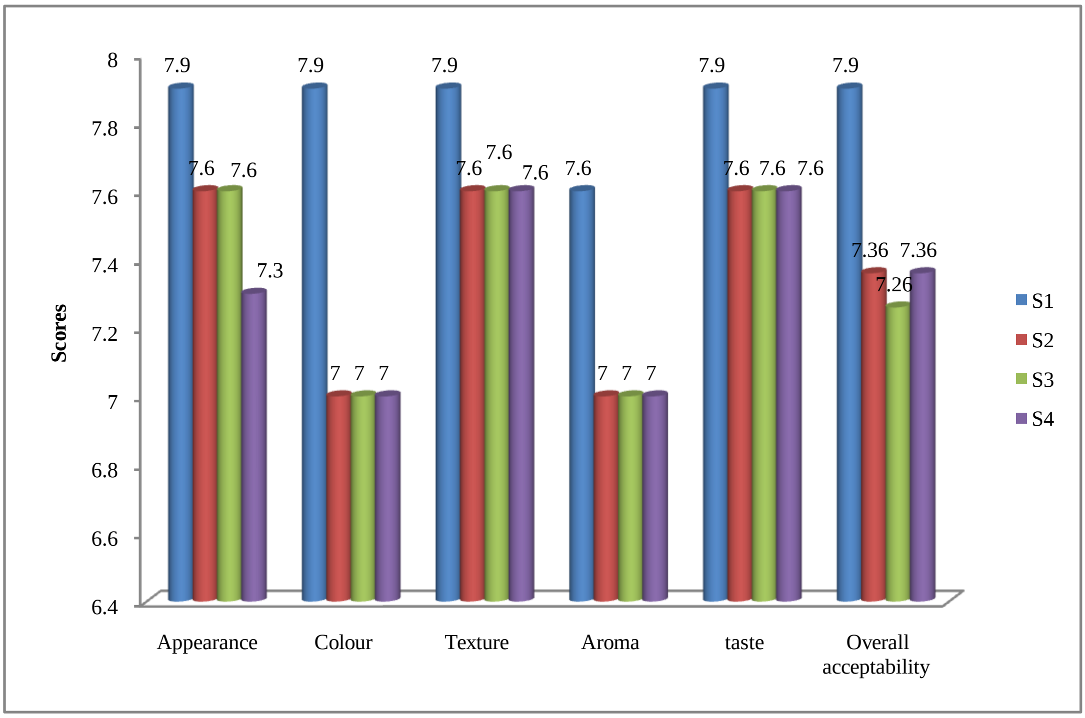


**Fig 4.9: Mean sensory scores for *panjiri* incorporated with partially defatted peanut cake flour and spinach leaf powder**

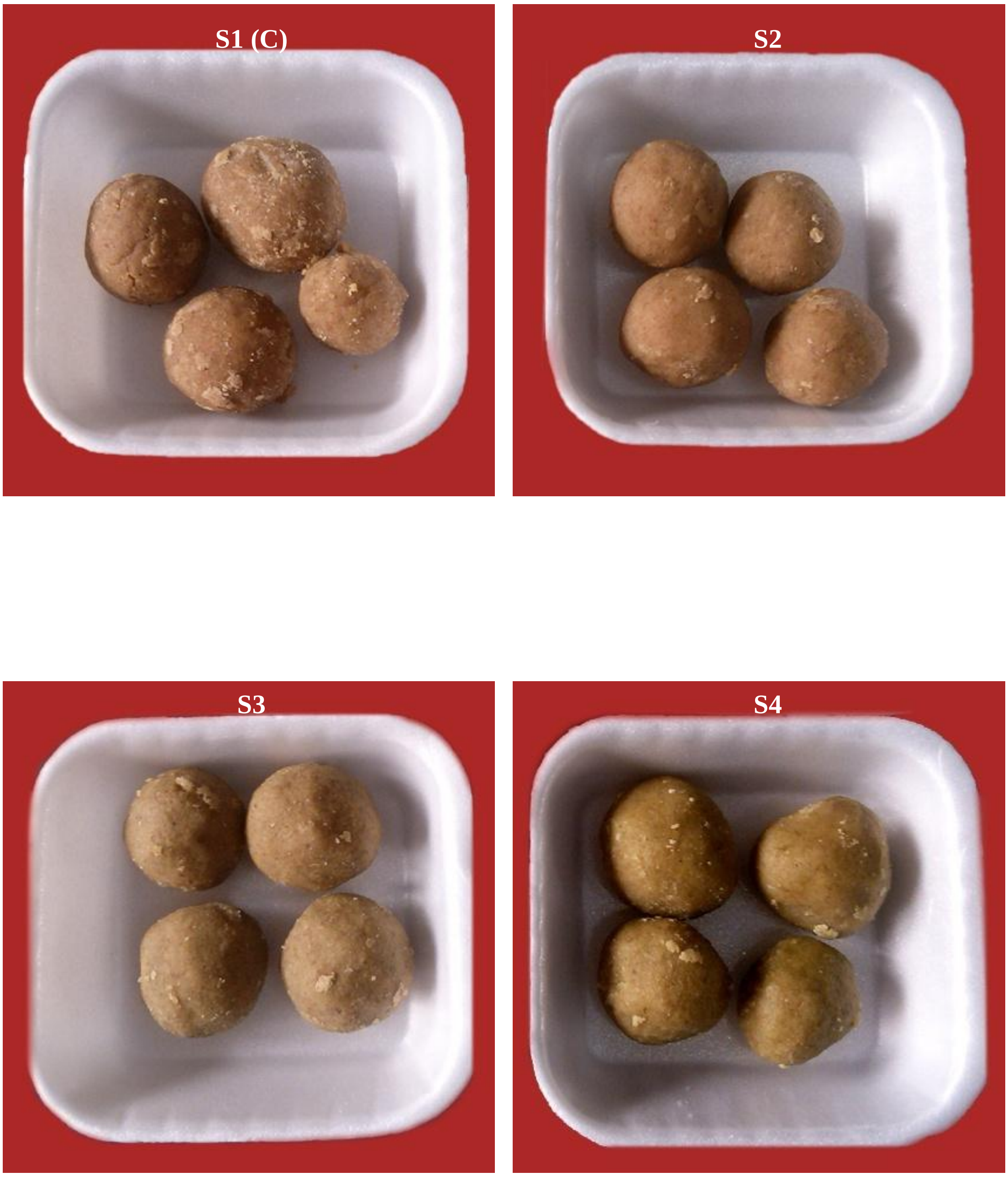


**Plate 9: Development of *pinni* with partially defatted peanut cake flour and spinach leaf powder**

**Sample 1 (Control):** Wheat flour + Chick pea flour+15 % partially defatted peanut cake flour
**Sample 2:** Same as 1 + 1 % spinach leaf powder
**Sample 3:** Same as 1 + 1.5 % spinach leaf powder
**Sample 4:** Same as 1 + 2 % spinach leaf powder

***PANJIRI***

*Panjiri* was prepared in four different treatments. S1 was control which was the most acceptable product from first standardization prepared using wheat flour, chickpea flour and 10 per cent peanut flour. Three treatments S2, S3 and S4 were prepared using spinach powder 1, 1.5 and 2 per cent levels respectively. The treatment S4 (2% spinach leaf powder) scored the highest score for the sensory attributes after the Control (S1) and was then selected as the final product for further analysis. The scores for the sensory parameters of different treatments given to *panjiri* are presented in Table 4.11 and Fig 4.9.

From the statistical analysis of the score, it was observed that S1 (Control) received the highest score of 7.90 for all the parameters except aroma followed by S2 (1% spinach leaf powder) and S4 (2% spinach leaf powder) with overall acceptability of 7.36. The scores of S2 and S4 were statistically insignificant with respect to appearance, taste and texture. The overall acceptability score for S2 and S4 were at par and hence, S4 (2% spinach leaf powder) was selected as the final value added *panjiri f*or further analysis and supplementation.

**Table 4.11: Mean sensory scores for *panjiri* incorporated with partially defatted peanut cake flour and spinach leaf powder**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Texture | Aroma | Taste | Overall Acceptability |
| S1 | 7.90 | 7.90 | 7.90 | 7.60 | 7.90 | 7.90 |
| S2 | 7.60 | 7.00 | 7.60 | 7.00 | 7.60 | 7.36 |
| S3 | 7.60 | 7.00 | 7.60 | 7.00 | 7.60 | 7.26 |
| S4 | 7.30 | 7.00 | 7.60 | 7.00 | 7.60 | 7.36 |
| **$\chi 2$ value** | $7.31^{NS}$ | 33.97** | $7.31^{NS}$ | 20.65** | $7.49^{NS}$ | 16.09** |

** Significant at 1% level of significance ($p$<0.01) NS- Non significant
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

**BISCUITS**

Four different treatments of biscuits were prepared using partially defatted peanut cake flour (DPF) and different proportions of spinach leaf powder as a source of green leafy vegetable (GLV). S1 was taken as control which was prepared using wheat flour, chickpea flour and 10 per cent peanut flour. Treatments S2 to S4 were prepared incorporating spinach powder at levels 1, 1.5 and 2 per cent respectively. As the other products, S1 (Control) scored the highest for all the sensory parameters with an overall acceptability score of 7.68 as revealed in Table 4.12 and Fig 4.10.

**Table 4.12: Mean sensory scores for biscuits incorporated with partially defatted peanut cake flour and spinach leaf powder**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Texture | Aroma | Taste | Overall Acceptability |
| S1 | 7.70 | 7.30 | 7.30 | 7.30 | 7.80 | 7.68 |
| S2 | 7.80 | 7.30 | 7.30 | 7.00 | 7.80 | 7.30 |
| S3 | 7.30 | 7.30 | 7.30 | 7.00 | 7.40 | 7.50 |
| S4 | 6.10 | 5.60 | 7.10 | 5.90 | 5.60 | 5.60 |
| **χ2 value** | 24.41** | 26.13** | $0.62^{NS}$ | 22.36** | 27.87** | 25.41** |

** Significant at 1% level of significance ($p$<0.01) NS- Non significant
S- Sample where S1 to S4 stands for Sample 1 to Sample 4

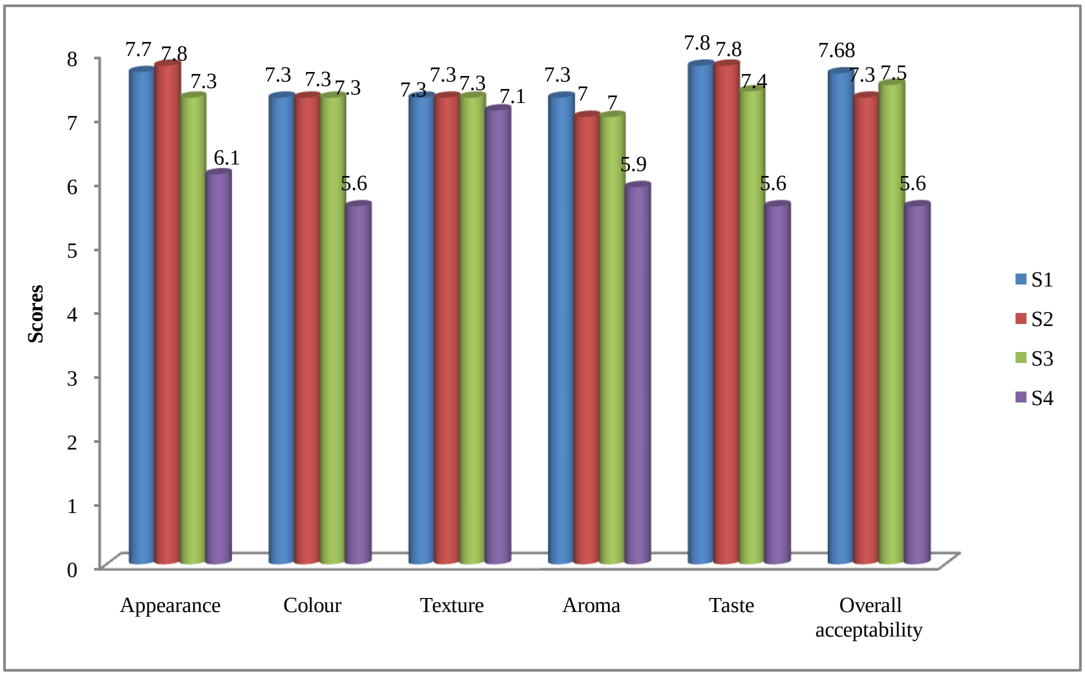


**Fig 4.10: Mean sensory scores of biscuits incorporated with partially defatted peanut cake flour and spinach leaf powder**

The difference in scores was found to be statistically significant with regard to all the sensory parameters for all the treatments except for texture. The highest mean scores for different sensory parameters of biscuits were observed for control (S1) followed by S3 treatment (1.5% GLV). The scores for appearance and taste were higher for S2 (1% GLV) when compared to the score obtained by S3 (1.5%) but the overall acceptability score was significantly higher for S3 (7.50) while for S2 (1% GLV) it was only 7.30. Among the treatments prepared using spinach powder, S4 (2% GLV) received the least scores for all the parameters with an overall acceptability of 5.60 because of the bitter taste contributed by

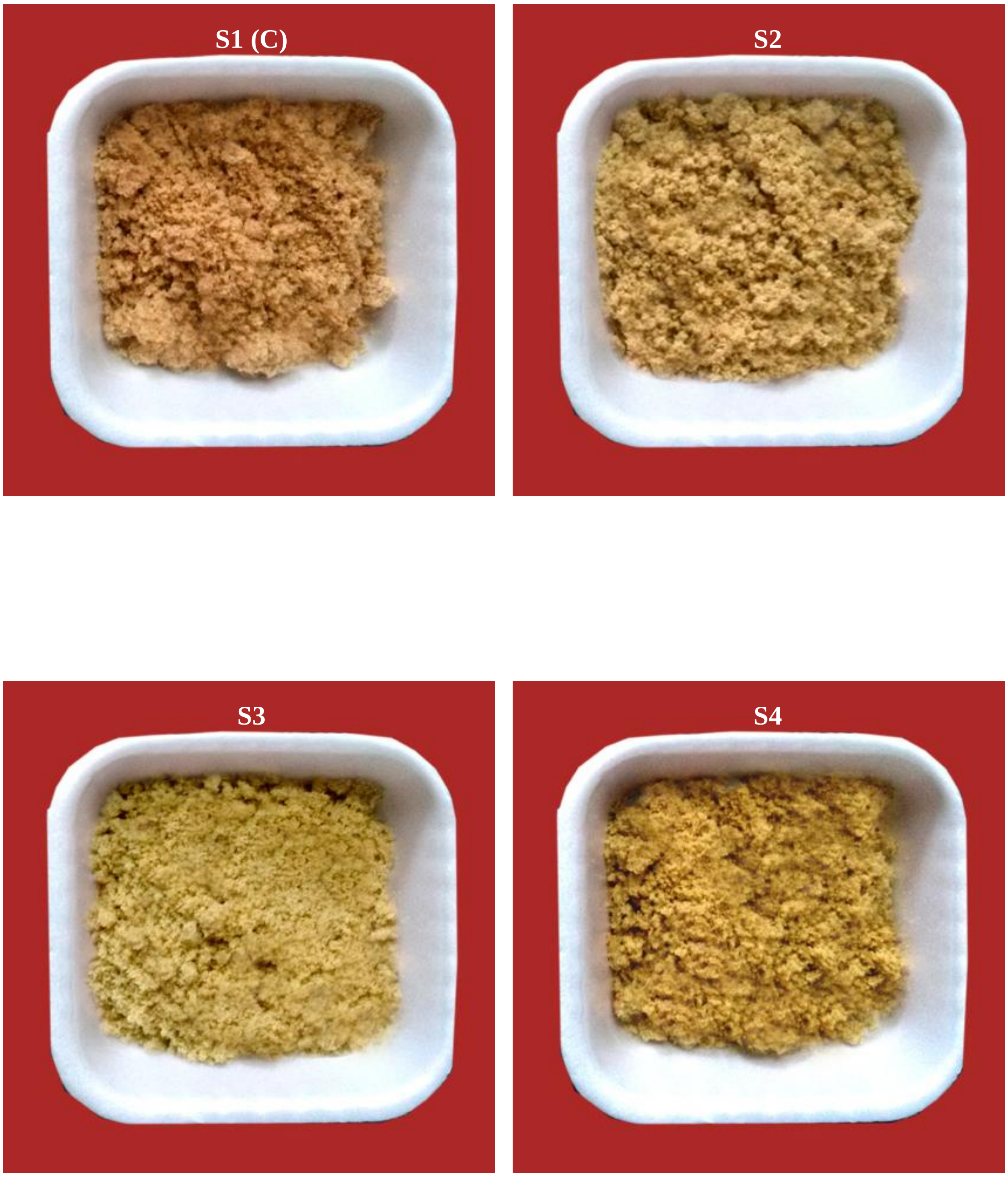


**Plate 10: Development of *pinni* with partially defatted peanut cake flour and spinach leaf powder**

**Sample 1 (Control):** Wheat flour + Chick pea flour+15 % partially defatted peanut cake flour
**Sample 2:** Same as 1 + 1 % spinach leaf powder
**Sample 3:** Same as 1 + 1.5 % spinach leaf powder
**Sample 4:** Same as 1 + 2 % spinach leaf powder

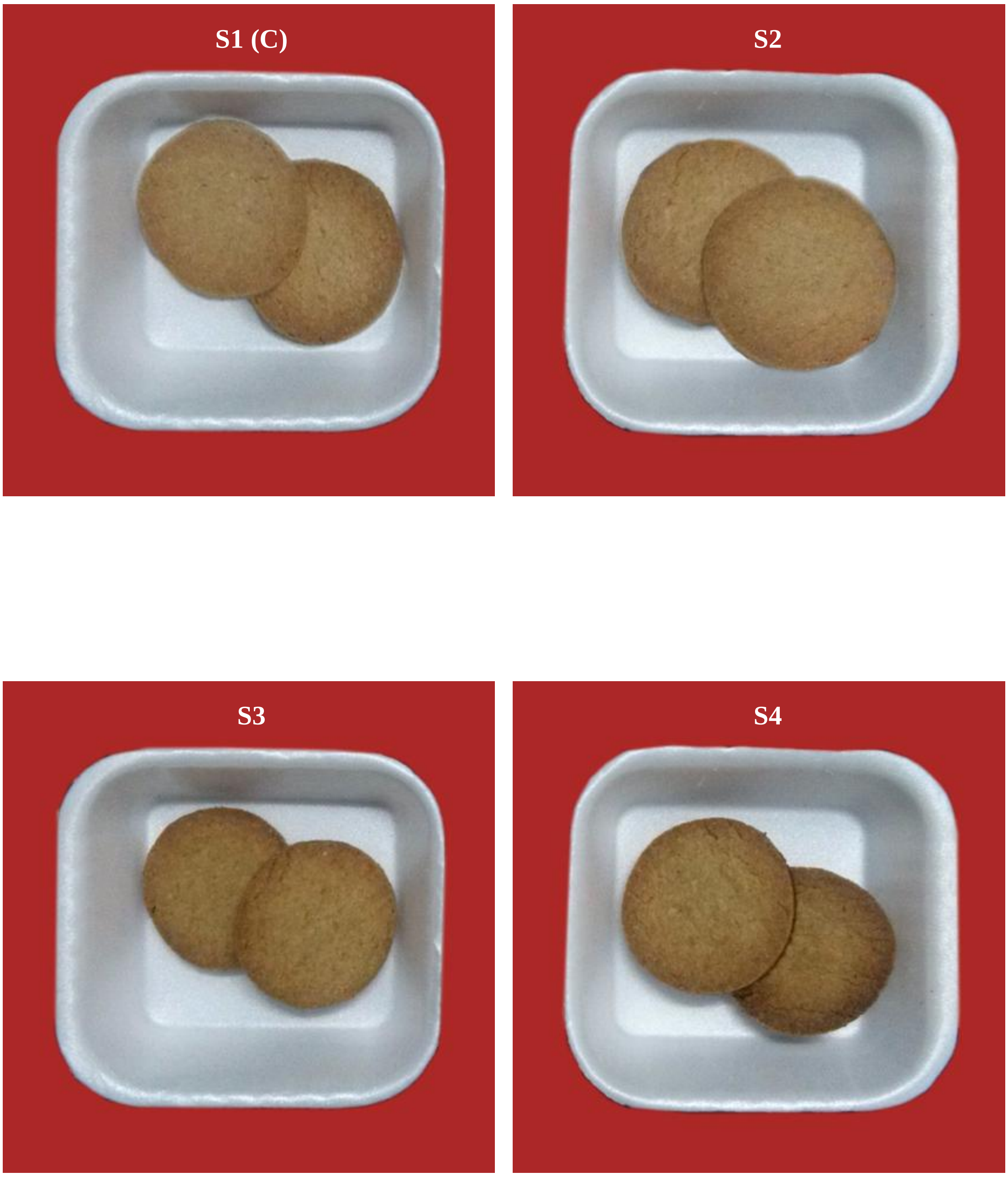


**Plate 11: Development of biscuits with partially defatted peanut cake flour and spinach leaf powder**

**Sample 1 (Control):** Wheat flour + Chick pea flour+10 % partially defatted peanut cake flour
**Sample 2:** Same as 1 + 1 % spinach leaf powder
**Sample 3:** Same as 1 + 1.5 % spinach leaf powder
**Sample 4:** Same as 1 + 2 % spinach leaf powder

spinach powder. Hence, biscuits of S3 treatment were selected as the final value added product for further analysis and supplementation. Effect of replacement of wheat flour with 5, 10 and 15 per cent dried moringa leaf (*Moringa oleifera Lam*) powder (DML) on the rheological, nutritional and quality characteristics of cookies were studied by Dachana and co workers (2010) and found that only 5 per cent of addition was acceptable. Biscuits prepared incorporating dehydrated *palak* (*Beta vulgaricus* L.) was reported acceptable at 4 per cent level (Kaur *et al* 2015).

Hence five value added products were formulated, standardized and developed using partially defatted peanut cake flour and dehydrated powdered greens like fenugreek leaf and spinach leaf for further nutritional analysis and supplementation with an aim to promise a solution to eradicate malnutrition in children. The composition of the final five value added products are presented in Table 4.13.

**Table 4.13: Composition of the value added products using partially defatted peanut cake flour and green leafy vegetable powder**

| Products | Ingredients (g) | | | |
|---|---|---|---|---|
| | Wheat flour | Chickpea flour | DPF | GLV |
| *Matthi* | 66.50 | 22.50 | 10 | 1 |
| *Seviyan* | 22.50 | 66.50 | 10 | 1 |
| *Pinni* | 60.50 | 22.50 | 15 | 2 |
| *Panjiri* | 60.50 | 22.50 | 15 | 2 |
| Biscuits | 66.00 | 22.50 | 10 | 1.5 |

DPF- Partially defatted peanut cake flour
GLV- Green leafy vegetable powder

### 4.2 Nutritional composition of developed products

#### 4.2.1 Proximate composition of raw ingredients and developed products

##### 4.2.1.1 Proximate composition of raw ingredients

The proximate composition of raw ingredients used for preparing the different value added products using partially defatted peanut cake flour and green leafy vegetable powder were analysed on their dry weight basis and are presented in Table 4.14. The proximate contents were the highest for partially defatted peanut cake flour except for moisture, carbohydrates and fiber. With respect to the moisture content of 100g of wheat flour and refined wheat flour, it was found to be 8.96 and 10.12 per cent respectively. Gopalan *et al* (2007) reported the moisture content of whole wheat flour and refined wheat flour as 12.2 and 13.3 percent respectively. Higher moisture content of 12.46 per cent was observed in wheat flour by Alam *et al* (2013) as well as for refined wheat flour of 13.29 per cent by Baljeet *et al* (2010). Moisture content of chick pea flour which was used as pulse source to complete the amino acid profile was found to be 6.10 per cent. A moisture content of 8.7 per cent in chickpea flour was reported by Yadav *et al* (2012b). Partially defatted peanut cake flour was found to have a moisture content of 3.12 per cent. Similar values were reported by Bansal (2013). Lower moisture content in the partially defatted peanut cake flour may be due to the drying process in the oven after the oil extraction.

**Table 4.14: Proximate composition of the raw ingredients (DW basis)**

| Raw ingredients | Moisture (%) | Crude Protein(%) | Crude Fat (%) | Crude Fiber(%) | Total Ash (%) | Carbohydrates(%) (by differences) |
|---|---|---|---|---|---|---|
| **Wheat flour** | 8.96±0.03 | 11.82±0.14 | 1.82±0.11 | 1.35±0.05 | 2.65±0.04 | 73.98±0.03 |
| **Refined wheat flour** | 10.12±0.12 | 9.12±0.08 | 0.97±0.29 | 0.51±0.08 | 1.42±0.23 | 77.78±0.07 |
| **Chickpea flour** | 6.10±0.18 | 17.08±0.19 | 4.76±0.15 | 1.15±0.03 | 1.98±0.09 | 68.92±0.12 |
| **Partially defatted peanut cake flour** | 3.12±0.23 | 53.18±0.05 | 8.96±0.24 | 5.23±0.15 | 3.76±0.21 | 25.75±0.07 |
| **Fenugreek leaf powder** | 4.66±0.04 | 3.43±0.11 | 0.98±0.07 | 5.34±0.06 | 19.32±0.12 | 66.21±0.05 |
| **Spinach leaf powder** | 5.88±0.06 | 2.54±0.09 | 0.19±0.05 | 5.02±0.03 | 18.77±0.10 | 67.54±0.08 |

Values are given as Mean ± SE

Among the raw ingredients, the highest protein content of 53.18 per cent was observed in partially defatted peanut cake flour. Similar values for protein in peanut flour were also reported by Bansal (2013). The protein content of two varieties of peanuts- Ashford and Barberton was found to be in the range 44.51 to 50.90 per cent (Fekria *et al* 2012). Chickpea flour was also found to have a good protein content of 17.08 per cent which was almost similar to the values reported by Yadav *et al* (2012b).The least protein content was found to be 2.54 per cent in spinach leaf powder. The protein content of wheat flour was found to be 11.82 per cent while Gupta and Singh (2005) found that wheat flour contains 9.1per cent protein on dry matter basis.

Fat content was found to be 8.96 per cent in partially defatted peanut cake flour followed by chickpea flour with 4.76 per cent fat. Madukwe *et al* (2013) and Fekria *et al* (2012) also reported similar fat content of 7.9 per cent in peanut flour. A fat content of 4.4 per cent in chickpea flour was observed by Yadav *et al* (2012b). Very low fat content was observed in wheat flour and refined wheat flour which was 1.82 and 0.97 per cent respectively. Farzana *et al* (2003) reported that refined wheat flour and whole wheat flour contain 1.6 and 1.1 per cent of fat respectively.

Crude fiber content ranged from 0.51 per cent in refined wheat flour to 5.34 per cent in fenugreek leaf powder. Wheat flour had a fiber content of 1.35 per cent. A fiber content of 0.3 and 1.9 per cent of fiber in refined wheat flour and whole wheat flour was reported by Gopalan *et al* (2007). Chickpea flour was found to have a fiber content of 1.15 per cent while a content of 1.6 per cent was reported by Mittal (2011). With regard to the ash content, highest ash content of 19.32 per cent was found in fenugreek leaf powder followed by spinach leaf powder with 18.77 per cent. While in chickpea flour and refined wheat flour, it was found to be 1.98 and 1.42 respectively. Yadav *et al* (2012b) also reported similar findings in chickpea flour.

Wheat flour and refined wheat flour was found to have the highest carbohydrate content of 73.98 and 77.78 per cent respectively. Madukwe *et al* (2013) and Fekira *et al* (2012) also reported a carbohydrate in similar range for wheat and refined wheat flour. Carbohydrate content of chickpea flour was 68.92 per cent and was similar with finding obtained by Yadav *et al* (2012b) and Bansal (2013). Least carbohydrate content of 25.75 per cent was obtained for partially defatted peanut cake flour. Fekria and his co workers (2012) as well as Bansal (2013) also obtained a carbohydrate content in the range 14 to 19.53 per cent for partrially defatted peanut flour.

**4.2.1.2 Proximate composition of developed products**

The incorporation of partially defatted peanut cake flour and powdered green leafy vegetables to the five products was found to have a significant increase in the proximate composition of the products except in the case of carbohydrate content of all the products as depicted in Table 4.15.

The moisture content increased significantly ($p$<0.01) for all the products except for *seviyan* which may be due to the addition of powdered green leafy vegetables. Although there was an increase in the moisture content of *seviyan,* it was found to be statistically insignificant. Kaur and her co workers (2015) observed a significant increase in the moisture, ash and fiber content when spinach was incorporated in products like biscuits and *pakoras.* A significant increase in the crude protein content of all the five value added products were observed compared to its control on the addition of partially defatted peanut cake flour. The protein content for the value added salty snacks like *matthi* and *seviyan* was found to be 16.58 and 23.49 per cent which increased from that of its control which was only 11.59 and 16.04 per cent respectively. While the sweet products like *pinni, panjiri* and biscuits, the protein content significantly ($p$<0.01) increased from 11.02 to 20.18 per cent, 11.27 to 18.97 per cent and 12.44 to 17.94 per cent respectively.

**Table 4.15: Proximate composition of the developed products (DW basis)**

| Products | Moisture (%) | Crude Protein (%) | Crude Fat (%) | Crude Fiber (%) | Total Ash (%) | Carbohydrate (%) (bydifferences) | Energy (Kcal/100g) |
|---|---|---|---|---|---|---|---|
| ***Matthi*** (control) | 3.32±0.01 | 11.59±0.02 | 18.86±0.04 | 0.23±0.01 | 0.48±0.01 | 65.52±0.03 | 477.67±0.19 |
| Acceptable (10%DPF+1%FLP) | 3.44±0.01 | 16.58±0.02 | 20.92±0.04 | 1.43±0.16 | 0.88±0.02 | 57.18±0.06 | 483.56±0.13 |
| **t-value** | 18.50** | 175.09** | 46.64** | 7.27* | 122.00** | 288.26** | 80.03** |
| ***Seviyan*** (control) | 2.35±0.01 | 16.04±0.10 | 16.28±0.04 | 1.75±0.02 | 1.25±0.02 | 62.65±0.02 | 461.53±0.36 |
| Acceptable (10%DPF+1%FLP) | 2.54±0.02 | 23.49±0.28 | 18.06±0.03 | 2.94±0.02 | 1.79±0.01 | 51.72±0.15 | 463.24±0.09 |
| **t-value** | 5.58$^{NS}$ | 19.94** | 36.39** | 77.90** | 93.53** | 76.78** | 6.28* |
| ***Pinni*** (control) | 4.31±0.01 | 11.02±0.05 | 25.11±0.05 | 1.41±0.01 | 2.54±0.02 | 56.01±0.09 | 494.64±0.08 |
| Acceptable (15%DPF+2%SLP) | 4.53±0.01 | 20.18±0.03 | 27.05±0.02 | 3.84±0.01 | 3.20±0.23 | 41.92±0.21 | 492.85±0.61 |
| **t-value** | 31.18** | 418.91** | 66.65** | 120.18** | 3.13$^{NS}$ | 145.08** | 16.30** |
| ***Panjiri*** (control) | 4.72±0.01 | 11.27±0.02 | 24.49±0.06 | 1.42±0.01 | 2.17±0.04 | 55.95±0.24 | 489.29±0.84 |
| Acceptable (15%DPF+2%SLP) | 4.91±0.01 | 18.97±0.06 | 26.96±0.02 | 3.86±0.04 | 2.89±0.02 | 42.32±0.08 | 487.82±0.14 |
| **t-value** | 10.52** | 166.13** | 28.65** | 48.31** | 13.07** | 92.49** | 9.94** |
| **Biscuit** (control) | 3.32±0.01 | 12.44±0.31 | 18.91±0.03 | 0.27±0.03 | 0.54±0.01 | 65.84±0.23 | 483.31±0.44 |
| Acceptable (10%DPF+1.5%SLP) | 3.34±0.01 | 17.94±0.02 | 19.35±0.09 | 1.36±0.02 | 1.25±0.02 | 56.90±0.21 | 473.51±0.29 |
| **t-value** | 27.30** | 18.64** | 5.10* | 51.88** | 46.48** | 24.15** | 34.88** |

Values are given as Mean±SE *Significant at 5% level of significance ($p$<0.05)
**Significant at 1% level of significance ($p$<0.01) NS- Non significant
DPF- Partially defatted peanut cake flour FLP- Fenugreek leaf powder SLP- Spinach leaf powder

Significant increase ($p < 0.01$, $p$<0.05) in the fat content was also observed in the products which may be contributed by the oil present in the partially defatted peanut cake flour and also by the fat used for frying in *matthi* and *seviyan*, roasting for *pinni* and *panjiri* and during the mixing of dough for biscuits, *matthi* and *seviyan*. The fat content in the value added products were found to be 20.92, 18.06, 27.05, 26.96 and 19.35 per cent for *matthi, seviyan, pinni, panjiri* and biscuits respectively while the fat content for their control ranged from 16.28 per cent in *seviyan* to 25.11 per cent for *pinni*. Pant (2011) showed higher value of fat content (35 g) for cereal-pulse based *laddo*, the higher content can be due to more addition of fat in recipe of *laddo*. High protein, fat and ash content in *pinni* prepared from the blend of wheat and chickpea flour was reported by Talwar and Brar (2015) in comparison with the nutrient content of *pinni* prepared from wheat flour and *suji* as well as wheat flour alone.

The fiber content for all the value added products increased significantly ($p < 0.01$, $p<0.05$) and ranged from 1.36 to 3.86 per cent. The increase in fiber content can be due to the incorporation of powdered green leafy vegetables in the products. Similar observations were obtained with respect to the total ash content of the value added foods. It increased significantly ($p < 0.01$) in *matthi, seviyan, panjiri* and biscuit whereas differed insignificantly in *pinni*. Increase in ash content can be due to the same reason as for fiber.

A significant decrease ($p < 0.01$) in the carbohydrate content of the products were observed on the addition of partially defatted peanut cake flour and powdered green leafy vegetables. The decrease in carbohydrate content was found to be 57.18 from 65.52 per cent in *matthi*, 51.72 from 62.65 per cent in *seviyan*, 41.92 from 56.01 per cent in *pinni*, 42.32 from 55.95 per cent in *panjiri* and 56.90 from 65.84 per cent in biscuits. The decrease in carbohydrate content may be attributed by the addition of partially defatted peanut cake flour and powdered green leafy vegetables which are low in carbohydrate content and on replacing wheat flour by some amount must have reduced the carbohydrate content. Another reason is the increase in moisture content in the value added products after the incorporation of partially defatted peanut cake flour and powdered green leafy vegetables.

The total energy content of developed value added products increased significantly and ranged from 463.24 per cent in *seviyan* to the highest content of 492.85 per cent in *pinni*. The increase in the energy content can be attributed by the significant increase in protein and fat. A significant increase in the moisture, protein ,fat, ash and energy content with a decrease in carbohydrate content was also observed by Purohit and Rajyalakshmi (2011) when products like l*addoo*, biscuits, extruded products, fryms and chutney were incorporated with defatted groundnut cake flour. Similar observations were also observed in *panjiri* supplemented with soy flour (Salve *et al* 2011). Agarwal and Sharma (2013) noted a significant increase in *matthri* fortified with garden cress seed flour with respect to protein and fat while the difference in other proximate parameters were found to be insignificant. Similar study conducted by Bansal (2013) reported that the proximate composition of *matthri, seviyan, panjiri* and biscuits increased significantly for all proximate parameters except for moisture and ash. Yadav *et al* (2012a) also observed an increase in all parameters except carbohydrate in biscuits incorporated with deoiled peanut cake flour. An increase in all the proximate composition was observed in defatted ground nut and melon kernel flour enriched *Robo* (Osuolale and Olayiwoola 2014).

### 4.2.2 Amino acids content of developed products

An increase in the amino acid concentration was observed on the addition of partially defatted peanut cake flour and powdered green leafy vegetables (GLV) as depicted in Table 4.16. Statistically significant ($p$<0.01) increase in the lysine content of all the products was observed except for s*eviyan*. The highest amino acid profile was observed in *seviyan* except for tryptophan compared to the other products which was due to the use of chickpea flour as the basic ingredient instead of wheat flour in the cereal-pulse mix. The increase in lysine content of the value added products from its control ranged from 445.09 to 540.98 mg/100g for *matthi*, 948.04 to 1016.96 mg/100g cent for *seviyan*, 451.85 to 587.81 mg/100g for *pinni*, 450.17 to 582.21 mg/100g for *panjiri* and 450.21 to 546.03 mg/100g for biscuits. Compared to the 100 per cent cereal biscuits, sorghum-soy and bread wheat-soy 1:1 ratio composite biscuits had at least double the protein content and the lysine content increased by 500-700 per cent (Serrem *et al* 2011). Omwamba and Mahungu (2014) reported a concentration of 88-90 mg per 100g lysine content in protein-rich ready-to-eat extruded snacks from a composite blend of rice, sorghum and soybean flour.

Methionine content among the products was highest for *seviyan* on the addition of partially defatted peanut cake flour and the increase was found to be from 180.30 mg/100g in the control to 204.76 mg/100g in the value added acceptable treatment. It was then followed by *panjiri* (170.94 to 185.96 mg/100g), *pinni* (168.24 to 182.31 mg/100g*)*, biscuit (175.25 to 180.85mg/100g) and *matthi (*158.53 to 177.67mg/100g). Statistically significant increase ($p$<0.01) in the methionine content is due to the addition of defatted peanut cake flour which has a high amino acid and protein profile. Supplementary meals fortified with soybean protein concentrates showed an increase in the amino acid profile (Awadalkareem *et al 2008)*. The authors noticed the highest increase in lysine content (507.73%) and methionine content (176.72%) on an addition of soybean protein concentrate at 22 per cent. Khanam and co workers (2013) also reported that supplementary foods prepared by incorporating soy protein concentrate, whey protein concentrate along with green gram dhal flour to roasted wheat flour increased the methionine content significantly and was more than the recommended pattern given by FAO/WHO for supplementary foods. Biscuits fortified with fish concentrates improved the total amino acid profile that is both essential and nonessential amino acids of the biscuits compared to biscuits prepared with wheat flour alone (Mohamed *et al* 2014).

The tryptophan content of the value added products ranged from 142.08 to 158.58 mg/100g on the addition of partially defatted peanut cake flour. The highest tryptophan content was observed in biscuits (158.58mg/100g) followed by *matthi* (151.26mg/100g), *seviyan* (149.97mg/100g), *panjiri* (147.98mg/100g) and *pinni* (142.08mg/100g). The amino acid content of biscuits supplemented with chickpea flour at 15 to 20 per cent improved the amino acid profile including methionine, lysine and tryptophan along with their protein profile (Youseef, 2015a). Youssef (2015b) also reported that the supplementation of 10 to 15 per cent of wheat bran along with wheat flour in the preparation of biscuits increased the lysine, methionine and tryptophan significantly along with the other amino acids and nutritional parameters.

**Table 4.16: Amino acids content of the developed products**

| Products | Lysine (mg/100g) | Methionine (mg/100g) | Tryptophan(mg/100g) |
|---|---|---|---|
| ***Matthi*** (control) | 445.09±1.10 | 158.53±0.18 | 125.44±0.82 |
| Acceptable (10%DPF+1%FLP) | 540.98±0.69 | 177.67±0.37 | 151.26±0.29 |
| **t-value** | 65.93** | 86.59** | 23.32** |
| ***Seviyan*** **(**control**)** | 948.04±1.17 | 180.30±0.04 | 133.43±0.11 |
| Acceptable (10%DPF+1%FLP) | 1016.96±17.63 | 204.76±0.28 | 149.97±0.27 |
| **t-value** | 4.18 NS | 84.51** | 48.95** |
| ***Pinni*** **(**control**)** | 451.85±0.42 | 168.24±0.32 | 128.47±0.24 |
| Acceptable (15%DPF+2%SLP) | 587.81±0.84 | 182.31±0.34 | 142.08±0.15 |
| **t-value** | 113.46** | 21.29** | 147.78** |
| ***Panjiri*** (control**)** | 450.17±0.49 | 170.94±0.36 | 132.15±0.09 |
| Acceptable (15%DPF+2%SLP) | 582.21±0.65 | 185.96±0.29 | 147.98±0.57 |
| **t-value** | 389.13** | 50.09** | 24.14** |
| **Biscuit (**control**)** | 450.21±0.01 | 175.25±0.03 | 123.56±0.30 |
| Acceptable(10%DPF+1.5%SLP) | 546.03±1.64 | 180.85±0.31 | 158.58±0.07 |
| **t-value** | 58.26** | 19.41** | 115.48** |

Values are given as Mean±SE **Significant at 1% level of significance ($p$<0.01)
DPF- Partially defatted peanut cake flour NS- Non significant
FLP- Fenugreek leaf powder SLP- Spinach leaf powder

### 4.2.3 Mineral and vitamin content of developed products

The products were analysed for minerals like calcium, iron, zinc, phosphorus and vitamins like vitamin C and Beta carotene and the comparison between their control and acceptable treatments are presented in Table 4.17. Significant increase ($p$ < 0.01, $p$<0.05) in the mineral content of the developed products was observed on the addition of partially defatted peanut cake flour and powdered green leafy vegetables like fenugreek leaf and spinach leaf powder compared to its control treatment.

**Table 4.17: Mineral and vitamin content of developed products (#fresh weight basis)**

| Products | Calcium (mg/100g) | Iron (mg/100g) | Zinc (mg/100g) | Phosphorus (mg/100g) | Vitamin C# (mg/100g) | βcarotene (µg/100g) |
|---|---|---|---|---|---|---|
| ***Matthi*** (control) | 24.38±0.06 | 2.52±0.01 | 1.10±0.02 | 122.38±0.72 | 0.24±0.01 | 21.99±0.03 |
| Acceptable(10% DPF+1%FLP) | 29.13±0.10 | 4.18±0.03 | 1.49±0.02 | 132.57±0.30 | 0.12±0.00 | 20.21±0.06 |
| **t-value** | 71.34** | 89.81** | 29.00** | 17.77** | 35.00** | 45.46** |
| ***Seviyan*** (control) | 50.39±0.05 | 3.14±0.03 | 1.33±0.03 | 131.68±0.29 | 0.81±0.01 | 91.73±0.18 |
| Acceptable(10% DPF+1%FLP) | 55.04±0.3 | 4.98±0.03 | 1.59±0.01 | 141.09±0.96 | 0.54±0.02 | 85.79±0.28 |
| **t-value** | 13.01** | 29.86** | 8.67* | 13.88** | 10.00* | 12.99** |
| ***Pinni*** (control) | 44.85±0.42 | 3.02±0.01 | 0.84±0.01 | 184.39±0.57 | 0.46±0.02 | 23.22±0.32 |
| Acceptable(15% DPF+2%SLP) | 50.23±0.01 | 4.86±0.01 | 0.99±0.01 | 191.81±0.26 | 0.20±0.01 | 18.34±0.29 |
| **t-value** | 13.06** | 127.10** | 10.09** | 15.83** | 21.36** | 114.51** |
| ***Panjiri*** (control) | 44.89±0.02 | 3.23±0.06 | 0.76±0.01 | 172.27±0.33 | 0.45±0.00 | 24.73±0.10 |
| Acceptable(15% DPF+2%SLP) | 48.68±0.02 | 4.89±0.02 | 0.93±0.01 | 182.56±0.72 | 0.25±0.02 | 19.44±0.11 |
| **t-value** | 569.00** | 26.05** | 11.93** | 26.14** | 11.72** | 26.06** |
| **Biscuit** (control) | 21.92±0.06 | 1.90±0.04 | 1.05±0.02 | 118.26±1.51 | 0.33±0.01 | 22.31±0.35 |
| Acceptable(10% DPF+1.5%SLP) | 27.98±0.04 | 3.45±0.11 | 1.3±0.02 | 118.43±0.42 | 0.10±0.01 | 18.62±0.32 |
| **t-value** | 22.07** | 113.50** | 104.00** | $0.13^{NS}$ | 15.37** | 11.63** |

Values are given as Mean±SE *Significant at 5% level of significance ($p$<0.05)
**Significant at 1% level of significance ($p$<0.01) NS- Non significant
DPF- Partially defatted peanut cake flour
FLP- Fenugreek leaf powder SLP- Spinach leaf powder

The calcium content increased from 24.38 to 29.13 mg for *matthi*, 50.39 to 55.04 mg in *seviyan*, 44.85 to 50.23 mg in *pinni*, 44.89 to 48.68 mg in *panjiri* and 21.92 to 27.98 mg in biscuits. The higher content of calcium was observed in the fried products than the content in baked biscuits. The iron content of the value added products ranged from 3.45 mg (Biscuits) to 4.98 mg (*seviyan*). *Matthri* when incorporated with dried green leafy powder (Mint, spinach and carrot leaf) was found to have high iron content of 5.37mg (Verma and Jain 2012). Prasad and co workers (2014) reported that the total iron content was found 11.69mg/100g in *paratha* incorporated with fresh green leafy vegetables while the total iron content was found 15.16mg/100g in *laddoo* incorporated with dehydrated green leafy vegetables. Youssef (2015b) also observed an increase in the calcium and iron content when wheat germ was incorporated to biscuits at 15 per cent level.

With respect to the zinc and phosphorous content of the value added products using partially defatted peanut cake flour and powdered green leafy vegetables, the increase was statistically higher when compared to its control treatment. The zinc content of the value added products ranged from 0.93 mg in *panjiri* to 1.59 mg in *seviyan*. The iron and zinc content was found to be the highest for *seviyan* prepared incorporating partially defatted peanut cake flour and green leafy vegetable powder. Phosphorous content was found the lowest in biscuits (118.43mg) and the highest in *pinni* (191.81mg). The cookies prepared by supplementing wheat with 30 per cent groundnut flour showed a high proximate profile with high level of iron and zinc content when compared to wheat biscuits (Madukwe *et al* 2013).

Hence, the increase in the mineral content is contributed by the addition of partially defatted peanut cake flour and powdered green leafy vegetables. Similar trend of increase in minerals like calcium and iron in *matthi, seviyan, panjiri* and biscuits incorporated with different levels of peanut flour were observed by Bansal (2013). In a study conducted by Nailwal (2012), the iron content in *mathi, seviyan* and *ladoo* was reported to be 1.53, 3.40 and 2.98 mg / 100 g with a calcium content of 44.1, 45.7 and 36.7 mg / 100 g for *mathi, seviyan* and *ladoo respectively*. In a study conducted by Salve *et al* (2011) calcium, phosphorus and iron were found to increase on supplementation with 10 per cent skimmed milk powder to *panjiri* prepared using cereal legume mix basically wheat flour, soy flour and chick pea flour in different combinations. Similar findings were also reported by Amegovu *et al* (2014) in supplementary foods.

The vitamin C content for all the value added products decreased significantly on the addition of partially defatted peanut cake flour and powdered green leafy vegetables. This is due to the loss of vitamin C by oxidation during the drying of green leafy vegetables to powder, roasting of peanut flour and the heat cooking process. Among the value added products the highest vitamin C content was observed in *seviyan* (0.54mg) followed by *panjiri* (0.25mg), *pinni* (0.2mg), *matthi* (0.12mg) and the least was found in biscuits (0.10mg). Youssef (2015a and 2015b) reported a vitamin C content of 2.3mg/100g in biscuits made incorporating 15 per cent wheat germ flour and a vitamin C content of 9.2mg/100g in biscuits prepared incorporating 25 per cent chickpea flour.

A significant decrease in the beta carotene content was also recorded in all the products. The beta carotene content ranged from 18.34 µg/100g, the lowest in *pinni* and the highest content being in *seviyan* (85.79 µg/100g) after value addition with partially defatted peanut cake flour. The highest beta carotene content in *seviyan* may be attributed due to the higher concentration of chickpea in it. Sadana *et al* (2008) noticed a considerable increase in the beta carotene content of *seviyan* with other minerals like calcium and iron when fortified with germinated wheat and soybean four. Higher beta carotene content was recorded by Khanam and co workers (2013) on fortifying supplementary foods with soy protein concentrate, whey protein concentrate and green gram dhal flour.

**4.2.4 *In- vitro* protein digestibility of developed products**

The digestibility is an important criterion that determines the availability of physiologically active amino acids and peptides and is affected by processing treatments (Duodu *et al* 2003). A significant ($p < 0.01$) increase in the *in -vitro* protein digestibility was observed in all the value added products prepared using partially defatted peanut cake flour and powdered green leafy vegetables as shown in Table 4.18. The increase is contributed by the addition of partially defatted peanut cake flour. *In- vitro* protein digestibility of raw peanuts was found to be 92.65 per cent (Abdualrahman 2013) while for partially defatted peanut cake flour it was found to be 98.99 per cent (Zhao *et al* 2012). The authors reported that the processing of peanut to flour reduces the antinutritional component which in turn increases *in-vitro* protein digestibility and protein availability.

On the addition of peanut flour in all the products, the *in-vitro* protein digestibility increased from 42.97 to 60.22 per cent for *matthi*, 57.89 to 68.69 per cent for *seviyan*, 44.98 to 80.13 per cent in *pinni*, 43.92 to 75.29 per cent in *panjiri a*nd 43.04 to 66.38 per cent in biscuits. Ayo and co workers (2007) also observed an increasing trend in the *in -vitro* protein digestibility of biscuits when soy flour was incorporated in the biscuits from 0-30 per cent.

The highest *in-vitro* protein digestibility was observed in *pinni* followed by *panjiri* which is because of the higher proportion of partially defatted peanut flour (15%) added to it while for the other products only 10 per cent peanut flour was added. A similar study also revealed that supplementation of soy flour in bakery products increased *the in vitro* protein digestibility (Rani *et al* 2008). The authors reported that the *in-vitro* protein digestibility of bread was 78.10 percent, cake 77.40 per cent and biscuits were 75.05 per cent on supplementation of soy flour. *Chikki* was prepared from peanut was enriched with protein, minerals and vitamins by incorporating soy protein isolate, calcium carbonate, ferrous fumerate, vitamin A and folic acid to meet the growing demand for health foods by Pallavi and co workers (2014). The authors reported a protein digestibility corrected amino acid score of nutra *chikki* was 0.78 whereas that of control *chikki* was 0.73 An increased *in-vitro* protein digestibility with a high amino acid profile in three products that is flake snack, instant beverage, and instant soup prepared using rice flour soybean flour, black sesame seed, and rice bran oil were reported by Satusap *et al* (2014).

**Table 4.18 *In -vitro* protein digestibility of developed products**

| Products | *In- vitro* protein digestibility (%) |
|---|---|
| ***Matthi*** (control) | 42.97±0.69 |
| Acceptable (10%DPF+1%FLP) | 60.22±0.28 |
| **t-value** | 49.49** |
| ***Seviyan*** **(**control**)** | 57.89±0.21 |
| Acceptable (10%DPF+1%FLP) | 68.69±0.05 |
| **t-value** | 66.54** |
| ***Pinni*** **(**control**)** | 44.98±0.03 |
| Acceptable (15%DPF+2%SLP) | 80.13±0.30 |
| **t-value** | 122.82** |
| ***Panjiri*** **(**control**)** | 43.92±0.32 |
| Acceptable (15%DPF+2%SLP) | 75.29±0.32 |
| **t-value** | 49.25** |
| **Biscuit (**control**)** | 43.04±0.43 |
| Acceptable (10%DPF+1.5%SLP) | 66.38±0.07 |
| **t-value** | 64.96** |

Values are given as Mean±SE **Significant at 1% level of significance ($p$<0.01)
DPF- Partially defatted peanut cake flour
FLP- Fenugreek leaf powder SLP- Spinach leaf powder

**4.3 Antinutritional compostion of the developed products**

The antinutritional composition analysed were phytin phosphorous, total phenol, tannin and aflatoxin content of developed products and is presented in Table 4.19. A statistical significant increase was observed in the phytate content of *matthi* (84.04mg/100g), *pinni* (96.03mg/100g), panjiri *(*94.78mg/100g) and biscuits (80.04mg/100g) while the increase in phytate content of *seviyan* was insignificant on value addition. With respect to the tannin content, a significant ($p$<0.01) reduction in the tannin content of the value added products were recorded except in biscuits in which the reduction was insignificant. The phytate contents were increased in complementary foods formulated from the combination of Fermented Popcorn, African Locust and Bambara Groundnut Seed Flour (Ijarotimi and Keshinro 2013). Phytate and tannin content were reported to be in acceptable limits in three complementary test gruels developed by blending sorghum (fermented), soybean (boiled and dehulled) and moderately ripe plantain flour in different ratios (Onoja *et al* 2014). Five nutritious samples of breakfast cereal were produced by mixing the flours (white rice-Soybean composites with graded levels of defatted coconut flour) at increasing ratios were prepared by Ojali and co workers (2015) and reported tannin compositions in a safe limit range.

**Table 4.19: Antinutritional composition of the developed products**

| Products | Phytin Phosphorus (mg/100g) | Total Phenol (mg/100g) | Tannin (mg/100g) |
|---|---|---|---|
| ***Matthi*** (control) | 81.01±1.06 | 89.99±0.04 | 50.91±0.02 |
| Acceptable (10%DPF+1%FLP) | 84.04±0.65 | 92.22±0.03 | 48.92±0.44 |
| **t-value** | 7.07* | 43.46** | 4.58* |
| ***Seviyan*** (control**)** | 89.28±0.33 | 90.26±0.07 | 44.25±0.30 |
| Acceptable (10%DPF+1%FLP) | 90.12±0.02 | 91.85±0.06 | 41.99±0.03 |
| **t-value** | $2.57^{NS}$ | 13.16** | 6.82* |
| ***Pinni*** (control**)** | 93.45±0.13 | 95.91±0.01 | 50.99±0.03 |
| Acceptable (15%DPF+2%SLP) | 96.03±0.03 | 96.80±0.03 | 49.83±0.27 |
| **t-value** | 39.88** | 18.06** | 4.78* |
| ***Panjiri*** (control**)** | 92.88±0.02 | 94.29±0.06 | 50.89±0.56 |
| Acceptable (15%DPF+2%SLP) | 94.78±0.02 | 95.94±0.04 | 46.96±0.22 |
| **t-value** | 22.82** | 58.17** | 10.97** |
| **Biscuit** (control**)** | 78.98±0.03 | 73.90±0.01 | 48.47±0.40 |
| Acceptable (10%DPF+1.5%SLP) | 80.04±0.06 | 75.20±0.02 | 46.94±0.02 |
| **t-value** | 164.55** | 65.00** | $3.64^{NS}$ |

Values are given as Mean±SE  *Significant at 5% level of significance ($p$<0.05)
**Significant at 1% level of significance ($p$<0.01)  NS- Non significant
DPF- Partially defatted peanut cake flour
FLP- Fenugreek leaf powder  SLP- Spinach leaf powder

Total phenols increased significantly ($p$<0.01) in all the products. Highest amount of total phenol content was recorded in *pinni* (96.80mg/100g), followed by *panjiri* (95.94mg/100g) then *matthi* (92.22mg/100g), *seviyan* (91.85mg/100g) and biscuits with 75.20 mg/100g of total phenols. High phytin phosphorus and phenol content in cereal based supplementary foods (Shah 2005). Rani and co workers (2008) observed that bread, cake and biscuits prepared with 15% Soy Flour contained significantly higher phytic acid, polyphenols and trypsin inhibitor activity than control. Their data further indicated that bread contained significantly lower antinutrients than cake and biscuit. Adenike (2013) observed an increase in the total phenol content but lower tannin content in fermented wheat-cowpea supplementary foods. A significant reduction in the tannin content of the value added products were observed except for biscuits. The decrease in tannin content of the products may be due to the deskinning of peanuts during processing of peanut flour.

Aflatoxin was not detected in any of the value added products because of the heat treatments applied to the flour and during the cooking process involved during the product development. Tannins and aflatoxin B1 were not detected in the fresh samples of peanut flour based value added products like fryums, chutney powder, extruded snacks, noodles, biscuits and *laddoo* (Purohit and Rajyalakshmi 2011). Soher *et al* (2013) studied the contamination of peanut samples by aflatoxins as well as in chicken burgers incorporated with deoiled peanut flour. They noticed that aflatoxin G1 (AFG1) was absent in all peanut samples; whereas, trace amounts of aflatoxin G2 (AFG2) was detected and recorded 0.170, 0.905 and 0.760 µg/kg, respectively for three samples out of five of the burger which was contributed by the growth in chicken meat.

**4.4 Impact of storage of developed products in different packaging material**

The most acceptable level of developed value added products using partially defatted peanut cake flour and powdered green leafy vegetables obtained after sensory evaluation was stored in three different packaging materials namely glass container, aluminium zip lock pouch + glass container and plastic zip lock pouch + glass container for a period of three months to check their shelf life. The developed products were subjected to sensory evaluation and microbial evaluation every fortnightly. The nutritional composition of the products were analysed after three months of storage period.

**4.4.1**. **Sensory evaluation of the developed products**

***Matthi***

The mean overall acceptability scores reduced for *matthi* stored in three different packaging materials namely glass containers,  aluminium zip lock pouch + glass container and plastic zip lock pouch + glass container after a period of three months is presented in Table 4.20 and Fig 4.11. For *matthi* stored in glass container, the mean overall acceptability was 7.83 at the beginning of storage which was then found to be 6.40 at the end of three months storage. While for *matthi* stored in aluminium zip lock pouch + glass container and plastic zip lock pouch + glass container, the mean scores reduced drastically to 5.96 and 5.82 respectively at the end of storage period. The reduction of the mean overall acceptability scores of the products may be due to the entry of moisture content during the retrieval of the product for analysis. Kaur and Kochar (2009) reported that *mathri* prepared incorporating dried carrot leaf powder received a score of 5.23 at the end of two months of storage while *matthri* prepared with fresh carrot leaf could not be stored due to its high moisture content.

**Table 4.20: Mean overall acceptability scores of *matthi* after storage in different packaging materials**

| Packaging material | Storage period (Days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0** | **15** | **30** | **45** | **60** | **75** | **90** |
| GC | 7.83 | 7.79 | 7.62 | 7.59 | 7.15 | 6.64 | 6.4 |
| Al + GC | 7.83 | 7.65 | 7.44 | 7.4 | 6.97 | 6.38 | 5.96 |
| P + GC | 7.83 | 7.48 | 7.18 | 6.99 | 6.89 | 5.87 | 5.82 |
| $\chi2$ value | $0^{NS}$ | 14.92** | 21.83** | 23.72** | 16.75** | 24.90** | 22.44** |

Values are Mean scores ** Significant at 1% level of significance ($p$<0.01)
NS- Non significant GC- Glass container
Al + GC- Aluminium zip lock pouch + Glass container
P + GC - Plastic zip lock pouch + Glass container

***Seviyan***

The mean overall acceptability scores of *seviyan* indicated a reduction with an increase in the days of storage in all the packaging materials it was stored in as shown in Table 4.21 and Fig 4.12.

**Table 4.21: Mean overall acceptability scores of *seviyan* after storage in different packaging materials**

| Packaging material | Storage period (Days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **0** | **15** | **30** | **45** | **60** | **75** | **90** |
| GC | 7.82 | 7.74 | 7.61 | 7.40 | 7.38 | 6.80 | 6.51 |
| Al + GC | 7.82 | 7.42 | 7.51 | 7.11 | 7.02 | 6.67 | 6.49 |
| P + GC | 7.82 | 7.24 | 7.05 | 6.50 | 5.98 | 5.83 | 4.81 |
| $\chi2$ value | $0^{NS}$ | 24.67** | 21.83** | 26.22** | 26.22** | 21.42** | 20.24** |

Values are Mean scores ** Significant at 1% level of significance ($p$<0.01)
NS- Non significant GC- Glass container
Al + GC- Aluminium zip lock pouch + Glass container
P + GC - Plastic zip lock pouch + Glass container

*Seviyan* stored in glass containers as well as in aluminium zip lock pouch + glass container was found to be acceptable till 90 days of storage with a mean score of 6.51and 6.49 respectively from a score of 7.82. Gulla and Waghray (2012) indicated a decrease in the sensory scores of extruded products prepared from the blends sesame-rice bran (20:80) and sesame-palmolein (20:80) after one month storage time. *Seviyan* incorporated with 20 per cent cow pea flour when stored up to 90 days in combination film package was found acceptable with a score as high as 7-7.1 when compared to those stored in high density polyethylene (HDPE) (Saurabh *et al* 2013).

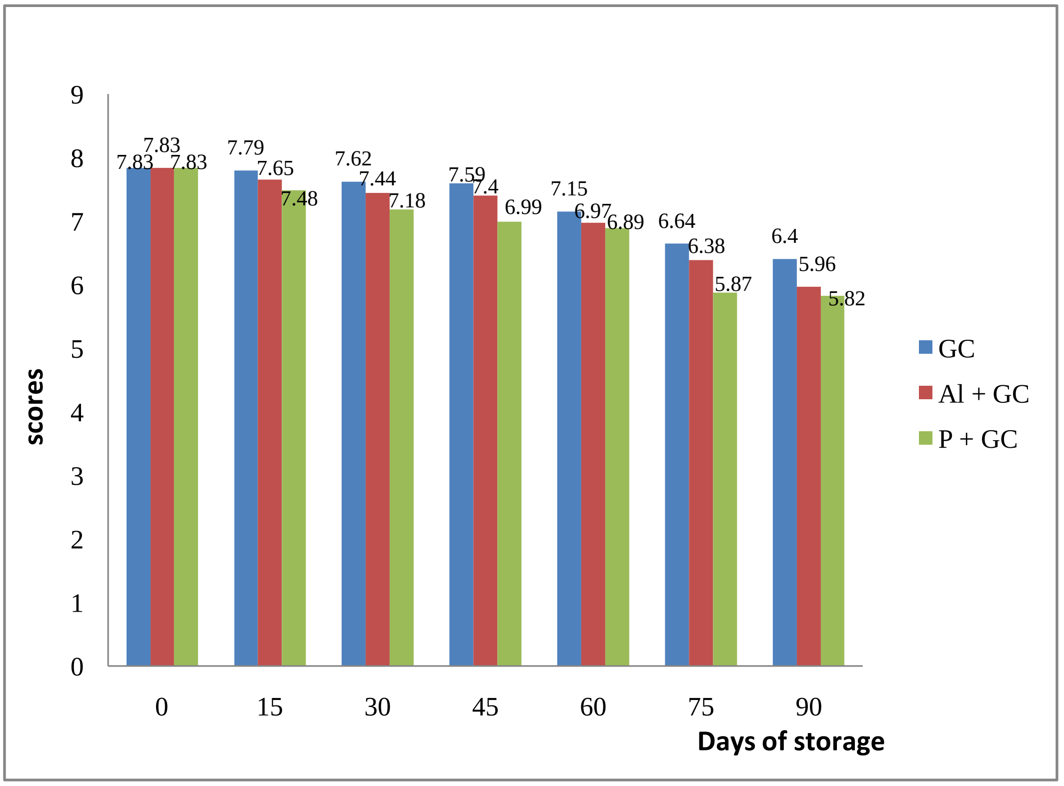


**Fig 4.11 Mean overall acceptability scores for *matthi* after 3 months storage period**

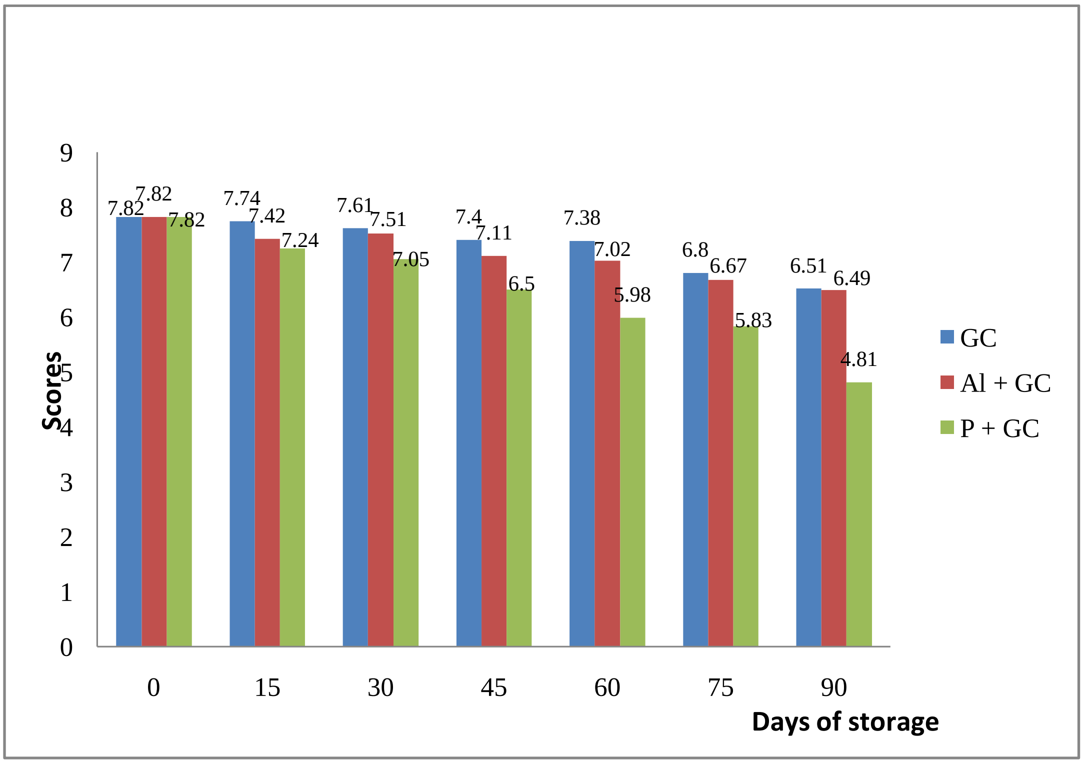


**Fig 4.12 Mean overall acceptability scores for *seviyan* after 3 months storage period**

***Pinni***

The mean overall acceptability scores of *pinni* reduced to 6.39 and 6.42 at the end of storage period for the product stored in glass containers and aluminium zip lock pouch + glass container respectively as indicated in Table 4.22 and Fig 4.13. It was but found acceptable while for *pinn*i stored in plastic zip lock pouch + glass container was found best acceptable till the 60$^{th}$ day of storage (two months) with a mean score of 5.96 and then reduced to 4.37 by the end of the storage period. Srivastava and co workers (2011) also observed similar changes in the overall acceptability of Virgin Coconut Meal *ladoo* samples stored at ambient temperatures in polypropylene (PP, 75 μ) and metallised polyester films. In *Kashi petha*, the overall acceptability score ranged from 7.2-3.2 and *crystallized petha* varied from 7.5-4.6 up to 90 days of refrigerated storage. C*rystallized petha* was considered edible up to 50 days and *Kashi petha* up to 30 days at 4 ± 1 °C which were packed in different materials namely laminated pouch, low density polyethylene, high density polyethylene (Pandey *et al* 2014).

**Table 4.22: Mean overall acceptability scores of *pinni* after storage in different packaging materials**

| Packaging material | Storage period (days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 75 | 90 |
| GC | 7.8 | 7.63 | 7.59 | 7.54 | 7.52 | 6.65 | 6.39 |
| Al + GC | 7.8 | 7.69 | 7.45 | 7.40 | 6.65 | 6.15 | 6.42 |
| P + GC | 7.8 | 7.09 | 6.67 | 6.46 | 5.96 | 5.12 | 4.37 |
| $\chi 2$ value | $0^{NS}$ | 20.46** | 21.34** | 24.38** | 26.13** | 26.03** | 20.09** |

Values are Meanscores **Significant at 1% level of significance ($p$<0.01) NS – Non significant
GC- Glass container Al + GC - Aluminium zip lock pouch + Glass container
P + GC- Plastic zip lock pouch + Glass container

***Panjiri***

As indicated in Table 4.23. and Fig 4.14, *Panjiri* stored in glass container as well as aluminium zip lock pouch + glass container was found to be acceptable till three months of storage period. The initial score of the product was found to be 7.87 which reduced to 6.43, 6.24 and 4.32 at the end of three months of storage when it was stored in glass containers, aluminium zip lock pouch + glass container and plastic zip lock pouch + glass conatiner respectively and was found to be significantly different ($p$ < 0.05). The product stored in plastic zip lock pouch + glass container was found to be best acceptable till the 45$^{th}$ day of storage with a mean overall acceptability score of 6.46 as was observed for *panjiri* stored in. Salve and his co workers (2011) reported that *panjiri* made from wheat flour, soybean flour and chick pea flour obtained a good overall acceptability score in both polyethylene and laminate packaging materials when stored for a period of three months.

**Table 4.23: Mean overall acceptability scores of *panjiri* after storage in different packaging materials**

| Packaging material | Storage period (Days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 75 | 90 |
| GC | 7.87 | 7.77 | 7.23 | 7.33 | 6.96 | 6.61 | 6.43 |
| Al + GC | 7.87 | 7.40 | 7.36 | 7.15 | 6.84 | 6.31 | 6.24 |
| P + GC | 7.87 | 7.23 | 6.72 | 6.50 | 5.92 | 5.29 | 4.32 |
| $\chi 2$ value | $0^{NS}$ | 24.45** | 22.93** | 23.42** | 22.08** | 26.17** | 22.71** |

Values are Mean scores ** Significant at 1% level of significance ($p < 0.01$) NS- Non significant
GC- Glass container Al + GC - Aluminium zip lock pouch + Glass container
P + GC- Plastic zip lock pouch + Glass conatiner

**Biscuits**

The mean overall acceptability score for the value added biscuits are presented in Table 4.24 and Fig 4.15.

**Table 4.24: Mean overall acceptability scores of biscuits after storage in different packaging materials**

| Packaging material | Storage period (Days) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 75 | 90 |
| GC | 8 | 7.85 | 7.69 | 7.63 | 7.51 | 6.93 | 6.91 |
| Al + GC | 8 | 7.84 | 7.62 | 7.26 | 7.35 | 7.01 | 6.58 |
| P + GC | 8 | 7.40 | 7.25 | 7.20 | 6.79 | 6.52 | 5.89 |
| $\chi 2$ value | $0^{NS}$ | 20.00** | 20.59** | 21.72** | 21.38** | 20.92** | 20.93** |

Values are Mean scores ** Significant at 1% level of significance ($p < 0.01$) NS- Non significant
GC- Glass container Al + GC - Aluminium zip lock pouch + Glass container
P + GC - Plastic zip lock pouch + Glass container

The initial score was found to be 8. The biscuits were found to be acceptable till the end of three months storage period. The scores reduced to 6.91, 6.58 and 5.89 for biscuits stored in glass container, aluminium zip lock pouch + glass conatiner and plastic zip lock pouch + glass container respectively at the end of storage period. The biscuits stored in glass container as well as the aluminium zip lock pouch + glass container retained better sensory parameters when compared to the biscuits stored in plastic zip lock pouch + glass conatiner. Purohit and Rajyalakshmi (2011) reported a significant ($p$<0.05) reduction in sensory scores were found for texture and taste (biscuit), taste (fryums), texture (noodles and extruded snacks). However, no significant decrease in the scores was observed for appearance, flavour and overall acceptability in all the products.

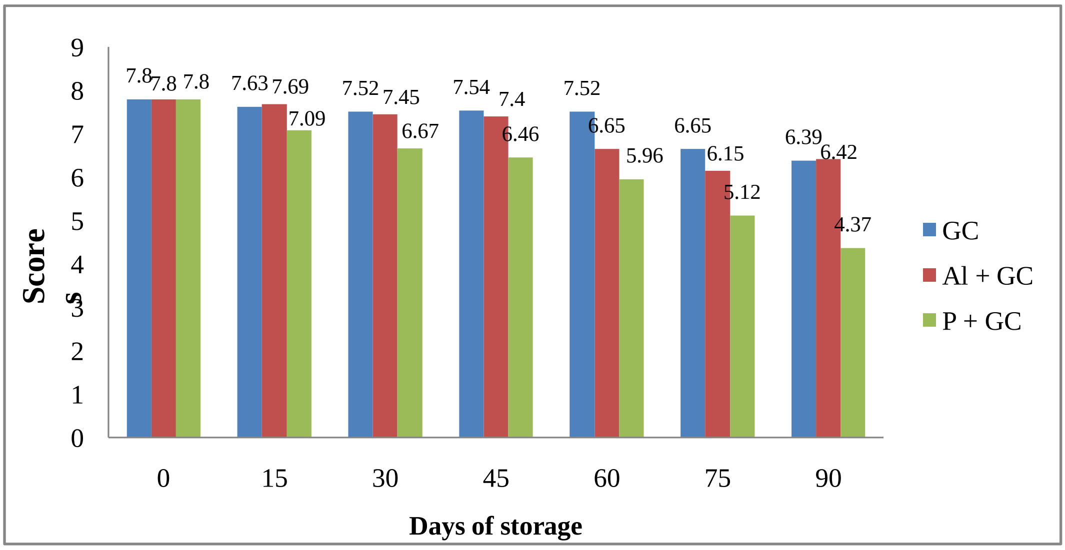


**Fig 4.13: Mean overall acceptability scores for *pinni* after 3 months storage**

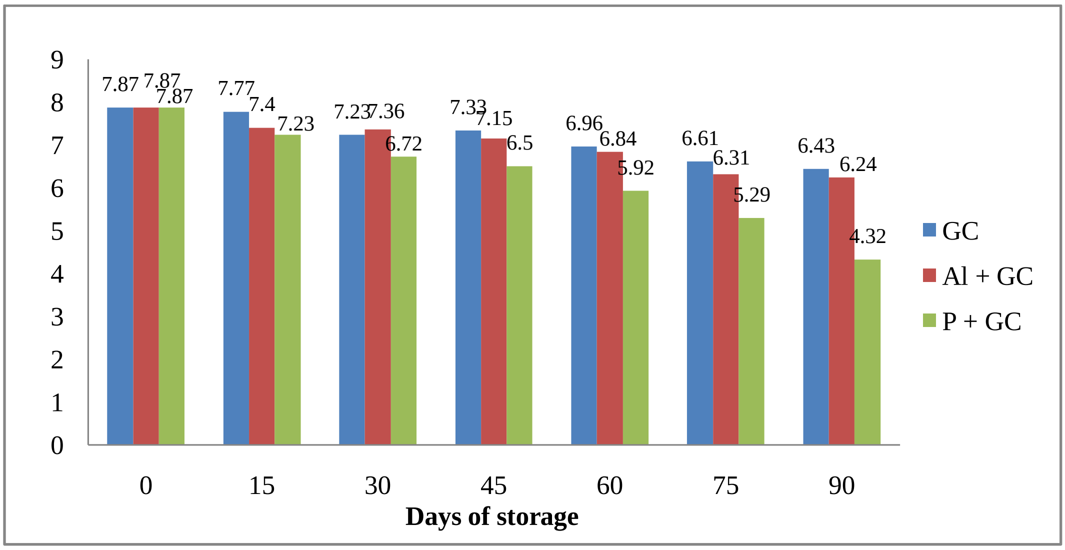


**Fig 4.14: Mean overall acceptability scores for *panjiri* after 3 months storage**

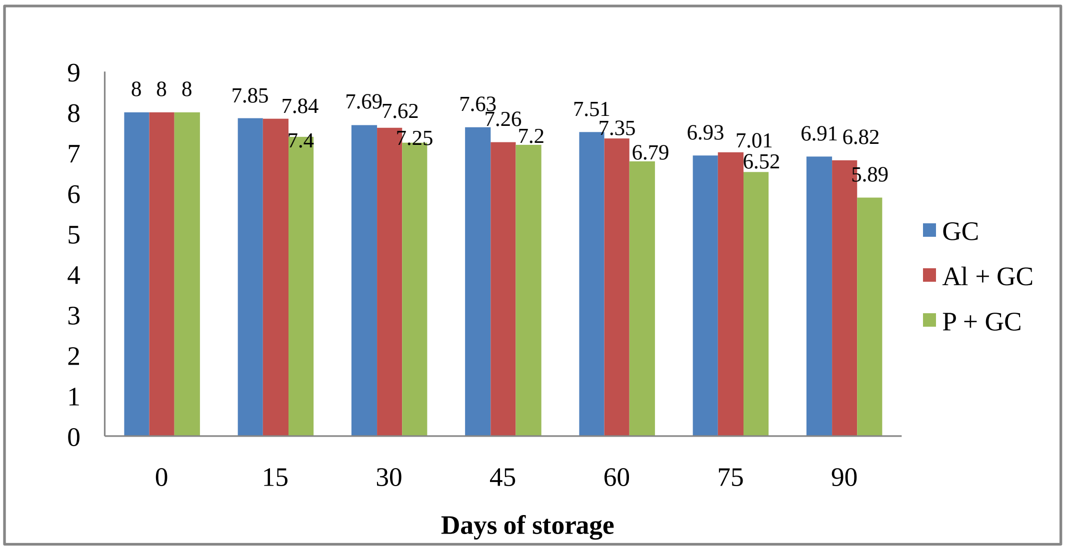


**Fig.4.15: Mean overall acceptability scores of biscuits after 3 months storage**

### 4.4.2 Nutritional Composition of the developed products

#### 4.4.2.1 Proximate Composition of the developed value added products in different packaging materials

***Matthi***

The analysis after a period of three months revealed that crude protein and crude fat showed no significant decrease for *matthi* stored in glass container and aluminium zip lock pouch + glass container while the parameters reduced when stored in plastic zip lock pouch + glass container significantly *(p* <0.05) as presented in Table 4.25.

**Table 4.25: Proximate composition of *matthi* after storage in different packaging material (DW basis)**

| Proximate composition (g / 100 g) | | Packaging Material | | |
|---|---|---|---|---|
| | | **Glass container** | **Aluminium zip lock pouch + Glass container** | **Plastic zip lock pouch + Glass container** |
| Moisture | Fresh | 3.44±0.01 | 3.44±0.01 | 3.44±0.01 |
| | Stored | $3.87^{b}$±0.02 | $3.92^{b}$±0.03 | $4.23^{a}$±0.02 |
| t-value | | 6.82* | 8.74* | 10.94** |
| Crude protein | Fresh | 16.58±0.01 | 16.58±0.01 | 16.58±0.01 |
| | Stored | $16.35^{a}$±0.02 | $16.25^{b}$±0.02 | $15.99^{c}$±0.02 |
| t-value | | $4.33^{NS}$ | $2.65^{NS}$ | 6.95* |
| Crude Fat | Fresh | 20.92±0.04 | 20.92±0.04 | 20.92±0.04 |
| | Stored | $19.61^{a}$±0.02 | $19.66^{a}$±0.02 | $19.20^{b}$±0.03 |
| t-value | | $4.15^{NS}$ | $1.96^{NS}$ | 7.49* |
| Crude Fiber | Fresh | 1.43±0.16 | 1.43±0.16 | 1.43±0.16 |
| | Stored | $1.39^{a}$±0.18 | $1.40^{a}$±0.02 | $1.36^{a}$±0.04 |
| t-value | | $3.20^{NS}$ | $4.28^{NS}$ | $2.91^{NS}$ |
| Total ash | Fresh | 0.88±0.02 | 0.88±0.02 | 0.88±0.02 |
| | Stored | $0.85^{a}$±0.02 | $0.83^{a}$±0.01 | $0.81^{a}$±0.01 |
| t-value | | 10.00* | 8.59* | 10.00* |
| Carbohydrates | Fresh | 57.18±0.06 | 57.18±0.06 | 57.18±0.06 |
| (by differences) | Stored | 57.93±0.02 | 57.94±0.03 | 58.41±0.03 |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p$ < 0.05)
*Significant at 5% level of significance ($p$<0.05)
**Significant at 1% level of significance ($p$<0.01) NS- Non significant

The moisture content for *matthi* stored in the glass container and aluminium zip lock pouch + glass conatiner increased significantly ($p$<0.05) and for those stored in plastic zip lock pouch + glass container at $p<0.01$. Kalra *et al* (1998) also observed an increase in the moisture content from 3.95 per cent to 57.48 per cent in *matthi* after 3 months of storage. Total ash reduced significantly ($p<0.05$) for *matthi* stored in different packaging materials but significant difference was not obtained between the product stored in different materials. Significant difference in the crude fiber content of *matthi* stored in different packaging materials were not observed after a storage period of three months. Significant ($p<0.05$) decrease in the protein and fat content of *matthi* stored in plastic zip lock pouch + glass container was observed.

Better retention of parameters was observed in *matthi* stored in the glass container and aluminium zip lock pouch + glass conatiner. Saha and Dunkwal (2009) also evaluation the shelf life quality with respect to nutritional composition of instant mixes used for the preparation of traditional Indian recipes like *mathri* and *pakoda*. They observed that the mixes stored in 200 gauge polythene retained their nutritional composition but the fatty acid and free fatty acid content increased after 90 days of storage.

***Seviyan***

The effect of storage on the proximate composition of *seviyan* in different packaging materials has been depicted in Table 4.26. Though an increase ($p<0.01$) was observed in the moisture (2.53 to 3.10 per cent) and total ash content of *seviyan* stored in all packaging material, a significant increase ($p<0.05$) was observed for those stored in plastic zip lock pouch + glass conatiner. Reduction in the crude protein and fat content was not statistically significant but better retention was observed for *seviyan* stored in glass container and aluminium zip lock pouch + glass container. Crude fiber showed no significant decrease in *seviyan* after storage. Waghray and Gulla (2010) studied the shelf life of *sev* and *boondi* made incorporating bengal gram flour and butylated hydroxyl anisole as an antioxidant packed in polypropylene cover for four months. They observed an increase in moisture content in *Sev* (2.2% to 3.7%), and in *boondi* (3.3% to 4.1%). Peroxide value of *Sev* (6.6 to 32.7 meq) and *boondi* (8.5 to 33.2 meq) also increased during storage.

Ambient storage behaviour for *sev* packed in two different packaging materials viz. samples packed in high-density polyethylene (HDPE) and the samples stored in combination film (CF) the with atmospheric packaging (APS) was studied by Saurabh *et al* (2013). They found that samples stored in combination film retained most nutrients during the storage when compared to those stored in HDPE. Kumari and Prakash (2009) observed that soy incorporated sorghum based *seviyan* stored in PET (polyethylene terephthalate) container was definitely better than steel, which was attributed to its low moisture and air ingress.

**Table 4.26: Proximate composition of *seviyan* after storage in different packaging material (DW basis)**

| Proximate composition (g / 100 g) | Packaging Material | | |
|---|---|---|---|
| | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| Moisture Fresh | 2.53±0.02 | 2.53±0.02 | 2.53±0.02 |
| Stored | $2.72^{c}$±0.01 | $2.81^{b}$±0.01 | $3.10^{a}$±0.02 |
| t-value | 5.49* | 9.50* | 13.12** |
| Crude protein Fresh | 23.49±0.28 | 23.49±0.28 | 23.49±0.28 |
| Stored | $23.25^{a}$±0.01 | $23.35^{a}$±0.05 | $23.29^{b}$±0.02 |
| t-value | $4.60^{NS}$ | $2.32^{NS}$ | $10.94^{NS}$ |
| Crude Fat Fresh | 18.06±0.03 | 18.06±0.03 | 18.06±0.03 |
| Stored | $17.93^{a}$±0.01 | $17.95^{a}$±0.01 | $17.88^{b}$±0.02 |
| t-value | $4.67^{NS}$ | $3.07^{NS}$ | $13.05^{NS}$ |
| Crude Fiber Fresh | 2.94±0.02 | 2.94±0.02 | 2.94±0.02 |
| Stored | $2.85^{a}$±0.02 | $2.87^{b}$±0.01 | $2.88^{b}$±0.01 |
| t-value | $2.93^{NS}$ | $0.18^{NS}$ | $1.78^{NS}$ |
| Total ash Fresh | 1.79±0.01 | 1.79±0.01 | 1.79±0.01 |
| Stored | $1.73^{a}$±0.01 | $1.75^{ab}$±0.02 | $1.71^{b}$±0.03 |
| t-value | 5.27* | 10.06* | 9.87* |
| Carbohydrates Fresh | 51.72±0.15 | 51.72±0.15 | 51.72±0.15 |
| (by differences) Stored | 51.52±0.01 | 51.27±0.09 | 51.14±0.22 |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p<0.05$) **Significant at 1% level of significance ($p<0.01$)
NS- Non significant

***Pinni***

Results of the proximate composition of value added *pinni* after storage of three months in different packaging materials is shown in Table 4.27.

As was seen for the other products, the moisture content increased significantly ($p < 0.01$) for *pinni* stored in plastic zip lock pouch + glass container from 4.91 to 5.56 per cent as presented in Table 4.27. Significant reduction in the crude protein was observed in plastic zip lock pouch + glass container. Significant reduction in the crude fat content was observed in *pinni* stored in aluminium zip pouch + glass container and in plastic zip pouch + glass container and the reduction was 18.06 to 17.85 per cent and 18.06 to 17.56 per cent respectively. The reduction in the crude fat content of *pinni* after a three month storage period though was significant; the reduction was highest in those stored in plastic zip lock pouch + glass container.

**Table 4.27: Proximate composition of *pinni* after storage in different packaging material (DW basis)**

| Proximate composition (g / 100 g) | Packaging Material | | |
|---|---|---|---|
| | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| Moisture Fresh | 4.91±0.01 | 4.91±0.01 | 4.91±0.01 |
| Stored | 5.11[b]±0.08 | 5.05[b]±0.04 | 5.56[a]±0.11 |
| t-value | 3.76* | 3.12* | 17.90** |
| Crude protein Fresh | 20.18±0.03 | 20.18±0.03 | 20.18±0.03 |
| Stored | 19.98[a]±0.02 | 19.92[b]±0.01 | 19.28[c]±0.02 |
| t-value | 0.99[NS] | 2.38[NS] | 4.55* |
| Crude Fat Fresh | 18.06±0.03 | 18.06±0.03 | 18.06±0.03 |
| Stored | 17.93[a]±0.01 | 17.85[b]±0.15 | 17.56[c]±0.07 |
| t-value | 3.45[NS] | 7.39* | 4.55* |
| Crude Fiber Fresh | 3.84±0.01 | 3.84±0.01 | 3.84±0.01 |
| Stored | 3.77[a]±0.01 | 3.79[a]±0.02 | 3.71[a]±0.04 |
| t-value | 6.24[NS] | 2.96[NS] | 2.11[NS] |
| Total ash Fresh | 3.20±0.23 | 3.20±0.23 | 3.20±0.23 |
| Stored | 3.22[a]±0.01 | 3.19[a]±0.35 | 3.16[a]±0.32 |
| t-value | 0.09[NS] | 1.96[NS] | 3.27[NS] |
| Carbohydrates Fresh | 41.92±0.21 | 41.92±0.21 | 41.92±0.21 |
| (differences) Stored | 49.99±0.03 | 50.20±0.18 | 50.73±0.05 |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p<0.05$) **Significant at 1% level of significance($p<0.01$)
NS- Non significant

Srivastava *et al* (2011) studied the effect of storage on VCM (Virgin coconut meal) based *laddoo*s packed in polypropylene (PP, 75 µ) and metallised polyester (MP, 75 µ) which were heat sealed. The samples were stored under ambient temperature (15°C - 34°C) conditions. After the storage period the samples packed in PP lost moisture and became hard and brittle, while those packed in MP remained soft. Peroxide and thiobarbituric acid values were higher in PP packed samples as compared to those packed in MP.

***Panjiri***

Significant increase ($p$ < 0.05) in the moisture content of *panjiri* stored in glass container and aluminium zip lock pouch + glass container was observed while the increase was even more significant ($p$ < 0.01) for *panjiri* stored in plastic zip lock pouch + glass container as depicted in Table 4.28.

**Table 4.28: Proximate composition of *panjiri* after storage in different packaging material (DW basis)**

| Proximate composition (g / 100 g) | Packaging Material | | |
|---|---|---|---|
| | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| Moisture Fresh | 4.53±0.08 | 4.53±0.08 | 4.53±0.08 |
| Stored | $4.77^{c}$±0.02 | $4.80^{b}$±0.12 | $5.04^{a}$±0.28 |
| t-value | 3.18* | 4.07* | 11.54** |
| Crude protein Fresh | 18.96±0.06 | 18.96±0.06 | 18.96±0.06 |
| Stored | $18.71^{a}$±0.08 | $18.78^{a}$±0.15 | $18.51^{b}$±0.19 |
| t-value | $2.81^{NS}$ | $4.28^{NS}$ | 12.11** |
| Crude Fat Fresh | 26.96±0.02 | 26.96±0.02 | 26.96±0.02 |
| Stored | $26.49^{a}$±0.01 | $26.54^{b}$±0.01 | $26.13^{c}$±0.02 |
| t-value | $1.92^{NS}$ | $1.96^{NS}$ | 5.50* |
| Crude Fiber Fresh | 3.86±0.04 | 3.86±0.04 | 3.86±0.04 |
| Stored | $3.81^{a}$±0.02 | $3.85^{a}$±0.05 | $3.80^{b}$±0.13 |
| t-value | $2.24^{NS}$ | $0.180^{NS}$ | $3.28^{NS}$ |
| Total ash Fresh | 2.89±0.02 | 2.89±0.02 | 2.89±0.02 |
| Stored | $2.83^{a}$±0.01 | $2.80^{a}$±0.12 | $2.75^{b}$±0.09 |
| t-value | 5.50* | 7.39* | 5.94* |
| Carbohydrates Fresh | 42.32±0.08 | 42.32±0.08 | 42.32±0.08 |
| (differences) Stored | 43.39±0.03 | 43.23±0.01 | 43.77±0.06 |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p$ < 0.05)
*Significant at 5% level of significance ($p$<0.05) **Significant at 1% level of significance($p$<0.01)
NS- Non significant

Reduction in the crude protein and fat content of *panjiri* was observed when stored in the different packaging materials but the reduction was not significant in the case of *panjiri* stored glass container as well asaluminium zip lock pouch + glass container. Significant reduction ($p$ < 0.01, $p$ < 0.05) in the crude protein and crude fat content was observed in the products stored in glass container + plastic zip pouch.

Total ash content reduced significantly ($p < 0.05$) for *panjiri* in all the three packaging materials, highest reduction being in the product stored in plastic zip lock pouch + glass container. In the case of crude fiber significant changes were not observed. Shelf life of *Panjiri* stored in polyethylene and laminated pouches for a period of three months were studied by Salve *et al* (2011). They observed that both the materials retained fair nutrient composition of *panjiri* during storage. Higher fatty acid value as well as moisture was observed.

**Biscuits**

The proximate composition of biscuits stored in different packaging materials after a period of three months storage is presented in Table 4.29.The decrease in the values of crude protein and crude fat in the biscuits stored in the different packaging materials were observed to be non significant but the reduction of fat was highest in the biscuits stored in plastic zip lock pouch + glass container. The increase in the moisture content was not significant for biscuits stored in glass container but it was significant ($p<0.05$, $p<0.01$) for the biscuits stored in aluminium lock pouch + glass container and for plastic zip lock pouch + glass container respectively. The values of total ash decreased significantly ($p<0.05$) for biscuits after storage in different packaging materials but no significant difference was observed between the products stored in different packaging materials. No significant changes in the fiber content of the biscuits were noticed after a period of three months storage in different packaging materials.

The proximate composition of the biscuits was significantly affected with respect to moisture and ash when stored in different packaging materials. Insignificant reduction was observed in the crude fiber and crude protein content of the biscuits after storage. Seevaratnam *et al* (2012) observed that moisture and crude fibre content of levels 20 per cent potato flour incorporated biscuits (4.9% and 2.5g/100 g) and control (5.0% and 2.1 g/100g) were almost similar after a period of 3 months storage. There was no rancidity development observed in the formulated biscuits up to 60 days. Nutritional composition namely protein and fat were retained in cookies incorporated with pumpkin seed powder when stored in metallised polyester polyethylene laminated pouches upto one month of storage (Karthiga and Uma 2015). Although the nutritional composition of the biscuits was retained fairly during storage, the moisture content increased considerably. The fatty acid value was minimal.

A significant ($p < 0.01$) increase in values of moisture content was found for all the value added products prepared using partially defatted peanut cake flour and powdered green leafy vegetables when stored in plastic zip lock pouch + glass container. This shows highest permeability of moisture in products stored in plastic zip lock pouch + glass container as compared to glass container and aluminium zip lock pouch + glass container after storage. Other components like crude protein, crude fat, and crude fiber were better retained in glass container and aluminium zip lock pouch + glass container after storage. Preethi and Chimmad (2010) showed that moisture content and protein content of supplementary foods increased and decreased respectively after storage period of 60 days, however no significant change was reported. Mishra *et al* (2014) also observed that during storage, ash; protein and fat content of weaning foods decreased significantly ($p < 0.05$) when stored in plastic container.

**Table 4.29: Proximate composition of biscuits after storage in different packaging material (DW basis)**

| Proximate composition (g / 100 g) | | Packaging Material | | |
|---|---|---|---|---|
| | | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| Moisture | Fresh | 3.83±0.01 | 3.83±0.01 | 3.83±0.01 |
| | Stored | $4.03^{c}$±0.02 | $4.12^{b}$±0.02 | $4.39^{a}$±0.02 |
| t-value | | $1.94^{NS}$ | 8.59* | 11.65** |
| Crude protein | Fresh | 17.94±0.02 | 17.94±0.02 | 17.94±0.02 |
| | Stored | $17.88^{a}$±0.03 | $17.80^{a}$±0.02 | $17.76^{b}$±0.14 |
| t-value | | $2.32^{NS}$ | $1.33^{NS}$ | $3.38^{NS}$ |
| Crude Fat | Fresh | 19.34±0.09 | 19.34±0.09 | 19.34±0.09 |
| | Stored | $19.22^{a}$±0.04 | $19.27^{a}$±0.16 | $19.21^{b}$±0.09 |
| t-value | | $3.78^{NS}$ | $2.32^{NS}$ | $3.30^{*}$ |
| Crude Fiber | Fresh | 1.36±0.02 | 1.36±0.02 | 1.36±0.02 |
| | Stored | $1.29^{a}$±0.01 | $1.30^{a}$±0.01 | $1.25^{a}$±0.02 |
| t-value | | $2.66^{NS}$ | $2.03^{NS}$ | $2.23^{NS}$ |
| Total ash | Fresh | 1.25±0.02 | 1.25±0.02 | 1.25±0.02 |
| | Stored | $1.09^{a}$±0.03 | $1.14^{a}$±0.07 | $1.11^{a}$±0.19 |
| t-value | | 5.94* | 7.30* | 6.92* |
| Carbohydrates | Fresh | 56.90±0.21 | 56.90±0.21 | 56.90±0.21 |
| (differences) | Stored | 56.49±0.01 | 56.37±0.01 | 56.28±0.03 |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p<0.05$) **Significant at 1% level of significance($p<0.01$)
NS- Non significant

#### 4.4.2.2 Amino acid profile of the developed value added products in different packaging materials

The amino acids namely lysine, methionine and tryptophan content were analyzed in the value added products developed incorporating partially defatted peanut cake flour and powdered green leafy vegetables storage period of three months and are presented in Table 4.30. Amino acids decreased in all the developed value added products. With regard to *matthi*, a significant ($p < 0.05$) decrease in lysine as well as tryptophan content was found when stored in plastic zip pouch + glass container after storage. No significant change in lysine, methionine and tryptophan content of *matthi* was found when stored in glass containers while significant decrease($p < 0.05$) the *matthi* stored in aluminium zip lock pouch + glass container and plastic zip pouch + glass container with respect to the methionine content. In case of lysine content of *seviyan*, no significant difference was obtained when stored in glass containers while a significant decrease in the lysine content was observed when the product was stored in aluminium zip lock pouch + glass container as well as plastic zip pouch + glass container. Methionine and tryptophan content of *seviyan* was found to be non significantly changed when stored in glass containers and in aluminium zip lock pouch + glass container but a significant ($p < 0.05$) reduction in the amino acid content was observed when stored in plastic zip pouch + glass container.

In the case of products like *pinni* and *panjiri*, all three amino acids reduced significantly ($p < 0.05$) after three months of storage in glass containers as well as aluminium zip lock pouch + glass container while the reduction in the amino acid content was even more significant ($p < 0.01$) in the products stored in plastic zip pouch + glass container. Lysine content in biscuits stored in all three packaging materials reduced significantly ($p < 0.05$, $p < 0.01$) after three months of storage. No significant reduction in the methionine and tryptophan content was observed when biscuits were stored in glass containers as well as aluminium zip lock pouch + glass container while the content significantly reduced ($p < 0.01$) for biscuits stored in plastic zip pouch + glass container. Elemo and co workers (2011) also observed a decrease in the amino acid profile except for sulphur containing amino acids in weaning foods produced from sorghum and cowpea based on a malted technology after a storage period of five months. After a period of two months storage, a reduction in the lysine content of lysine- fortified noodles were observed by Polpuech *et al* (2011).

**Table 4.30: Amino acid profile of the value added products after storage**

| Amino acids | Lysine (mg/100g) | | | Methionine (mg/100g) | | | Tryptophan (mg/100g) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Products** | **GC** | **Al zip lock pouch + GC** | **Plastic zip pouch + GC** | **GC** | **Al zip lock pouch + GC** | **Plastic zip pouch + GC** | **GC** | **Al zip lock pouch + GC** | **Plastic zip pouch + GC** |
| *Matthi* Fresh | 540.98±0.69 | 540.98±0.69 | 540.98±0.69 | 177.67±0.37 | 177.67±0.37 | 177.67±0.37 | 151.26±0.29 | 151.26±0.29 | 151.26±0.29 |
| Stored | $539.12^{a}$±0.76 | $539.25^{a}$±0.54 | $539.01^{b}$±0.23 | $176.83^{b}$±0.02 | $176.87^{a}$±0.05 | $175.80^{c}$±0.08 | $150.78^{b}$±0.01 | $150.90^{a}$±0.05 | $150.21^{c}$±0.03 |
| t-value | $1.43^{NS}$ | $0.99^{NS}$ | 7.09* | $2.60^{NS}$ | 4.20* | 4.75* | $2.96^{NS}$ | $4.28^{NS}$ | 8.59* |
| *Seviyan* Fresh | 1016.96±0.48 | 1016.96±0.48 | 1016.96±0.48 | 204.76±0.28 | 204.76±0.28 | 204.76±0.28 | 149.97±0.26 | 149.97±0.26 | 149.97±0.26 |
| Stored | $998.09^{a}$±0.30 | $995.78^{a}$±0.06 | $995.32^{b}$±0.20 | $198.78^{b}$±0.16 | $198.88^{a}$±0.09 | $198.50^{c}$±0.12 | $148.60^{b}$±0.06 | $148.68^{a}$±0.08 | $148.12^{c}$±0.15 |
| t-value | $2.65^{NS}$ | 3.43* | 6.68* | $3.09^{NS}$ | $2.98^{NS}$ | 8.88* | $3.23^{NS}$ | $4.28^{NS}$ | 8.55* |
| *Pinni* Fresh | 587.81±0.83 | 587.81±0.83 | 587.81±0.83 | 182.31±0.33 | 182.31±0.33 | 182.31±0.33 | 142.08±0.15 | 142.08±0.15 | 142.08±0.15 |
| Stored | $585.09^{a}$±0.02 | $585.12^{a}$±0.23 | $579.05^{b}$±0.05 | $181.69^{a}$±0.02 | $181.72^{a}$±0.03 | $180.54^{b}$±0.16 | $141.89^{a}$±0.04 | $141.80^{b}$±0.12 | $140.98^{c}$±0.14 |
| t-value | 2.55* | 4.67* | 12.95** | 4.26* | 6.49* | 17.03** | 6.23* | 8.74* | 12.09** |
| *Panjiri* Fresh | 582.21±0.64 | 582.21±0.64 | 582.21±0.64 | 185.96±0.28 | 185.96±0.28 | 185.96±0.28 | 147.98±0.57 | 147.98±0.57 | 147.98±0.57 |
| Stored | $579.11^{a}$±0.06 | $578.90^{a}$±0.15 | $575.01^{b}$±0.53 | $184.55^{b}$±0.02 | $184.60^{a}$±0.18 | $184.00^{c}$±0.35 | $146.66^{b}$±0.24 | $146.78^{a}$±0.22 | $145.07^{c}$±0.30 |
| t-value | 8.59* | 7.65* | 20.00** | 3.97* | 4.68* | 18.02** | 4.75* | 7.37* | 12.16** |
| Biscuit Fresh | 546.03±1.64 | 546.03±1.64 | 546.03±1.64 | 180.84±0.31 | 180.84±0.31 | 180.84±0.31 | 158.58±0.07 | 158.58±0.07 | 158.58±0.07 |
| Stored | $543.89^{a}$±0.09 | $543.77^{a}$±0.10 | $543.37^{b}$±1.09 | $179.82^{a}$±0.02 | $180.12^{a}$±0.07 | $179.09^{b}$±0.10 | $157.80^{b}$±0.02 | $157.98^{a}$±0.02 | $156.67^{c}$±0.01 |
| t-value | 6.91* | 5.43* | 9.01** | $1.93^{NS}$ | $1.43^{NS}$ | 3.98* | $2.88^{NS}$ | $3.91^{NS}$ | 19.50** |

Values are Mean±SE    Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)

*Significant at 5% level of significance ($p<0.05$)    **Significant at 1% level of significance($p<0.01$)
NS- Non significant    GC- Glass Container    Al- Aluminium

#### 4.4.2.3. Mineral and vitamin composition of the developed value added products in different packaging materials

Calcium, iron, zinc, phosphorus, beta carotene and vitamin C content were analyzed for the developed products after storage period of three months. The mineral and vitamin content of developed products decreased during storage period of three months in all the three packaging material. Vitamin C was absent when analysed at the end of storage period which may contributed by oxidation if ascorbic acid during storage.

The micronutrient content of *matthi* is presented in Table 4.31. A significant ($p < 0.05$) decrease in calcium was found in all packaging material after storage.

**Table 4.31: Mineral and vitamin content of *matthi* after storage in different packaging material (#fresh weight basis)**

| Micronutrients (/100g) | | Packaging Materials | | |
|---|---|---|---|---|
| | | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| Calcium(mg) | Fresh | 29.13±0.11 | 29.13±0.11 | 29.13±0.11 |
| | Stored | $25.23^{b}$±0.03 | $25.59^{a}$±0.34 | $20.45^{c}$±0.02 |
| t-value | | 5.21* | 6.93* | 4.18** |
| Iron(mg) | Fresh | 4.18±0.01 | 4.18±0.01 | 4.18±0.01 |
| | Stored | $3.99^{a}$±0.13 | $4.02^{a}$±0.02 | $3.52^{b}$±0.07 |
| t-value | | 8.51* | 5.56* | 2.43* |
| Phosphorus(mg) | Fresh | 132.57±0.30 | 132.57±0.30 | 132.57±0.30 |
| | Stored | $132.23^{b}$±0.23 | $132.45^{a}$±0.33 | $130.12^{c}$±1.20 |
| t-value | | $3.13^{NS}$ | $4.78^{NS}$ | 10.33* |
| Zinc(mg) | Fresh | 1.48±0.02 | 1.48±0.02 | 1.48±0.02 |
| | Stored | $1.47^{a}$±0.01 | $1.45^{a}$±0.02 | $1.39^{b}$±0.03 |
| t-value | | $2.91^{NS}$ | 8.65* | 5.32* |
| Beta Carotene# | Fresh | 20.20±0.10 | 20.20±0.10 | 20.20±0.10 |
| (µg) | Stored | $18.55^{b}$±0.16 | $18.67^{a}$±0.04 | $17.79^{c}$±0.02 |
| t-value | | $5.21^{NS}$ | 8.50* | 17.23** |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p$<0.05) **Significant at 1% level of significance ($p$<0.01)
NS- Non significant

The values of calcium and iron content of *matthi* showed significant ($p < 0.05$) difference in glass container as well as aluminium zip lock pouch + glass container and calcium reduced even more significantly ($p < 0.01$) when stored in plastic zip lock pouch + glass container. Phosphorus and zinc content reduced significantly ($p < 0.05$) for *matthi* when stored in aluminium zip lock pouch + glass conatiner as well as plastic zip lock pouch + glass container except for calcium in aluminium zip lock pouch + glass conatiner. Beta carotene content reduced significantly ($p < 0.05$, $p < 0.01$) when the product was stored in aluminium zip lock pouch + glass conatiner as well as plastic zip lock pouch + glass container.

**Table 4.32: Mineral and vitamin content of *seviyan* after storage in different packaging material (#fresh weight basis)**

| Micronutrients (/100g) | | Packaging Materials | | |
|---|---|---|---|---|
| | | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| Calcium(mg) | Fresh | 55.05±0.34 | 55.05±0.34 | 55.05±0.34 |
| | Stored | $53.17^{a}$±0.03 | $53.25^{a}$±0.21 | $52.18^{b}$±0.08 |
| t-value | | 5.21* | 4.28* | 6.23* |
| Iron(mg) | Fresh | 4.98±0.03 | 4.98±0.03 | 4.98±0.03 |
| | Stored | $4.81^{b}$±0.02 | $4.92^{a}$±0.01 | $4.66^{c}$±0.12 |
| t-value | | $5.43^{NS}$ | $3.23^{NS}$ | 9.12* |
| Phosphorus(mg) | Fresh | 141.09±0.96 | 141.09±0.96 | 141.09±0.96 |
| | Stored | $140.78^{a}$±0.23 | $140.85^{a}$±0.19 | $140.56^{b}$±0.24 |
| t-value | | $3.66^{NS}$ | $2.09^{NS}$ | $4.20^{NS}$ |
| Zinc(mg) | Fresh | 1.59±0.01 | 1.59±0.01 | 1.59±0.01 |
| | Stored | $1.48^{a}$±0.07 | $1.42^{a}$±0.03 | $1.35^{b}$±0.01 |
| t-value | | $5.45^{NS}$ | $3.66^{NS}$ | 6.88* |
| Beta Carotene# | Fresh | 85.79±0.28 | 85.79±0.28 | 85.79±0.28 |
| (µg) | Stored | $85.58^{a}$±0.02 | $85.61^{a}$±0.02 | $85.40^{b}$±0.19 |
| t-value | | $2.66^{NS}$ | $2.45^{NS}$ | 7.45* |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p<0.05$) NS- Non significant

In the case of *seviyan*, calcium content reduced significantly ($p < 0.05$) when the product was stored in all three packaging materials as presented in Table 4.32. The iron, zinc and beta carotene content decreased significantly ($p < 0.05$) when *seviyan* was stored in plastic zip lock pouch + glass container. No significant reduction was observed in the phosphorus content of *seviyan* in all three packaging materials. Among the packaging materials, *matthi* as well as *seviyan* retained better nutrient content in glass containers followed by aluminium zip lock pouch + glass container. Polpuech and co workers (2011) found similar findings for vitamin C and beta carotene content of lysine- fortified noodles which was almost negligible.

The iron as well as phosphorus content of *pinni* (Table 4.33) decreased significantly ($p < 0.05$) when stored in glass container as well as aluminium zip lock pouch + glass container while it reduced significantly ($p < 0.01$) when packed in plastic zip lock pouch + glass container. The calcium content of the product also reduced significantly ($p < 0.05$) in all the packaging materials after storage period.

**Table 4.33: Mineral and vitamin content of *pinni* after storage in different packaging material (#fresh weight basis)**

| Micronutrients (/100g) | | Packaging Materials | | |
|---|---|---|---|---|
| | | **Glass container** | **Aluminium zip lock pouch + Glass container** | **Plastic zip lock pouch + Glass container** |
| Calcium(mg) | Fresh | 50.23±0.01 | 50.23±0.01 | 50.23±0.01 |
| | Stored | $49.16^{a}±0.04$ | $49.32^{a}±0.05$ | $49.09^{b}±0.01$ |
| t-value | | 8.59* | 6.35* | 9.12* |
| Iron(mg) | Fresh | 4.86±0.01 | 4.86±0.01 | 4.86±0.01 |
| | Stored | $4.56^{b}±0.02$ | $4.61^{a}±0.12$ | $3.90^{c}±0.00$ |
| t-value | | 8.56* | 7.45* | 10** |
| Phosphorus(mg) | Fresh | 191.81±0.26 | 191.81±0.26 | 191.81±0.26 |
| | Stored | $182.62^{b}±0.33$ | $182.67^{a}±0.06$ | $181.78^{c}±0.09$ |
| t-value | | 4.78* | 4.52* | 6.78* |
| Zinc(mg) | Fresh | 0.99±0.01 | 0.99±0.01 | 0.99±0.01 |
| | Stored | $0.72^{b}±0.17$ | $0.77^{a}±0.16$ | $0.41^{c}±0.01$ |
| t-value | | $2.93^{NS}$ | $3.45^{NS}$ | 8.12* |
| Beta Carotene# | Fresh | 18.34±0.29 | 18.34±0.29 | 18.34±0.29 |
| (µg) | Stored | $17.54^{b}±0.01$ | $17.61^{a}±0.01$ | $17.56^{c}±0.20$ |
| t-value | | $3.78^{NS}$ | $4.50^{NS}$ | $3.54^{NS}$ |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p<0.05$) **Significant at 1% level of significance($p<0.01$)
NS- Non significant

No significant reduction was observed in the zinc content of *pinni* stored in glass containers as well as aluminium zip lock pouch + glass container, but it significantly reduced in the product stored in plastic zip lock pouch + glass container after three months. The decrease in the beta carotene content was not significant in the products.

In the case of *Panjiri*, calcium and phosphorus content decreased significantly ($p < 0.05$) after it was stored in all three packaging materials. While with regard to the iron, zinc and beta carotene content of the product, significant ($p < 0.05$) reduction was observed only for the product stored in plastic zip pouch + glass container for a period of three months as shown in Table 4.34.

**Table 4.34: Mineral and vitamin content of *panjiri* after storage in different packaging material (#fresh weight basis)**

| Micronutrients (/100g) | | Packaging Materials | | |
|---|---|---|---|---|
| | | **Glass container** | **Aluminium zip lock pouch + Glass container** | **Plastic zip lock pouch + Glass container** |
| Calcium(mg) | Fresh | 48.68±0.02 | 48.68±0.02 | 48.68±0.02 |
| | Stored | $47.93^{a}$±0.04 | $47.91^{b}$±0.05 | $47.56^{c}$±0.02 |
| t-value | | 3.13* | 4.23* | 5.66* |
| Iron(mg) | Fresh | 4.89±0.02 | 4.89±0.02 | 4.89±0.02 |
| | Stored | $3.98^{a}$±0.01 | $4.18^{a}$±0.02 | $3.72^{b}$±0.03 |
| t-value | | $3.91^{NS}$ | $2.61^{NS}$ | 5.23* |
| Phosphorus(mg) | Fresh | 182.56±0.72 | 182.56±0.72 | 182.56±0.72 |
| | Stored | $170.94^{a}$±0.02 | $171.23^{b}$±0.18 | $170.01^{c}$±0.23 |
| t-value | | 4.33* | 5.80* | 7.80* |
| Zinc(mg) | Fresh | 0.93±0.01 | 0.93±0.01 | 0.93±0.01 |
| | Stored | $0.91^{a}$±0.00 | $0.89^{a}$±0.05 | $0.80^{b}$±0.01 |
| t-value | | $4.13^{NS}$ | $5.09^{NS}$ | 5.23* |
| Beta Carotene# | Fresh | 19.44±0.11 | 19.44±0.11 | 19.44±0.12 |
| (µg) | Stored | $19.21^{b}$±0.03 | $19.30^{a}$±0.05 | $19.18^{c}$±0.12 |
| t-value | | $2.88^{NS}$ | $3.67^{NS}$ | 6.23* |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p<0.05$) NS- Non significant

The calcium content of biscuits decreased significantly **(**$p < 0.05$) when the product was stored in glass containers and plastic zip lock pouch + glass container while the decrease was insignificant when the biscuits were stored in aluminium zip lock pouch + glass container as indicated in Table 4.35. Phosphorus and zinc content did not reduce significantly when stored in glass containers as well as aluminium zip lock pouch + glass container but the reduction was significant when stored in plastic zip lock pouch + glass container for a period of three months. Iron as well as beta carotene content reduced significantly ($p < 0.05$) when the product was stored in all three packaging materials for three months.

**Table 4.35: Mineral and vitamin content of biscuits after storage in different packaging material (#fresh weight basis)**

| Micronutrients (/100g) | | Packaging Materials | | |
|---|---|---|---|---|
| | | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| Calcium(mg) | Fresh | 27.97±0.04 | 27.97±0.04 | 27.97±0.04 |
| | Stored | $25.92^{a}$±0.02 | $26.23^{a}$±0.06 | $25.88^{b}$±0.03 |
| t-value | | 5.21* | $3.35^{NS}$ | 6.00* |
| Iron(mg) | Fresh | 3.45±0.11 | 3.45±0.11 | 3.45±0.11 |
| | Stored | $2.77^{b}$±0.02 | $2.89^{a}$±0.02 | $2.51^{c}$±0.09 |
| t-value | | 6.92* | 5.98* | 7.78* |
| Phosphorus(mg) | Fresh | 118.43±0.42 | 118.43±0.42 | 118.43±0.42 |
| | Stored | $111.58^{b}$±1.20 | $112.09^{a}$±0.40 | $110.09^{c}$±0.08 |
| t-value | | $5.34^{NS}$ | $3.76^{NS}$ | 6.23* |
| Zinc(mg) | Fresh | 1.39±0.02 | 1.39±0.02 | 1.39±0.02 |
| | Stored | $1.29^{b}$±0.08 | $1.30^{a}$±0.09 | $1.22^{c}$±0.02 |
| t-value | | $3.13^{NS}$ | $2.80^{NS}$ | 5.43* |
| Beta Carotene# | Fresh | 18.62±0.32 | 18.62±0.32 | 18.62±0.32 |
| (µg) | Stored | $17.89^{a}$±0.01 | $17.80^{a}$±0.08 | $17.62^{b}$±0.00 |
| t-value | | 2.88* | 3.52* | 4.09* |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p < 0.05$)
*Significant at 5% level of significance ($p<0.05$) NS – Non significant

The mineral and vitamin content decreased in all value added products after a storage period of three months. The content was better retained in all the developed products when stored in glass containers and aluminium zip lock pouch + glass container. The mineral as well as vitamin content especially vitamin C of the developed products showed significant difference when stored in plastic zip lock pouch + glass container when compared to glass container and aluminium zip lock pouch + glass container showing a negative relation between increased oxygen permeability of plastic packaging with that of micronutrients after storage. Moreover, increased moisture content in supplementary foods packed in plastic zip lock pouch + glass container as compared to remaining other packaging materials also revealed an effect of moisture on deteriorating calcium, iron and vitamin C content of developed products.

Different studies argues that showed that calcium and vitamin C content of supplementary foods decreased significantly ($p < 0.05$) after storage period of upto two months (Preethi and Chimmad 2010), but contrary to this Kavitha and Parimalavalli (2014) reported a non significant decrease in iron content of weaning food porridge. Elemo and co workers (2011) also observed a reduction in vitamin C and vitamin A content in weaning foods after a period of two months storage. A significant decrease in zinc and calcium content of supplementary foods after storage period of sixty days was reported by different studies (Khan *et al* 2009 and Bassey *et al* 2013). Significant decrease in ash, protein, fat, and ascorbic acid content of supplementary foods was observed with increasing storage period packed in HDPE and LDPE and were stored at ambient temperature (Mishra and Mishra 2014). Elhardallou *et al* (2015) reported significant decrease ($p$ < 0.05) in calcium content and increase in moisture content of supplementary foods formulated from legumes and dates after storage of five months.

**4.4.2.4 *In-vitro* protein digestibility of the developed value added products in different packaging materials**

The *in- vitro* protein digestibility of the developed value added products were analyzed after storage period of three months in different packaging materials and is presented in Table 4.36.

**Table 4.36: *In-vitro* protein digestibility of the developed products after storage in different packaging materials (%)**

| Value added products | | Packaging Materials | | |
|---|---|---|---|---|
| | | Glass container | Aluminium zip lock pouch + Glass container | Plastic zip lock pouch + Glass container |
| *Matthi* | Fresh | 60.22±0.28 | 60.22±0.28 | 60.22±0.28 |
| | Stored | $58.98^{a}$±0.06 | $59.09^{a}$±0.11 | $58.77^{b}$±0.20 |
| t-value | | 4.55* | 8.04* | 8.50* |
| *Seviyan* | Fresh | 68.68±0.05 | 68.68±0.05 | 68.68±0.05 |
| | Stored | $67.66^{b}$±0.02 | $66.98^{a}$±0.03 | $66.80^{c}$±0.07 |
| t-value | | $2.12^{NS}$ | 4.58* | 7.23* |
| *Pinni* | Fresh | 80.13±0.30 | 80.13±0.30 | 80.13±0.30 |
| | Stored | $78.49^{a}$±0.31 | $78.52^{a}$±0.23 | $77.90^{b}$±0.21 |
| t-value | | 5.78* | 6.28* | 8.51** |
| *Panjiri* | Fresh | 75.28±0.32 | 75.28±0.32 | 75.28±0.32 |
| | Stored | $74.78^{a}$±0.01 | $74.65^{a}$±0.22 | $74.20^{b}$±0.08 |
| t-value | | 6.95* | 6.98* | 7.38** |
| Biscuit | Fresh | 66.38±0.07 | 66.38±0.07 | 66.38±0.07 |
| | Stored | $66.14^{a}$±0.03 | $66.09^{ab}$±0.01 | $65.88^{b}$±0.01 |
| t-value | | $2.36^{NS}$ | 7.49* | 8.99** |

Values are Mean±SE Figures with different superscripts –a, b, c are significantly different ($p$ < 0.05)
*Significant at 5% level of significance ($p$<0.05) **Significant at 1% level of significance($p$<0.01)
NS- Non significant

The *in -vitro* protein digestibility decreased in all the developed products after storage period of three months. The *in- vitro* protein digestibility of *matthi* showed significant ($p < 0.05$) decrease when stored in all three packaging materials after three months storage. A significant ($p < 0.05$) difference was found in case of *in-vitro* protein digestibility of *seviyan* stored in aluminium zip lock pouch + glass container as well as plastic zip lock pouch + glass container as compared to those stored in glass containers in which the decrease was not significant.

The *in-vitro* protein digestibility of *pinni* as well as *panjiri* showed significant ($p < 0.05$) decrease in case of products stored in glass containers as well as aluminium zip lock pouch + glass container but the decrease was even more significant ($p < 0.01$) for the products stored in plastic zip lock pouch + glass container. Nicole and co workers (2010) also reported a decrease in the *in-vitro* protein digestibility ready-to-eat composite porridge flours made by Soy-Maize-Sorghum-Wheat when stored in plastic pouches for 6 months. Preethi and Chimmad (2010) showed decrease in *in-vitro* protein digestibility of supplementary foods packed in ordinary zip lock packet after storage period of 45 days.

In the case of biscuits, no significant reduction was observed when it was stored in glass containers whereas the decrease was significant ($p < 0.05$, $p < 0.01$) when the biscuits were stored in aluminium zip lock pouch + glass container and plastic zip lock pouch + glass container respectively. Usman and co workers (2015) also observed a reduction in the *in-vitro* protein digestibility of biscuits produced from wheat flour and maize bran composite flour fortified with carrot extract after a storage period of 45 days. Thus, the *in-vitro* protein digestibility decreased in all the developed products after storage period of three months showing direct effect of storage on the products. Mishra *et al* (2014) reported significant ($p < 0.05$) difference in *in-vitro* protein digestibility in weaning foods stored in plastic container after storage period of sixty days.

**4.4.3 Aflatoxin in the developed products**

Aflatoxins were not detected in any of the samples before and after the storage period. Aflatoxin B1 were not detected in the fresh samples of peanut flour based value added products like fryums, chutney powder, extruded snacks, noodles, biscuits and *laddoo* (Purohit and Rajyalakshmi 2011). Soher *et al* (2013) studied the contamination of peanut samples by aflatoxins as well as in chicken burgers incorporated with deoiled peanut flour. They noticed that aflatoxin G1 (AFG1) was absent in all peanut samples; whereas, trace amounts of aflatoxin G2 (AFG2) was detected and recorded 0.170, 0.905 and 0.760 µg/kg, respectively for three samples out of five of the burger which was contributed by the growth in chicken meat.

**4.4.4 Microbial quality of the value added products**

The five value added products namely *matthi, seviyan, pinni, panjir*i and biscuits developed and stored in three different packaging materials like glass containers, aluminium zip lock pouch + glass container and plastic zip lock pouch + glass container at ($30\pm2^0$C) for a periods of 90 days were of good microbial quality till 60 days of storage. An increase in the total plate count (TPC) and fungal count was observed after 60 days of storage and it increased after 75 and 90 days of storage as presented in Tables 4.37 and 4.38. The counts were lower in those products which were stored in glass container and aluminium zip lock pouch + glass container compared to those stored in plastic zip pouch + glass container. The increase in the total plate count in *matthi* stored in different packaging materials after 75 days of storage was observed to be $1x10^{-4}$ cfu/g in glass container as well as aluminium zip pouch + glass container while it was $3x10^{-4}$cfu/g for *matthi* stored in plastic zip lock pouch + glass container. The count increased to 3 and $5x10^{-4}$ cfu/g after 90 days of storage in for *matthi* stored in glass container, aluminium zip pouch + glass container and plastic zip lock pouch + glass container respectively. The TPC counts ranged from $1\text{-}2x10^{-4}$cfu/g and $2\text{-}5x10^{-4}$cfu/g in s*eviyan* as well as biscuits stored in different packing materials after 75 and 90 days of storage respectively. *Pinni* and *Panjiri* also showed an increase ($2\text{-}6x10^{-4}$cfu/g) after the 75-90 days of storage. The bacterial count was within the limit given by FSSAI (2012) of less than 10000 per gram in all packaging material after storage period of 90 days.

The fungal count increased after 60 days of storage from $1\text{-}7x10^{-5}$cfu/g, $1\text{-}6x10^{-5}$cfu/g and 1-8 $x10^{-5}$cfu/g in *matthi*, *seviyan* as well as biscuits and *pinni* as well as *panjiri* respectively. The increase varied from $3\text{-}7x10^{-5}$ cfu/g in *matthi*, $3\text{-}5x10^{-5}$cfu/g in *seviyan*, 4-$8x10^{-5}$cfu/g in *pinni*, $5\text{-}7x10^{-5}$cfu/g in *panjiri* and $5\text{-}6x10^{-5}$ cfu/g in biscuits stored in different packaging materials after 90 days of storage. The yeast and mould count was within the limit as given by FSSAI (2012) (absent in 0.1 gram of sample). The highest increase in the TPC as well as fungal counts was found for the products stored in plastic zip lock pouch + glass container. However, *E.coli* and *Staphylococcus spp*. were not detected in any of the samples. *Escherichia coli* and *Staphylococcus aureus* counts were detected in chicken burger and chicken burger supplemented with 20 per cent roasted defatted peanut flour (R-DPF) as 5.00 and 6.20 log10 CFU/g respectively) by Soher *et al* (2013); however, only *E coli* was decreased significantly in burger supplemented with 10 per cent unroasted DPF and 20 per cent R-DPF. The authors also observed that the total fungal count decreased in burger supplemented with 10 per cent R-DPF. A decrease was observed in both total bacterial and fungal counts after storage at -20ºC for 60 days. Raja *et al* (2014) observed a significantly ($p$ $< 0.05$) increasing trend in the total plate count (log cfu/g) and yeast and mould count (log cfu/g) for the control as well as treatment samples of fish curls incorporated with corn flour, black gram flour and peanut flour on storage in LDPE pouches. Coliform counts (log cfu/g) were not detected until day 28 in all the products. The mean values for all the quality as well as the storage parameters were in the acceptable limits up to the day 21 of the storage.

**Table 4.37: Total plate count of developed products in different packaging materials after storage ($10^{-4}$cfu/g)**

| Developed products | Days | Packaging material | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Glass container | | | | | | Aluminium zip lock pouch + Glass container | | | | | | Plastic zip lock pouch + Glass container | | | | | |
| | **Fresh** | **15** | **30** | **45** | **60** | **75** | **90** | **15** | **30** | **45** | **60** | **75** | **90** | **15** | **30** | **45** | **60** | **75** | **90** |
| *Matthi* | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 3 | 5 |
| *Seviyan* | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 5 |
| *Pinni* | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 3 | 6 |
| *Panjiri* | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 3 | 6 |
| Biscuits | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 5 |

**Table 4.38. Yeast and mold count of developed products in different packaging materials after storage ($10^{-5}$cfu/g)**

| Developed products | Days | Packaging material | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Glass container | | | | | | Aluminium zip lock pouch + Glass container | | | | | | Plastic zip lock pouch + Glass container | | | | | |
| | **Fresh** | **15** | **30** | **45** | **60** | **75** | **90** | **15** | **30** | **45** | **60** | **75** | **90** | **15** | **30** | **45** | **60** | **75** | **90** |
| *Matthi* | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 2 | 4 | 0 | 0 | 0 | 2 | 3 | 7 |
| *Seviyan* | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 3 | 5 |
| *Pinni* | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 0 | 0 | 0 | 2 | 2 | 4 | 0 | 0 | 0 | 2 | 2 | 8 |
| *Panjiri* | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 0 | 0 | 0 | 2 | 3 | 6 | 0 | 0 | 0 | 2 | 3 | 7 |
| Biscuits | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 1 | 2 | 6 | 0 | 0 | 0 | 1 | 3 | 6 |

### 4.5 General information of preschool children and their mothers

To assess the nutritional status of preschool children a total sample of 110 preschool children were selected from four ICDS centers located in Ludhiana city and were divided into four groups. The group I, group II, group III and group IV consisted of 32, 28, 23 and 27 preschool children respectively.

The general information included socioeconomic status of households of selected preschool children and general profile of selected preschool children.

#### 4.5.1 Socioeconomic information of the households

The socioeconomic information of households of selected preschool children is presented in Table 4.39. The data revealed that majority of households in each group i.e. 56.25, 57.14, 78.26 and 74.07 per cent from group I, II, III and IV respectively belonged to nuclear family systems.

**Table 4.39: Socioeconomic profile of the households**

| Characteristics | | Frequency (%age) | | | |
|---|---|---|---|---|---|
| | Group 1 (n1=32) | Group 2 (n2=28) | Group 3 (n3=23) | Group 4 (n4= 27) | Overall (n=110) |
| **Type of family** | | | | | |
| Nuclear | 18 (56.25) | 16 (57.14) | 18 (78.26) | 20 (74.07) | 72 (65.45) |
| Joint | 14 (43.75) | 12 (42.86) | 5 (21.74) | 7 (25.93) | 38 (34.55) |
| **Composition of family** | | | | | |
| Small (upto 4) | 22 (68.75) | 19 (67.86) | 16 (69.57) | 21 (77.78) | 78 (70.91) |
| Medium (5-8) | 10 (31.25) | 9 (32.14) | 7 (30.43) | 6 (22.22) | 32 (29.09) |
| **Land holding** | | | | | |
| Yes | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| No | 32 (100) | 28 (100) | 23 (100) | 27 (100) | 110 (100) |
| **Total monthly income (Rs.)** | | | | | |
| Less than 7000 | 25 (78.13) | 12 (42.86) | 18 (78.26) | 15 (55.56) | 70 (63.64) |
| 7000-10,000 | 7 (21.87) | 16 (57.14) | 5 (21.74) | 12 (44.44) | 40 (36.36) |

Figures in parenthesis are in percentage

Only 38 subjects of the total 110 subjects belonged to joint family type. With regard to the composition of family, 78 households of the total (70.91%) had a small family composition that is up to 4 members while 32 households (29.09%) belonged to medium i. e.

almost 5-8 member family groups. The households of selected preschool children were mainly involved in labour work and were mainly migrated population to Punjab from other states so none of the households in each of the four groups had land holdings. Ghate (2014) reported that 92.33 per cent of preschool malnourished children's parents in Ethiopia were engaged as labourers, 3.67 per cent were Artisan, and where as 4 per cent were engaged in service only.

Almost 78.13 per cent of the families from group I, 42.86 per cent of group II, 78.26 per cent of group III and 55.56 per cent from group IV had a monthly income less than Rs. 7000. From the total number of households, 36.36 per cent had a monthly income between Rs.7000-10,000 i.e. 7, 16, 5 and 12 households from group I, II, III and IV respectively. Vinod *et al* (2011) conducted a survey on the socioeconomic status of the families of malnourished children under age 5 in the urban slums of Nagpur and found that majority of children' family were having per-capita monthly income less than rupees 900 i.e. 59.4 percent had per-capita monthly income between Rupees 450- 899 and 28.0 percent had less than rupees 450. Ghate (2014) also reported that all the household respondents belonged to lower socio economic status. From the respondents surveyed, 28.33 per cent of the children belonged to economical weaker section [EWS], 65.67 per cent belonged to lower income group [LIG], 6 per cent of the children belonged to middle income group [MIG].

**4.5.2 General Information of preschool children**

Out of the 110 preschool children, 12 (10.91%) belonged to the age group 2-3years, 50 (45.45%) belonged to 3-4 years age group and 48 (43.64%) belonged to the age group of 4-5 years as indicated in Table 4.40. In group I and II most of the children were between 4-5 years of age while most of the respondents from group III and IV were between the age 3-4 years. With respect to the sex of the child, 60 (54.55%) were males and 50 (45.45%) were females that is 18, 13, 12 and 17 number of respondents were males and 14, 15, 11 and 10 respondents were females from group I, II, III and IV respectively.

Majority of the preschool children, 34.36, 35.71, 30.43 and 33.33 per cent from group I, II, III and IV respectively were at the second position with respect to their birth order followed by 28.14, 28.57, 30.44 and 29.63 per cent of the children from group I to IV was at the third position. Jyothi and co workers (2003) reported that the proportion children with normal weight for age reduced by two-fold when the birth order increased from one to above three in 205 children surveyed from the rural areas of Mysore city.

With respect to their food habits, from group I, 14 (43.75%) were ovatarians followed by vegetarians (31.25%) and 8 (25%) were non-vegetarians. While in group II, 50 per cent were non-vegetarians, 28.57 per cent were ovatarians and rests (21.43%) were vegetarians. While in group III, Most of the respondents were vegetarians (52.17%) followed by 26.09 per cent were ovatarians. Almost 48.14 per cent of the children were ovatarians from group IV followed by vegetarians and non-vegetarians. Dietary information of about malnourished children in Ethiopia revealed that all of the respondents were non vegetarian and yet they rarely consumed non vegetarian foods i.e. 21.66 per cent of the households families consumed non – vegetarians foods once a month, where as 78.33 % consumed non vegetarian foods after two months only (Ghate 2014).

**Table 4.40: General information of the preschool children**

| Characteristics | Frequency (%age) | | | | |
|---|---|---|---|---|---|
| | **Group 1 (n1=32)** | **Group 2 (n2=28)** | **Group 3 (n3=23)** | **Group 4 (n4= 27)** | **Overall (n=110)** |
| **Age (years)** | | | | | |
| 2 – 3 | 5 (15.62) | 3 (10.71) | 4 (17.39) | 0 (0) | 12 (10.91) |
| 3 – 4 | 13 (40.63) | 12 (42.46) | 11 (47.83) | 14 (51.85) | 50 (45.45) |
| 4 – 5 | 14 (43.75) | 13 (46.43) | 8 (34.78) | 13 (48.15) | 48 (43.64) |
| **Sex** | | | | | |
| Male | 18 (56.25) | 13 (46.43) | 12 (52.17) | 17 (62.96) | 60 (54.55) |
| Female | 14 (43.75) | 15 (53.57) | 11 (47.83) | 10 (37.04) | 50 (45.45) |
| **Birth order** | | | | | |
| 1 | 8 (25.00) | 6 (21.43) | 5 (21.74) | 7(25.93) | 26 (23.64) |
| 2 | 11 (34.36) | 10 (35.71) | 7 (30.43) | 9 (33.33) | 37 (33.64) |
| 3 | 9 (28.14) | 8 (28.57) | 7 (30.44) | 8 (29.63) | 32 (29.09) |
| >3 | 4 (12.50) | 4 (14.29) | 4 (17.39) | 3 (11.11) | 15 (13.64) |
| **Food habits** | | | | | |
| Vegetarian | 10 (31.25) | 6 (21.43) | 12 (52.17) | 7 (25.93) | 35 (31.82) |
| Non vegetarian | 8 (25.00) | 14 (50.00) | 5 (21.74) | 7 (25.93) | 34 (30.91) |
| Ovatarian | 14 (43.75) | 8 (28.57) | 6 (26.09) | 13 (48.14) | 41 (37.27) |
| **Breast feeding pattern** | | | | | |
| Upto 6 months (exclusive) | 24 (75.00) | 15 (53.57) | 17 (73.91) | 14 (51.85) | 70 (63.64) |
| < 6 months | 8 (25.00) | 10 (35.71) | 6 (26.09) | 9 (33.33) | 33 (30.00) |
| > 6 months | 0 (0) | 3 (10.72) | 0 (0) | 4 (14.82) | 7 (6.36) |

Figures in parenthesis are in percentage

Most of the children, 75, 53.57, 73.91 and 51.85 per cent from group I, II, III and IV respectively were exclusively breast fed up to six months of age. About 10.72 per cent of children from group II and 14.82 per cent of children from group IV were breast fed for more than six months. While the rest 25 per cent from group I, 35.71 per cent from group II, 26.69 per cent from group III and 33.33 from group IV were breast fed for less than 6 months. While Patel *et al* (2010), out of 34 severely malnourished children, 5 (14%) children were exclusively breastfed for 6 months, and around two-third were bottle-fed. Akorede and Abiola (2013) revealed from their study that mothers' education affected the health status of the children which were 81.8 per cent of the mothers with no education and did not give colostrum to their children, 16.7 per cent of the mothers exclusively breastfed and majority (60.0%) of those that did not exclusively breastfeed had little or no education. Anuradha *et al* (2014) observed that out of 404 children, 37 children's mother did not fed colostrums to their children. The main reason for not giving colostrum was advised by grandmother of the baby. Breast feeding was given to 100 percent children. In general mothers fed breast milk to their children up to 1 to 2 years of age. Only 3 children's mother breast-fed till the age of 3 years.

**4.5.3 General information of the mothers of preschool children**

As depicted in Table 4.41, majority of mothers (54.55 %) of total sampled preschool children were in the age group of 25 - 30 years. The age group of remaining 39.09 and 6.36 per cent mothers of selected preschool children was 20 – 25 and 30 – 35 years respectively. Wong and co workers (2014) reported that the mothers of 274 malnourished children in Malaysia were between the age 30-35. About 43.64 per cent of the mothers from the total were illiterate followed by 36.36 per cent who received primary education that is up to 4$^{th}$ and 5$^{th}$ standard and only 20 per cent were educated up to 8$^{th}$ standard (higher secondary). Most of the mothers of the selected school children had to drop school because of low income in the family and had to start working at very small age. A study conducted by Algur *et al* (2012) observed that approximately 34 per cent of the mothers of under five children were illiterate and the families belong to lower middle class of socioeconomic classes. Ghate (2014) also observed similar trend in the educational qualification of mothers whose children were surveyed it was found that 40.66 per cent of mothers were illiterate, whereas 3.67 per cent were educated up to Higher Secondary School or 12 grade. Wong and co workers (2014) reported that most of the mothers of the malnourished respondent were educated up to secondary level. Jesmin *et al* (2011) observed that fathers were more educated than mothers of preschool children surveyed in Dhaka city, Bangladesh. The authors reported that about 54 per cent of fathers (n=204) had at least 15 years of schooling whereas only 37 per cent of the mothers had the same level of education. The majority (51.6%) of the fathers spent more than two hours at home each day with their children. Family education of 57 per cent of the respondents was recorded as below the medium level, with only 12.1 per cent in the highest category.

**Table 4.41: General information of the mothers of preschool children**

| Characteristics | Frequency (%age) | | | | |
|---|---|---|---|---|---|
| | **Group 1 (n1=32)** | **Group 2 (n2=28)** | **Group 3 (n3=23)** | **Group 4 (n4= 27)** | **Overall (n=110)** |
| **Age of mothers** | | | | | |
| 20-25 | 7 (21.88) | 5 (17.86) | 16 (69.57) | 15 (55.56) | 43 (39.09) |
| 25-30 | 25 (78.12) | 20 (71.43) | 7 (30.43) | 8 (29.63) | 60 (54.55) |
| 30-35 | 0 | 3 (10.71) | 0 (0) | 4 (14.81) | 7 (6.36) |
| **Education** | | | | | |
| Illiterate | 21 (65.62) | 12 (42.86) | 5 (21.74) | 10 (37.04) | 48 (43.64) |
| Primary | 5 (15.63) | 14 (50.00) | 10 (43.48) | 11 (40.74) | 40 (36.36) |
| Higher secondary | 6 (18.75) | 2(7.14) | 8 (34.78) | 6 (22.22) | 22 (20.00) |
| **Spacing between children (years)** | | | | | |
| 1 | 12 (37.50) | 8 (28.57) | 10 (43.48) | 9 (33.33) | 39 (35.45) |
| 2 | 15 (46.88) | 8 (28.57) | 9 (39.13) | 11 (40.74) | 43 (39.09) |
| 3 | 5 (15.62) | 10 (35.72) | 3 (13.04) | 5 (18.52) | 23 (20.91) |
| >3 | 0 (0) | 2 (7.14) | 1 (4.35) | 2 (7.41) | 5 (4.55) |

Figures in parenthesis are in percentage

A minimum of three years of spacing is essential between pregnancies for health benefits of both mother and children. On the basis of the information on birth spacing, it was observed that majority of 39.09 per cent of mothers of total sampled subjects had birth gap of 2 years between subsequent pregnancies. The required birth gap of 3 and more than 3 years was found for 20.91 and 4.55 per cent of mothers of total sampled preschool children respectively. About 35.45 per cent of mothers reported spacing of 1 year between subsequent pregnancies. The 1 and 2 years gap between pregnancies were accounted for accidental pregnancies and non availability of required information about spacing between children to the mothers. Moreover, it was also found that spacing of 2 or less than 3 years is more common between first and second pregnancy as compared to later pregnancies. Mwangome and co workers (2010) conducted a study in women of rural areas of Ghambia and reported that the women were not involved in decision-making on issues of marriage, child-bearing, and child-spacing which were out of their domain, although these affect them. Such decisions in many households in this community are either strongly influenced or are made solely by men.

**4.6 Ecological profile of the preschool children**

Ecological profile of the households is an important determinant of the nutritional status of preschool children as it has an influence on hygiene and sanitary environment in which the child lives. The data regarding ecological profile of households has been furnished in Table 4.42.

**Table 4.42: Ecological profile of the preschool children**

| Facilities | Frequency (%age) | | | | |
|---|---|---|---|---|---|
| | **Group 1 (n1=32)** | **Group 2 (n2=28)** | **Group 3 (n3=23)** | **Group 4 (n4= 27)** | **Overall (n=110)** |
| **Water supply** | | | | | |
| Tap water | 25 (78.13) | 20 (71.43) | 23 (100) | 26 (96.30) | 94 (85.45) |
| Hand pump | 7 (21.87) | 8 (28.57) | 0 (0) | 1 (3.70) | 16 (14.55) |
| **Disposal of refuse** | | | | | |
| Garbage containers | 29 (90.63) | 23 (82.14) | 23 (100) | 25 (92.59) | 100 (90.91) |
| Open | 3 (9.37) | 5 (17.86) | 0 (0) | 2 (7.41) | 10 (9.09) |
| **Toilet facility** | | | | | |
| Community | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Flush | 32 (100) | 28 (100) | 23 (100) | 27 (100) | 110 (100) |
| Dry latrine | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| **Drainage** | | | | | |
| Under ground | 32 (100) | 24 (85.71) | 23 (100) | 26 (96.30) | 105 (95.45) |
| Open | 0 (0) | 4 (14.29) | 0 (0) | 1(3.70) | 5 (4.55) |
| **Type of house** | | | | | |
| Semi *pucca* | 15 (46.87) | 16 (57.14) | 12 (52.17) | 12 (44.44) | 55 (50.00) |
| *Pucca* | 17 (53.13) | 12 (42.86) | 11 (47.83) | 15 (55.56) | 55 (50.00) |
| **Street drainage** | | | | | |
| Covered | 29 (90.63) | 28 (100) | 23 (100) | 22 (81.48) | 102 (92.73) |
| Uncovered | 3 (9.37) | 0 (0) | 0 (0) | 5 (18.52) | 8 (7.27) |

Figures in parenthesis are in percentage

The main source of water in all of the households in each of the four groups (85.45%) was tap water supply provided by municipality. While Chandran (2009) when studying the determinant of poor nutritional status of preschool children in rural areas of Kasargod district in Kerala, observed that Private well was the main source of water for 67 percent of families of preschool children. At the same time, 16.5 percent of families depends on neighboured well, 12.5 percent on public tap and 2.8 percent on public well. Garbage containers were provided to the locality of most households for disposal of wastes in case of subjects of all four groups.

All of the households of selected subjects had flush toilets none of the members of household were involved in open defecation. Underground drainage channels were built in the locality of 95.45 per cent of the households of selected subjects while 4.55 per cent had open drainage system for water removal. Most street drainages were covered. Chandran (2009) also reported that drainage facilities were also found to be lacking in 91.5 percent of families.

Half of the households had semi *pucca* with the floors of few rooms and outside courtyard were not built, whereas the other half of the selected preschool children had *pucca* houses. It was found that public facilities provided by municipality in the locality of households of selected subjects were adequate.

Jyothi *et al* (2003) reported that among the families of malnourished children under 5 surveyed in the rural areas of Karnataka, 91 per cent lived in tiled houses and only 9 per cent lived in reinforced cement constructed houses provided by the Government under the 'Janatha housing scheme'. Only 39 per cent had concrete flooring while rest of the houses had mud flooring. Around 20 per cent had only one room in the house for all purpose and only 42 per cent had separate bathrooms.

**4.7 General health and hygienic status of preschool children**

The data pertaining to the general health and hygiene status of preschool children has been presented in Table 4.43. The health profile of selected preschool children related to co morbidities revealed that majority of total sampled subjects (96.36 %) had cough and cold in past six months. About 56.36 per cent subjects reported diarrheal infection in past 6 months. Only 2.73 and 3.64 per cent of total sampled preschool children reported typhoid and jaundice respectively as related co morbidity in past six months. Some (5.45 %) of the preschool children suffered from other diseases like allergy, infections and lactose intolerance as related co morbidity specified as any other. All the subjects were vaccinated. Algur *et al* (2012) also reported that more than 85 per cent children under five at Kallalgali district were immunized. While Banteman *et al* (2014) reported most of the subjects under five years in a community of Northwest Ethiopia were not immunized for BCG and suffered from frequent diarrhea, fever and measles due to poor environment and sanitation. The authors also concluded that these made the subjects malnourished along with poor dietary intake and poor access to safe drinking water.

**Table 4.43: General health and hygiene status of the preschool children**

| Facilities | Frequency (%age) | | | | |
|---|---|---|---|---|---|
| | **Group 1 (n1=32)** | **Group 2 (n2=28)** | **Group 3 (n3=23)** | **Group 4 (n4= 27)** | **Overall (n=110)** |
| **Health profile** | | | | | |
| **Co morbidities during past six months*** | | | | | |
| Typhoid | 2 (6.25) | 0 (0) | 1 (4.35) | 0 (0) | 3 (2.73) |
| Diarrhea | 12 (37.50) | 19 (67.86) | 15 (65.22) | 16 (59.26) | 62 (56.36) |
| Cough and cold | 30 (93.75) | 28 (100) | 23 (100) | 25 (92.59) | 106 (96.36) |
| Jaundice | 3 (9.38) | 1 (3.57) | 0 (0) | 0 (0) | 4 (3.64) |
| Any other | 4 (12.50) | 1 (3.57) | 1 (4.35) | 0 (0) | 6 (5.45) |
| **Vaccination** | 32 (100) | 28 (100) | 23 (100) | 27 (100) | 110 (100) |
| **Hygiene profile** | | | | | |
| **Cleanliness of hands** | | | | | |
| Clean | 29 (90.62) | 23 (82.14) | 18 (78.26) | 27 (100) | 97 (88.18) |
| Dirty | 3 (9.38) | 5 (17.86) | 5 (21.74) | 0 (0) | 13 (11.82) |
| **Changing clothes** | | | | | |
| Twice a day | 12 (37.50) | 5 (17.86) | 6 (26.09) | 20 (74.07) | 43 (39.09) |
| Daily | 20 (62.50) | 23 (82.14) | 17 (73.91) | 7 (25.93) | 67 (60.91) |
| **Brushing teeth** | | | | | |
| Daily | 32 (100) | 28 (100) | 23 (100) | 27 (100) | 110 (100) |
| Twice daily | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| **Bathing during summer** | | | | | |
| Daily | 30 (93.75) | 18 (64.29) | 12 (52.17) | 12 (44.44) | 72 (65.45) |
| Twice a day | 2 (6.25) | 10 (35.71) | 11 (47.83) | 15 (55.56) | 38 (34.55) |
| **Bathing during winter** | | | | | |
| Once in two days | 32 (100) | 28 (100) | 23 (100) | 27 (100) | 110 (100) |
| Weekly | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| **Head bath** | | | | | |
| Daily | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Twice a week | 27 (84.37) | 24 (84.71) | 23 (100) | 27 (100) | 101 (91.82) |
| Weekly | 5 (15.63) | 4 (14.29) | 0 (0) | 0 (0) | 9 (8.18) |

Figures in parenthesis are in percentage

The hygiene status of selected preschool children revealed the practice of washing hands was observed in 88.18 per cent and changing of clothes twice daily in 39.09 per cent of total sampled preschool children. All the subjects brushed. Moreover the personal hygiene practices of bathing in summer and winters, head and trimming of nails were found satisfactory in selected preschool children. The prevalence of diarrhea among children was significantly higher in families where mothers less often washed their hands before feeding children (Takanashi 2009). Kageni (2011) reported that 53.1 per cent of the children never washed their hands before having food or feeding. The author also observed about 56.6 per cent of the children did not wear footwear all the time and 52.9 per cent water supply points were not protected. Studies reported that improved health and hygiene practices in fewer incidences of diseases thereby reducing mortality risk in children under five years (Waddington *et al* 2009 and Fink *et al* 2013).

**4.8 Assessment of nutritional status of preschool children**

Nutritional status of selected preschool children was assessed through dietary intake and anthropometric status. In case of dietary intake the information regarding food and nutrient of the selected subjects was obtained.

**4.8.1 Food intake of preschool children**

The mean daily food intake and per cent adequacy of food intake in selected preschool children belonging to 2 – 3 and 3-5 years age group and of different groups is presented in Table 4.44 as well as Fig 4.16 and Table 4.45 and Fig 4.17 respectively.

**Cereals & millets**

The results revealed that the mean daily intake of cereals in selected preschool children in 2-3 and 3-5 years age group was 74.81±0.08 and 85.35±0.34 g respectively. The mean daily intake was less than the suggested dietary intake of ICMR (2010) for all food groups except cereals and sugar group in case of children in 2-3 years age group and sugar in case of children in 3-5 years age group. Vinod *et al* (2011) also reported a lower intake of 123.8g and 158.8g of cereals by preschool children of age group 2-3 and 3-5 years with a per cent deficit of 29.26 and 41.19 per cent. While another study by Ghate (2014) revealed that consumption of cereal was less than RDA by children in Ethiopia. The deficient consumption level was 41.50 per cent for 1-3 years and 29.62 per cent for 4-6 years.

**Pulses**

The mean daily intake of pulses in selected children in 2-3 and 3-5 years age group was 12.76±0.04 and 14.23±0.11 g respectively. The data revealed that intake of pulses was inadequate in both 2-3 and 3-4 years age groups when compared with suggested dietary intake of ICMR (2010). It was further found the intake of pulses was 13.56±0.12, 14.86±0.08, 13.25±0.07 and 12.29±0.11 g per day by subjects of group I, II, III and IV respectively. The intake of pulses was at par with the results reported by Lakshmi and Padma (2004).

**Table 4.44: Mean daily food intake of preschool children of 2-5 years**

| Food groups (g / day) | 2 – 3 years n = 12 | SDI | 3 – 5 years n = 98 | SDI | Overall N = 110 |
|---|---|---|---|---|---|
| Cereals & millets | 74.81±0.08 | 60 | 85.35±0.34 | 120 | 80.08±0.04 |
| Pulses | 12.76±0.04 | 30 | 14.23±0.11 | 30 | 13.49±0.13 |
| Roots and tubers | 23±0.05 | 50 | 27.12±0.08 | 100 | 25.06±0.06 |
| Green leafy vegetables | 14.98±0.13 | 50 | 18.72±0.14 | 50 | 16.85±1.09 |
| Other vegetables | 25.23±0.05 | 50 | 23.14±1.02 | 100 | 24.18±0.17 |
| Fruits | 20.01±0.08 | 100 | 21.05±0.05 | 100 | 20.55±1.07 |
| Milk (ml) & milk products | 173.58±0.09 | 500 | 160.28±0.11 | 500 | 166.95 ±0.06 |
| Sugar | 19.12±0.07 | 15 | 25.66±0.14 | 20 | 22.41±0.16 |
| Fat / oil (visible) | 14.09±0.05 | 25 | 15.05±0.09 | 25 | 14.6101±0.12 |

Values are given as Mean±SE

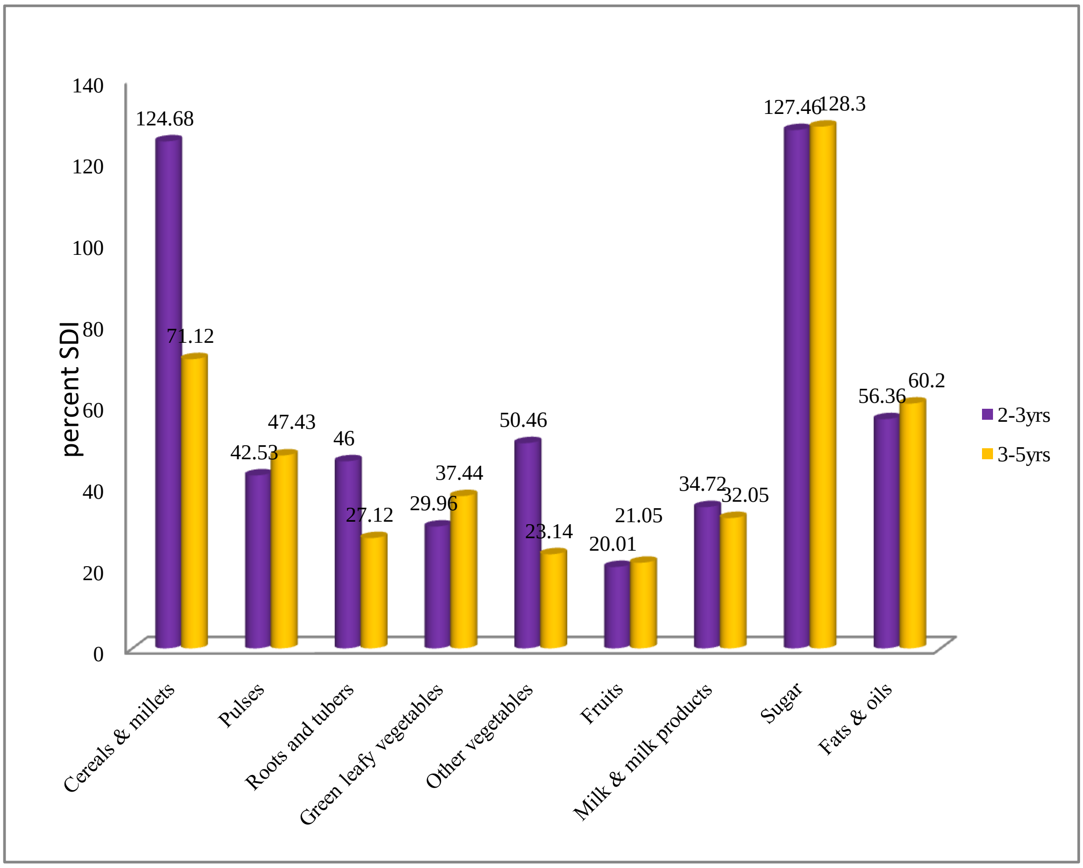


**Fig.4.16: Per cent adequacy of daily food intake of preschool children 0f 2-5 years**

**Roots and tubers**

The average daily intake of roots and tubers was higher by subjects of 3-5 years age group i.e. 27.12±0.08g as compared to that of 2-3 years age group (23±0.05g). The intake in both the groups was lower than that reported in suggested dietary intake of ICMR (2010). This shows insufficient consumption of roots and tubers by subjects of both age groups. The per cent adequacy of roots and tubers intake was 23 and 27.12 per cent in 2-3 and 3-5years age group respectively.

**Green leafy vegetables**

From the results it was observed that the mean daily intake of green leafy vegetables in selected preschool children in 2-3 and 3-5 years age group was 14.98±0.13 and 18.72±0.14 g respectively. The mean daily intake was less than the suggested dietary intake of ICMR (2010). The per cent adequacy of intake was 29.96 and 37.44 per cent for children in 2-3 and 3-5 years age group respectively. In case of subjects of different group the highest intake was observed by subjects of group IV (17.63±1.05g) followed by subjects of group I (17.13±1.04 g) then III (16.97±1.02 g) and II (15.67±0.24). Singh and Grover (2003) reported that the intake of green leafy vegetable was found to be 14 and 24 per cent in terms of per cent adequacy for 1 to 3 and 3 to 6 years children. Ghate (2014) reported a very low intake of green leafy vegetables by children i.e. 11.6g for 1-3 years and 19.4g for 4 - 6 years

**Other vegetables**

The mean daily intake of other vegetables by selected preschool children in 2-3 and 3-5 years age group was 25.23±0.05 and 23.14±1.02 g respectively. The mean daily intake was less than the suggested dietary intake of ICMR (2010). The per cent was 50.46 and 23.14 per cent in 2 -3 and 3 – 5 years age group respectively.

**Fruits**

The average intake of fruits by the preschool children in 2-3 and 3-5 year age group was 20.01±0.08 and 21.05±0.05 g respectively. Very lower fruit intake was reported by subjects of both age groups when compared to the suggested dietary intake of ICMR (2010). The preschool children in group I, II, III and IV reported fruit intake of 20.24±0.08, 20.35±1.07, 21.07±0.32 and 18.94±0.54 g per day respectively. Very less intake of fruits by children in the age group of 3 to 6 years was also reported by different authors (Jose and Indira 2000, Bathla 2012 and Arora 2015).

**Milk and milk products**

From the dietary intake data, the mean daily intake of milk and milk products by preschool children in the age group of 2-3 and 3-5 years was 173.58±0.09 and 160.28±0.11 g respectively. The intake was lower than that suggested by ICMR (2010). The per cent adequacy of intake of milk and milk products was 34.73 and 32.05 per cent in the age group of 2-3 and 3-5 years respectively. The preschool children in group I, II, III and IV were reported with an intake of milk and milk products of 172.45±1.07, 161.82±0.05, 168.25±0.09 and 165.38±0.06g per day respectively.

**Sugar**

The mean daily intake of sugar by preschool children in the age group of 2-3 and 3-5 years was 19.12±0.07 and 25.66±0.14 g respectively. The intake was sufficient when compared to suggested dietary by ICMR (2010). The percent adequacy of intake was 127.46 and 128.3 per cent in subjects of 2-3 and 3-5 years age group respectively. The sugar intake by selected subjects of group I, II, III and IV was found to be 23.87±0.97, 19.58±1.13, 24.95±0.42 and 21.24±0.16 respectively.

**Fat / oils**

The mean daily intake of visible component of fat and oil by subjects of 2-3 and 3-5 years age group was 14.09±0.05 and 15.05±0.09g respectively. The intake of sugar was lower when compared to suggested dietary by ICMR (2010). The per cent adequacy of sugar intake was 56.36 and 60.2 per cent in 2-3 and 3-5 years age group respectively. The sugar intake by selected subjects of group I, II, III and IV was 14.25±0.04, 15.19±0.08, 13.91±0.28 and 15.09±0.13 g per day respectively. Contrarily to the present study, per cent adequacy of fat and oil was reported highest as compared to that of other nutrients in the preschool (Kumari and Singh 2001). Higher fat per cent adequacy in preschool children was also reported by Bathla (2012).

The result revealed that mean daily intake of pulses, roots and tubers, green leafy vegetables, other vegetables, milk and milk products and fat / oils was inadequate and lower compared to suggested dietary by ICMR (2010). The average daily intake of cereals in case of children in the age group of 2-3 years and sugar was adequate. The average daily intake of cereals in case of children in the age group of 3-5 years was inadequate. Vinod *et al* (2011) also reported a lower intake of food from all food groups by children of age group 2-3 and 3-5 years. The present study was in line with the study conducted by Ghate (2014) who reported that consumption of cereals, pulses, green leafy vegetables, other vegetables, roots and tubers, fruits, milk and milk products, fats and oils, sugar and jaggery, was less than RDA in preschool children.

The study conducted by Black *et al* (2013) reported that financial constraints were the most common barriers for not trying the food. Food that household respondents could not afford were meat, sugar, milk, butter, potatoes, egg, iodised salt, lentil flour, chickpeas, barley and fruit. Nola *et al* (2014) reported a low intake of meat, fish, vegetables and fruits among preschool children in Bangang rural community Cameroon.

**Table 4.45: Mean daily food intake of preschool children**

| Food groups (g / day) | Group 1 (n1=32) | Group 2 (n2=28) | Group 3 (n3=23) | Group 4 (n4= 27) | Overall (n=110) |
|---|---|---|---|---|---|
| Cereals & millets | 85.12±0.09 | 83.54±0.16 | 75.23±0.05 | 76.43±0.12 | 80.08±0.04 |
| Pulses | 13.56±0.12 | 14.86±0.08 | 13.25±0.07 | 12.29±0.11 | 13.49±0.13 |
| Roots and tubers | 25.51±0.13 | 24.43±0.18 | 26.87±0.06 | 23.43±0.07 | 25.06±0.06 |
| Green leafy vegetables | 17.13±1.04 | 15.67±0.24 | 16.97±1.02 | 17.63±1.05 | 16.85±1.09 |
| Other vegetables | 24.53±0.15 | 24.78±0.05 | 23.97±0.15 | 23.44±0.23 | 24.18±0.17 |
| Fruits | 20.24±0.08 | 20.35±1.07 | 21.07±0.32 | 18.94±0.54 | 20.55±1.07 |
| Milk (ml) & milk products | 172.45±1.07 | 161.82±0.05 | 168.25±0.09 | 165.38±0.06 | 166.95 ±0.06 |
| Sugar | 23.87±0.97 | 19.58±1.13 | 24.95±0.42 | 21.24±0.16 | 22.41±0.16 |
| Fat / oil (visible) | 14.25±0.04 | 15.19±0.08 | 13.91±0.28 | 15.09±0.13 | 14.61±0.12 |

Values are given as Mean ± SE

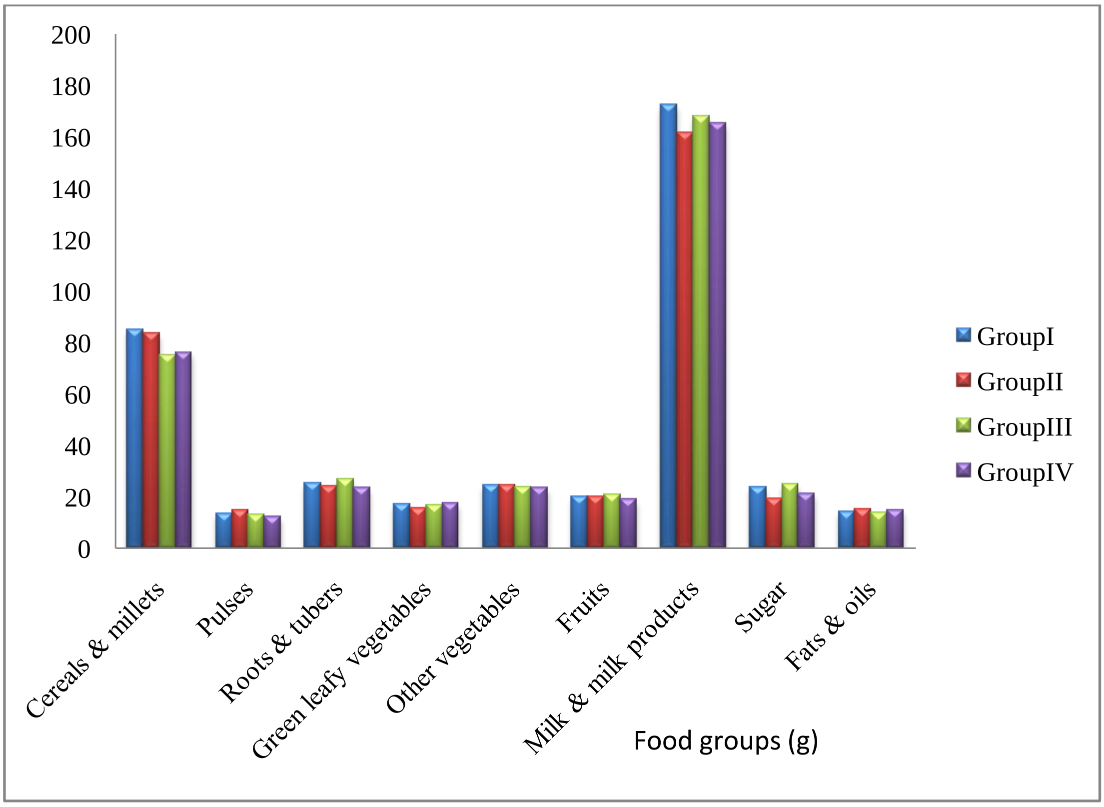


**Fig 4.17: Mean daily food intake of preschool children in the four groups**

### 4.8.2 Nutrient intake of preschool children

The mean daily food intake and per cent adequacy of food intake in selected preschool children belonging to 2 – 5 years age group and of different groups and per cent adequacy of nutrients is presented in Table 4.46, Fig 4.18 and Table 4.47.

**Energy**

The results on the nutrient intake revealed that the average daily intake of energy by selected preschool children in the age group of 2-3 and 3-5 years was 652.87±2.16 and 743.97±2.21 kcal respectively. The per cent adequacy of energy intake when compared to RDA given by ICMR (2010) was found 59.04 and 55.11 per cent in the two age groups respectively. The energy intake by the preschool children of group I, II, III and IV was 745.03±2.19, 723.12±3.14, 672.29±2.04 and 653.24±2.15 kcal respectively. Jood and co workers (1999) reported that the energy intake was marginally adequate in case of children in the age group of 2-3 years. Similarly inadequate energy intake by the preschool children in the age group of 1-4 years was reported by Khosla *et al* (2000). Higher per cent adequacy of energy intake was reported by Singh and Grover (2003). Similar results in terms of energy intake were reported by Bathla (2012) and Arora (2015). Vinod *et al* (2011) reported that the mean calorie intake of children in the age group 2-3 years was 842.6 Kcal, 3-4 years was 956.12 Kcal and 4-5 years was 1096.24 Kcal respectively.

**Protein**

Higher average daily protein intake was observed in the subjects in the age group of 3-5 years **(**17.07±1.61 g) as compared to that of children in the age group of 2-3 years (13.76±0.64 g). The results revealed that per cent adequacy of protein in terms of RDA given by ICMR (2010) were 82.39 and 84.93 per cent in the age group of 2-3 and 3-5 years respectively. The protein intake was 16.02±1.5, 15.43±1.47, 15.08±0.12 and 15.15±2.62 g by the subjects of group I, II, III and IV respectively. Similar results of mean protein intake were reported by Aggrawal *et al* (2001). Contrarily higher mean intake and per cent adequacy of protein intake were reported by Bathla (2012). The mean protein intake of children in the age group 2-3 years was reported to be 20.92 gm, 3-4 years was 23.12 gm and 4-5 years was 24.98 gm by Vinod *et al* (2011).The authors observed a protein deficit of 16-18 per cent.

**Fat**

Higher mean daily fat intake was observed in the selected subjects of the age group of 3-5 years (20.52±1.51 g) followed by subjects in the age group of 2-3 years (18.72±1.10 g). The per cent adequacy of fat intake by subjects in the age group of 2-3 and 3-5 years was 69.33 and 82.08 per cent respectively when compared to RDA given by ICMR (2010). The fat intake was 21.66±0.06, 19.42±0.34, 19.30±0.19 and 18.10±0.24 g by the subjects of group I, II, III and IV respectively. Higher values of fat intake were reported by Bathla (2012), whereas the results were in line as reported by Arora (2015).

**Table 4.46: Mean daily nutrient intake by preschool children of 2-5 years**

| Nutrients | 2 – 3 years n = 12 | RDA | 3 – 5 years n = 98 | RDA | Overall N = 110 |
|---|---|---|---|---|---|
| Energy (Kcal) | 652.87±2.16 | 1060 | 743.97±2.21 | 1350 | 698.42±2.53 |
| Protein (g) | 13.76±0.64 | 16.7 | 17.07±1.61 | 20.1 | 15.42±1.65 |
| Fat (g) | 18.72±1.10 | 27 | 20.52±1.51 | 25 | 19.62±1.92 |
| Thiamine (mg) | 0.33±0.11 | 0.5 | 0.42±0.08 | 0.7 | 0.37±0.03 |
| Riboflavin (mg) | 0.31±0.05 | 0.6 | 0.35±0.21 | 0.8 | 0.33±0.21 |
| Niacin (mg) | 2.52±0.11 | 8 | 3.23±0.13 | 11 | 2.91±0.15 |
| Dietary Folate (ùg) | 42.87±1.56 | 80 | 40.13±1.29 | 100 | 41.50±1.43 |
| Vitamin C (mg) | 17.74±0.44 | 40 | 21.32±0.31 | 40 | 19.53±0.22 |
| Vitamin B12 (ùg) | 0.23±0.27 | 0.6 | 0.25±0.44 | 0.6 | 0.24±0.36 |
| Iron (mg) | 2.98±0.12 | 9 | 3.18±0.16 | 13 | 3.09±0.19 |
| Calcium (mg) | 400.98±2.52 | 600 | 378.75±2.35 | 600 | 389.83±2.67 |
| Zinc (mg) | 1.52±0.14 | 5 | 2.08±0.26 | 7 | 1.80±0.15 |

Values are given as Mean ± SE

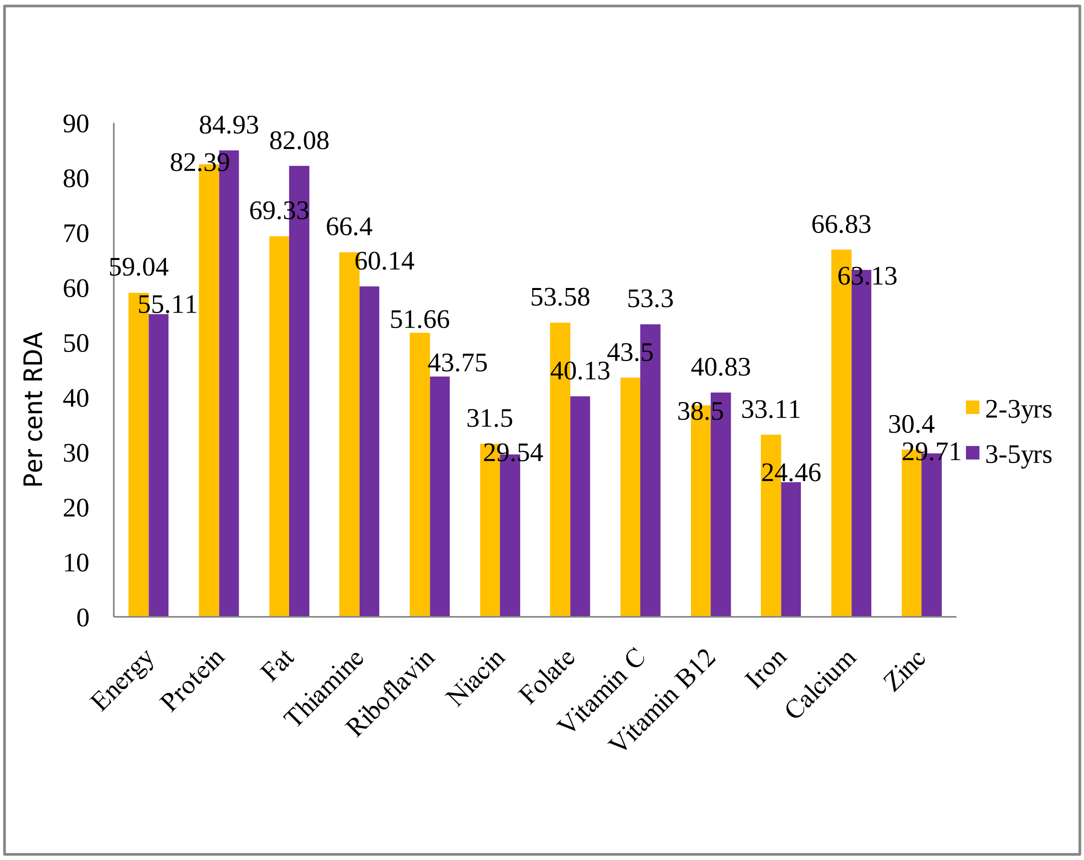


**Fig 4.18: Per cent adequacy of daily nutrient intake of preschool children of 2-5 years**

**Vitamin and mineral intake**

The mean daily intake of vitamins and minerals by preschool children and per cent adequacy of the nutrients is presented in Table4.46, Fig 4.18 and Table 4.47.

**Thiamine**

The mean daily intake of thiamine by selected preschool children in 2-3 and 3-5 years age group was 0.33±0.11 and 0.42±0.08 mg respectively. The intake was found to be lower when to RDA given by ICMR (2010). The per cent adequacy of thiamine was higher (66.4 %) in the age group of 2-3 years as compared to in the age group of 3-5 years (60.14 %). The intake was marginally inadequate by the subjects in the age group of 2-5 years. The mean intake of thiamine by the subjects in group I, II, III and IV was found to be 0.41±0.09, 0.37±0.04, 0.35±0.02 and 0.37±0.09 mg respectively. The results were in line with that reported by Arora (2015) whereas Bathla (2012) reported higher intake of thiamine by the children of preschool age. The deficiency of thiamine was reported upto 50 per cent by Yegammai and Lakshmi (1999).

**Riboflavin**

The mean daily intake of riboflavin by selected subjects in 2-3 and 3-5 years age group was 0.31±0.05 and 0.35±0.21 mg respectively. The intake was lower when to RDA given by ICMR (2010). The per cent adequacy of riboflavin intake was 51.66 and 43.75 per cent in the age group of 2-3 and 3-5 years respectively. The highest average intake of riboflavin was found by the subjects of group I (0.34±0.07 mg) followed by subjects of group II (0.32±0.18 mg) then group III (0.32±0.21 mg) and group IV (0.31±0.08). Higher mean intake of riboflavin was reported by Saxena and Stanley (2003) and Bathla (2012), whereas the riboflavin intake by subjects of present study was in line with that reported by Arora (2015).

**Niacin**

A mean daily niacin intake of 2.52±0.11 mg was observed in the preschool children of the age group of 2-3 years and 3.23±0.13 mg by the preschool children in the age group of 3-5 years. The intake of niacin was inadequate when compared to RDA given by ICMR (2010). The per cent adequacy of niacin was 31.50 and 29.54 per cent in the age group of 2-3 and 3-5 years respectively. The highest average intake of niacin was found by the subjects of group I (3.33±0.17 mg) followed by subjects of group III (2.92±0.07 mg), then group II (2.83±0.05) and IV (2.56±0.2 mg).The results of the present study were in line with the mean intake of niacin reported by Bathla (2012) and Arora (2015), whereas Saxena and Stanley (2003) reported higher mean daily intake of niacin by preschool children.

**Dietary Folate**

The data revealed that mean daily intake of riboflavin by selected subjects in 2-3 and 3-5 years age group was found to be 42.87±1.56 and 40.13±1.29 ug respectively. The folate intake was grossly inadequate when compared to RDA given by ICMR (2010). The per cent adequacy of dietary folate was 53.58 and 40.13 per cent in the age group of 2-3 and 3-5 years respectively. The highest average intake of folate was found by the subjects of group I (42.61±1.34 ug) followed by subjects of group II (41.23±1.50 ug) then of group IV (41.09±2.63 ug) and group III (41.08±1.12 ug). Higher results of intake of dietary were reported by Bathla (2012). The results of folate intake of present study were in line with the results reported by Saxena and Stanley (2003) and Arora (2015).

**Vitamin C**

The average daily intake of vitamin C was higher (21.32±0.31 mg) by subjects in the age group of 3 -5 years as compared to that of subjects in the age group of 2-3 years (17.74±0.44 mg). The intake of vitamin C was grossly inadequate when compared to RDA given by ICMR (2010). The per cent adequacy of vitamin C was 43.50 and 53.30 per cent in the age group of 2-3 and 3-5 years respectively. The mean intake of vitamin C by the subjects in group I, II, III and IV was found to be 21.18±0.18, 19.20±0.12, 19.48±0.24 and 18.26±0.06 mg respectively.

**Vitamin B12**

The mean daily intake of vitamin B12 by the subjects of 2-3 and 3-5 years was 0.23±0.27 ug and 0.25±0.44 ug respectively. The intake of vitamin B12 was inadequate when compared to the RDA values given by ICMR (2010). The per cent adequacy of vitamin B12 was 38.50 and 40.83 per cent in the age group of 2-3 and 3-5 years respectively. The mean intake of vitamin B12 by the subjects in group I, II, III and IV was found to be 0.26±0.12, 0.23±0.24, 0.22±0.16 and 0.22±0.25 ug respectively. The results of vitamin B12 intake reported by Bathla (2012) were higher when compared to results obtained from present study. The results of present study were in line with that reported by Arora (2015).

**Iron**

The mean daily intake of iron was observed higher that is 3.18±0.16 mg by subjects in the age group of 3-5 years as compared to intake of 2.98±0.12 mg by subjects in the age group of 2-3 years. The intake of iron was inadequate when compared to the RDA values given by ICMR (2010). The per cent adequacy of iron was 33.11 and 24.46 per cent in the age group of 2-3 and 3-5 years respectively. The mean intake of iron by the subjects in group I, II, III and IV was found to be 3.70±0.46, 2.98±1.15, 3.15±0.17 and 2.58±1.02 mg respectively.

**Table 4.47: Mean daily nutrient intake of preschool children**

| Nutrients (/ day) | Group 1 (n=32) | Group 2 (n=28) | Group 3 (n=23) | Group 4 (n= 27) | Overall (N=110) |
|---|---|---|---|---|---|
| Energy (Kcal) | 745.03±2.19 | 723.12±3.14 | 672.29±2.04 | 653.24±2.15 | 698.42±2.53 |
| Protein (g) | 16.02±1.50 | 15.43±1.47 | 15.08±0.12 | 15.15±2.62 | 15.42±1.65 |
| Fat (g) | 21.66±0.06 | 19.42±0.34 | 19.30±0.19 | 18.10±0.24 | 19.62±1.92 |
| Carbohydrates (g) | 99.73±0.06 | 83.93±0.06 | 86.12±0.14 | 85.23±0.15 | 88.74±0.12 |
| Thiamine (mg) | 0.41±0.09 | 0.37±0.04 | 0.35±0.02 | 0.37±0.09 | 0.38±0.03 |
| Riboflavin (mg) | 0.34±0.07 | 0.32±0.18 | 0.32±0.21 | 0.31±0.08 | 0.33±0.21 |
| Niacin (mg) | 3.33±0.17 | 2.83±0.05 | 2. 92±0.07 | 2.56±0.20 | 2.91±0.15 |
| Folate (ùg) | 42.61±1.34 | 41.23±1.50 | 41.08±1.12 | 41.09±2.63 | 41.50±1.43 |
| Vitamin C (mg) | 21.18±0.18 | 19.20±0.12 | 19.48±0.24 | 18.26±0.06 | 19.53±0.22 |
| Vitamin B12 (ùg) | 0.26±0.12 | 0.23±0.24 | 0.22±0.16 | 0.22±0.25 | 0.24±0.36 |
| Iron (mg) | 3.70±0.46 | 2.98±1.15 | 3.15±0.17 | 2.58±1.02 | 3.09±0.19 |
| Calcium (mg) | 420.81±1.98 | 385.12±2.44 | 382.24±1.47 | 371.09±2.03 | 389.83±2.67 |
| Zinc (mg) | 2.45±0.21 | 1.54±0.17 | 1.49±0.12 | 1.72±0.31 | 1.80±0.15 |

Values are given as Mean± SE

**Calcium**

The mean daily intake of calcium by selected subjects in 2-3 and 3-5 years age group was 400.98±2.52 and 378.75±2.35 mg respectively. The intake was lower when to RDA given by ICMR (2010). The per cent adequacy of calcium intake was 66.83 and 63.13 per cent in the age group of 2-3 and 3-5 years respectively. The highest average intake of calcium was found by the subjects of group I (420.81±1.98 mg) followed by subjects of group II (385.12±2.44) then group III (382.24±1.47) and group IV (371.09±2.03mg). Higher mean intake of riboflavin was reported by Saxena and Stanley (2003). Bathla (2012) reported mean intake of calcium (403 mg) in the preschool children in the age group of 2-4 years

**Zinc**

On the basis of data obtained, the mean daily intake of zinc by selected preschool children in 2-3 and 3-5 years age group was 1.52±0.14 and 2.08±0.26 mg respectively. The intake of zinc was found to be lower when to RDA given by ICMR (2010). The per cent adequacy of zinc was higher (30.4 %) in the age group of 2-3 years as compared to in the age group of 3-5 years (29.71 %). The mean intake of zinc by the subjects in group I, II, III and IV was found to be 2.45±0.21, 1.54±0.17, 1.49±0.12 and 1.72±0.31 mg respectively.

The results revealed that the per cent adequacy of energy intake was grossly inadequate in both the age group of 2-3 and 3-5 years. The intake of protein by the subjects of both age groups was inadequate and the fat intake was marginally inadequate in both the age groups. The intake of riboflavin, niacin, dietary folate, vitamin B12, vitamin C, iron, calcium an zinc were grossly inadequate in the diets of selected preschool children of both age groups. The low intake of micronutrients can be accounted for less consumption of cereals, legumes, green leafy vegetables and fruits in the diets of preschool children. The primary factor for the low intake of nutrients may be the low socioeconomic status of households of the selected subjects.

**4.8.3. Anthropometric profile of preschool children**

The anthropometric profile of preschool children of four different ICDS centers of Ludhiana city is presented in Table 4.48.

**Height**

Based on the data collected, the average height of preschool children of group I, II, III and IV was 95.82±0.18 cm, 95.85±0.17 cm, 94.98±0.27 and 95.75±0.22 cm respectively. The mean height was less than ICMR (2010) standards. Lakshmi and Padma (2004) reported mean height of preschool children 66.42 cm. The results were in line with that reported by Bains and Brar (2009).

**Weight**

The average height of preschool children of group I, II, III and IV was found 11.09±0.11 kg, 11.25±0.31 kg, 10.79±1.01 and 11.15±0.32 respectively. The mean weight was less than ICMR (2010) standards. Higher weight in rural preschool children was reported by Grover (2002). The lower values of mean height of studied subjects revealed poor nutritional status of the preschool children. Bhan and Kaur (2004) reported mean weight of preschool children in the age group of 2-5 years as 12.86 kg which was in line with the results of present study.

**Table 4.48: Anthropometric profile of the preschool children**

| Anthropometric indices | Group 1 (n1=32) | Group 2 (n2=28) | Group 3 (n3=23) | Group 4 (n4= 27) | Overall (n=110) |
|---|---|---|---|---|---|
| Height (cm) | 95.82±0.18 | 95.85±0.17 | 94.98±0.27 | 95.75±0.22 | 95.80±0.31 |
| Weight (kg) | 11.09±0.11 | 11.25±0.31 | 10.79±1.01 | 11.15±0.32 | 11.07±0.13 |
| BMI ($Kg/m^2$) | 12.42±0.21 | 12.88±0.09 | 13.05±1.10 | 13.15±1.14 | 12.85±1.01 |
| MUAC (cm) | 14.18±1.02 | 14.12±1.05 | 14.16±0.17 | 15.12±0.19 | 14.40±1.12 |
| Head circumference (cm) | 49.17±1.01 | 49.23±0.13 | 48.54±0.07 | 49.25±0.14 | 49.05±0.16 |
| Chest circumference (cm) | 49.08±1.22 | 49.17±0.19 | 48.25±0.13 | 47.00±1.04 | 48.37±0.19 |

Values are given as Mean± SE

**Body Mass Index (BMI)**

The mean average BMI of the preschool children was found to be 12.42±0.21, 12.88±0.09, 13.05±1.10 and 13.15±1.14 respectively. The mean BMI calculated was less than ICMR (2010) standards.

**Mid upper arm circumference (MUAC)**

The average height of preschool children of group I, II, III and IV was observed as 14.18±1.02 cm, 14.12±1.05 cm, 14.16±0.17 and 15.12±0.19 cm. The mean MUAC was less than Wolanski standards (1964), whereas, Singh and Grover (2003) reported higher weight of rural preschool children. Bhan and Kaur (2004) reported mean MUAC of preschool children in the age group of 1-5 years as 15.05 cm kg which was in line with the results of present study. Similar results were quoted by different authors (Bathla 2012 and Arora 2015). A study on rural Indian children reported that as much as 88 (42.9%) children were suffering from malnutrition according to MUAC criteria (< 13.5 cm) and nearly two thirds of the children were in the zone of anthropometric failure (Anwar *et al* 2013).

**Head circumference**

The average head circumference of preschool children of group I, II, III and IV was found to be 49.17±1.01 cm, 49.23±0.13 cm, 48.54±0.07 and 49.25±0.14 cm respectively. Similar results of head circumference were reported by different studies (Singh and Grover 2003 and Bhan and Kaur 2004). On the other hand slightly higher values of head circumference were reported by Bathla (2012).

**Chest circumference**

The average head circumference of preschool children of group I, II, III and IV was observed as 49.08±1.22cm, 49.17±0.19cm, 48.25±0.13cm and 47.00±1.04 cm respectively. Singh and Grover (2003) reported slightly higher values of chest circumference in the preschool children. Bhan and Kaur (2004) that chest circumference for preschool children in 3-4 and 4-5 years age group 104 and 101 per cent of reference standards.

It was found that height, weight and mid upper arm circumference values were lower than the reference standards. The lower values of anthropometric indices indicate the inadequate food and nutrient intake in preschool children.

**4.8.4. z-scores of preschool children**

The data regarding z-scores of preschool children of three different groups is presented in Table 4.49.

The weight for height z-scores observed in group I, II, III and IV were -1.92±0.18, -1.78±0.07, -1.87±0.12 and -1.79±0.15. The weight for age z-scores observed in group I, II, III and IV were -2.09±0.06, -1.88±0.07, -1.91±0.22 and -2.03±0.18 respectively. The height for age z-scores observed in group I, II, III and IV were -1.46±0.19, -1.29±0.18, -1.47±0.03 and -1.42±0.12. The results of z-scores were in line with that reported by Bathla (2012). Wang *et* *al* (2009) reported that percentage of stunting and wasting was 57 and 41 per cent respectively on the basis of z-scores in preschool children. Haq *et al* (2010) reported 32 per cent of preschool children in the age group of 2-5 years were underweight on the basis of z-score.

**Table 4.49: Mean z-scores of preschool children**

| z-score | Group 1 (n=32) | Group 2 (n=28) | Group 3 (n=23) | Group 4 (n= 27) | Overall (N=110) |
|---|---|---|---|---|---|
| Weight for height(WHZ) | -1.92±0.18 | -1.78±0.07 | -1.87±0.12 | -1.79±0.15 | -1.84±0.18 |
| Weight for age (WAZ) | -2.09±0.06 | -1.88±0.07 | -1.91±0.22 | -2.03±0.18 | -1.977±0.09 |
| Height for age (HAZ) | -1.46±0.19 | -1.29±0.18 | -1.47±0.03 | -1.42±0.12 | -1.41±0.21 |
| BMI for age | -1.75±0.09 | -1.68±0.14 | -1.65±0.05 | -1.72±0.12 | -1.70±0.05 |
| MUAC for age | -1.89±0.24 | -1.91±0.21 | -1.72±0.07 | -1.76±0.17 | -1.82±0.13 |

Values are given as Mean± SE

The BMI for age z-score in group I, II, III and IV were observed as -1.75±0.09, -1.68±0.14, -1.65±0.05 and -1.72±0.12 respectively. The MUAC for age z-score in group I, II, III and IV were -1.89±0.24, -1.91±0.21, -1.72±0.07 and -1.76±0.17 respectively. Bains and Brar (2009) reported that 11 per cent children were malnourished on the basis of z-score. Manyike *et al* (2014) reported that 60 of the 616 children under five (9.7%) had acute malnutrition based on WHZ-score. Moderate acute malnutrition (MAM) was present in 33 children (5.3%) while 27 (4.4%) had severe acute malnutrition in Southeast Nigeria.

The prevalence of undernutrition among the male subjects was 58.33 per cent and female subjects were 72 per cent (Table 4.50). Out of the total number of subjects, 2-3 per cent of the total subjects were severely malnourished.

**Table 4.50: Age wise standardized prevalence of stunting, wasting and underweight as well as mean z-scores of preschool children**

| z-scores | Height for age (HAZ) | Weight for age (WAZ) | Weight for Height (WHZ) |
|---|---|---|---|
| **Boys (N=60)** | | | |
| **>2.0 SD** | 0 (0) | 0 (0) | 0 (0) |
| **-2.0 to 2.0 SD** | 39 (65.00) | 24 (40.00) | 23 (38.34) |
| **<-2.0 SD** | 21 (35.00) | 34 (56.67) | 35 (58.33) |
| **< -3.0SD** | 0 (0) | 2 (3.33) | 2 (3.33) |
| **Girls (N=50)** | | | |
| **>2.0 SD** | 0 (0) | 0 (0) | 0 (0) |
| **-2.0 to 2.0 SD** | 38 (76.00) | 15 (30.00) | 13 (26.00) |
| **<-2.0 SD** | 11 (22.00) | 34 (68.00) | 36 (72.00) |
| **< -3.0SD** | 1 (2.00) | 1 (2.00) | 1 (2.00) |
| **Overall (N=110)** | | | |
| **>2.0 SD** | 0 (0) | 0 (0) | 0 (0) |
| **-2.0 to 2.0 SD** | 77 (70.01) | 39 (35.45) | 36 (32.73) |
| **<-2.0 SD** | 32 (29.09) | 68 (61.82) | 71 (64.55) |
| **< -3.0SD** | 1 (0.9) | 3 (2.73) | 3 (2.72) |

Figures in parenthesis are in percentages

Ramachandran and Gopalan (2010) also reported an increase in the underweight and stunting rate in 3-23 month infants and severe wasting at birth during their study in 0-59 month children. A study in under five children of Kallalgali, reported that 60 per cent of the child population under age 5 were malnourished (Algur *et al* 2012).

A study conducted by Akorede and Abiola (2013) in under five children of a community in Nigeria reported that 2.6 per cent an MUAC less than 12.5 cm with 2.3 per cent of the children malnourished. Raman *et al* (2013) reported a prevalence rate of 54 per cent malnutrition among under-five children, of which half of the children were in grade-I and grade-II. The authors also observed that the prevalence of malnutrition was higher in female children, mothers with low literacy levels, and belonging to lower socio-economic group. The prevalence of stunting, underweight and wasting among 475 children belonging to the age group 2 weeks to 5 years was found to be 41.26, 10.52 and 3.58 per cent respectively (Nola *et al* 2014).

**4.9 Impact of supplementation of developed value added products on nutritional status of selected malnourished preschool children**

Out of the 110 subjects, 30 preschool children of age group 3-5 years were selected as the control group and another 30 children of the same age group were selected as the experimental group. The most acceptable levels of all five developed foods were supplemented to children of the experimental group for a period of four months to assess the nutritional efficiency of developed products in combating malnutrition rampant among children under five years of age. The children were selected from two ICDS centers.

**4.9.1 Impact of supplementation on food intake**

The mean daily intake of food of the selected preschool subjects of both experimental and control groups before and after supplementation is presented in Table 4.51 and Fig 4.19. The mean daily intake of cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, milk and milk products, sugar and fat and oil before supplementation by the subjects of the control group was found to be 90.65±1.16 Kcal, 15.28±1.13 g, 17.48±1.12 g, 22.09±0.06 g, 23.92±1.80 g, 21.07±2.13 g, 143.77±3.10 g, 26.97±1.11 g and 17.61±0.92 g while the respective intake after supplementation increased significantly ($p < 0.05$) to 91.24±0.08 g in case of cereals and significantly ($p < 0.01$) reduced to 22.99±2.11g in case of other vegetables, whereas in case of other food groups the increase as well as decrease was not significant after supplementation.

**Table 4.51: Mean daily food intake of selected preschool children before and after supplementation**

| Food groups (g / day) | Before supplementation (n=30) | After supplementation (n=30) | % change | t-value |
|---|---|---|---|---|
| **Group A (Control)** | | | | |
| Cereals | 90.65±1.16 | 91.24±0.08 | 0.65 | 2.53* |
| Pulses | 15.28±1.13 | 15.04±2.08 | 1.57 | $0.32^{NS}$ |
| Green leafy vegetables | 17.48±1.12 | 17.93±1.21 | 2.57 | $1.88^{NS}$ |
| Roots and tubers | 22.09±0.06 | 22.18±1.26 | 0.36 | $0.38^{NS}$ |
| Other vegetables | 23.92±1.80 | 22.99±2.11 | 3.88 | 3.30** |
| Fruits | 21.07±2.13 | 21.90±1.08 | 3.94 | $1.08^{NS}$ |
| Milk and milk products | 143.77±3.10 | 143.92±2.89 | 0.10 | $0.18^{NS}$ |
| Sugar | 26.97±1.11 | 27.10±0.12 | 0.48 | $0.16^{NS}$ |
| Fats and oils | 17.61±0.92 | 17.92±1.94 | 1.76 | $0.37^{NS}$ |
| **Group B (Experimental)** | | | | |
| Cereals | 90.13±2.13 | 134.40±2.09 | 49.12 | 96.99** |
| Pulses | 16.01±0.95 | 28.49±1.65 | 77.95 | 97.66** |
| Green leafy vegetables | 16.95±1.55 | 18.85±1.13 | 11.21 | 21.38** |
| Roots and tubers | 21.78±0.99 | 22.75±2.25 | 4.45 | 3.97** |
| Other vegetables | 23.44±2.26 | 25.83±1.36 | 10.19 | 5.42** |
| Fruits | 22.05±1.98 | 22.45±2.20 | 1.81 | 1.87* |
| Milk and milk products | 144.22±2.25 | 145.69±1.16 | 1.02 | $0.27^{NS}$ |
| Sugar | 23.56±2.10 | 24.57±2.08 | 4.29 | 6.93** |
| Fats and oils | 17.49±1.09 | 19.19±1.74 | 9.71 | 13.00** |

Values are given as Mean± SE *Significant at 5% level of significance ($p<0.05$)
**Significant at 1% level of significance ($p<0.01$) NS- Non significant

A study conducted by Ghate (2014) in Ethiopia among the malnourished children for their food consumption revealed that there was a deficient consumption level of cereals by 41.50 per cent for 1-3 years and 29.62 per cent for 4-6 years 31.41per cent 7-9 years children.

The mean daily intake of green leafy vegetables was observed to be 11.6 per cent for 1-3 years, 19.4 per cent for 4 - 6 years and 18.02 per cent for 7-9 years. Consumption of milk was negligible but roots and tubers were consumed in excess. Results revealed that consumption of cereals, pulses, green leafy vegetables, other vegetables, fruits, milk and milk products, fats and oils, sugar and jaggery, was less than RDA which is why the subjects were malnourished.

While, the mean daily intake of cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, milk and milk products, sugar and fat and oil before supplementation by the subjects of the experimental group was 90.13±2.13 Kcal, 16.01±0.95 g, 16.95±1.55 g, 21.78±0.99 g, 23.44±2.26 g, 22.05±1.98 g, 144.22±2.25 g, 23.56±2.10 g and 17.49±1.09 g respectively, whereas the respective intake after supplementation increased and was found to be 134.40±2.09 kcal, 28.49±1.65 g, 18.85±1.13 g, 22.75±2.25 g, 25.83±1.36 g, 22.45±2.20 g, 145.69±1.16 g, 24.57±2.08 g, and 19.19±1.74 g respectively.

A significant increment ($p < 0.01$, $p < 0.05$) was reported in intake of all food groups except milk and milk products after supplementation by subjects of experimental group as depicted in Fig 4.19. Kapur and co workers (2003) also observed an increase in the food intake on giving nutrition education and supplements to children in urban slums of Delhi. Studies have emphasized on the consumption of wide variety of food including cereals for energy, lentils particularly for protein, vegetables for vitamins and minerals particularly iron rich and oil for the treatment of malnutrition among children (Pee and Bloem 2009). Chaparro and Dewey (2010) also observed an increase in the intake of cereals, pulses and fats when vulnerable groups were supplemented with lipid-based nutrient supplements.

**4.9.2 Impact of supplementation on nutrient intake**

The average daily intake of energy, protein, fat, thiamine, riboflavin, niacin, dietary folate, vitamin C, vitamin B12, iron, calcium and zinc by subjects of the control group before supplementation was 806.81±1.61 kcal, 17.46±1.69 g, 17.37±2.12 g, 0.52±0.112 mg, 0.29±3.12 mg, 3.38±0.61 mg, 42.03±2.28 ug, 17.15±1.04 mg, 0.19±0.91 ug, 4.36±1.12 mg, 372.47±1.64 mg and 2.36±1.66 mg respectively as presented in Table4.52. The per cent adequacy of nutrient intake by the subjects of both the groups has been depicted in Fig 4.20. The respective significant increase in intake after supplementation was observed only in the case of carbohydrates (114.37±2.01 g), thiamine (0.53±1.87 mg), riboflavin (0.32±2.75 mg) and niacin (3.46±0.52 mg). The mean intake of energy, protein and micronutrients except vitamin B12 was lower than recommended intake of ICMR (2010) for both groups before supplementation. The lower nutritional intake relates to the poor z-scores of the selected subjects. The poor consumption of micronutrients indicates the hidden hunger in selected preschool children.

**Table 4.52: Mean daily nutrient intake of selected preschool children before and after supplementation**

| Nutrients | Before supplementation (n=30) | After supplementation (n=30) | % change | t-value | RDA | % adequacy |
|---|---|---|---|---|---|---|
| **Group A (Control)** | | | | | | |
| Energy (Kcal) | 806.81±1.16 | 807.11±2.82 | 0.04 | 0.38 NS | 1350 | 59.79 |
| Protein (g) | 17.46±1.69 | 17.61±0.99 | 0.86 | 0.92 NS | 20.1 | 87.61 |
| Fat (g) | 17.37±2.12 | 17.74±2.08 | 2.13 | 1.25 NS | 25 | 70.96 |
| Carbohydrates(g) | 113.96±0.98 | 114.37±2.01 | 0.36 | 2.19* | | |
| Thiamine (mg) | 0.52±0.11 | 0.53±1.87 | 1.92 | 3.64** | 0.7 | 75.71 |
| Riboflavin (mg) | 0.29±3.12 | 0.32±2.75 | 10.34 | 2.18* | 0.8 | 40.00 |
| Niacin (mg) | 3.38±0.61 | 3.46±0.52 | 2.37 | 3.64** | 11 | 31.45 |
| Dietary Folate(ug) | 42.03±2.28 | 42.74±1.98 | 1.69 | 1.97 NS | 100 | 42.74 |
| Vitamin C (mg) | 17.15±1.04 | 17.53±1.17 | 2.22 | 1.41 NS | 40 | 43.82 |
| Vitamin B12(ug) | 0.19±0.91 | 0.20±0.78 | 5.26 | 1.19 NS | 0.2-1 | 20.00 |
| Iron (mg) | 4.36±1.12 | 4.48±2.27 | 2.75 | 1.09 NS | 13 | 34.46 |
| Calcium (mg) | 372.47±1.64 | 374.79±1.69 | 0.62 | 1.02 NS | 600 | 62.47 |
| Zinc (mg) | 2.36±1.66 | 2.38±1.08 | 0.84 | 1.46 NS | 7 | 34.00 |
| **Group B (Experimental)** | | | | | | |
| Energy (Kcal) | 800.24±2.12 | 1184.12±2.97 | 47.97 | 107.70** | 1350 | 87.71 |
| Protein (g) | 17.32±0.15 | 20.19±0.91 | 33.89 | 27.69** | 20.1 | 99.56 |
| Fat (g) | 16.76±1.78 | 20.04±1.08 | 19.57 | 24.43** | 25 | 80.16 |
| Carbohydrates(g) | 109.29±1.23 | 112.58±0.57 | 3.01 | 3.83** | | |
| Thiamine (mg) | 0.46±1.09 | 0.53±1.59 | 15.22 | 8.18** | 0.7 | 75.71 |
| Riboflavin (mg) | 0.32±1.78 | 0.46±2.09 | 43.75 | 12.91** | 0.8 | 57.50 |
| Niacin (mg) | 3.48±0.02 | 3.95±0.01 | 13.51 | 20.65** | 11 | 35.91 |
| Folate (ug) | 43.70±0.13 | 44.13±0.12 | 0.98 | 3.92** | 100 | 44.13 |
| Vitamin C (mg) | 17.59±0.11 | 19.54±0.08 | 11.08 | 23.47** | 40 | 48.85 |
| Vitamin B12 ug) | 0.21±0.00 | 0.32±0.12 | 52.38 | 10.17** | 0.2-1 | 32.00 |
| Iron (mg) | 4.52±1.06 | 7.46±0.07 | 65.04 | 30.59** | 13 | 57.38 |
| Calcium (mg) | 352.55±2.26 | 360.75±2.08 | 2.32 | 4.70** | 600 | 60.13 |
| Zinc (mg) | 2.35±0.02 | 2.51±0.03 | 6.81 | 7.61** | 7 | 35.86 |

Values are given as Mean± SE *Significant at 5% level of significance ($p$<0.05)
**Significant at 1% level of significance ($p$<0.01) NS- Non significant

In the case of the subjects in the experimental group, the intake of nutrients before supplementation was found to be 800.24±2.12 Kcal, 17.32±0.15 g, 16.76±1.78 g, 109.29±1.23 g, 0.46±1.09 mg, 0.32±1.78 mg, 3.48±0.02 mg, 43.70±0.13 ug, 17.59±0.11 mg, 0.21±0.00 ug, 4.52±1.06 mg, 352.55±2.26 mg and 2.35±0.02 mg for energy, protein, fat, carbohydrates, thiamine, riboflavin, niacin, folate, vitamin C, vitamin B12, iron, calcium and zinc respectively. The intake was not sufficient when compared to the RDA of nutrients as was observed among the subjects of control group. But after the supplementation of the products to the subjects of the experimental group, a significant increase ($p<0.01$) was observed in the intake of all nutrients and was found to be 1184.12±2.97 kcal, 20.19±0.91g, 20.04±1.08 g, 112.58±0.57g, 0.53±1.59 mg, 0.46±2.09 mg, 3.95±0.01 mg, 44.13±0.12 ug, 19.54±0.08 mg, 0.32±0.12 ug, 7.46±0.07 mg, 360.75±2.08 mg and 2.51±0.03 mg for energy, protein, fat, carbohydrates, thiamine, riboflavin, niacin, folate, vitamin C, vitamin B12, iron, calcium and zinc respectively.

Although the consumption of macro and micronutrients increased in experimental group after supplementation, but the intake was lower than recommended intake (ICMR 2010). Verma *et al* (2007) studied the dietary pattern of preschool children of the urban areas in the Rohtak city. The authors found that the caloric intake was less than 80 per cent of RDA among 82 per cent of children and the protein intake was less than 80 per cent of RDA among 93.1 per cent children. Their study revealed a significant association ($p < 0.001$) between low intake of calories and proteins in diet and the prevalence of malnutrition among the children under 5years studied. Vinod *et al* (2011) conducted a survey among 434 children below five years of age. The subjects were subjected to anthropometric measurements and revealed that 52.23 per cent were suffering from various grades of malnutrition. About 32.18 per cent children were in grade I, 16.09 per cent in grade II, 3.46 per cent in grade III and 0.5 per cent in grade IV malnutrition.

Statistical analysis showed significant ($p<0.01$) increase in the intake of all the nutrients by the children of experimental group met the standard intake suggested by ICMR (2010). Supplementary foods developed from cereal pulse mix were reported with high energy and protein (Amegovu *et al* 2014). Improvement in nutritional status of malnourished children after supplementation has been reported by present study. The findings were supported by Ghatge (2012) through the supplementation of soy *laddo* improved nutritional status of malnourished children. In another study supplementation of amylase rich *porridge* significantly enhanced nutritional profile of preschool children because it provided extra energy, protein and fat (Khader and Maheswari 2012, Mulik and Salunkhe 2014). The poor intake of energy, protein and other nutrients which in turn lead to poor nutritional status of preschool children of the control group is due to the poor socioeconomic status of their families as most of the families earned a very low monthly income.

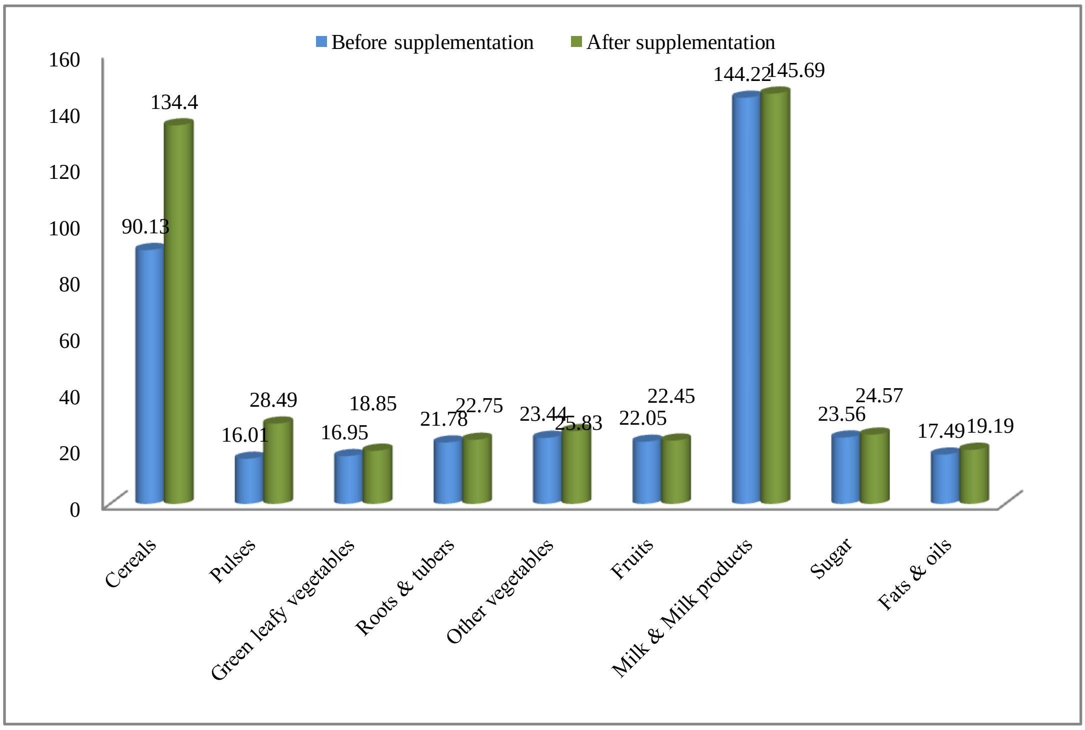


**Fig 4.19: Mean food intake of selected preschool children in the experiment group before and after supplementation**

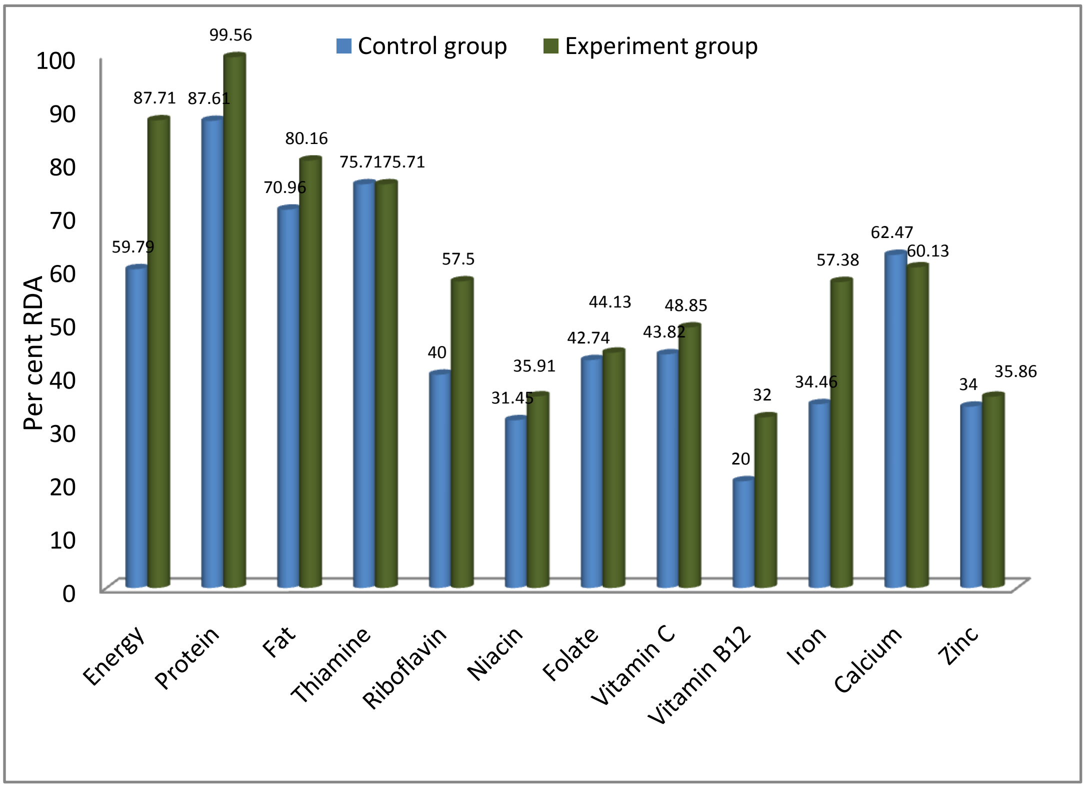


**Fig.4.20: Per cent adequacy of nutrient intake in the selected preschool children after supplementation**

### 4.9.3 Impact of supplementation on anthropometric profile

Significant ($p < 0.01$) increase was observed between the values of weight of two groups as given in Table 4.53. The weight of the control group and experimental group was observed to be 12.67±0.36 and 12.11±0.84 kg which increased to 12.71±0.59 and 13.82±0.08 kg. The greater increase was observed in the subjects of experimental group after supplementation. A weight gain was observed by Mahfuz and his co workers (2014) in children after 5 months of age when a group of children (Experimental) were provided with Ready-to-use-food and *pushti* packets while significant changes in weight was not observed for the subjects who were not provided with any supplements (Control group) in the slum areas of Bangladesh.

**Table 4.53: Mean anthropometric profile of selected preschool children before and after supplementation**

| Anthropometric indices | Before supplementation (n=30) | After supplementation (n=30) | % change | t-value |
|---|---|---|---|---|
| **Group A (Control)** | | | | |
| Height (cm) | 95.44±1.42 | 95.53±1.14 | 0.09 | 0.41 NS |
| Weight (kg) | 12.67±0.36 | 12.71±0.59 | 0.32 | 2.68** |
| BMI ($Kg/m^2$) | 12.83±0.09 | 12.97±0.30 | 1.09 | 2.03 NS |
| MUAC (cm) | 16.24±2.06 | 16.47±1.12 | 1.42 | 2.16NS |
| Headcircumference (cm) | 49.21±0.33 | 49.34±0.23 | 0.26 | 0.96 NS |
| Chest circumference (cm) | 50.62±1.21 | 50.72±2.02 | 0.19 | 0.58 NS |
| **GroupB (Experimental)** | | | | |
| Height (cm) | 95.79±1.07 | 96.02±1.43 | 0.24 | 0.92NS |
| Weight (kg) | 12.11±0.84 | 13.82±0.08 | 14.12 | 12.15** |
| BMI ($Kg/m^2$) | 12.77±0.53 | 14.64±0.09 | 14.64 | 8.67** |
| MUAC (cm) | 13.99±0.15 | 14.08±0.13 | 1.64 | 5.35** |
| Head circumference (cm) | 49.03±0.05 | 49.11±0.08 | 0.16 | 2.08 NS |
| Chest circumference (cm) | 49.36±0.52 | 49.43±0.20 | 0.14 | 2.48* |

Values are given as Mean± SE *Significant at 5% level of significance ($p$<0.05)
**Significant at 1% level of significance ($p$<0.01) NS- Non significant

The BMI of the subjects of the control group was found to be 12.83±0.09 $Kg/m^2$ before supplementation which showed an insignificant increase of 12.97±0.30 $Kg/m^2$ while in the case of the subjects of the experiment group, the BMI before supplementation was found to be 12.77±0.53 $Kg/m^2$ which increase significantly ($p$<0.01) to 14.64±0.09 $Kg/m^2$. Significant changes in the MUAC, Head and Chest circumference was not observed in the subjects of the control group after supplementation. While for the subjects of the experimental group the MUAC and chest circumference before supplementation was found to be 13.99±0.15cm and 49.36±0.52cm which significantly ($p$<0.01, $p$<0.05) increased to 14.08±0.13 cm and 49.43±0.20 cm. Highest increment in BMI (14.64 %) followed by weight (14.12%) was observed in subjects of experimental group. No significant increment was observed in anthropometric profile by children of control group except for weight. Ash and co workers (2003) reported that the supplementation of the energy dense foods had good impact on growth status of the children. Similar findings have been reported in children supplemented with the Amylase Rich Flour (ARF) food (Hossain *et al* 2005).

#### 4.9.4 Impact of supplementation on z-score

The mean values of z – score before and after supplementation of developed products is presented in Table 4.54. On analyzing the data obtained before and after supplementation of the value added products, it was revealed that weight for height (WHZ), weight for age (WAZ), BMI for age and MUAC for age z-scores were less than -2SD in children of experimental group suggesting moderately malnourished status of selected children. Significant ($p$<0.05) improvement in height for age, weight for age and BMI for age of the subject in control group was noticed while a significant ($p$<0.01) difference was observed in the z-scores of weight for height, weight for age, height for age and BMI for age after supplementation. Significant ($p$<0.05) increase in MUAC of age also was observed in the experiment group after supplementation.

The results showing the significant improvement in the z-scores of the subjects in the experiment group revealed that the intake of the value added products actually had a positive effect on the nutritional status of the malnourished. Manary and his coworkers (2004) observed that children more than 1 year old receiving Ready -to-use-food (RTUF) which supplied 2100KJ/day were more likely to improve the Weight-for-height (WHZ) z-score than those receiving RTUF supplement or maize/soy flour. An average weight gain of 5.2 g/kg/day in the RTUF group was observed by the authors when compared to 3.1 g/kg/day for the maize/soy and RTUF supplement groups. Six months later, 96% of all children that reached WHZ>0 were not wasted. Sandige *et al* (2004) also determined the efficacy of home-based therapy with ready-to-use food (RTUF) in producing catch-up growth in 260 malnourished children and to compare locally produced RTUF with imported RTUF. They noticed that 78% of all children, 95% of those with HIV-negative status and 59% of those with HIV-positive status improved their WHZ scores and were not wasted while 8% of those receiving locally produced RTUF and 75% of those receiving imported RTUF reached had an improved WHZ score. Masuda *et al* (2014) also observed a significant improvement in the Height for age, weight for age and mid upper arm circumference for age in preschool undernourished children after they were supplemented with spirulina rich products.

**Table 4.54: Mean z-score of selected preschool children before and after supplementation**

| z-score | Before supplementation (n=30) | After supplementation (n=30) | % change | t-value |
|---|---|---|---|---|
| **Group A (Control)** | | | | |
| Weight for height (WHZ) | -2.24±0.09 | -2.05±0.12 | 8.48 | 3.93 NS |
| Weight for age (WAZ) | -2.08±0.02 | -2.02±0.08 | 2.88 | 4.72* |
| Height for age (HAZ) | -1.06±0.12 | -1.22±0.16 | 15.09 | 5.95* |
| BMI for age | -2.08±0.21 | -1.92±0.18 | 7.69 | 4.47* |
| MUAC for age | -1.97±0.02 | -1.98±0.12 | 0.51 | 3.19 NS |
| **Group B (Experimental)** | | | | |
| Weight for height (WHZ) | -2.26±0.75 | -1.68±0.16 | 25.66 | 13.59** |
| Weight for age (WAZ) | -2.16±0.06 | -1.96±0.02 | 9.25 | 9.85** |
| Height for age (HAZ) | -1.45±0.20 | -1.63±0.20 | 12.41 | 7.58** |
| BMI for age | -2.09±0.06 | -1.47±0.09 | 29.66 | 20.12** |
| MUAC for age | -2.05±0.14 | -1.78±0.12 | 13.17 | 2.15* |

Values are given as Mean± SE *Significant at 5% level of significance ($p<0.05$)
**Significant at 1% level of significance ($p<0.01$) NS- Non significant

A reduction in the prevalence rate of the malnourished subjects was noticed in the experiment group after supplementation as depicted in Table 4.55. The prevalence rate of normal weight-for-age status among the subjects in experimental group increased from 16.67 to 56.67 per cent while the rate of mildly malnourished reduced from 83.33 to 43.33 per cent. The rate of prevalence of wasting and stunting also reduced in the malnourished category and increased the rate of normal status among the subjects of experimental group.

Significant increase in the normal nutritional status or decrease in malnourished status of the subjects belonging to the control group was not observed. Adeladza (2009) reported that poor socio-economic factors form underlying causes of the poor nutritional status. In another study (Kanjilal *et al* 2010) burden of stunting was observed among the children of urban area from poor socioeconomic status. Hence socioeconomic status can be attributed as the determinant of nutritional status of children. Improvement in nutritional status of malnourished children after supplementation has been reported by present study. The findings were supported by Ghatge (2012), the supplementation of *laddo* prepared with soy flour improved nutritional status of malnourished children. In another study supplementation of amylase rich *porridge* significantly enhanced nutritional profile of preschool children (Khader and Maheswari 2012, Mulik and Salunkhe 2014).

**Table 4.55: Age wise prevalence of underweight, wasting and stunting in the selected preschool children**

| z score | Weight –for-age (WAZ) | | Weight-for-height (WHZ) | | Height-for-age (HAZ) | |
|---|---|---|---|---|---|---|
| | **Before n=30** | **After n=30** | **Before n=30** | **After n=30** | **Before n=30** | **After n=30** |
| **Group A (Control)** | | | | | | |
| > +2.0 SD | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) |
| -2.0 SD to +2.0 SD (Normal) | 19(63.34) | 18(60) | 12(40) | 14(46.67) | 20(63) | 17(56.67) |
| <-2.0 SD (Moderately malnourished) | 11(36.66) | 12(40) | 18(60) | 16(53.33) | 10(37) | 13(43.33) |
| <-3.0 SD (Severely malnourished) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) |
| **Group B (Experimental)** | | | | | | |
| > +2.0 SD | 0(0.0) | 0(0.0) | 0(0.0) | 2(6.66) | 0(0.0) | 0(0.0) |
| -2.0 SD to +2.0 SD (Normal) | 5(16.67 ) | 17(56.67) | 9(30) | 17(56.67) | 16(53.33) | 17(57) |
| <-2.0 SD (Moderately malnourished) | 25(83.33) | 13(43.33) | 21(70) | 11(36.67) | 14(46.67) | 13(43) |
| <-3.0 SD (Severely malnourished) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) |

Figures in parenthesis is in percentages

### 4.9.5 Impact of supplementation on blood profile

The mean values of biochemical profile of selected preschool children before and after supplementation are presented in Table 4.56. The mean levels of hemoglobin, blood albumin and protein in the subjects of the control group before supplementation was reported to be 9.58±0.08 g/dl, 4.46±0.17g/dl and 6.50±0.04 g/dl respectively whereas for the subjects in the experiment group, it was found to be 9.08±0.17 g/dl, 4.38±0.22 g/dl and 6.46±0.06 g/dl respectively.

**Table 4.56: Mean biochemical profile of selected preschool children before and after supplementation**

| Biochemical parameters | Before supplementation (n=30) | After supplementation (n=30) | % change | t-value |
|---|---|---|---|---|
| **Group A (Control)** | | | | |
| Protein (g/dl) | 6.50±0.04 | 6.55±0.08 | 0.77 | 1.22 NS |
| Albumin (g/dl) | 4.46±0.17 | 4.52±0.01 | 1.35 | 1.37 NS |
| MCV (fl) | 75.30±1.53 | 75.49±1.37 | 0.25 | 0.99 NS |
| MCH (pg) | 22.63±0.18 | 22.68±0.21 | 0.22 | 1.18 NS |
| MCHC (g/dl) | 28.10±0.25 | 29.00±0.27 | 3.20 | 0.93 NS |
| Hemoglobin (g/dl) | 9.58±0.08 | 9.61±0.10 | 0.31 | 1.59 NS |
| **Group B (Experimental)** | | | | |
| Protein (g/dl) | 6.46±0.06 | 7.06±0.13 | 9.28 | 11.06 ** |
| Albumin (g/dl) | 4.38±0.22 | 5.14±0.91 | 17.35 | 9.59 ** |
| MCV (fl) | 75.75±0.29 | 76.93±0.25 | 1.56 | 8.87** |
| MCH (pg) | 22.41±0.06 | 23.57±0.27 | 5.17 | 12.99** |
| MCHC (g/dl) | 29.11±0.09 | 29.72±0.55 | 2.09 | 7.51** |
| Hemoglobin (g/dl) | 9.08±0.17 | 9.86±0.13 | 8.59 | 8.54** |

Values are given as Mean± SE **Significant at 1% level of significance ($p<0.01$)
NS- Non significant

The biochemical assessment of the subjects from the control group did not reveal any significant changes in their blood profile after supplementation. A Significant ($p < 0.01$) increment in blood levels of protein, albumin, MCV, MCH, MCHC and hemoglobin was observed in the subjects of experimental group after supplementation. Highest increase (17.35 %) was seen for blood albumin levels followed by blood protein (9.28%) and hemoglobin (8.59%) levels in the subjects of experimental group. Similar increase in the haemoglobin content of malnourished children after supplementation was observed by Hyder and co workers (2000). Owino *et al* (2007) have reported that supplementation of energy dense foods improved the hemoglobin concentration. In another study supplementation of fortified


**Plate 12: Assessment of anthropometric parameters of preschool children**

**Plate 13: Assessment of biochemical parameters of selected preschool children**

beverage for 6 months significantly improved the hematologic and anthropometric measurements and significantly lowered the overall prevalence of anemia deficiency among the children (Sivakumar *et al* 2006).

The present study revealed that the five value added products developed using partially defatted peanut cake flour and green leafy vegetable powder were wholesome and had high sensory acceptability. The developed products were nutritious with good amount of protein, fat and energy as well as liberal amounts of mineral and vitamin content. The products were acceptable for sensory parameters after a storage period of three months. The supplementation of the developed value added products for four months improved the dietary intake, anthropometric as well as the biochemical profile of malnourished preschool children of the experiment group.

**CHAPTER V**

# SUMMARY

Malnutrition among under-five children is a one the prevalent major public health issue India faces today. The prevalence of undernutrition in under 5 children in India is among the highest in the world. Every year about 2.3 million deaths among 6-60 months aged children in developing countries are linked with malnutrition, which is about 41per cent of the total deaths in this age group. On the other hand, India has many intervention programmes running under the government as well as the non-governmental agencies. The success of programs depends on various factors including regional or state level needs, community perceptions and behaviors, acceptability of intervention measures by households, food security issues, food beliefs or taboos, likes or dislikes, cooking and child rearing practices, quality and quantity of the food items served. Hence here comes the importance of popularization of underutilized food ingredient that has a high nutritional profile like protein, fat and calories to find a solution to the problem of undernutriton.

Partially defatted peanut cake flour is one such ingredient which has been utilized only for cattle feed and manure because of the poor sanitation facilities in the oil mills. Partially defatted peanut cake flour contains 3.12 per cent of moisture, 53.18 per cent of protein, 8.96 per cent fat, 5.23 per cent fiber, 3.76 per cent ash and 25.75 per cent carbohydrates, thus making it a highly nutritious food ingredient. Low cost weaning formulations can be made in the traditional ways. Keeping in mind the present scenario of undernutrition in the country and the rich nutritional profile of partially defatted peanut cake flour, the present study was undertaken to develop five value added products incorporating partially defatted peanut cake flour and powdered green leafy vegetables with optimum nutrition and sensory attributes and to determine the efficacy of value added products using partially defatted peanut cake flour on the nutritional status of malnourished preschool children.

In the present study, five value added products namely *matthi*, *seviyan, pinni, panjiri* and biscuits were developed and standardized using different combinations of ingredients like wheat flour, chickpea flour, partially defatted peanut cake flour and powdered green leafy vegetables like fenugreek leaf powder in salty products like *matthi* and *seviyan* and spinach leaf powder in sweet products like *pinni, panjiri* and biscuits. The products were developed with optimum nutritional profile with respect to proximate composition, amino acid content, micronutrient content, their *in-vitro* protein digestibility as well as acceptable sensory attributes. The antinutritional parameters like tannin, phytin phosphorus, total phenol and aflatoxin were also assessed using standard procedures. All the five products were then packed and stored at room temperature in three different packaging materials namely glass container, glass container + aluminium zip lock pouch and glass container + plastic zip lock pouch for a period of three months to assess their shelf life after the storage period with respect to sensory attributes, nutritional composition and microbial quality of the products. Further the acceptable products were then supplemented to malnourished preschool subjects of age group 3-5 years to evaluate their efficacy on the nutritional status of the malnourished children.

Four samples of all the five products were prepared using cereal-pulse as the basic ingredient for control were wheat flour constituting the cereal part and bengal gram flour for the pulse and using different levels of partially defatted peanut cake flour as well as powdered green leafy vegetables. As per the results of sensory evaluation of the products, the salty products like *matthi* and *seviyan* as well as biscuit were found to be acceptable with an incorporation of 10 per cent partially defatted peanut cake flour and 1 per cent fenugreek leaf powder and 1.5 per cent spinach leaf powder respectively. While for *pinni* and *panjiri*, a higher level of incorporation of partially defatted peanut cake flour (15%) and 2 per cent of spinach leaf powder was found to be acceptable.

The value added products were found to have a better nutritional profile especially with respect to crude protein and fat when compared to its control. The proximate composition of the value added products like moisture, crude protein, crude fat, crude fiber and total ash ranged from 2.54 to 4.91 per cent, 16.58 to 23.49 per cent, 18.06 to 27.05 per cent, 1.36 to 3.86 per cent and 0.88 to 3.20 per cent respectively. The highest protein was observed in *seviyan* while the highest fat and energy content was recorded in *pinni* due to higher levels of partially defatted peanut cake flour. The amino acid profile also improved on value addition. Lysine content was in the range 540.98 to 1016.96 mg per 100g for the five value added products, methionine content ranged from 177.67 to 204.76 mg per 100g and the tryptophan content ranged from 142.08 to 158.58mg per 100g of the products. The highest lysine as well as methionine content was recorded in *seviyan* while highest tryptophan content was recorded in biscuits. Highest calcium content of 55.04 mg and iron content of 4.98 mg was observed in the value added *seviyan* followed by *pinni* and *panjiri*. The zinc and phosphorous content ranged from 0.93 to 1.59 mg and 118.43 to 191.81 mg per 100g of product respectively. Lower vitamin C content was observed in all the value added products but was higher compared to the control. Highest beta carotene content of 85.79µg/100g was recorded in *seviyan* while the content ranged from 18.34 to 20.21 µg/100g for the other products. On the addition of peanut flour in all the products, the *in vitro* protein digestibility increased from 42.97 to 60.22 per cent for *matthi*, 57.89 to 68.69 per cent for *seviyan*, 44.98 to 80.13 per cent in *pinni*, 43.92 to 75.29 per cent in *panjiri a*nd 43.04 to 66.38 per cent in biscuits.

Statistical increase was observed in the phytate content of all the products like *matthi* (84.04mg/100g), *pinni* (96.03mg/100g), *panjiri* (94.78mg/100g) and biscuits (80.04mg/100g) while the increase in phytate content in *seviyan* was insignificant. The tannin content reduced significantly in all the value added products while the total phenols increased significantly ($p$<0.01) in all the products. Highest amount of total phenol content was recorded in *pinni* (96.80mg/100g), followed by *panjiri* (95.94mg/100g) then *matthi* (92.22mg/100g) and biscuits with 75.20 mg/100g of total phenols. Aflatoxin was not detected in any of the value added products.

The shelf life studies of the value added products when stored in three different packaging materials for a period of three months revealed decreasing scores with respect to the sensory attributes of the products. The mean overall acceptability scores reduced with increase in the days of storage. Most products stored in different packaging materials were highly acceptable till the 75$^{th}$ day of storage and some products stored in plastic zip lock pouch + glass container were not acceptable at the end of storage period. On analyzing the nutritional composition of the developed value added products after storage, the results revealed a significant ($p$<0.05, $p$<0.01) increase in the moisture content and a significant ($p$<0.05) decrease in total ash content of all the products. A significant ($p$<0.05) reduction in the crude protein and fat content of *matthi*, *pinni* and *panjiri* was noticed when the products were stored in plastic zip lock pouch + glass container for three months. A significant reduction the fat content of the biscuits stored in plastic zip lock pouch + glass container was noticed. With regard to the amino acid profile of the value added products after storage, a significant decrease was observed in the methionine as well as tryptophan content of *matthi* and *seviyan* stored in plastic zip lock pouch + glass container while significant reduction was observed in all the three amino acids of *pinni* and *panjiri* after storage in different packaging materials. In the case of value added biscuits, only lysine content reduced significantly after storage.

A significant decrease in the calcium content of all the products was observed after storage in different packaging materials. Iron also reduced significantly in *matthi, pinni* and biscuits stored in all three packaging materials while the reduction was observed in *seviyan* and *panjiri* stored in plastic zip lock pouch + glass container. Zinc content reduced significantly for all products stored in plastic zip lock pouch + glass container. The beta carotene content of biscuits reduced after storage while reduction in the content was observed for *seviyan* and *panjiri* stored in plastic zip pouch + glass container and for *matthi* stored in aluminium zip lock pouch + glass container and plastic zip pouch + glass container. Vitamin C reduced to nil and a significant reduction in the *in-vitro* protein digestibility of all the developed products were also noticed at the end of storage. The microbiological quality reduced after 60 days of storage of the value added products in all the packaging materials.

The bacterial as well as fungal counts were observed to be higher in the value added products stored in plastic zip lock pouch + glass container when compared to the products stored in glass containers and aluminium zip lock pouch + glass container. The counts were however in the safe limits as prescribed by FSSAI (2012).

The data on the socioeconomic status of the families of the preschool children revealed that most of the children that are 56.25, 57.14, 78.26 and 74.07 per cent from group I, II, III and IV respectively belonged to nuclear family systems. Most of the families earned a monthly income of less than rupees 7000, about 78 per cent of the families from group I, 43 per cent of group II, 78 per cent of group III and 56 per cent from group IV. The age wise distribution of children data revealed that 10.91 per cent belonged to the age group 2-3years, 45.45 per cent belonged to 3-4 years age group and 43.64 per cent belonged to the age group of 4-5 years. In group I and II most of the children were between 4-5 years of age while most of the respondents from group III and IV were between the age 3-4 years. With respect to the health and hygienic practices, all the selected preschool children were vaccinated and most of the children followed clean hygienic practices. The mean daily intake of cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, milk and milk products, sugar and fats in the selected subjects in the age group 2-3 and 3-5 years age group was found to be 74.81±0.08 and 85.35±0.34 g, 12.76±0.04 and 14.23±0.11 g, 23±0.05 and 27.12±0.08g, 14.98±0.13 and 18.72±0.14 g, 25.23±0.05 and 23.14±1.02g, 20.01±0.08 and 21.05±0.05 g, 173.58±0.09 and 160.28±0.11 g, 19.12±0.07 and 25.66±0.14 and 14.09±0.05 and 15.05±0.09g respectively. The per cent adequacy of energy intake was inadequate in both the age groups 2-3 as well as 3-5 years age groups compared to the RDA. The intake of other macro nutrients like protein and fat was also inadequate in both the age groups. The intake of B complex vitamins, vitamin C, minerals like iron, calcium and zinc was also found to be grossly inadequate by the children of both the age groups. With regard to the anthropometric measurements, the study revealed that height, weight and mid upper arm circumference measures were lower than the standards prescribed due to the low intake of food and nutrients by the children.

The mean daily intake of cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, milk and milk products, sugar and fat and oil before supplementation by the subjects of the control group was found to be 90.65±1.16 Kcal, 15.28±1.13 g, 17.48±1.12 g, 22.09±0.06 g, 23.92±1.80 g, 21.07±2.13 g, 143.77±3.10 g, 26.97±1.11 g and 17.61±0.92 g while the respective intake after supplementation increased significantly ($p < 0.05$) to 91.24±0.08 Kcal in case of cereals and significantly ($p < 0.01$) reduced to 22.99±2.11g in case of other vegetables, whereas in case of other food groups there was no significant changes after supplementation. While the mean daily intake of cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, milk and milk products, sugar and fat and oil before supplementation by the subjects of the experimental group was 90.13±2.13 Kcal, 16.01±0.95 g, 16.95±1.55 g, 21.78±0.99 g, 23.44±2.26 g, 22.05±1.98 g, 144.22±2.25 g, 23.56±2.10 g and 17.49±1.09 g respectively, whereas the respective intake after supplementation increased and was found to be 134.40±2.09 kcal, 28.49±1.65 g, 18.85±1.13 g, 22.75±2.25 g, 25.83±1.36 g, 22.45±2.20 g, 145.69±1.16 g, 24.57±2.08 g, and 19.19±1.74 g respectively. Hence, a significant increment ($p$<0.01, $p$<0.05) was observed in the intake of all food groups except for milk and milk products in the experimental group. The supplementation of the developed value added products in the children of the experimental group significantly increased the intake of all the macro as well as micro nutrients. The mean increment in the anthropometric measurements of weight, BMI, MUAC and chest circumference significantly ($p$<0.01, $p$<0.05) increased after supplementation in the children of the experimental group. Due to the positive changes in the anthropometric measurements, the z –scores also significantly increased for WHZ, WAZ, BMI for age and MUAC for age of the children of the experimental group after supplementation. Highest change was observed for BMI for age (29.66%) followed by Weight for height (25.66%). A significant ($p$<0.01) increase in the blood protein, albumin, MCV, MCH, MCHC and haemoglobin was observed in the subjects of the experimental group after supplementation. The highest increment was observed in blood albumin (17.35%) followed by blood protein (9.28%) and then haemoglobin (8.59%) levels of the subjects of the experimental group. Whereas in the case of subjects of the control group was observed with non significant changes in their anthropometric except weight as well as biochemical parameters after supplementation.

**Conclusion**

Based on the results obtained from the present study, the following conclusions have been drawn:

- Five value added products namely *matthi, seviyan, pinni, panjiri* and biscuits were developed and standardised using wheat flour and chick pea flour in the ratio 3:1, partially defatted peanut cake flour and powdered green leafy vegetables like fenugreek and spinach leaf powder with an aim to improve the nutritional status of the malnourished preschool children.
- Incorporation of partially defatted peanut cake flour was acceptable in value added products like m*atthi, seviyan* and biscuits at 10 per cent level and in *pinni and panjiri* at 15 per cent level.
- Incorporation of fenugreek leaf powder was acceptable at 1 per cent in *matthi and seviyan.* Spinach leaf powder was found acceptable at 1.5 per cent in biscuits and 2 per cent in *pinni and panjiri.*

- The developed value added products were found to be high in energy, protein and fat with liberal amounts of micronutrients and high protein digestibility.
- Aflatoxin was not detected in any of the developed products.
- The shelf life studies revealed that the value added products stored in glass containers and aluminum zip lock pouch + glass container retained better sensory parameters as well as nutrition composition and better microbiological quality.
- The selected preschool children of the experimental group was supplemented with the value added products that is 120g of *matthi*, 140 g of *seviyan, pinni, panjiri* and biscuits which provided one third of their RDA requirement.
- Significant increase was found in the intake of all food groups except for milk and milk products as well as all the macro and micro nutrients by the subjects of experimental group after supplementation.
- A significant increment in the anthropometric measurements mainly weight (14.12%), BMI (14.64%), mid upper arm circumference (1.64%) and chest circumference (0.14%) of the subjects of experimental group was observed.
- The biochemical profile also showed a significant increment with respect to the blood albumin (17.35%) followed by blood protein (9.28%) then haemoglobin (8.59%). Mean corpuscular volume, mean corpuscular haemoglobin as well as mean corpuscular haemoglobin concentration also improved in the subjects of the experimental group after supplementation.
- The supplementation of the value added products to the subjects of the experimental group for a period of four months reduced the percentage of moderately malnourished children 83.33 to 43.33 for the z-scores of weight for age, 70 to 36.67 for the z-scores of weight for height and 46.67 to 43 for the z-scores of height for age.

**Recommendations**

- Supplementation of 120-140g of the developed value added products namely *matthi, seviyan, pinni, panjiri* and biscuits using wheat flour and chick pea flour in the ratio of 3:1, partially defatted peanut cake flour at 10-15 per cent and powdered green leafy vegetable at 1-2 per cent increased the nutritional status of the preschool children fulfilling one third of their recommended protein and energy requirement.
- Developed value added products were nutritious, inexpensive and can be included in the supplementary feeding programmes run by the government and non-government agencies to combat malnutrition

## REFERENCES


Abdualrahman M A Y (2013) Chemical, *in-vitro* protein digestibility, minerals and amino acids composition of edible peanut seeds (*Arachis hypogaea* L.). *Sci Intl* **1**: 199-202

Adebayo-Oyetoro A O, Olatidoye O P, Ogundipe O O, Balogun O I and Faboya A O (2011) Quality evaluation of weaning foods produced from the blend of Ofada rice (Oryza sativa) and Bambara groundnut (Voandzeia subterranean L.). *Electronic J Envtal Agri Fd Chem* **10**: 2322-30

Adeladza A (2009) The influence of socio-economic and nutritional characteristics on child growth in kwale district of Kenya. *AJFAND* **9(7**):1570-90

Adenike O M (2013) Studies on the Nutritional quality, anti-nutritional factors, amino acid profile and functional properties of co-fermented wheat/cowpea. *Elixir Fd Sci* **54**: 12360-364

Adenuga W (2010) Nutritional and sensory profile of sweet potato based infant food fortified with cowpea and peanuts. *J Fd Technol* **8(5)**: 223-8

Adjou E S, Yehournon B, Sossou C M, Soumanon M M and DeSouza C A (2012) Occurrence of mycotoxins and associated mycoflora in peanut cake product (*kulikuli*) marketed in Benin. *Afri J Biotech* **11(78)**: 14354-360

Agarwal N and Sharma S (2013) Garden Cress : A non-conventional traditional plant item for food products. *Indian J Traditional Knowledge* **12(4)**: 699-706

Aggarwal K, Kushwah A, Kushwah H S and Rajput L P (2001) Dietary analysis and assessment of nutritional status of preschool children or urban and rural population. *The Ind J Nutr Dietet* **38**: 231-35

Akeson W R and Stachman M A (1964) A pepsin pancreatin digest index of protein quality evaluation. *J Nutr* **83**: 257-261

Akorede Q J and Abiola O M (2013) Assessment of nutritional status of under five children in Akure south local government, Ondo state, Nigeria. *Intl J Res Reviews Applied Sci* **14(3**): 671-81

Alam M J, Talukder M U, Rahman M N, Prodhan U K and Huq AKO (2013) Evaluation of the nutritional and sensory quality of functional breads prepared from whole wheat and soybean flour. *Annals Fd Sci Technol* **14(2)**: 171-75

Algur V, Yadavannavar M C and Patil S S (2012) Assessment of nutritional status of under five children in urban field practice area. *Intl J Current Res Reviews* **4(22)**: 122-26

Aly S E, Faham S E, Ibrahim M A, Hathout A S and Sabry B A (2013) Characterissation and microbial quality of low fat chicken burger containing defatted peanut flour. *J Applied Sci Res* **9(11)**: 5599-608

Amegovu K A, Ogwok P, Owor S, Yiga P, Musalima H J, Mandha J (2014) Sensory acceptability of sorghum peanut blend (SPB) and corn soy blend plus (CSB+) by young children with moderate acute malnutrition in Karamoja, Uganda. *J Fd Res* **3**:17-26

Anwar F, Gupta M K, Prabha C and Srivastava R K (2013) Malnutrition among rural Indian children: An assessment using web of indices. *Intl J Public Health Epidemiol* **2(4)**: 078-084

Anuradha R, Sivanandham R, Salome S D, Roop D, Sampavi S, Sabu S R and Prasad R (2014) Nutritional Status of Children Aged 3-6 Years in a Rural Area of Tamil Nadu. *J Clin Diagonistic Res* **8(10**): JC01-04

AOAC (2000) Official Method of Analysis Association of Official Analytical Chemist, 17tth ed. Washington DC

Arora P (2015) Nutrient adequacy and anthropometric status of preschool children of women migrant labourers. M.Sc Thesis, Punjab Agricultural University, Ludhiana

Ash D M, Tatala S R, Frongillo E A , Ndossi G D and Latham M C (2003) Randomized efficacy trial of a micronutrient-fortified beverage in primary school children in Tanzania. *Am J Clin Nutr* **77(4)**:891-8

Awadalkareem A M, Mustafa A I and Tinay A H E (2008) Protein, Mineral Content and Amino Acid Profile of Sorghum Flour as Influenced by Soybean Protein Concentrate Supplementation. *Pakistan J Nutr* **7(3)**: 475-9

Ayo J A, Ayo V A, Nkama I and Adewor R (2007) Physicochemical, *in-vitro* digestibility and organoleptic evaluation of "*Acha*" wheat biscuits supplemented with soybean flour. *Nigerian Fd J* **25(1)**: 176-80

Aziah N A A, Noor M A Y and Ho L H (2012) Physicochemical and organoleptic properties of cookies incorporated with legume flour. *Intl Fd Res* **19(4)**: 1539-43

Bains K and Brar J K (2009) Assessment of nutritional status of 1-5 years old children belonging to farm families of Punjab. *The Ind J Nutr Dietet* **46**: 345-50

Baljeet S Y, Ritika B Y and Roshan L Y (2010). Studies on functional properties and incorporation of buckwheat flour in biscuit making. *Intl Fd Res J* **17**: 1067-76

Bansal P (2013) Development of value added products with peanut flour for nutritional and health benefits. M.Sc. thesis (Food and Nutrition). Punjab Agricultural University, Ludhiana, Punjab.

Banteman G, Belaynrew W and Dube J (2014) Assessment of Factors Associated with Malnutrition among Under Five Years Age Children at Machakel Woreda, Northwest Ethiopia: A Case Control Study. *J Nutr Fd Sci* **4(1**): 2-7

Barabalok R, Colbarn C R and Smith R J (1974) Rapid screening method for examining corn and corn derived products for possible aflatoxin contamination. *J Assoc Off Anal Chem* **57**:764-66

Bassey F, Mcwatters K, Edem C and Iwegbue M A C (2013) Formulation and nutritional evaluation of weaning food processed from cooking banana, supplemented with cowpea and peanut. *Fd Sci Nutr* **1(5)**: 384-91

Bathla S (2012) Dietary diversity in relation to nutrient adequacy and anthropometric status of rural preschool children. M.Sc Thesis, Punjab Agricultural University, Ludhiana.

Beuchat L R, Champreeda P, Garcia V V, Oupadissakoo C, Haruthaithanasan V, Rosar R R and Mobesa R C (1992) Some New Groundnut Products in Southeast Asia. Groundnut – A Global Prespective (**ed**.) Nigam, S.N., International Crop Research Institute for the Semi-arid Tropics, Patancheru, Andhra Pradesh, India, pp. 249-255

Bhagowalia P, Chen S E and Masters W A (2014) Effects and determinants of mild underweight among preschool children across countries and over time. *Econ Hum Biol* **9**:66–77

Bhan N B and Kaur J (2004) Anthropometric measurements of preschool boys. *The Ind J Nutr Dietet* **41**: 113-17

Bharati S, Pal M and Bharati P (2008) Determinants of nutritional status of pre-school children in India. *J Biosoc Sci* **40**:801–14

Black R, Victora C G, Walker S, Bhutta Z, Christian P, de Onis M, Ezzati M, McGregor S G, Katz J, Martorell R, Uauy R (2013) The Maternal and Child Nutrition Study Group- Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* **82 (9890)**: 427–51

Black R E, Allen L H, Bhutta Z A, Caulfield L E, De Onis M, and Ezzati M (2008) Maternal and child undernutrition: Global and regional exposures and health consequences. *Lancet* **371**:243-60

Booth V H (1971) Problems in determination of FDNB-available lysine. *J Sci Fd Agric* **22**:658-66

Carpenter K J (1960) The estimation of available lysine in animal protein foods. *Biochem J* **77**:604-10

Chandran V K P (2009) Nutritional status of preschool children: a socio-economic study of rural areas of Kasaragod district in Kerala. Abstract of Ph.D thesis. Kannur University, Kerala.

Chaparro C M and Dewey K G (2010) Use of lipid-based nutrient supplements (LNS) to improve the nutrient adequacy of general food distribution rations for vulnerable sub-groups in emergency settings. *Maternal Child Nutr* **6(1)**: 1-69

Cherry J P (1990) Peanut protein and product functionality. *J Amr Oil Chem Soc* **67**: 293-301

Concon J M (1975) Rapid and simple method for the determination of tryptophan in cereal grains. *Anal Biochem* **67**: 206

Dachana K B, Rajiv J, Dasappa I and Prakash J (2010) Effect of dried moringa (*Moringa oleifera Lam*.) leaf on rheological, microstructural, nutritional, textural and organoleptic characteristics of cookies. *J Fd Qual* **33(5)**: 660-77

Dacie J V and Lewis S M (1975) Practical Haematology. Churchill living stone. Edinburg, Great Britain. 5$^{th}$ edition, Pp:31

David B and Frankhausar (2010) Pour plate technique for bacterial enumeration (Cited from http://biology.clc.uc.edu/frankhauser/Labs/Microbiology/Meat_Milk/Pour_Plate.html)

De Onis M, Onyango A W, Borghi E, Garza C and Yang H (2006) Comparison of World Health Organisation Standards and the National Center for Health Statistics/ WHO International Growth Reference: Implication for Child Health Programme. *Public Health Nutr* **9**: 942-7

Desai B B, Kotecha P M and Salunkha D K (1999) Composition and nutritional quality. **In**: Introduction of Science and Technology of groundnut: Biology, Production, Processing and Utilisation. Naya Prakash Publishing, New Delhi, India. Pp-185-199

Devi K B, Vidhya R and Jaganmohan R (2013) Determination and isolation of protein from different fractions of defatted groundnut oil cake. *Afr J Plant Sci* **7(8)**:394-400

Doumas B T, Watson W A and Biggs H G (1971) Qantitative determination of Albumin in human serum on Beckman Coulter Clinical Chemistry AU analyzers. *Clin Chem Acta* **31**: 87-96

Duodu K G, Taylor J R, Belton P S and Hamaker B R (2003) Factors affecting sorghum protein digestibility. *J Cereal Sci* **38**:117- 131

Elemo G N, Elemo B O and Okafor G N C (2011) Preparation and Nutritional Composition of a Weaning Food Formulated from Germinated Sorghum (*Sorghum bicolor*) and Steamed Cooked Cowpea (*Vigna unguiculata* Walp.). *Amr J Fd Technol* **6**: 413-421

Elhardallou B S, Farh G S and Gobouri A A (2015) Production, storage and evaluation of homemade and processed diet, based on wheat, legumes, sesame and dates; for under-five children. *Fd Nutr Sci* **6**:605-11

FAO (2013) reliefweb.int/report/world/fao-statistical-yearbook-2013-world-food-and-agriculture.

Farzana C, Deshpande B and Begum M J (2003) Nutritional components of wheat products. *Ind J Nutr Dietet* **40**: 141-46

Fekria A M, Isam A M A, Suha O A and Elfadil E B (2012) Nutritional and functional characterization of defatted seed cake flour of two Sudanese groundnut (*Arachis hypogaea*). *Intl Fd Res J* **12**: 629-37

Fink G, Olgiati A, Hawela M, Miller J M and Matafwali B (2013) Association between early childhood exposure to malaria and children's pre-school development: evidence from the Zambia early childhood development project. *Malar J* **12**: 12-19

FSSAI (2012) *The food safety and standards (Food product standards and food additives) regulations*. Pp. 25-26. Food Safety and Standards Authority of India, Commercial Law Publishing (India) Pvt. Ltd. New Delhi, India

Gamlath S and Ganesharanee R (2008) Extruded products with Fenugreek (Trigonella foenum-graecium) chickpea and rice: Physical properties, sensory acceptability and glycaemic index. *J Fd Engineering* **90(1)**: 44-52

Ganesh Kumar S, Harsha Kumar H N, Jayaram S, Kotian M S (2010) Determinants of low birth weight: A case control study in a district hospital in Karnataka. *Indian J Pediatr* **77**:87–9

Ghate P R (2014) Food consumption patterns and malnourished Ethiopian children: is there a link? *Res Expo Intl Multidisciplinary Res J* **4(1)**: 8-15

Ghatge N S (2012) Food intake pattern of malnourished preschool children after supplementation of soyaladoo. *Intl Res J Social Sci* **1**:36-40

Global Nutrition Report (2014) Actions and Accountability to Accelerate the World's Progress on Nutrition. International Food Policy Research Institute, Washington DC. p88

Gopalan C, Ramasastri B V and Balasubramaniam (2007) *Nutritive value of Indian Foods.* NIN, ICMR, Hyderabad

Granato D and Ellendersen L S N (2009) Almond and peanut flour supplemented with iron as potential ingredients to develop gluten-free cookies. *Cienc Technol Aliment* **29(2)**: 395-400

Gregory A, Davidson, R and Hutcheon D A (2012) Substituting peanut flour for wheat flour in muffin recipe to increase protein intake. *J Academy Nutr Dietet* **112(9**): 112

Grover K (2002) Nutritional status of rural preschool children belonging to different agroclimatic regions of Punjab. Ph.D. dissertation. Punjab Agricultural University, Ludhiana , India

Gulla S and Waghray K (2012) Blending of oils: A case study on storage stability and sensory characteristics of a ready to eat extruded snack. *J Nutr Dietet Fd Sci* **2(1)**:12-18

Gupta H O and Singh N N (2005) Preparation of wheat and quality protein maize based biscuits and their storage, protein quality and sensory evaluation. *J Fd Sci Technol* **42**(1): 43-46

Gupta S and Prakash J (2011) Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. *Intl Fd Res J* **18**: 667-75

Haq I, Shah M S, Bachh A A and Ansari M A (2010) Validity of Weech's formula in detecting undernutrition in children. *Nepal Med Coll J* **12(4)**: 229-33

Harper A E (1981) Amino acid scoring patterns. Joint FAO/WHO/UNU Expert Consultation on Energy and Protein Requirements. FAO Nutr. Meet. Rep. Ser. No. 37. WHO, Geneva, 71 pp

Haug W and Lantzsch H J (1983) Sensitive method for the rapid determination of phytic acid in cereals and cereals products. *J Sci Fd Agri* **3**: 1423-6.

Horn M J, Jones D B and Blum A E (1946) Colorimetric determination of methionine in proteins and foods. *J Biol Chem* **166**:313-20

Hossain M I, Wahed M A and Ahmed S (2005) Increased food intake after the addition of amylase-rich flour to supplementary food for malnourished children in rural communities of Bangladesh. *Food Nutr Bull* **26(4)**:323-9

HUNGaMA (2011) Fighting Hunger and Malnutrition. . http://www.naandi.org/taxo1s/ hungama-report/

Hunter I and Bonford V N (1968) *Clinical Haematology*. Academic Press, New York

Hyder S M, Haseen F, Khan M, Schaetzel T, Jalal C S, Rahman M, Lonnerdal B, Mannar V and Mehansho H (2000) A multiple-micronutrient-fortified beverage affects hemoglobin, iron, and vitamin A status and growth in adolescent girls in rural Bangladesh. *J Nutr* **137(9)**:2147-53

ICMR (2010) .Nutrient requirements and recommended dietary allowances for indians. A Report of the Expert Group of the Indian Council of Medical Research 2009. NATIONAL INSTITUTE OF NUTRITION Indian Council of Medical Research, Hyderabad. Pp334

Ijarotimi S O and Keshinro O O (2013) Determination of Nutrient Composition and Protein Quality of Potential Complementary Foods Formulated from the Combination of Fermented Popcorn, African Locust and Bambara Groundnut Seed Flour. *Pol J Fd Nutr Sci* **63(3)**: 155-166

IPS (Inter Press Services) (2014) Child Malnutrition Costs Global Economy Billions- Yearly Report. 49p

Jelliffe D (1966) The Assessment of Nutritional Status of the Community. WHO, Genera, Switzerland

Jesmin A, Yamamoto S S, Malik A A and Hague M A (2011).Prevalence and Determinants of Chronic Malnutrition among Preschool Children: A Cross-sectional Study in Dhaka City, Bangladesh. *J Health Popul Nutr* **29(5)**: 494–499

Jood S, Bishnoi S and Sehgal S (1999) Nutritional status of rural lactating women from three zones of Haryana in winter season. *J Dairying Fd Home Sci* **181**:155-65

Jose M P and Indira V (2000) Maternal employment and nutritional status of preschool children. *The Ind J Nutr Dietet* **37**:110-15

Joshi P and Mathur B (2010) Preparation of value added products from the leaf powders of dehydrated less utilized green leafy vegetables. *J Horticulture and Forestry* **2(9)**: 223-28

Juliana K K and Zhengxing C (2008) Effects of processing methods on the physic-functional properties of peanut flour (*Arachis hypogaea* L.) *Biotechnol* **7**: 168-74

Jyothi L A, Bhegum K, Saraswathi G and Prakash J (2003) Nutritional status of rural preschool children- mediating factors. *J Family Welfare* **49(2**): 45-56

Kageni K L (2011) Diarrhoea morbidity and nutritional status among pre- school children of hawking mothers in Nairobi city markets, Nairobi county, Kenya. M.Sc. Thesis. Public Health in the School of Health Sciences, Kenyatta University.

Kalra C L, Sehgal R C, Nagender A, Mohan L and Berry S K (1998) Preparation, quality standards and storage of *matthi*- a traditional savoury product. *J Fd Sci Technol* **35(1)**: 25-29

Kanjilal, B, Mazumdar, P G, Mukherjee M, and Rahman M H (2010) Nutritional status of children in India: household socio-economic condition as the contextual determinant. *Intl J Equity Health* **9**: 19-25

Kapur D, Sharma S and Agarwal K N (2003) Effectiveness of nutrition education, iron supplementation or both on iron status in children. *Indian Pediatrics* **40**:1131-1144

Karthiga K and Uma M D (2015) Formulation and evaluation of pumpkin seed powder incorporated cookies. Proceeding of the 47th ANNUAL NATIONAL CONFERENCE OF NSI, 9-10 October, National Society of India, Hyderabad. PSFSN-07

Kaur P, Dahiya S and Rana R (2015) Development and Nutritional evaluation of Beta-carotene rich products using beet leaf (*Palak*) and Carrot. *Intl J Res* **2(2)**:1324-32

Kaur T J and Kochar G K (2009) Development and Sensory Evaluation of Beta Carotene Rich Food Preparations Using Underexploited Carrot Greens. *J Hum Ecol* **28(3**): 207-212

Kavitha S and Parimalavalli R (2014) Development and evaluation of extruded weaning foods. *European Acad Res* **2(4)**:5197-210

Khader V and Maheswari U K (2012) Effect of feeding malted foods on the nutritional status of pregnant women, lactating women and preschool children in Lepakshi Mandal of Ananthapur district, Andhra Pradesh, India. *Int J Biotechnol Mol Biol Res* **4(4**):35-46

Khan N T, Zanvar S V, Arya A B and Nerlekar P J (2009) Acceptability and nutrient composition of supplementary foods developed for vulnerable groups. *Asian J Home Sci* **3**(2):149-54

Khanam A, ChikkeGowda K R, Swamylingappa B (2013) Functional and nutritional evaluation of supplementary food formulations. *J Fd Sci Technol* **50**(**2**):309–16

Khosla S, Singh I and Sangha J (2000) A study of nutritional profile of preschool living in urban slums of Ludhiana city. *J Res Punjab Univ* **37**:124-32

Kumari R K R and Prakash J (2009) Influence of soy protein incorporation on acceptability and shelf-stability of sorghum based '*seviya*'. *Indian J Sci Technol* **2(4)**: 53-59

Kumari S and Singh S (2001) Nutritional status of children belonging to scheduled caste: a study in Samastipur district of Bihar. *The Ind J Nutr Dietet* **38**:428-36

Lakshmi U K and Padma P (2004) Impact of NSS programme on the nutritional status pf preschool children. *The Ind J Nutr Dietet* **41**:229-40

Larmond E (1970) Methods of sensory evaluation of food. *Can Deptt Agric Pubs* 1970:s1284

Liu D C, Hu X H, Zhang W N, Wang Y and Liu Y F (1996) Research on preparation and functional properties of peanut flour and peanut protein concentrate. *China Oils Fats* **21(3**): 5-7

Madukwe E U, Edeh R I and Obizoba I C (2013) Nutrient and Organoleptic Evaluation of Cereal and Legume Based Cookies**.** *Pakistan J Nutr* **12 (2)**: 154-7

Mahfuz M, Ahmed T, Ahmed A M S, Islam M M and Hossain M I (2014) Weight Gain in Malnourished Children after 5 Months Food Supplementation in a Slum Setting in Bangladesh. *Fd Nutr Sci* **5**: 1370-8

Manary M J, Ndekha M J, Ashorn P, Maleta K and Briend A (2004) Home based therapy for severe malnutrition with ready-to-use food. *Arch Dis Child* **89**:557–61

Mandal S, Prabhakar V R, Pal J, Parthasarathi R, Biswas R (2015) An assessment of nutritional status of children aged 0-14 years in a slum area of Kolkata. *Intl J Med Public Health* **4(2)**: 159-62

Manyike P C, Chinawa J M, Ubesie A, Obu H A, Odetunde O I and Chinawa A T (2014) Prevalence of malnutrition among pre-school children in, South-east Nigeria. *Italian J Pediatrics* **40**:75-80

Masuda K, Inoue Y, Inoue R, Nakamura A, Chitundu M, Murakami J, Ota Y and Matsugami (2014) Spirulina Effectiveness Study on Child Malnutrition in Zambia. Institute of Development Studies- Special collections. 49-56

Meshram I I, Balakrishna N, Arlappa N, Mallikarjun K R, Laxmaiah A and Brahmam G N V (2014) Prevalence of Undernutrition, Its Determinants, and Seasonal Variation Among Tribal Preschool Children of Odisha State, India. *Asia Pac J Public Health* **26**: 470-80

Mishra G and Mishra A A (2014) Studies on Effect of HDPE and LDPE on storage stability of weaning Food prepared from pulse, banana and pineapple pomace. *IJIAS* **7(2)**:502-11.

Mishra G, Mishra A A and Shukla R N (2014) Development of pulse, banana and pineapple pomace based weaning food and its quality evaluation during storage. *Intl J Development Res* **4(6)**:1257-62

Mishra R N (2015) Hunger, Undernutrition and Food Security in India . SS Current Affairs Mishra on Union Budget. Pp 1-9.

Mittal A, Singh J and Ahluwalia S K (2007) Effect of maternal factors on nutritional status of 1-5-year old children in urban slum population. *Indian J Community Med* **32**:264–7

Mittal S (2011) *Organoleptic and nutritional evaluation of gluten free products for celiac disease patients.* M.Sc Thesis, Punjab Agricultural University, Ludhiana.

Mohamed G F, Sulieman A M, Soliman N G and Bassiuny S S (2014) Fortification of Biscuits with Fish Protein Concentrate. *World J Dairy Fd Sci* **9(2)**: 242-49

Mosha T C and Vincent M M (2004) Nutritional value and acceptability of homemade maize/sorghum-based weaning mixtures supplemented with rojo bean flour, ground sardine and peanut paste. *Intl J Fd Sci Nutr* **55**: 301-15

Mulik M and Salunkhe A (2014) Effectiveness of 'krishna poshak mix' on nutritional status of rural anganwadi children. *Intl J Sci Res* **3(4)**:206-09

Mwangome M, Prentice A, Plugge E and Nweneka C (2010) Determinants of Appropriate Child Health and Nutrition Practices among Women in Rural Gambia. *J Health Popul Nutr* **28(2)**: 167–72

Nabuuma D, Nakimbugwe D, Byaruhanga Y B, Saalia F K, Phillips R D and Chen J (2013) Formulation of a drinkable peanut-based therapeutic food for malnourished children using plant sources. *Intl J Fd Sci Nutr* **64(4)**: 467-75

Nailwal N (2012) *Organoleptic and nutritional evaluation of antioxidant rich products of sweet potato (Ipomoea batatas).* M.Sc Thesis, Punjab Agricultural University, Ludhiana.

Ndife J, Kida F and Fagbemi S (2014) Production and quality assessment of enriched cookies from whole wheat and full fat soya. *European J Fd Sci Technol* **2(1)**: 19-28

Nicole M, Fei H Y and Claver I P (2010) Characterization of Ready-to-Eat Composite Porridge Flours Made by Soy-Maize-Sorghum-Wheat Extrusion Cooking Process. *Pakistan J. Nutr* **9 (2)**: 171-8

NIN (1986) Anaemia and endurance capacity (Physical performance). Annual Report. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad. Pp:164-5

Nola N P, Sop M M K, Mananga M J, Ekoe T and Gouado I (2014) Assessment of nutritional status of preschool children in the Bangang rural community, Cameroon. *Intl J.Biotechnol Fd Sci* **2(2)**: 44-52

NPB (2009) Peanut flour power. National Peanut Board. www.national peanutboard.org.

Nyirahakizimana H, Mwamburi L, Walhisi J, Mutegi C K, Christie M E and Wagacha J M (2013) Occurrence of Aspergillus species and aflatoxin contamination in raw and roasted peanuts from formal and informal markets in Eldoret and Kericho town, Kenya. *Advances in Microbiol* **3**: 333-42

Ojali U G, Elijah A U, Nicholas A O and Morayo B R (2015) Proximate composition and anti-nutrient properties of breakfast cereals made from blends of local rice, soybeans and defatted coconut flours. *J Nutr Fd Sci* S11: 006. doi: 10.4172/2155-9600.1000S11-006

Oluwole O B, Awonorin S O, Henshaw F, Elemo G N and Ebuchi O A T (2013) Assessment of microbial changes and nutritional qualities of extruded White Yam (*Dioscorea rotundata*) and Bambara groundnut (*Uigna subterranean*) blends. *Fd Nutr Sci* **4**: 100-107

Omwamba M and Mahungu S M (2014) Development of a Protein-Rich Ready-to-Eat Extruded Snack from a Composite Blend of Rice, Sorghum and Soybean Flour. *Fd Nutr Sci* **5(14)**: 1309-17

Onis M, Blossne M and Borghi E (2011) Prevalence of stunting among pre-school children 1990-2020. *Growth Assessment and Surveillance Unit, Public Health Nutrition* **14**: 1–7

Onoja U S, Akubor P I, Gernar D I and Chinmma C E (2014) Evaluation of Complementary Food Formulated from Local Staples and Fortified with Calcium, Iron and Zinc. *J Nutr Fd Sci* **4(6)**: 2-6

Osuolale J K and Olayiwoola A S (2014) Development and quality evaluation of defatted groundnut and melon kernel flour based ethnic product "*Robo". Afri J Fd Sci* **8(6)**:311-15

Owino V O, Kasonka L M, Sinkala M M, Wells J K, Eaton S, Darch T, Coward A, Tomkins A M and Filteau S M (2007). Fortified complementary foods with or without alpha-amylase treatment increase hemoglobin but do not reduce breast milk intake of 9-mo-old Zambian infants. *Am J Clin Nutr* **86(4)**:1094-103

Pallavi B V, Chetana R and Reddy S Y (2014) Processing, physico-chemical, sensory and nutritional evaluation of protein, mineral and vitamin enriched peanut *chikki* - an Indian traditional sweet . *J Fd Sci Technol* **51(1)**:158–62

Pandey S, Jha A, Khemariya P, Kumar S and Rao M (2014) Shelf-life and microbiological safety studies of refrigerated *petha* sweet. *J Fd Sci Technol* **51(11**): 3452–57

Pant R (2011) *Developemnt and nutritional evaluation of value added cereal pulse based products using drumstick leaf.* M.Sc Thesis, Punjab Agricultural University, Ludhiana

Patel D, Gupta P, Shah D and Sethi K (2010) Home-based Rehabilitation of Severely Malnourished Children in Resource Poor Setting. *Indian Pediatrics* **47**:694-701

Pee D S and Bloem W M (2009) Current and potential role of specially formulated foods and food supplements for preventing malnutrition among 6- to 23-month-old children and for treating moderate malnutrition among 6- to 59-month-old children. *Fd Nutr Bull* **30**:34-63

Pee S D and Bloem M W (2008) Current and Potential role of specially formulated foods and food supplementation for preventing malnutrition among 6-8 months old and treating moderate malnutrition among 6- 59 month old children. WHO, UNICEF, WFP and UNHCR Consultation on the Dietary Management of Moderate Malnutrition in Under-5 Children by the Health Sector September 30th October 3rd, 2008.

Pelkman C L, Fishell V K, Maddox D H, Pearson T A, Mauger D T and Kris-Etherton P M (2004) Effects of moderate-fat (from monounsaturated fat) and low-fat weight-loss diets on the serum lipid profile in overweight and obese men and women. *Am J Clin Nutr* **79**:204–12.

Phuka J C, Maleta K, Thakwalakwa C, Cheung Y B, Briend A, Manary M J and Eshorn P (2013) Complementary feeding with fortified spread is likely to reduce the incidence of severe stunting among 6-18 months old rural Malawian infants. *Arch Pediatr Adolesc Med* **162(7)**: 619-26

Piper C S (1950) Soil and plant analysis. Interscience Publication, Inc. New York. Pp:212

Polpuech C, Chavasit V, Srichakwal P and Panangvait P (2011) Effects of fortified lysine on the amino acid profile and sensory qualities of deep-fried and dried noodles. *Malyasian J Nutr* **17(2)**: 237-48

Prasad R, Gupta A, Parihar R and Gangwar K (2014) *In vitro* method for predicting the bioavailability of iron from Bathua (*Chenopodium album*) and Fenugreek (*Trigonella foenum graecum*) leaf in Indian cookies. *J Applied Natural Sci* **6 (2)**: 701 - 6

Preethi B and Chimmad B (2010) Utilization of linseed for value addition to supplementary food. *Karnataka J Agric Sci* **23**(5):765-68.

Purohit C and Rajyalakshmi P (2011) Quality of products containing defatted groundnut cake flour. *J Fd Sci Technol* **48**: 26-35

Quisumbing, A R and Haddad L P C (1999) Gender and Poverty: New Evidences from Ten Developing Countries. International Food Policy Research Institute, Washington DC. p95

Raghuramulu N, Mahadevan N K and Kalyana S S (1983) *A manual of laboratory techniques.* NIN, ICMR, Hyderabad, India. Pp:254-56

Raja W H, Kumar S, Bhat Z F and Kumar P (2014) Effect of ambient storage on the quality characteristics of aerobically packaged fish curls incorporated with different flours. *SpringerPlus* **3(106)**: 1-10

Rajawat P, Kushwaha A and Kushwaha H S (2002) Organoleptic and nutritive storing of extruded faba bean supplemented cereal recipes. *Ind J Nutr Dietet* **39**:123-25

Rama Rao D, Kiresur V R and Sastry R K (2000) Technological Forecasting of Future Oilseeds Scenario in India (ICAR-AP CESS Project). National Academy of Agricultural Research Management, Rajendranagar, Hyderabad

Ramachandran P and Gopalan H S (2010) Undernutrition & risk of infections in preschool children. *Indian J Med Res* **130**: 579-83

Raman D R, Pithadia P R., Kaushik L K, Jitesh M P and Sudha Y B (2013) A study on assessment of nutritional and immunization status of under-five children in urban slums of Jamnagar city, Gujarat. *Health line* **4(2)**: 35-9

Rangana S (1995) *Handbook of analysis and quality control for fruit and vegetable products.*Tata Mc Graw Hill Publishing Company limited, New Delhi

Ranganna, S. (2001). Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Ranganna, S. (Ed.). Tata McGraw-Hill Publications, New Delhi. 719-24

Rani V, Grewal R B and Khetarpaul N (2008) Sensory and nutritional evaluation of soy supplemented nutritious baked products. *J Dairying, Fd Home Sci* **27 (3/4)** : 209 – 15

Robinson H W and Hogden C G (1940) The biuret reaction in the determination of serum proteins II: Measurements made by a Duboscq colorimeter compared with values obtained by kjeldahl procedure . *J Biol Chem* **135**:727-31

Sadana B, Bakhetia P and Agarwal R (2008) Nutritional evaluation of germinated wheat and Soybean based supplementary foods. *Indian J Ecol* **35(1)**: 87-90

Saha R and Dunkwal V (2009) Development and Nutritional Analysis of Value Added Spread Instant Mix. *J Hum Ecol* **28(3)**: 187-90

Salve R V, Mehrajfatema Z M, Kadam M L and More S G (2011) Formulation, nutritional evaluation and storage study of supplementary food (*panjiri)*. *J Fd Process Technol* **2**:131-36

Sandige H, Ndekha M J, Briend A, Ashorn P and Manaray M J (2004) Home-Based Treatment of Malnourished Malawian Children with Locally Produced or Imported Ready-to-Use Food. *J Pediatric Gastroenterol Nutr* **39**:141–6

Sashidhar R B, Bhat R V and Vasanthi S (1989) Non competitive Enzyme Linked Immuno-Sorbent Assay for detection of aflatoxin $B_1$. *Indian J Exp Biol* **26**:984-89

Satusap P, Chavasit V, Kriengsinyos W and Judprasong K (2014) Development of cereal and legume based food products for the elderly. *SpringerPlus* **3**: 2-8

Saurabh S, Jyoti J, Genitha T R and Vikas T P R (2013) Studies on Development, Quality Evaluation and Packaging Materials on the Storage Stability of Snack Food (*SEV*). *Intl J Agric Fd Sci Technol* **4(6)**: 515-22

Saxena A and Stanley J U (2003) Seasonal food intake and nutrient distribution patterns among rural Rajput children in Rajathan. *The Ind J Nutr Dietet* **40**:333-40

Schmid M A, Salomeyesudas B, Satheesh P, Hanley J and Kuhnlein H V (2007) Intervention with traditional food as a major source of energy, protein, iron, vitamin C and vitamin A for rural Dalit mothers and young children in Andhra Pradesh, South India. *Asia Pac J Clin Nutr* **16**:84–93

Seevaratnam V, Banumathi P, Premalatha M R, Sundaram S P and Arumugam T (2012) Studies on the Preparation of Biscuits Incorporated with Potato Flour. *World J Dairy Fd Sci* **7 (1)**: 79-84

Serrem, Charlotte A, de Kock, Henriëtte L , Taylor, John R N (2011) Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour. *Intl J Fd Sci Technol* **46(1)**: 74-83

Shah K (2005) *Development and nutritional evaluation of supplementary foods using defatted soy flour*. M.Sc Thesis, Punjab Agricultural University, Ludhiana.

Singh I and Grover K (2003) Nutritional profile of urban preschool children of Punjab. *Anthropologist* **5**:149-53

Sivakumar B, Nair K M, Sreeramulu D, Suryanarayana P, Ravinder P, Shatrugna V, Kumar P A, Raghunath M, Rao V V, Balakrishna N, Kumar P U and Raghuramulu N (2006) Effect of micronutrient supplement on health and nutritional status of schoolchildren. *Biochemical status Nutr* **22(1**):S15-25

Soher E A, Faham S E, Ibrahim M A, HathoutA S and Sabry B A (2013) Characterization and microbiological quality of low-fat chicken burger containing defatted peanut flour. *J Applied Sci Res* **9(11)**: 5599-608

Srivastava S, Neerubala, Singh S and Shamim M Z (2015) Nutritional composition of weaning food using malted cereal and pulses flour for infants. *Intl J Pure App Biosci* **3 (1)**: 171-85

Srivastava Y, Semwal A D, Sharma G K and Bawa A S (2011) Utilization of Virgin Coconut Meal (VCM) in the Production of Ready-to-Eat Indian Traditional Sweet Meat Using Response Surface Methodology. *Fd Nutr Sci* **2**: 214-21

Stephens A M, Dean L L, Davis J P, Osborne J A and Sanders T H (2010) Peanuts, peanut oil and fat free peanut flour reduce CVD risk factors and the development of artherosclerosis in Syrian golden hamsters. *J Fd Sci* **75**: H116-22

Takanashi K (2009) Survey of food-hygiene practices at home and childhood Diarrhea in Hanoi, Viet Nam. *J. Clinical Nutri* **11**:37-45

Talwar G and Brar S K (2015) Study of Physiochemical, Sensory and Color Properties of Pinni Variants. *Indian J Sci Technol* **8(7)**: 629-34

Tate R V, Chavan J K, Patil P B and Kadam S S (1990) Processing of commercial peanut cake into food-grade meal and its utilization in preparation of cookies. *Plt Fd Human Nutr* **40**: 115-21.

Tharanathan R N, Wankhede D B, Madhava R R and Raghavendra R (1975) Carbohydrate composition of groundnuts (*Arachis hypogaea*). *J Sci Fd Agric* **26**: 749-54.

Torheim L E, Ouattara F, Diarra M M, Thiam F D, Barikmo I, Hatloy A and Oshaug A (2004) Nutrient adequacy and dietary diversity in rural Mali: association and determinants. *European J Clin Nutr* **58(4)**: 594-604.

Toure A, Xiaoming Z, Sangare A, Diallo M T, Xia L, Bangoura M, Bangoura M L and Brook J (2007) Production and characterization of a weaning food from Dissioule rice and Philippine peanut locally grown in Guinea. *Amr J Fd Technol* **2**: 421-27.

Udenigwe C C, Ramprasath V R, Aluko R V and Jones P J (2008) Potentials of resveratrol in anti-cancer and anti-inflammatory therapy. *Nutr Review* **66(8**): 445-54.

UN (2011) Inter-agency Group for Child Mortality Estimation *Levels & Trends in Child Mortality: Report 2011*, New York: UNICEF.

UNICEF (2012) Programming Guide, Infant and Young Child Feeding. p89.

UNICEF (2013) Improving Child Nutrition- The Achievable Imperative for Global Progress. p132.

UNICEF-WHO-The World Bank (2012) Levels and Trends in Child Malnutrition. *UNICEF-WHO-The World Bank Joint Child Malnutrition Estimates.* p35.

Usman G O, Ameh U E, Alifa O N and Babatunde R M (2015) Proximate Composition of Biscuits Produced from Wheat Flour and Maize Bran Composite Flour Fortified with Carrot Extract. *J Nutr Fd Sci* **5(5)**: 1-2.

Van de Poel E, Hosseinpoor A R, Speybroeck N, Van Ourti T and Vega J (2008) Socioeconomic inequality in malnutrition in developing countries. *Bull World Health Organ* **86**: 282–91.

Venkataraghavan U (1998) Newer dimensions in the progressing of oilseeds for food use. *Indian Fd Indus* **17**: 272-75.

Verma R, Khanna P,  Gaur D, Meena and Prinja S (2007) Assessment Of Nutritional Status And Dietary Intake Of Pre-School Children In An Urban Pocket. *The Internet J Nutr Wellness* **6(1)**: 101-12.

Verma S and Jain S (2012) Fortification of *mathri* with fresh and dehydrated vegetables and assessment of nutritional quality. *Raj J Extn Edu* **20**: 155-58.

Victora and Cesar (2010) Worldwide Timing of Growth Faltering: Revisiting implications for Interventions. *Pediatrics* **125(3)**: 473-76.

Vinod N, Swarnakanta L, Smita P and Pushpa D (2011) Nutritional status and dietary pattern of under five children in urban slum area. *National J Community Med* **2(1**): 143-48.

Waddington H, Snilstveit B, White H, and Fewtrell L (2009) Water, Sanitation and Hygiene Interventions To Combat Childhood Diarrhoea in Developing Countries. Vol. 31. Delhi: International Initiative for Impact Evaluation.

Waghray K and Gulla S (2010) Butylated Hydroxyanisole (BHA) to Maximize the Oxidative Stability of Snacks: A Case Study with *Sev* and *Boondi. J Hum Ecol* **32(2**): 97-99.

Wang X, Hojer B, Guo S, Luo S, Zhou W and Wang Y (2009) Stunting and overweight in the WHO child growth standards- malnutrition among children in a poor area of China. *Pub Health Nutr* **12**: 1991-98.

WHO (2006) World Health Organization Child Growth Standards: Methods and Development. Geneva.

WHO (2011) Severe Acute Malnutrition. (http://www.who.int/pem/topics/en/index.html).

Win M M, Abdul-Hameed A, Baharin B S, Anwar F, Sabu M C and Pak-Dek M S (2011) Phenolic compounds and antioxidant activity of peanut’s skin, hull, raw kernel and roasted kernel flour. *Pak J Bot* **43(3**): 1635-42.

Wolanski N (1964) Arm circumference 1-60 months. In Assessment of nutritional status of community by D B Jelliffe WHO, Geneva.

Wong H J, Moy F M and Nair S (2014) Risk factors of malnutrition among preschool children in Terengganu, Malaysia: a case control study. *BMC Public Health* **14**: 785-89.

World Bank. India (2014) Undernourished children: A call for reform and action. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/, contentMDK:20916955~pagePK:146736~piPK:146830~theSitePK:223547,00.html

Yadav D N, Thakur N and Sunooj K V (2012a) Effect of Partially De-Oiled Peanut Meal Flour (DPMF) on the Nutritional, Textural, Organoleptic and Physico Chemical Properties of Biscuits. *Fd Nutr Sci* **3**: 471-76.

Yadav R B, Yadav B S and Dhull N (2012b) Effect of incorporation of plantain and chickpea flour on the quality characteristics of biscuits. *J Fd Sci Technol* **49(2)**: 207-13.

Yadav D N, Thakur N, Sunooj K V and Singh K K (2013) Effect of de-oiled peanut meal flour (DPMF) on the textural, organoleptic and physico chemical properties of bread. *Intl Fd Res J* **20(3**): 1307-12.

Yegammai C and Lakshmi J (1999) Nutriitonal profile of institutionalized orphan children in Pondicherry. *The Ind J Nutr Dietet* **35**: 221-27.

Youssef H M K E (2015a) Production of high nutritive value and physical and sensory characteristic wheat biscuits fortified with chick pea flour. *Life Sci J* **12(6)**: 193-97.

Youssef H M K E (2015b) Assessment of Gross Chemical Composition, Mineral Composition, Vitamin Composition and Amino Acids Composition of Wheat Biscuits and Wheat Germ Fortified Biscuits. *Fd Nutr Sci* **6**: 845-53.

Yu J, Ahmedna M and Goktepe I (2007) Peanut protein concentrates: production and functional properties is affected by processing. *Fd Chem* **103**: 121-29.

Zhao X, Chen J and Du F (2012) Potential use of peanut by-products in food processing: a review. *J Fd Sci Technol* **49(5)**: 521-29.

Zhou Y, Wang J, Yang X, Lin D, Gao Y, Su Y, Yang S, Zhang Y and Zheng J (2013) Peanut allergy, allergen composition and methods of reducing allergenicity- A review. *Intl J Fd Sci* **13(06)**: 261-69.

Zuguo M and Laurence M G (2007) Standard deviation of anthropometric z-scores as a data quality assessment tool using the 2006 WHO growth standards: A cross country analysis. *Bulletin World Health Organization* **85**: 441-48.

**APPENDIX I**

**9 POINT HEDONIC RATING SCALE**

**Name ____________________________** **Date _____________**

**Product __________________________**

Test this sample and check how much you like or dislike one. Use appropriate scale to show your attitude by assigning points that best express your feelings about the sample. An honest expression of feeling will help us.

| Treatment | Appearance | Colour | Texture | Aroma | Taste | Overall Acceptability | Remarks |
|---|---|---|---|---|---|---|---|
| **S1** | | | | | | | |
| **S2** | | | | | | | |
| **S3** | | | | | | | |
| **S4** | | | | | | | |

| **Rating** | **Scores** |
|---|---|
| Like extremely | 9 |
| Like very much | 8 |
| Like moderately` | 7 |
| Like slightly | 6 |
| Neither like nor dislike | 5 |
| Dislike slightly | 4 |
| Dislike moderately | 3 |
| Dislike very much | 2 |
| Dislike extremely | 1 |

_____________

**Signature**

## APPENDIX II

### Parent Consent Letter

**Dear Parents,**

I, T. Bindhya Dhanesh (L-2012-HSc-89D), am a Ph.D student of the Food and Nutrition department, College of Home Science, Punjab Agricultural University, Ludhiana. As a part of my research work, I am carrying out a study on the impact of supplementation of value added products using partially defatted peanut cake flour on the nutritional status of preschool children. I hope that the positive changes will be helpful for our community, state as well as the country to eradicate malnutrition.

I am humbly requesting for your permission to allow me to select your son/daughter who is suffering from mild/moderate malnutrition to be a part of my research work for the supplementation of value added products like *matthi*, *seviyan*, *pinni*, *panjiri* and biscuits using partially defatted peanut cake flour and green leafy vegetable powder for a period of four months and for further assessment of their nutritional profile.

The assessment involves anthropometric as well as biochemical assessment of their blood profile before and after supplementation of the value added products. The products will be supplemented to your children in the respective anganwadis (ICDS centers) they attend with the help of their teacher and anganwadi worker.

This research has been approved by the Ethics Committee of Punjab Agricultural University, Ludhiana under No. DR 12505-14/16-4-2014. If you have any queries you may contact me Bindhya Dhanesh (Ph.D. student) at 8557997966 or my advisor Dr. Anita Kochhar (Professor and Head) at 9988880346.

Many thanks in advance for your consideration of this research.

Regards,

T. Bindhya Dhanesh (Ph.D Research student)

Dr. Anita Kochhar

Professor and Head

Dept of Food and Nutrition, PAU, Ludhiana

## ਮਾਪਿਆਂ ਦੀ ਸਹਿਮਤੀ ਲਈ ਪੱਤਰ

**ਪਿਆਰੇ ਮਾਪਿਓ**

ਮੈਂ, ਟੀ. ਬਿੰਦੀਆ ਦਾਨੇਸ਼ (L-2012-HSc-89D), ਪੰਜਾਬ ਖੇਤੀਬਾੜੀ ਯੂਨੀਵਰਸਿਟੀ ਲੁਧਿਆਣਾ ਦੇ ਫੂਡ ਅਤੇ ਨਿਊਟ੍ਰੀਸ਼ਨ ਵਿਭਾਗ ਵਿਖੇ ਪੀ.ਐਚ.ਡੀ. ਦੀ ਵਿਦਿਆਰਥਣ ਹਾਂ। ਆਪਣੇ ਖੋਜ ਕਾਰਨ ਲਈ ਮੈਂ ਸਕੂਲ ਨਾ ਜਾਣ ਵਾਲੇ ਛੋਟੇ ਬੱਚਿਆਂ ਦੇ ਪੌਸ਼ਟਿਕ ਪੱਧਰ ਉਪਰ ਡੀਫੈਟਿਡ ਮੂੰਗਫਲੀ ਦੇ ਆਟੇ ਦੀ ਵਰਤੋਂ ਨਾਲ ਤਿਆਰ ਕੀਤੇ ਭੋਜਨ ਪਦਾਰਥਾਂ ਦੇ ਪ੍ਰਭਾਵ ਦਾ ਮੁਲਾਂਕਣ ਕਰਨ ਲਈ ਅਧਿਐਨ ਕਰ ਰਹੀ ਹਾਂ। ਮੈਨੂੰ ਆਸ ਹੈ ਕਿ ਮੇਰੇ ਅਧਿਐਨ ਦੇ ਸਾਕਾਰਆਤਮਕ ਬਦਲਾਅ ਸਮਾਜ, ਰਾਜ ਅਤੇ ਦੇਸ਼ ਵਿੱਚੋਂ ਕੁਪੋਸ਼ਣ ਨੂੰ ਦੂਰ ਕਰਨ ਵਿੱਚ ਸਹਾਈ ਸਿੱਧ ਹੋਣਗੇ।

ਮੇਰੀ ਆਪਜੀ ਨੂੰ ਬੇਨਤੀ ਹੈ ਕਿ ਆਪ ਆਪਣੇ ਪੁੱਤਰ/ਪੁੱਤਰੀ ਜੋਕਿ ਥੋੜ੍ਹੇ/ਦਰਮਿਆਨੀ ਪੱਧਰ ਤੱਕ ਕੁਪੋਸ਼ਣ ਦਾ ਸ਼ਿਕਾਰ ਹੈ, ਨੂੰ ਇਸ ਖੋਜ ਕਾਰਨ ਵਿੱਚ ਸ਼ਾਮਿਲ ਕਰਨ ਲਈ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਦਿਓ ਤਾਂਜੋ ਉਹਨਾਂ ਨੂੰ ਡੀਫੈਟਿਡ ਮੂੰਗਫਲੀ ਦੇ ਆਟੇ ਅਤੇ ਹਰੀਆਂ ਪੱਤੇਦਾਰ ਸਬਜ਼ੀਆਂ ਦੇ ਪਾਊਡਰ ਦੀ ਆਂਸ਼ਿਕ ਤੌਰ ਤੇ ਵਰਤੋਂ ਕਰਕੇ ਤਿਆਰ ਕੀਤੇ ਗਏ ਸਪਲੀਮੈਂਟਿਡ ਭੋਜਨ ਪਦਾਰਥਾਂ ਜਿਵੇਂ ਕਿ ਮੱਠੀ, ਸੇਂਵੀਆਂ, ਪਿੰਨੀ, ਪੰਜੀਰੀ ਅਤੇ ਬਿਸਕੁੱਟ ਆਦਿ ਚਾਰ ਮਹੀਨੇ ਤੱਕ ਖਾਣ ਲਈ ਦਿੱਤੇ ਜਾਣ ਅਤੇ ਇਸ ਮਗਰੋਂ ਉਹਨਾਂ ਦੇ ਪੌਸ਼ਟਿਕ ਪੱਧਰ ਦਾ ਮੁਲਾਂਕਣ ਕੀਤਾ ਜਾ ਸਕੇ।

ਅਧਿਐਨ ਦੌਰਾਨ ਬੱਚਿਆਂ ਨੂੰ ਸਪਲੀਮੈਂਟਿਡ ਭੋਜਨ ਪਦਾਰਥਾਂ ਖੁਆਉਣ ਤੋਂ ਪਹਿਲਾਂ ਅਤੇ ਇਸ ਮਗਰੋਂ ਉਹਨਾਂ ਦੇ ਐਂਥਰੋਪੋਮੈਟ੍ਰਿਕ (ਸਰੀਰਕ ਵਿਕਾਸ) ਅਤੇ ਖੂਨ ਦੀ ਜਾਂਚ ਕਰਕੇ ਉਹਨਾਂ ਦੇ ਜੀਵ-ਰਸਾਇਣਕ ਬਦਲਾਅਵਾਂ ਦਾ ਮੁਲਾਂਕਣ ਕੀਤਾ ਜਾਵੇਗਾ। ਤੁਹਾਡੇ ਬੱਚਿਆਂ ਨੂੰ ਇਹ ਭੋਜਨ ਪਦਾਰਥ ਆਂਗਨਵਾੜੀ (ਆਈ.ਸੀ.ਡੀ.ਐਸ. ਕੇਂਦਰ) ਵਿਖੇ ਉਹਨਾਂ ਦੇ ਅਧਿਆਪਕ ਅਤੇ ਆਂਗਨਵਾੜੀ ਵਿੱਚ ਕੰਮ ਕਰਨ ਵਾਲੇ ਕਾਮਿਆਂ ਦੁਆਰਾ ਦਿੱਤੇ ਜਾਣਗੇ।

ਇਸ ਖੋਜ ਕਾਰਜ ਨੂੰ ਪੰਜਾਬ ਖੇਤੀਬਾੜੀ ਯੂਨੀਵਰਸਿਟੀ ਲੁਧਿਆਣਾ ਦੀ ਆਚਾਰ ਸਮਿਤੀ ਵੱਲੋਂ DR 12505-14/16-4-2014 ਅਧੀਨ ਮਨਜ਼ੂਰੀ ਦਿੱਤੀ ਗਈ ਹੈ। ਜੇਕਰ ਤੁਸੀਂ ਹੋਰ ਕੁੱਝ ਪੁੱਛਣਾ ਚਾਹੁੰਦੇ ਹੋ ਤਾਂ ਤੁਸੀਂ ਮੇਰੇ ਨਾਲ 8557997966 ਨੰਬਰ ਉਪਰ ਜਾਂ ਮੇਰੇ ਸਲਾਹਕਾਰ ਡਾ. ਅਨੀਤਾ ਕੋਚਰ (ਪ੍ਰੋਫੈਸਰ ਅਤੇ ਮੁੱਖੀ) ਨਾਲ 998880346 ਨੰਬਰ ਉਪਰ ਸੰਪਰਕ ਕਰ ਸਕਦੇ ਹੋ।

ਇਸ ਖੋਜ ਕਾਰਜ ਨੂੰ ਸਮਝਣ ਲਈ ਮੈਂ ਤੁਹਾਡੀ ਸ਼ੁਕਰਗੁਜ਼ਾਰ ਹਾਂ।

ਆਦਰ ਸਹਿਤ

ਟੀ. ਬਿੰਦੀਆ ਦਾਨੇਸ਼ (ਪੀ.ਐਚ.ਡੀ. ਵਿਦਿਆਰਥੀ)

ਡਾ. ਅਨੀਤਾ ਕੋਚਰ
ਪ੍ਰੋਫੈਸਰ ਅਤੇ ਮੁੱਖੀ
ਫੂਡ ਅਤੇ ਨਿਊਟ੍ਰੀਸ਼ਨ ਵਿਭਾਗ

**Consent Slip**

I have read the consent letter and I am clear about the procedures on the assessment and supplementation details mentioned in the same. I hereby permit my son/daughter to be a part of your research study.

| Name of the parent (Father/Mother) | Signature |
|---|---|
| | |

## ਸਹਿਮਤੀ

ਮੈਂ ਸਹਿਮਤੀ ਪੱਤਰ ਨੂੰ ਪੜ੍ਹ ਲਿਆ ਹੈ ਅਤੇ ਮੈਨੂੰ ਇਸ ਪੱਤਰ ਵਿੱਚ ਦਰਸਾਈ ਗਈ ਮੁਲਾਂਕਣ ਪ੍ਰਕਿਰਿਆ ਅਤੇ ਸਪਲੀਮੈਂਟਸ਼ਨ ਦੇ ਬਿਓਰੇ ਸਬੰਧੀ ਕੋਈ ਸ਼ੰਕਾ ਨਹੀਂ ਹੈ। ਮੈਂ ਆਪਣੇ ਪੁੱਤਰ/ਪੁੱਤਰੀ ਦੇ ਇਸ ਖੋਜ ਕਾਰਜ ਵਿੱਚ ਸ਼ਾਮਿਲ ਹੋਣ ਸਬੰਧੀ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਦਿੰਦਾ ਹਾਂ।

| **ਮਾਤਾ ਜਾਂ ਪਿਤਾ ਦਾ ਨਾਮ** | **ਦਸਤਖਤ** |
|---|---|
| | |

**APPENDIX III**

**Sr. No.**
**Date:**

**<u>SURVEY OF MALNOURISHED PRESHOOL CHILDREN IN LUDHIANA CITY</u>**

**I. GENERAL INORMATION**

1. Informant's name :
2. Informant's address :
3. Informants relation with the child:
4. Religion of the family :
5. Type of family : Nuclear/Joint
6. Education profile of mother :
7. Family income
8. Source of income : <one minium wage/>one minimum wage
9. Land holding (in hect) : 1-2/ 2-4/ 4-10
10. Food habits : Vegetarian/ Non-vegetarian/ Ovatarian
11. Composition of family

| S. NO | Relationship with the subject | Sex | Age | Education | Occupation |
|---|---|---|---|---|---|
| | | | | | |

**II. INFORMATION ABOUT THE CHILD**

a) Name :
b) Age group : 3-4/4-5

c) Date of birth :

d) Sex :

e) Birth order :

f) Formal education : Yes/No

If yes, specify Anganwari/ Govt. school/ Private school/ Others

g) Vaccination among children

| **Vaccine** | **Yes/No** | **Vaccine** | **Yes/No** |
|---|---|---|---|
| Hepatitis B (at birth) | | Polio (at birth) | |
| BCG (birth to 6 wk) | | Hepatitis B (4 to 6 wks) | |
| DPT/ OPV (6wk) | | Hepatitis B (24wk) | |
| Polio Measles (12months) | | MMR (18 month) | |
| DPT/ Polio Booster I (18 month) | | Typhoid (24 month) | |
| DPT/ Polio Booster II (18 month) | | Rotavirus | |

h) Associated co-morbidities among children:

| **Disease** | **Yes/No** | **Frequency of occurrence in last one year** |
|---|---|---|
| Typhoid | | |
| Diarrhea | | |
| Jaundice | | |
| Cough and cold | | |
| Malaria | | |
| Tuberculosis | | |
| Severe anemia | | |
| Rickets | | |
| Any other | | |

i) Any tonic/ medicine/ appetizer being given to child? Yes/No

(Please specify)

j) Provision of regular health check up? Yes/No

Frequency

k) Health facilities: Availability

Accessibility

Yes/No

Yes/No

l) If yes, then specify — 1) Government hospitals
2) Primary health center
3) Private hospital
4) Chemist shop

**III. INFORMATION ABOUT MOTHER**

- Age of marriage :
- Spacing between children:
- Breast feeding pattern : Exclusive for 0-3months/ Predominant for 0-3 months
  Exclusive for 4-6 months/ Predominant for 4-6 months
- Introduction of weaning foods:

**IV. INFORMATION ABOUT SOCIOECONOMIC STATUS OF FAMILY**

**a) Hygienic and sanitary conditions**

- Hand — Clean/dirty
- Hand wash after toilet — yes/no
- Mouth and hand wash — before meal/after meal/never
- Cutting of nails — weekly/monthly/whenever
- Habit of eating clay — yes/no
- Cleaning of ears — yes/no
- Cleaning of teeth — twice in a day/daily/weekly
- Combing of hair — twice in a day/daily
- Bath in summer — daily/twice a day
- Bath in winters — daily/once in two days/weekly/ frequently
- Head bath — daily/weekly/fortnightly
- Frequency of lice in hair — occasionally/rarely
- Use of hanky — yes/no
- Change of clothes — twice in a day/daily/once in two days

**b.) Ecological conditions**

- Water supply — Tap water/ Hand pump/ Any other
- Electricity — Yes/No
- Disposal of refuse — Garbage pits/ Any other
- Toilet facility — Yes/ No

- Type of toilet — Community toilet/ Flush system/ Dry latrine/ Out in open
- Drainage — Underground/ Open
- Bathroom — Yes/No
- Kitchen garden — Yes/No
- Type of house — Brick house (Full pucca)/ Semi pucca
- Floor covering — Yes/No
- Street — Clean/ Dirty
- Street drainage — Covered/ Uncovered/ No arrangement
- Water supply — Wells/ Taps (Municipality supply)/ Hand pump? Electric motor
- Mode of waste disposal — Dustbin/ Open (on road)/ Municipal corporation arrangement

## V. ANTHROPOMETRIC PROFILE

| Parameter | Before supplementation | After supplementation |
|---|---|---|
| Height (cm) | | |
| Weight (kg) | | |
| BMI (kg/m$^2$) | | |
| Head circumference (cm) | | |
| Chest circumference (cm) | | |
| MUAC (cm) | | |
| Degree of malnutrition on the basis of z score | | |

## VI. BIOCHEMICAL PROFILE

| Parameter | Before supplementation | After supplementation |
|---|---|---|
| Albumin (g/dl) | | |
| Total protein (g/dl) | | |
| Haemoglobin (g/dl) | | |
| MCV (fl) | | |
| MCH (pg) | | |
| MCHC (g/dl) | | |

## VII. DIETARY PROFILE : by 24 Hour Recall method for 3 consecutive days

| Meal | Menu | Amount of cooked food consumed | | | Raw equivalent consumed by the child (g/day) | | |
|---|---|---|---|---|---|---|---|
| | | 1st day | 2nd day | 3rd day | 1st day | 2nd day | 3rd day |
| Early Morning | | | | | | | |
| Breakfast | | | | | | | |
| Mid Morning | | | | | | | |
| Lunch | | | | | | | |
| Dinner | | | | | | | |
| Bed-time | | | | | | | |

## LIST OF ACCEPTED / SUBMITTED RESEARCH PAPERS

| S.No | Title | Authors | Journal | Score | Remarks |
|---|---|---|---|---|---|
| 1. | Malnutrition - The Persisting Global Threat Due To Food Insecurity | Bindhya Dhanesh T. and Anita Kochhar | International Journal of Health Sciences and Research | Impact Factor-3.5.<br>ICV -92.8 | Published |
| 2. | Peanut Processing and It's Potential Food Applications | Bindhya Dhanesh T. and Anita Kochhar | International Journal of Science and Research | Impact Factor-4.438.<br>ICV -6.14 | Published |
| 3. | Nutritional Evaluation of Value Added Products Using Partially Defatted Peanut Cake And Dehydrated Green Leafy Powder Developed for the Malnourished | Bindhya Dhanesh T. and Anita Kochhar | Nutrition and Food Science | NAAS – 5.09 | Submitted |
| 4. | Efficacy of value added products developed incorporating partially defatted peanut cake flour on the nutritional profile of malnourished preschool children | Bindhya Dhanesh T., Anita Kochhar and Mohammed Javed | Plant foods for human nutrition | NAAS – 8.43 | Submitted |

IJHSR International Journal of Health Sciences and Research
www.ijhsr.org ISSN: 2249-9571

*Review Article*

# Malnutrition - The Persisting Global Threat Due To Food Insecurity

Bindhya Dhanesh T[1], Anita Kochhar[2]

[1]Ph.D. Scholar, [2]Professor,
Dept. of Food and Nutrition, Punjab Agricultural University, Ludhiana, Punjab, India.

Corresponding Author: Bindhya Dhanesh T

*Received: 05/02/2015* *Revised: 24/02/2015* *Accepted: 04/03/2015*

## ABSTRACT

Malnutrition is an underlying cause of death of approximately one-third of the global total of children's deaths every year. Globally, an estimated 52 million children under-five years of age, or 8%, were wasted in 2011. Seventy percent of the world's wasted children live in Asia, most in South-Central Asia. These children are at substantial increased risk of severe acute malnutrition and death. One of the targets of the first Millennium Development Goal (MDG) is to reduce the proportion of people who suffer from hunger by half between 1990 and 2015, with hunger measured as the proportion of the population who are undernourished and the prevalence of children under five who are underweight. Many countries remain far from reaching this target, and much of the progress made has been eroded by the recent global food price and economic crises. As we enter the final five years to achieve the MDGs, we look upon one of the greatest challenges of our time with one billion people hungry, 129 million and 195 million children underweight and stunted respectively and more than 2 billion people deficient in micronutrients. Reducing child malnutrition requires nutritious food, breastfeeding, improved hygiene, health services, and prenatal care. Poverty and food insecurity seriously constrain accessibility of nutritious diets, including high protein quality, adequate micronutrient content and bioavailability, macro-minerals and essential fatty acids, low anti-nutrient content, and high nutrient density

*Keywords:* Malnutrition, Underweight, Stunted, Poverty, Food Insecurity

## INTRODUCTION

*"We have the means, we have the capacity, to eliminate hunger from the face of the earth in our lifetime. We need only the will."*
*-- John F. Kennedy, 1963*

Malnutrition has been the most serious global challenge since the early 70's whose prevention appears to be problematic from then to this century even after the introduction of several nutritional intervention programmes in the various parts of the globe. Two form of malnutrition, mainly Undernutrition and Overnutrition have been persisting since many years even after undertaking several measures. Undernutrion contributes to more than one-third of all deaths in children under the age of five. In 2011, it was reported that globally, 165 million children were stunted, 101 million underweight and 52 million wasted, all belonging to the under five category. [1] Although, the basic magnitude of this problem is well known and widely agreed upon; the fact that poverty, malnutrition and food insecurity share complex relationships with one another is less appreciated. Malnutrition and poverty can have non-food determinants and manifestations but food insecurity has proven to be an essential subset of overall poverty and of nutrition insecurity. Food insecurity and malnutrition represent serious impediments to sustainable agriculture, poverty reduction and equity.

Stunting and emaciation, major forms of undernutrition reduce a child's chance of survival, while also hindering optimal health and growth. Stunting is associated with suboptimal brain development, which is likely to have long-lasting harmful health consequences for cognitive ability, school performance and as a result leads to low future earnings. This in turn affects the development potential of nations. [2,3] A stunted child enters adulthood with greater propensity for developing obesity and other chronic diseases. With increasing urbanization and shift in lifestyle and dietary patterns, the result could be a burgeoning epidemic of such conditions in many low and middle income countries. With the upcoming new evidences, a more strong understanding of the short and long-term consequences of undernutrition has been learned. There is even stronger chances that undernutrition can trap children and families as a result communities and nations in an interrelated cycle of poor nutrition, illness and poverty. [4]

In May 2012, The World Health Assembly, the decision making body of World Health Organisation (WHO), agreed on a new target: reducing the number of stunted children under the age of five by 40 per cent by 2015. [5] The United Nations Secretary-General has included elimination of stunting as a goal in his Zero Hunger Challenge, launched in June 2012. [5] This emphasis on stunting has led to a review of national programmes and strategies to increase the focus on prevention and integrated programmes.

With the initiation of SUN movement in 2010, there has been a major shift in the global nutrition landscape. The SUN movement seeks to build national commitment to accelerate progress to reduce stunting and other forms of undernutrition as well as overweight. More than 30 countries in Africa, Asia and Latin America have joined SUN. They are expanding their nutrition programmes, supported by donor countries, United Nations organizations, civil society and private sector. It assists nations in meeting obligations to ensure fulfillment of their citizens' right to food. [4] As initially codified in the Universal Declaration of Human Rights and reaffirmed by the International Covenant on Economic, Social and Cultural Rights, the right to food is a fundamental human right. Through SUN, countries are working to increase access to affordable and nutritious food, as well as demand for it. They are also addressing the other factors that determine nutritional status, such as improved feeding and care practices, clean water, sanitation, health care, social protection and initiatives to empower women

**Major causes of Malnutrition- Food and Nutritional insecurity**

Nutritional status is influenced by three broad factors: food, health and care. Optimal nutritional status results when children have access to affordable, diverse, nutrient-rich food; appropriate maternal and child-care practices; adequate health services; and a healthy environment including safe water, sanitation and good hygienic practices. These factors directly influence nutrient intake and the presence of disease. [6] Food, health and care are affected by social, economic and political factors. The combination and relative importance of these factors differ from country to country. Understanding the immediate and underlying causes of undernutrition in a given context is critical to delivering appropriate, effective and sustainable solutions and adequately meeting the needs of the most vulnerable people. [7]

The immediate causes of undernutrition are inadequate dietary intake and Diseases. [3] Inadequate dietary intake is in turn due to the household food security and inadequate care and feeding practices while Disease arise as a result of unhealthy household environment and inadequate health services. The major contribution is by the inadequate dietary intake whose basic cause lies in poor access to adequate quantity and quality of resources like land, education, employment, income and technology which may be due to inadequate financial, human, physical and social capital.

Food insecurity and malnutrition represents serious impediments to sustainable developments, poverty reduction, equity and achievement of the Millennium Development Goals. Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. [8] Food security has four dimensions: food availability, access to food, stability of supply and access, and safe and healthy food utilization. Stability depends on food production, incomes, markets and transfer programmes (both public and private) and can be adversely affected by shocks due to weather, price fluctuations, human induced disasters and political and economic factors. Utilization refers to the proper use of food and includes the existence of appropriate food processing and storage practices, adequate knowledge and application of nutrition and child care and adequate health and sanitation services. Food security is a key factor in good nutrition, together with health, sanitation and care practices. [9]

A similar definition was given for food security but adds a psychological dimension in terms of the absence of feelings of deprivation, restricted choice, or anxiety related to the quantity or quality of available food. [10] A striking feature of these definitions then is that food security is largely rationalized in terms of its contribution to improved nutrition, with an oft-ignored psychological dimension being the only major distinction. Nutrition security, however, is defined not only in terms of physical and economic access but also in terms of adequate utilization and absorption of nutrients. Nutrition security therefore depends not only on adequate food security but also on adequate care practices (food storage and preparation, appropriate feeding practices, including breastfeeding) and adequate health (including hygiene and sanitation).

It is reported that Global crop production has expanded threefold over the past 50 years, largely through higher yields per unit of land and crop intensification. Global per capita food supply rose from about 2 200 kcal/day in the early 1960s to over 2 800 kcal/day by 2009. At 3 370 kcal/person/day, Europe currently has the highest average per capita food supply. Cereals occupy more than half of the world's harvested area and are the most important food source for human consumption. Of the 2.3 billion tonnes of cereals produced each year, 1 billion are destined for human consumption, 750 million tonnes are used as animal feed and 500 million tonnes are either processed by industry, used as seed, or wasted. [8]

Food insecurity is essentially a subset of overall poverty and of nutrition insecurity, but both poverty and malnutrition can have nonfood determinants or manifestations. These complex relationships are explained in four possible cases of independence and overlap. [11] In category 1

(C1), one's own food needs and nonfood requirements for nutrition are satisfied, but the individual is still poor (perhaps lacking access to education, for example). In C2, one's own food needs are satisfied but the individual is still poor and malnourished (perhaps lacking access to health services that are important for nutrition). In C3, an individual is food insecure and therefore both poor and nutrition insecure. And in C4 an individual is neither food insecure nor poor but malnourished.

Some authors states that temporal dimensions are factors in these issues. [11] For any of the four categories, an individual may have adequate income, food availability, and nutrition at a given point of time but be highly vulnerable to other health issues. Thus, there is a distinction between chronic and acute forms of ill-being, or between current states and vulnerability to more adverse states. In nutrition, there are also long-standing distinctions between chronic indicators (such as height for age) and acute indicators (such as weight for height). There are many indicators used for the temporal dimensions: Underlying structural indicators include Gross domestic productivity per capita, Agricultural productivity, Governance quality, Literacy, Fertility Rates, Exposure to natural disasters and vulnerability to price hikes; Food security indicators are micro and macro nutrient availability, poverty, self reported hunger and food aid requirements and Nutrition security which includes stunting and wasting prevalence along with prevalence of underweight mothers.

While poverty, food security, and nutrition could in principle be measured at common levels of aggregation, nutrition is usually measured at the individual level, and poverty and food security are usually measured at the household level. Nutrition research has shown that lifelong physical, cognitive, and economic outcomes are largely determined in the first 1,000 days of life. [12] This implies that the bulk of nutritional investments should be targeted toward women and very young children. The generally positive process of economic and political development involves income growth (poverty reduction), reduced food insecurity, and improved health and childcare practices. Finally, there is a feedback loop from improved nutrition, health, and monetary outcomes into economic development. For example, nutrition and health increase labour productivity via their effect on cognitive ability and physical activity. But higher incomes can also lead to economic diversification, greater investments in education, reduced fertility rates, and even stronger demands for better governance.

**Consequences of Malnutrition**

There are short-term and long-term consequences of undernutrition. The short-term consequences are mortality, morbidity and disability. Stunting and other forms of undernutrition are clearly a major contributing factor to child mortality, disease and disability. Specific nutritional deficiencies such as vitamin A, iron or zinc deficiency also increase risk of death. Undernutrition can cause various diseases such as blindness due to vitamin A deficiency and neural tube defects due to folic acid deficiency. Earlier research clarified the harmful impact of inadequate intake of specific micronutrients such as iron, folic acid and iodine on development of the brain and nervous system and on subsequent school performance. The impact of iron deficiency, which reduces school performance in children and the physical capacity for work among adults, has also been well documented. [3]

Undernutrition early in life clearly has major consequences for future educational, income and productivity outcomes. Stunting is associated with poor school achievement and poor school performance. Recent longitudinal studies among cohorts of children from Brazil, Guatemala, India, the Philippines and South Africa confirmed the association between stunting and a reduction in schooling, and also found that stunting was a predictor of grade failure. [13] Reduced school attendance and educational outcomes result in diminished income-earning capacity in adulthood. [14] It is seen that the developmental impact of stunting and other forms of undernutrition happens earlier and is greater than previously thought. Brain and nervous system development begins early in pregnancy and is largely complete by the time the child reaches the age of 2. The timing, severity and duration of nutritional deficiencies during this period affect brain development in different ways, influenced by the brain's need for a given nutrient at a specific time. While the developing brain has the capacity for repair, it is also highly vulnerable, and nutrient deficiencies during critical periods have long-term effects. [15]

This new knowledge, together with the evidence that the irreversible process of stunting happens early in life, has led to a shift in programming focus. Previously the emphasis was on children under age 5, while now it is increasingly on the 1,000-day period up to age 2, including pregnancy. Improvements in nutrition after age 2 do not usually lead to recovery of lost potential.

A consequence that is also emerging more clearly is the impact of stunting and subsequent disproportionate and rapid weight gain on health later in life. These long-term effects are referred to as the Foetal Programming Concept: Poor foetal growth, small size at birth and continued poor growth in early life followed by rapid weight gain later in childhood raises the risk of coronary heart disease, stroke, hypertension and type II diabetes. Attaining optimal growth before 24 months of age is desirable; becoming stunted but then gaining weight disproportionately after 24 months is likely to increase the risk of becoming overweight and developing other health problems. [16]

**Current Global Nutrition Status**

Almost 870 million people, or 12.5 percent of the world's population, were undernourished in 2010-2012; the vast majority of them (852 million) live in developing countries. Between 2005 and 2011, one out of four African countries reported a stunting rate of at least 40 percent. Stunting rates also exceeded 40 percent in South and South East Asia during the same period, with peaks in India, the Lao People's Democratic Republic, Nepal and Timor-Leste. African countries show the highest rates of underweight prevalence. During 2005-2011, 16 African countries showed underweight rates of at least 20 percent, with the highest levels recorded in Africa. [8] With the increased urbanization along with the reduction of undernutrition, an increase in the population of overweight in the world has also been observed. Different forms of malnutrition have been discussed below.

**Stunting**- Globally an approximate of 165 million children (26%) under the age of five were stunted in 2011. But this burden is not equally distributed around the world. Sub-African (40%) and South Asia (39%) are home to three fourth of the World's stunted children. Eighty percent of the world's stunted children live in 14 countries. According to the highest population they are ranked first and they are India (36% of global burden and 48% of stunting prevalence) followed by Nigeria, Pakistan, China, Indonesia, Bangladesh, Ethiopia, Congo, Philippines, Tanzania, Egypt, Kenya, Uganda and Sudan. [4]

The global prevalence of stunting children under the age of 5 has declined by 36 per cent over the past two decades- from an estimated 40 per cent in 1990 to 26 per cent in 2011. An annual reduction of 2.1 per cent per year was observed. The greatest declines in stunting prevalence occurred in East Asia and the Pacific. This region experienced about a 70 per cent reduction in prevalence – from 42 per cent in 1990 to 12 per cent in 2011. This major reduction was largely due to improvements made by China. The prevalence of stunting in China decreased from more than 30 per cent in 1990 to 10 per cent in 2010. Latin America and the Caribbean reduced stunting prevalence by nearly half during this same period. The South Asia and Middle East and North Africa regions have both achieved more than a one-third reduction in stunting prevalence since 1990. However, progress in reducing stunting prevalence in sub-Saharan Africa was limited to 16 per cent, from 47 per cent in 1990 to 40 per cent in 2011. More than one third of countries in sub-Saharan Africa have very high stunting prevalence. [8]

**Underweight** - Globally an estimated 101 million children under the age 5 years (16% of child population under age 5) were underweight in 2011. Underweight prevalence is highest in South Asia, which has a rate of 33 per cent, followed by sub-Saharan Africa, at 21 per cent. South Asia has 59 million underweight children, while sub-Saharan Africa has 30 million. Globally, underweight prevalence has declined, from 25 per cent in 1990 to 16 per cent today – a 37 per cent reduction. The greatest reductions have been achieved in Central and Eastern Europe and the Commonwealth of Independent States, where prevalence has declined by 87 per cent, and in East Asia and the Pacific, where it fell 73 per cent (largely by the reductions made in China). [4]

**Wasting** - Moderate and severe wasting represents an acute form of undernutrition, and children who suffer from it face a markedly increased risk of death. Globally in 2011, 52 million children under 5 years of age were moderately or severely wasted, an 11 per cent decrease from the estimated figure of 58 million in 1990. More than 29 million children under 5, an estimated 5 per cent, suffered from severe wasting. The highest wasting prevalence is in South Asia, where approximately one in six children (16 per cent) is moderately or severely wasted. The burden of wasting is highest in India, which has more than 25 million wasted children. This exceeds the combined burden of the next nine high-burden countries. In sub-Saharan Africa, nearly 1 in 10 children under the age of 5 (9 per cent) were wasted in 2011, a prevalence that has decreased about 10 per cent since 1990. The number of wasted children in sub-Saharan Africa as a proportion of the world's total has increased over the same period of time. Countries like South Sudan, India, Timor-Leste, Sudan, Bangladesh and Chad have a very high prevalence of wasting – above 15 per cent. The ten most affect countries are India (Highest burden estimate of 20%) followed by Nigeria, Pakistan, Indonesia, Bangladesh, China, Ethiopia, Congo, Sudan and Philippines. Worldwide, of the 80 countries with available data, 23 countries have levels of wasting greater than 10 per cen. [17,4]

**Overweight**- Overweight is an upcoming major form of malnutrition mainly due to urbanization and food insecurity (Unequal distribution of foods). Rates of overweight continue to rise across all regions. Overweight was once associated mainly with high-income countries, but in 2011, 69 per cent of the global burden of overweight children under 5 years old were in low- and middle-income countries. However, the prevalence of overweight remains higher in high-income countries (8 per cent) than in low-income countries (4 per cent). Globally, an estimated 43 million children under 5 years of age are overweight, or 7 per cent of children under 5 years old. In 2011, approximately 10 million children in sub-Saharan Africa and 7 million in East Asia and the Pacific were overweight. Prevalence estimates have more than doubled since 1990 in sub-Saharan Africa (from 3 per cent in 1990 to 7 per cent in 2011), meaning that more than three times as many children are affected today. A similar trend in estimates of child overweight has been observed in the Middle East and North Africa region. [4]

**Low Birth Weight** - The World Health Assembly has set a new target to reduce low birth weight by 30 per cent between 2010 and 2025. In 2011, more than 20 million infants, an estimated 15 per cent globally, were born with low birth weight. [4] India alone accounts for one third of the global burden. South Asia has by far the greatest regional incidence of low birth weight, with one in four newborns weighing less than 2,500 grams at birth. The incidence of low birth weight exceeds 20 per cent in India, Mauritania, Nauru, Pakistan, and the Philippines, and in sub-Saharan Africa the incidence is greater than 10 per cent. More than 50 per cent of the global burden of low birth weight is attributed to 5 of the 24 countries profiled in this report. The major five countries that account for more than half of global low birth weight burden are India (7.5 million), Pakistan (1.5 million), Bangladesh (0.7million), Nigeria (0.8 million) and Philippines (0.5 million). [17]

One of the major challenges in measuring incidence of low birth weight is the fact that more than half of the world's children had not been weighed at birth. This reflects a lack of appropriate newborn care and also presents a challenge to accurately estimating low birth weight incidence.

**Countries with overlapping Stunting, Wasting and Overweight In Children Under Age Five [17]**

| Overlap/ Indicator group | No. of Countries | Total Population (Millions) | Countries |
|---|---|---|---|
| Stunting Only | 12 | 212 | Democratic People's Republic of Korea, El Salvador, Guatemala, Honduras, Liberia, Nauru, Nicaragua, Solomon Islands, Togo, Uganda, Viet Nam, Zimbabwe |
| Wasting Only | 6 | 68 | Guyana, Oman, Saudi Arabia, Senegal, Sri Lanka, Suriname |
| Overweight only | 25 | 603 | Algeria, Argentina, Belarus, Belize, Bosnia and Herzegovina, Brazil, Chile, Costa Rica, Dominican Republic, Gabon, Georgia, Kazakhstan, Kuwait, Kyrgyzstan, Mexico, Mongolia, Montenegro, Morocco, Paraguay, Peru, Serbia, The former Yugoslav Republic of Macedonia, Tunisia, Uruguay, Uzbekistan |
| Stunting and Wasting only | 38 | 2462 | Bangladesh, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Haiti, India, Kenya, Lao People's Democratic Republic, Maldives, Mali, Mauritania, Myanmar, Namibia, Nepal, Niger, Nigeria, Pakistan, Philippines, Somalia, South Sudan, Sudan, Tajikistan, Timor-Leste, United Republic of Tanzania, Vanuatu, Yemen |
| Stunting and Overweight only | 7 | 45 | Armenia, Bolivia, Equatorial Guinea, Lesotho, Malawi, Rwanda, Swaziland |
| Wasting and overweight only | 2 | 70 | Republic of Moldova, Thailand |
| Stunting, Wasting and Overweight | 17 | 468 | Albania, Azerbaijan, Benin, Bhutan, Botswana, Comoros, Djibouti, Egypt, Indonesia, Iraq, Libya, Mozambique, Papua New Guinea, Sao Tome and Principe, Sierra Leone, Syrian Arab Republic, Zambia |

**Measures to Combat Malnutrition**

While a significant number of the world's 52 million wasted children live in countries where cyclical food insecurity and protracted crises exacerbate their vulnerability, the majority reside in countries not affected by emergencies. In these countries factors such as frequent incidence of infectious diseases, inadequate caring capacity and social and cultural practices are the major factors that need to be addressed to reduce wasting.

**Nutrition**- specific interventions are actions that have a direct impact on the prevention and treatment of undernutrition, in particular during the 1,000 days covering pregnancy and the child's first two years. These interventions should be complemented by broader, nutrition-sensitive approaches that have an indirect impact on nutrition status. Equity considerations in nutrition programming are particularly important, as stunting and other forms of undernutrition afflict the most vulnerable populations. [18]

UNICEF reports of 2014 states that the global agricultural system is currently producing enough food to feed the world, but access to adequate, affordable, nutritious food is more challenging. Improving dietary diversity by increasing production of nutritious foods is achievable, particularly in rural populations. It is done by producing nutrient-dense foods, such as fruits and vegetables, fish, livestock, milk and eggs; increasing the nutritional content of foods through crop biofortification and post-harvest fortification; improving storage and preservation of foods to cover 'lean' seasons; and educating people about nutrition and diet. In several settings these types of interventions have been shown to improve dietary patterns and intake of specific micronutrients, either directly or by increasing household income. However, the impact on stunting, wasting and micronutrient deficiencies is less clear. Thus, more effort is needed to align the pursuit of food security with nutrition security and improved nutritional outcomes. [17]

Similarly, social protection involves policies and programmes that protect people against vulnerability, mitigate the impacts of shocks, improve resilience and support people whose livelihoods are at risk. Safety nets are a type of social protection that provides or substitutes for income: Targeted cash transfers and food access-based approaches are the two main categories of safety nets intended to avert starvation and reduce undernutrition among the most vulnerable populations. Food-based safety nets are designed to ensure livelihoods (such as public works employment paid in food), increase purchasing power (through food stamps, coupons or vouchers) and relieve deprivation by providing food directly to households or individuals. [9]

## CONCLUSION

More research and evidence is needed on the long-term outcomes of different programmes on undernutrition and how they can be better targeted, how long they are needed and with what interventions. Similarly, ensuring an effective food distribution system is an essentiality than the production of food as there is sufficient production to feed the entire world. Use of locally available foods, development of newer products from high protein, fat and calorie food that are readily available and cheap and use of simpler food processing techniques also help people improve their family's undernourished status. Nutrition education should be made more effective along with provision of sample preparations of different combination of foods or food materials that can improve one's nutritional status which can later be prepared at homes. But social safety net programmes can definitely be one way to ensure more equitable nutrition-sensitive development if they are aligned with local and national needs and an understanding of capacity, resources and timeliness aspects in scaling up.

## REFERENCES


1. UNICEF-WHO-The World Bank. 2012. Levels and Trends in Child Malnutrition. *UNICEF-WHO-The World Bank Joint Child Malnutrition Estimates*.p35.

2. Black, R.E. Allen, L.H. Bhutta, Z.A. Caulfield, L.E. De Onis, M. and Ezzati, M. 2008. Maternal and child undernutrition: Global and regional exposures and health consequences. *Lancet*. 371:243-60.
3. WHO. 2011. Severe Acute Malnutrition. (http://www.who.int/pem/topics/en/index.html).
4. UNICEF. 2013. Improving Child Nutrition- The Achievable Imperative for Global Progress. p132.
5. UNICEF. 2012. Programming Guide, Infant and Young Child Feeding. p89.
6. UNICEF. 2009. Tracking Progress on Child and Maternal Nutrition- A Survival and Developmental Priority. p119.
7. IPS (Inter Press Services). 2014. Child Malnutrition Costs Global Economy Billions- Yearly Report. p49.
8. FAO.2013.reliefweb.int/report/world/fao-statistical-yearbook-2013-world-food-and-agriculture.
9. Haedey, D. 2013. The Global Landscape of Poverty, Food Insecurity and Malnutrition and Implications for Agricultural Development Strategies. International Food Policy Research Institute (IFPRI), Washington. p27.
10. Dev, S.M. and Sharma, A.N. 2010 Food Security in India- Performance, Challenges and policies. Oxfam, New Delhi, India. p46.
11. Quisumbing, A.R. and Haddad, L.P.C. 1995. Gender and Poverty: New Evidences from Ten Developing Countries. International Food Policy Research Institute, Washington DC. p95.
12. Victora and Cesar. 2010. Worldwide Timing of Growth Faltering: Revisiting implications for Interventions. *Pediatrics*. 125(3): 473-76.
13. Dewey, D. Kathryn, G. and Begum, K. 2011. Long Term Consequences of Stunting in Early Life. *Maternal and Child Nutrition*. 7: 5-18.
14. Martorell and Reynaldo. 2010. "Weight gain in the first two years of life is an important predictor of schooling outcomes" in Pooled Analyses from five birth cohorts from Low and Middle income Countries. *Journal of Nutrition*. 140(2): 349-54.
15. Cusick, Sarah, E. and Georgheff, M.K. 2012. Nutrient Supplementation and Neurodevelopment: Time is the Key. *Archives of Pediatrics and Adolescent Medicine*. 166(5): 481-84.
16. Uauy, Ricardo, Juliana, K. and Corvalan, C. 2011. How can the developmental Origin of Health and Disease (DoHaD) Hypothesis contribute to Improving Health in Developing Countries. *American Journal of Clinical Nutrition*. 94(6): 1759S.
17. Global Nutrition Report. 2014. Actions and Accountability to Accelerate the World's Progress on Nutrition. International Food Policy Research Institute, Washington DC. p88.
18. De Onis, M. Onyango, A.W. Borghi, E. Garza, C. and Yang, H. 2006. Comparison of World Health Organisation Standards and the National Center for Health Statistics/ WHO International Growth Reference: Implication for Child Health Programme. *Public Health Nutrition*. 9: 942-7.



How to cite this article: Bindhya DT, Kochhar A. Malnutrition - the persisting global threat due to food insecurity. Int J Health Sci Res. 2015; 5(3):309-317.


*******************

# Peanut Processing and It's Potential Food Applications

**Bindhya Dhanesh T[1], Anita Kochhar[2]**

[1] Ph.D. Scholar, Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana, Punjab, India

[2] Professor, Department of Food and Nutrition, Punjab Agricultural University, Ludhiana, Punjab, India

**Abstract:** ***Peanut is one of the most important oil and protein producing crops in the world. Most peanuts grown in the world are used for oil production, peanut butter, confectionaries, roasted peanuts and snack products, extenders in meat product formulations, soups and desserts. Being a source of good fat namely poly and monounsaturated fatty acids; they are also used in weight management diets as they provide satiety. The substantial amounts of by-products are generated in the process of peanut harvest and peanut oil extraction. A large portion of peanut meals, skins, hulls, and vines is regarded as the agriculture wastes. With respect to it's high nutritive value especially being an excellent source of protein it can also be incorporated in many food preparations as supplementary food and emergency foods which can be supplied to populations suffering from hunger and malnutrition especially in the developing and underdeveloped countries. Earlier, many researchers focused on the investigation of producing and utilising edible oil and kernel. Since very little attention was given to the other by-products of peanut processing, at present, researches are carried out to improve the utilisation of other by-products other than oil and raw kernel as are proved to be having important nutritional and health benefits. This paper briefly describes various peanut by-products produced. Materials, processing, and potential applications in food manufacture of emerging materials, as are also briefly discussed.***

**Keywords:** Peanut, Peanut by-products, Utilization, Nutritional and Health benefits

## 1. Introduction

Peanuts known as the 'Poor man's nut' are the edible seeds of legume *Arachis hypogaea Linn.* The botanical name *Arachis hypogaea Linn* is derived from two Greek words, *Arachis* means 'a legume' and *hypogaea* means 'below ground' referring to the formation of pods in the soil. The world peanut production totals approximately 29 million metric tonnes per year, with the China being the world's largest producer, followed by India with a production of 7 million tonnes in 2012. The major groundnut producing countries in the world are China, India, Nigeria, USA, Indonesia, Argentina, Sudan, Senegal and Myanmar which accounts for nearly 70 per cent of the total world peanut production [8]. The U.S. is one of the world's leading peanut exporters, with average annual exports of between 200,000 and 250,000 metric tons. Argentina and China are other significant exporters [8].

Among all the nuts, peanuts have an excellent nutritional profile due to which it is widely used in the diets for weight management and meeting appropriate protein levels in the body. Peanut is a rich source of protein ranging from 21 per cent to 36.4 percent, 18 per cent of carbohydrates and 36-54 per cent fat [24]. Peanuts have a desirable fatty acid profile for which it is used for weight management diets and is rich in vitamins, minerals and several bioactive compounds. They contain several known heart healthy nutrients including MUFA and PUFA, potassium, magnesium, copper, niacin, arginine, fiber, alpha-tocopherol, folates, phytosterols and flavanoids [24]. Important bioactive compounds like catechins and procyanidins are found in peanut skin which are known for anti-inflammatory effect on pro-inflammatory enzymes and nitrous oxide levels [17]. Peanuts along with other legumes are considered a part of meat and meat alternative group in the Food Guide Pyramid. Groundnut consists of mainly of two globulins namely arachin (93% of defatted seed protein) and co-arachin.

Groundnut protein can be incorporated into a variety of food products without serious problem in terms of colour and flavor. The pleasant aroma, nutty flavor and smooth texture of roasted groundnut have found great acceptance. In India, edible groundnut flour is used in developing a variety of cost effective food formulations such as multipurpose food, fortified flour, paustic atta, malted food, chewy candies and high protein biscuits [5, 18, 20].

Malnutrition is the consequence of much food insecurity, which stems from poor food quality and quantity, severe repeated infections or combinations of all three [27]. Being a cheap source of good quality protein, peanuts can be utilized in the form of flour, protein isolates, and meal in low cost mixed products. Though it is deficient in some amino acids, its digestibility is comparable with that of animal protein [23]. The vast food preparation incorporating groundnut to improve the protein level has helped in reducing malnutrition in developing countries. Groundnut protein is increasingly becoming important as food source in developing countries where protein from animal source is not within the means of the majority of populace.

## 2. Processing of Peanuts

Peanut processing starts with harvesting. Small scale producers follow the traditional method of harvesting which involves plowing and manually stacking the plant for field curing. Harvesting begins with mowing of mature peanut plants. These are then inverted by specialized machines with peanut pods on top into windrows for field curing or open-air drying. Mature peanuts are picked up from the windrows and using thrashing operators peanut pods are separated from the plant and accumulated in hoppers [1].

Harvesting is then followed by mechanical drying. Moisture of the peanuts is usually kept below 12 per cent, to prevent aflatoxin production [18]. On-farm dryers are also used which usually consists of storage trailers with air channels along with the storage bins with air vents. Peanuts are dried to a moisture level of 7 to 10 per cent. These peanuts are then further cleaned, stored and processed for various uses.

Achaya [2] reported that processing of peanuts have been done for in-shell consumption and shelling peanuts for other uses. In-shell processing begins precleaning which involves separation of foreign materials from peanut pods using a series of screens and blowers. The pods are then washed in wet, coarse sand that removes stains and discolouration. The sand is then screened from the peanuts for reuse. The nuts are then dried and powered with talc or kaolin to whiten the shells.

Processing of shelled peanut starts with the precleaning technique to separate foreign materials. The cleaned peanuts are then sized so that the pods can be crushed without damaging the kernels. The shells are then crushed by passing between rollers. The peanut is then crushed, pushing the shells and peanuts through the perforations. Shells are aspirated. The crushed shells and peanut kernels are then separated with oscillating shaker screens and aspirators. Peanut kernels are then sized using screens, bagged and shipped [2].

Roasting imparts the typical flavor to peanuts which can be achieved by dry roasting or oil roasting. During roasting, amino acids and carbohydrates react to produce tetrahydrofuran derivatives [3].

## 3. Processing of Peanuts to Different Byproducts

Raw or roasted peanuts are usually used as a snack and as an additive. They are used as such as an ingredient in confectionary products like candies, Breakfast cereals, Bakery products like doughnut, extruded products, milk, cheese, yoghurt etc. Most important byproduct of peanut processing most widely used is the peanut oil. The peanut cake or meal obtained after oil extraction which can be full fatted, partially defatted or defatted is later used as flour, isolates and concentrates [6].

Oil extraction from the peanut kernel is a well-established industrial since the early 1950s. They have thus supported in setting up of factories for this purpose, which, are large-scale plants situated in or near urban areas. Commercially oil is extracted from groundnut by three methods including hydraulic pressing, screw pressing and solvent extraction.

The ghani mill originated from India where these indigenous oil crushers have been improved over the time [1]. The original animal-powered ghani consists of a wooden mortar and a pestle. The mortar is fixed to the ground while the pestle attached to one or a pair of bullocks (or buffaloes or camel) is rotated in the mortar where the kernels are crushed. The oil runs through a hole at the bottom of the mortar. An animal-powered ghani can process 5 to 15 kg of kernels at a time. An improved version of the ghani has been developed in India, known as the Wardha Ghani. It was larger as well as more efficient than the traditional ghani. An engine-powered ghani is now replacing, to a large extent.

Problems of hygiene in ghani oil are unlikely because vegetable oils are naturally sterile. Ghani cake is known to be exceptionally hard and is not prone to mould infestation unless wetted. However, the ghani has its disadvantages, which are mainly economic such as high running costs. Animals need to be trained. Artisan training is also essential [2].

Peanut oil extraction using expellers has been well explained by Nautiyal [18]. Oil extraction by pressing can be achieved by single, duo or duplex expeller which is driven by an electrical motor or a v-belt from a separate diesel engine. When using a single expeller, the decision on whether to pass the seed once or twice should be based on economic considerations. A second pressing raises the oil extraction rate and therefore, yields additional quantities, but also increases processing costs. Thus, a second pressing is justified only when the increase in revenues is at least equal to the increase in cost.

It has been found that even the most perfect expeller leaves at least 6 percent of the oil in the expeller cake. It is possible to recover these losses using a solvent extraction plant and can reduce the residual oil in cake to less than 1 percent. Technologists have also observed a major drawback of expeller process, especially in view of the bias of the memorandum towards small-scale production, is that it is by nature suited to large scale extraction. Other drawbacks include high investment costs, the need for highly skilled labour, low employment generation and danger of explosion if the plant is not kept in perfect conditions [2]. However, this requires a good cake collection system and a sufficient supply of oil seeds in order to maintain the solvent extraction plant running at sufficiently high capacity utilization rate.

## 4. Food Applications of Peanut byproducts

George Washington Carver was a well known educator, farmer and a food scientist who developed peanut products that revolutionized the agricultural economy. His research developed 300 products and 105 ways of preparing peanuts for human consumption. According to a study in University of Georgia, peanuts were used to make products like Peanut butter, Variety Breads including - White and whole peanut bread, cookies, cakes and brownies, doughnuts and yeast products, pies & desserts, peanut milk, and cheese -type products, Non-milk beverages, soups, peanuts with meats, RTE cereals, peanut paste and noodles/fermented peanut pastes, coated nuts and RUTF – Read-to-use therapeutic foods [6].

**Peanut Oil -** Groundnut oil is used primarily as a cooking and salad oil. Groundnut oil is excellent fat for pan-frying or deep fat frying. Pastries shortening, oleomargarine, mayonnaise, salad dressing and other food products can be easily made with this bland vegetable oil [7]. For use in mayonnaise, it should retain its natural yellow colour, but for oleomargarine, it should be colourless, for shortening and other plastic fats, it should contain an antioxidant. Peanut oil has also been experimented in weaning foods as a source of fat along with other ingredients [6]. Groundnut is used extensively for massaging polio patients It is also used as a carrier of adrenaline in the treatment of asthma [9].

**Composite flours** - Groundnut cake flour is used to improve protein content and quality of several cereal- based food products in India, Kenya, Malawi, Nigeria, Senegal and Zimbabwe [7, 10]. In India alone, there have been several agriculture-products with groundnut as the protein-enriching medium. The partially defatted flour is used to improve the nutritional quality of various cereal-based products such as *gonfa*, millet (Pennisetum glaucum) based product and *epo-ogi*, a corn (Zea mays) based gruel. In Sudan, acceptable and nutritionally superior quality *kisra* is prepared from sorghum flour fortified with defatted groundnut flour [7]. The addition of defatted groundnut flour results in an improvement of baking ease, colour and texture of the final product.

Fortification with groundnut and subsequent fermentation improves the in vitro digestibility of the sorghum flour [21]. In developing countries where sorghum is a staple diet, there is a need to have a nutritional improvement programme on sorghum. Acceptable *gari*, a commonly used cassava-based Nigerian food, can be prepared with 15 percent defatted groundnut flour which showed an increase in the amount of protein and a remarkable increase in the concentration of all amino acids.

**Protein isolates** - The technology now exists for the production of groundnut proteins in the form of concentrates and isolates, which are acceptable for human consumption. Groundnut protein isolates are akin to soy protein isolates. Defatted materials obtained from oil extraction processes may be soluble in neutral to base reaction washes to extract much of the protein which subsequently separated from the whey formed by reducing the pH to isoelectrical levels. Isolates once separated are neutralized with alkali and may be spray dried.[16]

Groundnut cake or meal can be used for human consumption after partial hydrolysis of protein by fermentation using certain moulds. Such products are racially digestible and nutritious [17, 26]. Spray-dried groundnut protein isolate can be used to replace non-fatmilk solids in the ice cream. Coprecipitated isolates containing protein (95%) can be prepared from various combinations of groundnut seed, cottonseed and soybean flours and rice flour [19]. Fortified milk systems were prepared by blending pasteurized whole milk with dried skim milk and groundnut protein isolate, to increase the TS to 15, 18, 20 or 23 percent. This was followed by processing at 80°C for 30 min and storage at 4°C for 24 hours. Curds were prepared by lactic culturing of the processed milk systems. Curd obtained from fortified milk showed an increase yield stress along with curd strength with enlarged concentration of added protein.

**Fermented products** - Groundnut cake are used after partial hydrolysis of the component protein by fermentation using certain moulds. Such products are readily digestible, tasty and nutritious. *Oncom* is a popular dish of Indonesia and can be prepared by pressing the kernels to remove oil. It is usually done by soaking the cake in water for 24 h and then draining it. High starch material such as cassavais added to it. It is then steamed, incubated with *Neurospora intermedia or Rhizopus oligosporus* and fermented for 1 to 2 days at 25 to 30°C after wrapping in banana leaves. It may be fried in oil or margarine and consumed [21].

**Bakery products** - Groundnut cake meal or defatted meal can be used to prepare bakery products with excellent oraganoleptic qualities [15]. Studies have shown that value added products like breads, biscuits, cookies and other products could be excellent vehicles for enhancing the utilization of groundnut protein especially in the diets of malnourished people in the developing countries [4].

**Groundnut milk** - Groundnut milk can be prepared by soaking kernels in 1 percent sodium bicarbonate ($NaHCO3$) solution for 16 to 18 hours. The kernels are grounded in aqueous medium. The wet mass is steeped for 4 to 5 hour and filtered through cheesecloth to remove the product. In India groundnut milk called Miltone® is a commercial reality. Miltone® consists of groundnut milk extended with buffalo milk. It is prepared by adding shelled groundnuts to boiling water, removed from heat and is soaked for 7 minutes. It is then drained, deskinned. They are then soaked in 2% $NaHCO3$ overnight. They are then rinsed with tap water; blend in warming blender with water (1:5 w/v) for 4 to 5 minutes. The homogenate is filtered through cheese cloth. Whey powder is added to the filterate at 4% level (w/v), mixed thoroughly for 1 hour and boiled for 10 minutes to get groundnut milk [21]. Ground nut milk is usually fermented with *Lactobacillus acidophilus* and used as probiotic drink [11]

Peanut milk is one option to try if you follow a casein-free diet because, contrary to its name, it does not contain real milk. Sweeteners or seasonings such as cinnamon are also added. Peanut milk provides some nutritional benefits you won't get from cow's milk such as vitamin E, magnesium and vitamin B-6, and is packed with heart-healthy unsaturated fats [11].

***Mishi*** - *Mishi* is concentrated, spiced yoghurt prepared from whole milk in Sudan and usually consumed along with bread. *Mish*i can also be prepared from peanut milk by boiling the milk for 3 minutes then cooling to 45°C and inoculating with yoghurt culture (1:1 mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* grown in whole milk for 6 hours) at 5% level. This is then incubated at 45°C for 16 hours. Spices like garlic, ajwain and black pepper are added and refrigerated. Whey is drained through a cheese cloth and salt is added at 1% level [16].

**Groundnut-based yoghurt** - Groundnut yoghurt may be prepared by the pasteurization of groundnut milk containing 5 percent lactose. After cooling yoghurt culture is inoculated and incubated at 37°C for 4h. Final product before consumption may be refrigerated .

**Groundnut Dahi** – The nutty flavour in peanut milk is due to the hexanal compound which is generated by the action of lipoxygenase on fatty acids. Dr. R. T. Patil and his team at the Central Institute of Post Harvest Engineering and Technology (CIPHET) under ICAR has developed a commercially viable process for the inactivation of lipoxygenase enzyme[12]. This was coupled with use of modern airless grinding and de-odourising technique. By using such prepared peanut milk, highly acceptable chocolate/vanilla flavoured beverages have been developed with about 12% total solids and 3.25% protein. The process for the preparation of acceptable curd (Dahi) with 15 % total solids and 4.25 % protein has also been optimized. .

**Groundnut bars** - The formulation contains 72 percent finely ground groundnuts, 12 percent maltose syrup, 9.5 percent finely ground sugar, 3 percent roasted desiccated coconut, 2 percent finely ground rice, 1 percent roasted sesame (*Sesamum indicum*) seed and 0.5 percent salt [25]. The ingredients are mixed at 60°C and passed through a peanut-butter mill. The mixture is pressed into a rectangular-shaped mould.

**Groundnut butter** - Commercial manufacture and consumption of groundnut butter is largely an American art. Groundnut butter is mainly used as a spread for bread or biscuits, in sandwiches, in candies and frostings or icings. It is a fair sources of calcium, iron, thiamine, riboflavin and excellent source of niacin. Manufacture of groundnut butter involves roasting for controlled browning at 160°C for 40 to 60 minutes; cooling to stop the cooking process; blanching to remove the skins (testa); and then graded to remove light, scorched or discoloured kernels [21]. Addition of salt, stabilizers and other optional ingredients including sweeteners are measured and blended with the butter prior to cooling and packaging. Other additives include hydrogenated oil, antioxidants, honey, lecithin, whey.

**Groundnut cheese** - Cheese like products have been made from groundnut like protein isolate just as cheese is made from cow's milk. It has good quality protein, is easily prepared and low in cost. It is being used for "Mixed" feeding of undernourished groups in the developing countries [21]. A processed cheese spread has been prepared from groundnut protein based tone milk in India. It has a smooth consistency and milky flavour.

**Tofu *(curd)*** - Tofu from groundnut is a famous product in China and Japan. Soaking the groundnut kernels overnight and grinding into an emulsion may prepare it. The emulsion is boiled and filtered. The curd may be precipitated from the resulting fluid by adding calcium or magnesium sulphate. The product is left to settle and transferred to boxes lined with cloth filters or spread on trays. It may be sold as slices or slabs, curd is served in soup; the wet curd can be deep fried in oil [11].

**Groundnut sweets** - In India, groundnut is used to prepare *laddu* and *chikki*. To prepare *laddu*, groundnut kernels are roasted and seed coat is removed, the separated cotyledons are mixed with thick, hot jaggery syrup. Small portions of the mixture are pressed to balls or *laddus*. *Chikk*i is very popular product in Western India. It is prepared by mixing roasted and decorticated groundnut kernels with hot slurry of sugar. The mixture is spread in a thick layer on a tray or similar flat surface and then cut into small pieces on cooling. Roasted groundnuts are also used in the preparations of various other traditional Indian recipes such as *khichadi, guradani, barfi* and vegetable curries [14].

National Institute for Nutrition, Hyderabad, India has introduced a sweet prepared by groundnut, jaggery and wheat flour with low fat and high energy, named *Suruchi* [14]. The product was tested on the school children for its calorific value and consumer acceptance. The United Nations Development Programme (UNDP), in partnership with the Food and Agriculture Organization of the United Nations (FAO), in collaboration with the Technology Mission on Oilseeds and Pulses Ministry of Agriculture has published a "Culinary Preparations with Groundnut" of 42 delicious preparations with groundnut with the intent to promote groundnut as food crop for sustained nutritional security [25].

**Partially defatted groundnuts** – The preparation procedure involves removing the oil from the groundnuts and then reconstituting and roasting the kernels. Roasted groundnut kernels without skins contains high percent of protein, oil and carbohydrates along with many essential minerals and vitamins. This process consists essentially of simple mechanical operations: i.) pressing ii.) reconstitution and iii.) drying and roasting, either raw (with skin) or blanched groundnuts are hydraulically pressed to remove the desired amount of oil. The pressed groundnuts are boiled in water to expand them and to restore their original shape and size. Salt and other ingredients can be added during the expansion step. The expanded groundnuts are then dried and roasted [22].

**Groundnut protein film** - Groundnut protein film is one of the alternative edible films that can be used in an intermediate moisture food (IMF) due to its promising characteristics: bland flavour, low oxygen permeability and its ability to incorporate antimicrobial agents. A study proved that the predicted sorbic acid profile in coated food showed that groundnut protein might be used to retard sorbic acid migration from surface to food core and extend the product shelf life [13].

**Value-added peanut based nutraceuticals** - Peanut skin has low economic value despite the high content of antioxidants such as phenolics and can be an inexpensive source of antioxidants for use as dietary supplements. Peanut skins are obtained by direct peeling, blanching, and roasting. Total phenolics (TPs), total antioxidant activity (TAA) and free radical scavenging capacity of peanut skin extracts were determined by Yu and co workers [28]. High free radical scavenging capacities of peanut skin extracts were observed with high vitamin C.

## 5. Conclusion

Groundnut is also consumed directly and is used in processed food and snacks. Approximately one-third of world production is used in the confectionery products. Utilization of oil, meal and confectionery groundnuts are all increasing concurrent with a gradual shift away from oil and meal into confectionery use.

Initiating strong programs can investigate the underlying functional components and properties of peanut by-products which in turn proves it's potential as food and feed additive. Another important challenge is in the potential applications of byproducts with modern technology (such as superfine grinding technology, microwave-assisted and ultrasound-assisted technology) both directly as food or feed supplements for animal and human consumption, and indirectly, as potentially health promoting byproducts in the meat supply, to offset and replace the carcinogenic effects of chemical food additives. Problems with the world food supply remain a serious matter which is the main cause of hunger and malnutrition across the world. With that as background, the development of by-products from peanut industry will make a significant contribution in all these areas in the years to come.

## References

[1] Achaya KT (1990) Oilseeds and oilmilling in India. A cultural and historical Survey, Oxford and IBH publishing Co. Pvt. Ltd. Calcutta.
[2] Achaya KT (1993) FAG/WHO Expert Consultation on Fat and Oils. www.fao.org/docrep
[3] Ahmed EH and Young CT (1982) Composition, nutrition and flavour of peanuts. Peanut Science and Technology, American Peanut Research and Association, Yoakum, Texas, USA, pp. 655-658.
[4] Bansal P (2013) Development of value added products using peanut flour for nutritional and health benefits. M.Sc. Thesis (Food and Nutrition). Punjab Agricultural University, Ludhiana, Punjab. 129p.
[5] Bassey FI, McWatters KH, Edem CA and Iwegbur CMA (2013) Formulation and Nutritional evaluation of weaning food processed from cooking banana and supplementation with cowpea and peanut. *Food Sci. Nutr*. 1(5): 384-91.
[6] Chinnan MS (2011) Peanut Further Processing. Department of Food Science and Technology, College of Agricultural and Environmental Sciences, University of Georgia, Griffin, p46
[7] Desai BB, Kotecha PM and Salunkhe DK (1999) Groundnut protein product. In: Introduction science and technology of groundnut: biology, production, processing and utilization. Naya Prokash Publishers, New Delhi, India, pp 546–582
[8] Devi KB, Vidhya R and Jaganmohan R (2013) Determination and Isolation of Protein from Different Fractions of Defatted Groundnut Oil Cake. *Afr. J. Plant Sci* 7(8): 394-400
[9] FAO- Food and Agricultural Organisation (1994) Expert's recommendations on fats and oils in human nutrition. Fats and Oils in Human Nutrition: Report of Joint Expert Consultation, FAO Food and Nutrition Paper No. 57. 9
[10] Fekria AM, Isam ASA, Suha OA and Elfadil EB (2012) Nutritional and functional characterization of defatted seed cake flour of two Sudanese groundnut (Arachis hypogaea). *Intl. Food Res. J.* 12: 629-37.
[11] Giyarto, Djaafar TF, Rahaya ES and Utami (2012) Fermentation of peanut milk by Lactobacillus acidophilus SNP-2 for production of non-dairy probiotic drink. *Proceedings of 3rd International Conference of Indonesian Society for Lactic Acid Bacteria: Better :Life with LAB: Exploring Novel function of LAB*. 9p.
[12] ICAR- Indian Council of Agricultural Research (2009) Development of Groundnut based Flavoured Beverages and Curd. www.icar.org.in/un/node/588
[13] Jangchud A, Parameswarakumar, Mallikarjunan MS, Chinnan H, YunYun, Anuvat, Jangchud P, Mallikarjunan and Hao YY (1999) Sorbic acid migration in an intermediate moisture food coated with peanut protein film, Annual International Meeting,Toronto, Ontario, Canada, 18-21 July, 1999. 23 pp.; ASAE Paper No. 996147; American Society of Agricultural Engineers (ASAE); St Joseph; USA
[14] Kadam SS and Chauhan JK (1991) Utilisation of groundnut in India and scope for novel and alternative uses. Use of tropical grain legume: Proceedings of a Consultants Meeting, 27-30 March 1989, ICRISAT centre, India.
[15] Kane LE, Davis JP, Oakes AJ, Dean LL and Sanders TH (2012) Value added processing of peanut meal. *J. Food Biochem*. 36(5): 520-31.
[16] Kim N, KimYJ and Nam YJ (1992) Characterisation and functional properties of protein isolates from various peanut cultivars. *J. Food Sci*. 57(2): 406-10.
[17] Lewis WE, Harris GK, Sanders TH, White LB and Dean LL (2013) Antioxidant and Anti-inflammatory effects of Peanut skin extracts. *Biomed. Life Sci*. 4(8A): 22-32.
[18] Nautiyal PC (2002) Groundnut Post-Harvest Operations. InPGO- Post Harvest Compendium, National Research Center for Groundnut, Indian Council of Agricultural Research, p127
[19] Patee HE and Young CY (1982) Peanut Science and Technology, American Peanut Research and Education Society, Inc. Yoakum, Taxas, USA
[20] Purohit C and Rajyalakshmi P (2011) Quality of products containing defatted groundnut cake flour. *J. Food Sci. Technol*. 48: 26-35.
[21] Singh B (1992) Aspects of groundnut utilization and possible improvements of Indiginous food in some countries of semi-arid tropical Africa. In Groundnut a Global Prespective (ed.)
[22] Singh MP and Memon AH (1993) Harvest and postharvest technology scheme All India coordinated ICAR, Research Scheme, Faculty of Agricultural Engineering and technology, Gujarat Agricultural University, Junagadh, Gujarat, India.
[23] Singh B and Singh U (1991) Peanut as a source of protein for human foods. *Plt. Food Hum. Nutr*. 41: 165-77.
[24] Spadaro JJ (1979) Uses of defatted and partially defatted peanut four. *J. Amr. Oil Chem. Soc*. 56: 474-75.

[25] Sulochana BN, Bhargavi K, Reddy TY and Basu MS (2000) Culinary Preparations with groundnut. UNDP Sub-programme on "Promoting Groundnut as Food Crop for Sustained nutritional Security" Implemented by National Research Centre for Groundnut, Junagadh in Collaboration with Acharya NG Ranga Agricultural University, RRS, Anantpur, Andhrapradesh.
[26] Tate RV, Chavan JK, Patil PB and Kadam SS (1990) Processing of commercial peanut cake into food-grade meal and it's utilization in preparation of cookies. *Plt. Food Hum.Nutr*. 40:115-21.
[27] United Nations Children's Fund (UNICEF) (2007) Progress for children: A world fit for children statistical review- UNICEF, New York (http://www.unicef.org/progress for children/2007nb/index_41505.htm)
[28] Yu JM, Ahmedna M, Goktepe I and Dai J (2006) Peanut skin procyanidins: Composition and antioxidant activities as affected by processing. *J Food Compos Anal* 19:364–371.

# Nutritional Evaluation of Value Added Products Using Partially Defatted Peanut Cake And Dehydrated Green Leafy Powder Developed for the Malnourished

Bindhya Dhanesh T[1] and Anita Kochhar[2]

[1] Ph. D Scholar [2] Professor and Head
Department of Food and Nutrition, College of Home Science, Punjab Agricultural University, Ludhiana, Punjab
Email- dhanesh.bindhya@gmail.com

## ABSTRACT

Adequate complementary feeding of infants with home based foods from the age of six months, while continuing breast feeding is crucial to prevent malnutrition. Thus there is a need to popularize low cost complementary foods. Partially defatted peanut flour is a cheap underutilized by product of peanut after oil extraction with a high nutritional profile. Five value added products namely *Matthi, Seviyan, Pinni, Panjir*i and Biscuits with different proportion of DPF and Green leafy vegetable (GLV) powder were developed and evaluated for their sensory attributes. The products were acceptable with a 10 per cent DPF and 1 per cent fenugreek leaf powder for *Matthi and Seviyan* While for *Pinni and Panjiri* 15 per cent of DPF and 2 per cent of spinach leaf powder was found to be acceptable. In the case of biscuits, DPF of 10 per cent and spinach powder of 1.5 per cent was acceptable. The nutritional analysis of the products revealed a significant increase in the proximate composition especially protein in the range of 18-20 per cent, fat 1-3 per cent, fiber 20-25 per cent and energy 460-500 Kcal. Mineral composition like iron, calcium and zinc also increased in the fortified products. Higher percent of *invitro* protein digestibility and higher amino acid profile was observed in the fortified products compared to the control which were not fortified. Thus the study revealed that the value added products prepared by using partially defatted peanut flour and powdered green leafy vegetables can be a promising solution to eradicate malnutrition.

**Keywords:** Partially defatted peanut cake flour, Green leafy vegetables, Value added products, Sensory attributes, Nutritional analysis

## INTRODUCTION

Nutrition of infants and young children is critical for their survival, cognitive development and growth not only during the childhood but for their whole life span. The treatment of malnutrition, as well as its prevention, among under five children requires consumption of nutritious food, including exclusive breastfeeding for the first 6 months of life and in combination with complementary foods thereafter till at least 24 months of age along with an hygienic environment and access to preventive (immunization, vitamin A supplementation etc) as well as good (prenatal) care (Pee and Bloem 2008). Poverty and food insecurity seriously constrain accessibility of nutritious diets, including high protein quality, adequate micronutrient content and bioavailability, macro-minerals and essential fatty acids, low anti-nutrient content, and high nutrient density. Hence, popularization of low cost nutritious food particularly for vulnerable groups like infants, young children and adolescent girls is the main concern.

Peanut meal, an underutilized by-product left after oil extraction is a rich source of protein. Peanut meal can be dried and ground in a flour form that can be added to various daily consumed foods (Zhao *et al*

2012). Peanuts have a desirable fatty acid profile and are rich in vitamins, minerals and bioactive materials. Peanut flour which is most commonly used for fortification contains protein ranging in between 47-55 per cent which contributes to a good amount of protein. Peanut flour has also been used to replace animal protein in a variety of products. The cake contains 45-60 per cent protein, 22-30 per cent of carbohydrates, 3.8-7.5 per cent crude fiber and 4-6 per cent minerals (Desai *et al*., 1999).

Defatted groundnut flour produced from cake blends easily and enhances or enriches the nutritive value of wheat flour and other flour (Purohit and Rajyalakshmi, 2011). The defatted groundnut flour, an underutilized by-product of groundnut processing, has potentials to be used in food system as low fat groundnut concentrate to be used extenders in meat processing, in production of beverages, fermented products, composite flours and protein supplements of bakery products and weaning formulation (Tate *et al*., 1990; Venkataraghavan, 1998). Hence the present study was undertaken to develop value added products using partially defatted peanut cake flour along with small quantities of powdered green leafy vegetables and were analysed for their nutritional composition to know if they have an enhanced nutritional profile making it fit to reduce the incidence of malnutrition and to improve the nutritional status of malnourished.

## MATERIALS AND METHODS

### Procurement and Processing of raw materials

Different ingredients for the development of value added products like Wheat flour, Refined wheat flour, Chick pea flour, Raw peanuts , Seasonal green leafy vegetable i.e. spinach and fenugreek leaves as well as other ingredients like oil, ghee, salt, powdered sugar were procured from the local market of Ludhiana in a single lot.

Peanuts were purchased and checked for any infestation or damage. They were then roasted, de-skinned. Oil was extracted by using oil extraction machine. The residual cake was then collected and further dried in the oven at 65 ºC for half an hour. Dried cake was ground to fine powder. Green leafy vegetable like spinach and fenugreek leaves were procured dried in a tray drier at 60°C for 5-6 hours (constant weight was achieved in this time). The dried spinach and fenugreek leaves were ground to fine powder stored in separate airtight containers.

### Formulation and development of the products

Five value added products namely *Matthi, Seviyan, Pinni, Panjir*i and Biscuits were developed. The basic ingredient used for all the products was cereal-pulse mix flour. Pulse flour was taken in one-third amount of cereal flour. This mix was replaced for the main ingredient listed in the standard procedure. Wheat and refined flour were used as a cereal source and chickpea flour was used as a pulse source. The standard procedures used for product development were as follows:

1. ***Matthi-*** Refined wheat flour (100g), carom seeds and salt (1/2 tsp) is mixed with 7g of dalda thoroughly. Stiff dough is prepared using water. Small balls are rolled out and flattened. They are then pricked with fork and deep fried in oil

2. ***Seviyan-*** Basic ingredient is chickpea flour. To 100g of chick pea flour salt is added and soft dough is prepared using water and 5ml of oil. It is then filled into a seviyan machine. The dough is then extruded out into hot oil and deep fried.

3. ***Pinni-*** Wheat flour (100g) is roasted in 50g ghee. It is then mixed well with powdered sugar.

4. ***Panjiri-*** Wheat flour (100g) is roasted in 60 g of ghee. It is then removed from flame and mixed well with powdered sugar and rolled into small ball when warm.

5. **Biscuits-** 100g of wheat flour is sieved with a pinch of baking powder and kept a side. Fat (54g) and sugar (52g) is creamed well on a flat surface. The flour is added to the cream slowly and folded in and mixed thoroughly to form soft dough. The dough is then rolled and cut out into desired shapes. These are baked in the oven at 180°C for 20 minutes.

**Sensory evaluation of the value added products**

The ready-to-eat supplementary foods were prepared in the Food Laboratory of Department of Food and Nutrition, Punjab Agricultural University, Ludhiana. The five ready-to-eat supplementary foods were first standardized with different levels with peanut flour and 10 per cent flour was added to salty snacks like *Matthi* and *Seviyan* as well as biscuits while 15 per cent of peanut flour was added to the sweet products like *Pinni* and *Panjiri*. Different levels of incorporation of fenugreek leaf powder in *matthi* and *seviyan*; spinach leaves powder in *pinni*, *panjiri* and biscuits were further done along with the acceptable proportion of peanut flour. Each of the five developed ready-to-eat supplementary foods for malnourished children was compared treatment wise by ten trained panelists including faculty of department of Food and Nutrition of Punjab Agricultural University in the age range of 45 to 55 years using 9 point hedonic scale for different parameters such as appearance, colour, texture, aroma, taste and overall acceptability (Larmond 1970). The composition of the different products subjected to sensory evaluation as presented in Table 1.

**Table 1. Composition of the different value added products using peanut flour (DPF) and powdered green leafy vegetables (GLV)**

| Products | Ingredients | | | |
|---|---|---|---|---|
| ***2. Matthi*** | | | | |
| Variations | Refined Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 75.00 | 25.00 | - | - |
| S2 | 67.00 | 22.50 | 10 | 0.5 |
| S3 | 66.50 | 22.50 | 10 | 1.00 |
| S4 | 66.00 | 22.50 | 10 | 1.50 |
| ***6. Seviyan*** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 25.00 | 75.00 | - | - |
| S2 | 22.50 | 67.00 | 10 | 0.50 |
| S3 | 22.50 | 66.50 | 10 | 1.00 |
| S4 | 22.50 | 66.00 | 10 | 1.50 |
| ***7. Pinni*** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 75.00 | 25.00 | - | - |

| | | | | |
|---|---|---|---|---|
| S2 | 62.00 | 22.00 | 15 | 1.00 |
| S3 | 61.50 | 22.00 | 15 | 1.50 |
| S4 | 61.00 | 22.00 | 15 | 2.00 |
| ***8. Panjiri*** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 75.00 | 25.00 | - | - |
| S2 | 62.00 | 22.00 | 15 | 1.00 |
| S3 | 61.50 | 22.00 | 15 | 1.50 |
| S4 | 61.00 | 22.00 | 15 | 2.00 |
| **9. Biscuits** | | | | |
| Variations | Wheat flour (g) | Chickpea flour (g) | DPF (g) | GLV (g) |
| S1 | 75.00 | 25.00 | - | - |
| S2 | 67.00 | 22.00 | 10 | 1.00 |
| S3 | 66.50 | 22.00 | 10 | 1.50 |
| S4 | 66.00 | 22.00 | 10 | 2.00 |

***S1 is taken as the Control for all the products**

From the sensory score, the most acceptable product was selected and subjected to nutritional analysis along with its control.

**Nutritional Analysis of the value added products**

The developed value added products were then subjected to nutritional analysis for proximate, mineral, vitamin and amino acid content using standard procedures. *Invitro* protein digestibility was also analysed. Both the control (without peanut flour and green leafy vegetable powder) and the acceptable product were analysed so to compare the increase in the nutritional profile.

1. **Proximate Composition** - Proximate composites like Moisture, Crude Protein, Crude Fat, Crude Fiber, Crude Ash, Carbohydrates and Energy were analysed using standard procedures suggested by AOAC (2000).

2. **Total minerals** - Elements namely iron, calcium, zinc and phosphorus were estimated using atomic absorption spectrophotometer (AAS, Varian model) after wet digestion (Piper, 1950).

3. **Vitamins** – Vitamins like Ascorbic Acid was analysed using standard procedures given in AOAC (2000) and Beta carotene was estimated by column chromatography method as explained by Rangana (1995)

4. ***In vitro* protein digestibility** - It was carried out by the by macro kjeldahl method (Akeson and Stachman 1964).

5. **Amino acids-** Amino acids like Tryptophan (Concon 1975), Methionine (Horn *et al* 1946) and lysine (Carpenter 1960) as modified by (Booth 1971) were analysed.

6. **Anti nutritional compostion-** Phytin phosphorous was analysed using the procedure suggested by Haug and Lantzsch (1983), Total phenols (AOAC 2000), Tannin (Ranganna 2001) and Aflatoxins from the samples were extracted by using the method of Barabalok *et al* (1974) and further detected using the Pressure Mini Column methods (PCM) Sashidhar *et al* (1989).

**Statistical Analysis**

The sensory scores were analysed using Kruskal-Wallis test and paired t-test was applied for the nutritional attributes. The values are expressed as Mean±SE (Standard error)

## RESULT AND DISCUSSION

### Sensory evaluation of the value added products using defatted peanut cake flour and powdered green leafy vegetables

The sensory scores for the value added products with the incorporation of peanut flour and GLV are presented in Table 2. It was observed that too high and too low incorporation of GLV was not acceptable for *Matthi, Seviyan and* Biscuits. While increasing the GLV content was found to be acceptable in case of *Pinni and Panjiri.*

Highest scores were obtained for the Control in the case of all the products followed by S3 (10% DPF and 1% GLV) in the case of *Matthi and Seviyan*. Bansal (2013) also reported that traditional Indian snack *matthi* were prepared with peanut flour at 10, 20 and 30 per cent level of incorporation. Peanut flour at the level of incorporation of 10 per cent in *matthi* was found to be acceptable. Gupta and Prakash (2011) reported that an incorporation of 'Keerae' (*Amaranthus paniculatus*) upto 4 per cent level in products like *Mathri* and *Thalipeeth* was acceptable. Kaur and her co workers (2015) also prepared *Matthi* and Biscuits incorporating dehydrated *palak* (*Beta vulgaricus* L.) and reported that the products were acceptable at 4 per cent level.

*Pinni and Panjiri* were for found to be acceptable with 15 per cent peanut flour and 2 per cent of spinach powder. *Pinni* prepared with different combination of cereal and pulse flours were studied for sensory and nutritional parameters by Talawar and Brar (2015). The authors found that Control (Wheat flour) *pinni* scored the highest scores for sensory attributes followed by *pinni* prepared using wheat flour and *suji* followed by those prepared using wheat flour and chickpea flour.

In the case of biscuits, highest scores were obtained for the Control and among the samples. Sample 3 (10% DPF and 1.5% GLV) received the highest scores for all parameters after the control. Yadav and his co workers (2012) have reported that incorporation of deoiled peanut flour in biscuits was most acceptable at 5 per cent (8.60) and was acceptable upto 15 per cent but more amounts had a negative effect.

**Table 2. The Sensory Scores for the Value added products using Peanut Flour and GLV powder**

| Proportions | Parameters | | | | | |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Texture | Aroma | Taste | Overall Acceptability |
| ***Matthi*** | | | | | | |
| S1 | 7.90 | 7.90 | 7.90 | 7.50 | 7.90 | 7.90 |
| S2 | 7.10 | 7.20 | 7.50 | 7.10 | 7.40 | 7.16 |
| S3 | 7.00 | 7.20 | 7.50 | 7.20 | 7.40 | 7.18 |
| S4 | 5.70 | 5.90 | 6.10 | 5.70 | 6.40 | 5.86 |
| $\chi 2$ value | 27.131** | 24.342** | 19.084** | 28.497** | 15.775** | 24.966** |
| ***Seviyan*** | | | | | | |
| S1 | 7.70 | 7.00 | 8.00 | 7.70 | 8.00 | 7.68 |
| S2 | 7.70 | 7.00 | 7.70 | 7.00 | 7.20 | 7.40 |

| | | | | | | |
|---|---|---|---|---|---|---|
| S3 | 7.00 | 7.00 | 8.00 | 7.00 | 7.30 | 7.48 |
| S4 | 6.30 | 5.30 | 7.40 | 5.40 | 5.00 | 5.84 |
| $\chi 2$ value | 30.715** | 38.329** | 30.594** | 34.134** | 29.163** | 30.889** |
| ***Pinni*** | | | | | | |
| S1 | 7.80 | 7.80 | 7.80 | 7.80 | 7.80 | 7.80 |
| S2 | 7.50 | 6.90 | 7.60 | 7.00 | 7.60 | 7.44 |
| S3 | 7.50 | 6.90 | 7.60 | 7.00 | 7.60 | 7.50 |
| S4 | 7.30 | 6.00 | 7.50 | 7.00 | 7.30 | 7.62 |
| $\chi 2$ value | $7.485^{NS}$ | 24.409** | $5.087^{NS}$ | 20.647** | $5.688^{NS}$ | 13.548** |
| ***Panjiri*** | | | | | | |
| S1 | 7.90 | 7.90 | 7.90 | 7.80 | 7.90 | 7.90 |
| S2 | 7.60 | 7.00 | 7.60 | 7.00 | 7.60 | 7.36 |
| S3 | 7.60 | 7.00 | 7.60 | 7.00 | 7.60 | 7.26 |
| S4 | 7.30 | 7.00 | 7.60 | 7.00 | 7.60 | 7.36 |
| $\chi 2$ value | $7.313^{NS}$ | 33.968** | $7.313^{NS}$ | 20.647** | $7.485^{NS}$ | 16.089** |
| **Biscuits** | | | | | | |
| S1 | 8.00 | 7.90 | 7.80 | 7.80 | 7.90 | 8.00 |
| S2 | 7.80 | 7.30 | 7.30 | 7.00 | 7.80 | 7.30 |
| S3 | 7.30 | 7.30 | 7.30 | 7.00 | 7.40 | 7.50 |
| S4 | 6.10 | 5.60 | 7.10 | 5.90 | 5.60 | 5.60 |
| $\chi 2$ value | 24.408** | 26.131** | $0.616^{NS}$ | 22.359** | 27.866** | 25.408** |

Scores are presented as the mean values Level of significance ($p$ <0.01)
** Significant at 1% level *Significant at 5% level NS- Not significant

Hence, the most acceptable combination of ingredients was selected for each product as is presented in Table 3 and was further analysed for their nutritional composition along with their control which has not been fortified with any peanut flour or powdered green leafy vegetable.

**Table 3. Composition of the value added products using partially defatted peanut cake flour (DPF) and Powdered green (GLV)**

| Products | Ingredients (g) | | | |
|---|---|---|---|---|
| | **Wheat flour** | **Chickpea flour** | **DPF** | **GLV** |
| *Matthi* | 66.50 | 22.50 | 10 | 1 |
| *Seviyan* | 22.50 | 66.50 | 10 | 1 |
| *Pinni* | 61.50 | 21.50 | 15 | 2 |
| *Panjiri* | 61.50 | 21.50 | 15 | 2 |
| Biscuits | 66.00 | 22.50 | 10 | 1.5 |

**Nutritional Evaluation of the value added products**

**Proximate Composition**

The proximate composition of both the control and acceptable products were analysed and is presented in Table 4. Moisture content increased significantly ($p$ < 0.05) on incorporation of peanut flour and GLV powder except for *seviyan*. Protein content increased significantly ($p < 0.05$) in all the products. Significant difference ($p < 0.05$) in fat content was observed in all the products except *Matthi*. Highest fiber content was observed in *pinni* followed by *panjiri*. The fiber increased significantly ($p < 0.05$) in *seviyan, panjiri, matthi* and *pinni*. The difference in the total ash content of *pinni* was found to be insignificant. Similar study conducted by Bansal (2013) reported that the proximate composition of *matthri*, *seviyan, panjiri* and biscuits increased significantly for all proximate parameters except for moisture and ash.

The significant increase in the protein content is attributed by the peanut flour incorporated in all the products. Agarwal and Sharma (2013) noted a significant increase in *matthri* fortified with garden cress seed flour with respect to protein and fat while the difference in other proximate parameters were found to be insignificant. *Matthri* when incorporated with dried green leafy powder (Mint, spinach and carrot leaves) were found to have high protein content of 7.44 per cent (Verma and Jain, 2012). *Panjiri* developed by using cereal and legume flour like wheat flour, soybean flour and chick pea flour in different combination and fortified with 10% skimmed milk powder contained higher amount of protein and other nutrients. They contained proteins (16.2 to 21.1%), fat (1.9 to 4.5%), fiber (1.28 to 1.78%), ash (0.7 to 1.40%) and carbohydrates (67.66 to 77.2%). Also showed that soy flour / chickpea flour alone or in combination, both increased the amount of protein significantly. The total energy expressed in terms of Kcal per 100 g of product varied from 350.7 to 395.8 (Salve *etal* 2011).

**Table 4 . Proximate composition of developed products (dry weight basis) (g / 100 g)**

| **Products** | **Moisture** | **Crude Protein** | **Crude Fiber** | **Crude Fat** | **Total Ash** | **Carbohydrates (by differences)** | **Energy (Kcal/100g)** |
|---|---|---|---|---|---|---|---|
| ***Matthi*** (control) | 3.32±0.008 | 11.59±0.017 | 0.23±0.012 | 18.86±0.035 | 0.48±0.014 | 68.85±0.027 | 491.67±0.19 |
| Acceptable (DPF+FLP) | 3.44±0.014 | 16.58±0.015 | 1.43±0.161 | 20.92±0.040 | 0.88±0.017 | 60.48±0.056 | 495.56±0.13 |
| **t-value** | 18.500** | 175.09** | 7.272* | 46.641** | 122.00** | 288.261** | 80.032** |
| ***Seviyan*** **(**control**)** | 2.35±0.014 | 16.04±0.096 | 1.75±0.017 | 16.28±0.037 | 1.25±0.017 | 64.55±0.020 | 469.53±0.36 |
| Acceptable (DPF+FLP) | 2.54±0.018 | 23.49±0.280 | 2.94±0.020 | 18.06±0.029 | 1.79±0.012 | 54.23±0.153 | 471.24±0.09 |
| **t-value** | $5.584^{NS}$ | 19.937** | 77.904** | 36.386** | 93.531** | 76.780** | 6.279* |
| ***Pinni*** **(**control**)** | 4.31±0.012 | 11.02±0.048 | 1.41±0.008 | 25.11±0.049 | 2.54±0.023 | 63.01±0.092 | 494.64±0.08 |
| Acceptable (DPF+FLP) | 4.53±0.006 | 20.18±0.026 | 3.84±0.012 | 27.05±0.020 | 3.20±0.225 | 45.52±0.206 | 506.00±0.61 |
| **t-value** | 31.177** | 418.914** | 120.176** | 66.645** | $3.128^{NS}$ | 145.080** | 16.295** |
| ***Panjiri*** | 4.72±0.011 | 11.27±0.023 | 1.42±0.014 | 24.49±0.064 | 2.17±0.037 | 62.33±0.240 | 500.68±0.84 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **(**control**)** | | | | | | | |
| Acceptable (DPF+FLP) | 4.91±0.008 | 18.97±0.057 | 3.86±0.036 | 26.96±0.021 | 2.89±0.017 | 47.21±0.083 | 507.69±0.14 |
| **t-value** | 10.522** | 166.133** | 48.306** | 28.649** | 13.073** | 92.493** | 9.939** |
| **Biscuit (**control**)** | 3.32±0.005 | 12.44±0.306 | 0.27±0.033 | 18.91±0.029 | 0.54±0.012 | 73.43±0.226 | 466.31±0.441 |
| Acceptable (DPF+FLP) | 3.34±0.013 | 17.94±0.018 | 1.36±0.017 | 19.350±0.09 | 1.25±0.024 | 62.54±0.211 | 476.90±0.290 |
| **t-value** | 27.30** | 18.64** | 51.88** | 5.10* | 46.48** | 24.148** | 34.88** |

**Values are expressed as Mean±SE (Standard Error)** **Level of significance (p<0.05)**

**** Significant at 1% level** ***Significant at 5% level** **NS- Not significant**

**Amino Acid Profile**

An increase in the amino acid concentration was observed on the addition of partially defatted peanut cake flour and powdered green leafy vegetables (GLV) as depicted in Table 5. Statistically significant increase in the lysine content of all the products were observed except for *Seviyan*. While methionine and tryptophan increased significantly in all the products on fortification with peanut flour and GLV powder. Compared to the 100% cereal biscuits, sorghum-soy and bread wheat-soy 1:1 ratio composite biscuits had at least double the protein content and the lysine content increased by 500-700% (Serrem *eta*l 2011). Omwamba and Mahungu (2014) reported a concentration of 88-90 per cent lysine content in Protein-Rich Ready-to-Eat Extruded Snack from a Composite Blend of Rice, Sorghum and Soybean Flour.

**Table 5. Amino acid content of the developed products (mg / 100 g)**

| Products | Lysine | Methionine | Tryptophan |
|---|---|---|---|
| ***Matthi*** (control) | 445.087±1.098 | 158.533±0.176 | 125.436±0.822 |
| Acceptable (DPF+FLP) | 540.983±0.693 | 177.670±0.371 | 151.263±0.293 |
| **t-value** | 65.929** | 86.588** | 23.318** |
| ***Seviyan* (**control**)** | 948.036±1.170 | 180.296±0.035 | 133.430±0.110 |
| Acceptable (DPF+FLP) | 1016.960±17.634 | 204.763±0.281 | 149.973±0.266 |
| **t-value** | 4.184$^{NS}$ | 84.513** | 48.952** |
| ***Pinni* (**control**)** | 451.850±0.416 | 168.243±0.323 | 128.473±0.241 |
| Acceptable (DPF+FLP) | 587.810±0.837 | 182.308±0.337 | 142.080±0.150 |

| | | | |
|---|---|---|---|
| **t-value** | 113.464** | 21.299** | 147.778** |
| ***Panjiri*** **(**control**)** | 450.170±0.487 | 170.940±0.355 | 132.150±0.086 |
| Acceptable (DPF+FLP) | 582.2132±0.646 | 185.960±0.285 | 147.983±0.573 |
| **t-value** | 389.130** | 50.092** | 24.143** |
| **Biscuit (**control**)** | 450.210±0.0115 | 175.253±0.031 | 123.563±0.302 |
| Acceptable (DPF+FLP) | 546.013±1.642 | 180.846±0.311 | 158.580±0.071 |
| **t-value** | 58.264** | 19.413** | 115.481** |

**Values are expressed as Mean±SE (Standard Error)** **Level of significance (p<0.05)**
**** Significant at 1% level** ***Significant at 5% level** **NS- Not significant**

**Mineral And Vitamin Concentration**

As shown in Table 6, the mineral like calcium, iron and zinc increased significantly in the fortified products compared to the control which was not fortified with peanut flour and GLV powder. But in the case of their phosphorus content, a significant increase was only observed for *Matthi*, while for biscuit it remained almost the same and for the other products, a drop in phosphorus content was observed. *Matthri* when incorporated with dried green leafy powder (Mint, spinach and carrot leaves) were found to have high iron content of 5.37mg (Verma and Jain, 2012). In a study conducted by Salve et al (2011) calcium, phosphorus and iron were found to increase on supplementation with 10% skimmed milk powder to *panjiri* prepared using cereal legume mix basically wheat flour, soy flour and chick pea flour in different combinations. The cookies prepared by supplementing wheat with 30 per cent groundnut flour showed a high proximate profile but the zinc content highly reduced in groundnut biscuits when compared to wheat biscuits (Madukwe *et a*l, 2013).

**Table 6 . Mineral and Vitamin content of the developed products (mg / 100 g) (#fresh weight basis)**

| **Supplementary Foods** | **Calcium** | **Iron** | **Zinc** | **Phosphorus** | **Vitamin C#** | **Bcarotene** |
|---|---|---|---|---|---|---|
| ***Matthi*** (control) | 24.38±0.056 | 2.52±0.014 | 1.10±0.015 | 122.38±0.715 | 0.240±0.005 | 21.99±0.032 |
| Acceptable (DPF+FLP) | 29.13±0.100 | 4.18±0.032 | 1.49±0.024 | 132.57±0.295 | 0.123±0.003 | 20.21±0.059 |
| **t-value** | 71.339** | 89.803** | 29.000** | 17.767** | 35.000** | 45.463** |
| ***Seviyan*****(**control**)** | 50.39±0.047 | 3.14±0.030 | 1.33±0.025 | 141.09±0.962 | 0.810±0.006 | 91.73±0.177 |
| Acceptable (DPF+FLP) | 55.039±0.33 | 4.98±0.031 | 1.59±0.005 | 131.68±0.284 | 0.543±0.022 | 85.79±0.281 |
| **t-value** | 13.014** | 29.859** | 8.667* | 13.877** | 10.000* | 12.996** |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Pinni*** **(**control**)** | 44.85±0.421 | 3.02±0.006 | 0.84±0.012 | 191.81±0.255 | 0.458±0.017 | 23.22±0.321 |
| Acceptable (DPF+FLP) | 50.23±0.011 | 4.86±0.008 | 0.99±0.011 | 184.39±0.572 | 0.200±0.010 | 18.34±0.293 |
| **t-value** | 13.060** | 127.096** | 10.094** | 15.834** | 21.356** | 114.513** |
| ***Panjiri*** **(**control**)** | 44.89±0.018 | 3.23±0.056 | 0.76±0.006 | 182.56±0.722 | 0.453±0.003 | 24.73±0.097 |
| Acceptable (DPF+FLP) | 48.68±0.023 | 4.89±0.023 | 0.93±0.008 | 172.27±0.331 | 0.247±0.020 | 19.44±0.106 |
| **t-value** | 569.00** | 26.050** | 11.930** | 26.135** | 11.717** | 26.062** |
| **Biscuit (**control**)** | 21.92±0.058 | 1.90±0.040 | 1.05±0.020 | 118.26±1.512 | 0.327±0.008 | 22.31±0.353 |
| Acceptable (DPF+FLP) | 27.98±0.035 | 3.45±0.110 | 1.3±0.023 | 118.43±0.421 | 0.103±0.012 | 18.62±0.316 |
| **t-value** | 22.068** | 113.50** | 104.000** | 0.128^NS | 15.371** | 11.632** |

**Values are expressed as Mean±SE (Standard Error)** **Level of significance (p<0.05)**
**** Significant at 1% level** ***Significant at 5% level** **NS- Not significant**

The vitamin content like the vitamin C and beta carotene content also reduced significantly on fortification of the products which may be due to the reason that peanut flour is deficient in these vitamins and replacement of some amount of wheat flour and chickpea flour reduced the vitamin content. Peanut flour required more roasting during preparation due to which the vitamin C content must have reduced in all the products. Sadana *et al* (2008) noticed a considerable increase in the calcium, iron and beta carotene content of *seviyan* when fortified with germinated wheat and soybean four.

***Invitro* protein digestibility**

The in*vitro* protein digestibility of the products increased considerably which was statistically significant (p<0.05) on the fortification of products with peanut flour and GLV powder.

**Table 7. *Invitro* protein digestibility (%) of the developed products**

| **Supplementary Foods** | **In vitro protein digestibility** |
|---|---|
| ***Matthi*** (control) | 42.967±0.688 |
| Acceptable (DPF+FLP) | 60.220±0.280 |
| **t-value** | 49.489** |
| ***Seviyan*** **(**control**)** | 57.893±0.205 |
| Acceptable (DPF+FLP) | 68.687±0.054 |
| **t-value** | 66.540** |

| | |
|---|---|
| ***Pinni* (control)** | 44.980±0.030 |
| Acceptable (DPF+FLP) | 80.130±0.300 |
| **t-value** | 122.824** |
| ***Panjiri* (control)** | 43.920±0.315 |
| Acceptable (DPF+FLP) | 75.286±0.322 |
| **t-value** | 49.249** |
| **Biscuit (control)** | 43.037±0.431 |
| Acceptable (DPF+FLP) | 66.377±0.072 |
| **t-value** | 64.959** |

**Values are expressed as Mean±SE (Standard Error)** **Level of significance (p<0.05)**
**** Significant at 1% level** ***Significant at 5% level** **NS- Not significant**

Table 7 shows that the highest increase was seen in the case of *Pinni* from 44.980 to 80.130 per cent and *Panjiri* from 43.92 to 75.283 per cent which may be due to the highest percentage of peanut flour fortification. Serrem *et al* (2011) observed that the *invitro* protein digestibility of biscuits increased by 170 per cent in sorghum- soy biscuits compared normal wheat flour biscuits. Baba and his co workers (2012) Invitro protein digestibity of sprouted sorghum fortified with peanut and cow pea was found to be 96.9 per cent which was significantly higher than sorghum sprouts (89.9%).

**Antinutritional composition of the developed products**

With respect to the antinutritional composition of the products, the phytin and total phenol increased significantly for *pinni*, *panjiri* and biscuits while the increase in phytin content of fortified *seviyan* was insignificant as shown in Table 8. This may be due to the GLV powder added to the products. Tannin content reduced significantly for all products except for biscuits on fortification of the products with peanut flour and GLV powder. The antinutritional components like phytin and tannins of biscuits prepared from wheat flour and ground nut flour were analysed by Madukwe *et al* (2013) and they reported an insignificant difference for the phytin and tannin composition in wheat biscuits well as biscuits prepared from blends of wheat and groundnut flour. Aflatoxin was not detected in any of the products.

**Table 8. Antinutritional composition in the developed products (mg / 100 g)**

| Products | Phytin Phosphorus | Total Phenol | Tannin |
|---|---|---|---|
| ***Matthi*** (control) | 81.006±1.056 | 89.993±0.042 | 50.906±0.015 |
| Acceptable (DPF+FLP) | 84.036±0.646 | 92.223±0.029 | 48.916±0.442 |
| **t-value** | 7.066* | 43.456** | 4.575* |
| ***Seviyan* (control)** | 89.280±0.325 | 91.846±0.064 | 44.253±0.304 |

| | | | |
|---|---|---|---|
| Acceptable (DPF+FLP) | 90.116±0.020 | 90.263±0.072 | 41.986±0.028 |
| **t-value** | 2.568$^{NS}$ | 13.159** | 6.822* |
| ***Pinni*** **(**control**)** | 96.030±0.026 | 95.910±0.009 | 50.986±0.028 |
| Acceptable (DPF+FLP) | 93.453±0.126 | 96.796±0.028 | 49.830±0.270 |
| **t-value** | 39.875** | 18.057** | 4.783* |
| ***Panjiri*** **(**control**)** | 94.783±0.017 | 94.286±0.057 | 50.890±0.555 |
| Acceptable (DPF+FLP) | 92.883±0.024 | 95.943±0.043 | 46.963±0.218 |
| **t-value** | 22.824** | 58.169** | 10.973** |
| **Biscuit (**control**)** | 78.980±0.032 | 73.900±0.006 | 48.473±0.403 |
| Acceptable (DPF+FLP) | 80.043±0.057 | 75.200±0.015 | 46.943±0.024 |
| **t-value** | 164.545** | 65.000** | 3.643$^{NS}$ |

**Values are expressed as Mean±SE (Standard Error)** **Level of significance (p<0.05)**
**** Significant at 1% level** ***Significant at 5% level** **NS- Not significant**

**Conclusion**

Five value added products namely *Matthi, Sevyan, Pinni, Panjiri* and Biscuits prepared using cereal-pulse mix, partially defatted peanut cake flour and powdered green leafy vegetables were highly acceptable. For salty snacks like *Matthi*, *Seviyan* as well as biscuits partially defatted peanut cake flour was added at a concentration of 10 per cent while for sweet products like *Pinni* and *Panjiri*, it was added at 15 per cent level. Sensory evaluation of products prepared using peanut flour and different proportion of powdered green leafy vegetables revealed that the acceptable level of fortification of Fenugreek leaf powder in *Matthi* and *Seviyan* was found to be 1 per cent and Spinach leaf powder in *Pinni* and *Panjiri* was acceptable at 2 per cent level while for biscuit it was acceptable at 1.5 per cent level.

Nutritional analysis of the acceptable products products revealed a statistically significant increase in all the proximate components like protein, fat, carbohydrates, fiber and energy. An increase in minerals like calcium, zinc and iron was also observed but there was a decrease in phosphorus content in all the products. Amino acids like lysine, tryptophan and methionine increased significantly due to the addition of peanut flour compared to the control with an increase in *invitro* protein digestibility for all products. Insignificant differences were seen in the antinutritional composition of the products on fortification with peanut flour and powdered green leafy vegetables. Thus, on the basis of this present study, these products is highly recommended for various supplementary programmes aiming to eradicate malnutrition among the vulnerable groups.

**References**


Agarwal N and Sharma S (2013) Garden Cress : A non-conventional traditional plant item for food products. *Indian J of Traditional Knowledge*. 12(4): 699-706

Akeson W R and Stahmann MA (1964) A pepsin pancreatin digest index of protein quality evaluation. *J Nutr* 83: 257-261.

AOAC (2000) Official Method of Analysis Association of Official Analytical Chemist, 17tth ed. Washington DC.

Baba GM, Modu S, Falmata AS, Hajjagana L, and Ibrahim Z (2012) Evaluation of the nutritional value of sprouted sorghum fortified with cowpea and groundnut. *Scholarly Journal of Agricultural Science.* 2(11): 292-296

Bansal P (2013) Development of value added products with peanut flour for nutritional and health benefits. M.Sc. thesis (Food and Nutrition). Punjab Agricultural University, Ludhiana, Punjab. 129p.

Barabalok R, Colbarn C R and Smith R J (1974) Rapid screening method for examining corn and corn derived products for possible aflatoxin contamination. *J Assoc Off Anal Chem* 57:764-66.

Booth VH (1971) Problems in determination of FDNB-available lysine. *J Sci Food Agric* 22:658-66.

Carpenter KJ (1960) The estimation of available lysine in animal protein foods. *Biochem J* 77:604-10.

Concon JM (1975) Rapid and simple method for the determination of tryptophan in cereal grains. *Anal Biochem* 67: 206.

Desai BB, Kotecha PM and Salunkha DK (1999) Composition and nutritional quality. In: Introduction of Science and Technology of groundnut: Biology, Production, Processing and Utilisation. Naya Prakash Publishing, New Delhi, India. Pp-185-199.

Gupta S and Prakash J. 2011. Nutritional and sensory quality of micronutrient-rich traditional products incorporated with green leafy vegetables. Intl. Food Res J. 18: 667-75

Haug, W and Lantzsch, HJ (1983) Sensitive method for the rapid determination of phytic acid in cereals and cereals products. *J Sci. Food Agri* 3: 1423-1426.

Horn MJ, Jones DB, Blum AE (1946) Colorimetric determination of methionine in proteins and foods. *J Biol Chem* 166:313-20.

Kaur P, Dahiya S and Rana R. 2015. Development and Nutritional evaluation of Beta-carotene rich products using beet leaf (*Palak*) and Carrot. Intl. J Res. 2(2):1324-32

Larmond E (1970) Methods of sensory evaluation of food. *Can Deptt Agric Pubs* 1970:s1284.

Madukwe EU, Edeh RI and Obizoba IC (2013) Nutrient and Organoleptic Evaluation of Cereal and Legume Based Cookies. *Pakistan Journal of Nutrition* 12 (2): 154-157

Omwamba M and Mahungu SM (2014) Development of a Protein-Rich Ready-to-Eat Extruded Snack from a Composite Blend of Rice, Sorghum and Soybean Flour. *Food and Nutr Sci*.5(14): 1309-17

Pee SD and Bloem MW (2008) Current and Potential role of specially formulated foods and food supplementation for preventing malnutrition among 6-8 months old and treating moderate malnutrition among 6- 59 month old children. WHO, UNICEF, WFP and UNHCR Consultation on the Dietary Management of Moderate Malnutrition in Under-5 Children by the Health Sector September 30th October 3rd, 2008.

Piper C S (1950) Soil and plant analysis. Interscience Publication, Inc. New York. Pp:212

Purohit C and Rajyalakshmi P (2011) Quality of products containing defatted groundnut cake flour. *J. Food Sci. Tech*. 48: 26-35

Rangana S (1995) *Handbook of analysis and quality control for fruit and vegetable products.*Tata Mc Graw Hill Publishing Company limited, New Delhi.

Ranganna, S. (2001). Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Ranganna, S. (Ed.). Tata McGraw-Hill Publications, New Delhi. 719-724

Sadana B, Bakhetia P and Agarwal R (2008) Nutritional evaluation of germinated wheat and Soybean based supplementary foods. Indian J Ecol. 35(1): 87-90.

Salve RV, Mehrajfatema ZM, Kadam ML, More SG (2011) Formulation, Nutritional Evaluation and Storage Study of Supplementary Food (*Panjiri*). J Food Process Technol 2:131

Sashidhar R B, Bhat R V and Vasanthi S (1989) Non competitive Enzyme Linked Immuno-Sorbent Assay for detection of aflatoxin $B_1$. *Indian J Exp Biol* 26:984-89.

Serrem, Charlotte A. , de Kock, Henriëtte L. , Taylor, John R.N.(2011)Nutritional quality, sensory quality and consumer acceptability of sorghum and bread wheat biscuits fortified with defatted soy flour.International journal of food science & technology.46(1): 74-83

Talawar G and Brar SK (2015). Study of Physiochemical, Sensory and Color Properties of *Pinni* Variants. *Ind J Sci Technol.* 8(7): 629-34

Tate RV, Chavan JK, Patil PB and Kadam SS (1990) Processing of commercial peanut cake into food-grade meal and its utilization in preparation of cookies. *Plt. Food Hum Nutr.* 40: 115-21.

Venkataraghavan U (1998) Newer dimensions in the progressing of oilseeds for food use. *Indian Food Industry*. 17: 272-75

Verma S and Jain S (2012) Fortification of *mathri* with fresh and dehydrated vegetables and assessment of nutritional quality *Raj. J. Extn. Edu. 20 : 155-158*,

Yadav DN, Thakur N and Sunooj KV (2012) Effect of Partially De-Oiled Peanut Meal Flour (DPMF) on the Nutritional, Textural, Organoleptic and Physico Chemical Properties of Biscuits. *Food Nutr Sci.* 3:471-76.

Zhao, X, Chen, J and Du, F (2012) Potential use of peanut by-products in food processing: a review. *J. Food Sci. Technol*. 49: 521-29.

# EFFICACY OF VALUE ADDED PRODUCTS DEVELOPED INCORPORATING PARTIALLY DEFATTED PEANUT CAKE FLOUR ON THE NUTRITIONAL PROFILE OF MALNOURISHED PRESCHOOL CHILDREN

Bindhya Dhanesh T[1], Anita Kochhar[2] and Mohammed Javed[3]

[1] Ph. D Scholar [2] Professor and Head [3]Professor

[1]and [2]Department of Food and Nutrition, College of Home Science, Punjab Agricultural University

[3] Department of Stat, Math and Physics, College of Basic Sciences, Punjab Agricultural University Ludhiana, Punjab

Email- dhanesh.bindhya@gmail.com

## ABSTRACT

The efficacy of value added products prepared by incorporating partially defatted peanut cake flour (DPF) and dehydrated green leafy vegetable powder on the nutritional and health status of malnourished preschool children were determined in the present study. Five value added products namely *matthi, seviyan, pinni, panjiri* and biscuits were developed using DPF at the level of 10 percent and 15 per cent in salty snacks and sweet products respectively. Powdered green leafy vegetables were incorporated at 1-2 per cent level in the products. The products were found to be rich in their proximate composition upon analysis. The developed foods were supplemented to 30 preschool malnourished children under 5 years of experimental group selected on the basis of their anthropometric and nutritional profile for four months. The control group of other 30 malnourished preschool children was not given any supplements. The calories and proteins provided by 120-150g the product in the range of 400 to 450 kcal and 10g respectively. It was revealed that supplementation of developed products reported significant ($p<0.01$, $p<0.05$) increase in the intake of all macro and micronutrients in the experimental group. Significant ($p<0.01$) increase in weight, BMI, MUAC, chest circumference and Z-scores by subjects of experimental group was revealed after supplementation. Hence, the value added products developed incorporating partially defatted peanut cake flour and powdered green leafy vegetables could be a promising solution to treat malnutrition in children under five years if introduced in supplementary feeding programs run by different governmental agencies and NGOs.

**Keywords:** Partially defatted peanut cake flour; malnourished children; anthropometric; nutritional profile; supplementary feeding

## Introduction

Malnutrition among under-five children is a one the prevalent major public health issue India faces today. The prevalence of undernutrition in under 5 children in India is among the highest in the world, and is nearly double that of Sub-Saharan Africa (World Bank, 2014). Every year about 2.3 million deaths among 6-60 months aged children in developing countries are linked with malnutrition, which is about 41% of the total deaths in this age group (Bhagowalia et al, 2011). A study conducted by the authors among children aged between 3 months and 3 years of age belonging to 130 districts through Demographic and Health Surveys in 53 countries over a period from 1986 to 2006 found that mild malnutrition was more prevalent than severe under-weight. The study concluded that the prevalence of mild undernutrition requires greater attention for health care and nutrition intervention programmes among preschool children in developing countries. Hence, it is necessary for various governmental and non-governmental organizations to detect malnutrition at an early stage for planning and implementing timely interventions at the community level.

Bharati and co workers (2008) observed that the lowest percentages of under-weight children according to the Z-score were found in the states of Goa, Kerala, and Punjab which are the three most developed states in India through nutritional assessment of preschool children. While in the North-Eastern states of India too, the prevalence of undernutrition was low were women are well-educated. Hence it was concluded that the overall development, enhancement of level of education and low gender inequality are the key factors for improvement in the health status of Indian children

In India, the risk of infection is associated with lower BMI (Body Mass Index) for age and wasting among the preschool children which indicates a deficiency in calorie intake compared to other indicators like weight for age and height for age (Mittal et al, 2007). Other than the dietary deficiency, maternal age, weight and anaemia during adolescent age and pregnancy in mother significantly affects child's nutritional status (Mittal et al, 2007 and Ganesh et al, 2010). In an intervention study by Schmid et al (2007) compared dietary intake and nutrient sources among Dalit mothers for their children aged 6-39 months living in villages based on improved access to the traditional Dalit food system. They observed that there was no significant difference in children's food intake between the intervention and control villages. Socioeconomic inequality such as poverty, illiteracy, lack of awareness regarding the quality of food items, large family and poor sanitary environment are the key factors associated with malnutrition (Van et al, 2008)

Among the complementary feeding techniques, Responsive complementary feeding where the mother feeds her child in response to child cues and psychomotor abilities, when low can contribute to malnutrition. In a study significant improvement in child's self-feeding and mother's verbal responsiveness was observed among 8-20 month old children, but a weight gain was not observed (Aboud et al, 2009). Weight gain thus requires proper nutritious food, its availability and access especially in states with high food insecurity. Under-nutrition is more prevalent among marginalized groups such as slum dwellers, tribal population, and rural remote areas; therefore, there is a need for strengthening both coverage and quality of service regarding production, distribution, availability and access of good nutritious food for the target groups.

On the other hand, India has many intervention programmes running under the government as well as the non-governmental agencies. The success of programs depends on various factors including regional or state level needs, community perceptions and behaviors, acceptability of intervention measures by households, food security issues, food beliefs or taboos, likes or dislikes, cooking and child rearing practices, quality and quantity of the food item served (Sahu et al, 2015). Hence here comes the importance of popularization of underutilized food ingredient that has a high nutritional profile like protein, fat and calories which is capable to find a solution to the problem of undernutriton.

Partially defatted peanut cake flour is one such ingredient which has been utilized only for cattle feed and manure. In India, it has not been widely incorporated in foods because of the poor sanitation facilities in the oil mills (Purohit and Rajyalakshmi, 2011). Bansal and Kochhar (2014) studied the proximate composition of partially defatted peanut cake flour. The author reported that DPF contains 2.55 per cent of moisture, 52.75 per cent of protein, 14.39 per cent fat, 11.02 per cent fiber, 5.2 per cent ash, 14 per cent carbohydrates, 396.91 per cent energy. It is also a source of calcium (74%) and iron (2.6%), thus making it a highly nutritious food ingredient. Low cost weaning formulations can be made in the traditional ways. Appropriate process characteristics and blend formulations were developed for the preparation of a high protein-energy weaning food (Mosha and Vincent 2004). The product was based on a blend of dissi-oule rice flour (70%), Philippine peanut flour (20%), skim milk powder (10%), maltodextrin (1.97%), lecithin (0.17%) and hydrogenated peanut oil (0.5%). These ingredients were mixed, blended and fortified by dry mixing with vitamins and minerals. Weaning food made from dissi-oule rice and Philippine peanut had superior nutritional quality and was found acceptable. Thus, the present study was undertaken to determine the efficacy of value added products using partially defatted peanut cake flour on the nutritional status of malnourished preschool children.

## Materials and Methods

Raw ingredients for the product development were purchased from the local market of Ludhiana for developing five value added product namely *matthi, seviyan, pinni, panjiri* and biscuits. Raw peanuts were first roasted and deskinned. Oil was extracted using an oil extracting machine (local). The cake residue was collected and dried in the oven at 65°C for 25-30 minutes. The dried cake was then ground into fine powder. Spinach (*Spinacia oleracea*) and Fenugreek (*Trigonella foenum-graecum*) leaves were washed and cleaned. They were then chopped and dried in the oven at 80 °C for 4 hours which was then powdered. Five value added products namely *Matthi, Seviyan, Pinni, Panjiri* and Biscuits were developed. The basic ingredient used for all the products was cereal-pulse mix flour. Pulse flour was taken in one-third amount of cereal flour. This mix was replaced for the main ingredient listed in the standard procedure. Wheat and refined flour were used as a cereal source and chickpea flour was used as a pulse source. Partially defatted peanut cake flour was incorporated at 10 per cent level in *matthi, seviyan* and biscuits while for *pinni* and *panjiri*, 20 per cent was added. Powdered green leafy vegetables were added at 1 per cent level in *matthi* and *seviyan*, 1.5 per cent in biscuits and 2 per cent in *Pinni* and *Panjiri*.

### Nutritional analysis of the products

Proximate composites like Moisture, Crude Protein, Crude Fat, Crude Fiber, Crude Ash, Carbohydrates and Energy were analysed using standard procedures suggested by AOAC (2000).

### Supplementation of the value added products

#### i. Selection of subject

Sixty malnourished preschool children of age 3-5 years were selected on the basis of their anthropometric profile from two ICDS centers (Integrated Child Development Services Scheme) belonging to the rural areas of Ludhiana District, Punjab. Thirty malnourished preschool children were selected as control that were not given any supplementary feeds while another 30 were selected as the experimental group who received the value added products daily for a period of four months. The study was approved by the ethical committee of Punjab Agricultural University, Ludhiana (No. DR 12505-14/16-4-2014)

#### ii. Supplementation of products

The developed value added products were supplemented daily for 90 days to evaluate it's impact on the nutritional status of the 30 malnourished preschool children belonging to the experimental group. The products provided 400-405 Kcal of energy and 10-11g of protein which would meet one-third of their daily nutrient requirements. The quantity of each product provided is depicted in Table 1.

**Assessment of food and nutrient intake of the subjects**

Dietary intake of subjects was recorded by "24 hour recall method" to assess the food intakes of the subjects. The 24-hour recall method is widely used standard method at national and international level to provide information on foods consumed by the individual over the previous 24 hours given by FAO.

The individual cooked intake was converted into raw amounts of each food item using a formula:

Individual Raw Intake = Total raw amount for each food item (g) × Individual cooked intake (volume) / Total cooked amount of the preparation (volume)

From the raw amounts, the average daily intake of nutrients was calculated using the Indian Nutrition Software (Diet Soft). The average nutrient intake (3 days) was compared with the recommended dietary allowances given by ICMR (2010).

**Anthropometric assessment**

Height, weight, mid upper arm circumference, chest circumference and head circumference were measured using standard methods (Jelliffe 1966).

**Z-score classification**

To evaluate the nutritional status of the selected preschool children, the data on weight and height was classified according to z-scores. The z-scores for different indices like weight for age (WAZ), height for age (HAZ), body mass index for age, MUAC for age, head circumference for age were calculated using 'WHO Anthro plus software' (Zuguo and Laurence 2007). The prevalence of malnutrition was calculated on the basis of z-score cut off level WHO standards (2006). The data were compiled and appropriate statistical test were applied.

**Results and Discussion**

The five value added products were prepared using cereal-pulse flour as the basic ingredient with 10 per cent of partially defatted peanut cake flour and 1per cent of dried fenugreek powder in salty snacks like *matthi, seviyan* and 1.5 per cent of spinach powder in biscuits. While for sweet products like *pinni* and *panjiri*, 15 per cent of partially defatted peanut cake flour and 2 per cent of dried spinach powder was added. These products were then subjected to chemical analysis to determine their nutritional profile.

**Nutritional Composition of the Value added products**

The developed value added products were analysed for their proximate composition. The analysis revealed that a high protein of 16.58, 23.49, 20.18, 18.97 and 17.94 g and energy content of 495.56, 471.24, 506, 507.69 and 476.90 Kcal was observed in *Matthi, Seviyan, Pinni, Panjiri* and Biscuits respectively after value addition with partially defatted peanut cake flour. The products were also observed with high fat content as shown in Table 2. Similar study conducted by Bansal (2013) reported that the proximate composition of *matthri, seviyan, panjiri* and biscuits increased significantly for all proximate parameters except for moisture and ash. Agarwal and Sharma (2013) also observed a significant increase in *matthri* fortified with garden cress seed flour with respect to protein and fat.

*Matthri* when incorporated with dried green leafy powder (Mint, spinach and carrot leaves) were found to have high protein content of 7.44 per cent (Verma and Jain, 2012).

**Effect of supplementation of the value added products in malnourished preschool children**

The developed value added products were then supplemented to 30 malnourished children of the experiment group aged 3-5 years belonging to two ICDS centers daily for a period of four months. The control group also compromising of 30 malnourished children was not provided any supplementary feeds. The daily food and nutrient intake as well as the anthropometric measurements and the z-scores were assessed before and after supplementation for both the control and experimental group to determine the effect of supplementation of the value added products.

**i. Daily Food intake of the subjects before and after supplementation**

The mean daily food intake of selected preschool subjects before and after supplementation is presented in Table 3. The intake of different food groups by the subjects of the control group after supplementation a significantly ($p < 0.05$) increase from 90.65 1.156g to 91.24 0.076g and 23.92g to 22.99g in case of cereals and vegetables respectively, whereas in case of other food groups the increase was non significant after supplementation. The mean daily intake of cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, sugar and fat and oil after supplementation by the subjects of the experiment group increased significantly except for milk and milk products. Highest increase was observed in consumption of cereals (49.12%), pulses (77.95%), green leafy vegetables (11.21), vegetables (10.19) and fats and oils (9.7 %).revealed that consumption of cereal was less than RDA. A study conducted by Ghate (2014) in Ethiopia among the malnourished children for their food consumption revealed that there was a deficient consumption level of cereals by 41.50% for 1-3 years and 29.62% for 4-6 years 31.41%7-9 years children. The mean daily intake of green leafy vegetables was observed to be 11.6% for 1-3 years, 19.4 % for 4 - 6 years and 18.02 % for 7-9 years. Consumption of milk was negligible but roots and tubers were consumed in excess. Deficiency in the consumtion of flesh foods were also observed by the author. Results revealed that consumption of cereals, pulses, green leafy vegetables, other vegetables, fruits, milk and milk products, fats and oils, sugar and jaggery, was less than RDA which is why the subjects were malnourished.

**ii. Mean nutrient intake of the subjects before and after supplementation**

As depicted in Table 4, significant increase in the energy and protein intake of the subjects from control group was not observed and did not meet the recommended daily dietary allowance. A significant ($p<0.05$) increase in the carbohydrate, thiamine, riboflavin and niacin was shown in the control group after supplementation. While a significant ($p<0.05$) increase in all the nutrient was observed in the subjects of experimental group. The energy and protein increased significantly from 800.24 to 1184.12Kcal and 17.32 to 20.19g respectively for subjects belonging to experimental group. Their intake met the recommended allowance for energy and protein. Verma *et al* (2007) studied the dietary pattern of preschool children of the urban areas in the Rohtak city. The authors found that the caloric intake was less than 80% of RDA among 82% of children and the protein intake was less than 80% of RDA among 93.1% children. Their study revealed a significant association ($p < 0.001$) between low intake of calories and proteins in diet and the prevalence of malnutrition among the children under 5years studied. Vinod *et al* (2011) conducted a survey among 434 children below five years of age. The subjects were subjected to anthropometric measurements and revealed that 52.23 % were suffering from various grades of malnutrition. 32.18 % children were in grade I, 16.09 % in grade II, 3.46 % in grade III and 0.5 % in grade IV malnutrition. At the same time, a dietary survey was conducted in 20% subsample and the survey revealed that the mean calorie intake of children in the age group 2-3 years was 842.6 Kcal, 3-4 years was 956.12 Kcal and 4-5 years was 1096.24 Kcal respectively which were lower than the recommended allowances according to ICAR (2010).

### iii. Anthropometric profile of the subjects before and after supplementation

Significant ($p < 0.05$) increase was observed between the values of weight of two groups as given in Table 5. The mean increment in the anthropometric profile revealed significant ($p < 0.01$) increase in weight, BMI, MUAC and chest circumference by subjects of experimental group after supplementation. Highest increment (14.64 %) in BMI followed by weight (14.12%) was observed in subjects of experimental group. No significant increment was observed in anthropometric profile by children of control group. Mean weight of the supplemented children increased by the end of study period compared to the baseline value. A weight gain was observed by Mahfuz and his co workers (2014) in children after 5 months of age when a group of children (Experimental) were provided with Ready-to-use-food and pushti packets while significant changes in weight was not observed for the subjects who were not provided with any supplements (Control group) in the slum areas of Bangladesh. Ash and co workers (2003) reported that the supplementation of the energy dense foods had good impact on growth status of the children. Similar findings have been reported in children supplemented with the Amylase Rich Flour (ARF) food (Hossain *et al* 2005).

### iv. Mean z-scores of the subjects before and after supplementation

Before supplementation of products, the z-scores for weight for height, weight for age, height for age, BMI for age as well as MUAC for age was less than -2SD which indicated that all the children were moderately malnourished. Significant ($p<0.01$) improvement in height for age and BMI for age of the subject in control group was noticed while a significant ($p<0.05$) was observed in the z-scores of weight for height, weight for age, height for age and BMI for age after supplementation. Significant ($p<0.01$) increase in MUAC of age also was observed in the experiment group after supplementation. This revealed that the intake of the value added products actually had a positive effect on the nutritional status of the malnourished children. Manary and his coworkers (2004) observed that children more than 1 year old receiving Ready -to-use-food (RTUF)which supplied 2100KJ/day were more likely to reach Weight-for-height (WHZ) z-score more than zero than those receiving RTUF supplement or maize/soy flour. An average weight gain of 5.2 g/kg/day in the RTUF group was observed by the authors when compared to 3.1 g/kg/day for the maize/soy and RTUF supplement groups. Six months later, 96% of all children that reached WHZ>0 were not wasted. Sandige *et al* (2004) also determined the efficacy of home-based therapy with ready-to-use food (RTUF) in producing catch-up growth in 260 malnourished children and to compare locally produced RTUF with imported RTUF. They noticed that 78% of all children, 95% of those with HIV-negative status and 59% of those with HIV-positive status improved their WHZ scores and were not wasted while 8% of those receiving locally produced RTUF and 75% of those receiving imported RTUF reached had an improved WHZ score. Masuda et al (2014) also observed a significant improvement in the Height for age, weight for age and mid upper arm circumference for age in preschool undernourished children after they were supplemented with spirulina rich products.

### v. Prevalence of underweight, wasting and stunting in the subjects after supplementation

A reduction the prevalence rate of the malnourished subjects was noticed in the experiment group after supplementation as depicted in Table 7. The rate of normal weight-for-age status among the subjects in experimental group increased from 16.67 to 56.67 per cent while the rate of mildly malnourished reduced from 83.33 to 43.33 per cent. The rate of prevalence of wasting and stunting also reduced in the malnourished category and increased the rate of normal status among the subjects of experimental group. Significant increase in the normal nutritional status or decrease in malnourished status of the subjects belonging to the control group was not observed. Adeladza (2009) reported that poor socio-economic factors form underlying causes of the poor nutritional status. In another study (Kanjilal *et al* 2010) burden of stunting was observed among the children of urban area from poor socioeconomic status. Hence socioeconomic status can be attributed as the determinant of nutritional status of children. Improvement in nutritional status of malnourished children after supplementation has been reported by present study. The findings were supported by Ghatge (2012), the supplementation of *laddo* prepared with soy flour improved nutritional status of malnourished children. In another study supplementation of amylase rich *porridge* significantly enhanced nutritional profile of preschool children (Khader and Maheswari 2012, Mulik and Salunkhe 2014).

**Conclusion**

Five value added products namely *matthi, seviyan, pinni, panjiri* and biscuits were prepared incorporating partially defatted peanut cake flour and powdered green leafy vegetables to improve the protein and energy content of the products. The nutritional analysis revealed that the products had high protein, fat and energy content. The impact of supplementation of these products was then studied in malnourished children. A total of 60 mildly malnourished children from two aganwadis were selected based on their anthropometric measurements, out of which 30 were taken as control group and 30 as experimental group. The subjects of the experimental group were supplemented for 4 months with 120g of *matthi,* 140g of *seviyan* and *pinni* each and 150g of *panjiri* and biscuits each daily which provided them 400-405 Kcal of energy and 10-11g of protein. One product was supplemented a day. The study revealed a significant increase in the dietary and nutrient intake of the subjects in the experimental group when compared to the control group which did not receive any supplements. Statistically significant increase was also noticed in the anthropometric measurements like weight, BMI, MUAC and chest circumference as well as the z-scores after supplementation. The prevalence of underweight, wasting and stunting reduced to 13, 11 and 13 per cent from 25, 21 and 14 per cent respectively in the subjects of the experimental group after supplementation.

**References:**

Van de Poel E, Hosseinpoor AR, Speybroeck N, Van Ourti T and Vega J (2008) Socioeconomic inequality in malnutrition in developing countries. Bull World Health Organ. 86:282–91

Aboud FE, Shafique S and Akhter S (2009) A responsive feeding intervention increases children's self-feeding and maternal responsiveness but not weight gain. J Nutr. 139:1738–43

Bharati S, Pal M and Bharati P (2008) Determinants of nutritional status of pre-school children in India. J Biosoc Sci. 40:801–14.

Ganesh Kumar S, Harsha Kumar HN, Jayaram S, Kotian MS (2010) Determinants of low birth weight: A case control study in a district hospital in Karnataka. Indian J Pediatr. 77:87–9.

Schmid MA, Salomeyesudas B, Satheesh P, Hanley J and Kuhnlein HV (2007) Intervention with traditional food as a major source of energy, protein, iron, vitamin C and vitamin A for rural Dalit mothers and young children in Andhra Pradesh, South India. Asia Pac J Clin Nutr. 16:84–93.

Mittal A, Singh Jand Ahluwalia SK (2007) Effect of maternal factors on nutritional status of 1-5-year old children in urban slum population. Indian J Community Med. 32:264–7.

Bhagowalia P, Chen SE and Masters WA (2011)Effects and determinants of mild underweight among preschool children across countries and over time. Econ Hum Biol. 9:66–77

World Bank. India (2014) Undernourished children: A call for reform and action. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,contentMDK:20916955~pagePK:146736~piPK:146830~theSitePK:223547,00.html

Sahu SK, Kumar SG, Bhat BV, Premarajan KC, Sarkar S, Roy G and Joseph N (2015) Malnutrition among under-five children in India and strategies for control.J Nat Sci Biol Med. 6(1): 18–23.

Purohit C and Rajyalakshmi P (2011) Quality of products containing defatted groundnut cake flour. J. Food Sci. Tech. 48: 26-35

Mosha TC and Vincent MM (2004) Nutritional value and acceptability of homemade maize/sorghum-based weaning mixtures supplemented with rojo bean flour, ground sardine and peanut paste. Intl. J. Food Sci Nutr. 55: 301-15

Bansal P and Kochhar A (2014) Sensory and Nutritional Evaluation of Value Added Products using Peanut Flour for Nutritional and Health Benefits. Intl. J Agri. Innovations Res. 3(1): 27-32

WHO (2006) World Health Organization Child Growth Standards: Methods and Development. Geneva

Zuguo M and Laurence M G (2007) Standard deviation of anthropometric z-scores as a data quality assessment tool using the 2006 WHO growth standards: A cross country analysis. Bulletin of the World Health Organization 85:441-48

AOAC (2000) Official Method of Analysis Association of Official Analytical Chemist, 17th ed. Washington DC.

ICMR (2010) .Nutrient requirements and recommended dietary allowances for Indians. A Report of the Expert Group of the Indian Council of Medical Research 2009. National Institute of Nutrition, Indian

Council of Medical Research, Hyderabad. Pp334.

Jelliffe D (1966). The Assessment of Nutritional Status of the Community. WHO, Genera, Switzerland.

Verma S and Jain S (2012) Fortification of mathri with fresh and dehydrated vegetables and assessment of nutritional quality Raj. J. Extn. Edu. 20 : 155-158,

Agarwal N and Sharma S (2013) Garden Cress : A non-conventional traditional plant item for food products. Indian J of Traditional Knowledge. 12(4): 699-706

Ghatge NS (2012) Food intake pattern of malnourished preschool children after supplementation of soya ladoo. I Res J Social Sci. 1:36-40.

ICMR (2010) Nutrient requirements and recommeneded dietary allowances. National Institute of Nutrition. ICMR Hyderabad

Khader V and Maheswari U K (2012) Effect of feeding malted foods on the nutritional status of pregnant women, lactating women and preschool children in Lepakshi Mandal of Ananthapur district, Andhra Pradesh, India. Int J Biotechnol Mol Biol Res 4(4):35-46.

Mulik M and Salunkhe A (2014) Effectiveness of 'krishna poshak mix' on nutritional status of rural anganwadi children. IJSR 3(4):206-09.

Ash D M, Tatala S R, Frongillo E A , Ndossi G D and Latham M C (2003) Randomized efficacy trial of a micronutrient-fortified beverage in primary school children in Tanzania. Am J Clin Nutr 77(4):891-8.

Hossain M I, Wahed M A and Ahmed S (2005) Increased food intake after the addition of amylase-rich flour to supplementary food for malnourished children in rural communities of Bangladesh. Food Nutr Bull 26(4):323-9.

Adeladza A (2009) The influence of socio-economic and nutritional characteristics on child growth in kwale district of Kenya. AJFAND 9(7):1570-90.

Kanjilal, B, Mazumdar, PG, Mukherjee M., and Rahman, MH (2010) Nutritional status of children in India: household socio-economic condition as the contextual determinant. Intl. J Equity Health, 9: 19

Verma R, Khanna P, Gaur D, Meena, Prinja S (2007) Assessment Of Nutritional Status And Dietary Intake Of Pre-School Children In An Urban Pocket. The Internet J. Nutr.Wellness. 6(1)

Masuda K, Inoue Y, Inoue R, Nakamura A, Chitundu M, Murakami J, Ota Y and Matsugami (2014) Spirulina Effectiveness Study on Child Malnutrition in Zambia. Institute of Development Studies- Special collections . 49-56

Mahfuz M, Ahmed T, Ahmed AMS, Islam MM and Hossain MI (2014) Weight Gain in Malnourished Children after 5 Months Food Supplementation in a Slum Setting in Bangladesh. Food Nutri. Sci. 5: 1370-1378

Vinod N, Swarnakanta L, Smita P and Pushpa D (2011) Nutritional status and dietary pattern of under five children in urban slum area. National J Community Med. 2(1): 143.148

Ghate PR (2014) Food consumption patterns and malnourished Ethiopian children: is there a link? Res. Expo Intl. Multidisciplinary Res. J. 4(1): 8-15

Sandige H, Ndekha MJ, Briend A, Ashorn P and Manaray MJ (2004) Home-Based Treatment of Malnourished Malawian Children with Locally Produced or Imported Ready-to-Use Food. Journal of Pediatric Gastroenterology and Nutrition. 39:141–146

Manary MJ, Ndekha MJ, Ashorn P, Maleta K and Briend A (2004) Home based therapy for severe malnutrition with ready-to-use food. Arch Dis Child. 89:557–561

**Table1. Amount and nutrients provided by the value added products**

| Products | Quantity (g) | Calories (Kcal) | Protein (g) |
|---|---|---|---|
| *Matthi* | 120 | 400.55 | 10.4 |
| *Seviyan* | 140 | 400.53 | 11 |
| *Pinni* | 140 | 400.20 | 11 |
| *Panjiri* | 150 | 405.09 | 10.5 |
| Biscuits | 150 | 404.33 | 10.2 |

**Table 2. Proximate composition of the value added products (g/100g)**

| Products | Moisture | Crude Protein | Crude Fiber | Crude Fat | Total Ash | Carbohydrate (by differences) | Energy (Kcal/100g) |
|---|---|---|---|---|---|---|---|
| *Matthi* | 3.44±0.014 | 16.58±0.015 | 1.43±0.161 | 20.92±0.040 | 0.88±0.017 | 60.19±0.056 | 495.56±0.13 |
| *Seviyan* | 2.54±0.018 | 23.49±0.280 | 2.94±0.020 | 18.06±0.029 | 1.79±0.012 | 51.23±0.153 | 471.24±0.09 |
| *Pinni* | 4.53±0.006 | 20.18±0.026 | 3.84±0.012 | 27.05±0.020 | 3.20±0.225 | 45.73±0.206 | 506.00±0.61 |
| *Panjiri* | 4.91±0.008 | 18.97±0.057 | 3.86±0.036 | 26.96±0.021 | 2.89±0.017 | 47.32±0.083 | 507.69±0.14 |
| Biscuits | 3.34±0.013 | 17.94±0.018 | 1.36±0.017 | 19.350±0.09 | 1.25±0.024 | 62.10±0.211 | 476.90±0.290 |

**Table 3. Mean daily food intake of selected preschool children before and after supplementation**

| Food groups (g / day) | Before (n=30) | After (n=30) | % change | Paired t-value |
|---|---|---|---|---|
| **Group A (Control)** | | | | |
| Cereals | 90.65±1.156 | 91.24±0.079 | 0.65 | 2.53* |
| Pulses | 15.28±1.131 | 15.04±2.08 | 1.57 | $0.324^{NS}$ |
| Green leafy vegetables | 17.48±1.123 | 17.93±1.205 | 2.57 | $1.88^{NS}$ |
| Roots and tubers | 22.09±0.064 | 22.177±1.26 | 0.36 | $0.375^{NS}$ |
| Other vegetables | 23.92±1.80 | 22.99±2.11 | 3.88 | 3.302** |
| Fruits | 21.07±2.13 | 21.90±1.08 | 3.94 | $1.08^{NS}$ |
| Milk and milk products | 143.77±3.101 | 143.92±2.89 | 0.10 | $0.182^{NS}$ |
| Sugar | 26.97±1.11 | 27.10±0.117 | 0.48 | $0.160^{NS}$ |
| Fats and oils | 17.61±0.92 | 17.92±1.94 | 1.76 | $0.370^{NS}$ |
| **Group B (Experimental)** | | | | |
| Cereals | 90.13±2.13 | 134.40±2.09 | 49.12 | 96.99** |
| Pulses | 16.01±0.95 | 28.49±1.65 | 77.95 | 97.66** |
| Green leafy vegetables | 16.95±1.55 | 18.85±1.13 | 11.21 | 21.38** |
| Roots and tubers | 21.78±0.987 | 22.75±2.25 | 4.45 | 3.97** |
| Other vegetables | 23.44±2.26 | 25.83±1.36 | 10.19 | 5.42** |
| Fruits | 22.05±1.98 | 22.45±2.20 | 1.81 | 1.87* |
| Milk and milk products | 144.22±2.25 | 145.69±1.16 | 1.02 | $0.271^{NS}$ |

| | | | | |
|---|---|---|---|---|
| Sugar | 23.56±2.10 | 24.57±2.08 | 4.29 | 6.93** |
| Fats and oils | 17.49±1.09 | 19.19±1.74 | 9.71 | 13.00** |

Values are given as Mean± SE, *Significant at 5% level of significance, **Significant at 1% level of significance, NS= Non significant

**Table 4. Mean daily nutrient intake of selected preschool children before and after supplementation**

| Nutrients | Before (n=30) | After (n=30) | % change | Paired t-value | RDA | % adequacy |
|---|---|---|---|---|---|---|
| **Group A (Control)** | | | | | | |
| Energy (Kcal) | 806.81±1.161 | 807.11±2.82 | 0.037 | 0.38[NS] | 1350 | 59.79 |
| Protein (g) | 17.46±1.69 | 17.61±0.99 | 0.86 | 0.92 [NS] | 20.1 | 87.61 |
| Fat (g) | 17.37±2.12 | 17.74±2.08 | 2.13 | 1.25 [NS] | 25 | 70.96 |
| Carbohydrates (g) | 113.96±0.975 | 114.37±2.01 | 0.36 | 2.19* | | |
| Thiamine (mg) | 0.52±0.112 | 0.53±1.87 | 1.92 | 3.64** | 0.7 | 75.71 |
| Riboflavin (mg) | 0.29±3.12 | 0.32±2.75 | 10.34 | 2.18* | 0.8 | 40.00 |
| Niacin (mg) | 3.38±0.61 | 3.46±0.52 | 2.37 | 3.64** | 11 | 31.45 |
| Dietary Folate (ug) | 42.03±2.28 | 42.74±1.98 | 1.69 | 1.97 [NS] | 100 | 42.74 |
| Vitamin C (mg) | 17.15±1.04 | 17.53±1.17 | 2.22 | 1.41 [NS] | 40 | 43.82 |
| Vitamin B12 (ug) | 0.19±0.91 | 0.20±0.78 | 5.26 | 1.19 [NS] | 0.2-1 | 20.00 |
| Iron (mg) | 4.36±1.12 | 4.48±2.27 | 2.75 | 1.09 [NS] | 13 | 34.46 |
| Calcium (mg) | 372.47±1.64 | 374.79±1.69 | 0.62 | 1.02 [NS] | 600 | 62.47 |
| Zinc (mg) | 2.36±1.66 | 2.38±1.08 | 0.84 | 1.46 [NS] | 7 | 34.00 |
| **Group B (Experimental)** | | | | | | |
| Energy (Kcal) | 800.24±2.12 | 1184.12±2.97 | 47.97 | 107.70** | 1350 | 87.71 |
| Protein (g) | 17.32±0.15 | 20.19±0.91 | 33.89 | 27.69** | 20.1 | 99.56 |
| Fat (g) | 16.76±1.78 | 20.04±1.08 | 19.57 | 24.43** | 25 | 80.16 |
| Carbohydrates (g) | 109.29±1.23 | 112.58±0.57 | 3.01 | 3.83** | | |
| Thiamine (mg) | 0.46±1.09 | 0.53±1.59 | 15.22 | 8.18** | 0.7 | 75.71 |
| Riboflavin (mg) | 0.32±1.78 | 0.46±2.09 | 43.75 | 12.91** | 0.8 | 57.50 |
| Niacin (mg) | 3.48±0.02 | 3.95±0.01 | 13.51 | 20.65** | 11 | 35.91 |
| Folate (ug) | 43.70±0.13 | 44.13±0.12 | 0.98 | 3.92** | 100 | 44.13 |
| Vitamin C (mg) | 17.59±0.11 | 19.54±0.08 | 11.08 | 23.47** | 40 | 48.85 |
| Vitamin B12 (ug) | 0.21±0.002 | 0.32±0.12 | 52.38 | 10.17** | 0.2-1 | 32.00 |
| Iron (mg) | 4.52±1.06 | 7.46±0.07 | 65.04 | 30.59** | 13 | 57.38 |
| Calcium (mg) | 352.55±2.26 | 360.75±2.08 | 2.32 | 4.70** | 600 | 60.13 |
| Zinc (mg) | 2.35±0.015 | 2.51±0.025 | 6.81 | 7.61** | 7 | 35.86 |

Values are given as Mean± SE, *Significant at 5% level of significance, **Significant at 1% level of significance, NS= Non significant

**Table 5. Mean anthropometric profile of selected preschool children before and after supplementation**

| Anthropometric indices | Before (n=30) | After (n=30) | % change | Paired t-value |
|---|---|---|---|---|
| **Group A (Control)** | | | | |
| Height (cm) | 95.44±1.42 | 95.53±1.14 | 0.09 | 0.41 NS |
| Weight (kg) | 12.67±0.36 | 12.71±0.59 | 0.32 | 2.68** |
| BMI (Kg/m$^2$) | 12.83±0.09 | 12.97±0.30 | 1.09 | 2.03 NS |
| MUAC (cm) | 16.24±2.06 | 16.47±1.12 | 1.42 | 2.16 NS |
| Head circumference (cm) | 49.21±0.33 | 49.34±0.23 | 0.26 | 0.96 NS |
| Chest circumference (cm) | 50.62±1.21 | 50.72±2.02 | 0.19 | 0.58 NS |
| **Group B (Experimental)** | | | | |
| Height (cm) | 95.79±1.07 | 96.02±1.43 | 0.24 | 0.92 NS |
| Weight (kg) | 12.11±0.84 | 13.82±0.08 | 14.12 | 12.15** |
| BMI (Kg/m$^2$) | 12.77±0.53 | 14.64±0.09 | 14.64 | 8.67** |
| MUAC (cm) | 13.99±0.15 | 14.08±0.13 | 1.64 | 5.35** |
| Head circumference (cm) | 49.03±0.05 | 49.11±0.08 | 0.16 | 2.08 NS |
| Chest circumference (cm) | 49.36±0.52 | 49.43±0.20 | 0.14 | 2.48* |

Values are given as Mean± SE, *Significant at 5% level of significance, **Significant at 1% level of significance, NS= Non significant

**Table 6. Mean z-score of selected preschool children before and after supplementation**

| z-score | Before (n=30) | After (n=30) | % change | Paired t-value |
|---|---|---|---|---|
| **Group A (Control)** | | | | |
| Weight for height (WHZ) | -2.24±0.09 | -2.05±0.12 | 8.48 | 3.93 NS |
| Weight for age (WAZ) | -2.08±0.02 | -2.02±0.08 | 2.88 | 4.72 NS |
| Height for age (HAZ) | -1.06±0.12 | -1.22±0.16 | 15.09 | 5.95* |
| BMI for age | -2.08±0.21 | -1.92±0.18 | 7.69 | 4.47* |
| MUAC for age | -1.97±0.02 | -1.98±0.12 | 0.51 | 3.19 NS |
| **Group B (Experimental)** | | | | |
| Weight for height (WHZ) | -2.26±0.75 | -1.68±0.16 | 25.66 | 13.59** |
| Weight for age (WAZ) | -2.16±0.06 | -1.96±0.02 | 9.25 | 9.85** |
| Height for age (HAZ) | -1.45±0.20 | -1.63±0.20 | 12.41 | 7.58** |
| BMI for age | -2.09±0.06 | -1.47±0.09 | 29.66 | 20.12** |
| MUAC for age | -2.05±0.14 | -1.78±0.12 | 13.17 | 2.15* |

Values are given as Mean± SE, *Significant at 5% level of significance, **Significant at 1% level of significance, NS= Non significant

**Table 7. Age wise prevalence of underweight, wasting and stunting in malnourished preschool children**

| z score | Weight –for-age (WAZ) | | Weight-for-height (WHZ) | | Height-for-age (HAZ) | |
|---|---|---|---|---|---|---|
| | **Before n=30** | **After n=30** | **Before n=30** | **After n=30** | **Before n=30** | **After n=30** |
| **Group A (Control)** | | | | | | |
| > +2.0 SD | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) |
| -2.0 SD to +2.0 SD (Normal) | 19(63.34) | 18(60) | 12(40) | 14(46.67) | 20(63) | 17(56.67) |
| <-2.0 SD (Moderately malnourished) | 11(36.66) | 12(40) | 18(60) | 16(53.33) | 10(37) | 13(43.33) |
| <-3.0 SD (Severely malnourished) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) |
| **Group B (Experimental)** | | | | | | |
| > +2.0 SD | 0(0.0) | 0(0.0) | 0(0.0) | 2(6.66) | 0(0.0) | 0(0.0) |
| -2.0 SD to +2.0 SD (Normal) | 5(16.67 ) | 17(56.67) | 9(30) | 17(56.67) | 16(53.33) | 17(57) |
| <-2.0 SD (Moderately malnourished) | 25(83.33) | 13(43.33) | 21(70) | 11(36.67) | 14(46.67) | 13(43) |
| <-3.0 SD (Severely malnourished) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) | 0(0.0) |

Values are given as Mean± SE, *Significant at 5% level of significance, **Significant at 1% level of significance, NS= Non significant

## VITA

| | | |
|---|---|---|
| Name of the Student | : | T. Bindhya Dhanesh |
| Father's name | : | Sri. T. R. Dhanesh |
| Mother's name | : | Smt. Girija Dhanesh |
| Nationality | : | Indian |
| Date of birth | : | 18$^{th}$ June, 1986 |
| Permanent address | : | Thattil House, Puthenvettuvazhi,<br>Chembukkavu- east, Thrissur<br>Kerala- 680020 |

**EDUCATIONAL QUALIFICATION**

| | | |
|---|---|---|
| Bachelor's Degree | : | B.Sc. Home Science |
| University | : | Calicut University, Kerala |
| Year of award of degree | : | 2007 |
| OCPA | : | 8.66/10.00 |
| Master's Degree | : | M.Sc. Food Science and Nutrition |
| OCPA | : | 8.9/10.00 |
| University | : | Kerala Agricultural University, Thrissur, Kerala. |
| Year of award | : | 2010 |
| Title of Master's Thesis | : | Comparative evaluation of fresh fruit juices sold by street vendors versus restaurants |
| Ph.D. | : | Ph.D. Food and Nutrition, Minor subject – Food Science and Technology |
| OCPA | : | 8.4/10.00 |
| University | : | Punjab Agricultural University, Ludhiana, Punjab, India. |
| Year of award of degree | : | 2016 |
| Title of Ph.D. Dissertation | : | Impact of supplementation of value added products using partially defatted peanut cake flour on the nutritional status of malnourished children |