Development of Value Added Products from Amaranth (*Amaranthus L.)* Grain

Thesis

Submitted in partial fulfillment of the requirements

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Master of Community Science

In

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by

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Certified that **Shri/Smt/Kumari Chungkham Nganthoibi (Admission No./Regn. No. PG18-05)** has satisfactorily prosecuted her course of research for a period of not less than two semesters and that the thesis entitled "**Development of Value Added Products from Amaranth (*Amaranthus L.*) Grain** submitted by her to the Central Agricultural University, Imphal - 795004 (Manipur) in partial fulfillment of the requirements for the award of the degree of **Master of Community Science** in the subject of **Food Science and Nutrition** is the result of original research work conducted by her under my supervision and is sufficiently of high standard to warrant its presentation to the examination.

I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any University.

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CERTIFICATE – II

This is to certify that the thesis entitled **"Development of Value Added Products from Amaranth (*Amaranthus L.*) Grain** submitted by **Shri/Smt/Kumari Chungkham Nganthoibi (Admission No./Regn. No. PG18-05)** submitted to the Central Agricultural University, Imphal - 795004 (Manipur) in partial fulfillment of the requirements for the award of the degree of **Master of Community Science** in the subject of **Food Science and Nutrition** has been approved by the Student's Advisory Committee after oral examination in collaboration jointly with a Dean's Nominee.

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DECLARATION

I hereby declare that the thesis entitled "**DEVELOPMENT OF VALUE ADDED PRODUCTS FROM AMARANTH (*AMARANTHUS L.)* GRAIN"** is an authentic record of the work done by me and that no part thereof has been presented for the award of any degree, diploma, associateship, fellowship or any other similar title.

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(Chungkham Nganthoibi)

Place: Tura, Meghalaya

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LIST OF ABBREVIATION

AAS	Atomic Absorption Spectrophotometer
AF	Amaranth Flour
AIDS	Acquired Immunodeficiency Syndrome
AOAC	Association of Official Analytical Chemists
&	And
et al.	And others
B.L.Q.	Below Limit Quantification
CRM	Certified Reference Materials
CN	Cashew Nut
Conc.	Concentrated
º C	Degree Celsius
EEAI	Essential Amino Acid Index
FSSAI	Food Safety and Standards Authority of India
Fig.	Figure
GF	Gram Flour
GFB	Gluten free bread
g	gram (s)
h	Hour
HIV	Human Immunodeficiency viruses
IFCT	Indian Food Composition Table
IPC	Isoelectric Protein Concentrate
KW	Kruskal-Wallis
Kcal	Kilocalorie
LDL	Low Density Lipoproteins
M	Mass
min	Minute (s)
mg	Milligram (s)
µg	Microgram
µm	Micrometre

ml	mililitre
N	Normality
NIST	National Institute of Standard and Technology
O.D	Optical Density
%	Percent
PR	Parboiled Rice
PER	Protein Efficiency Ratio
PAGF	Popped Amaranth grain
Q.L.	Quantification Limit
RAGF	Roasted Amaranth Grain Flour
rpm	Revolution per minute
SAG	Soaked Amaranth Grain
SD	Standard Deviation
SRLP	Sustainable Rural Livelihood Programme
Sec	Second
Spp.	Species
tsp	teaspoon
i.e.	That is
TR	Total Reducing
U.S	United State
vlv	Volume by volume
WF	Wheat Flour
w.r.t.	With respect to
w/w	Weight by weight
w/v	Weight by volume
wt	Weight

ABSTRACT

The aim of the study was to standardization of methodology to use different form (broken, roasted, powdered, whole grain etc) of amaranth grain, to formulate and develop value added products of amaranth grain and to analyze the nutritional, biochemical and sensory evaluation of the developed products. The developed products such as Cake, *Besan burfi*, Coconut *Ladoo*, Cashewnut *burfi* and *Dosa* were evaluated for their nutritional composition, sensory characteristics and biochemical analysis. Ms-Excel 2007 was used for statistical analysis. The results on comparative nutritional composition for Amaranth Flour (AF), Wheat Flour (WF) and Gram Flour (GF) revealed that moisture content was higher in WF than AF & GF. Higher protein content was found in GF (18.77 g) followed by AF (16.5 g) and WF (10.36 g). Dietary fibre reported significantly higher in GF (25.22 g) and AF (16.8 g) than WF (2.76 g). Minerals content reported high in AF than WF but can be comparable with GF. Lysine, tryptophan and lenoleic content observed higher in GF than AF and WF. Different forms of amaranth grain flour *i.e.* Roasted Amaranth Grain Flour (RAGF), Popped Amaranth Grain Flour (PAGF) and Soaked Amaranth Grain (SAG) were incorporated in popularly consumed food products. Mean scores of sensory characteristics revealed that the products were accepted in terms of their appearance, texture, taste, aroma and overall acceptability. Sensory evaluation of the developed products showed that amaranth flour could be incorporated up to 50 percent in cake, *besan burfi* and cashewnut *burfi* and up to 20 percent in coconut *ladoo* and *dosa*. Independent-Samples Kruskal-Wallis Test was incorporated in order to check the significant difference of the products. Pairwise comparisons test was done in control & different proportion of the products such as cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and dosa. The results of the test were found significant in all the products ($p \leq 0.05$). Amaranth grain flour was incorporated in the place of major ingredients of the developed products and made a comparison between the most accepted products and with that of the control for their biochemical analysis. The results on biochemical analysis revealed that incorporation of amaranth flour enhanced the nutritional composition of the products. With the addition of amaranth grain flour up to 50 percent improved protein, fat dietary fibre and minerals content such as iron, calcium, zinc, phosphorus of the developed products.

Keywords: Amaranth grain, Value added products, Nutritional content, Sensory evaluation and Biochemical analysis.

Chapter 1

INTRODUCTION

In India, the amaranth grain are commonly known as Rajgira (king seed), Ramdana (seed sent by the god) is known to be very nutritious pseudo-cereal with high protein content as compared to the true cereals which is also gluten-free (Bhat *et al*., 2015; Sneha and Haripriya, 2018). Amaranth belongs to the family *Amaranthaceae.* The word *amaranthus* is derived from the Greek word "*anthos"* (flower) which means everlasting or unwilting and currently it is known as third millennium crop plant (Rastogi and Shukla, 2013). The genus amaranth is mainly comprised of about 400 species among which few of them are found throughout the world and are distributed in temperate, sub-tropical and tropical climate zones (Suma *et al*., 2002; Sauer, 1967).

Based on their utilization method the species is divided into grain amaranth, vegetable amaranth, ornamental and weedy amaranth (Sauer, 1967). India is one of the centres of distribution of amaranth, the other centre being tropical America. About 20 species are found cultivated in India (Rastogi and Shukla, 2013).The most species widely grown for human consumption of amaranth grains are*: Amaranthus cruentus L., Amaranthus hypochondriacus L. and Amaranthus caudatus L.* (Pablo *et al.,* 2011; Lozoya-Gloria, 1994). In India Amaranth is grown in Himachal Pradesh, Jammu and Kashmir, Kerala, Uttarkhand, Sikkim, Assam, Nagaland, Tripura, Jharkhand, and Tamil Nadu at both hills and plains area (Dua *et al.,* 2009). When compared to cereals grains, amaranth grains are lentil shaped and are very small (approximately 1mm diameter), light and colour varies from black to red usually cream (Belton and Taylor, 2002; Beniwal *et al.,* 2019). Some researchers also have been reported that the colors of the amaranth grain ranging from pale yellow to black due to its protein content, brown to black , white, gold, coffee and pink (Segura *et al.,* 1994; Morales *et al.,* 1988; Lehman, 1992; Grobelnik *et al.,* 2009; Bressani , 2003).

The Amaranth grains have known to be very high nutritional and functional values associated with the quality and quantity antioxidant potential (Gorinstien *et al.,* 2002, Gorinstien *et al.,* 2007). The nutritive value of amaranth is mainly associated to their proteins that make up an important parameter of bio-macromolecules involved in physiological function (Esan *et al.,* 2018). Moreover, amaranth grains have higher protein content, higher digestibility, higher protein efficiency ratio than cereals (Salcedo Chavez *et al.,* 2002). The proximate composition of amaranth grain is on average composed of 13.1 to 21.0 percent of crude protein; 5.6 to 10.9 percent of crude fat; 48 to 69 percent of starch; 3.1 to 5.0 percent (14.2 percent) of dietary fibre 2.5 to 4.4

percent of ash respectively (Mlakar *et al.,* 2009). (Beatriz and Suzana Cae tano da, 2012) reported when compared with quinoa and other common cereal grain (12.9-16.5 percent), the protein content of amaranth grain (14.60 percent and 13.80 percent respectively) is significantly higher than that of maize (10.20 percent) and comparable to that of wheat (14.30 percent). According to literature, amaranth grain is a rich source of carbohydrate, lipids, energy, and dietary fibre and has significantly higher content of lysine and acceptable level of tryptophan and methionine than other cereals and leguminous grains of common usage (Bressani, 1989; Teutonica & Knorr, 1985) but deficient in leucine (Morales *et al.,* 1988). Protein concentration of amaranth is in between a range of 12.5 percent or 17.5 percent (Teutonica & Knorr, 1985).The amount of protein present in amaranth grain has a superior amino-acid profile compare to other plant foods. Most cereals are deficient in some amino acids; for example corn is deficient in lysine and tryptophan (Bressani and Gracia, 1990), rice and wheat in lysine (Howe *et al.,* 1965). The amaranth is gluten free and easy to digest and the grain 90 percent digestible because of its ease of digestion (Morales *et al*., 1988). Amaranth grain proteins are formulated mainly of globulins and albumins. It can be considered as gluten free grains because of the very little or no storage of prolamin proteins, which are the main storage in cereals and major components of the toxic proteins, cause celiac disease (Grobelnik *et al.,* 2009; Alvarez-Jubete *et al.,* 2010 a; Valencia-Chamorro, 2003). Amaranth proteins are made up of about 40 percent albumins, 20 percent globulins, 25-30 percent glutelins, and 2-3 percent prolamins (Schoenlechner *et al.* 2008). The concentration of sulphur containing amino acid is higher than legumes which make it an important and inexpensive source of protein (Segura *et al.,* 1994). Similarly it has twice the level of calcium in milk, five times the level of iron in wheat and higher in sodium, potassium, and vitamins A, E, C, and folic acid than cereals grains (Becker *et al.,* 1981). The grains also contain high vitamin and mineral contents, such as riboflavin, niacin, ascorbic acid, calcium, magnesium, and low level of anti-nutritional factors (Zapotoczny *et al.,* 2006) and a good source of zinc and phosphorus. It helps for the building of strong bones and a muscle; helps hydration and boost energy (kalac, 2000). Amaranth grain consists of 6 to 9 percent oil which higher than most other cereals. The total carbohydrate present in amaranth grain excluding its crude fiber is 33.67 percent (*i.e.* 66.33 percent including fiber) (Emire and Arega, 2012; Mburu *et al*., 2011) they reported the carbohydrate content of amaranth is 62.9 percent. The carbohydrates present in amaranth grain consist primarily of starch made up of both glutinous and non-glutinous fractions. The unique aspect of amaranth grain starch is that sizes of the starch granules (1 to 3 µm diameter) are smaller and polygonal that found in other cereal grains (Becker *et al.,* 1981; Stone and Lorenz, 1984). Waxy and non waxy starch granules had been found in the grains (Konishi *et al.,* 1985). Amaranth starch has higher water binding capacity, higher sorption capacity at higher water activity values, as well as higher solubility, higher swelling power and enzyme susceptibility (Singhal and Kulkarni, 1990). Additionally, amaranth grain has been shown to exhibit antioxidant activity and this has been attributed to its content of polyphenols, anthocyanins, flavonoids, and tocopherols (Escudero *et al.,* 2011). Tocopherols in the grain which include c- and d- tocotrienols, the unsaturated form of vitamin E are the good antioxidant activity and are examined as hypocholestrolemic agents (Escudero *et al.,* 2006) and have anti-tumour activity, suppression in the synthesis of cholesterol, serum cholesterol regulatory- levels (Schnetzler and Breene, 1994) lower the synthesis of low density lipoproteins-cholesterol and regulates the enzyme lipoprotein lipase (Leon *et al.,* 2001; Qureshi *et al.,* 1996).

It has various health benefits include decreasing plasma cholesterol levels, stimulating the immune system, reducing blood glucose levels and improving conditions of hypertension and anaemia. Moreover, it has been reported to have anti-allergic activities (Caselato and Amaya, 2012). Some researchers reported that consumption of Amaranth grain have certain health benefits and shown that improvement in well being to prevention and specific illness including recovery from severely malnourished children and increase in the body mass index of people who are emaciated by HIV/AIDS (SRLP, 2005; Tagwira *et al.,* 2006). In animal studies the oil that content in the grain has been shown to lower total serum triglycerides and levels of low density lipoproteins (LDL) (Escudero *et al.,* 2006). The similar effects have been reported in human (Martirosyan *et al.,* 2007). Anti-nutritional and toxic factors contain in both amaranth grain and leaves like large amounts of oxalates, nitrates and saponin (Segura *et al.,* 1994). In today's food industry all over the world, the amaranth is processed as food and used as an ingredient in prepared products (Schnetzler and Breene, 1994).

A variety of heat processing methods can be applied to grain amaranth, in preparation for the consumption. Heat processing affects the nutritional value of foods (Rehman and Shah, 2005), and also affects the level of phyto-chemicals (Xu *et al.,* 2007) and functional properties (Muyonga *et al*., 2007). The grain can be used in different form for consumption, of which puffing form is the most popular. Other processing techniques include cooking in water, extruding, toasting, substituting it into flakes (Bressani *et al.,* 1993) or pastas and baking products such as biscuits (Brenner and Williams, 1995). Amaranth grain used as a culinary with acceptable of high protein, high fibre, alternative to wheat, easy to replacement in the traditional cuisine found in Indian diet (Dixit *et al.,* 2011). In recent times, clinical studies have been assessed for the properties of amaranth in cholesterol reduction, antioxidant, anticancer, anti-allergic, and anti-hypersensitivity agent and used as a diet for the people who have suffering from celiac disease and immunodeficiency (Caselato-Sousa and Amaya-Farfan, 2012).

Hence in the present study value addition of different products with incorporation of amaranth grain flour are undertaken and developed cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa* by incorporating amaranth grain flour at different percent level.

OBJECTIVE OF THE STUDY

i. Standardization of methodology to use different form (broken, roasted, powdered, whole grain etc) of amaranth grain.
ii. To formulate and develop value added products of amaranth grain.
iii. To analyse the nutritional, biochemical and sensory evaluation of the developed products.

Chapter 2

REVIEW OF LITERATURE

A literature review is a comprehensive summary of previous research topic. The literature review surveys scholarly articles, books, and other sources relevant to a particular area of research. The reviews should enumerate, describe, summarize, objectively evaluate and clarify the previous research. It should give a theoretical base for the research and help the author determine the nature of research. The literature review acknowledges the work of previous researchers, and in so doing, assures the reader that your work has been well conceived. Keeping in view the objectives of the study, an attempt was made to review the literature which had meaningful relation to the study and are presented under the following sub categories;

2.1. Processing amaranth grain flour.

2.2. Value added products of amaranth grain and sensory evaluation.

2.3. Analysis on nutritional and biochemical composition of amaranth grain flour.

2.1. Processing amaranth grain flour

Erwin, (1934); Saunders and Becker, (1984) reported popping of amaranth seed increase the volume up to 1050 percent whereas Bresssani (1990) indicated that during heat processing of amaranth seeds in 210-240ºC changes in expansion, increase volume and water absorption index due to exposure time increased from 0 to 40 sec. It was recommended for breakfast cereals.

Popping the seeds of amaranth had higher PER than either raw or toasted seeds reported by Sanchez- Marroquin *et al.,* 1986.

(Betschart *et al.,* 1981; Oke, 1983) reported heat treatment overcome milling problems due to small size and grittiness of seeds.

Singhal and kulkarni (1990) conducted an experiment on effect of puffing on oil characterization of amaranth (*Rajgeera*) seeds. They report that the effect puffing indicated the percent of unsaturation in the oil to decrease from 75.5 percent to 62.3 percent and reduced lenoleic acid from 46.8 to 27.6 percent. However, increase squalence by 15.5 percent due to puffing of amaranth seeds.

The properties of two selected amaranth starches were studied by Uriyapongson and Duarte (1994) using a traditional wet milling and two dry wet milling methods. It was found that dry wet milling gives higher starch yield than wet milling but needed less time to isolate starch. Protein content did not differ significantly among starch isolated with these methods. The dry wet milled starches had lower viscosity and thermodynamics; more starch damaged and found clear paste than wet milled.

Bejosano and Corke (1998) studied the effect of heat treatment and the presence of antinutrients in Amaranthus genotype and reported that heating increased the protein digestibility in whole meals but decreased it in iso-electric protein concentrate (IPC). Whole meals and IPC were slightly deficient in leucine and lysine. They also revealed that amaranth protein is of better quality than those of other cereals.

Popping, dry roasting, extrusion cooking and drum drying are the different types of dry heating processing techniques. The influence of dry heated on seeds of amaranth, its physico chemical, nutritional and functional properties obtained good attention (Rekha , 1997).

Markowshi *et al.* (2006) analyzed rheological behavior of hot air puffed amaranth seeds revealed that rheological behavior of hot puffed seed is influence by puffing temperature. It was observed displayed viscoelastic behavior and an increase in the elastic parameter and decrease in viscous parameters with a rise in puffing temperature.

Resio *et al.* (2005) analyzed swelling power, Solubility, and water absorption of amaranth and compared with corn starch. The results revealed that the swelling power and water absorption capacity were higher for amaranth than for corn starch.

Zapotoczny *et al.* (2006) conducted a study on effect of temperature on the physical, functional and mechanical characteristics of hot air puffed amaranth seeds and reported that processed amaranth seeds at 290ºC are characterized by acceptable color, physical, functional and mechanical properties. Further the results of the study revealed that the seeds puffing at 290ºC acquire a product describing by good color, geometric and fat absorption properties compared with raw materials and seed puffed at 300ºC. It was suggested that 290ºC is the optimum temperature for hot air puffing of amaranth seeds.

Chauhan and Singh (2013) studied on influence of germination process of amaranth grain (*Amaranthus spp.)* on their proximate composition and physicochemical properties. It was observed that higher protein and fiber were shown at 16 hr germinated amaranth grains as compared to raw amaranth grain. Also reported, no changes in ash content of germinated amaranth flour whereas decreased fat content at 12, 16 18 and 20 hours germination period. The bulk density of germinated flour were lowered and water absorption index was highest at 16 hrs germination period but water solubility index was lowest at this germination time as compared to ungerminated amaranth flour.

Muyonga *et al.* (2014) conducted a research study on the effect of heat processing methods of two selected varieties of amaranth grain *i.e. A. hypochondriacus L.* and *A. cruentus L.* on physicochemical and nutraceutical properties. It was observed that higher protein content and antioxidant activity exhibits in *A. creuntus L.* than *A. hypochondriacus L.* Yet, *amaranthus hypochondriacus L.* exhibits high viscosity. Both the protein digestibility and antioxidant activity are affected when expose to dry heat of grain amaranth. Heat processing methods such as popping have shown higher negative effect on protein digestibility whereas roasting is more damaging antioxidant activity.

Njoki *et al.* (2014) studied the effect of dry and wet heat processing techniques of amaranth grain on the nutrient and anti nutrients content. The result of the study revealed that dry (roasted and popping) and wet (boiling and slurries) heat as processing techniques diminished the anti nutrients content. Yet moist heat was found more effective in their reduction in antinutrients when compared with the dry heated samples. From the result, it was observed that processing of amaranth grain by dry heat and moist heat reduced anti nutrients and enhances the digestibility and starch gelatinized. And also report that there is no significant effect on proximate composition of amaranth grain during processing. Therefore processing techniques are essential to reduce on anti nutrients and aids in utilization of nutrients by consumer especially the children, lactating mothers, HIV affected and infected, elderly and other people who may be at risk.

A research study conducted by Adeniyi and Obatalu (2014) examined the optimum germination temperature for maximum improvement of the functional properties of amaranth grain using as an emulsifier in food processing. The dry grains were germinated at 30ºC, 32ºC, 34ºC, 36ºC, 38ºC and 40ºC which were designated on T30, T32, T34, T36, T38, and T40 respectively and T00 for the negative control. The water and oil absorption capacities were increased from T00 to T30. The emulsifier capacity was 2.01 percent in T00 and increased to 24.63 percent in T30 and increased in germination temperature to the maximum value of 31.17 percent in T40.

Okoth *et al.* (2017) reported that steeping and germination were used reduced the levels of antinutrients and enhance the bioavailability of minerals in the grains.

Solanki *et al.* (2018) studied on effect of popping methods on popping characteristics of amaranth grain .The grains can be popped through intense, short and dry heat and stated that popped seeds are very soft in texture and to be use incorporation into new food formulations or are ready to eat. Two different popping methods were studied *i.e.* traditional process (batch type popping machine) and improve process (fluidized bed system). Hence popping seed is very important for developing value added products. In this study popping characteristics such popping volume, popping fold and popping rate were evaluated.

Chemeda and Bussa (2018) conducted a study on effect of processing methods (soaking and roasting) on nutritional and anti nutritional value on amaranth grain and potential future application of amaranth grain in *injera* making and reported as the amaranth grain has good nutritional qualities and less amount of tannin and phytic acid. The study indicates that amaranths grain has a good proximate composition and essential mineral elements. The results also revealed that, processing methods had significantly affected the nutritional qualities. In this study, roasting reduced crude protein content 3.44 percent and iron by 1.8 mg /100 g. Moreover, soaking significantly reduces the anti-nutrients than roasting though it had effect some nutritional qualities.

Beniwal *et al.* (2019) reported that processing of grain resulted in reduction of saponin and tannin content of amaranth and quinoa grain and decreased significantly the non nutritional component. Germination was the best treatment among the processing treatments in improving nutritional value in term of protein content.

2.2. Value added products of amaranth flour and sensory evaluation.

Rathod and Udipi (1991) studied on developing weaning mixes using amaranth in three forms- malted, roasted, and puffed and leafy vegetable together with a cereal in one of four forms- malted wheat, raw milled rice, puffed rice and rice flakes. The result of the study revealed that incorporated amaranth grains into weaning foods are acceptable to children.

Duarte *et al.* (1996) evaluated the acceptability of cooking quality parameters in the spaghetti samples incorporated amaranth, buckwheat and *lupin* flours and analyzed cooked weight, cooking loss, firmness, and total carbohydrate loss during cooking. Spaghetti prepared from composite flour had higher content of lysine than control durum wheat flour. And spaghetti incorporated light or dark buckwheat, and amaranth flour decreased significantly in vitro protein digestibility were observed. The result of the study reported that composite flour pasta can be develop with high levels of lysine than commercial pasta prepared from 100 percent durum wheat flour and also with acceptable cooking quality and sensory attributes.

Park-Sangha and Morita (2004) conducted a study on the dough properties and baking quality including sensory evaluation by substituting hard wheat flour "*Cameria*" by amaranth (*Amaranthus hypochondriacus*) flour. The results of the study reported that the loaf volume of bread baked with 5, 10, and 20 percent of Amaranth flour substitution were 94, 89 and 83 percent respectively of the control (wheat only).

Sindhuja *et al.* (2005) carried out a study on effect of incorporation of amaranth flour on the quality of cookies. The results of the study revealed that the dough properties and pasting characteristics were affected by incorporation of amaranth flour. Incorporation of amaranth flour improved the quality of composite amaranth-wheat flour cookies at 25-30 percent replacement of wheat flour. With the increasing level of amaranth flour, the cookies became less hard as well as also enhance the surface cracking of the cookies. The qualities of cookies also improved with the inclusion of emulsifiers such as lecithin and glycerol monostearate each at 0.25 percent level.

Arcila and Mendoza (2006) have conducted a study on elaboration of an instant beverages amaranth seeds (*Amaranthus cruentus*) and its potential use in the human diet prepared from mixing amaranth seed flour with rice flour, corn flour, milk whey and powder milk and formulate five formula. The products were evaluated with non trained panel using 9 points hedonic rating scale sensory evaluation results. The results of the study revealed that the greatest acceptance was 30 percent of amaranth seed flour, 30 percent of powder milk, 5 percent of rice flour and 5 percent of corn flour and reported amaranth seeds must be considered as a nutritional alternative for the production of highly protein instant beverages.

Chillo *et al.* (2008) analyzed the different effects on the quality of *amaranthus* flour spaghetti with the addition of quinoa (CQA), chick pea (CCA) or broad bean flour (CBA) and determine breakage susceptibility of dry spaghetti, cooking resistance, instrumental stickiness in cooking and over cooking, cooking loss and sensory properties at the optimal cooking time. The spaghetti prepared from *Amaranthus* flour had same or lower dry breakage susceptibility and cooking resistance, higher cooking loss and visibly lower instrumental stickiness than compared to that of spaghetti made from durum semolina and did not observed relevant sensory differences.

Another study conducted by Alvarez-Jubete *et al.* (2010) on baking properties and microstructure of pseudo cereals flour in gluten free bread formulation. The study investigate the baking properties of amaranth, quinoa and buckwheat as potential healthy an high quality ingredients in formulation of gluten free bread and reported that incorporated pseudo cereals gluten free bread had significantly higher volume as compared to the control gluten free and shown significantly softer crumb texture effect due to the presence of natural emulsifiers in the pseudo cereals flour. It was found no significant differences in the acceptability of pseudo cereals gluten free bread in comparison with the control. Therefore pseudo cereals are healthy and good quality ingredients in the development of gluten free product.

Lemos *et al.* (2012) studied on the effect of incorporation of whole amaranth flour on the physical properties and nutritional value of cheese bread. Incorporation at 10, 15 and 20 percent levels of amaranth flour in different formulations. The results of the study reported that increasing the levels of amaranth darkened the products, reduce specific volume, and increased comprehension force. Bread with incorporation of 10 percent amaranth flour found slight differences in physical properties compared with the control and demonstrated the possibility in the formulation of cheese bread.

Emire and Arega (2012) studied on the development of value added product from blends of amaranth flour with wheat flour and quality characterization of cosmopolite flours and revealed that amaranth flour had better dense nutrient than wheat flour in proximate chemical composition and mineral concentration.

Martinez *et al.* (2013) investigated the technological and sensory quality of pasta prepared from bread wheat flour replaced with whole meal amaranth flour (*Amaranthus Mantegazzianus*) at four levels 15, 30, 40, and 50 percent w/w compared with control pasta prepared from bread wheat flour. The results of the study reported that the maximum incorporation level was 30 percent w/w; an equilibrium point between an acceptable pasta quality and the enriched nutritional and functional properties from the incorporation of amaranth flour.

Breshears and Crowe (2013) developed GFB (Gluten free bread) with the incorporation of amaranth flour and *montina* flour for the purpose of comparing sensory and objectives qualities to a commercially marketed GFB. Their result suggest that amaranth and *montina* flour aids in improving the nutritional quality of GFB even though required additional testing to aids in formulation modifications of this standardized lean bread recipe in order to produce a similar product in sensory qualities to commercially marketed gluten free bread.

Mugalavai (2013) conducted a study on effect of amaranth: Maize flour ratio on the quality and acceptability of *ugali* and porridge (Kenya cereal staples). The study reported that the more use of amaranth in a mixture, the higher its nutritive value, and improved its functional properties.

Alencar *et al.* (2015) evaluate the influence of sweeteners and pseudo cereals, physicochemical properties, proximate composition and sensory properties in gluten free bread formulations. The results revealed that incorporation of amaranth, quinoa flour and sweeteners gives similar specific volume, firmness and water activity to those of the control formulation. The samples those incorporated sweetener did not differ significantly for the sweet stimulus from the control bread but with respect to bitter stimulus the bread incorporated with quinoa flour and sweeteners showed higher maximum intensity. The result of this study suggested that develop gluten free bread with pseudo cereals such as amaranth and quinoa flour and sweeteners with similar sensory and physicochemical properties to those develop with starch based formulation.

Shyam and Raghuvanshi (2015) prepared eggless cake by using different proportion of amaranth flour into refined wheat flour with the constant level of whey protein concentrated by U.S. wheat Associates in 1983. It was found that seed weight, volume are less than other cereal as amaranth seeds are tiny and lighter in weight, Water absorption capacity and fat absorption capacity had more in amaranth flour. Cakes prepare from blends containing varying different proportion (20, 40, 60, 80 and 100 percent) of amaranth, using the sponge cake method. The overall acceptability score of cake with amaranth flour was higher than that of control cake.

Rosa *et al.* (2015) study on influence of the different addition of amaranth flour and rice flour on pasta buckwheat flour revealed that the best quality attribute were observed made from 100 percent buckwheat flour pasta followed by the pasta substitution with 15 percent amaranth flour but less accepted made from 100 percent buckwheat flour in terms of the color attributes .furthermore described that incorporated pasta had higher water absorption and higher weight gain shorter cooking time and less loss of solids.

Another study conducted by Chauhan *et al.* (2016) on physical, textural and sensory characteristics of wheat and amaranth flour blend cookies. The cookies were evaluated for physical (thickness, diameter, spread ratio and bake less), textural and sensory attributes formulated with whole amaranth flour ranging from 20, 40, 60, 70 and 100 percent. The study revealed that the physical properties of amaranth enriched cookies were affected in a positive way. Color attributes of the cookies were significantly influenced by the incorporation of 60 percent amaranth flour was well accepted by sensory characteristics.

Man *et al.* (2017) assessed the effect of the whole amaranth flour incorporated at different levels on the quality characteristics of cookies and evaluated for physical, chemical and organoleptic. Sensory evaluation scores for overall acceptability and sensory qualities gradually decreased with the incorporation of above 50 percent whereas developed from 50 percent of wheat flour and 50 percent of amaranth flour was the most acceptability by the sensory panelists.

Sneha and Haripriya (2018) studied on development of amaranth grain (*Amranthus cruentus*) based instant dosa mix and it quality characteristics. The study was carried out to utilize gluten free, nutritious and low cost amaranth grain along with Bengal gram dhal and vegetables to produce a convenience food that can be consumed by celiac patients in India. The study recommends germination of amaranth grains for its better nutritive value and its utilization in the preparation of the traditional recipes *dosa*.

Akande *et al*. (2018) prepared blend flour from locally available, nutrient dense, inexpensive and relatively underutilized food substances such as rice, grain amaranth and carrot. Physical properties, proximate composition, amino acid profile, minerals, vitamins content, antioxidant and sensory characteristic of the enriched *Masas* were evaluated and compared with a negative control (100 percent rice flour *masa*). The study revealed that enrichment of rice with grain amaranth and carrots have the potential of enhancing the nutritional value of a low protein rice based snack (*masa*).

Bhatt *et al.* (2018) studied on development and quality characterization of pasta containing amaranth flour. Amaranth flour was incorporated in the ratio of 10, 20 and 30 percent in the wheat flour. Flour analysis revealed that the amaranth flour had better nutrients than semolina and wheat flour in physico-chemical composition. The final products revealed that use of amaranth flour as improvement agents is well suited in the pasta making and it can be used for the patient suffering with lifestyle disease.

2.3. Analysis on nutritional and biochemical composition of amaranth grain flour

Carlsson (1980) reported that the total lipid content of amaranth grain ranging from 5.4 to 17 percent dry matter and has a high level of unsaturated (about 75 percent) containing 50 percent lenoliec acid.

Betschart *et al.* (1981) investigated the milling characteristics and distribution of nutrients with *Amaranthus cruentus* seed components and the effect of dry heat on nutrition quality. The seed coat- embryo fraction were the most highly concentration nutrients which consist of 2.3-2.6 times as much as nitrogen, fat and ash; 2.4-3 times the quantity of thiamin, riboflavin and niacin; and 1.4-2.5 times of concentration of several mineral elements. Dry heat processing method hot air popping seed showed 1.7 protein energy ratio and nitrogen digestibility of 77 percent and did not differ significantly from those of the control seed.

Ruiz and Bressani (1990) conducted a study on effect of germination on the chemical composition and nutritive value of amaranth grain. Their study revealed that the chemical composition of amaranth grain changes in the germination process. All the vitamin content, mainly riboflavin and ascorbic acid enhanced during this process. Total and reducing sugars and damaged starch value increased whereas stacchyose and raffinose decreased. They reported germination did not increase the protein value of amaranth grain or its biological utilization but germination seeds decreased their nutritive value during cooking.

Escudero *et al.* (1999) revealed that the protein concentration of the amaranth flour was 15.74 percent and dietary fiber content was 53.81 percent.

Sandak *et al.* (2000) reported that amaranth contained the highest percentage of protein (14.41 percent) followed by barley and wheat flour. Amaranth was rich in the essentials amino acids lysine, leucine and isoleucine.

Escuredo *et al.* (2004) study on comparison of the chemical composition and nutritional value of *amaranthus cruentus* flour and its protein concentrate reported that used of processing technique of *amaranth cruentus* flour to obtain a protein concentrate levels to a marked improvements of its nutritional quality and increase the content of factors that directly or indirectly influence lipid metabolism.

Pisarikova *et al.* (2005) investigated amino acid contents and biological value of protein before and after heat treatment in six selected varieties and flour species of amaranth grain. It was found that both the heat treated and untreated amaranth has high content of lysine and arginine and as well as an adequate amount of cysteine and lower level of methionine, valine, isoleucine and leucine. The chemical score of essential amino acid and essential amino acid index (EAAI) were determined. The favorable nutritional quality of amaranth protein of EEAI value shows 90.4 percent which is almost comparable with egg protein. Heat processing method like popping at 170 to 190 ºC for 30 sec has been shown to reduce EAAI to 85.4 percent.

Phosphorus, potassium, magnesium and calcium were the superior minerals in the raw seeds of *amaranthus caudatus and cruentus* (Gamel *et al.* 2006).

Capriles *et al.* (2008) evaluated the effects on physical and sensory properties of regular and reduced fat pound cakes and revealed that substitution of the sum of wheat flour and corn starch by 20 percent and 3 percent amaranth flour decreased the specific volume of convectional pound cake but insignificant effect in reduced fat products. With the increasing level of amaranth flour darkened crush and crumbs of cakes, which decreased color acceptability. Sensory evaluation revealed that overall acceptability scores was reduced with the incorporation of 30 percent amaranth flour, due to its lower specific volume and darker color.

Mlakar *et al.* (2009) briefly describes crop important, botany and chemical composition, including new findings on nutritive values and properties of grain amaranth processed as food and reported that grain amaranth has been tested and recognized by many authorities as a gluten free foodstuff suitable for incorporation into the diet for celiac disease patients. On the other hand, lack of gluten is a limiting factor for application of grain amaranth into the composite flour for leavened products.

Mariotti *et al.* (2009) reported that amaranth flour had 2.01 percent of moisture; 15.78 percent of protein; 8.16 percent of lipids; and 8 percent of fibre.

Alvarez-Jubete *et al.* (2009) carried out a study on nutritive value and chemical composition of pseudo-cereals as gluten free ingredients and reported that presently, the gluten free products which are available in the market are considered of low quality and poor nutritional value. In the present study, they studied amaranth, quinoa and buckwheat as potential healthy ingredients for enhancing the nutritional quality of gluten free breads. The results suggested the pseudo-cereals (amaranth, quinoa and buckwheat) are useful in the formulation of nutrients enriched gluten free products.

Mlakar *et al.* (2009) indicated that amaranth grain was composed of 13.1 to 21.0 percent of crude protein; 5.6 to 10.9 percent of crude fat; 48 to 69 percent of starch; 3.1 to 14.2 percent of dietary fibre and 2.5 to 4.4 percent of ash.

Mendonca *et al.* (2009) stated amaranth protein presents lowering cholesterol effect and investigates its mechanisms hypercholesterolaemia was induce in male hamsters through diet rich in casein consisting regular levels of cholesterol feed during 3 weeks and reported that amaranth protein has a metabolic effect on endogenous cholesterol metabolism.

Alvarez-Jubete *et al.* (2009) analyzed the vitamin E composition of pseudo cereals such amaranth, quinoa and buckwheat seed and reported vitamin E content differed significantly due to different grain type. It was found the highest vitamin E content (expressed as alpha tocopherol equivalents) in quinoa (24.7 µg) followed by amaranth (15.4 µg) and buckwheat (6.3 µg) grain respectively. Impact of baking on vitamin E content were investigated and reported that the gluten free breads incorporated pseudo cereals ad significantly higher content of vitamin E compared with the gluten free control. Pseudo cereals such amaranth, quinoa and buckwheat grain shown to be good sources of vitamin E and suggested may be used as ingredients in the formulation of gluten free products for enhancing vitamin E content and overall nutritional quality.

Mbruru *et al.* (2011) studied raw and processed amaranth grain for their nutritional content. They reported moisture content was 10.2 and 2.4 percent; protein 17.2 and 16.7 percent, fat 7.0 and 7.0 percent; ash 2.7 and 2.6 percent; crude fibre 3.8 and 3.1 percent; Carbohydrate 59.2 and 68.3 percent respectively.

Tomoskozi *et al.* (2011) investigated the effects of flour and protein isolates preparation from amaranth and quinoa seeds on the rheological properties of wheat dough and bread crumb. They revealed that substitution of wheat flour by amaranth and quinoa flour changes in rheological properties of dough and test bread quality parameter (volume crumb and firmness). The results of the study also revealed that that amaranth and quinoa flour use for the purpose of bread making is mainly enhance the nutritive value of protein. The addition of protein isolates did not significantly affect the main rheological parameters of dough and bread crumb. They report that the incorporation of 10 percent amaranth or quinoa flour did not cause significantly changes in rheological properties however incorporation of 20 percent and 30 percent shown in significant changes in stability, the degree of softening and elasticity. And also report that substitution of wheat flour by amaranth or quinoa resulted in a water absorption capacity.

Emire and Arega (2012) reported that the proximate analysis of amaranth-wheat blended flour shows significantly nutrient improvement as an amount of amaranth blend increase.

Mburu *et al.* (2012) reported protein content of amaranth grain species ranges from 12.5 percent to 17.6 percent which was relatively higher than that of maize and most other grains. The methionine and lysine content reported 0.06 to 1.7 and 3.4 to 6.4 g /16 N respectively.

Amaranth seeds and products- the source of bioactive compounds analyzed by Ogrodowska *et al*. (2014) reported that seed processing technique did not change protein , fat and starch content of amaranth grain. However, tocopherol content was decreased while in popping and in flakes. Further, revealed that high squalence content and main component of amaranth seeds and products is starch, for about 50 percent of dry matter.

Alencar *et al.* (2015) reported that incorporation of amaranth and quinoa flour have shown greater amount of proteins, Lipids and ash and therefore improving the nutritional profile when compared to control.

Chauhan *et al.* (2015) conducted a study on total dietary fiber and antioxidant activity of gluten free cookies made from raw and germinated amaranth (*Amaranthus Spp.)* flour. The chemical, functional and pasting properties of raw and germinated flour were studied. The results of the study reported that germination decreased fat from 6.68 g to 4.7 g per 100 g and carbohydrate 62.41 g to 60.70 g per 100 g whereas an increased in protein from 15.05 g to 16.5 g per 100 g, total dietary fiber from 9.52 g to 12.9 g per 100 g and antioxidant activity from 10.23 g to 14.71 g per 100 g respectively. The chemical, functional and pasting properties were significantly influenced by germination process and also reported significantly increased in antioxidant activity and total dietary fiber of germinated flour. The study revealed that germinated amaranth flour has higher content of protein, total dietary fiber and antioxidant activity than raw amaranth flour. Therefore, cookies prepared from amaranth grain flour could be an effective alternative for celiac disease and health conscious peoples by providing them higher nutritional value product.

Bhat *et al.* (2015) studied on evaluation of nutraceutical properties of *Amaranthus hypochondriacus L.* grains and formulation of value added cookies. In this study, the dried *Amaranthus hypochondriacus (L.)* grains were investigated for phytochemical content, antioxidant and antimicrobial activity to understand the nutraceutical properties. They observed that the cookies can act as a good source of nutrients such as protein, carbohydrates, and dietary fiber and hence a potential source of energy.

Man *et al.* (2017) reported that ash, fiber and the protein contents of the blend flour cookies increased with increasing amounts of amaranth flour.

Akande *et al*. (2018) reported that increased significantly the contents of Protein, fat, ash and fiber of rice based *masas* enriched with grain amaranth and carrot powder. Essential amino acids distribution was within or above recommended dietary allowance except for lysine and also increases a very unusual in vitamins and minerals. Total phenol content and antioxidant activities had shown positive effects of the enriched products.

Esan *et al*. (2018) conducted a study to determine biochemical and nutritional composition of two accessions of *amaranthus cruentus* seed flour and to evaluate the protein quality and the potential use of its flour to formulate functional foods. Nutraceutical, amino acid profile of the samples were determined. The study revealed that the essential amino acid composition in amaranth flour making more suitable non wheat material for composite flours used for the fortified food and complementary weaning food production. Moreover, it can be used in food product development for celiac patient based on their protein quality. Additionally, the lysine content is available in abundant in these two accessions and which is limiting in other cereals.

Beniwal *et al.* (2019) studied the different processing treatment including cooking, germination and roasting of the grain on their flour and revealed that amaranth and quinoa grain has a good source of nutrients that high in protein and mineral content.

Siwatch *et al.* (2019) investigated the effect of cooking, germination and fermentation on the proximate composition, physiochemical, thermal, pasting and micro structural properties of amaranth flour. They revealed that the protein content of amaranth flour increased significantly after germination and fermentation and it was observe amylase content has significantly decrease after various processing treatment. They also revealed that various processing treatments (cooking, germination and fermentation) significantly increased the phenolic content and significantly reduced tannin and phytate content.

Chapter 3

Materials and Methods

The materials and method describes in details all the material that have been used to conduct a study as well as the procedures that are undertaken. A methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with branch of knowledge.

3.1. Location of Research
3.2. Total sample
3.3. Units of study
3.4. Sampling Methodology
 3.4.1. Sample collection
 3.4.2. Preparation of amaranth grain flour
  3.4.2.1.Roasted amaranth grain flour (RAGF)
  3.4.2.2.Popped amaranth grain flour (PAGF)
  3.4.2.3.Soaked amaranth grain (SAG)
 3.4.3. Development & standardization of recipes by incorporating different form of amaranth grain
3.5. Biochemical Analysis
3.6. Sensory Analysis
3.7. Statistical Analysis

3.1. Location of Research

The study was conducted at College of Community Science, Department of Food Science and Nutrition. Food Analysis Lab was used for biochemical analysis and product development was done in Food Science and Nutrition Lab.

3.2. Total Sample

Many products namely cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa* were taken**.** Selected products were incorporated with different level form of amaranth grain.

3.3. Unit of study

Different products with amaranth grain flour were considered as unit of study.

3.4. Sampling Methodology

3.4.1. Sample collection

Raw amaranth seed grain *(Amaranthus cruentus L.)* and all the ingredients required for this experiment were procured from the local Tura Supermarket, Meghalaya.

3.4.2. Preparation of Amaranth Grain Flour

The various steps followed in the preparation of amaranth grain flour are shown in the flow chart given below.

3.4.2.1. Roasted Amaranth Grain Flour (RAGF)

For roasting, amaranth grains were heated on a hot pan at high flame for 4-5 minutes until the color of the grain change to golden yellow and flavor produced. The grains were stirred in a regular interval. The roasted grains were cooled and milling was done by electrical grinder at high speed uniform particle size flour. The obtained flour was sieve and stored in air tight container.

Amaranth grain
↓
Cleaning dust and impurities
↓
Roasting (4-5min)
↓
Grinding
↓
Sieving
↓
Roasted amaranth grain flour

Fig. 1 Flow chart of RAGF

3.4.2.2. Popped Amaranth Grain Flour (PAGF)

According to Teutonica and knorr, 1985 the grains were cleaned and washed thoroughly**.** The grains were placed in a hot stainless steel pan of about 220ºC for 10-20 seconds or until they popped. The grains are stirred continuously to prevent them from burning while popping. Saunders and Becker, 1984 reported that popping amaranth grains increase the volume of up to 1050 percent and gives the grains a gritty flavor. Similar procedures were followed for this study. The popped grains were cooled and grinded to fine flour by using electrical grinder and stored in air tight container.

Popping of Amaranth grains

Amaranth grain

↓

Cleaning dust and impurities and washed thoroughly

↓

Popping (10-20sec)

↓

Grinding

↓

Sieving

↓

Popped amaranth grain flour

Fig 2: Flow chart of PAGF

3.4.2.3. Soaked amaranth grain (SAG)

The grains were cleaned for dust and impurities. Place the grain in a bowl and soak for 2-3 hrs. Rinse and pour off water before grinding. The soaked grains were grinded by using electrical grinder.

Soaking of Amaranth Grain

Amaranth grain

↓

Cleaning dust and impurities

↓

Soaking the grains (2-3hr)

↓

Grinding

Fig 3: Flow chart of SAG

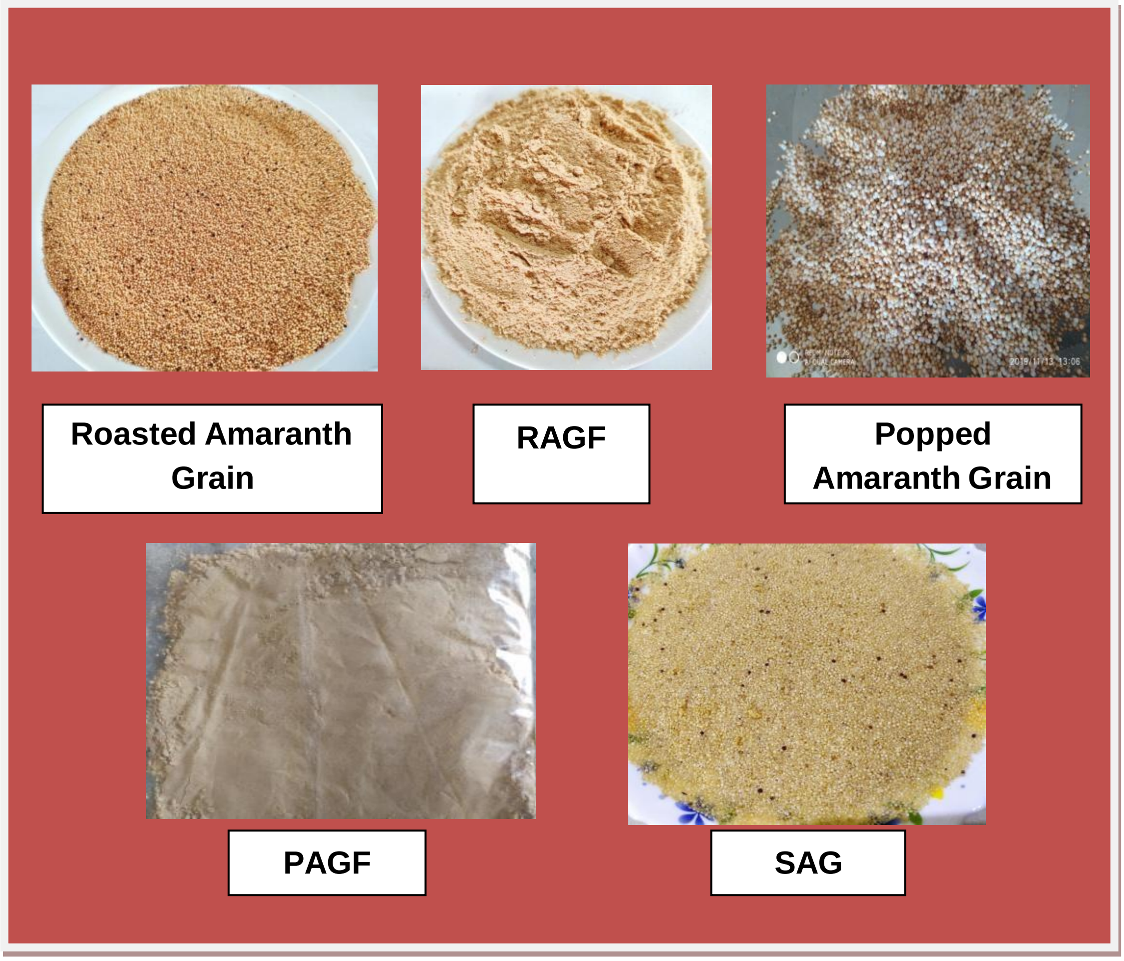

Plate 1: Roasted Amaranth Grain, RAGF, Popped Amaranth Grain, PAGF and SAG

3.4.3. Development & standardization of recipes by incorporating different form of amaranth grain

The literature was referred to find out the correct raw materials suitable for the development of different products from amaranth grain in order to find out the appropriate products, recipes were tried and standardized with different form of amaranth grain *i.e.* Roasted Amaranth Grain Flour (RAGF), Popped Amaranth Grain Flour (PAGF) and Soaked Amaranth Grain (SAG). The most acceptable product has been taken as final. The study was designed to develop and evaluate the effect of incorporation of amaranth grain flour at different proportion to the different products such as cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa*. The products prepared without incorporation of amaranth grain flour was considered as control. The levels of incorporation of amaranth flour were 5, 10, 15, 20 and 50 percent levels in the preparation of each selected products.

Table 3.1: Ingredients used for preparation of Cake with different proportions

Ingredients	Control	Type A (5%)	Type B (10%)	Type C (15%)	Type D (20%)	Type E (50%)
Wheat flour	100g	95 g	90 g	85 g	80 g	50 g
RAGF	-	5 g	10 g	15 g	20 g	50 g
Powder sugar	100 g	100 g	100 g	100 g	100 g	100 g
Butter	100 g	100 g	100 g	100 g	100 g	100 g
Eggs	120 g	120 g	120 g	120 g	120 g	120 g
Baking powder	1 tsp	1 tsp	1 tsp	1 tsp	1 tsp	1 tsp
Vanilla essence	Few drops	Few drops	Few drops	Few drops	Few drops	Few drops

Method of preparation

i. Sieve the wheat flour and baking powder at least three times.
ii. Beat the egg till they form foam.
iii. Beat the sugar and butter separately and add beaten egg into it and mix well until it becomes fluffy.
iv. Add the wheat flour into it and few drops of vanilla essence and mix well together.
v. Pre-heat oven at 180º C temperature for 15 minutes and baked in a dusted for 20-25 minutes.

Table 3.2: Ingredients used for preparation of *besan burfi* with different proportion

Ingredients	Control	Type A (5%)	Type B (15%)	Type C (20%)	Type D (50%)
Bengal gram flour	150 g	145 g	135 g	130 g	75 g
PAGF	-	5 g	15 g	20 g	75 g
Ghee	75 g	75 g	75 g	75 g	75 g
Sugar powder	70 g	70 g	70 g	70 g	70 g
Almond	20 g	20 g	20 g	20 g	20 g
Cardamom powder	A pinch	A pinch	A pinch	A pinch	A pinch

Method of preparation

i. Heat the ghee in a non-stick pan.
ii. Add the gram flour and saute it on low heat for 10-15 minutes. Stir continuously to prevent from burning or till it start changing colour and gives out a nice aroma.
iii. Add the cardamom powder and almond into it then mix well. Remove from the heat and let it cool for some times.
iv. Add the powder sugar and mix well.
v. Pour the mixture on a grease tray and spread it evenly.
vi. Let it cool for 2 to 3 hr and then cut into square diamond shape pieces

Table 3.3: Ingredients used for preparation of coconut *ladoo* with different proportion

Ingredients	Control	Type A (10%)	Type B (20%)
Coconut fresh	100 g	90 g	80 g
PAGF	-	10 g	20 g
Sugar	35 g	35 g	35 g
Milk powder	5 g	5 g	5 g
Almond	5 g	5 g	5 g

Method of preparation

i. Grate the fresh coconut and mix thoroughly with sugar; keep it aside for few minutes.
ii. Fry grated coconut in a khadai for few minutes.
iii. Stir smoothly and fry until the sugar melts and become sticky.
iv. After the mixture becomes light transparent brownish colour then milk powder was added to it and again fried for few minutes.

v. Remove from heat and roll into small balls when it is still hot.

Table 3.4: Ingredients used for preparation of cashewnut *burfi* with different proportion

Ingredients	Control	Type A (10%)	Type B (15%)	Type D (50%)
Cashew nut	150 g	140 g	135 g	75 g
PAGF	-	10 g	15 g	75 g
Sugar	75 g	75 g	75 g	75 g
Water	75 ml	75 ml	75 ml	75 ml
Ghee	5 g	5 g	5 g	5 g
Cardamom powder	½ tsp	½ tsp	½ tsp	½ tsp

Method of preparation

i. Place the cashew nut in the mixer jar. Grind the cashew nut in little a quantity and then strain the cashew powder through a sieve.
ii. Add 75 g of sugar and 75 ml of water into the pan and let the sugar dissolve in water.
iii. Add the cashew nut powder into the pan and cook until it gets dense consistency on a low flame.
iv. The cashew paste has turned quite thick in consistency and mix thoroughly ½ tsp cardamom powder and 5 g of ghee into it.
v. Continue cooking until it gets thick in consistency and the soft ball stage.
vi. Cool the cashew paste into the grease steel plate. Grease hand with some ghee and roll it to make a ball.
vii. Place the roll ball over the butter paper and cut it into diamond shape pieces.

Table 3.5: Ingredients used for preparation of *dosa* with different proportion

Ingredients	Control	Type A (10%)	Type B (20%)
Parboiled rice	110 g	100 g	90 g
Raw rice	20 g	20 g	20 g
SAG	-	10 g	20 g
Black gram dhal	150 g	150 g	150 g
Fenugreek seed	5 g	5 g	5 g
Salt	For taste	For taste	For taste

Method of preparation

i. Soaked the ingredients *i.e*. parboiled rice, raw rice, black gram dhal, fenugreek seed and amaranth grain separately for 2-3 hrs.
ii. Blend all the soaked ingredients separately with little amount of water and mix well together and make a good consistency batter.
iii. Ferment the batter for 8-10hr or overnight.
iv. Heat a non stick pan and put a spoonful batter on it and back of the spoon spread it evenly,
v. Dizzle some oil around and cook on medium heat it is crispy from the underside.

3.5. Biochemical analysis of the developed products.

The methodology of biochemical analysis has been divided into proximate; minerals and other nutrients composition. Estimation of moisture, ash, crude fibre, crude protein, crude fat, energy and carbohydrate have been listed under the proximate analysis, minerals namely iron calcium, zinc and phosphorus and others nutrients *i.e.* total sugar, reducing sugar and total dietary fibre has also been incorporated.

3.5.1. Proximate Analysis of the developed products by using standard method

1. Method of Estimation of moisture

Moisture content in the sample was estimated by using the standard method analysis (AOAC, 2000).

Procedure:

Clean and wash petri dish or crucible. Dry it. Put the dish in dessicator. Take out from dessicator and take weight of the dish. Measure 10g of food sample crucible and dried in hot air oven for 8 hours at 105°C. China crucible with dried material was transferred to dessicator, cooled and weighed. The loss in weight represented the moisture content of sample.

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

Loss weight = initial weight - final weight

*initial weight is weight of the petri dish +weight of sample before drying

*final weight is weight of the petri dish and food sample together after drying

2. Ash of sample

Ash content in the sample was determined by using the standard method analysis (AOAC, 2000).

Principle: Dry ashing procedures use a high temperature muffle furnace capable of maintaining temperatures of between 500 and 600˚C. Water and other volatile materials are vaporized and organic substances are burned in the presence of the oxygen in air to CO2, H2O and N2.

Procedure:

Wash and weigh the crucible and take weight as in moisture estimation. Take 5 g of food sample and put it in crucible. Place the crucible in a muffle furnace at 550°C for 4 hours. After cooling the residue left in the crucible was weighed.

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

*Weight of ash = final weight- weight of crucible

3. Energy

Procedure:

Energy value of the food sample can be calculated by multiplying the figure for the percentage of protein, fat, and carbohydrate 4, 9 and 4 respectively and adding the figures obtained.

Calculation:

Kcal /100 g = (4 × % protein) + (9 ×% fat) + (4 ×% carbohydrate)

3. Estimation of Crude protein

Crude protein in the sample was estimated by using Association of Official Analytical Chemists (AOAC, 2000).

Principle

The sample is digested with conc. H_2SO_4 in the presence of a catalyst to convert the nitrogen in protein or any other organic material to ammonium sulphate. By steam distillation of this salt in the presence of strong alkali, ammonia is liberated and collected in boric acid solution as ammonium borate which is estimated against a standard acid by titration. On an average most proteins have 16 % nitrogen in their composition. In other words 1 mg nitrogen equals to 6.25 mg protein. Thus, by finding out the ammonia formed, from a known amount of sample, one can calculate the amount of protein present. (1ml of 0.1 N acid=1.401 mg N)

Reagents

Conc. sulphuric acid

Digestion mixture: potassium sulphate and copper sulphate in the ratio of 5:1

4% boric acid

40% sodium hydroxide

Mixed indicator: methyl red and bromocresol green

0.1N sulphuric acid

Procedure:

Weight 0.2 g of sample and 4 g of digestion mixture and 10 ml of conc. H_2SO_4 and put it in clean digestion tubes and put it Kelplus digestion equipment KES12L (VA). One of the samples should be kept for blank (only digestion mixture and acid no food sample should be added). Digest the sample at 300°C (pre-digestion) and 420°C as final digestion. Cool the sample in block itself. Dilute the digested sample by adding 30 ml of distilled water. Distlled the sample by using 40% NaOH in Kjeldahl Plus distillation (Kelplus-classic DXVA, Pelican equipment) set by using 40 % NaOH for nine minutes. Collect the distilled ammonia in 4 % boric acid. The determination of the amount of nitrogen trapped in the flask was done by titrating with a standard solution of 0.1 N HCL or $H_2 SO_4$. The nitrogen value was multiplied by 6.25 or conversion factor to obtain the protein content of food sample.

4. Estimation of Crude fat

The estimation of crude fat was done by the standard method analysis (AOAC, 2000). The automated apparatus Socs Plus (SCS6, Pelican equipment, India) was used to analyze the samples.

Principle:

Fat is extracted with mixture of ethers from known weight of sample. Ether extracted is decanted into dry weighing dish, and ether is evaporated. Extracted fat is dried to constant weight. Result is expressed as % fat by weight.

Reagents

Petroleum ether

Cotton

Filter paper

Procedure:

Clean and take the weight of beaker. Mark each beaker. Insert thimble into the beaker. Take 2 g of the sample and transferred to the thimble. Load the beaker and thimble into the system. Set the initial temperature of the equipment to 120°C. After boiling, reduce the temperature to 90°C. Run the equipment for 45 minutes. In recovery periods (after 45 minutes), the temperature of the equipment should rise to 120°C and closed the nozzle and the equipment was run for 15 minutes. Remove the beaker from the system and put it into hot air oven. After 15 to 20 minutes, removed the beakers and placed in a dessicator, take out the thimble and take weight. Mark the final weight as W_2. Calculate the crude fat by using the following formula:

$$\% \text{ fat} = \frac{W_2 - W_1}{W} \times 100$$

Where,

W_2 = final weight of the beaker

W_1= initial weight of the beaker

W= weight of the sample

5. Carbohydrate

The content of the available carbohydrate is determined by difference method, *i.e.,* by subtracting from 100 the sum of the values (per 100 g) for moisture, protein, fat, ash and crude fibre.

6. Estimation of Crude fiber

Crude fibre was estimated by using the standard method of analysis (AOAC, 2000).

Principle:

Crude fibre is loss on ignition of dried residue remaining after digestion of sample with 1.25 % (w/v) H_2SO_4 and 1.25 % (w/v) NaOH solutions under specific conditions. Method is applicable to materials from which the fat can be extracted to obtain a workable residue, including grains, meals, flours, feed, fibrous materials and pet foods.

Reagents

1.25% NaOH

1.25% H_2SO_4

Amyl alcohol

Procedure:

Fibra Plus crucibles were oven dried, cooled, weighed and marked as W_1. 5 g of sample was weighed and transfer to crucibles. The crucibles were placed in metal adapters of Fibra plus (FES, 6, Pelican equipment, India) hot extraction unit (Pelican India Limited) ensuring the proper sealing of crucibles against the adapter rubber. The acid, base and distilled water was heat up on a hot plate. Approximately 150 ml of the 1.25% of H_2SO_4 was poured into the extractor unit of Fibra plus from the top. Equipment was switch on and the initial temperature was set at 500°C. After boiling starts, the temperature was reduced to 400°C. The sample was boiled for 40 minutes in acid. After boiling, acid was drained off and rinsed with distilled water thrice, so as to ensure that the sample was free from acid residue. Acid washed sample was then boiled with 150 ml of 1.25 percent NaOH for 40 minutes in the same process as acid wash. The sample was rinsed with distilled water thrice or more so as to assure no alkali residue was left within the sample. The crucibles with digested samples were removed from the equipment and dried in hot air oven until the samples were free of moisture. The samples were cooled down in a dessicator and the crucibles were weighed (W_1). Crucibles with dried samples were placed in the muffle furnace for 4 hours at 550°C. After ashing, the crucibles were removed from furnace, cooled in dessicator and weighed (W_2). The loss in weight was recorded and calculated fiber content of the sample as:

$$\% \text{ Crude fibre} = \frac{W_3}{W} \times 100$$

Where,

$W_3 = W_1 - W_2$

W_1=Weight of residue before ignition

W_2= Weight residue after ignition

W= Weight of sample

3.5.2. Minerals analysis of the developed products by using standard method

7. Estimation of iron, calcium and zinc

Iron, calcium and zinc content in the sample were done according to the method of (AOAC 20th edition, 999.11).

Reagents

Double Distilled Water- Milli- Q

CRM: NIST Traceable Make: Sigma Aldrich/ Merck

Nitric Acid: Purity not less than 65 % sigma Aldrich

Hydrochloric Acid: 6 M

Nitric Acid: 0.1 M

Procedure:

20 g of test portion was weighed and dried in a drying oven at 100ºC. The sample crucible was placed in a muffle furnace at initial temperature not higher than 100ºC. Increase temperature at a maximum rate of 50ºC / h to 450ºC. Let the crucible stand for at least 8 hrs or overnight. Wet ash with 1-3 ml water and evaporate on water bath or hot plate. Put crucible back in furnace at no more than 200ºC and raise temperature (50ºC-100ºC / h) to 450ºC. Ashing was done at 450ºC for 1-2 hrs or longer. Repeat the same procedure until products was completely ashed *i.e.* ash should be white / grey or slightly colored. 5 ml of HCL was added to crucible ensuring that all ash comes into contact with acid. Evaporate acid on water bath or hot plate. Dissolve the residue in 10 ml of 0.1 M HNO_3. The solution was diluted if necessary with 0.1 M Nitric acid. Calculation of the concentration is generally done automatically by the software (*i.e.* Wizard) of the AAS instrument.

8. Estimation of Phosphorus

The estimation of phosphorus content was done according to the procedure of Fisher, (1971).

Reagents

Ammonium molybdate solution

Hydroquinone solution

Sodium sulphite solution

Conc. HCL

Standard solution

Procedure:

The ash solution prepared from the food sample was used for the determination of phosphorus. For the development of colour 0.2 ml aliquot was taken in a test tube and diluted to 1ml with distilled water. 2 ml of ammonium molybdate, 1ml of hydroquinone and 1 ml of sodium sulphite solutions are added and mix the contents. The volume was made to 10 ml with distilled water; mix the contents and blue colour was measured after 30 min in spectrophotometer at 660 nm. For the blank, instead of test solution, 1 ml of glass distilled water was taken and rest of procedure is same as for the sample. Take 0.2, 0.4, 0.6, 0.8 and 1.0 ml of working standard in the test tubes and developed the colour in the same way as for the sample. These solutions contained 5, 10, 15, 20, and 25 μg phosphorus, respectively and a standard curve was prepared against O.D. The concentration of phosphorus in unknown sample was calculated from the standard curve and the results are expressed as mg P /100 g sample.

3.5.3. Estimation of total sugar and reducing sugar

Total sugar and reducing sugar was estimated according to the procedure of FSSAI manual of Fruits and Vegetables 2016.

Reagents

1) Fehling solution A: dissolve 69.28 gm copper sulphate ($CuSO_4.5H_2O$) in distilled water. Dilute to 1000 ml. Filter and store in amber colored bottle.

2) Fehling solution B: Dissolve 346 gm Rochelle salt (potassium sodium tartrate) ($K Na C_4 H_4 O_6 4H_2O$) and 100 gm NaOH in distilled water. Dilute to 1000 ml. Filter and store in amber coloured bottle.

Procedure:

Take 25 ml aliquot containing (if possible) 50 - 200 mg reducing sugars and titrate with mixed Fehling A and B solution using Lane and Eynon volumetric method. For inversion at room temperature, transfer 50 ml aliquot clarified and deleaded solution to a 100 ml volumetric flask, add 10 ml HCl (1+1) and let stand at room temperature for 24 hrs. (For immediate inversion, the sample with HCl can be heated at 70ºC for 1 hr). Neutralise exactly with conc. NaOH solution using phenolphthalein indicator and dilute to 100 ml. Titrate against mixed Fehling A and B solution (25 ml of Fehling's solution can be considered for the purpose) and determine total sugar as invert sugar (calculate added sugar by deducting reducing sugars from total sugars).

Calculation:

Reducing and total reducing sugar can be calculated as,

$$\text{Reducing sugar (\%)} = \frac{\text{mg.of the invert sugar} \times \text{vol.made up} \times 100}{\text{TR} \times \text{wt.of the sample} \times 1000}$$

$$\text{Total reducing sugar(\%)} = \frac{\text{mg.of invert sugar} \times \text{final vol. made up} \times \text{original volume} \times 100}{\text{TR} \times \text{wt. of the sample} \times \text{aliquot taken for inversions} \times 1000}$$

Total sugar (as sucrose)(%)= (Total reducing sugar - Reducing sugar)× 0.95 + Reducing sugar

Added sugar = Total sugars - Reducing sugar

3.5.4. Estimation of total dietary fibre

Total dietary fibre in the sample was estimated by using Indian standard (IS: 11062-1984, Reaff. 2005).

Reagents

Acetone
Chloroform- Methanolmixture - 2:1 v/v.
Ethyl alcohol- 80 percent v/v
Glucoamylase- of Rhizopus mold origin, having an activity of 5000-10000 units per gm solid
Hydrochloric acid- 5 N
Pancreatin- of porcine pancreas origin, having an activity of X N F specifications (* Specification of water for general laboratory use)
Pepsin- of porcine Stomach Mucosa origin having an activity of 30 units per mg solid
Diethyl Ether
Phosphate buffer- 0.1 M, pH 6.0
Sodium hydroxide -3 N
Thymol

Preparation of assay sample

i. The sample of food grains was milled to a particle size of 0.5-1 mm in a Wiley mill. Moist foodstuffs such as fruits vegetables was sliced and homogenized before dying. The dry matter content of all the samples is determined as the weight after drying for 5 hour at 105ºC.
ii. Extraction of liquids- The step is recommended for foodstuffs containing more than 5 percent of lipids to facilitate the subsequent removal of free sugars by ethyl alcohol extraction using chloroform methanol mixture. This system removes the free, bound and polar lipids.
iii. Removal of free sugars- About 3 g moisture and lipid free sample was taken in a glass centrifuge tube of 100 ml capacity. 50 ml of boiling 80 percent ethyl alcohol was added. Stir well and centrifuge at 2000 rpm for 5 minutes. Supernatant was discarded. Procedure was repeated twice with 80 percent ethyl alcohol.

1. Estimation of dietary fibre

i. **Pepsin digestion-** To the centrifuge tube containing the sample residue (iii) 50 ml of water was added and autoclave at 120ºC for 20 minutes to gelatinize the starch. The contents of the tube were cooled and adjust to pH 1.5 with 5M HCL. 50 mg of pepsin and 200 ul of chloroform was added, & incubated at 37ºC for 20 hours. PH 6.0 was adjusted to 3 N NaOH and proceeds to the next step.

ii. **Pancreatin and Glucoamylase Digestion-** To the contents of the centrifuge tube, 25 ml of phosphate buffer, 100 mg of pancreatin, 20 mg of glucoamylase and a few crystals of thymol were added & incubated at 37ºC for 18 hours. Centrifuge at 3000 g for 30 minutes. Supernatant was collected and washed the residue three times with water. Washings were added to the supernatant. The residue was taken after washings for the estimation of insoluble fraction of the dietary fibre. Procedure was preceded for the determination of the soluble fraction taking the supernatant along with the washings.

iii. **Insoluble fraction of dietary fibre-** The residue was washed from (ii) three times with acetone and then with ether. The residue was dried to a constant weight in a hot air oven or vacuum oven. This represents the insoluble fraction of the dietary fibre.

iv. **Soluble fraction of dietary fibre-** Supernatant was diluted from (ii) with four volumes of ethyl alcohol. Centrifuge at 3000 g for 30 minutes and collect the residue. The residue was washed, three times with ethyl alcohol, three times with acetone and then with diethyl ether. Dry to a constant weight. This represents the soluble fraction of the dietary fibre.

Total dietary fibre in the sample was calculated by using the following formula:

$$\text{Total dietary fibre} = \frac{\text{Mass of the soluble fraction} + \text{Mass of the insoluble fraction}}{\text{Mass of the sample}} \times 100$$

3.6. Sensory Analysis

The sensory evaluation was carried out by evaluating five major sensory characteristics such as appearance, texture, taste, aroma and overall acceptability by panel of thirty semi-trained panelists member from the Department of Food Science and Nutrition, which include teaching staffs, non-teaching staff and final year students of Community Science and Nutrition & Dietetics students of College of Community

Science Central Agricultural University, Tura Meghalaya. The panelist judges on nine point Hedonic scale on the basis of their appearance, texture, taste, aroma and overall acceptability where nine indicated "like extremely" and one indicated "dislike extremely".

3.7. Statistical Analysis

For the data analysis, the obtained observation data were analyzed with appropriate statistical methods namely mean & Standard deviation (SD) were incorporated wherever necessary. For analysis Microsoft excel software programme was used. Independent-Samples Kruskal-Wallis Test was incorporated in order to check the significant difference of the formulated products. The results of the study were given in the form of appropriate tables and graph.

Chapter 4

RESULTS AND DISCUSSIONS

The study was designed to develop value added product by incorporating Amaranth grain flour at different percent. Amaranth grain flour was incorporated in the place of major ingredients of the developed products. The developed products such as Cake, *Besan burfi*, Coconut *ladoo*, Cashewnut *burfi* and *Dosa* were evaluated for their nutritional & biochemical composition and sensory characteristics. The results and discussions have been presented systematically under the following heads.

4.1. Nutritional composition of wheat flour, gram flour and amaranth grain flour
4.2. Sensory evaluation of developed products
4.3. Biochemical analysis of developed products

4.1. Nutritional composition of wheat flour, gram flour and amaranth grain flour

Nutritional compositions of Amaranth Flour (AF), Wheat Four (WF) and Gram Flour (GF) in terms of sixteen nutrients as per 100 g were compared by using the secondary data given by Ramesh and Prakash (2020) and Longvah *et al.* (2017). Moisture content of WF (11.34 g) was higher than AF (9.20 g) and GF (8.56 g) as shown in table 4.1. The moisture content of AF also reported higher by Resio *et al.* 2005 (10.5 percent) and Mubru *et al.* 2011 (10.2 percent). GF (18.77 g) had higher level of protein than AF (16.5 g) and WF (10.36 g) however AF had higher protein content when compared with wheat flour. Previous researchers (Akanksha, 2016) reported the highest amount of protein content in amaranth grain than cereals of regular consumption (wheat 12 -14 percent, rice 7-10 percent, corn 9 -10 percent). According to the table carbohydrate content found higher in WF (74.27 g) whereas AF and GF was almost similar *i.e*. 39.8 g and 39.56 g respectively. Higher carbohydrate content (72.15 percent) in amaranth was revealed by Jain and Grewal (2015). Amaranth flour (16.8 g) contain less dietary fiber than gram flour (25.22 g) however, when compared to wheat flour (2.76 g) AF has higher content of dietary fiber. The values of total dietary fibre (16.8 g) given in the table 4.1 are similar with the data reported by Repo- Carrasco-Valencia *et al.,* (2009) *i.e.* 14-16 percent. However, Carpriles *et al.* (2008) reported less dietary fibre than the data presented in the table.

Table 4.1: Comparison nutrient composition of amaranth flour, wheat flour and gram flour as per 100g through Indian Food Composition table (IFCT) and (Ramesh and prakash, 2020)

Nutrients	Flour Types		
	Amaranth flour	Wheat flour	Gram flour
Moisture (g)	8.43	11.34	8.56
Protein (g)	16.5	10.36	18.77
Fat (g)	7.82	0.76	5.11
Carbohydrate (g)	39.8	74.27	39.56
Dietary fiber (g)	16.8	2.76	25.22
Iron (mg)	9.64	1.77	6.78
Calcium (mg)	159	20.40	150
Zinc (mg)	3.55	0.88	3.37
Phosphorus (mg)	610	110	267
Magnesium (mg)	339	30.60	160
Copper (mg)	0.73	0.17	0.85
Sodium (mg)	4.69	1.54	26.56
Potassium (mg)	520	148	935
Lysine (mg)	1.063	212.3	1236.94
Tryptophan (mg)	0.27	107.7	178.31
Linoleic (mg)	37.5	325	2220

Dietary fiber is another constituent in amaranth found abundantly and naturally rich in dietary fibre consumption is very beneficial to the maintenance of health (Champ *et al.* 2003). Mineral content such as iron, calcium, phosphorus and magnesium was found significantly higher in AF followed by GF and WF. AF had 9.64 g iron, 159 mg calcium, 610 mg phosphorus and 339 mg magnesium. Akanksha, 2016 revealed that calcium, iron, and potassium content were 272.03 mg, 13.76 mg and 329.87 showed that very close with the values given in the table. WF *i.e*. 1.77 g iron, 20.40 mg calcium and 110 mg phosphorus content and GF had 6.78 g iron, 150 mg calcium, and 267 mg phosphorus. The zinc content of AF and GF found almost similar *i.e*. 3.55 and 3.77 respectively whereas WF had low content of zinc *i.e.* 0.88 mg. Higher content of sodium and potassium was indicated in GF when compared with AF and GF. Lysine content of AF reported lower than GF and WF however amaranth grain has two to three times of lysine than wheat, rice and maize (Segura *et al.,* 1994, Bressani, 1989). Amaranth is rich in lysine and tryptophan, which are nutritionally critical amino acid and essential amino acid that is lacking in main cereal crops (Mburu *et al.* 2011). Lenoleic content was found higher in gram flour. Maurya and Arya (2008) reported amaranth oil is primarily unsaturated oil which content high amount of lenoleic acid (about 50 percent).

4.2 Sensory analysis of the developed products

The products namely cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa* were formulated using different form of amaranth grain flour. Sensory attributes namely appearance, texture, taste; aroma and overall acceptability was done for their acceptability by using nine point hedonic rating scale method.

4.2.1 : Preparation of cake by incorporating RAGF

Five types of cakes were prepared by using roasted amaranth grain flour (RAGF) *i.e.* Type A cake prepared by using 5 percent RAGF, Type B cake by 10 percent RAGF, Type C cake by 15 percent RAGF, Type D cake by 20 percent RAGF and Type E by 50 percent RAGF. Cake without incorporation of amaranth grain flour was used as control sample. In this present study, the sensory mean scores of control and incorporated amaranth grain flour cake at various proportions were discussed in table 4.2 and figure 4. The mean scores of control cake were 7.5, 7.2, 8.0, 7.2, and 8.0 for appearance, texture, taste, aroma and overall acceptability respectively.

Table 4.2: Mean scores of sensory characteristics of cake (n=30)

Sensory attributes	Cake sample code & proportion					
	Control (WF:100%)	Type A WF:RAGF (95:5)	Type B WF:RAGF (90:10)	Type C WF:RAGF (85:15)	Type D WF:RAGF (80:20)	Type E WF:RAGF (50:50)
Appearance	7.5±0.51	8.1±0.83	8.2±0.70	8.0±0.70	7.7±0.59	7.4±0.63
Texture	7.2±0.45	8.2±0.67	8.2±0.70	7.9±1.27	8.0±0.70	7.7±0.70
Taste	8.0±0.37	8.0±0.70	8.2±0.79	7.9±0.45	8.2±0.59	8.0±0.59
Aroma	7.2±0.45	8.2±0.70	8.0±0.70	8.0±0.59	8.3±0.48	8.2±0.41
Overall Acceptability	8.0±0.37	8.4±0.50	8.3±0.72	8.2±0.67	8.2±0.41	8.1±0.35
KW-Test for overall acceptability of cake = 0.031						

Type A cake mean scores of texture and aroma were similar *i.e.* 8.2 whereas appearance, texture, and overall acceptability were 8.1, 8.0, 8.4 respectively. Type B cake mean score of appearance, texture, taste found similar *i.e.* 8.2 whereas aroma and overall acceptability were 8.0 and 8.3 respectively. The overall acceptability of Type C cake and Type D cake were same *i.e.* 8.2 which fells in the category of "like very much". The mean scores overall acceptability of Type D cake was slightly decrease as compare to other types *i.e.* 8.1 which is "like very much". It was observed that all the types of cake were acceptable in terms of appearance, texture, taste, aroma and overall acceptability. The highest acceptable was Type A as compared to control and others types of cake. The overall acceptability scores revealed that Type A cake prepared with incorporation of 5 percent RAGF was like extremely by the panel of judges. Furthermore, Type E cake prepared with incorporation of amaranth flour up to 50 percent was found acceptable by the panelist. Shyam and Raghuvanshi (2015) reported that incorporation of 40 percent amaranth flour eggless cake was found the most acceptable than control. However, they prepared eggless cake with the constant level of whey protein concentrate and using sun dried followed by oven dried amaranth grain flour. Capriles *et al.* (2008) evaluated the effects on physical and sensory properties of regular and reduced fat pound cakes and revealed up to 20 percent amaranth flour in conventional cake and up to 30 percent in reduced fat cake could be substituted to the sum of wheat flour and corn starch. Replacement of amaranth flour up to 30 percent decrease the overall acceptability scores for conventional cake due to lower specific volume and darker color. The increasing level of amaranth flour darkened the crush and crumbs of cakes, which decrease the color acceptability.

4.2.2. Preparation of *Besan burfi* by incorporating PAGF

Four types of *besan burfi* were prepared by using popped amaranth grain flour (PAGF) *i.e.* Type A *besan burfi* prepared by using 5 percent PAGF, Type B *besan burfi* by 15 percent PAGF, Type C *besan burfi* by 15 percent PAGF, Type D *besan burfi* by 50 percent PAGF. *Besan burfi* without incorporation amaranth flour used control sample. The mean values score of sensory evaluation for the acceptability of control and experimental *besan burfi* are shown in table 4.3 and figure 5. Sensory scores of *besan burfi* revealed that incorporation of 5 percent PAGF was found the most acceptable by the panellist with respect to appearance 8.4, texture 8.2, taste 8.3, aroma 8.2 and overall acceptability 8.2 score. The highest mean scores of 8.4 for appearance was obtained with 5 percent level of amaranth flour incorporation whereas the lowest score 7.4 obtained from 50 percent level of amaranth flour incorporation. The mean score of overall acceptability of *besan burfi* prepared with 15, 20 & 50 percent level of incorporation of amaranth flour were 8.0, 7.6 & 7.9 respectively.

Table 4.3: Mean score of sensory characteristics of *besan burfi* (n=30)

Sensory attributes	***Besan burfi* sample code & proportion**				
	Control (GF:100%)	**Type A GF:PAGF (95:5)**	**Type B GF:PAGF (85:15)**	**Type C GF:PAGF (80:20)**	**Type D GF:PAGF (50:50)**
Appearance	7.8±0.69	8.4±0.74	8.2±0.56	7.7±0.64	7.4±0.59
Texture	7.8±1.08	8.2±0.77	7.8±0.69	7.8±0.58	7.6±0.41
Taste	8.3±0.59	8.3±0.81	8.1±0.74	7.8±0.72	7.9±0.51
Aroma	7.9±0.66	8.2±0.67	8.0±0.70	7.7±0.74	7.7±0.59
Overall acceptability	8.0±0.70	8.2±0.77	8.0±0.65	7.6±0.50	7.9±0.50
KW-Test for overall acceptability of *besan burfi* = 0.05					

Incorporation up to 50 percent was found acceptable which is like moderately on nine point hedonic rating scale. Different kind of food products can be developed from amaranth alone or blended powder with other cereals namely bread, cakes, cookies, porridge, flat bread, snacks, biscuit etc (Ljubica *et al.* 2009). Jain and Grewal (2015) suggested that amaranth flour can be substituted up to 40 percent in the ready to eat snacks without affecting the sensory properties of snacks.

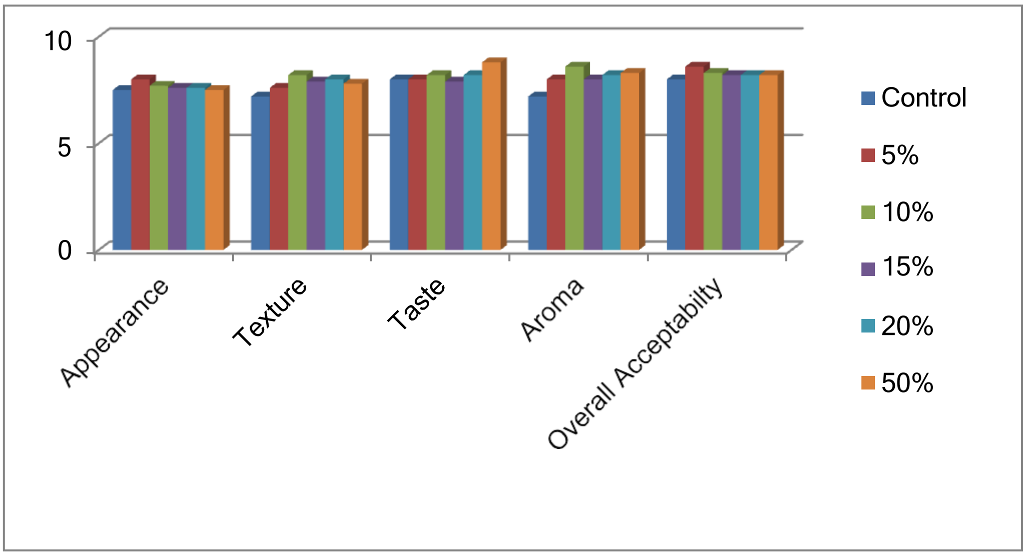

Fig 4: Sensory evaluation of cake

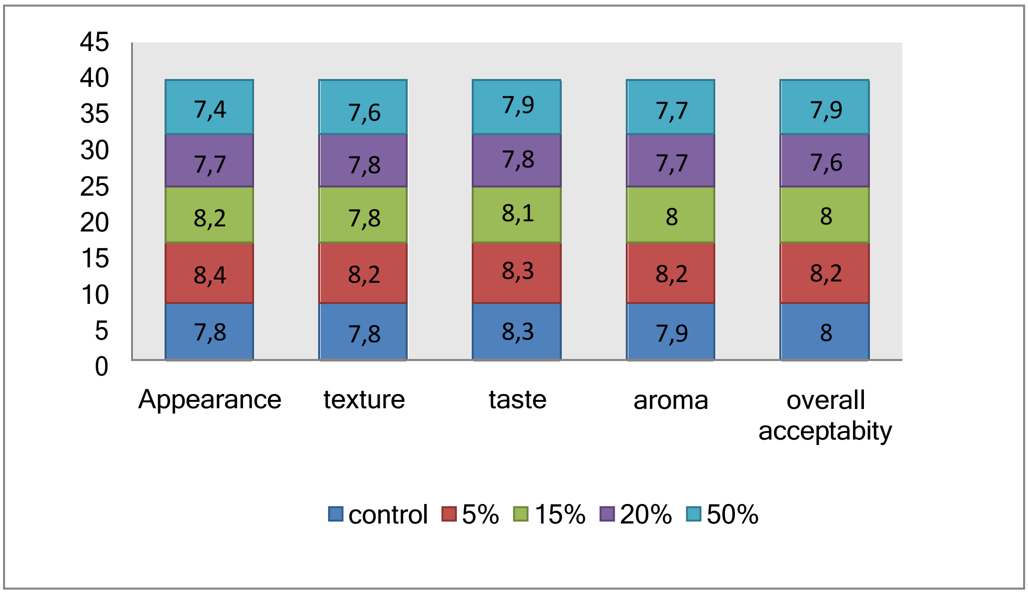

Fig 5: Sensory evaluation of *besan burfi*

4.2.3. Preparation of coconut *ladoo* by incorporating PAGF

Two types of coconut *ladoo* were prepared by using popped amaranth grain flour (PAGF) *i.e.* Type A coconut *ladoo* prepared by using 10 percent PAGF, Type B coconut ladoo by 20 percent PAGF. Coconut *ladoo* without incorporation amaranth flour used control sample. The mean values score of sensory evaluation for the acceptability of coconut *ladoo* prepared without and with incorporation of amaranth flour are shown in table 4.4 and figure 6.

Table 4.4: Mean scores of sensory characteristics of coconut *ladoo* (n=30)

Sensory attributes	Coconut ladoo sample code & proportion		
	Control (Coconut: 100%)	Type A Coconut: PAGF (90:10)	Type B Coconut: PAGF (80:20)
Appearance	7.8±0.51	7.7±0.59	7.7±0.45
Texture	7.8±0.77	7.6±0.79	7.1±0.35
Taste	7.8±0.63	7.2±0.70	7.6±0.50
Aroma	7.6±0.59	7.6±0.72	7.3±0.50
Overall acceptability	7.8±0.51	7.8±0.74	7.4±0.51
KW-Test for overall acceptability of coconut ladoo = 0.005			

According to the table it was observed that Type A coconut *ladoo* prepared by incorporating 10 percent of PAGF to the control was the most acceptable which is" like moderately". The mean score of overall acceptability of coconut *ladoo* prepared with 10 and 20 percent level of incorporation PAGF were 7.8 and 7.6 respectively. According to the table control reported similar with Type A when compared among the samples (Type A & Type B). Incorporation up to 20 percent was found acceptable by the panel of the judges. Similarly, Virgina *et al.* (2014) reported that *ladoo* prepared with 20 percent amaranth seeds and 10 percent watermelon seeds found the highest score for their appearance, body and texture, taste and flavor and overall acceptability. *Ladoo* prepared from 20 percent and 30 percent amaranth flour were like very much whereas 40 percent amaranth flour was like moderately (Akanksha, 2016).

4.2.4. Preparation of cashewnut *burfi* by incorporating PAGF

Three types of cashewnut *burfi* were prepared by incorporating popped amaranth grain flour (PAGF) *i.e.* Type A cashewnut *burfi* prepared by using 10 percent PAGF, Type B cashew nut *burfi* by 15 percent PAGF, Type C cashewnut *burfi* by 50 percent PAGF. Cashewnut *burfi* without incorporation of amaranth flour was used as control sample. The mean score of sensory evaluation for the acceptability of cashewnut *burfi* prepared without and with incorporation of amaranth flour are shown in table 4.5 and figure 7.

Table 4.5: Mean scores of sensory characteristics of cashewnut *burfi* (n=30)

Sensory Attributes	Cashew nut burfi sample code & proportion			
	Control CN:100%	Type A CN:PAGF(90:10)	Type B CN:PAGF(85:15)	Type C CN:PAGF(50:50)
Appearance	7.8±0.35	6.4±0.50	7.4±0.63	7.2±0.67
Texture	7.6±0.50	6.2±0.67	7.4±0.51	7.6±0.50
Taste	8±0.53	7.4±0.50	7.8±0.41	7.7±0.45
Aroma	7.8±0.51	7.4±0.51	7.8±0.35	7.8±0.41
Overall acceptability	7.8±0.35	7.2±0.45	7.8±0.56	7.6±0.50
KW-Test for overall acceptability of cashewnut burfi = 0.05				

The results of sensory mean scores of cashewnut *burfi* was shown in table 4.5 and revealed that Type B prepared by incorporating 15 percent of PAGF to the control was found the most acceptable by panelist. The mean score of overall acceptability of cashewnut *burfi* prepared with 15 and 50 percent level of incorporation amaranth flour were 7.8 and 7.6 respectively. The cashewnut *burfi* without incorporation of amaranth flour was considered as control and overall acceptability was 7.8. When compared among the prepared products, control and incorporation of 15 percent of amaranth flour were found similar and the most acceptable than incorporation of 10 and 50 percent level. Further it was observed that incorporation up to 50 percent was found acceptable. Similarly, cookies prepared by substituting 20 percent and 50 percent level of *rajkeera* seed flour were accepted reported by Chavan *et al.* (2005) and Reddy (2008).

4.2.5. Preparation of *dosa* by incorporating SAG

Two types of *dosa* were prepared by incorporating soaked amaranth grain SAG *i.e.* Type A *dosa* prepared with 10 percent of SAG and Type B with 20 percent of SAG. *Dosa* without incorporation was used as control. The mean scores of sensory characteristics of *dosa* incorporated SAG at various levels was depicted in table 4.6 and figure 8. It was revealed that two types of *dosa* were developed by incorporating 10 percent and 20 percent of SAG to the control were found acceptable by the judges.

Table 4.6: Mean scores of sensory characteristics of *dosa* (n=30)

Sensory attributes	***Dosa* sample & proportion**		
	Control Parboiled Rice (PR): 100%	**Type A PR:SAG (90:10)**	**Type B PR:SAG (80:20)**
Appearance	7.2±0.45	7.3±0.46	7.8±0.63
Texture	7±0.51	7.6±0.49	7.6±0.50
Taste	7.7±0.45	7.6±0.49	7.8±0.56
Aroma	7.6±0.48	7.7±0.46	7.8±0.35
Overall acceptability	7.4±0.50	7.7±0.42	7.6±0.61
KW-Test for overall acceptability of dosa = 0.020			

Dosa without incorporation amaranth grain used control sample. It was found that 10 percent was the most acceptable than control and Type B. Incorporation of SAG up to 20 percent was acceptable by panel of a judge which is like moderately on nine point hedonic rating scale. (Sneha & Haripriya, 2018) studied development of amaranth grain (*amaranthus cruentus*) based instant *dosa* mix its quality characteristics. Sensory evaluation revealed that all the samples score similar for all the attributes and recommend germination of amaranth grain for its better nutritive value.

Salve *et al.* (2010) reported that substitution of 100 percent rajkeera seed (amaranth seed) flour in masala biscuits and coconut cookies was found accepted organoleptically.

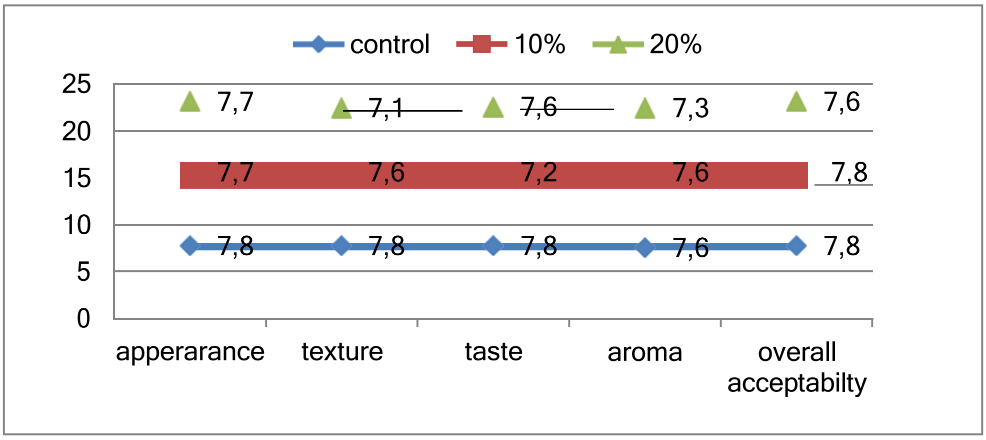

Fig 6: Sensory evaluation of coconut *ladoo*

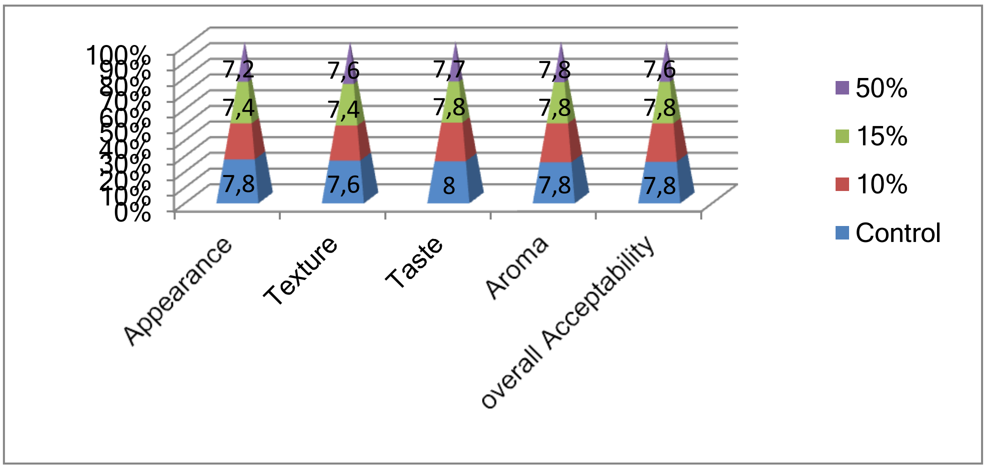

Fig 7: Sensory evaluation of cashewnut *burfi*

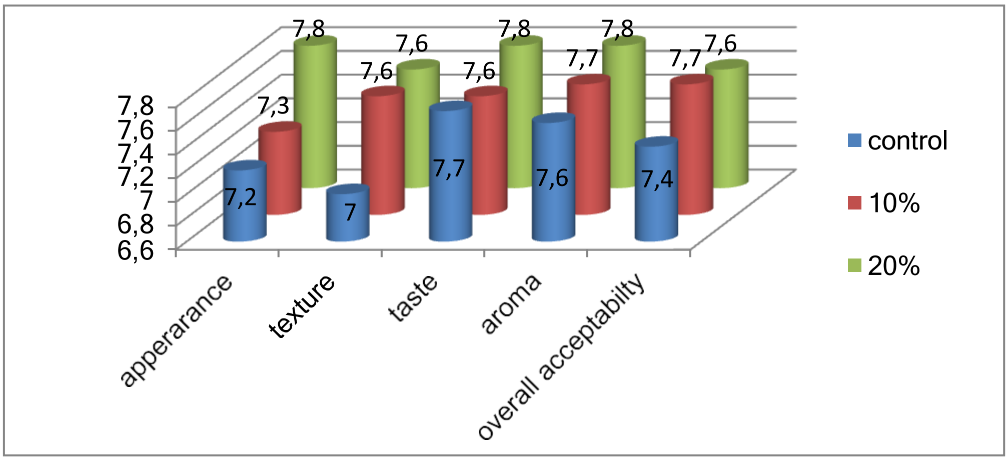

Fig 8: Sensory evaluation of *dosa*

4.2.6. Statistical comparisons of control and experimental Products based on overall acceptability

Significance of results was tested in proportion by incorporating Independent-Samples Kruskal-Wallis Test in order to check the significance of the results. The significance level is 0.05. The null hypothesis was formulated that sample 1 and sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed.

4.2.6.1. Comparison between control and experimental cake

Table 4.7: Control and experimental cake

Sample 1- sample 2	Test statistic	Std. Error	Std. Test statistic	Adj.sig.
Control- prop-5	-10.067	11.008	-914	1.000
Control- prop-4	-15.733	11.008	-1.429	1.000
Control- prop-3	- 18.267	11.008	-1.659	1.000
Control- prop-2	-29.600	11.008	-2.689	0.108
Control- prop-1	-32.733	11.008	-2.973	0.004*
Prop-5- prop-4	5.667	11.008	.515	1.000
Prop-5- prop-3	8.200	11.008	.745	1.000
Prop-5- prop-2	19.533	11.008	1.774	1.000
Prop-5- prop-1	22.667	11.008	2.059	0.592
Pro-4- prop-3	2.533	11.008	230	1.000
Pro-4- prop-2	13.867	11.008	1.260	1.000
Pro-4- prop-1	17.000	11.008	1.544	1.000
Prop-3-prop-2	11.333	11.008	1.030	1.000
Prop-3-prop-1	14.467	11.008	1.314	1.000
Prop-2-prop-1	3.133	11.008	.285	1.000

***Significant**

Cake was formulated by incorporating different proportion of amaranth grain flour to the control *i.e.* Prop-1 (Type A - 5 percent), Prop-2 (Type B - 10 percent), Prop-3

Type C- 15 percent), Prop-4 (Type D - 20 percent) and Prop-5 (Type E - 50 percent). The pairwise comparisons test was employed between the control and different proportion of the experimental products as shown in table 4.7 and figure 9. The results was found significant in prop-1 when compared with control ($p<0.05$) of cake but no significant difference were shown in others group.

4.2.6.2. Comparison between control and experimental *besan burfi*

Table 4.8: Control and experimental *besan burfi*

Sample 1- sample 2	Test statistic	Std. Error	Std. Test statistic	Adj.sig.
Prop -3 - control	23.400	10.050	2.328	0.199
Prop -3- Prop-2	23.400	10.050	2.328	0.199
Prop -3- Prop-1	35.400	10.050	3.523	0.004*
Prop -3- Prop-4	46.800	10.050	4.657	0.000*
Control- Prop-2	.000	10.050	.000	1.000
Control- Prop-1	-12.000	10.050	-1.194	1.000
Control- Prop-4	-23.400	10.050	-2.328	0.199
Prop-2- Prop-1	12.000	10.050	1.194	1.000
Prop-2- Prop-4	23.400	10.050	2.328	0.199
Prop-1- Prop-4	11.400	10.050	1.134	1.000

*** Significant**

Besan burfi was prepared by incorporating different proportion of amaranth grain *i.e.* Prop-1 (Type A - 5 percent), Prop-2 (Type B - 15 percent), Prop-3 (Type C - 20 percent) and Prop - 4 (Type D - 50 percent). The pairwise comparisons between the control and experimental *besan burfi* are depicted in table 4.8 and figure 9. Among the comparisons of control and experimental *besan burfi*, the significant differences were observed in prop-3 & Pro-1 ($p<0.05$) and Prop-3 & Prop-4 ($p<0.05$) and However, other comparisons have not shown any significant results.

4.2.6.3. Comparison between control and experimental coconut *ladoo*

Table 4.9: Control and experimental coconut *ladoo*

Sample 1- sample 2	Test statistic	Std. Error	Std. Test statistic	Adj.sig.
Prop-2- control	15.733	5.782	2.721	0.020*
Prop-2-Prop-1	16.867	5.782	2.917	0.011*
Control-Prop-1	-1.133	5.782	-196	1.000

***Significant**

Two types of coconut *ladoo* was prepared by incorporating different proportion of amaranth grain to the control *i.e.* prop-1 (Type A - 10 percent) and prop-2 (Type B - 20 percent). The pair comparison test was carried out between control and different proportions of coconut ladoo are shown in table 4.9 and figure 9. Henceforth, the experimental product coconut *ladoo* found significant results in Prop-2 & control ($p<0.05$) and prop-2 & prop-1 ($p<0.05$).

4.2.6.4. Comparison between control and experimental cashewnut *burfi*

Table 4.10: Control and experimental cashewnut *burfi*

Sample 1- sample 2	Test statistic	Std. Error	Std. Test statistic	Adj.sig.
Prop-1- Pro-3	-19.667	7.452	-2.639	0.050*
Prop-1- Prop-2	-34.000	7.452	-4.563	0.000*
Prop-1- Control	35.400	7.452	4.751	0.000*
Prop-3-Prop-2	14.333	7.452	1.923	0.327
Prop-3- Control	15.733	7.452	2.111	0.208
Prop-2- Control	1.400	7.452	.188	1.000

***Significant**

Cashewnut *burfi* was formulated by incorporating different levels of amaranth grain *i.e.* prop-1(Type A – 5 percent), prop-2(Type B – 15 percent) and prop-3 (Type C – 50 percent). Pair comparison test was employed between the control and different proportion of the products and the data are shown in Table 4.10 and figure 9. Statistical analysis revealed a significant difference was found in prop-1 & prop-3 ($p \leq 0.05$), prop-1-& prop-2; prop-1 & control ($p<0.05$). However, other comparisons were found not significant.

4.2.6.5. Comparison between control and experimental *dosa*

Table 4.11: Control and experimental *dosa*

Sample 1- sample 2	Test statistic	Std. Error	Std. Test statistic	Adj.sig.
Control- Prop-2	-10.733	5.898	-1.820	0.206
Control -Prop-1	-16.267	5.898	-2.758	0.017*
Prop-2- Prop-1	5.533	5.898	.938	1.000

***Significant**

Dosa was formulated by incorporating different proportion of amaranth grain *i.e.* prop-1 (Type A - 10 percent) and prop-2 (Type B - 20 percent). Pairwise comparison test was carried out between the control and different proportion of experimental *dosa* and are presented in table 4.11 and figure 9. The results of the test revealed a significant difference was observed in control - prop-1 ($p<0.05$) but not significant in other comparisons.

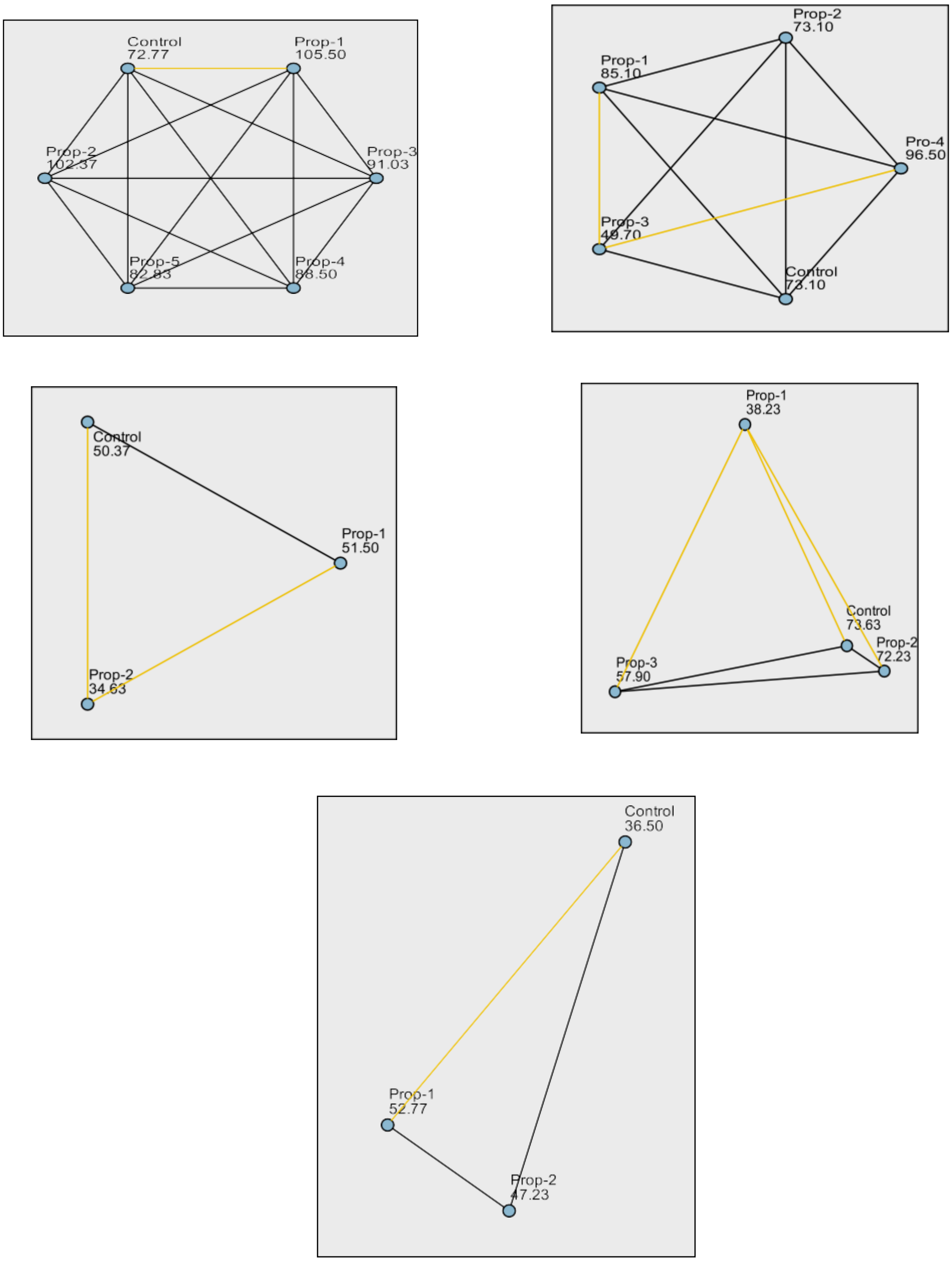

Fig 9: Pairwise Comparisons of cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa* respectively

4.3. Biochemical analysis of developed products

Under biochemical analysis of developed products the nutrient has been classified under macro nutrients, micro nutrients and minerals for better comparison and understanding. The finding of the results of the developed products such as cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa* are presented in the table 4.12, 4.13 and 4.14 respectively. The comparison was carried between the control and most accepted products on nine point hedonic rating scale. The most acceptable cake sample was found Type A (5 percent) however in order to check the highest changes in the nutrients content by incorporating the maximum level of amaranth grain, Type E (50 percent) was taken for biochemical analysis just for the comparison and the results have been shown.

4.3.1. Macro nutrients composition of developed products

Macronutrients composition such as energy, total fat, protein and carbohydrate of value added products are presented in table 4.12 and figures 10, 11, 12 and 13.

Table 4.12: Macro Nutrients composition of different control and experimental products

Group	Type of products	Energy (Kcal)	Total fat (g)	Protein (g)	Carbohydrate (g)
Cake	Control (WF: 100%)	399.51	24.27	8.75	36.52
Experiment	Type A (WF: RAGF: 95:5%)	392.68	22.92	9.98	36.62
	Type E (WF: RAGF:: 50:50%)	393.91	23.63	8.84	36.47
Besan burfi	Control (GF: 100%)	514.48	29.00	12.10	51.27
Experiment	Type A (GF: PAGF: 95:5 %)	503.33	27.05	13.18	51.79
Coconut ladoo	Control (Coconut: 100%)	521.30	27.38	6.15	62.57
Experiment	Type A (Coconut: PAGF: 90:10%)	553.92	33.68	9.60	53.10
Dosa	Control (PR: 100%)	370	1.20	16.10	73.77
Experiment	Type A (PR: SAG: 90:10%)	366.34	0.98	15.43	73.95

It was found that wheat flour cake (control) had 399.5 kcal energy, 24.27 g total fat, and 8.75 g protein and 36.52 g carbohydrate whereas Type A cake had 392.68 kcal energy, 22.92 g total fat, 9.98 g protein and 36.62 carbohydrate. Type E (50 percent) cake had 393.91 kcal, 23.63 g, 8.84 g and 36.47 g of energy, total fat, protein and carbohydrate respectively. Clearly, observed that incorporation of amaranth grain flour to the control cake increased the protein content. It was observed that incorporation of 5 percent (Type A) RAGF increased protein content and decreased energy and total fat content. Similarly, substitution of 50 percent (Type E) enhanced protein content particularly and reduced energy and total fat content. Carbohydrate content did not bring any changes by increasing the level of amaranth grain flour. Energy and total fat content of *besan burfi* was found higher in control such as 514.48 kcal and 29 g respectively. Higher protein content was found in Type A (5 percent) *i.e.* 13.18 g. Carbohydrate content was almost similar in control and incorporated *besan burfi*. Protein content was increased in Type A *besan burfi* prepared with 5 percent of popped amaranth grain flour to control *besan burfi* due to higher amount of protein in amaranth grain and bengal gram flour *i.e.* 13.27 g and 18.77 g as per 100 g respectively (Longvah *et al.* 2017). Incorporated amaranth grain flour coconut *ladoo* increased the nutritional composition than control. Energy, total fat and protein were found higher in Type A (5 percent) such as 553.92 kcal, 33.68 g, 9.60 g respectively than control. Carbohydrate content was decrease in incorporated coconut *ladoo*. With the addition of 10 percent (Type A) PAGF to the control coconut *ladoo* increased the content of energy, fat, protein and decrease carbohydrate content. *Dosa* incorporated amaranth grain decreases macro nutrients composition when compared to control dosa. Type A (10 percent) *dosa* had 366.34 kcal energy, 0.98 g total fat, 15.43 g protein and 73.95 g carbohydrate. Macronutrients such as energy, total fat, protein and carbohydrate decreased in Type A *dosa* by incorporating 10 percent level of SAG when compared to control although , a good amount of protein content was obtained. The results of macronutrients study showed that after incorporation of amaranth grain at various levels in cake, *besan burfi*, coconut *ladoo* and *dosa* increased the content of energy, total fat, protein and carbohydrate. Salve *et al.* (2010) reported incorporation of *rajkeera* (amaranth seed) helped to enhance the content of protein, iron and calcium. Similarly, Mendoza and Bressani (1987) reported that extrusion cooking of amaranth grain enhanced its protein quality. Traditional snacks made of maize replaced with pure amaranth had enhanced nutritional quality especially protein and iron content and their acceptability by sensory analysis. Sudha and Leelavati (2012) reported that protein content of pasta by using 10 percent amaranth seed flour increased from 9.56 to 16.57 percent. Zohu *et al.*(2002) described the protein content of amaranth products was higher two to three times than those of products developed with rice and /or maize flours and other starch. Gross *et al.* (1989) reported amaranth seed had higher value of protein than other cereals grain but less than most leguminous seeds.

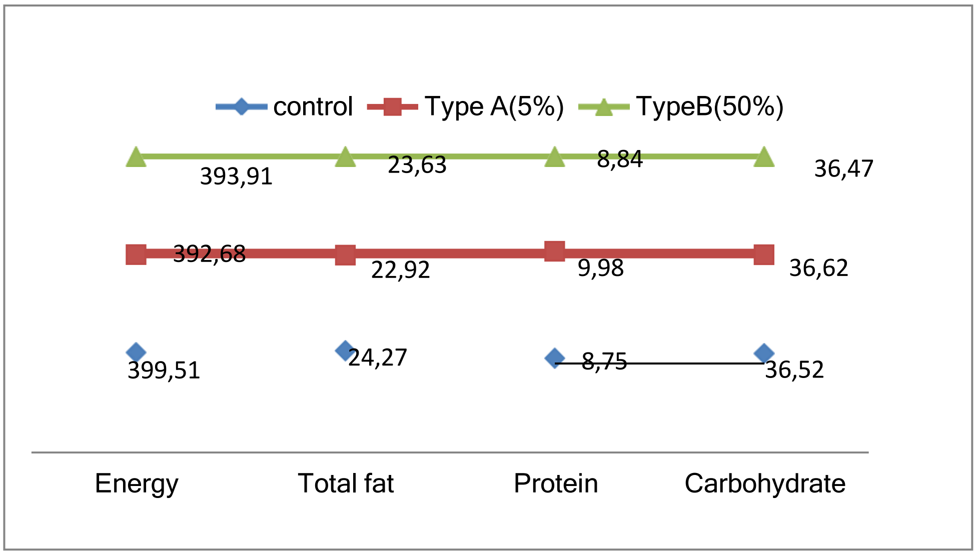

Fig 10 : Macro nutrients composition of cake

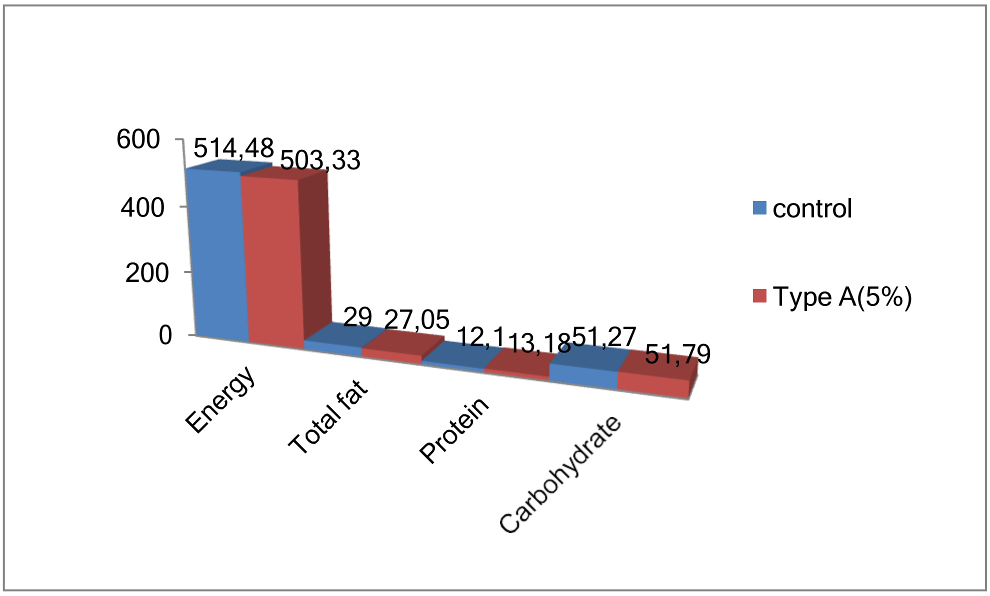

Fig 11: Macro nutrients composition of *besan burfi*

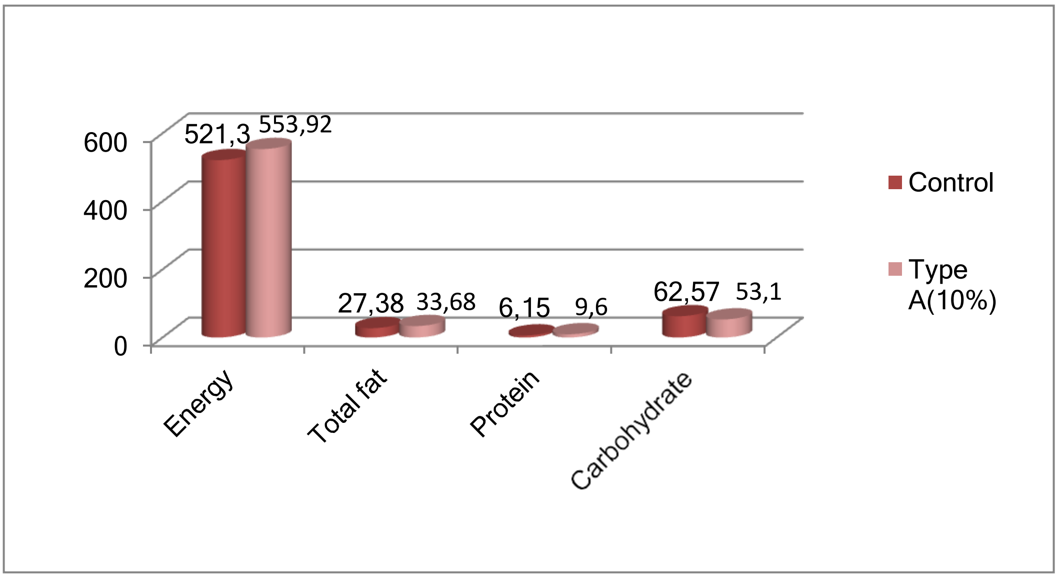

Fig 12: Macronutrients of composition of coconut *ladoo*

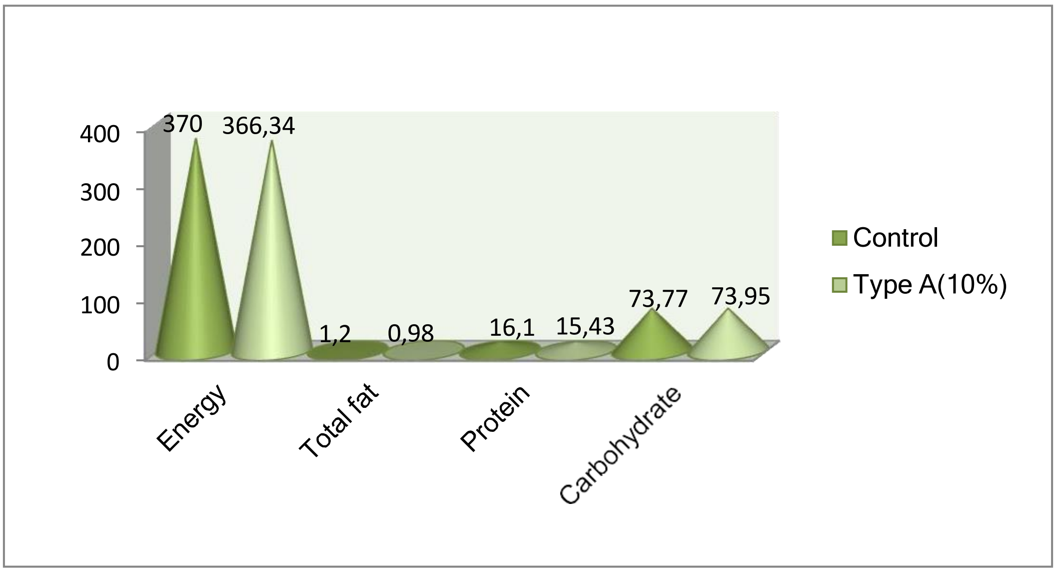

Fig 13: Macro nutrients composition of *dosa*

4.3.2. Micro Nutrients composition of developed products

The values of micro nutrients composition of the developed products are depicted in the table 4.13 and figures 14, 15, 16, and 17. Moisture content was increased in Type E cake *i.e*. 30.46 with the addition of 50 percent of RAGF. The total ash content of control was 0.97 which increased to 1.12 with incorporation of 5 percent level of RAGF and decreased in Type E (50 percent) *i.e*. 0.60. Total dietary fibre was found almost similar such as control (4.39); Type A (4.33) and Type B (4.12). Crude fibre of control cake was 2.94 decreased in Type A *i.e.* 1.98 and Type E *i.e.* 1.29. Type A and Type E cake contained 4.33 and 4.12 total dietary fibre respectively, which were almost similar with control.

Table 4.13: Micro Nutrients composition of different control and experimental products

Group	Type of products	Moisture (%)	Total ash (%)	Crude fiber (g)	Total Dietary Fiber (g)	Sugar (g)	Reducing Sugar (%)
Cake	Control (WF: 100%)	29.49	0.97	2.94	4.39	25.14	B.L.Q. (Q.L.=0.5)
Experiment	Type A (WF: RAGF: 95:5%)	29.36	1.12	1.98	4.33	40.08	B.L.Q. (Q.L.=0.5)
	Type E (WF: RAGF: 50:50%)	30.46	0.60	1.29	4.12	25.65	B.L.Q. (Q.L.=0.5)
Besan burfi	Control (GF: 100%)	6.96	0.67	1.92	6.65	17.83	B.L.Q. (Q.L.=0.5)
Experiment	Type A (GF: PAGF: 95:5 %)	6.65	1.33	2.66	7.39	19.79	B.L.Q. (Q.L.=0.5)
Coconut ladoo	Control (Coconut: 100%)	1.75	2.15	1.03	3.80	31.42	B.L.Q. (Q.L.=0.5)
Experiment	Type A (Coconut: PAGF: 90: 10%)	1.57	2.05	1.37	4.40	38.42	B.L.Q. (Q.L.=0.5)
Dosa	Control (PR: 100%)	5.80	3.13	0.21	7.70	0.65	B.L.Q. (Q.L.=0.5)
Experiment	Type A (PR: SAG:: 90:10%)	6.26	3.38	0.28	7.23	0.60	B.L.Q. (Q.L.=0.5)

Sugar content was found in Type A cake. Control *besan burfi* had 6.96 moisture, 0.67 total ash, 1.92 crude, 6.65 dietary fibre and 17.83 respectively whereas Type A *besan burfi* had 6.65 moisture, 1.33 total ash, 2.66 crude fibre, 7.39 dietary fibre and 19.79 sugar respectively. Moisture and total ash content of Type A *besan burfi* were 6.65 and 1.33 respectively which were increased than control. Clearly shows that incorporation of amaranth grain flour increased the content of moisture, ash, dietary fibre and sugar of *besan burfi* than control. Crude fibre and total dietary fibre increased with the addition of 5 percent PAGF (Type A) to the control. Crude fibre of control *besan burfi* increase from 1.92 g to 2.66 g and dietary fibre increase from 6.62 g to 7.39 g in incorporation of 5 percent PAGF. Sugar content increased from 17.83 to 19.79. Coconut *ladoo* (control) had 1.75 , 2.15, 1.03, 3.80 and 31.42 whereas Type A (10 percent) were 1.57, 2.05, 1.37, 4.40 and 38.42 w.r.t. moisture, total ash, crude fibre, total dietary fibre and sugar respectively. Crude fibre and total dietary fibre of coconut *ladoo* increased in with the substitution of PAGF at 10 percent level as well as sugar content was also increased. Crude fibre content of control coconut *ladoo* was 1.03 which was increased to1.37. Total dietary fibre and sugar content increased from 3.8 to 4.40 and 31.42 to 38.42 respectively. Control *dosa* had 5.80, 3.13 0.21, 7.70 and 0.65 whereas Type A *dosa* prepared by incorporating 10 percent of soaked amaranth grain (SAG) had 6.26, 3.38, 0.28, 7.23 and 0.60 for their moisture, total ash, crude fibre and total dietary fibre and sugar respectively. Higher moisture and total ash content were found in Type A *dosa*. Crude fibre, dietary fibre and sugar were found almost similar with control. The results of micronutrients analysis indicated that increased the amount of moisture, total ash, crude fibre, total dietary fibre and sugar content with the increased in incorporation level of amaranth flour. With the incorporation of 10 percent of SAG to the control *dosa* increased moisture, total ash and crude fibre content and reduced total dietary fibre and sugar content. Incorporation of 10 percent amaranth revealed in increase of 18 times the amount of dietary fibre (Lemos *et al.* 2012). (Chauhan *et al.* 2016; Sanz- Panella *et al.* (2013) reported that higher amount of total dietary fibre in amaranth flour cookies, followed by wheat flour cookies and raw amaranth flour cookies respectively. This was due to the higher total dietary fibre content in germinated amaranth flour. Similarly, Bhat *et al.* (2015) described fortified cookies prepared by incorporation of 7 percent amaranth flour, 7 percent refined flour and 18 percent oats can affect as good source of protein, carbohydrate and dietary fibre and a potential source of energy.

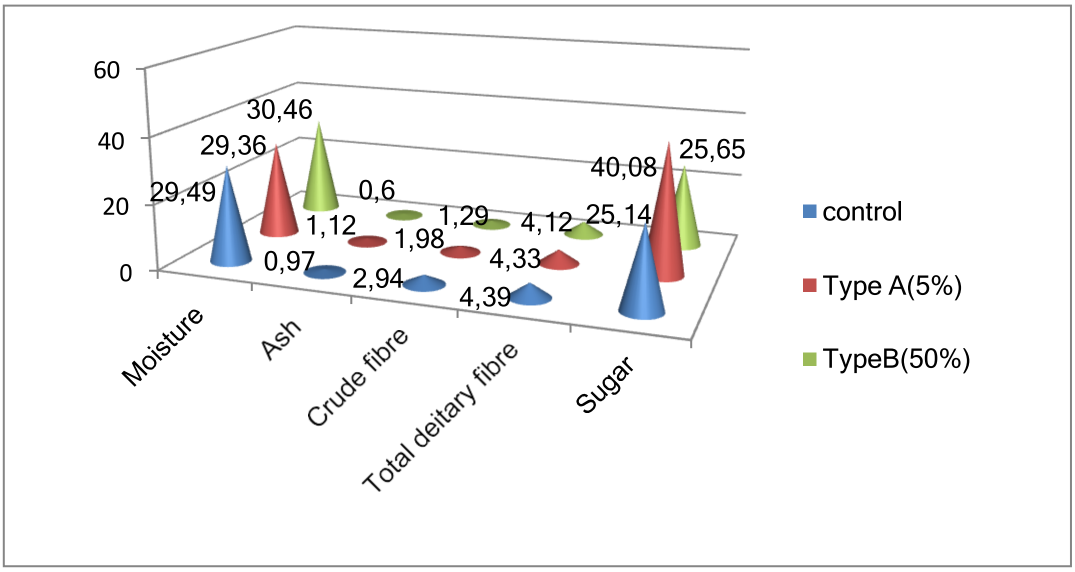

Fig14: Micro nutrients of different types of cake

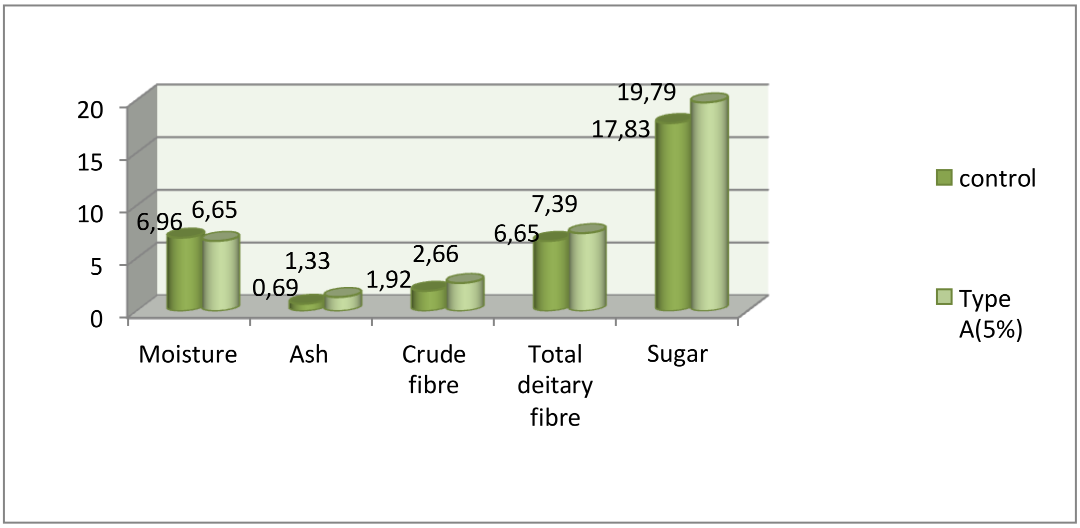

Fig 15: Micro nutrients of different types of *besan burfi*

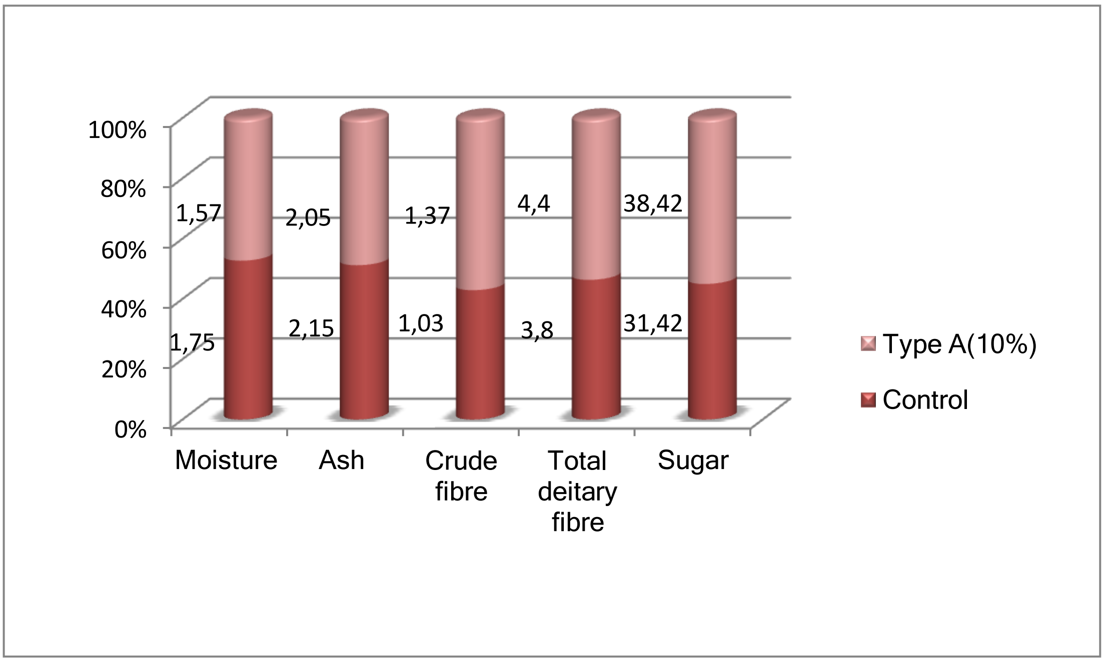

Fig 16: Micro nutrients of different types of coconut l*adoo*

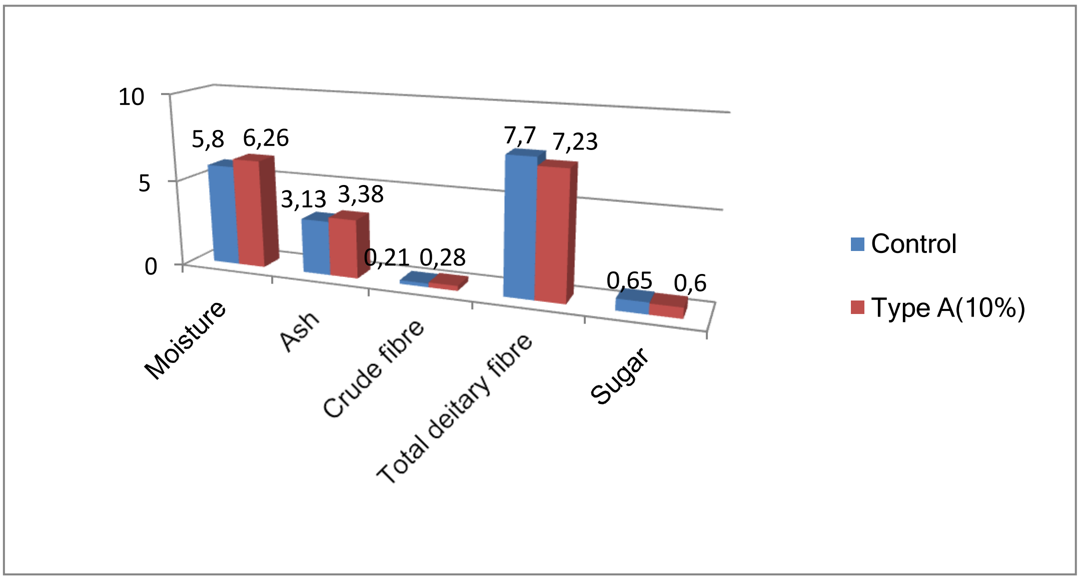

Fig17: Micro nutrients of different types of *dosa*

4.3.3 Minerals Composition of developed products

The values of minerals composition of the developed products are shown in the table 4.14 and figures 18, 19, 20 and 21. Control cake had 0.46 mg of iron which increased to 5.56 mg in Type A prepared with 5 percent of amaranth grain flour. The iron content increased in Type E prepared by incorporation of 50 percent of amaranth grain than control however decreased than Type A.

Table 4.14: Minerals composition of different control and experimental products

Group	Type of product	Iron (mg)	Calcium (mg)	Zinc (mg)	Phosphorus (mg)
Cake	Control (WF: 100%)	0.46	56.47	0.33	184.28
Experiment	Type A (WF: RAGF:: 95:5%)	5.56	118.68	3.97	18.54
	Type E (WF: RAGF:: 50:50%)	3.47	160.25	3.08	38.22
Besan burfi	Control (GF: 100%)	2.16	154.29	3.38	40.58
Experiment	Type A (GF: PAGF:: 95:5 %)	3.39	167.05	4.32	47.41
Coconut ladoo	Control (Coconut: 100%)	3.21	167.38	3.56	3.75
Experiment	Type A (Coconut: PAGF:: 90:10%)	2.99	189.22	3.29	2.97
Dosa	Control (PR: 100%)	1.62	119.82	1.62	72.92
Experiment	Type A (PR: SAG:: 90:10%)	2.96	145.23	3.25	110.68

Calcium content of control cake was 56.47 mg, Type A and Type E was double and triple times than control *i.e.*118.68 mg and 160.25 mg respectively. Clearly shows that calcium content had relatively high in amaranth grain. Zinc content of control was 0.33mg, Type A and Type E were 3.97 mg and 3.03 mg. Zinc content was found higher in formulated cake prepared with amaranth grain, showing that amaranth grain is good source of zinc. Phosphorus content was higher in control. The results of mineral content of *besan burfi* are presented in the above table. Total iron, calcium, zinc, phosphorus was 2.16 mg, 154.29 mg, 3.38 mg and 40.58 mg respectively.

Type A *besan burfi* prepared by incorporating 5 percent of amaranth grain had 3.39 mg. 167.05 mg, 4.32 mg, 47.41 w.r.t. iron, calcium, zinc and phosphorus respectively and reported higher minerals content than control however phosphorus content was higher in control. Control coconut *ladoo* had 3.21, 167.38, 3.56, 3.75 w.r.t. iron, calcium, zinc and phosphorus respectively. Type A coconut *ladoo* prepared by incorporating 10 percent of amaranth grain was found 2.99 mg iron, 189.22 mg calcium, 3.29 mg zinc and 2.97 phosphorus. Calcium was higher in Type A than control. Minerals such as iron, calcium, zinc, phosphorus for control *dosa* was 1.62 mg, 119.82 mg, 1.62 mg and 72.92 mg respectively. The experimental *dosa* Type A prepared by substituting 10 percent of SAG was found higher in minerals content such as iron, 2.96 mg, calcium, 45.23 mg, zinc, 3.25 mg and phosphorus, 110.68 mg; showing that minerals content was increased in Type A than control. The formulated products by incorporating amaranth grain flour enhanced essential minerals content namely, iron, calcium, zinc and phosphorus. It was obtained that all the minerals increased remarkably after incorporation of amaranth flour to different products. Type A and Type E cake substituted with 5 percent and 50 percent level of RAGF increased double or triple times of iron, calcium and zinc content than control cake whereas decreased in phosphorus content. Iron content of Type A *besan burfi* incorporation with 5 percent of PAGF increased from 2.16 to 3.39 mg, calcium from 154.29 to 167.85 mg, zinc 3.38 to 4.3 and phosphorus 40.88 to 47.41 mg. Total calcium content was increased in Type A coconut *ladoo* with the incorporation of 10 percent level of PAGF. Control coconut *ladoo* had 167.38 mg of calcium increased to 189.22 mg in Type A. The incorporation levels of 10 percent SAG to the control *dosa* increased iron, calcium, zinc, and phosphorus content significantly compared to control. Schmidt (1977) and Barker *et al.* (1979) reported higher minerals content in amaranth grain when compared to other cereals. Emire and Arega (2012) revealed that zinc, calcium and iron content of bread increased significantly with the addition of amaranth flour. Bhat *et al.* (2015) described that fortified multigrain cookies with amaranth grain showed very good nutritional properties and minerals content. Hence it can be considered as healthy for consumption. Similarly, incorporation of *rajkeera* seed (amaranth seed) in masala biscuits and cookies helped to increased protein, iron and calcium content (Salve *et al.* 2010). Muyonga *et al.* (2008) developed snacks food commonly by children in Uganda by incorporating wheat flour or maize flour with amaranth flour reported improved protein content and quality as well as iron, zinc and calcium content of snacks. Alvarez-Jubete *et al.* (2009) revealed that gluten free bread containing psuedocereals indicates that higher levels of protein, fat, fibre and minerals than the control bread. (Gamel *et al.* 2006; Betschart *et al*.1981) reported that phosphorus, potassium, magnesium and calcium were the dominants minerals in raw amaranth seeds.

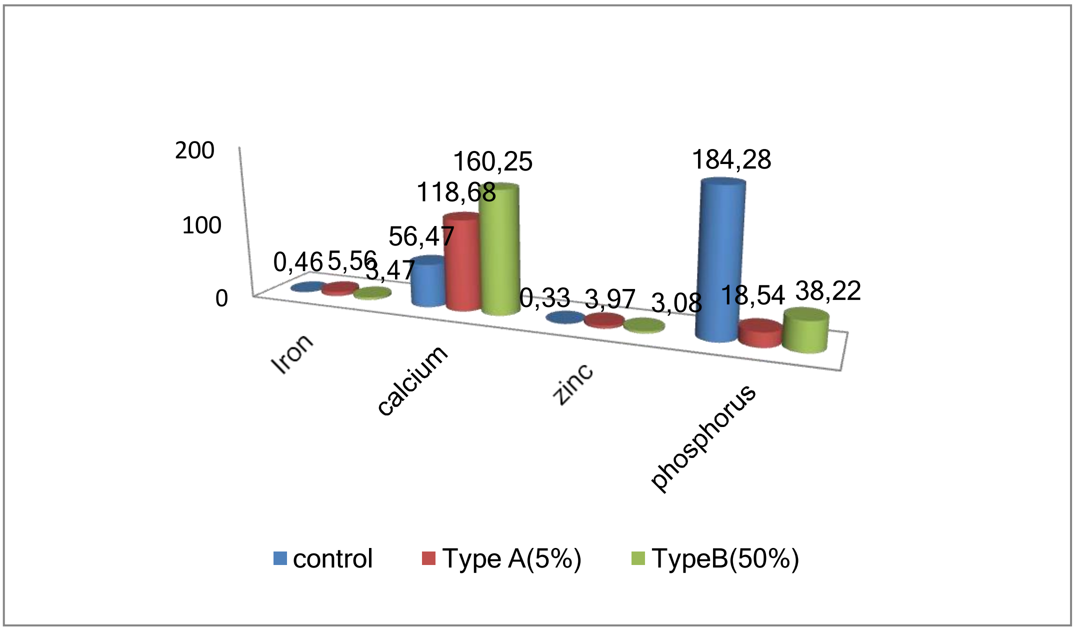

Fig 18: Minerals composition of cake

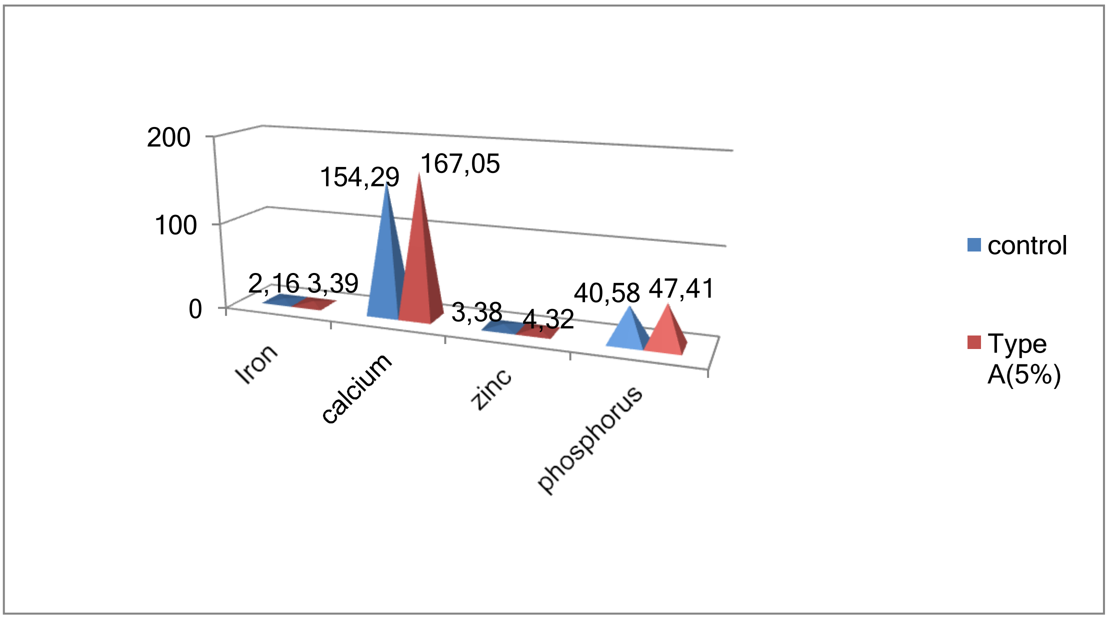

Fig 19: Minerals composition *besan burfi*

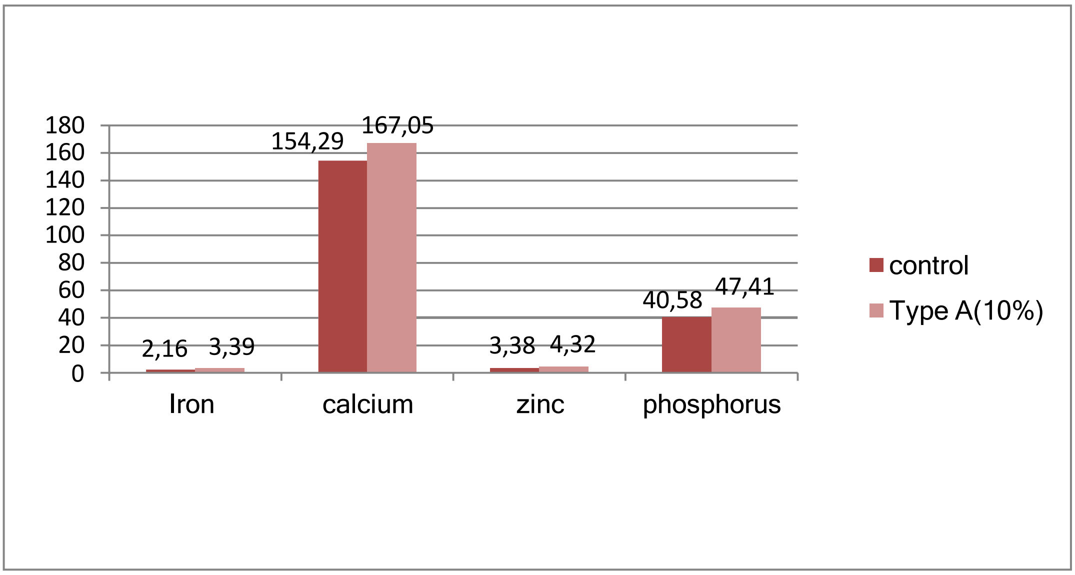

Fig 20: Minerals composition of coconut *ladoo*

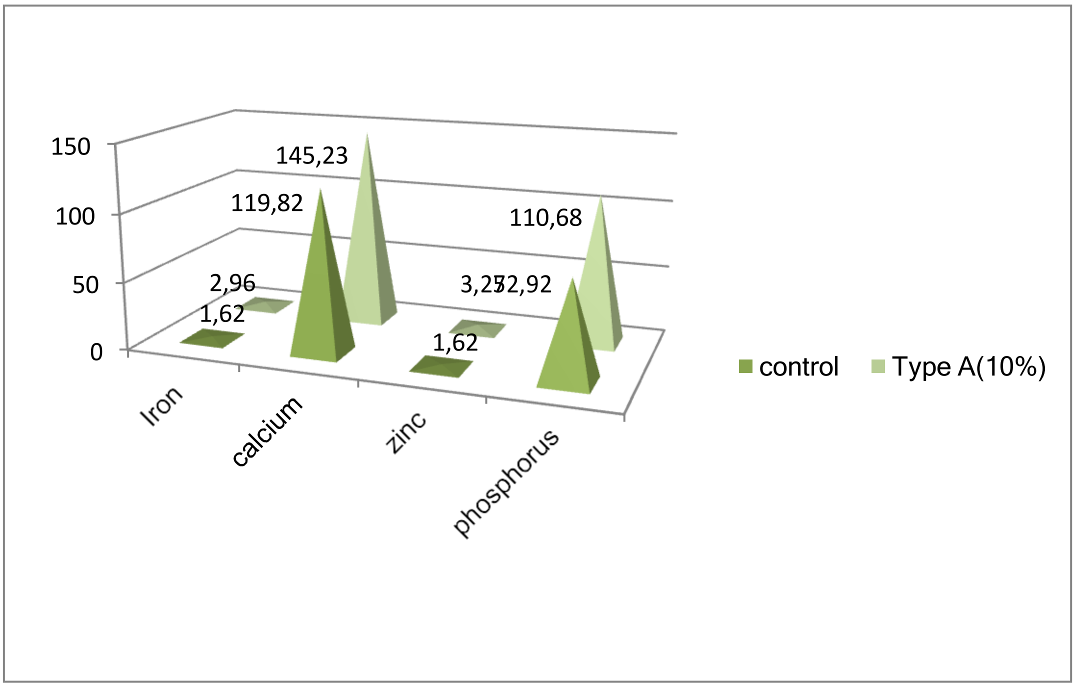

Fig 21: Minerals composition of *dosa*

Control

Type A (5 %) Type B (10 %) Type C (15 %)

Type D (20 %)

Type E (50 %)

Plate 2: Cake

Control

Type A (5 %)

Type B (15 %)

Type C (20 %)

Type D (50 %)

Plate 3: *Besan burfi*

Control

Type A (10 %)

Type B (20 %)

Plate 4: Coconut *ladoo*

Control

Type A (10 %)

Type B (15 %)

Type C (50 %)

Plate 5: Cashewnut *burfi*

Control

Type A (10 %)

Type B (20 %)

Plate 6: *Dosa*

Chapter 5

SUMMARY AND CONCLUSION

The study was conducted with the objectives of standardization of methodology to use different form of amaranth grain, to formulate and develop value added products of amaranth grain and to analyze the nutritional, biochemical and sensory evaluation of the developed products. Thus, gives the knowledge and information pertaining to nutritional composition of amaranth grain and its acceptability of the developed products. The present study was conducted at College of Community Science, Department of Food Science and Nutrition. Food Analysis Lab was used for biochemical analysis and product development was done in Food Science and Nutrition lab. Raw amaranth grain and the entire ingredients required were procured from local supermarket Tura, Meghalaya. Amaranth grain flour was prepared in the formed of roasted, popped and soaked. The different products were developed by using Roasted Amaranth Grain Flour (RAGF), Popped Amaranth Grain Flour (PAGF) and Soaked Amaranth Grain (SAG) at various proportion. The products include cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa*. The developed products were evaluated for their nutritional & biochemical composition and sensory properties. Ms-Excel 2007 software programme was used for statistical analysis.

The results on comparative nutrients composition for Amaranth flour (AF), Wheat flour (WF) and Gram flour (GF) revealed that moisture content was higher in WF than AF & GF. Higher protein content was found in GF (18.77) followed by AF (16.5) and WF (10.36). Dietary fibre reported significantly higher in GF (25.22) and AF (16.8) than WF (2.76). Minerals content reported high in AF than WF but can be comparable with GF. Lysine, tryptophan and lenoleic content observed higher in GF than AF and WF.

The products namely cake, *besan burfi*, coconut *ladoo*, cashewnut *burfi* and *dosa* were developed by using amaranth grain flour / grain and evaluated their sensory acceptability by thirty semi-trained panels on nine points hedonic rating scale from the department of Food and Nutrition, teaching staffs, non-teaching staff and final year students of Food Science and Nutrition & Nutrition and Dietetics of College of Community Science Central Agricultural University, Tura Meghalaya. The results on mean scores of sensory characteristics indicated that the products were accepted in terms of their appearance, texture, taste, aroma and overall acceptability. Mean scores of overall acceptability of cake with 5 percent, 10 percent, 15 percent, 20 percent and 50 percent of RAGF were 8.6, 8.3, 8.2, 8.2 and 8.2 respectively. PAGF was incorporated in *besan burfi* at 5, 15, 20 and 50 percent and overall acceptability were 8.2, 8, 7.6, 7.9 respectively ; coconut ladoo at 10 & 20 percent w.r.t. 7.8 and 7.4

respectively and Cashewnut *burfi* at 10, 15 and 50 percent w.r.t. 7.2, 7.8, 7.6 respectively. SAG was incorporated in dosa at 10 and 20 percent. The average scores for overall acceptability were 7.7 and 7.6 respectively. Sensory evaluation of the developed products showed that amaranth flour could be incorporated up to 50 percent in cake, *besan burfi* and cashewnut *burfi* and up to 20 percent in coconut ladoo and dosa.

Independent-Samples Kruskal-Wallis Test was employed in order to check the significant difference of the products. The results found significant in prop-1 when compared with control (0.004) of cake but no significant difference were shown in others group. The significant differences were observed in prop-3 & prop-1 (0.004) and prop-3 & prop-3 & prop-4 (0.05) of experimental *besan burfi*. However, other comparisons have not shown any significant result. The experimental product coconut *ladoo* found significant result in Prop-2 & control (0.020) and prop-2 & prop-1(0.11). Statistical analysis revealed a significant difference was observed in prop-1 & prop-3 (0.50), prop-1 & prop-2; prop-1 & control (<0.05) of cashewnut *burfi*. The results of the test revealed a significant difference was observed in control & prop-1 (0.017) of *dosa* but not significant result found in other comparisons.

Amaranth grain flour was incorporated in the place of major ingredients of the developed products. Comparison on biochemical analysis was carried out between the most accepted products and with that of the control. Macronutrients content of the developed products reported that after incorporation of amaranth grain flour did not bring major changes in the entire products although increased protein content in *besan burfi* and improved protein and fat content in *coconut ladoo*.

The results on micronutrients composition of the developed products indicated that the values obtained from moisture, ash, crude fibre, dietary fibre are very close and found almost similar in some product with their respective control. Sugar content was increased after incorporation. Reducing sugar was observed as B.L.Q. (below limit of quantification); Q.L. (Quantification limit = 0.5).

Iron, calcium, zinc content increased after incorporation of amaranth grain flour in all the products as compared with their respective control. Iron content in cake increased twice or thrice levels after addition up to 50 percent of amaranth grain flour. Phosphorus content was increased in *dosa* incorporated SAG up to 10 percent when compared with that of the control.

Based on the results, it can be concluded that amaranth grain is a good source of protein, fat, dietary fibre and minerals such as iron, calcium, zinc and phosphorus and hence can be considered as healthy for human consumption. Amaranth grain is known to be very nutritious pseudo cereals and can be use in the preparation of popularly consumed traditional recipes. The present study revealed that amaranth can be substituted wheat cereal and gram flour up to 50 percent and can be replace coconut and parboiled rice up to 20 percent. The products prepared by incorporating amaranth grain flour were accepted in terms of their appearance, texture, taste, and overall acceptability by the judges of sensory panel. The study indicated that it can be contribute to the dietary nutritional deficiencies and need to be popularizing the use of amaranth in daily diets since it is underutilized crop exhibit very potential nutritious grain.

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Appendices

DEVELOPMENT OF VALUE ADDED PRODUCTS FROM AMARANTH (*Amaranthus L.)* GRAIN

Hedonic Rating Score Card (n=30)

Name of the Product: ....

Name: ....

Sample code	Appearance	Texture	Taste	Aroma	Overall acceptability

Signature

Note:

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