DEVELOPMENT OF SHELF STABLE PRODUCTS FROM SUNFLOWER (*Heliantus annuus* L.) SEED KERNELS

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UNIVERSITY OFAGRICULTURAL SCIENCES

GKVK, BENGALURU-560065

2012

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Thesis submitted to the

University of Agricultural Sciences, Bengaluru

in partial fulfillment of the requirements
for the award of the degree of

MASTER OF SCIENCE (Agriculture)

in

FOOD SCIENCE AND NUTRITION

BENGALURU **JULY, 2012**

Dedicated to

My loving

Parents,

Brother, Sister

& My Guide

DEPARTMENT OF FOOD SCIENCE AND NUTRITION
UNIVERSITY OF AGRICULTURAL SCIENCES
BENGALURU

CERTIFICATE

This is to certify that the thesis entitled "**Development of shelf stable products from sunflower (*Helianthus annuus* L.) seed kernels"** submitted by **Ms. SINDHU SINGH, ID No. PAL 0196,** for the award of degree of **MASTER OF SCIENCE (Agriculture)** in **FOOD SCIENCE AND NUTRITION** of the University of Agricultural Sciences, Bengaluru, is a record of the research work carried out by her during the period of her study in this University, under my guidance and supervision and no part of the thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or other similar titles.

Bengaluru
July, 2012

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ACKNOWLEDGEMENT

With regardful memories ……

It is my pleasure to glance back and recall the path one traveled during the day of hard work and perseverance. In every one's life, the day arises when one has to shape the feelings in words. Sometimes, the words become unable to express the feelings of the mind, because, the feelings of heart are beyond the reach of the words. When, I came to complete this manuscript, so many memories have rushed through my mind which is full of gratitude to those who encouraged and helped me at various stages of this research. It gives me immense pleasure to record my feelings at this place.

It is my privilege to express my deep sense of reverence, gratitude and thanks to ***Dr. Neena Joshi****, Professor and Head, Department of Food Science and Nutrition, UAS, GKVK, Bangalore and the esteemed Chairman of my Advisory Committee, for all the efforts she has put through her inspiring guidance, suggestions, generous help and encouragement throughout the study period, I have been lucky enough to get an opportunity to work under her guidance.*

I am extremely grateful to the members of my Advisory Committee of ***Dr. Sunanda Sharan*** *Prof. Dept. of Food Science and Nutrition UAS, GKVK, Bangalore,* ***Dr. Y. G. Shadakshari,*** *Geneticist, AICRP in Sunflower**,** UAS, GKVK, Bangalore,* ***Dr. K. V. Jamuna,*** *Associate Professor. Bakery Training Unit Hebbal, Bangalore,* ***Dr. V. Palanimuttu****, Associate Professor, Post Harvest Technology, UAS, GKVK, Bangalore, who gave unflinching cooperation and timely suggestions throughout my course of investigation for their encouragement, co-operation and constructive suggestions.*

I would like to extend my sincere thanks to ***Dr. Kamal G. Nath, Dr. Vijayalakshmi****,* ***Dr. H. B. Shivaleela, Dr. Umadevi Hiremath, Dr. M.L. Revanna, Dr. Usha Ravindra,*** *Department of Food Science and Nutrition, for their generous help, co-operation and inspiration during the course of study. I am extremely grateful to* ***Dr. Neena Joshi*** *and* ***Mrs. Nagarekha Palli, MSRCHM,*** *for their kind support and* *guidance for the development of products during the course of study. I also thank Mr. Shivalingayya, laboratory assistant, Mrs. Rangamma and Mrs. Lakshmibai and other staff members of Food Science and Nutrition Department for their kind help during my work.*

The thesis must surely bear the imprint of the love and affection showered on me by my family members. I want to extend my appreciation and respects to my parents for their boundless love, needy inspirations like showers to a drying crop and for their unshakable confidence in me. I am greatly beholden of vocabulary and owe deep sense of honor to my beloved parents ***Sri Mohan Singh*** *and* ***Smt. Manjula Singh*** *for their love and dedicated efforts in shaping my career since childhood. It is time to express gratitude to my dear sister* ***Shilpa Singh*** *my dear brothers* ***Deepak Singh*** *for her immense encouragement.*

Friends are our biggest assets who make life colourful and cheerful. I fail in my duty if I do not express my warm thanks to my unmemorable friends. Their lively companionship and spontaneous help enabled me to complete this mammoth task. To name few ***Ravi shankar, Naveen Kumar, Tanuja, Ashwini, Sunitha, Veena, Elnaz, Jayalaxmi, Geetha, Deepti, Preeti and*** *my loving* ***juniors*** *for their cooperation during my research work.*

*I place on record with sincerity, the indebtedness to my seniors****, Deepa Terdal, Savita H, Savitry B, Geeta D, Shilpa Y and Gopika M*** *for guiding and encouraging me in all aspects.*

Finally, I frankly admit that it is not possible to remember all the faces that stood behind the facade at this juncture and omission of any name does not mean lack of gratitude.

Bengaluru

July, 2012 ***(Sindhu Singh, M.)***

DEVELOPMENT OF SHELF STABLE PRODUCTS FROM SUNFLOWER (*Heliantus annuus* L.) SEED KERNELS

THESIS ABSTRACT

Karnataka is a major producer of sunflower. Use of sunflower as a food is under exploited. Sunflower seeds are easily susceptible for rancidity due to the presence of unsaturated fatty acids. Therefore, an experiment on sunflower kernels was undertaken to develop some shelf stable products. Dehulled sunflower seeds were fried using different frying mediums such as sunflower oil, palmolein oil and sunflower + vanaspati. Frying mediums were treated with antioxidants such as BHA, vitamin E and citric acid. Fried samples were packed in LDPE pouches and were stored in ambient conditions. Samples were drawn in triplicates for every storage interval i.e. fresh, 6 week, 12 week and 18 week. Storage stability was determined by estimating moisture content, peroxide value, acid value and TBA values for the presence of rancidity. Among the oils, palmolein was less susceptible to rancidity. The order of effectiveness in inhibiting the oil oxidation was BHA > vitamin E > citric acid. Fried products such as namkeens and dry roasted flavoured seeds; Non fried products such as chikki, barfi, marzipan, bread, sauce, soup, cookies and salted seeds were developed. Comparative evaluation of products with appropriate controls was done on nine point hedonic scale by 20 semi trained panel members for sensory parameters appearance, texture, colour, taste and overall acceptability. Shelf life, nutritive value and cost of production of selected products were evaluated. The products were found to be shelf stable, nutritious and low cost.

Signature of the Student | Signature of the Major Advisor

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ಈ ಎಲ್ಲಾ ಎಣ್ಣೆಗಳ° ಪಾಮೊಲಿನ್ ಎಣ್ಣೆAiÀÄ£ÀÄß G¥ÀAiÉÆÃV¹zÀ ¥ÀzÁxÀð ಕಡಿಮೆ ಕಮಟ PÀAಡುಬಂvÀÄ. ಉತ್ಕರ್ಷಣೆಯನ್ನು ತಡೆಯುವುದರಲ್ಲಿ ಉತ್ಕರ್ಷಣ ನಿರೋಧಕದ ಕ್ರಮªÀÅ C£ÀÄPÀªÀÄªÁV ºÉZÁVzÉ - ©.ºÉZï.J> «l«Ä£ï E > ¹nPï D¹qï G¥ÀAiÉÆÃV¹ ಕರೆದ ಪದಾರ್ಥಗ¼ÁzÀ ನಮಕೀನ್ ಮತ್ತು ಸುವಾಸಿತ ಹುರಿದ ಬೀಜಗಳನ್ನು ತಯಾರಿಸ¯Á¬ÄvÀÄ. EvÀgÉ ಪದಾರ್ಥಗ¼ÁzÀ ಚಿಕ್ಕಿ, §¦ðÃ, ಮಾರ್ಜಿಪಾನ, ಬ್ರೆಡ್, ಸಾಸ್, ಸೂಪ್, ಕೂಕ್ಕಿಸ್, ಮತ್ತು ಉಪ್ಪಿನಸೂರ್ಯಕಾಂತಿ ಬೀಜಗಳನ್ನು ತಯಾರಿಸಲಾಗಿತ್ತು. ಸೂರ್ಯಕಾಂತಿಯಿಂದ ತಯಾರಿಸಿದ ಆಹಾರ ಪದಾರ್ಥಗಳನ್ನು ದಗೇಂದ್ರಿಯ ಪರೀಕ್ಷೆಗೆ ಒಳಪಡಿಸಲಾಯಿತು. ಅವುಗಳ ಜೀವಿತಾವಧಿ, ಪೋಷಕಾಂಶಗಳು ಹಾಗೂ ತಯಾರಿಸಲು ಆದ ವೆಚ್ಚಗಳನ್ನೂ ಸಹ ಮೌಲ್ಯಮಾಪನಕ್ಕೊಳಪಡಿಸಲಾಯಿತು. ಈ ಪರೀಕ್ಷೆಯಿಂದ ತಿಳಿದು ಬಂದಿದ್ದೇನೆಂದರೆ. ಈ ಪದಾರ್ಥಗಳು ಸ್ವಯಂ ಸ್ಥಿರತೆಯನ್ನು ಹೊಂದಿದ್ದು, ಪೊಷಕಾಂಶ ಭರಿತವಾಗಿವೆ ಹಾಗೂ ಕಡಿಮೆ ವೆಚ್ಚದಲ್ಲಿ ತಯಾರಿಸಬಹುದು ಎಂಬುದು ಕಂಡುಬಂದಿದೆ.

«zÁåyðAiÀÄ ¸À»	ªÀÄÄRå ªÀiÁUÀðzÀ±ÀðPÀgÀ ¸À»
(¹AzÀÄ ¹AUï, JA.)	(¤Ã£Á eÉÆ¶)

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Introduction

I. INTRODUCTION

Sunflower (*Helianthus annus* L.) belongs to the family Compositae. It is an annual, erect and herbacious plant with leaves simple, alternate with stout petioles and lanceolate in shape. Sunflower (*Helianthus annus* L.) is an important vegetable oilseed crop in the world, native to southern parts of USA and Mexico and ranks fourth next to groundnut, soybean and rapeseed. In Greek "Helios" means sun and "anthos" means flower, popularly known as "*Surajmukhi*" or "*Sooryakanthi*" belonging to the family Asteraceae. The name is just apt for a plant that turns its flower to face directly into the sun as it passes and also looks like the sun in its yellow rays. Sunflower is the oil of preference among the consumers throughout the world due to its health appeal and in India too, sunflower oil is the largest selling oil in the branded oil segment. Seeds of sunflower contain 39-49 per cent edible oil, 14-19 per cent protein and 7.5 -9.4 per cent of soluble sugars (Nagaraj, 1995). Sunflower oil is rich in PUFA (poly unsaturated fatty acids) which reduces the cholesterol content in blood and thereby help in reducing the chances of pulmonary diseases (Valenzuela *et al*., 2002). Besides oil, almost every part of sunflower has commercial value. It is used in the manufacturing paints, resins, plastics, soap, cosmetics and many other industrial products.

Sunflower crop was introduced to India during 1969 to bridge the gap of recurring edible oil shortage in the country. The commercial cultivation of sunflower started in India during 1972-73 with a few imported varieties from USSR and Canada. Now, the crop has been well accepted by the farming community because of its desirable attributes such as short duration, photoperiod insensitivity, adaptability to wide range of soil and climatic conditions, drought tolerance, lower seed rate, high seed multiplication rate and high quality of edible oil (Reddy *et al*., 2007). The major sunflower growing countries are Argentina, Russia, India, France, Italy, China and USA (Srinivasan, 2005). Presently in India, it is grown in an area of 897.22 lakh hectares with annual production of 624.69 lakh tonnes having productivity of 696 kg/ha. The major sunflower producing states in our country are Karnataka, Andhra Pradesh, Maharashtra, Tamil Nadu and Haryana. In Karnataka, sunflower is being grown in an area of 410 lakh hectare with a production of 219 lakh tonnes having a productivity of 534 kg/ha (Anon., 2011-2012). Sunflower is also grown as an inter crop with groundnut, pigeon pea, soybean, black gram, ragi and castor. Since, it is a photo insensitive crop; it can be grown throughout the year. Oil cake is rich in high quality protein (40-44 per cent) and used as cattle and poultry feed.

In other parts of world the medium sized seeds are dehulled, roasted and sold as peanut substitutes and confection or snack item. Roasted and salted sunflower seed either dehulled or whole is popular around the world as sweetmeat and savoury. The broken or whole kernels with or without roasting are used in a variety of bakery products, salads, candies and some other food dishes. They are also used for sprinkling on syrup or pancakes and waffles, blended with honey, butter and salt to make a spread (Chakrapani, 1997).

Sunflower seed contains about 19.8 g of protein, 52.1 g of lipid, 17.9 g of carbohydrate, 1 g of crude fibre, 3.7 g of minerals, 280 mg of calcium, 5 mg of Iron and it yields 620 kcal of energy per 100 g of seeds (Gopalan *et al.,* 2007). However, nutrient content is influenced by the cultivar and other factors.

Sunflower seed is important in human nutrition for its oil content and in animal nutrition for its protein content in the form of defatted flour (Sastry and Subramanian, 1985). It contains 40-45 per cent good quality oil which is rich in linoleic acid an essential fatty acid and α-Tocopherol (Shahbaz and Hassain 2000; Lusas, 1985). However, the levels of linoleic acid in sunflower oil are too high for high stability application, such as frying (Yoshida *et al.,* 2002; Purdy, 1996). Sunflower kernel contains high levels of vitamin E, phenolic acids, choline, arginine and lignins compared to some nuts (Holiday and Phillips, 2001). Sunflower seed oil taste has been described as “light” by Shahbaz and Hussain (2000).

Lipid oxidation is one of the most common causes of flavour quality deterioration (Narwar, 1996; Min and Boff, 2002). It lowers the sensory perception, nutritional quality and safety of lipids. The oxidation not only makes the food less acceptable or unacceptable to consumers but also causes great economic losses to the food industry. The initial product of lipid oxidation by autoxidation, enzymatic and photosensitized oxidations is hydroperoxide. The hydroperoxides are decomposed to produce volatile compounds (Min and Boff, 2002) and oxidized dimers, trimers or polymers (Choi and Min, 2005). The volatile compounds are aldehydes, ketones, alcohols, hydrocarbons, and furans, which are responsible for undesirable rancid flavor of oils. Some products from the decomposition of hydroperoxides are potentially toxic at relatively low concentration (Przylski and Eskin, 1994).

The shelf-life of the product is defined as the time the specific product can be stored under specified conditions that retains organoleptic acceptability. Shelf-stability is due to a combination of factors, otherwise known as the “hurdle effect”. The interaction of these factors affects the chemical reactions. Controlling the various factors and interactions maximizes the total effect and achieves shelf-stability (Gupta, 2005). Consumer demand for healthy ingredients in bakery, snack and cereal products has risen dramatically over recent years. Sunflower seed is growing in popularity and offers a cost effective, flavor enhancing and nutritious alternative to other nuts and seeds. A perception of a short shelf life of sunflower kernel has limited its usage. Sunflower seeds are easily susceptible for rancidation due to the presence of unsaturated fatty acids. Autoxidation of unsaturated lipids is a catalytic process involving a free-radical chain reaction mechanism, with formation of hydroperoxides, and further reactions of oxidation, breakdown and polymerization. Therefore oxidation rates can be decreased by the addition of antioxidants. The high oleic sunflower kernels which are stable because of its fatty acid profile can be used in the development of snack products to overcome the problem of rancidity. The relatively short shelf-life of most commercially available vegetable oils limits their usefulness in various applications. A high-stability vegetable oil could be used to reduce inventory turn-over and extend the life of frying oils and fried foods (Narwar, 1996). Highly stable oil could also have application in rations for emergency preparedness, extended space travel, international food-aid and military uses (Merrill *et al*., 2008).

Antioxidant is used to improve the flavour quality of oil. Various antioxidants are used to increase the oxidative stability of vegetable oils. In addition to naturally occurring antioxidants such as tocopherols, and rosemary extract, other antioxidants include ascorbyl palmitate (AP), butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG), tert-butylhydroquinone (TBHQ), and citric acid. With the exception of citric acid, which is used for metal chelation, all of these antioxidants function by quenching free radicals (Narwar, 1996; Frankel, 2005). Several antioxidants such as tocopherols, BHA and citric acid have been tried to decrease the oxidation during storage.

Fried foods have provided culinary delight to people worldwide for centuries. Large-scale production of snack food is done in deep fat fryers. Deep-frying is a cooking process, with which water containing foodstuff is immersed into edible oils or fats at temperatures between 140 – 180 °C. In the first phase, within a few seconds, a thin crust forms, whose structure crucially affects the deep-frying process and the quality of the food with regards to fat absorption and crispness (Gesellschaft, 2010).

Similarly sunflower seeds can lend themselves for non fried food also especially those that are traditionally made with nuts and seeds. Eg. Cookies, dragee, chikki (Bajaj *et al.*, 1991; Gupta *et al.*, 1996; Gupta and Sharma, 2007).

Utilization of sunflower seeds as such in Indian diets is minimal. However, studies have shown that sunflower seeds can be used as such and as a source of nutrients and antioxidants. In this context sunflowers seeds can be considered as under exploited for food use.

In the health conscious world today, nutrition helps in selling new products prepared from novel nutrient sources and sunflower is power house of several nutrients. Roasted peanuts, almonds, cashew nuts etc. are few popular snacks foods but are costly; sunflower seed kernels may be cheaper substitutes. The lipid profile of the sunflower seed is unique; however rancidity due to high poly unsaturated fatty acids content is a problem. Sunflower seed kernels are rich source of many nutrients and could be used for the preparation of various protein enriched food products at lower cost. Thus keeping in view of health benefits, nutrients, taste and economics of sunflower kernels, the present investigation was undertaken with the following objectives:

- Development and evaluation of shelf stable products.
- Evaluation of physico-chemical characteristics of the products
- Evaluating shelf life of the products.

Review of Literature

II. REVIEW OF LITERATURE

Sunflower seeds are rich store house of several nutrients. Their cultivation in India as a major crop is fairly recent. Since the seeds as such do not form a part of the traditional Indian dietary. Therefore these can be considered as under exploited. An attempt was therefore made to study the "**Development of shelf stable products from sunflower seed kernels"**. Literature related to this study is reviewed in this chapter under the following headings:

2.1 Nutritive value of sunflower seeds and oil

2.2 Effect of storage on oil seed quality and their products

2.3 Effect of processing of oil seeds and their products

2.4 Antioxidant and storage stability of fried products

2.5 Suitability of type of oil for frying snack foods

2.6 Assessment of rancidity of oil and oil products

2.7 Value added products from sunflower seeds

2.1 Nutritive value of sunflower seeds and oil

Gopika, (2009) evaluated four cultivars of sunflower kernels. The mean nutrient composition of the seeds per 100 grams was 4.48g moisture, 20.89g, 40.33g fat, 3.57g ash, 27.36g carbohydrate, 556 Kcal energy, 84.59mg calcium, 640.59mg phosphorus, 4.67 mg iron, 37.47mg vitamin E and 3.77mg zinc.

In the Indian food composition tables the nutritive value of sunflower seeds per 100 g is reported as moisture of 5.5 g, protein 19.8 g, fat content 52.1 g, minerals content 3.7 g, crude fibre content 1.0 g, carbohydrate 17.9 g and energy 620 Kcal, calcium 280mg and phosphorus 670mg (Gopalan *et al.* 2007)

Sen and Bhattacharya (2000), found 3.2 per cent moisture, 3.4 per cent ash, 1.4 per cent fibre, 55.5 per cent oil, 30.5 per cent protein and 4.2 per cent carbohydrate in decorticated sunflower seeds. Pajin *et al.* (2006) found that the sunflower kernels have moisture content of 6.34 per cent, oil content 39.62 per cent, protein content 21.03 per cent, cellulose 5.8 per cent and peroxide value of 0.46 mmol/kg and free fatty acid content of 0.49 per cent in Delija sunflower variety.

Anjum *et al.* (2006) performed proximate analysis of roasted and unroasted seeds. They found that the moisture contents of the control (unroasted sunflower oilseeds) variety KL-39 and FH-330 were 7.0 and 6.3 per cent, respectively. Contents of protein, fiber, and ash were 24.94 and 21.00; 7.01 and 9.50; and 5.00 and 5.50 per cent, respectively.

Pawar *et al.* (2001) found that sunflower kernels contain 19.8 per cent proteins, 50.1 per cent fat, 3.7 per cent ash, 1.6 per cent polyphenols and 1.7 per cent phytate on dry weight basis. Dehulling kernels increased relative concentrations of these components on unit weight basis.

Proximate principles were reported as indicated below by Srilatha and Krishnakumari (2003) in Sunflower seed (whole) and sunflower seed (dehulled).

	Sunflower seed (whole) (g/100g)	**Sunflower seed (dehulled) (g/100g)**
Moisture	05.50	06.54
Protein	18.72	19.30
Fat	32.47	62.35
Crude fibre	28.36	03.00
Ash	03.49	07.05
Carbohydrate	06.11	03.50

Praveena *et al.* (2000) examined sunflower hybrids. The major fatty acids namely oleic and linoleic acids were 36-50 per cent and 42-54 per cent respectively. Micronutrients like zinc, copper, manganese and iron were analyzed in various genotypes; zinc content ranged from 50 to 107.2 µg/g, copper 24.4-39.6 µg/g, manganese 28.2-89.6 µg/g and iron between 305 and 392 µg/g. Alpha, beta and gamma tocopherols ranged between 405 and 485, 35 and 56 and 4 and 10 mg/kg, respectively. MSFH 8 had high levels of tocopherols and micronutrients.

Canibe *et al.* (1999) studied the chemical composition, digestibility and protein quality of 12 sunflower (*Helianthus annus L*) cultivars. Twelve sunflower cultivars grown in Spain were analyzed. The dehulled seeds contain an average of 32.2MJ/kg gross energy, 653g/kg fat, 60g/kg total non-starch polysaccharides (NSP) and 6g/kg lignin on dry matter basis. The sunflower seed hulls contained 20.2 MJ/kg gross energy, 53g/kg fat, 562g/kg total NSPs and 239g/kg lignin on dry matter basis. The dehulled partially defatted samples contained an average 74.6g nitrogen per kg and 1.409mg/g phenolic compounds (chlorogenic acid+caffeic acid+derivative 1+derivative 2) varying from 0.677 to 2.847mg/g.

Vasishatha *et al.* (1992) studied variations in the characteristics and oil compositions in different genetic varieties of sunflower. Analysis of 30 varieties of sunflower seed (*Helianthus annus* L.) showed that oil contents ranged from 24.1 per cent to 50.4 per cent, and protein contents from 9.2 per cent to 28.8 per cent. Total saturated fatty acid content in the oils varied from 10.7 to 17.9%. Linoleic acid was the predominant fatty acid present.

Nolasco *et al.* (2004) studied the tocopherol oil concentration in field grown sunflower. Significant variations (389 to 1873 µg g oil−1) in the total tocopherol concentration of sunflower seed oil have been reported. Tocopherol concentration decreased when oil weight per seed increased. Tocopherol concentration stabilized for oil weight per seed higher than 23mg/seed. This exponential relationship accounted for 73 per cent of the variability in tocopherol concentration (507 to 1203 µg/g oil) despite differences in hull type, locations, hybrids, and radiation treatments.

Murthy and Shobana (1997) studied the total tocopherol content of selected edible oils in Indian markets. Analysis of edible oils from different plant types showed a range of tocopherol content as low as 1.48 mg/g in soybean oil. Marked difference existed in tocopherol content of crude and refined oils of all varieties analyzed. The tocopherol content is believed to be influenced by refining status and shelf life of oil storage condition, plant source and maturation of oil seed and method of analysis: colorimetric method of analysis appears to be influenced by other interfering pigments present in oil.

Rama Prasad *et al.* (1992) evaluated omega-3, omega-6 unsaturated fatty acid composition of commercially available vegetable oils. Maximum amount of n-3 fatty acids and n-6 fatty acids 10.4mg/100mg and 56.53 mg/100mg were observed in mustard oil and sunflower oil, respectively.

Sripad *et al.* (1982) conducted a study on extractability of polyphenols of sunflower seed in various solvents. They found that protein content, chlorogenic acid, caffeic acid and quinic acid of 54 g, 1.86 g, 0.56 g, 0.39 g per 100 g of defatted sunflower flour respectively.

Mikolajczak *et al.* (1970) conducted a study on phenolic and sugar components of Armavirec variety sunflower. The aqueous methanol extract yielded three disaccharides and a trisaccharide (1.9%) identified a sraffinose. The disaccharide is isolated in largest amount (4.4% of the defatted meal) was sucrose. Another, which yielded only glucose on complete acid hydrolysis, is probably α, α'-D-trehalose. The third disaccharide was cleaved to glucose and fructose by the same treatment. Total phenolic content of the defatted meal was about 2.4% and the total amount of sugars isolated 9.7 per cent.

2.2 Effect of storage on oil seed quality and their products

Miller *et al.* (1986) studied the effect of storage conditions on mould growth and oil quality of confectionery and high-oil sunflower seeds. Confectionery and high-oil sunflower seeds were stored under favourable conditions (25ºC; 50% relative humidity (RH) and unfavorable conditions (30ºC; 80% RH) for 23 weeks. The correlation between free fatty acid value and total mould count was r=0.56; p<0.01 and r=0.77; p<o.o5 for high-oil and confectionery type respectively.

Budin and Breene (1993) conducted a study on factors affecting the shelf stability of sunflower nuts. dehulled, raw, whole sunflower kernels of high-oleic acid (HOA) and high-linoleic acid (HLA) types were shelf-stable at 23 and 37°C for over one year. Dry-roasted HOA kernels were more stable than dry-roasted HLA kernels. Oil roasted HLA kernels were more stable than dry-roasted ones. Stability of roasting oil and storage temperature had no appreciable effect on shelf stability of kernels.

Villiers *et al.* (1986) studied the behavior of decorticated sunflower seeds stored under favorable and unfavorable conditions. Storage study was done on 98% decorticated sunflower seeds. Kernels were stored for 6 months under favorable (25º, 50% relative humidity) and unfavorable (30ºC, 75% relative humidity) conditions. Under favorable conditions it was found that deterioration of oils started after 1 month of storage. The FFA values increased from 0.16 per cent to 9.94 per cent and the IF decreased from 600 to 74 minutes for samples exposed to air. Significantly higher mould growth occurred on kernels stored under unfavorable conditions.

Fritsch *et al.* (2006) conducted a study on shelf life of sunflower kernels. The shelf life for roasted sunflower kernels was greater than 12 months when stored in nitrogen flushed pouches and as low as 8 wk when exposed to air at 38°C. Hexanal was a better index for shelf life of roasted sunflower kernels than was peroxide. The shelf life of raw sunflower kernels was >12 months in packages providing some moisture but no oxygen protection.

Sisman and Delibas (2004) conducted a study on storing sunflower seeds and quality losses during storage. Quality losses with respect to moisture levels were high. By controlling the moisture levels to 8% the quality or sunflower seed can be maintained.

Pajin and Jovanovic (2003) conducted a study on dragee product based on sunflower. During the storage peroxide value in the dragee product increased from 0.5 to 9.0mmol /kg during the 5 months of storage. The free fatty acid content also increased from 1.3 per cent in fresh dragee product to 2.5 per cent after 5 months of storage. The packaging material metalized polyester/polyethylene, labeled met PET/PE, has the lowest oxygen permeability (8.0 mL m-2/dan Ap 1 bar) and because of this it had the strongest influence in the prevention of hydrolytic and oxidative changes in the final product.

Vidyasagar *et al.* (1964) conducted studies on storage of packed groundnut candy bar. It has a shelf life of over six months in flexible packs under tropical conditions and thus meets the “defence forces” requirements. Storage stability of this product may be attributed to the antioxidant property of sesame, which is one of the constituents.

Wrapping of individual candy bars in butter paper or cellophane and packing in paper/foil/polyethylene laminate (0.02mm) was found to be suitable for retail purposes. For bulk packing, wrapping of individual bars in cellophane and subsequent packing in convenient lots in polyethylene bags (500gauge) followed by sealing and final packing in waxed cartons was found to be suitable.

Lee and Resurreccion (2006) conducted a study on consumer acceptance of roasted peanuts affected by storage temperature and humidity conditions. Consumer acceptance ratings, including overall appearance, colour and texture were affected by storage water activity and time but not storage temperature. Consumer intensity ratings of crunchiness were affected by storage water activity and time but not storage temperature. Aroma acceptance, flavour acceptance and roasted peanutty and stale/ oxidized rancid intensity ratings of roasted peanuts were dependent on storage temperature, water activity and time.

Abegaz *et al*. (2004) conducted a study to know the role of moisture in flavor changes of model peanut confections during storage. The effect of antioxidant, sugar, and moisture and storage time on oxidative stability was determined by peroxide value, instrumental volatile and descriptive sensory analysis. Peanut pastes with 2g H_2O /100g added moisture had lower peroxide value.

Grosso *et al.* (2007) conducted a study on sensory profiles of cracker coated and roasted peanuts stored under different temperatures. Mean values of oxidized and cardboard flavor intensities in cracker coated peanut (CCP) and roasted peanut (RP) samples stored at 23, 30 and 40ºC, while intensity of roasted peanutty flavor decreased during storage. Prediction models for these sensory attributes from storage time and temperature variables were developed. Flushing RP with nitrogen had a protective effect against development of oxidized flavors, not observed in CCP. The coating of CCP contributed to the development of oxidized flavor. When oxidized flavor (=36.2) was used as an indicator of storage deterioration, CCP had a predicted shelf life of 78,56 and 32 days at 23,30 and 40ºC, respectively, whereas in RP it was 116,105 and 94 days, respectively. Sensory profiles predicted better shelf life of RP and CCP.

Yousuf Ali Khan *et al.* (1979) conducted a study on shelf-life of sunflower oil and groundnut oil. Raw sunflower oil and raw groundnut oil were stable hydrolytically and oxidatively for 1080 and 660 days respectively. Refined groundnut oils did not register increase in free fatty acid contents whereas peroxide values widely differed from each other. Refined groundnut oil even without added antioxidants stored in closed container without access to air showed low peroxide value at the end. Acceptability tests showed that the raw sunflower and groundnut oils were acceptable till they attained a peroxide value of about 25 and beyond this limit, there was rapid deterioration in the palatability of the preparations.

Raghav *et al.* (1999) studied the storage stability of oil in different packaging materials. Storage of raw sunflower oil were carried out in four different packaging materials viz., plastic, tin, hindolium and high density polyethylene (HDPE) pouches. It was observed that during storage, different packaging materials and heat treatment affected the colour, odour, free fatty acids and iodine value of oil. The airtight HDPE pouches (gauge) with heat-treated oil were found to be the best packaging materials for storage of oil up to a period of 16 weeks.

The effects of air-drying temperature and storage time on several characteristics of crude sunflower oil and they were evaluated in terms of FFA and PV (Bax *et al.*, 2004). Long storage affected oil content to a greater extent than air-drying temperature. FFA and PV varied between

0.53 and 1.22 per cent and between 10.7 and 23.3meq O_2/kg, respectively, when samples of uniform initial moisture content (approximately 28%) were dried at various temperatures between 25 and 90°C to approximately 7 per cent moisture content, stored for 8 months, and then analyzed. Both oil quality characteristics increased exponentially with air-drying temperature and linearly with storage time.

Makhoul *et al.* (2006) conducted a study on identification of some rancidity measures at the end of the shelf life of sunflower oil. The chemical rancidity measures at the end of the sensory shelf life were peroxide value of 338-352.8 meq peroxide/kg, CD of 1.20-1.24 per cent conjugated dienoic acid, Anisidine value of 21.45-45, TBA values of 23.4-37, and Hexnal content of 4.79 mg/kg, while Iodine value exhibited a decrease of 8.5-10 per cent.

Mathews *et al*. (1998) conducted a study on packaging of raw groundnut oil in tin free steel cans and tinplate containers. The study indicated that there was no significant difference in the peroxide value, free fatty acids and the quality of the oil between the two types of containers. Large area of iron exposure caused an increase in peroxide value. Incorporation of free fatty acids resulted in the acceleration of peroxide value.

Oxidative rancidity in groundnut oil and its evaluation by sensory and chemical indices and their correlation was studied by Narasimhan *et al.,* (1986). Stored and commercial groundnut oil samples were tested for sensory parameters of odour and flavour along with chemical values to explore any functional relationship between them. The relationship between Peroxide value and odour as well as flavour was found to be significant.

Adnan *et al.* (1980) conducted a study on lipid oxidative stability of reconstituted partially defatted peanuts. Peroxide value and fatty acid composition were measured during storage of reconstituted partially defatted peanuts. These values were compared with those of unreconstituted partially defatted peanuts, whole peanuts and the corresponding oils. The stability of the oil during storage, as measured by peroxide value, is much greater within the peanuts than in the corresponding extracted oil.

Narasimhamurthy and Raina (1998) studied the changes in the physico-chemical characteristics of oils during heating and frying were studied in respect of groundnut, sesame and coconut oils (heating at 180ºc for 72 hr and frying under laboratory conditions). The results indicated relatively greater alterations in heated oils compared to fried oils. Peroxide value, iodine value, and free fatty acids showed significant changes in heated oils compared to fried oils.

Daramola and Asunni (2006) studied the nutrient composition and storage studies on roselle extract enriched deep-fat-fried snack food. Roselle extract fortified deep-fat-fried snack food (ReSF) developed was evaluated for nutritional and organoleptic enrichment. Effect of the extract and package films on oxidative changes in ReSF as affected by display conditions were also examined. ReSF is rich in dietary Fe (1965 µg/g sample) with variable organoleptic profile. The Roselle extract exerted inhibitory activities on peroxidation. Display of ReSF under day or dark as opposed to display under direct sunlight exerted protection (PF = 0.90) of product from light induced deterioration. Application of translucent film for packaging of ReSF conferred protection on the snack food against light induced peroxidation.

2.3 Effect of processing of oil seeds and their products

Madhusudan *et al.* (1986) studied the effect of roasting on the physico-chemical properties of sunflower proteins. Dehulled sunflower seeds were salt roasted and the physico-chemical properties of the roasted and control samples were compared. The roasted sample exhibited a decrease in nitrogen solubility, available lysine and an increase in in-vitro digestibility. Roasting did not lead to significant changes in gel filtration pattern, intrinsic viscosity, sedimentation velocity pattern on secondary structure of total or isolated proteins.

Anjum *et al.* (2006) studied the microwave roasting effects on the physico-chemical composition and oxidative stability of sunflower seed oil. Micro waved sunflower seeds (*Helianthus annus* L.) of two varieties, KL-39 and FH-330, were extracted using *n*-hexane. Roasting decreased the oil content of the seeds significantly ($P < 0.05$). The oilseed residue analysis revealed no changes in the contents of fiber, ash, and protein that were attributable to the roasting. Analysis of the extracted oils demonstrated a significant increase in FFA, *p*-anisidine, saponification, conjugated diene, conjugated triene, density, and color values for roasting periods of 10 and 15 min. The iodine values of the oils were remarkably decreased. A significant ($P < 0.05$) decrease in the amounts of tocopherol constituents of the micro waved sunflower oils also was found. However, after 15 min of roasting, the amount of a-tocopherol homolog's was still over 76 and 81 per cent of the original levels for the KL-39 and FH-330 varieties, respectively. In the same time period, the level of d-tocopherol fell to zero. Regarding the FA composition of the extracted oils, microwave heating increased oleic acid 16–42 per cent and decreased linoleic acid 17–19 per cent, but palmitic and stearic acid contents were not affected significantly ($P > 0.05$).

Effects of microwave roasting were also investigated by Yoshida *et al.,* (2001). Studied the effect on the molecular species and fatty acid composition of triacylglycerols (TAG) in sunflower seeds (*Helianthus annus* L.). Seeds were exposed to microwaves for 6, 12, 20 or 30 min at 2450 MHz, after which TAG, isolated from the total lipid fraction by TLC, were analyzed for fatty acid composition by GC and for molecular species by silver nitrate-silica gel TLC. Separation according to degree of unsaturation and total chain length of fatty acids present led to identification of 14 different groups and the main compounds observed were dilinoleolin (25-26.2%), trilinolein (14.4-17.7%), dilinoleostearin (15.1-15.8%), dioleolinolein (12.2-12.4%) and triolein (10.5-11.3%). Microwave roasting for 20 min led to significant decreases ($P < 0.05$) in the diene content of TAG and in the proportion of molecular species containing >4 double bonds. Fatty acid composition was not affected by microwave roasting for <less than or equal to>12 min, but at longer roasting times percentages of oleic and palmitic acids increased, whereas that of linoleic acid decreased.

Venkatesh and Prakash (1993) studied the effect of physical and chemical treatments on functional properties of the total proteins on sunflower seed. The effect of wet heating, dry heating, and washing with acidic butanol on nitrogen solubility profiles, functional properties such as foaming indices and emulsification indices, and other related parameters is investigated in water and NaCl extracts from dehulled, defatted, and powdered samples of sunflower seeds. The results showed that autoclaving at 2 kg/cm^2 and roasting at both 100 and 150ºC affect nitrogen solubility of the proteins in water and NaCl. The foam volume indicates a decrease as a result of acidic butanol treatment, whereas it decreased by 40 per cent in the untreated sample. Foam from samples roasted at 150ºC or autoclaved at 1 and 2 kg/ cm^2 collapses faster during a period of 120 min as compared to the sample roasted at 100ºC and control. The emulsification stability was higher in water for all the samples as compared to those in sodium chloride solution.

Interrelation between the quality of sunflower oils and the content of tocopherols in sunflower kernels when roasted in a microwave oven was investigated (Yoshida *et al.,* 2002). Only minor increases ($P < 0.05$) were detected in the physicochemical properties of the oils (including carbonyl value, p-anisidine value, colour development) on prolonged roasting. The level of phospholipids in the oils decreased significantly ($P < 0.05$) on roasting. After 30 min roasting, 92 per cent tocopherols still remained in the kernels. Exposure of sunflower seeds to microwaves for 12 min resulted in no significant loss or change in the content of tocopherols or PUFA in the kernels.

Farag (1999) studied the effect of radiation and other processing methods on protein quality of sunflower meal. The effect of gamma irradiation from a ^{60}Co source (10 and 20kGy), dry heating (121ºC for 10,20 and 30 min), autoclaving (121ºC at 103.5kPa for 10,20 and 30 min) and their combination on chlorogenic acid, soluble protein, available lysine and in-vitro protein digestibility of sunflower meal were studied. The moisture content of the raw sample was 78g/kg as is and on a dry matter basis. The meal contained 26.7g/kg chlorogenic acid, 330g/kg crude protein, 78.5 per cent soluble protein and 2.63g 16g/N available lysine. Digestibility of raw meal was 81.5 per cent. Chlorogenic acid, soluble protein and available lysine of raw meal decreased during dry heating, autoclaving and radiation processing. The digestibility was significantly affected by processing method ($p<0.05$), as well as by the time of dry heating and autoclaving. The influence of combination methods revealed that irradiation alone had a little effect on chlorogenic acid and in-vitro protein digestibility. Autoclaving plus irradiation up to 20kGy markedly improved the digestibility (90%). Therefore, the results suggested that the combination of autoclaving for 10 min plus irradiation up to 20kGy has a beneficial effect on the protein quality of sunflower meal with little effect on its content of soluble protein, available lysine and markedly reduced chlorogenic acid by 87 per cent, more than other processing methods.

2.4 Antioxidant and storage stability of fried products

Ruiz *et al.* (1999) studied the influence of used frying oil quality and natural tocopherol content on oxidative stability of fried potatoes. Fried potatoes that had been fried in oils of differing quality were stored at 60°C for up to 30 d and evaluated for polar compounds, polymers, peroxide value, oil stability index, and α-tocopherol content. The induction period could not be explained only on the basis of the degree of unsaturation or polar compound levels in fried potatoes before storage. α-Tocopherol content also had a significant influence as potatoes fried in HOSO, with 16% polar compounds and only 10 mg/kg α-tocopherol at the starting point of storage, were oxidized more rapidly than potatoes fried in SO with a comparatively higher degradation level, 19% polar compounds, and 100 mg/kg α-tocopherol.

Koh *et al.* (2011) conducted the deep frying performance of enzymatically synthesized palm-based medium and long-chain triacylglycerols (mlct) oil blends. Palm-based MLCT oil in the presence of synthetic or natural antioxidants showed significantly better ($P<0.05$) thermal resistance and oxidative strength than refined, bleached, and deodorized (RBD) palm olein throughout the five consecutive days of frying. Rancimat induction period, free fatty acid content, anisidine value, E1% 1cm at 232 and 268 nm, color, percentage of oil uptake, and viscosity measurement can be used as oil quality parameters to indicate the degree of oil deterioration under continuous stressed frying conditions. No significant changes ($P>0.05$) in the saturated/unsaturated fatty acids ratio across frying periods indicated good oxidative stability of the palm-based MLCT oil.

Kim *et al.* (2007) conducted the study on hydroperoxide as a prooxidant in the oxidative stability of soybean oil. The initial peroxide value of the oil increased from 0 to 2, 4, 6, 8 and 10, the headspace oxygen decreased and the volatile compounds increased at $p < 0.05$. Hydroperoxide accelerated the oxidation of soybean oil. The correlation coefficient (R2) between the headspace oxygen and the volatile compounds was 0.95. The increase of tertiary butyl hydroquinone (TBHQ) from 0 to 50 ppm for the oil of PV 4 or 8 had a significant effect on the oxidative stability at $p < 0.05$. The increase from 50 to 100 ppm for the oil of PV 4 or 8 did not significantly increase the stability at $p > 0.05$. The oxidative stability of PV 8 meq/kg and 50 ppm TBHQ was better than the control with PV 0 and 0 ppm TBHQ at $p < 0.05$. TBHQ was an effective antioxidant to improve the oxidative stability of soybean oil.

Antioxidant functions of tocopherol and tocotrienol homologues in oils, fats, and food systems were studied by Christine *et al.* (2010). α-tocopherol generally showed better antioxidant activity than γ-tocopherol in fats and oils, but at higher concentrations γ -tocopherol was found to be a more active antioxidant. It has been stated that generally γ-tocotrienol has higher antioxidant effect than α-tocotrienol, and tocotrienols may be better antioxidants than their corresponding tocopherols in certain oils and fats systems. Depending on the food system, in certain cases tocopherols were better antioxidants than synthetic antioxidants such as butylhydroxy toluene (BHT) or butylhydroxy anisole (BHA). However, in certain other food systems the synthetic antioxidants were more effective to increase the shelf life and the stability of foods than those containing tocopherols.

Cheung *et al.* (2007) studied the antioxidant protection of edible oils. The antiperoxidation effect of the presence of the chinese herbs, du-zhong (*Cortex Eucommia ulmoides*) and ginseng (*Panax ginseng C.A. Mayer*) in corn oil was also investigated over 26 days' storage at 55°C. Corn oil to which was added the herbs du-zhong, ginseng or both had increased resistance to oxidation (conjugated diene level and lipid peroxide formation) over 26 days. Results have implications for increasing the shelf-life and usage time of cooking oils by addition of herbs which can increase resistance of the oil to oxidation. Results have implications also for health, as it is possible that ingestion of these herbs could increase resistance of polyunsaturated fatty acids of cell membranes and lipoproteins to oxidation within the body.

Oil replenishment during deep-fat frying of frozen foods in sunflower oil (SO) and high-oleic acid sunflower oil (HOSO) was performed by Romero *et al.,* 1998. Total polar content and compounds, related to thermoxidative changes, and diacylglycerides, related to hydrolytic changes, increased in all oils during frying but reached higher levels in SO than in HOSO. Nevertheless, the increased levels of diacylglycerides observed may result from the frozen potatoes pre-fried in palm oil. Oleic acid in HOSO and linoleic acid in SO significantly decreased, but the fatty acid modifications that occurred during the repeated fryings were not only related to thermoxidative alteration but also to interactions between the bath oil and the fat in the fried products. HOSO performed more satisfactorily than SO in repeated fryings of frozen foods. Moreover, frequent addition of fresh oil throughout the deep-frying process minimized thermoxidative and hydrolytic changes in the frying oils and extended the frying life of the oils.

Ninfali *et al.* (2001) conducted the study on antioxidant capacity of extra-virgin olive oils. Significant correlation was found between oxygen radical absorbance capacity (ORAC) values of different olive oils and the total amount of phenolics. For extra-virgin olive oils, maximal ORAC values reached 6.20 ± 0.31 µmol Trolox equivalent/g, while refined and seed oils showed values in the 1–1.5 µmol Trolox equivalent/ g range. Spectrofluorometric method is useful to assess the quality of olive oils and to predict, in combination with the rancidity tests, their stability against oxidation.

Shiela *et al.* (2004) performed the storage stability evaluation of some packed vegetable oil blends. Oils and oil blends containing a higher initial PV (18.9–20.7 meq O_2/kg) showed a slight reduction in value at 40°C, whereas oils having lesser PV of 5-10 showed a slight increase during the storage period. Among the minor components studied, only b-carotene showed a reduction, 8.9–60.2% at 27°C and 48–71% at 40°C, for the different oil blends studied. The observed results indicated that the packed oil blends studied were stable under the conditions of the study, and the minor components, other than b-carotene, remained unaltered in the package even at the end of 6 months of storage.

Lake and Scholes (1997) studied the quality and consumption of oxidized lipids from deep-frying fats and oils in New Zealand. The TBARS and conjugated diene levels were compared with those for oxidized corn oil used in a feeding trial and indicated a similar oxidation level, although the amount of fat consumed in the feeding trial would be 30–50% higher. These results show that well-maintained deep frying fat has oxidation levels sufficient to cause elevation of plasma lipid oxidation levels as observed in a human feeding trial.

Normand *et al.* (2001) evaluated the effect of tocopherols on the frying stability of regular and modified canola oils. Frying stability was compared based on the rates of formation of free fatty acids (FFA) and total polar compounds (TPC). No significant differences were observed in the rates of FFA formation among the canola oils during frying. Nevertheless, regular canola (RCO) and high-oleic, low-linolenic acid canola (HOLLCO) oils produced less FFA compared to higholeic (HOCO) and low-linolenic acid (LLCO) canola oils. However, LLCO and HOCO both had significantly ($P < 0.05$) faster rates of TPC formation compared to HOLLCO or RCO. HOLLCO with the highest level of tocopherols (893 mg/kg) exhibited a slow rate of degradation which accounted for a halflife of 48–60 h of frying. RCO, with a lower level of tocopherols (565 mg/kg), however, had the slowest degradation rate with a half-life of >72 h. In contrast, HOCO and LLCO with 601 and 468 mg/kg tocopherols, respectively, both exhibited a half-life for tocopherols of 3–6 h of frying. An inverse relationship was observed between TPC formation and the reduction of tocopherol. Thus, the greater frying stability of RCO and HOLLCO appears to be affected far more by the rate of tocopherol degradation than by any changes in fatty acid composition.

Neff *et al.* (2003) studied the effect of γ-tocopherol on formation of nonvolatile lipid degradation products during frying of potato chips in triolein. Results showed that γ-tocopherol reduced the production of nonvolatile degradation products in the triolein absorbed by the potato chips and in the triolein in the fryer. Fryer oil samples and extracted potato chip oils with 400ppm γ-tocopherol had a significantly lower production of degradation compounds than did samples with 100 ppm γ-tocopherol. Both fryer oils and potato chips containing 100 ppm γ-tocopherol had significantly fewer nonvolatile degradation products than did the samples without γ-tocopherol.

Rehman (2003) performed the evaluation of antioxidant activity of methanolic extract from peanut hulls in fried potato chips. Free fatty acids (FFA) and peroxide values (POV) were used as criteria to assess MEPH as an antioxidant. Potato chips treated with BHA and BHT showed

POVs of 29.0 and 25.0 mEq/kg whereas FFA values were 0.0086 and 0.074%, respectively, after six months storage at 45°C. These results illustrate that MEPH, at various concentrations, exhibited very strong antioxidant activity which was almost equal to synthetic antioxidants (BHA & BHT). Subjective evaluation studies also showed that potato chips treated with 1200–1600 ppm MEPH after six months storage at 45°C, were organoleptically acceptable.

Seppanen *et al.* (2010) determined the antioxidant functions of tocopherol and tocotrienol homologues in oils, fats, and food systems. α-tocopherol generally showed better antioxidant activity than γ-tocopherol in fats and oils, but at higher concentrations γ-tocopherol was found to be a more active antioxidant. Depending on the food system, in certain cases tocopherols were better antioxidants than synthetic antioxidants such as butylhydroxy toluene (BHT) or butylhydroxy anisole (BHA). However, in certain other food systems the synthetic antioxidants were more effective to increase the shelf life and the stability of foods than those containing tocopherols.

Man and Tan (1999) studied the effects of natural and synthetic antioxidants on changes in refined, bleached, and deodorized (RBD) palm olein during deep-fat frying of potato chips. The systems were RBD palm olein without antioxidant (control), with 200 ppm butylated hydroxytoluene (BHT), 200 ppm butylated hydroxyanisole (BHA), 200 ppm oleoresin rosemary, and 200 ppm sage extract. Fried oil samples were analyzed for peroxide value (PV), thiobarbituric acid (TBA) value, iodine value (IV), free fatty acid (FFA) content, polymer content, viscosity, E1% 1 cm at 232 and 268 nm, colour, fatty acid composition, and C18:2/C16:0 ratio. Generally, in the oil, oleoresin rosemary gave the lowest rate of increase of TBA value, polymer content, viscosity, E1% 1 cm at 232 and 268 nm compared to control and three other antioxidants.

The order of effectiveness ($P < 0.05$) in inhibiting oil oxidation in RBD palm olein was oleoresin rosemary > BHA > sage extract > BHT > control.

Nor *et al.* (2009) studied the antioxidative properties of curcuma longa leaf extract in accelerated oxidation and deep frying studies. The extract was capable of retarding oil oxidation and deterioration significantly at 0.2% concentration, better than 0.02% BHT for the Oxidative Stability Index (OSI) in an accelerated oxidation study and also the peroxide value in deep frying studies. Curcuma longa leaf extract, which had a polyphenol content of 116.3 ± 0.2 mg/g, possessed heat-stable antioxidant properties and may be a good natural alternative to existing synthetic antioxidants in the food industry.

2.5 Suitability of type of oil for frying snack foods

Naghshineh *et al.* (2010) studied the effect of saturated/ unsaturated fatty acid ratio on physicochemical properties of palm olein–olive oil blend. The physicochemical properties of oil samples namely iodine value, peroxide value (PV), anisidine value, TOTOX value (total oxidation value, TV), free fatty acid (FFA), cloud point, color and viscosity were considered as response variables. Apart from FFA, all the response variables were significantly influenced by type and concentration of oils. The oil blend containing 10% POO (palm olein oil) and 90% OO (Olive oil) showed the highest TV (6.10); whereas the blend containing 90% POO and 10% OO exhibited the least TV (2.41). This study indicated that the chemical stability of oil blend significantly (P\0.05) increased with increasing the proportion of polyunsaturated/monounsaturated fatty acid.

Kiatsrichart *et al.* (2003) studied the pan-frying stability of nusun oil, a mid-oleic sunflower oil. The food oil sensor values increased from zero to 19.9 for the canola sample and from zero to 19.8 for the mid-oleic sunflower sample after 24 min of heating. The apparent first-order degradation rate for the mid-oleic sunflower sample was 0.102 ± 0.008 per min, whereas the rate for the canola sample was 0.092 ± 0.010 per min. The acid value increased from approximately zero prior to heating to 1.3 for the canola sample and from zero to 1.0 for the mid-oleic sunflower sample after 24 min of heating.

Normand *et al.* (2006) performed the comparison of the frying stability of regular and high-oleic acid sunflower oils. The rate of FFA formation was greater for HOSFO than RSFO during 72 h of frying. The content of tocopherols was much higher in RSFO and their degradation was markedly slower than that observed for HOSFO.

Karakaya and Simsek (2011) studied the changes in total polar compounds, peroxide value, total phenols and antioxidant activity of various oils used in deep fat frying. The amount of TPC in corn, soybean and olive oils increased significantly with the time increment. The PV of the oils did not exceed the maximum acceptable limit of 10 mequiv O_2/kg after 125 min frying except for hazelnut oil (10.64 mequiv O_2/ kg). Deep-fat frying did not cause any significant change in the TP of corn oil, soybean oil and olive oil. A significant decrease in the antioxidant activity was observed after 50 min frying using hazelnut oil and corn oil. However, the antioxidant activity of soybean oil and olive oil significantly decreased after 75 and 25 min frying, respectively.

Sandhya Rani *et al*. (2010) studied the quality changes in *trans* and *trans* free fats/oils and products during frying. The oxidative stability as determined by peroxide, anisidine values and TOTOX number, increased whereas the total unsaturated fatty acids and iodine value decreased with time of heating in all the samples. The *trans* free speciality fat was as stable as vanaspati showing similar quality parameters, while sunflower oil showed a higher degree of deterioration.

The layered fat used for traditional products such as *Chiroti* dough consisted 14% *trans* fatty acids (TFA), which was reduced to 4–7%, and correspondingly 18:2 was increased in the product upon frying in sun-flower oil. Accordingly, *trans* fatty acids increased in the medium from 0 to 7.5%. *Chiroti* when fried in vanaspati with TFA 18%, their content in both products (16%) and in medium (17%) remained similar.

Houhoula *et al.* (2002) studied the kinetic study of oil deterioration during frying and a comparison with heating. The results showed that the content of polar compounds, conjugated dienes, conjugated trienes, and *p*-anisidine value (*p*-AV) increased linearly with the time of frying at a rate depending on temperature. The rate constants showed a significant but low increase with temperature, except for the rate constant of conjugated trienes that was not correlated to frying temperature. The FA content, as a function of process time during frying at 185°C, showed a significant increase in palmitic acid (C16:0) and a significant decrease in linoleic acid (C18:2). Oleic acid (C18:1) also showed a small but significant decrease. The same results were obtained for the oil heated at 185°C. Examination of *p*-AV or conjugated dienes with polar compounds showed that both *p*-AV and conjugated dienes had a linear relationship with total polar compounds, with correlation coefficients of 0.946 and 0.862, respectively.

Tarmizi and Ismail (2008) performed the comparison of the frying stability of standard palm olein (SPOo) and special quality palm olein (SQPOo). The rate of free fatty acid (FFA) formation was slightly higher for SPOo than SQPOo during 56 h of frying. An equilibrium state was reached at around 40 h for SPOo and 32 h for SQPOo, whereby FFA varied within a narrow range of 0.30–0.32 and 0.22–0.25%, respectively. The SPOo had higher levels of polar compounds, averaging 11.8%, compared to the 10.2% in SQPOo. However, SPOo had lower levels of polymer compounds compared to SQPOo, averaging 2.1 and 2.5%, respectively. Hence, this work confirms that frying performance using SPOo was comparable to SQPOo for use in industrial production of snack foods (potato chips).

Loh *et al* (2006) studied the oxidative stability and storage behaviour of fatty acid methyl esters derived from used palm oil. Frying oil methyl esters (UFOME) obtained can be treated with different types of antioxidants, either synthetic or natural, at different treatment levels, such as vitamin E, 3-*tert*-butyl-4- hydroxyanisole (BHA), 2,6-di-*tert*-butyl-4-methyl-phenol (BHT), 2,5-di-*tert*-butyl hydroquinone (TBHQ), and *n*-propyl gallate (PG), to investigate their oxidative stability and storage behaviour. The order of increasing antioxidant effectiveness with respect to the oxidative stability of UFOME is: vitamin E < BHT < TBHQ < BHA < PG. Because methyl esters derived from residual oil of SBE have an induction period of 14.6 h, their treatment with antioxidants is unnecessary.

Ebong *et al*. (1999) studied the Influence of palm oil (*Elaesis guineensis*) on health. Studies have revealed that relative to fresh palm oil, oxidized palm oil induces an adverse plasma lipid profile, free fatty acids, phospholipids and cerebrosides. Additionally, oxidized palm oil induces reproductive toxicity and organotoxicity particularly of the kidneys, lungs, liver and heart. Available evidence suggests that at least part of the oxidized oil impact on health reflects generation of toxicants due to oxidation. The reduction of the dietary level of oxidized oil and/or the level of oxidation may reduce the health risk associated with consumption of oxidized fats.

Frying stability of canola oil blended with palm olein, olive, and corn oils was studied by Farhoosh *et al.* (2009). The fatty acid composition, peroxide value (PV), acid value (AV), iodine value (IV), total tocopherols (TT) content, and total phenolics (TP) content of canola oil (CAO), palm olein oil (POO), olive oil (OLO), corn oil (COO), and the binary and ternary blends of the CAO with the POO, OLO, and COO were determined. In general, frying stability of the CAO was significantly (P\0.05) improved by the blending, and the frying performance of the ternary blends was found to be better than that of the binary blends.

Kalogianni *et al.* (2009) studied the effect of the presence and absence of potatoes under repeated frying conditions on the composition of palm oil. The presence of potatoes during frying in palm oil increased the concentration of polymerization products and polar compounds compared to oils without potatoes significantly. The effects of frying load on oil quality depended on frying time. No significant effect of frying load was observed up to frying times of 13 h (or 10 frying batches). However, frying oil quality was affected by frying load once frying times exceeded 24 h (or 20 batches).

Warner and Fehr (2008) studied the mid-oleic/ultra low linolenic acid soybean oil (MO/ULLSBO). Frying oils were analyzed for total polar compounds to determine the frying stability of the oil. Tortilla chips were analyzed for hexanal as an indicator of oxidative deterioration. Results showed no significant differences between the total polar compound levels for MO/ULLSBO and hydrogenated soy bean oil (HSBO) after 55 h of frying, indicating a similar fry life. However, total polar compound levels for ULLSBO and SBO were significantly higher than for either MO/ULLSBO or HSBO, indicating a lower oil fry life. Based on these results, MO/ ULLSBO not only had a good fry life but also produced oxidatively stable fried food, and therefore would be a healthful alternative to HSBO.

Gharachorloo *et al.* (2010) studied the effects of microwave frying on physicochemical properties of frying and sunflower oils. The results obtained from the chemical tests demonstrated that used frying oil had lower polar compounds, a higher induction period, and more saturated fatty acids than sunflower oil. The interesting point observed was that peroxides formed as the result of oxidation chain reactions were not broken down and were built up due to the lower temperature and shorter period of frying.

2.6 Assessment of rancidity of oil and oil products

Allendorf *et al.* (2012) performed Application of a Handheld Portable Mid-Infrared Sensor for Monitoring Oil Oxidative Stability. Aliquots were drawn at 5 day intervals and analyzed by benchtop and portable handheld mid-infrared devices (4,000–700 cm-1) and reference methods (IUPAC 2301, 2302, AOCS Cd 8-58, and Shipe 1979. Models developed from reference tests and handheld spectra showed prediction errors (SECV) of 1 meq/kg for peroxide value, 0.09% for acid value and 2% for determination of unsaturated fatty acids in different oils. Spectral regions *3,012–2,850 cm-1 (C–H stretching bands/shoulders of fatty acids), *1,740 cm-1 (C=O stretching of esters), and *1,114 cm-1 (–C–O stretching) were found to be important for prediction. Handheld-FTIR instruments combined with multivariate-analysis showed promise for determination of oil quality parameters.

Ramadan (2010) performed the Rapid antiradical method for screening deep fried oils. In this rapid method, the neutralization of the stable radical 2, 2-diphenyl-1-picrylhydrazyl (DPPH) by antioxidants present in the oil during frying was measured. Radical scavenging activity (RSA) of different oils and oil blends was recorded during frying. The preliminary results obtained suggest that antiradical measurement could be used to quantify the oxidative and hydrolytic deterioration of vegetable oils during deep frying.

2.7 Value added products from sunflower seeds

Gopika (2009) studied the evaluation of sunflower seed kernels for preparing shelf stable added value food products. Five products namely chikki, caramel, butter, spicy snacks and hurigalu were standardized with sunflower either 100 percent or 50 percent substitution with ground nut. Three varieties of sunflower namely, KBSH 44, KBSH 41 and confectionery-1 were evaluated. Percent free fatty acid and peroxide values were higher in ground nut and KBSH 41 compared to rest. All the products were accepted by semi trained judges. Stored products showed good shelf life in laminated pouches and glass jar. Peroxide value and free fatty acid content of stored products were within the safe valley.

Leelavathi *et al.* (1991) conducted a study on the utilization of sunflower kernels in bakery products. Roasted sunflower grits showed that the overall quality of the bread was not changed up to 10 per cent level, while at the same level defatted sunflower flour significantly lowered the overall quality. Use of roasted grits improved the taste of biscuits and it could be used up to 20 per cent level without affecting the overall quality. On the other hand, sunflower flour lowered the overall quality even at 10 per cent level of incorporation. Incorporation of either defatted flour or roasted grits improved the taste of cakes while the overall quality improved with the increase in the level of roasted grits even up to 30 per cent level.

Wills *et al.* (1984) studied the enrichment of biscuits with sunflower protein. Sunflower flour and sunflower protein isolate were added to biscuits as a replacement for wheat flour. Up to about 20 per cent replacement of wheat flour could be effected before any significant change in sensory properties was detected by a taste panel or there was any deleterious effect on the baking qualities of the dough mixture.

Bajaj *et al.* (1991) conducted a study on the development of nutritious cookies utilizing sunflower seed kernels and wheat germ. Wheat germ and sunflower kernels were substituted at a level of 0, 5, 10, 15, 20, 25 and 30 per cent of wheat flour for the preparation of cookies. The crude protein, ash and crude fibre contents increased with the addition of sunflower kernels and wheat germ. The cookies containing 30 per cent wheat germ and 20 per cent sunflower kernels were found to be superior in overall acceptability. Nutritious cookies can be prepared by replacing wheat flour with sunflower kernels or wheat germ up to a level of 20 per cent without adversely affecting the overall acceptability of the product.

Gupta *et al.* (1996) studied the characteristics of cookies and muffins supplemented with full fat sunflower grits. Cookies and muffins prepared by supplementing sunflower grits were evaluated for sensory and chemical attributes. Scores of organoleptic evaluation suggested that overall acceptability of the cookies was adversely affected by replacement of wheat flour with sunflower grits, where as that of the muffins was adversely affected, if the replacement of wheat flour with sunflower grits exceeded 10 per cent level. Chemical analysis showed that in cookies, the average crude protein, ash, ether extract and crude fibre increased significantly by 46.42, 140.82, 24.07 and 37.08 per cent and in muffins by 41.47, 82.15, 13.17 and 112.68 per cent respectively. In supplemented cookies, average available lysine, methionine, cystine, and tryptophan contents increased by 17.17, 11.20, 10.91 and 12.71 per cent respectively.

Pawar and Machewad (2004) studied the organoleptic quality of bread enriched with high protein products from sunflower meal. Defatted sunflower flour meal could be added to the wheat flour up to 10% level without much adverse effects on both physico-chemical characteristics of dough and the bread prepared from the same.

Srilatha and Krishnakumari (2003) studied proximate composition and protein quality evaluation of recipes containing sunflower cake. Traditional recipes for *chapatis* (a shallow fried item), biscuits and *pakodis* (a deep fried item) were modified to incorporate whole, dehulled and partially dehulled cake at 10 and 20 per cent levels of the mix. The proximate compositions of sunflower cake and sunflower cake containing recipes were analyzed. Incorporation of sunflower cake into recipes at 10 and 20 per cent levels contributed a significant increase in protein and fibre values. There was 4.7 to 5.8 per cent increase in protein and a 2.2 to 6.0 per cent increase in fat contents of the products containing 20 per cent cake. Among the three recipes, *pakodi* containing 10 per cent sunflower cake was found most acceptable, hence selected for evaluation of protein quality. The PER value of *pakodis* containing partially dehulled cake was 2.17, followed by *pakodis* containing whole seed cake with a PER of 1.95. Digestibility coefficient (DC) of *pakodi* containing partially dehulled sunflower cake was 89 per cent and that with whole seed cake was 86 per cent.

Hegazy *et al.* (1991) peanut hull flour (49% fibre content) was used in preparation of low calorie cakes by replacing wheat flour at different levels (10, 20 and 30%). Cakes were subjected to physical and sensory evaluations. Flavour and general acceptability of cakes prepared with 30 per cent peanut hull flour was significantly less than that of cakes prepared with 10 and 20 per cent which scored values closer to those of control cakes.

Gupta and Sharma (2007) conducted a study on textural profile analysis of sunflower-sesame kernel confection (chikki). The quality attributes measured were hardness, cohesiveness, springiness, chewiness and resilience. The highest values of hardness, chewiness and resilience were attained for the snacks prepared using jaggery (brown sugar): sunflower kernel: sesame kernel in the ratio of 50:35:25. The highest values of cohesiveness and springiness were observed with 50:25:15 (jaggery: sunflower: sesame) proportions. The sensory term overall acceptability of the snacks is significantly correlated with instrumental cohesiveness, springiness and chewiness, which are the desired quality attributes of the snacks. The confection (chikki) prepared taking jaggery, sunflower and sesame kernels as ingredients are an organoleptically accepted product.

Dreher *et al.* (2006) conducted a study on sunflower butter. Sunflower butter was found to have a good overall nutritional value with a protein quality approximately equal to that of peanuts. Roasting conditions had a significant impact on nutritional and sensory quality, colour and spreadability of sunflower butter. Taste panelists generally rated sunflower butter lower than peanut butter.

Gupta *et al.* (2007) performed instrumental texture profile analysis of shelled sunflower seed caramel snack using surface methodology. The textural profile analysis was conducted on the snacks using a texture analyzer. The quality attributes measured were hardness, cohesiveness, springiness, chewiness, and resilience as a function of sugar and sunflower kernels content. The sugar and shelled seed proportions affect the textural characteristics of the product significantly. The values of hardness, cohesiveness, springiness, chewiness, and resilience varied from 2.048 to 42.030, 1.002 to 5.003, 1.138 to 1.69, 2.773 to 228.146, and 0.301 to 0.779, respectively. The highest values of hardness and chewiness were attained for the product with 70:30 sugar and shelled sunflower seed proportion respectively. Similarly the highest values of cohesiveness, springiness and resilience were observed in 50: 30, 50:40, and 50:50 proportions respectively. The lowest values of hardness and chewiness were observed in 50:50 (sugar: shelled sunflower seed) proportion respectively. Similarly the lowest values of cohesiveness were observed in 70:50 whereas the lowest values of springiness and resilience were observed in 70:30 proportions respectively. Hardness, cohesiveness and chewiness tended to increase whereas springiness and resilience decreased with increase in sugar proportion.

Gajera *et al.* (2008) studied the influence of peanut butter on quality characteristics of biscuits. Biscuits were prepared by replacing hydrogenated fat (vanaspati) with peanut butter in the ratios 100:00, 75:25, 50:50, 25:75, 0:100 in the standard biscuit recipe, and their quality evaluated. There was an increase in the protein content with a decrease in total fat content when the proportion of peanut butter increased in the biscuits. Sensory acceptability of the biscuit was better when vanaspati was substituted by 50 per cent peanut butter.

Paraskova *et al.* (2001) conducted a study to determine the level of acceptance by Bulgarian consumers (N=601) of three American cultivars of roasted peanuts and to identify the type of commercial peanut butter preferred using sensory affective tests. The products evaluated were roasted peanuts (Spanish type, cv. Georgia Green, and cv. Flavorunner) and three types of commercial American peanut butter [very low sodium (creamy, regular creamy and extra crunchy]. The mean overall acceptability rating for roasted flavoured peanuts (6.9, like slightly) was significantly higher ($P \leq 0.05$) than that for georgia green (6.1, like slightly, which was significantly higher than for Spanish type (5.6, neither like nor dislike). Mean overall acceptance of extra crunchy peanut butter was higher (6.7, like slightly; $P \leq 0.05$) than acceptance of regular creamy (6.4, like slightly) and very low sodium (5.4, neither like nor dislike) types. Consumers rated the overall acceptance of regular creamy peanut butter higher ($P \leq 0.05$) than that of very low sodium creamy peanut butter. Results of the survey indicated good potential for sale of georgia green and flavored roasted peanuts and extra crunchy and regular creamy peanut butter in Bulgaria.

Ahmed and Ali (1986) conducted a study on textural quality of peanut butter as influenced by peanut seed and oil contents. Oil content peanut seed content and the interaction of both influenced the textural quality of peanut butter. Spreadability as measured by sensory methodology as well as instrumental measures indicated better quality as percent oil increased from 90-95 per cent. The higher peanut seed content had a significant improvement on the spreadability of the butter containing 40 per cent oil with no influence for the 50 per cent oil sample.

Gatta and Piergiovanni (1996) studied the effects of incorporation of defatted sunflower (*Helianthus annus* L.) meal into wheat bread at levels of 5-20 per cent on bread quality (as assessed by protein and trypsin inhibitor content, loaf vol. and wt., and appearance) was investigated. Bread containing 10 per cent sunflower meal was found acceptable. Although incorporation of sunflower meal improved protein content of bread, it also greatly increased levels of trypsin inhibitors in bread thus partially eliminating the nutritional benefits of incorporating sunflower meal.

Das *et al.* (2005) conducted a study on nutrient composition of some nuts and oilseeds based recipes of Assam, India. The study revealed that all recipes are energy dense. Protein content of groundnut chikki was observed to be 6.2g, fat 11g, minerals 0.9g, crude fibre 0.6g, carbohydrates 76.1g, energy 428kcal, calcium 26mg and that of iron was 3mg/100g of sample.

San Juan *et al.* (2005) conducted a study on consumer-based optimization of peanut-chocolate bar using response surface methodology. The acceptability of the sensory properties of a peanut-chocolate bar was optimized for consumer acceptance using response surface methodology. The factors studied included sugar, peanuts, cocoa powder and a process variable, degree of roast. Twenty-seven peanut-chocolate bar formulations with two replications were evaluated for consumer acceptance (n=168) for overall liking and acceptance of colour, appearance, flavour, sweetness and texture using 9-point hedonic scales. In terms of overall liking, the use of dark-roasted peanuts received the largest number of acceptable formulations when compared to the medium and light-roasted peanuts. Sensory evaluation indicated that sweetness acceptance was the limiting factor for acceptability. An acceptable peanut-chocolate bar can be obtained by using formulations containing 44-54 per cent dark-medium or light-roasted peanuts.1-4 per cent cocoa powder and 41-55 per cent sugar.

Sheppard and Rudolf (1991) examined the peanuts and peanut products for total lipids, fatty acids and proximate. The four major types and several peanut products were analyzed for total lipids, fatty acids content, fat, ash and protein. No significant differences in fat, ash or protein content were found between the various peanut types. Peanut products did not always exhibit the same fatty acid and sterol profiles as peanuts.

Materials and Methods

III. MATERIAL AND METHODS

The methodology used in the study has been discussed under the following headings.

3.1 Procurement of sample

3.2 Dehulling of sunflower seeds

3.3 Effect of frying oils

3.4 Effect of antioxidants

3.5 Development of shelf stable product

- 3.5.1 Fried products
- 3.5.2 Non fried products

3.6 Storage study

- 3.6.1 Shelf life of fried seeds
- 3.6.2 Shelf life of products
  - 3.6.2.1 Fried products
  - 3.6.2.2 Non fried products

3.7 Sensory evaluation

3.8 Functional properties

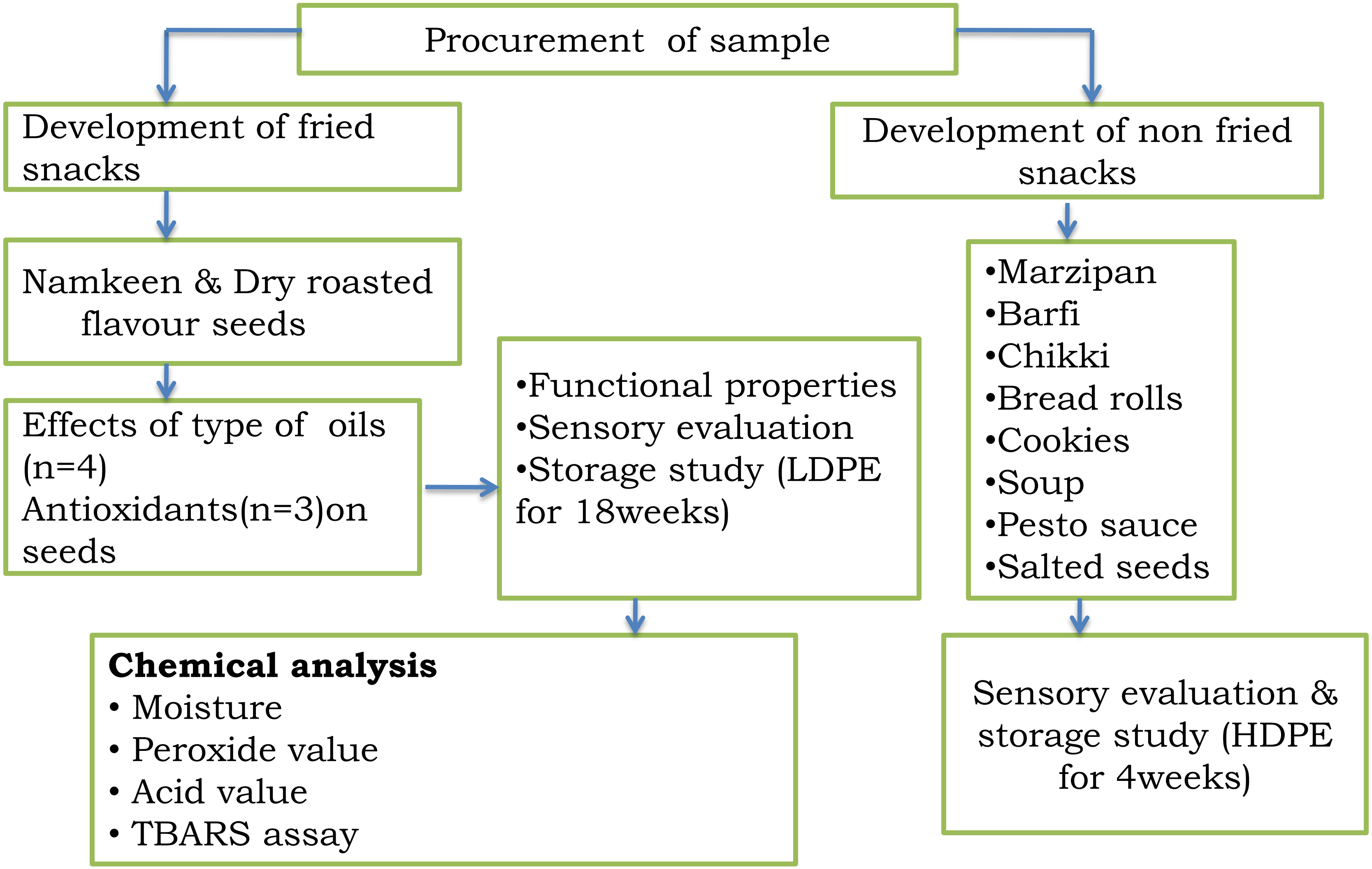
3.9 Method of analysis

- 3.9.1 Moisture
- 3.9.2 Estimation of total lipids
- 3.9.3 Peroxide value
- 3.9.4 Acid value
- 3.9.5 TBARS assay

3.10 Nutrient composition of the developed products

3.11 Cost of production

3.12 Statistical analysis



STUDY DESIGN

3.1 Procurement of the sample

The sunflower seed genotype used for the study is KBSH 44. The samples were procured from All India Coordinate Research Project on Sunflower, UAS, GKVK, Bangalore. Other samples like almonds, cashew nuts, poppy seeds, walnuts, ground nuts and melon seeds and different types of oil such as palmolein oil, sunflower oil, ground nut oil and vanaspati were procured from the local market in Bangalore.

3.2 Dehulling of sunflower seeds

Dehulling was done mechanically. Sunflower seeds were cleaned, graded and dehulled by agitating in mixer fitted with disc type blade. The seeds were allowed to agitate in slow speed for one minute. The dehulled product was winnowed for the separation of kernels, hull and unhulled seeds. Hulled kernels were used in the study (Gopika, 2009).

3.3 Effect of frying oils

Sunflower seeds were fried using four types of oils like ground nut oil, palmolein, vanaspathi and sunflower oil. Fried seeds were evaluated by a panel of semi trained judges (n=20). The products were evaluated for variables - Appearance, Texture, Aroma, Taste and Overall acceptability on a nine point hedonic scale. Where 9=like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5=neither like nor dislike, 4=dislike slightly, 3=dislike moderately, 2=dislike very much, 1= dislike extremely. Score sheet used for the evaluation of products is included in **Annexure-I.**

3.4 Effect of antioxidants

The antioxidants used for frying the seeds were vitamin E (120mg/100g of oil), BHA (0.02%) and citric acid (1%). Oil without any antioxidants was served as control. These levels were in confirmation with FSSAI (2006).

Type of oil	Antioxidants
Refined sunflower oil	Control
	Vitamin E
	BHA
	Citric acid
Refined sunflower oil+ vanaspati	Control
	Vitamin E
	BHA
	Citric acid
Refined palmolein oil	Control
	Vitamin E
	BHA
	Citric acid

3.5 Development of shelf stable products

The following products were selected for the study. There method of preparation is included in subsequent paragraphs.

Sl No	Fried products
1	Namkeen
2	Dry roasted favoured seeds
	Non fried products
3	Chikki
4	Barfi
5	Marzipan
6	Cookies
7	Bread
8	Pesto sauce
9	Soup
10	Salted seeds

Weighed amount of palmolein oil was heated in a pan and the beaten rice and dehulled seeds were deep fried separately

↓

Both the ingredients were mixed and excess fat was taken off on the absorbent paper

↓

Then the mixture was seasoned with curry leaves, dry coconut, raisins and red chilli and were stored in a plastic jars

Fig. 1: Flow chart for the preparation of namkeen

Weighed amount of dehulled sunflower seeds were coated with spice mix

↓

Then the seeds were spread on the non stick cookie sheet in a single layer and baked at 90°c for 30 min

↓

Cooled at room temperature and oil was sprayed onto the seeds and seasonings were added and stored in plastic jars.

Fig. 2: Flow chart for the preparation of dry roasted sunflower seeds

Weighed amount of seeds and sugar were powdered together in a blender

Syrup was prepared with sugar and water

Soft dough was made with powdered sugar and nut seeds with the help of syrup

Rolled into thick sheet and cut to diamond shape, wrapped in suitable packaging material and sealed.

Fig. 3: Flow chart for the preparation of Barfi

Weighed amount of jaggery was heated in a pan with little amount of water to a temperature of approximately 115-118°C

↓

At this temperature weighed amount of roasted seed kernels were transferred to the pan and mixed well and cooked for 30 sec to attain a semisolid consistency

↓

Hot mixture was poured to an oiled wooden board and was spread and rolled to a thickness of 5mm

↓

The rolled spread was then cut into square slabs and removed from the board and cooled to room temperature

↓

Chikki was wrapped in suitable packaging material and sealed

Fig. 4: Flow chart for the Preparation of Chikki

Weighed amount of dehulled seeds and sugar was powdered in a blender

↓

Syrup was prepared with sugar and water

↓

Soft dough was made with powdered mixture with the help of syrup

↓

Food colours and granulated sugar were added to the dough and were made into shapes and wrapped in suitable packaging material

Fig. 5: Flow chart for the preparation of marzipan

Weighed amount of icing sugar was taken on a
flat surface and margarine, vanilla essence,
maida flour, seeds were added and the
mixture was kneaded by adding
Cold milk.

↓

The dough was rested for half an hour

↓

Dough was rolled, cut into squares baked
at 200°C for 15 min. and wrapped in suitable
packaging material

Fig. 6: Flow chart for the preparation of cookies

Weighed amount of salt, sugar and yeast was dissolved in water, Maida and margarine was added and made into dough

↓

The dough was kept aside for about 30 – 40 minute

↓

The dough was made into a shapes or rolls and kept for 10 min

↓

Milk was applied on the top and seeds were sprinkled and baked at 180°c for 20 min

Fig. 7: Flow chart for the preparation of bread rolls

Weighed amount of basil leaves were cleaned and washed, garlic was peeled, cheese was grated and dehulled seeds were added

↓

All the ingredients were combined and ground into a smooth paste

↓

Seasonings were used to the sauce as required and stored in a glass jars

Fig. 8: Flow chart for the preparation of pesto Sauce

Weighed amount of dry tomatoes and dehulled
Seeds were powdered

↓

Then garlic salt, oregano, parsley, pepper
powder, garam masala and a pinch of
sugar were added

↓

Powder was mixed with water and boiled
for 5-10 minutes

Fig. 9: Flow chart for the preparation of soup

Weighed amount of salt was taken in cold water and whole sunflower seeds were added and boiled for two hours

↓

Then seeds were taken out and spread on the baking sheet and roasted in the oven for 30 min

↓

Olive oil was sprayed onto the seeds and seasoned with garlic or onion powder and salt

Fig. 10: Flow chart for the preparation of salted sunflower seeds

3.5.1 Fried products

Fried products such as Namkeens and dry roasted sunflower flavoured seeds were developed. Namkeens was developed using sunflower and other seeds such as fried gram, ground nut and cashew nut. Dry roasted sunflower flavoured seeds were developed by incorporating different flavours to the sunflower seeds. The basic method of preparation is shown in flow charts (Fig. 1and 2) and the ingredient composition is provided in **Annexure-II.**

3.5.2 Non fried products

Non fried products such as chikki, barfi, marzipan, bread, sauce, soup, cookies and salted seeds were developed. Products were prepared by using sunflower seed kernels and other seeds like ground nut seeds, cashew nut, almond, walnut, poppy seeds, sesame seeds and melon seeds. The products were prepared alone for comparative evaluation. . The basic method of preparation is shown in flow charts (Fig.3 to 10) and the ingredient composition is provided in **Annexure-II.**

3.6 Storage studies

3.6.1 Shelf life of fried seeds

20 g of samples were packed in individual HDPE packets and stored in ambient conditions at room temperature (25-30^{o}C) and relative Humidity (40-60%).samples were drawn in triplicates for every storage interval i.e. fresh, 6 week, 12 weeks and 18 weeks. Storage period was for 6 months. In all for each variation 12 packets were stored. Shelf life of fried seeds with different oils (paragraph 3.3) and antioxidants (Paragraph 3.4) were assessed through estimation of moisture content, peroxide value, acid value and TBARS assay. Methods for these estimations are provided in the later paragraphs.

3.6.2 Shelf life of products

3.6.2.1 Fried products

Shelf life of the fried products such as namkeens and dry roasted sunflower flavored seeds was evaluated. The products were stored for a period of 4 weeks at room temperature (25-30ºC) and relative Humidity (40-60%). Each product was stored in high density polyethylene and in PET jars and kept at room temperature. The products were packed in portioned individual packets to enable the removal for every storage interval.

Storage study interval: Weekly once

Parameters for evaluation: Appearance, Texture, Aroma, Taste, Overall acceptability and absence of rancidity.

3.6.2.2 Non fried products

Shelf life of the selected products such as chikki, barfi and cookies was evaluated. The products were stored for the period of 4 weeks at ambient room temperature (25-30ºC) and relative Humidity (40-60%). Each product was stored in high density polyethylene and kept at room temperature. The products were packed in portioned individual packets to enable the removal for every storage interval.

Storage study interval: Weekly once

Parameters for evaluation: Appearance, Texture, Aroma, Taste, Overall acceptability and absence of rancidity.

3.7 Sensory evaluation

Products developed were evaluated by a panel of semi trained judges (n=20). The products were evaluated for Appearance, Texture, Aroma, Taste and Overall acceptability on a nine point hedonic scale. Where 9=like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5=neither like nor dislike, 4=dislike slightly, 3=dislike moderately, 2=dislike very much, 1= dislike extremely. Score sheet used for the evaluation of products is included in **Annexure-I**. For the storage study a five point scale was used where 5= Excellent, 4= Good, 3= neither good nor bad, 2=Poor, 1=Very poor. Score sheet used for the evaluation of stored products is included in **Annexure-III**.

3.8 Functional properties

3.8.1 Fat absorption capacity (Rosario and Flores, 1981)

One gram sample was mixed with 10ml of either distilled water or in 15ml oil for 30min. The contents were allowed to stand at 30ºC in a water bath for 30min and then centrifuged at 3000-5000 rpm for 20-30 min. After centrifuging the volume of the supernatant was recorded and used for determination of water and oil absorption and the results were expressed as ml/g sample.

3.8.2 Volume expansion

The volume of 100g of each sample was determined by gently pouring the grain into a 250 ml graduated cylinder. The volume was recorded in ml for bulk density. The values for bulk density were expressed as g/ml. Percent increase in the volume of fried seeds over raw seeds was expressed as volume expansion (%).

3.9 Methods of analysis

3.9.1 Moisture estimation (AOAC, 1980)

Moisture was determined by taking about 10 g of sample in petridish and dried in an oven at 105º C till the weight of the petridish with its content was constant. Each time before weighing, the petridish was cooled in desiccators. Moisture content of the sample was expressed in g/100g of sample.

$$\text{Moisture content (g/100g)} = \frac{\text{Initial weight (g) - Final weight (g)}}{\text{Weight of the sample (g)}} \times 100$$

3.9.2 Estimation of total lipids (Bligh and Dyer, 1959)

Total lipids were estimated using the Bligh and Dyer method. The lipids extracted in a mixture of chloroform and methanol (2:1 v/v) **(Annexure- IV).**

3.9.3 Peroxide value (Raguramulu *et al.,* 2003)

0.5 to 1g of clear melted fat was weighed accurately in the boiling flask. To this 30 ml of acetic acid-chloroform mixture was added and fat was dissolved. 1ml of saturated potassium iodide was added. After 5min 100 ml of distilled water was added. The liberated iodine was titrated against N/1000ml sodium thiosulphate. When the end point approached 1ml of freshly prepared starch was added and titration was completed till the blue colour disappears. Blank was carried out using all the reagents without the oil **(Annexure-V).**

Calculation:

$$\text{Peroxide value of oil (meq/kg of sample)} = \frac{\text{(Titre-blank) x N x 1000}}{\text{Weight of oil (g)}}$$

3.9.4 Acid value (Raguramulu *et al.,* 2003)

Acid value of seed oil was determined according to AOAC Official Method. Percentage free fatty acids (FFAs) were calculated using oleic acid as a factor **(Annexure-VI).**

$$\text{Acid value} = \frac{\text{a x 0.00561 x 1000}}{\text{wt (g) of substance}}$$

3.9.5 TBARS assay (Raghuramulu *et al*., 2003)

One gm of fat sample was dissolved in 10 ml of carbon tetrachloride, to which 10 ml of TBA reagent was added. The tubes were immersed in the boiling water bath for 30 min and cooled. The absorbance was determined at 535 nm against a blank that contained all the reagents minus the lipids. The malondialdehyde concentration of the sample was calculated using the following formula **(Annexure-VII).**

$$\text{mg of malondialdehyde per 100g of sample} = \frac{0.4189 \times \text{OD of samlpe} \times 100}{1 \times \text{Wt of sample (g)} \times 1000}$$

3.10 Nutrient composition of the developed products

Nutritive value for all the added value food products were computed per 100g product using food composition tables **(Gopalan *et al.,* 2007).**

3.11 Cost of production

Cost of production of sunflower seeds and its products were calculated by taking into consideration only the variables such as ingredients, electricity and labour expenses. The fixed cost such as equipment and infrastructure was not factored into the calculation **(Annexure-VIII).**

3.12 Statistical analysis (Fisher and Yates, 1963)

The data was tabulated keeping in view the objectives of the study. Analysis of variance technique (F-test) was employed for the chemical analysis and sensory characteristics to test the significant difference between varieties in the study. Two-way analysis of variance with three observations was employed for the storage study. The data was analysed using the mini tab software.

Experimental Results

IV. EXPERIMENTAL RESULTS

The results of the study conducted on "**Development of shelf stable products from sunflower seed kernels"** are presented in this chapter. Results of the study are presented under the following headings.

4.1 Effect of frying in different types of oils

- 4.1.1 Sensory evaluation of fried seeds with different oils
- 4.1.2 Functional properties of fried seeds

4.2 Effect of different antioxidants on shelf life of fried sunflower seeds

- 4.2.1 Sensory characteristic - rancidity
- 4.2.2 Moisture
- 4.2.3 Peroxide value
- 4.2.4 Acid value
- 4.2.5 TBARS assay

4.3 Development of fried products

- 4.3.1 Comparative evaluation of sensory characteristics for fried products
- 4.3.2 Shelf life studies of fried products

4.4 Development of non fried products

- 4.4.1 Comparative evaluation of sensory characteristics for non fried products
- 4.4.2 Shelf life studies of non fried products

4.5 Nutrient composition of the developed products

4.6 Cost of production

4.1 Effect of frying in different types of oils

Sunflower seeds were fried with different oils such as sunflower, palmolein, vanaspathi and groundnut to determine the effect on acceptability and functional properties. The results are explained in the paragraphs 4.1.1 and 4.1.2

4.1.1 Sensory evaluation of fried seeds with different oils

The Mean scores of sensory characteristics for fried sunflower seeds with different oils are presented in Table1 and Fig 11. The mean scores indicated that seeds fried with palmolein oil showed better acceptability (appearance-7.00, texture-7.4, colour-7.2, taste-7.6 and over all acceptability 8.00) compared to those fried in other oils. However, there was no significant difference among the different types of oil used to fry sunflower seeds.

4.1.2 Functional properties of fried seeds

Functional properties typical to frying operation such as fat absorption and volume expansion were used as a parameter to evaluate the suitability of type of oil for frying.

Fat absorption**:** The results for fat absorption are given in the Table 2. Fat absorption for sunflower seeds fried with ground nut oil and vanaspati (10.0 ml/g) was more followed by palmolein (8.75 ml/g) and sunflower oil (8.66 ml/g). However, there was not much variation observed in fat absorption for sunflower seeds fried with different oils.

Volume expansion**:** The mean scores of volume expansion for sun flower fried seeds with different oils are presented in the Table 2. Statistically there were no significant differences found in the volume expansion for sunflower seeds fried with different oils. However, ground nut oil (1.87%) had higher volume expansion followed by palmolein and vanaspathi (1.85%) and sunflower oil (1.84%).

Table 1: Mean scores of sensory characteristics for sunflower seeds fried with different oils

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Sunflower	6.8	7.4	6.6	7.0	7.4
Palmolein	7.0	7.6	7.2	7.6	8.0
Vanaspati	6.8	7.0	6.4	6.4	6.6
ground nut	7.0	7.0	6.8	6.8	7.4
F-value	NS	NS	NS	NS	NS
SEm±	0.58	0.5	0.35	0.48	0.49

NS: Non-significant

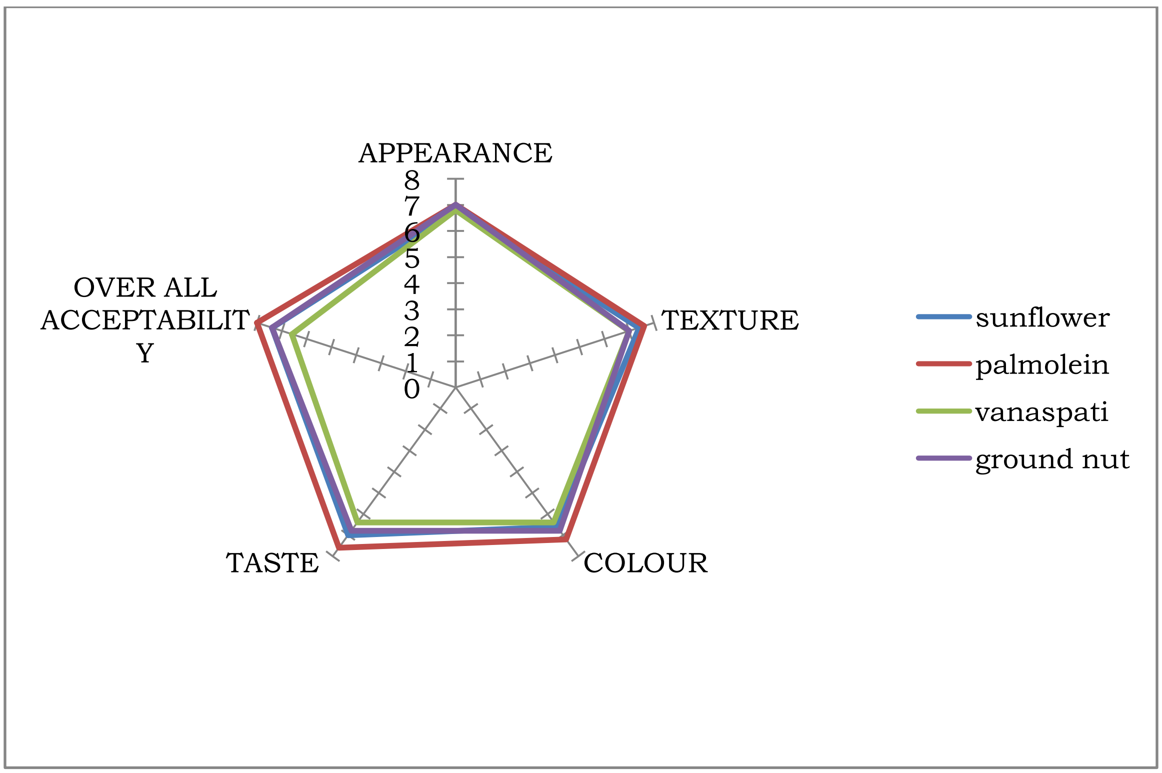


Fig. 11: Mean scores of sensory characteristics for sunflower seeds fried with different oils

Table 2: Mean scores of fat absorption and volume expansion for sun flower seeds fried with different oils

	Fat absorption (ml/g)	**Volume expansion (g/ml)**
Sunflower oil	8.66	1.84
Palmolein	8.75	1.85
Ground nut	10.00	1.87
Vanaspathi	10.00	1.85
F-value	NS	NS
SEm	0.88	0.02
CD	2.88	0.09

NS: Non-significant

4.2 Effect of antioxidants on shelf life of fried sunflower seeds

Anti-oxidant means a substance which when added to food retards or prevents oxidative deterioration of food and does not include sugar, cereal, oils, flours, herbs and spices. Types of antioxidants used were BHA, vitamin E and citric acid which are approved by FSSAI (2006). Presence of rancidity is the major constraint in the storage of fried seeds. Therefore to assess the presence of rancidity the following parameters were studied.

4.2.1 Sensory characteristic- rancidity

The oxidative stability of the oils treated with different antioxidants was determined by the presence of rancidity subjectively is indicated(†) in the Table 4.The rancid flavour was perceived or detected earliest in seeds fried in sunflower oil in 6^{th} week corresponding to peroxide value of 10.23-12.13 meq/kg. However, only in case of seeds fried in sunflower oil treated with BHA the samples remained free from rancid flavour. Addition of vanaspati in sunflower helped to stabilize the oxidative rancidity. Same was the case with palmolein.

4.2.2 Moisture content

Moisture is one of the important factor which is responsible for the deterioration of quality of the product during storage, as the duration of storage increases moisture content of the product registered a small but significant increase.

The mean scores for moisture content of the stored seeds fried with different oils (sunflower, sunflower + vanaspati and palmolein) treated with different antioxidants (vitamin E, BHA and citric acid) are presented in the Table 3 and Fig 12. It was observed that increase of moisture content of samples was from 4.40% to 5.66% for the seeds fried in sunflower oil, 4.21% to 4.79% for seeds fried in sunflower + vanaspati

Table 3: Moisture content (%) of stored sunflower seeds fried with different oils treated with different antioxidants

Treatments	FRESH			WEEK 6			WEEK 12			WEEK 18		
	Frying medium											
	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein
Control	4.43	4.22	4.10	4.96	4.48	4.22	5.36	4.72	4.43	5.81	5.10	4.71
Vitamin E	4.41	4.21	4.04	4.71	4.35	4.16	5.24	4.59	4.34	5.69	4.91	4.59
BHA	4.40	4.21	4.01	4.71	4.33	4.12	5.21	4.54	4.30	5.66	4.79	4.53
Citric Acid	4.43	4.21	4.07	4.88	4.05	4.22	5.31	4.67	4.37	5.76	4.97	4.66
SE	0.009			0.011			0.012			0.028		
CV	0.212			0.250			0.255			0.561		
F- value	*			*			*			*		
CD	0.015			0.018			0.020			0.048		

*Significant at 5% level

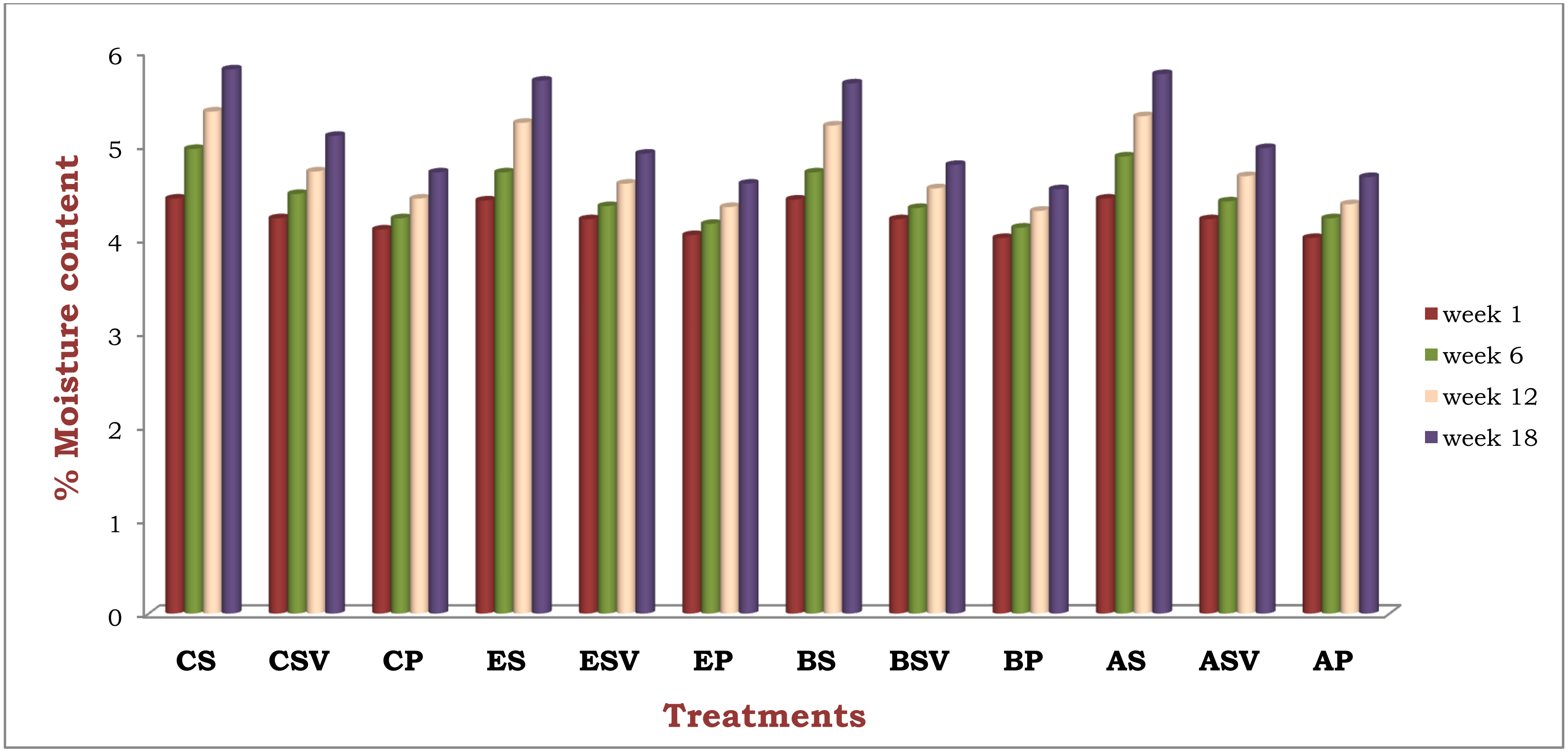


Fig. 12: Moisture content (%) of stored sunflower seeds fried with different oils using different antioxidants

CS- Sunflower control, **CSV**- sunflower +vanaspati control, **CP**- palmolein control, **ES**- sunflower + vitamin E, **ESV**-sunflower+vanaspati+vitamin E, **EP**-palmolein+vitamin E, **BS**-sunflower+BHA, **BSV**-sunflower+vanaspati +BHA, **BP**- palmolein+BHA, **AS**-sunflower+acid, **ASV**- sunflower +vanaspati+acid, **AP-** palmolein+acid and 4.01% to 4.53% for seeds fried in palmolein oil during storage. Although there was an increase in moisture content during storage in all the treatments, in case of those treated with BHA it was significantly lower throughout the storage period. The addition of BHA to palmolein further improved the oxidative stability when used as deep frying oil.

Statistically there was a significant difference for the moisture content of stored fried sunflower seeds with different oils treated with different antioxidants throughout the storage period.

4.2.3 Peroxide value

Hydroperoxides are the primary products of lipid peroxidation; therefore determination of peroxides can be used as oxidation index for the early stages lipid oxidation.

Peroxide value of stored sunflower seeds fried with different oils (sunflower, sunflower + vanaspati and palmolein) treated with different antioxidants (vitamin E, BHA and citric acid) are presented in the Table 4 and Fig 13. The results revealed the increase in peroxide value of control was from 3.36 meq/kg to 24.20 meq/kg for the seeds fried in sunflower oil, 3.05 meq/kg to 9.58 meq/kg for the seeds fried in sunflower + vanaspati and 1.6 to 8 for the seeds fried in palmolein treated with BHA compared to other antioxidants during the storage period. There was as steady increase in the peroxide value of the palmolein oil treated with the BHA during the storage (1.60, 4.50 and 6.35), but this was seen to be least in comparison to those treated vitamin E and citric acid. The lowest peroxide value at the end of storage was for palmolein oil treated with 0.02% BHA. Higher peroxide values were recorded for other two frying oils.

Table 4: Peroxide value (meq/kg) of stored sunflower seeds fried with different oils treated with different antioxidants

Treatments	FRESH			WEEK 6			WEEK 12			WEEK 18		
	Frying medium											
	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein
Control	3.36	3.05	1.60	12.13†	7.15	5.30	13.93†	7.75	7.30	24.20	9.85	8.00
Vitamin E	3.26	3.05	1.60	10.23†	5.05	3.30	13.80†	7.05	5.75	18.70	8.50	7.05
BHA	3.36	3.05	1.60	5.35	2.60	1.60	6.75	5.90	4.50	10.65	8.10	6.35
Citric Acid	3.30	3.05	1.60	10.80†	5.40	4.20	13.95†	8.15	6.10	19.16	9.40	7.43
SE	0.089			0.104			0.327			1.671		
CV	3.383			1.718			3.895			14.600		
F-value	*			*			*			*		
CD	0.151			0.176			0.552			2.816		

*significant at 5% level †presence of rancidity

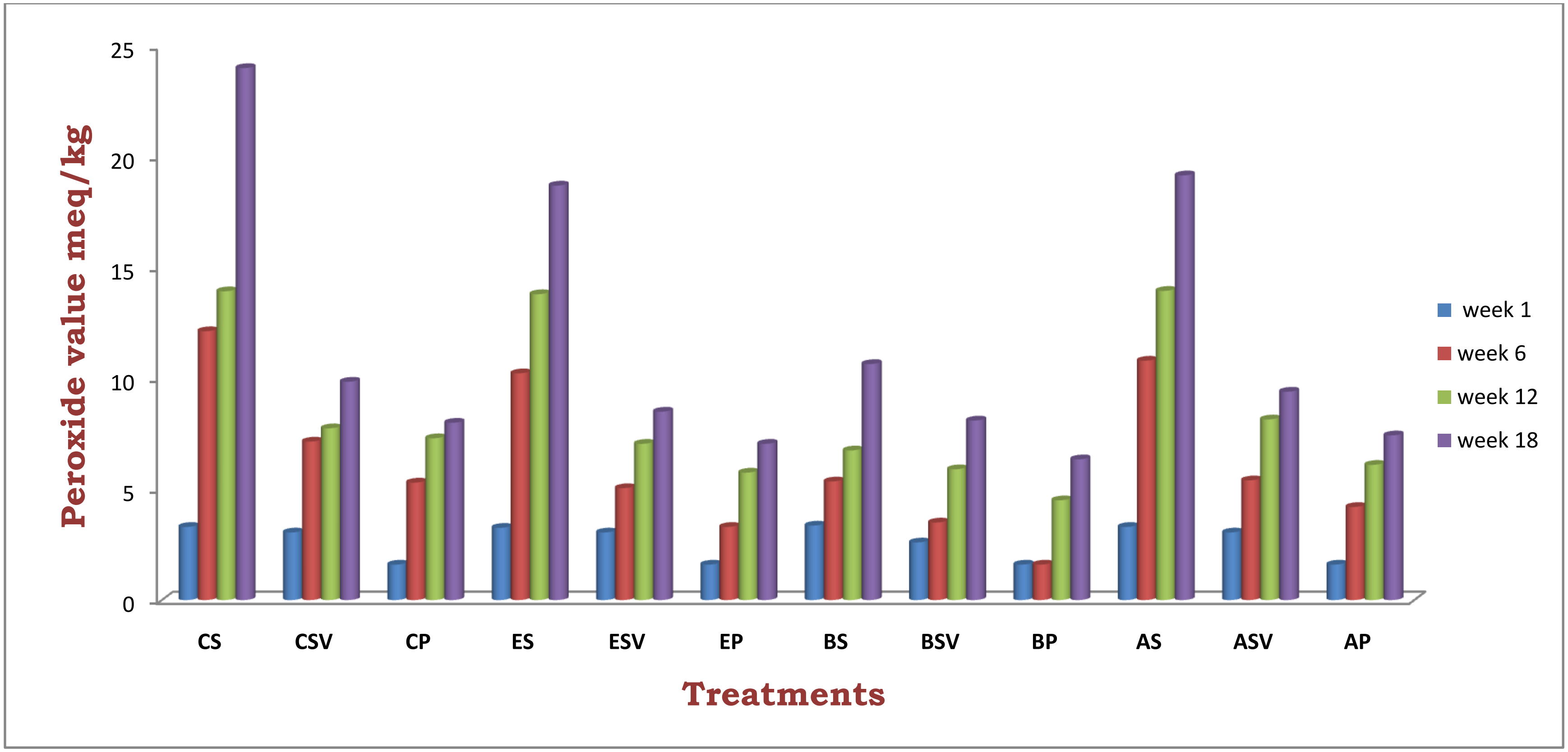


Fig. 13: Peroxide value (meq/kg) of stored sunflower seeds fried with different oils using different antioxidants

CS- Sunflower control, **CSV**- sunflower +vanaspati control, **CP**- palmolein control, **ES**- sunflower + vitamin E, **ESV**-sunflower+vanaspati+vitamin E, **EP**-palmolein+vitamin E, **BS**-sunflower+BHA, **BSV**-sunflower+vanaspati +BHA, **BP**- palmolein+BHA, **AS**-sunflower+acid, **ASV**- sunflower +vanaspati+acid, **AP-** palmolein+ acid

Statistically there was a significant difference for the peroxide value of stored fried sunflower seeds with different oils treated with different antioxidants throughout the storage period.

4.2.4 Acid value

It is one of the indicators used to assess the oil quality. The mean scores for acid value of the stored seeds fried with different oils (sunflower, sunflower + vanaspati and palmolein) treated with different antioxidants (vitamin E, BHA and citric acid) are presented in the Table 5 and Fig 14. It is apparent from the study that addition of the antioxidants like BHA, vitamin E and citric acid retarded the development of rancidity during storage in the sunflower seeds fried with different oils. Among the oils, palmolein treated with BHA recorded the lowest acid value compared to other oils. Among the antioxidants BHA results in better protection than vitamin E and citric acid.

Statistically there was a significant difference for the acid value of stored fried sunflower seeds with different oils treated with different antioxidants throughout the storage period.

4.2.5 TBARS assay

The TBA test has been widely used as an objective measure of secondary oxidation products of oils. It relates to the level of malondialdehyde formed during oxidation of lipids. It is assumed that accumulations of these products were responsible for the development of rancid odours and off-flavour of the oil.

The mean scores for TBARS value of the stored seeds fried with different oils (sunflower, sunflower + vanaspati and palmolein) treated with different antioxidants (vitamin E, BHA and citric acid) are presented in the Table 6 and Fig 15. It was observed that increase of TBA value

Table 5: Acid value (mgKOH/g) of stored sunflower seeds fried with different oils treated with different antioxidants

Treatments	FRESH			WEEK 6			WEEK 12			WEEK 18		
	Frying medium											
	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein
Control	3.02	2.43	1.50	3.97	3.50	3.13	4.85	4.85	3.92	5.94	5.35	5.15
Vitamin E	2.60	2.43	1.50	2.69	2.35	2.26	3.70	3.26	2.88	4.45	3.95	3.75
BHA	2.09	2.43	1.50	2.38	2.27	2.18	3.50	3.05	2.83	3.76	3.64	3.22
Citric Acid	2.07	2.43	1.50	2.27	3.70	2.27	4.29	3.84	3.33	5.35	4.93	4.12
SE	0.200			0.173			0.223			0.256		
CV	9.389			6.052			4.545			5.736		
F- value	*			*			*			*		
CD	0.336			0.293			0.326			0.432		

*significant at 5% level

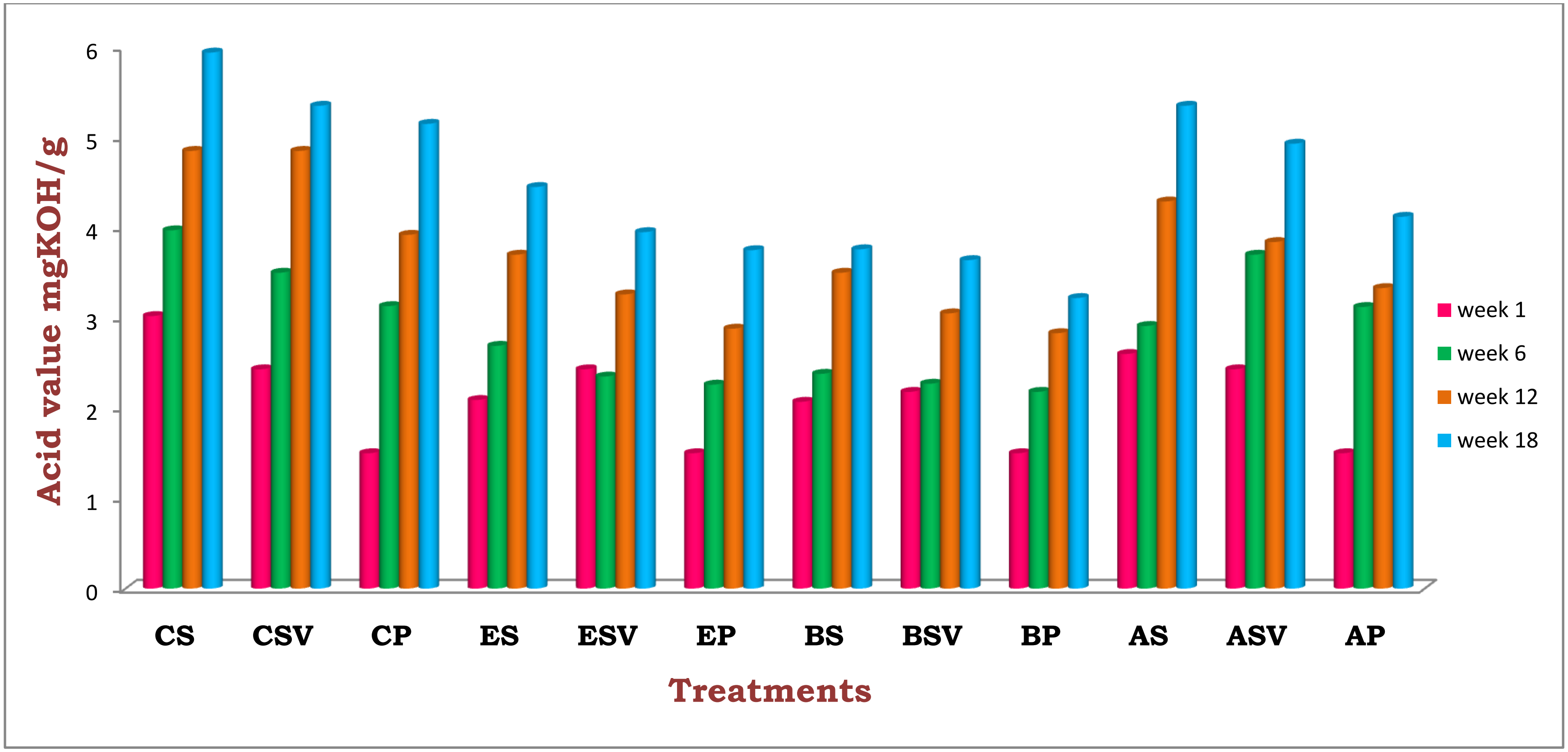


Fig. 14: Acid value (mgKOH/g) of stored sunflower seeds fried with different oils using different antioxidants

CS- Sunflower control, **CSV**- sunflower +vanaspati control, **CP**- palmolein control, **ES**- sunflower+vitamin E, **ESV**-sunflower+vanaspati+vitamin E, **EP**-palmolein+vitamin E, **BS**-sunflower+BHA, **BSV**-sunflower+vanaspati +BHA, **BP**- palmolein+BHA, **AS**-sunflower+acid, **ASV**- sunflower +vanaspati+acid, **AP-** palmolein+acid

Table 6: TBARS assay (µ moles malondialdehyde/kg) of stored sunflower seeds fried with different oils treated with different antioxidants

Treatments	FRESH			WEEK 6			WEEK 12			WEEK 18		
	Frying medium											
	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein	Sunflower	Sunflower + vanaspati	Palmolein
Control	0.46	0.39	0.35	0.57	0.54	0.53	0.66	0.62	0.59	0.79	0.78	0.67
Vitamin E	0.46	0.39	0.35	0.54	0.53	0.48	0.63	0.57	0.54	0.64	0.62	0.59
BHA	0.46	0.39	0.35	0.47	0.47	0.46	0.49	0.49	0.49	0.60	0.53	0.51
Citric Acid	0.46	0.39	0.35	0.59	0.53	0.49	0.63	0.59	0.54	0.66	0.61	0.55
SE	0.003			0.002			0.007			0.006		
CV	0.312			0.398			1.223			1.069		
F- value	*			*			*			*		
CD	1.124			0.003			0.011			0.114		

*Significant at 5% level

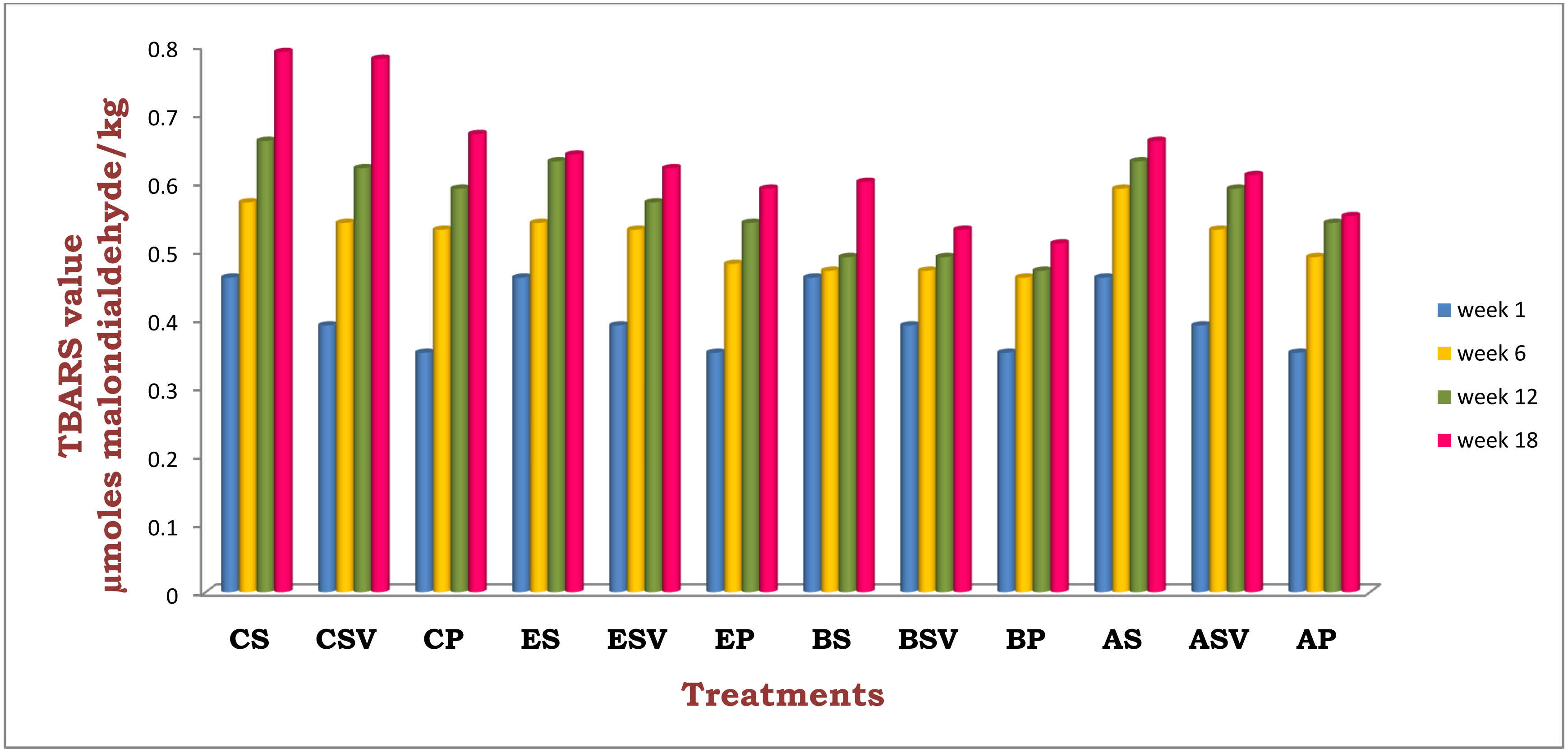


Fig. 15: TBARS value (µ moles mlondialdehyde/ kg) of stored sunflower seeds fried with different oils using different antioxidants

CS- Sunflower control, **CSV**- sunflower +vanaspati control, **CP**- palmolein control, **ES**- sunflower+vitamin E, **ESV**-sunflower+vanaspati+vitamin E, **EP**-palmolein+vitamin E, **BS**-sunflower+BHA, **BSV**-sunflower+vanaspati +BHA, **BP**- palmolein+BHA, **AS**-sunflower+acid, **ASV**- sunflower +vanaspati+acid, **AP-** palmolein+acid was from 0.47 to 0.60 µ moles malondialdehyde/kg in sunflower oil, 0.47 to 0.60 µ moles malondialdehyde/kg in sunflower + vanaspati and 0.46 to 0.51 µ moles malondialdehyde/kg in palmolein oil treated with BHA compared to vitamin E and citric acid throughout the storage period. The addition of BHA to palmolein improves the oxidative stability when used as deep frying oil.

Statistically there was a significant difference for the TBARS value of stored fried sunflower seeds with different oils treated with different antioxidants throughout the storage period.

Development of shelf stable products

Shelf stable food product is the one that can be safely stored in a sealed container at room or ambient temperature for a usefully long shelf life. Shelf stable products were developed using sunflower seeds. Several seeds such as cashew nut, almond, walnut, ground nut, melon seeds, poppy seeds, sesame and coconut are used in different cuisines in fried and non fried products. Therefore an attempt has been made to make the same popular products using sunflower seeds. A comparative evaluation of products from sunflower seeds was done with the seeds and nuts used traditionally.

4.3 Development of fried products

Fried snacks are popular and versatile food ingredient. The results obtained with regard to development of fried products using different types of oils on sensory attributes, functional properties and shelf life studies are presented here.

4.3.1 Comparative evaluation of sensory characteristics for fried products

Namkeens

Table 7 depicts the comparative evaluation of sensory characteristics for namkeen made from sunflower and other seeds (Fig.16 and plate 2)

Namkeens are the fried snacks and were prepared using sunflower seeds and compared with other seeds such as cashew, roasted bengal gram and ground nut .All the variations that were tried viz., namkeen with sunflower and other seeds were found to be highly acceptable. There was no statistical significant difference between the products. Products with cashew nut and sunflower had marginally higher scores for all the sensory characteristics.

Dry roasted flavoured seeds

Table 8 depicts the mean scores of sensory evaluation of dry roasted sunflower with an incorporation of different flavors (Fig.17 and plate 2).

All the variations that were tried in the development of dry roasted flavoured seeds by the incorporation of different flavours were found to be highly acceptable. There were no statistical difference between the products for the sensory parameters such as appearance, texture and colour except taste and over all acceptability. It was found that garlic flavour had higher acceptability than other recipes. Statistically significant differences were found between the recipes for the sensory attributes such as taste and over all acceptability.

Fried grams

Cashew nuts

Sunflower seeds

Groundnuts

Plate 1: Product "Namkeen" prepared from sunflower and other seeds

Table 7: Comparative evaluation of sensory characteristics for product namkeen made from sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Sunflower	7.90	7.36	7.45	7.54	7.72
Ground nut	7.90	7.90	7.63	7.63	7.63
Fried Bengal gram	7.81	7.54	7.81	7.81	7.54
Cashew nuts	8.09	8.00	7.63	7.72	7.72
F-value	NS	NS	NS	NS	NS
SEm±	0.26	0.27	0.28	0.29	0.27

NS: Non-significant

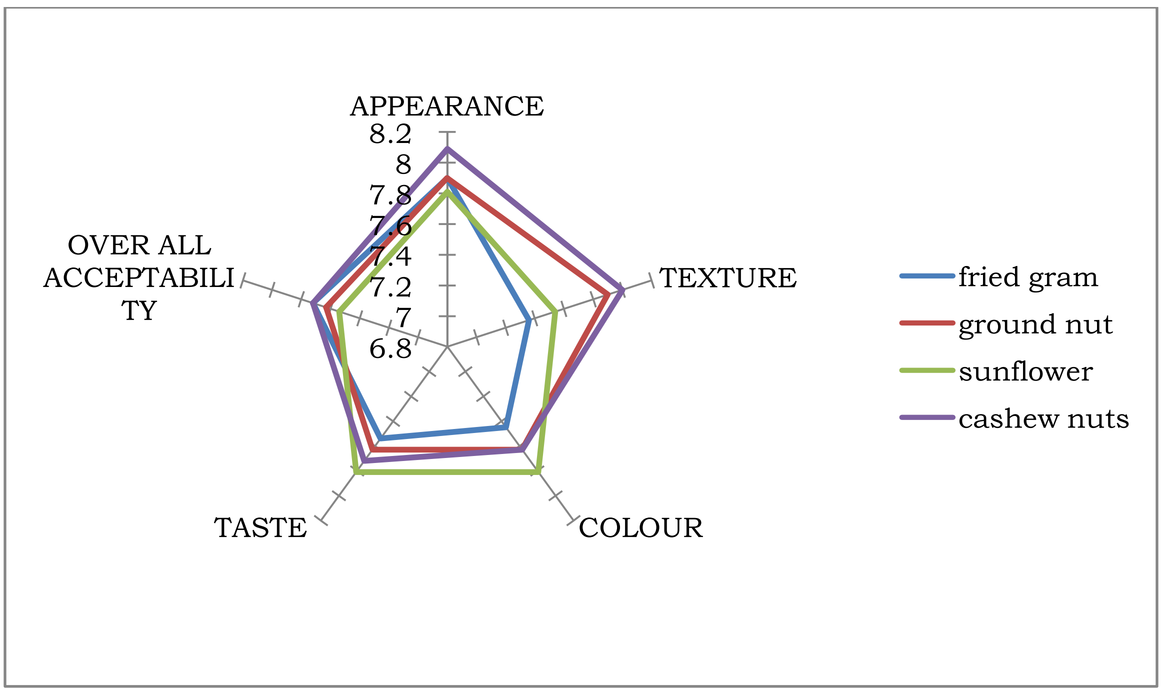


Fig. 16: Mean scores of sensory characteristics for product namkeen

Commercial control

Seeds flavoured with Garlic

Plain seeds

Seeds flavoured with onion

Seeds flavoured with onion and garlic

Plate 2: Product "Dry roasted flavoured seeds'' prepared using sunflower and other seeds

Table 8: Mean scores of sensory characteristics for product Dry roasted flavoured seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Commercial	7.77	7.55	7.44	7.11	7.00
Garlic flavoured	7.88	7.55	7.44	7.44	7.55
Onion flavoured	7.88	7.22	7.55	6.88	7.11
Garlic+onion flavoured	7.55	7.55	7.11	6.66	6.33
Plain	7.77	7.55	7.22	5.66	5.77
F-value	NS	NS	NS	*	*
SEm±	0.32	0.34	0.26	0.42	0.46
CD	0.94	0.98	1.03	1.20	1.31

*Significant at 5 % level NS: Non-significant

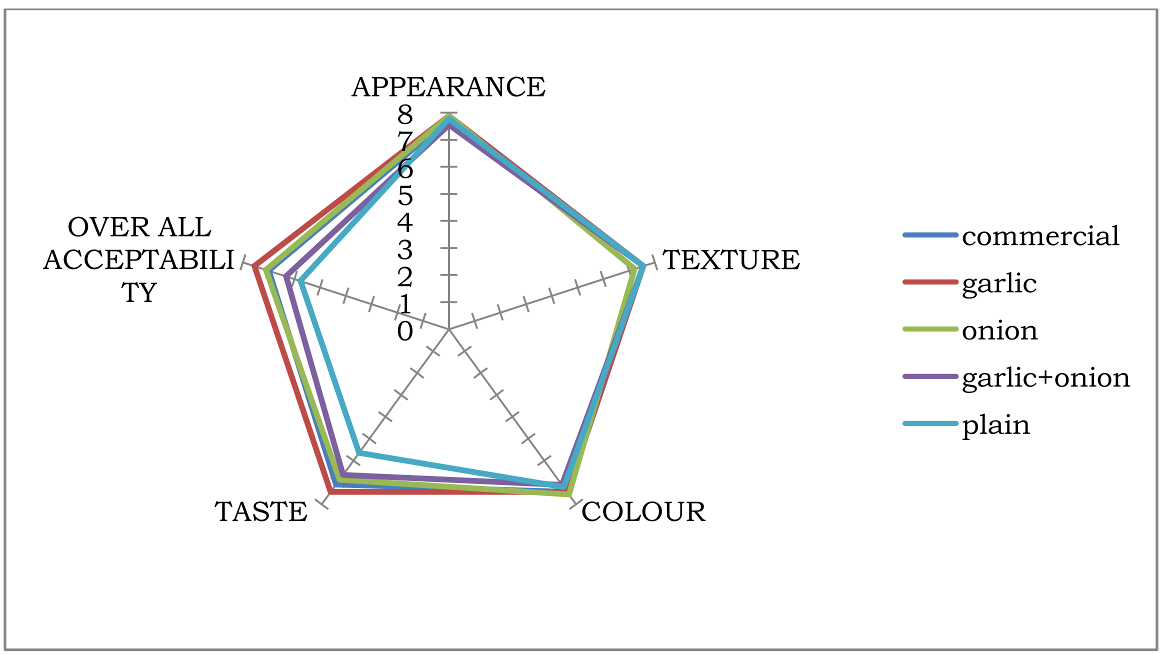


Fig. 17: Mean scores of sensory characteristics for product Dry roasted flavoured seeds

4.3.2 Shelf life studies of fried products

As with many nuts and seeds, sunflower seeds are susceptible to oxidation after roasting. Exposure to oxygen leads to the development of rancidity and unacceptable flavours. Oxidation rates can be decreased with the help of packaging. Two types of packaging materials used were HDPE and PET jars.

Namkeens

Effect of storage on sensory characteristics for the product namkeen made from sunflower and other seeds stored in different packaging materials are shown in the table 9. The product exhibited good shelf stability because all the parameters that were evaluated did not differ statistically as a result of storage period in HDPE. The only character that was slightly affected by storage was appearance. In the case of products stored in PET jars there was no deterioration in the sensory parameters as exhibited by the scores. It can be concluded that namkeen stored in HDPE had marginally better shelf life compared to PET jars.

Dry roasted flavoured seeds

Effect of storage on sensory characteristics for dry roasted flavoured seeds stored in different packaging materials (Table 10) revealed that dry roasted flavored seeds prepared by the incorporation of different flavors stored in HDPE had higher sensory scores for all the sensory attributes as compared to that of stored in PET jars. When analyzed statistically, the changes in the sensory attributes were found to be non-significant from initial to fourth week in both packaging material of storage for appearance, texture and colour. While the overall acceptability had shown significant difference between two packaging material for the four weeks of storage.

Table 9: Effect of storage on sensory characteristics for the product namkeens made from sunflower and other seeds stored in different packaging materials

		HDPE				PET jars			
APPEARANCE	**Treatments**	**WK1**	**WK2**	**WK3**	**WK4**	**WK1**	**WK2**	**WK3**	**WK4**
	Cashew	5.00	5.33	5.00	5.00	5.00	5.00	5.00	4.66
	Fried gram	5.00	5.00	5.00	5.00	5.00	5.00	4.66	5.00
	Peanut	4.33	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	Sunflower	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.66
	F-value	*	NS	NS	NS	NS	NS	NS	NS
	SEM	0.16	0.16	0.28	0.57	0.40	0.40	0.16	0.23
	CD	0.54	0.54	0.94	1.88	1.33	1.33	0.54	0.76
TEXTURE	**Treatments**	**WK1**	**WK2**	**WK3**	**WK4**	**WK1**	**WK2**	**WK3**	**WK4**
	Cashew	5.00	5.00	5.00	3.66	5.00	4.33	4.33	4.66
	Fried gram	5.00	5.00	5.00	5.00	5.00	4.33	4.00	5.00
	Peanut	5.00	5.00	5.00	5.00	5.00	4.33	4.33	5.00
	Sunflower	5.00	5.00	5.00	5.00	5.00	4.33	4.33	4.66
	F-value	NS	NS	NS	*	NS	NS	NS	NS
	SEM	0.28	0.28	0.28	0.33	0.48	0.33	0.28	0.23
	CD	0.94	0.94	0.94	1.08	1.33	1.08	0.94	0.76
COLOUR	**Treatments**	**WK1**	**WK2**	**WK3**	**WK4**	**WK1**	**WK2**	**WK3**	**WK4**
	Cashew	5.00	4.33	4.33	4.33	4.33	4.33	5.00	4.00
	Fried gram	5.00	4.33	4.33	4.33	4.33	4.33	4.00	4.33
	Peanut	5.00	4.33	4.33	4.33	4.33	4.33	4.33	4.33
	Sunflower	5.00	4.33	4.33	4.33	4.33	4.33	4.33	4.00
	F-value	NS	NS	NS	NS	NS	NS	*	NS
	SEM	0.28	0.33	0.33	0.33	0.33	0.33	0.23	0.23
	CD	0.94	1.08	1.08	1.08	1.08	1.08	0.76	0.76
TASTE	**Treatments**	**WK1**	**WK2**	**WK3**	**WK4**	**WK1**	**WK2**	**WK3**	**WK4**
	Cashew	4.33	3.66	4.33	3.66	3.66	3.66	4.33	4.00
	Fried gram	4.33	3.66	4.33	3.66	3.66	3.66	4.00	3.66
	Peanut	4.33	3.00	4.33	3.66	3.66	3.66	4.33	3.66
	Sunflower	4.33	2.33	3.66	3.66	3.66	3.00	4.33	3.33
	F-value	NS	NS	NS	NS	NS	NS	NS	NS
	SEM	0.33	0.95	0.44	0.66	0.66	0.76	0.28	0.50
	CD	1.08	3.12	1.43	2.17	2.17	2.49	0.94	1.63
OVER ALL ACCEPTABILITY	**Treatments**	**WK1**	**WK2**	**WK3**	**WK4**	**WK1**	**WK2**	**WK3**	**WK4**
	Cashew	4.33	3.66	4.33	4.33	4.33	4.33	4.33	4.00
	Fried gram	4.33	3.66	4.33	3.66	4.33	4.33	4.00	3.66
	Peanut	3.66	3.66	4.33	4.33	4.33	4.33	4.33	4.33
	Sunflower	3.66	3.00	3.66	3.66	3.66	4.33	3.66	3.33
	F-value	NS	NS	NS	NS	NS	NS	NS	NS
	SEM	0.52	0.76	0.44	0.52	0.44	0.33	0.40	0.40
	CD	1.71	2.49	1.43	1.71	1.43	1.08	1.33	1.33
ABSENCE OF RANCIDITY	**Treatments**	**WK1**	**WK2**	**WK3**	**WK4**	**WK1**	**WK2**	**WK3**	**WK4**
	Cashew	4.33	4.33	4.33	3.00	3.00	3.66	3.00	3.00
	Fried gram	4.33	3.66	4.33	3.00	3.00	3.66	3.00	3.00
	Peanut	3.66	3.66	4.33	3.00	2.33	3.66	2.33	2.33
	Sunflower	3.66	3.00	3.66	3.00	2.33	3.00	2.33	2.33
	F-value	NS	NS	NS	NS	NS	NS	NS	NS
	SEM	0.52	0.70	0.44	1.00	1.17	0.76	1.17	1.17
	CD	1.71	2.30	1.43	3.26	3.84	2.49	3.84	1.66

*Significant at 5 % level NS: Non-significant

Table 10: Effect of storage on sensory characteristics for dry roasted flavoured seeds stored in different packaging materials

Packaging material	Duration (days)	Appearance	Texture	Colour	Taste	Absence of rancidity	Overall acceptability
PET jars	Week 1	4.55	4.45	4.45	4.35	5.00	4.50
	Week 2	4.55	4.45	4.45	4.35	5.00	4.50
	Week 3	3.75	3.60	3.70	3.55	4.40	3.70
	Week 4	3.65	3.40	3.65	3.35	4.05	3.50
HDPE	Week 1	4.85	4.75	4.75	4.55	5.00	4.70
	Week 2	4.55	4.45	4.45	4.35	5.00	4.50
	Week 3	4.25	3.85	4.00	3.70	4.50	4.00
	Week 4	4.10	3.55	3.80	3.60	4.45	3.85
	Packaging						
	F-value	NS	NS	NS	NS	NS	NS
	SEm±	0.073	0.09	0.09	0.11	0.08	0.09
	CD	-	-	-	-	-	-
	Duration						
	F-value	NS	NS	NS	NS	NS	*
	SEm±	0.09	0.08	0.11	0.13	0.09	0.10
	CD	-	-	-	-	-	0.30

*Significant at 5 % level NS: Non-significant

4.4 Development of non fried products

Different non fried snack products like barfi, chikki, marzipan, cookies, bread, pesto sauce, soup and salted seeds were developed. These products are traditionally prepared from other nuts and oil seeds.

4.4.1 Comparative evaluation of sensory characteristics for non fried products

Table 11, 12, 13, 14, 15, 16, 17 and 18 depicts the Comparative evaluation of sensory characteristics for products barfi, chikki, marzipan, cookies, bread rolls, pesto sauce, soup and salted seeds made from sunflower and other seeds (Fig. 18, 19, 20, 21, 22, 23, 24 and 25).

Barfi

The mean scores for sensory attributes of barfi developed with cashew nut, almond, sunflower seeds and coconut were compared and the results are presented in the Table 11, Fig. 18 and plate 3. All the variations that were tried viz., barfi with sunflower and other seeds such as cashew nut, almond and coconut were found to be highly acceptable. The mean scores of different recipes showed that the coconut barfi had higher mean score for overall acceptability (8.00). Significant differences were found between the recipes for all the sensory attributes except texture.

Chikki

The mean score for sensory parameters of chikki developed with sunflower seeds were compared with other seeds such as groundnut, melon seeds and sesame and the results were presented in the Table 12, Fig. 19 and plate 4. All the variations that were tried were found to be highly acceptable. Products with sesame had marginally higher score for

Cashew nut

Almond

Sunflower seeds

Coconut

Plate 3: Product "BARFI" prepared using sunflower and other seeds

Table 11: Comparative evaluation of sensory characteristics for product barfi made from sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Cashew nut	8.09	7.27	7.9	7.54	7.09
Almond	8.36	7.81	8	7.45	7.72
Sunflower	6.36	6.9	5.9	6.27	6.63
Coconut	8.18	7.18	7.9	7.81	8
F-value	*	NS	*	*	*
SEm±	0.23	0.31	0.25	0.23	0.28
CD	0.66	0.9	0.73	0.68	0.81

*Significant at 5 % level NS: Non-significant

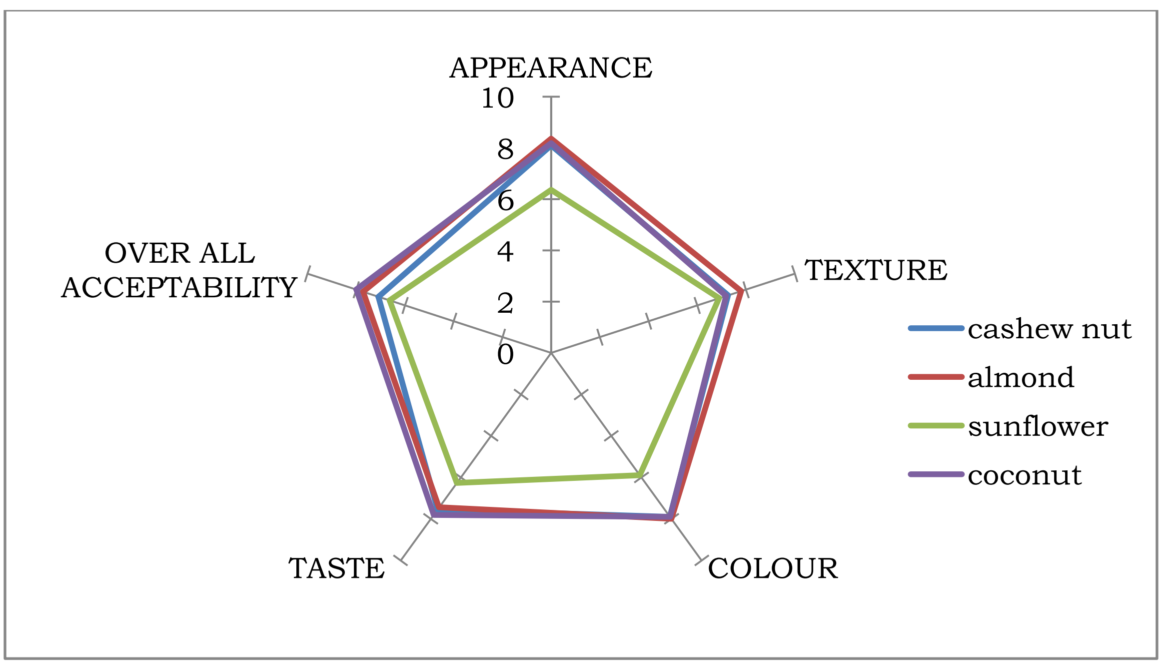


Fig. 18: Mean scores of sensory characteristics for product barfi

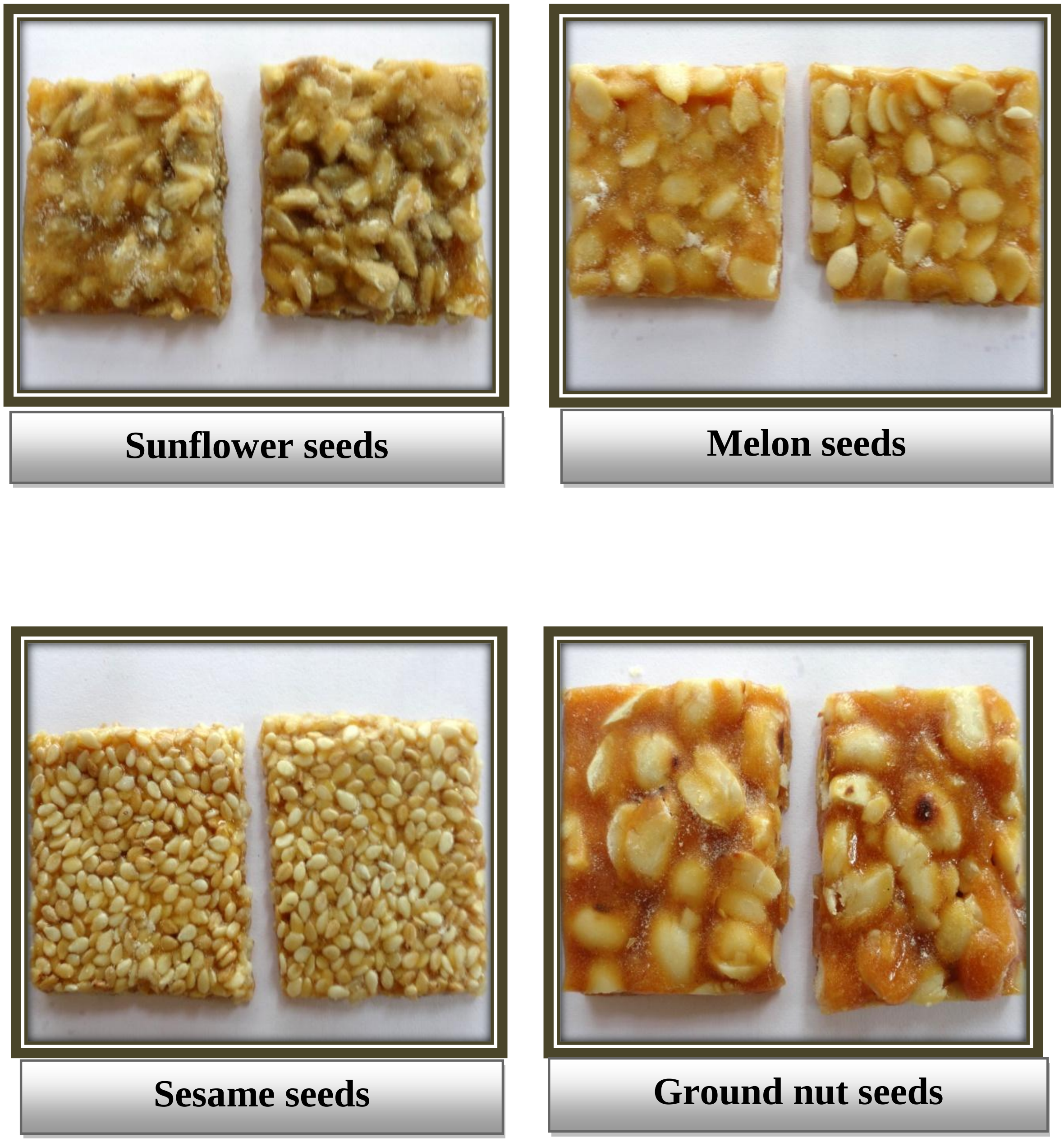


Plate 4: Product "Chikki'' prepared using sunflower and other seeds

Table 12: Comparative evaluation of sensory characteristics for product chikki made from sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Ground nut	7.63	7.54	7.63	7.45	7.63
Melon seeds	7.9	7.81	7.81	8	8
Sunflower	6.18	5.81	6.09	6.36	6.18
sesame	8.18	7.81	7.81	7.81	8.09
F-value	*	*	*	*	*
SEm±	0.32	0.32	0.35	0.38	0.32
CD	0.93	0.94	1	1.09	0.93

*Significant at 5 % level

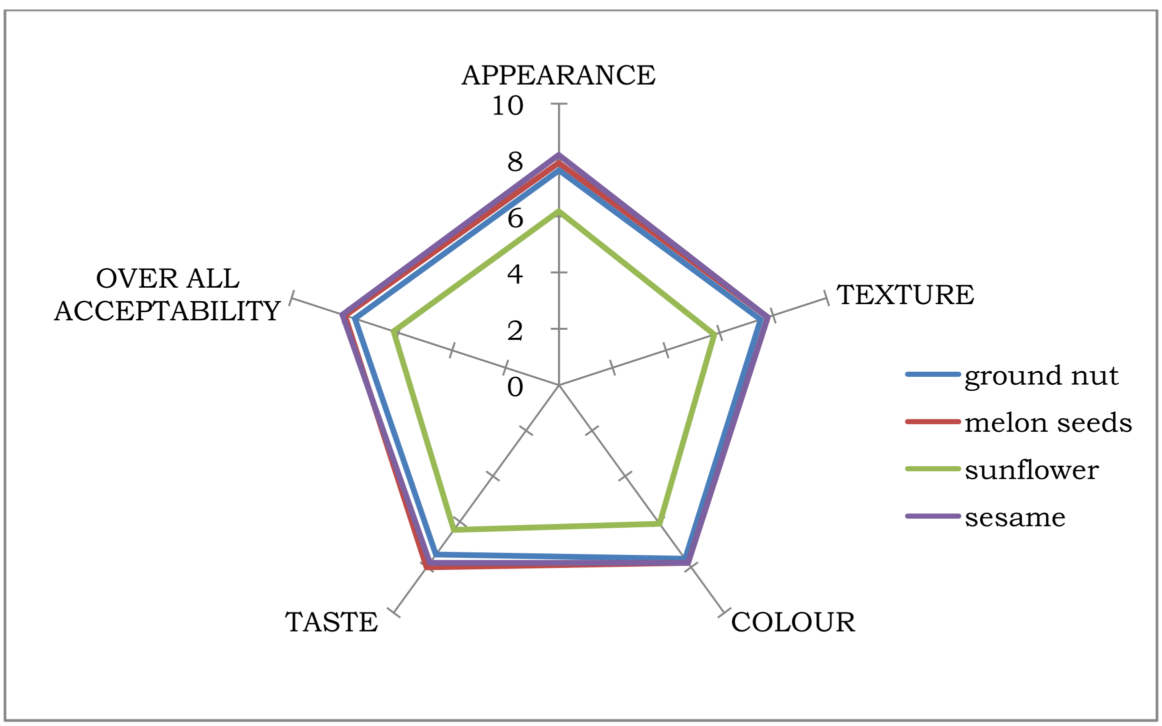


Fig. 19: Mean scores of sensory characteristics for product chikki

all the sensory characteristics. When analyzed statistically significant differences were found between the recipes for all the sensory attributes.

Marzipan

The mean scores for sensory attributes of marzipan developed with sunflower seeds, cashew nut, ground nut and melon seeds were compared and the results are presented in the Table 13, Fig. 20 and plate 5. All the variations that were tried viz., marzipan with sunflower and other seeds such as cashew nut, groundnut and melon seeds were found to be highly acceptable. There was no statistically significant difference between the products. Products with groundnut and melon seeds had marginally higher scores for all the sensory characteristics.

Cookies

Table 14 shows the mean scores for sensory parameters of cookies developed with sunflower and were compared with other seeds such as almond, cashew nut and groundnut were found to be highly acceptable. There were no statistical difference between the products for the sensory parameters like appearance, color and taste. It was found that product with cashew nut had higher acceptability than the other recipes. Significant differences were found between the recipes for the sensory parameters like texture and overall acceptability (Fig. 21 and plate 6).

Bread rolls

The mean scores for sensory attributes of bread developed with sunflower and poppy seeds, sesame and melon were compared and the results are presented in the Table 15. Products with poppy seeds, sesame and melon seeds had marginally higher scores for all the sensory attributes. The inclusion of different seeds did not affect the sensory score for the appearance, colour, taste and overall acceptability (Fig: 22 and plate 7).

Pumpkin seeds

Cashew nut seeds

Sunflower seeds

Melon seeds

Plate 5: Product "Marzipan'' prepared using sunflower and other seeds

Table 13: Comparative evaluation of sensory characteristics for product marzipan made from sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Sunflower	7.09	7.09	6.72	6.81	6.9
Cashewnut	7.54	7.54	7.27	7.45	7.36
Peanut	7.54	7.18	7.45	7.18	7.18
Melon	7.72	7.36	7.27	7.18	7.18
F-value	NS	NS	NS	NS	NS
SEm±	0.24	0.29	0.29	0.29	0.3
CD	0.7	0.83	0.83	0.83	0.86

NS: Non-significant

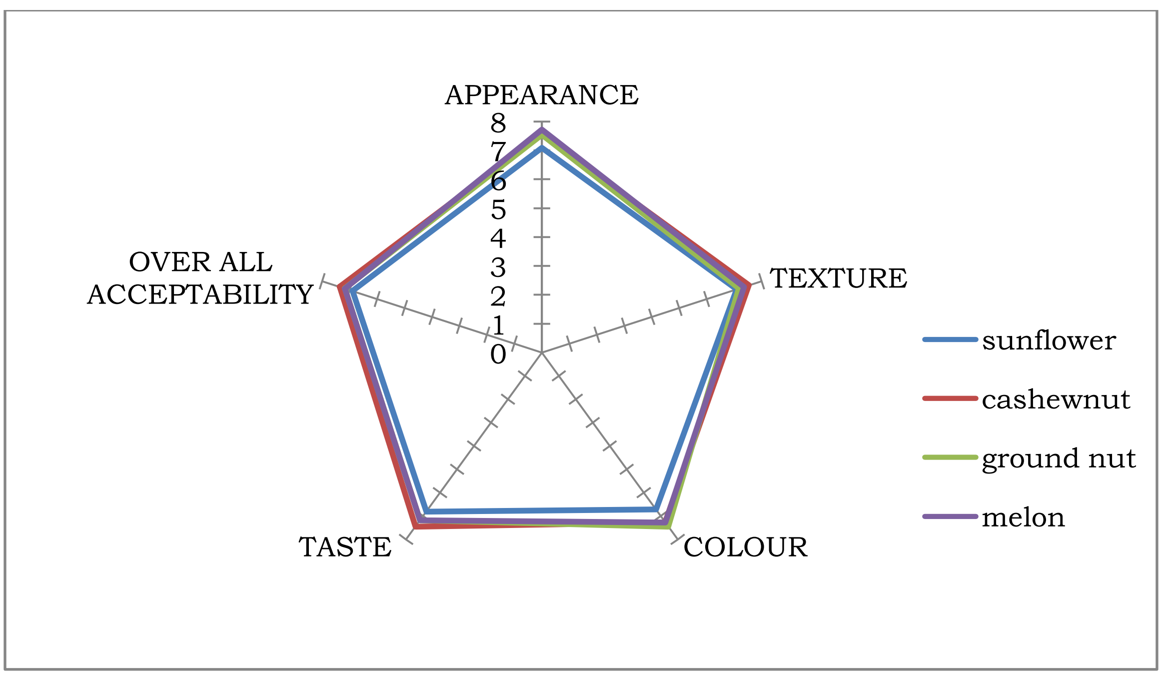


Fig. 20: Mean scores of sensory characteristics for product Marzipan

Sunflower seeds

Cashew nut

Pea nuts

Almond

Plate 6: Product "Cookies" prepared using sunflower and other seeds

Table 14: Comparative evaluation of sensory characteristics for product cookies made from sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Sunflower	7.25	7.12	7.00	7.00	7.37
Almond	7.75	7.62	7.37	7.62	7.37
Cashew	7.75	7.50	7.62	7.62	7.75
Ground nut	7.62	6.75	7.00	7.12	6.75
F-value	NS	*	NS	NS	*
SEm±	0.30	0.23	0.26	0.35	0.28
CD	0.87	0.67	0.76	1.03	0.83

*Significant at 5 % level NS: Non-significant

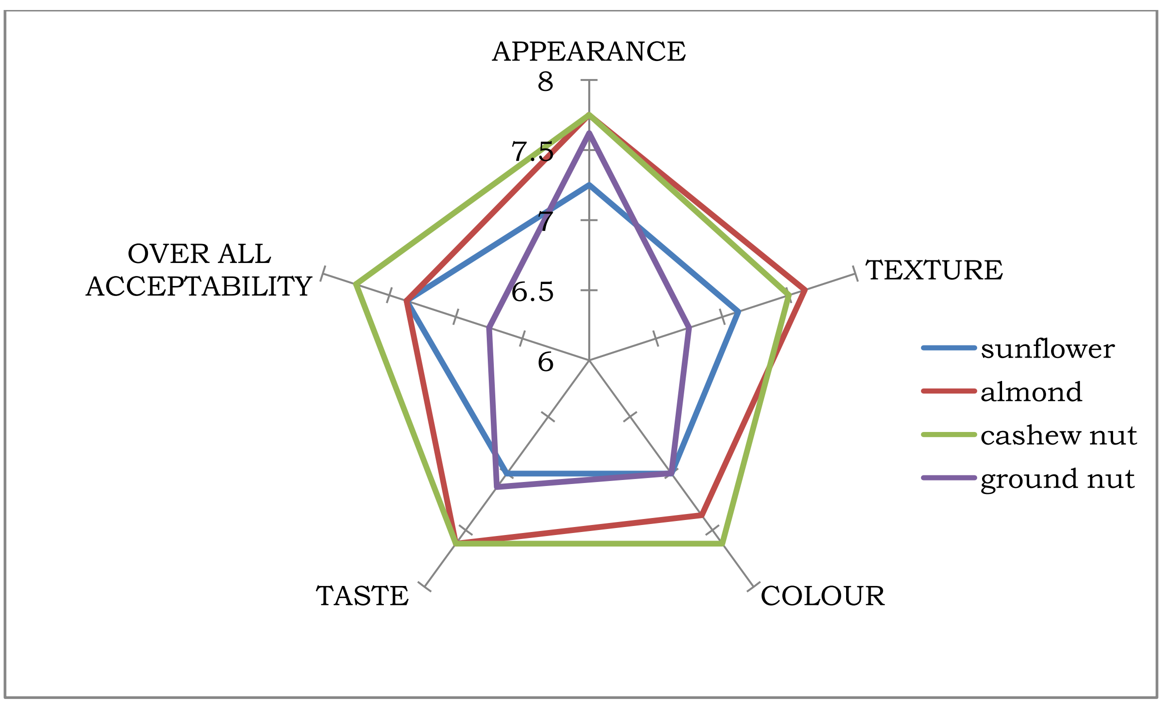


Fig. 21: Mean scores of sensory characteristics for product Cookies

Poppy seeds

Sesame seeds

Sunflower seeds

Melon seeds

Plate 7: Product "Bread rolls" prepared using sunflower and other seeds

Table 15: Comparative evaluation of sensory characteristics for product bread rolls garnished with sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Poppy	7.62	7.25	7.50	7.00	6.87
Sesame	7.37	7.00	7.50	7.25	6.87
Sunflower	6.75	6.25	7.25	6.50	6.00
Melon	7	7.12	7.37	7	6.87
F-value	NS	*	NS	NS	NS
SEm±	0.32	0.24	0.22	0.27	0.33
CD	0.93	0.72	0.65	0.80	0.96

*Significant at 5 % level NS: Non-significant

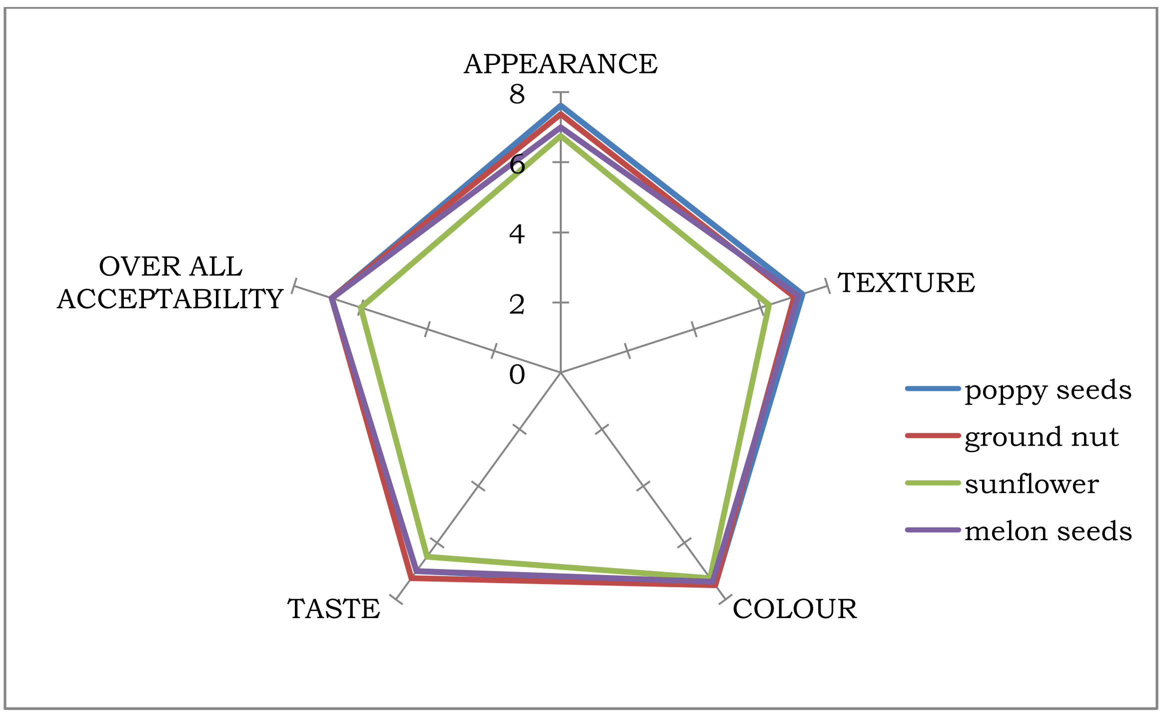


Fig. 22: Mean scores of sensory characteristics for product bread rolls

Pesto sauce

The mean scores for sensory attributes of pesto sauce developed with sunflower seeds were compared with other seeds such as ground nuts, walnut and commercial product and the results are presented in the Table 16. The mean scores of different recipes showed that commercial product had higher mean score for overall acceptability (6.54). It was found that commercial product had higher acceptability than the other recipes. Significant differences were found between the recipes for all sensory attributes except texture and taste (Fig: 23 and plate 8).

Soup

The mean scores for sensory attributes of soup developed with sunflower seeds, almond, cashew nut and melon seeds were compared and the results are presented in the Table 17. The mean score for sensory parameters of soup developed with sunflower and other seeds such as almond, cashew nut and melon seeds were found to be highly acceptable. There were no statistical difference between the products for the sensory parameters like appearance, texture and colour. It was found that the products with cashew nut had higher acceptability than the other recipes. Significant differences were found between the recipes for the sensory parameters like taste and overall acceptability (Fig: 24 and plate 9).

Salted seeds

The mean sensory score of salted seeds with different flavors are presented in Table 18. All the variations that were tried in the development of salted seeds with sunflower by incorporating different flavors were highly acceptable. There was no statistical difference between the products. Products with onion and onion+garlic flavor had

Commercial control

Sunflower seeds

Walnuts

Ground nut

Plate 8: Product "Pesto sauce" prepared using sunflower and other seeds

Table 16: Comparative evaluation of sensory characteristics for product pesto sauce made from sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Ground nut	5.54	5.54	5.63	5.63	5.54
Sunflower	5.45	5.54	5.27	5.63	5.45
Walnut	5.90	6	6.18	5.63	5.63
Commercial	7	6.72	6.9	6.54	6.54
F-value	*	NS	*	NS	*
SEm±	0.37	0.47	0.36	0.33	0.31
CD	1.05	1.36	1.03	0.96	0.91

*Significant at 5 % level NS: Non-significant

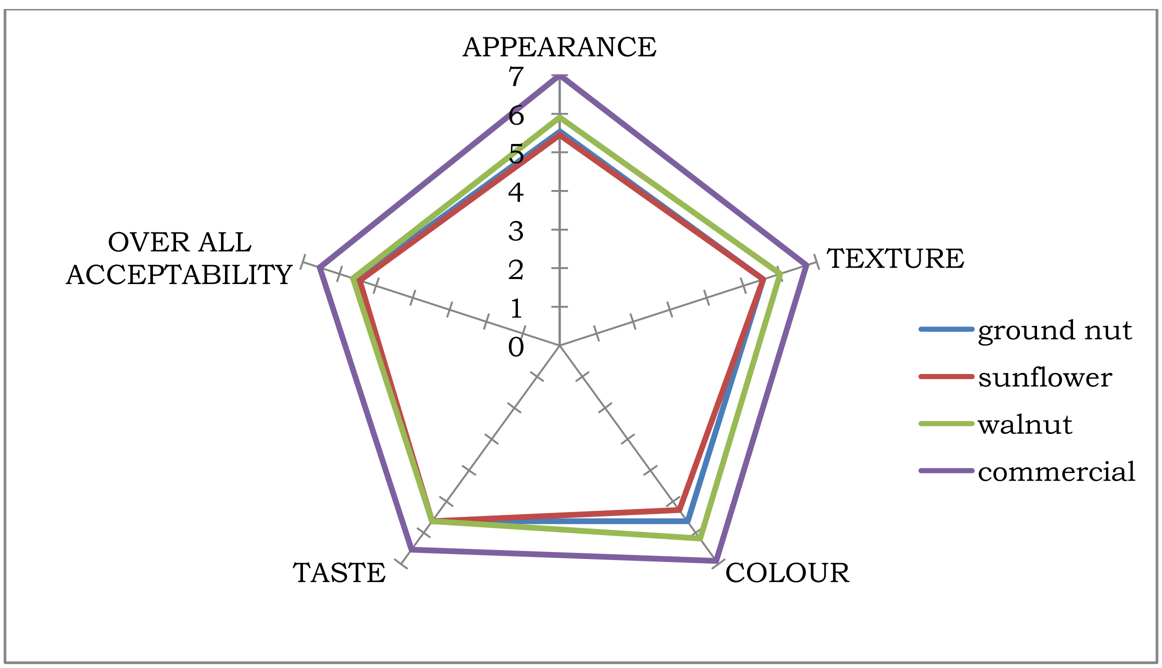


Fig. 23: Mean scores of sensory characteristics for product Pesto sauce

Cashew nut

Melon seeds

Almond

Sunflower seeds

Plate 9: Product "Soup" prepared from sunflower and other seeds

Table 17: Comparative evaluation of sensory characteristics for product soup made from sunflower and other seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Sunflower	7.2	7.2	6.6	6.4	6.2
Almond	7.4	7.0	7.2	7.2	7.2
Cashew nut	7.4	7.4	7.4	7.8	8.0
Melon seeds	7.6	6.8	6.8	6.8	7.0
F-value	NS	NS	NS	*	*
SEm±	0.57	0.5	0.41	0.38	0.44
CD	1.72	1.52	1.25	1.14	1.32

*Significant at 5 % level   NS: Non-significant

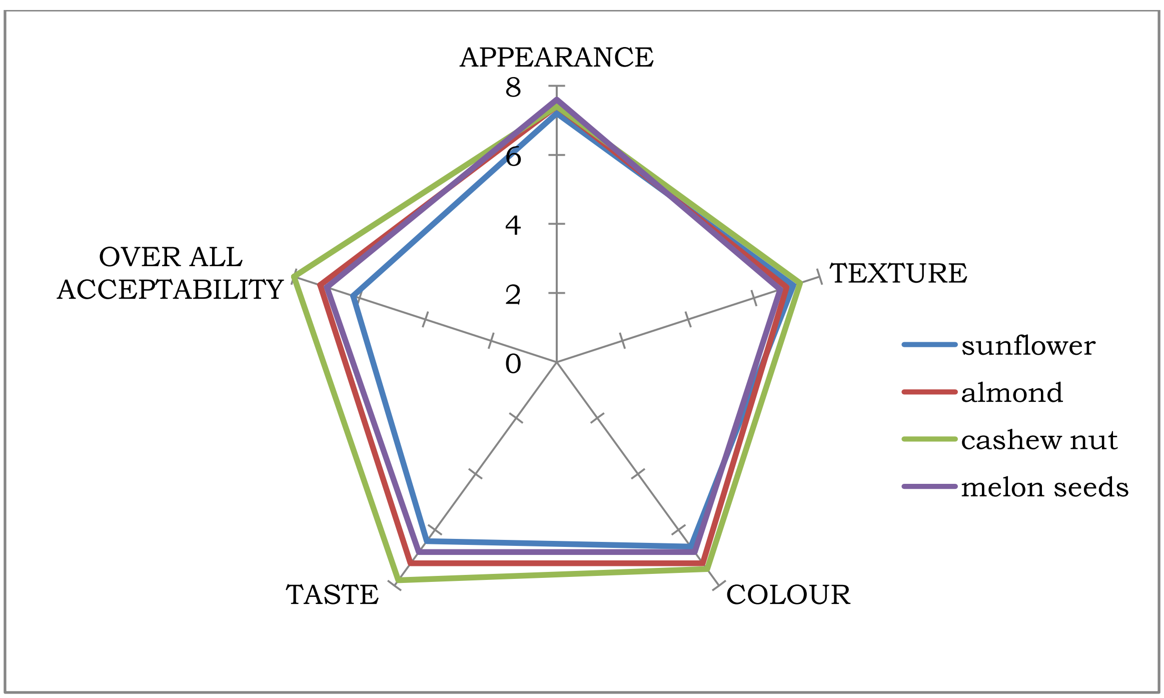


Fig. 24: Mean scores of sensory characteristics for product soup

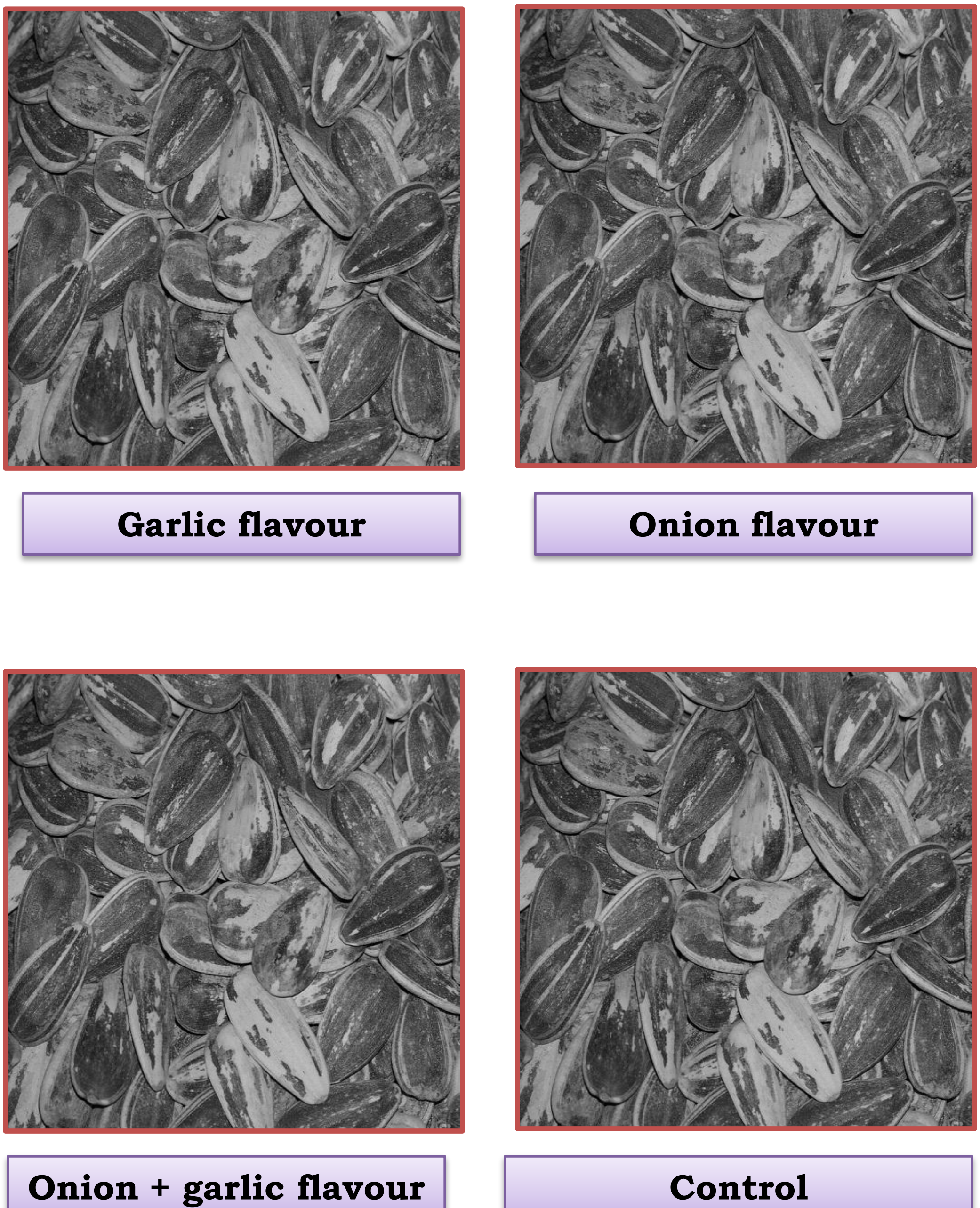


Plate 10: Product "Salted seeds" prepared from sunflower seeds

Table 18: Mean scores of sensory characteristics for product salted seeds

Variation	Appearance	Texture	Colour	Taste	Overall acceptability
Control	7.4	7.6	7.4	7.6	8.4
Garlic	7.4	7.6	7.6	7.8	7.8
Onion	7.4	7.6	7.6	7.8	8.2
Garlic+onion	7.4	7.6	7.8	7.8	8.2
F-value	NS	NS	NS	NS	NS
SEm±	0.24	0.24	0.23	0.21	0.27
CD	0.73	0.73	0.7	0.63	0.82

NS: Non-significant

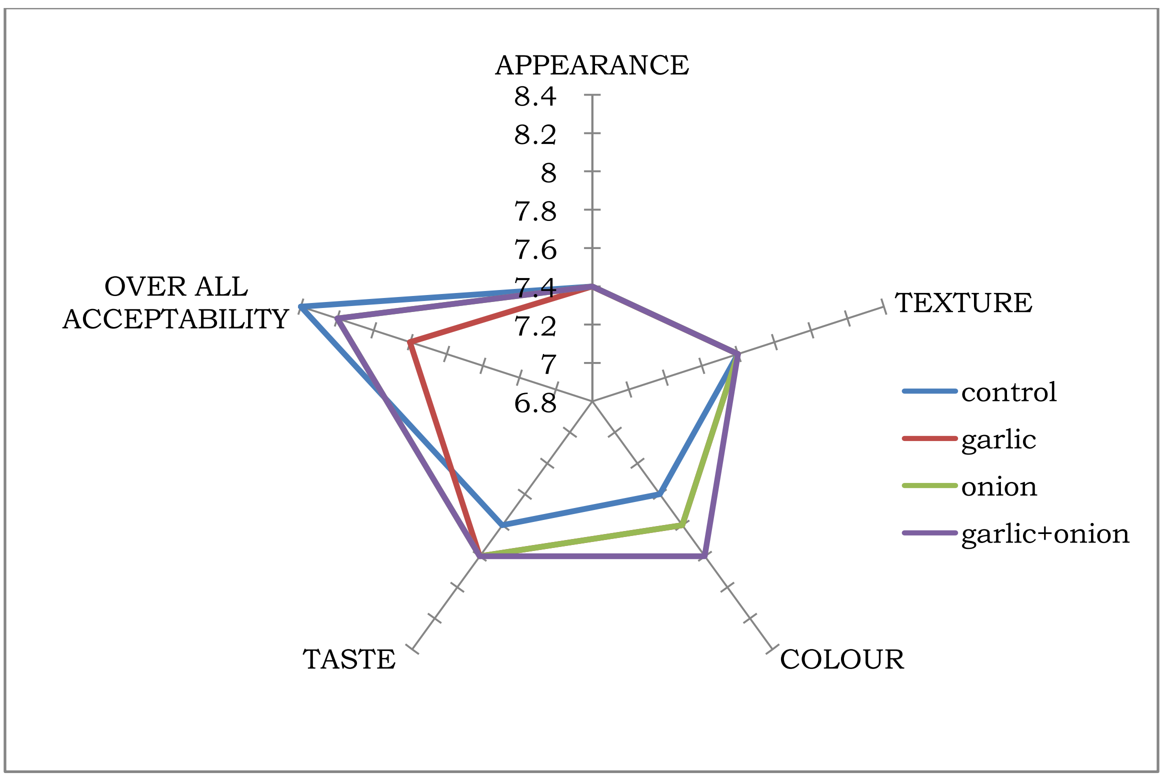


Fig. 25: Mean scores of sensory characteristics for product salted seeds

marginally higher score for all the sensory attributes (Fig: 25 and plate 10).

4.4.2 Shelf life studies of non fried products

Table 19, 20 and 21 shows the effect of storage on sensory characteristics and rancidity for products barfi, chikki and cookies. Barfi was a product from pulverized sunflower and other seeds and nuts. Chikki was from whole sunflower seeds and nuts. While cookies was a baked product. Thus, different types of products were selected for this study.

Barfi

Effect of storage on sensory characteristics for the product barfi made from sunflower and other seeds stored in HDPE are shown in the table 19. The results revealed that there was a significant difference decrease in the mean score for all the sensory parameters as the storage period begins to progress. Barfi could be kept for one week.

Chikki

Effect of storage on sensory characteristics for the product chikki made from sunflower and other seeds stored in HDPE are shown in the Table 20. The results revealed that chikki made from sesame scored higher acceptability followed by ground nut, melon and sunflower in the 1^{st} and 2^{nd} week compared to rest during the storage period. For all the sensory characteristics except appearance and rancid flavor the samples were acceptable upto 4^{th} week. Upto 3^{rd} week samples of chikki made from sunflower exhibited no rancidity. Thus the chikki can be stored upto four weeks. The shelf life was comparable with other seeds and nuts.

Table 19: Effect of storage on sensory characteristics for the product barfi made from sunflower and other seeds

	Treatments	Week 1	Week 2	Week 3	Week 4
APPEARANCE	**Cashew**	5.00	5.00	2.33	3.33
	Almond	5.00	4.66	3.00	1.66
	coconut	5.00	4.66	1.66	1.66
	Sunflower	4.00	4.33	2.00	2.66
	F-value	*	NS	*	*
	SEM	0.28	0.40	0.23	0.44
	CD	0.94	1.33	0.76	1.43
TEXTURE	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	4.66	3.33	2.33	2.66
	Almond	5.00	4.00	2.33	1.66
	coconut	5.00	4.00	1.66	1.66
	Sunflower	4.00	4.00	2.00	2.00
	F-value	*	*	NS	*
	SEM	0.16	1.66	0.28	0.288
	CD	0.54	0.54	0.94	0.94
COLOUR	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	5.00	4.33	2.33	2.66
	Almond	4.33	3.66	2.33	1.66
	coconut	5.00	4.66	1.66	1.66
	Sunflower	3.33	3.33	2.00	2.33
	F-value	*	*	NS	*
	SEM	0.37	0.33	0.28	0.33
	CD	1.21	1.08	0.94	1.08
TASTE	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	4.33	3.33	1.66	3.00
	Almond	4.33	3.66	1.66	1.66
	coconut	4.33	3.66	1.00	1.66
	Sunflower	2.33	3.00	1.33	2.00
	F-value	*	NS	NS	*
	SEM	0.33	0.28	0.50	0.23
	CD	1.08	0.94	1.63	0.76
OVER ALL ACCEPTABILITY	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	4.33	4.00	2.33	2.66
	Almond	4.33	3.66	2.33	1.66
	coconut	4.33	3.66	1.66	1.66
	Sunflower	3.33	3.00	1.33	1.00
	F-value	*	*	*	*
	SEM	0.33	0.23	0.33	0.28
	CD	1.08	0.76	1.08	0.94
ABSENCE OF RANCIDITY	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	5.00	4.66	2.33	2.33
	Almond	5.00	4.33	2.33	2.33
	Coconut	5.00	2.00	2.33	2.00
	Sunflower	3.66	2.00	2.33	1.00
	F-value	*	*	NS	NS
	SEM	0.33	0.37	0.52	0.47
	CD	1.08	1.21	1.71	1.53

*Significant at 5 % level NS: Non-significant

Table 20: Effect of storage on sensory characteristics for the product chikki made from sunflower and other seeds

	Treatments	WEEK 1	WEEK 2	WEEK3	WEEK4
APPEARANCE	**sesame**	5.00	5.00	4.66	4.66
	Peanut	4.33	4.66	4.66	4.33
	melon	4.33	5.00	4.66	4.33
	Sunflower	4.33	4.00	3.33	2.66
	F-value	*	NS	*	*
	SEM	0.33	0.23	0.44	0.60
	CD	1.08	0.76	1.43	1.95
TEXTURE	**Treatments**	WEEK 1	WEEK 2	WEEK3	WEEK4
	sesame	4.33	4.33	5.00	4.33
	Peanut	5.00	4.66	4.66	4.33
	melon	4.66	5.00	4.66	2.66
	Sunflower	4.33	4.00	3.33	3.33
	F-value	NS	*	*	NS
	SEM	0.28	0.23	0.50	0.66
	CD	0.94	0.76	1.63	2.17
COLOUR	**Treatments**	WEEK 1	WEEK 2	WEEK3	WEEK4
	sesame	5.00	4.33	5.00	4.66
	Peanut	4.66	4.33	4.66	4.33
	melon	5.00	5.00	4.66	4.33
	Sunflower	3.66	3.33	3.33	3.33
	F-value	NS	*	*	NS
	SEM	0.47	0.28	0.50	0.60
	CD	1.53	0.94	1.63	1.95
TASTE	**Treatments**	WEEK 1	WEEK 2	WEEK3	WEEK4
	sesame	5.00	5.00	3.33	3.33
	Peanut	5.00	4.66	4.00	3.36
	melon	4.33	4.33	4.00	3.66
	Sunflower	3.66	3.33	2.66	3.33
	F-value	NS	*	*	NS
	SEM	0.47	0.40	0.23	0.44
	CD	1.53	1.33	0.76	1.43
OVER ALL ACCEPTABILITY	**Treatments**	WEEK 1	WEEK 2	WEEK3	WEEK4
	sesame	5.00	5.00	4.00	3.33
	Peanut	5.00	4.66	4.00	3.66
	melon	4.33	4.33	4.00	4.33
	Sunflower	3.66	3.66	2.66	3.33
	F-value	NS	NS	*	NS
	SEM	0.47	0.40	0.33	0.52
	CD	1.53	1.33	1.08	1.71
ABSENCE OF RANCIDITY	**Treatments**	WEEK 1	WEEK 2	WEEK3	WEEK4
	sesame	5.00	5.00	3.00	3.00
	Peanut	5.00	5.00	3.00	2.33
	melon	3.66	5.00	3.66	3.66
	Sunflower	3.66	3.00	3.66	2.00
	F-value	NS	*	NS	NS
	SEM	0.55	0.57	0.84	0.79
	CD	1.80	1.88	2.77	2.60

*Significant at 5 % level   NS: Non-significant

Cookies

The mean sensory scores for cookies made from sunflower and other seeds are presented in the Table 21. The results revealed that cookies made from cashew nut scored higher acceptability during storage followed by almond, ground nut and sunflower. The cookies from sunflower could be stored upto three weeks.

4.5 Nutritive value of developed products

Macronutrients such as protein, fat, carbohydrate, and fibre and micronutrients such as calcium, phosphorous, iron, zinc and vitamin E were computed using food composition tables for all ten products namely namkeen, dry roasted flavoured seeds, chikki, barfi, marzipan, cookies, bread, soup, pesto sauce and salted seeds. The nutrient compositions of the products are presented in the Table 22.

The mean macronutrients were higher in sunflower products for energy, cashew nut products for protein and ground nut for fat. The micronutrients were higher in the sunflower products compared to products prepared from other seeds.

4.6 Cost of production

4.6.1 Variable cost of the developed products using dehulled sunflower and other seeds

Variable cost of the developed products using dehulled sunflower and other seeds are shown in Table 23, **ANNEXURE VIII**

Namkeen

The variable cost of the products estimated to be Rs. 7.83/100 gm, Rs. 8.43/100 gm, Rs. 21.03/100 gm and Rs. 8.83/100 gm for namkeens

Table 21: Effect of storage on sensory characteristics for the product cookies made from sunflower and other seeds

	Treatments	Week 1	Week 2	Week 3	Week 4
APPEARANCE	**Cashew**	5.00	5.00	5.33	4.66
	Almond	5.00	5.00	4.00	4.66
	Peanut	5.00	5.00	5.00	4.00
	Sunflower	5.00	4.66	3.66	3.66
	F-value	NS	NS	*	*
	SEM	0.57	0.16	0.23	0.28
	CD	1.88	0.54	0.76	0.94
TEXTURE	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	5.00	5.00	4.33	4.66
	Almond	5.00	5.00	4.00	4.66
	Peanut	5.00	5.00	5.00	4.00
	Sunflower	5.00	4.66	3.66	3.66
	F-value	NS	NS	*	*
	SEM	0.28	0.16	0.23	0.28
	CD	0.94	0.54	0.76	0.94
COLOUR	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	5.00	5.00	5.33	4.00
	Almond	5.00	5.00	4.00	4.66
	Peanut	5.00	5.00	5.00	4.00
	Sunflower	5.00	4.66	3.66	3.00
	F-value	NS	NS	*	*
	SEM	0.28	0.16	0.23	0.16
	CD	0.94	0.54	0.76	0.54
TASTE	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	5.33	4.33	5.00	4.00
	Almond	5.00	5.00	4.00	3.66
	Peanut	5.00	4.33	5.00	4.00
	Sunflower	5.00	4.66	3.00	2.33
	F-value	NS	NS	*	*
	SEM	0.16	0.28	0.28	0.23
	CD	0.54	0.94	0.94	0.76
OVER ALL ACCEPTABILITY	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	5.00	4.33	4.33	4.66
	Almond	5.00	5.00	3.33	3.66
	Peanut	4.33	4.33	4.33	3.33
	Sunflower	4.33	4.66	3.33	2.33
	F-value	*	NS	*	*
	SEM	0.23	0.28	0.33	0.33
	CD	0.76	0.94	1.08	1.08
ABSENCE OF RANCIDITY	**Treatments**	**Week 1**	**Week 2**	**Week 3**	**Week 4**
	Cashew	5.33	5.33	5.33	4.33
	Almond	5.00	5.00	3.66	3.00
	Peanut	5.00	4.33	4.33	2.66
	Sunflower	5.00	4.00	3.33	2.33
	F-value	NS	NS	*	*
	SEM	0.16	0.23	0.44	0.40
	CD	0.54	0.76	1.43	1.33

*Significant at 5 % level   NS: Non-significant

Table 22: Nutritive value of developed products (per 100g)

Products	Protein (g)	Fat (g)	Carbohydrate (g)	Energy (K Cal)	Fibre (g)	Calcium (mg)	Phosphorous (mg)	Iron (mg)	Zinc (mg)	Vitamin E (mg)
Namkeen										
Sunflower	7.24	22.87	57.50	496.30	0.64	54.65	255.70	14.45	0.81	5.39
Fried gram	7.61	16.5	63.02	462.10	0.74	24.45	210.80	14.95	0.01	0.44
Cashew nut	7.43	22.17	58.15	493.06	0.68	23.36	225.80	14.45	0.81	0.57
Ground nut	7.99	21.24	58.67	489.10	0.93	28.80	212.40	14.00	0.53	1.38
Dry roasted flavored seeds										
Sunflower	21.8	52.39	44.30	630.7	1.00	280.00	670.00	5.00	5.06	36.33
Marzipan										
Sunflower	6.66	17.36	72.23	472.00	0.33	101.30	224.00	1.77	1.68	12.10
Cashew nut	7.13	15.63	73.70	464.00	0.43	24.60	150.60	2.03	1.99	0.30
Ground nut	8.50	13.36	74.96	452.33	1.033	53.00	117.33	0.93	1.30	2.31
Water melon seeds	11.37	17.53	62.52	579.33	0.26	48.00	313.00	3.80	-	-
Barfi										
Sunflower	9.95	26.05	67.60	819.00	0.50	146.00	335.50	2.57	2.53	18.16
Cashew nut	10.65	23.45	72.00	795.00	0.65	36.00	225.50	5.88	2.99	0.46
Almond	10.05	29.45	60.20	855.00	0.85	121.00	245.50	5.16	1.78	12.93
Coconut	6.85	31.15	68.10	530.00	3.30	406.00	105.00	7.87	2.50	-
Chikki										
Sunflower	10.15	29.37	70.24	722.03	0.32	191.61	360.80	4.20	1.63	11.71
Ground nut	12.90	23.77	74.34	695.53	1.00	96.61	200.80	2.95	1.25	2.28
Melon	71.30	29.62	63.54	726.03	0.25	101.61	493.80	5.40	-	-
Sesame	5.90	24.97	73.79	693.53	0.93	76.61	310.80	6.35	3.93	0.07

Products	Protein (g)	Fat (g)	Carbohydrate (g)	Energy (K Cal)	Fibre (g)	Calcium (mg)	Phosphorous (mg)	Iron (mg)	Zinc (mg)	Vitamin E (mg)
Pesto sauce										
sunflower	4.32	40.61	3.80	43.28	0.95	122.4	96.86	2.18	0.93	4.05
Walnuts	2.18	38.78	2.11	5.700	1.05	-	-	-	-	-
Ground nut	3.24	40.03	2.51	361.30	1.11	104.40	67.86	1.94	0.65	1.50
Commercial	4.21	37.60	4.02	349.30	1.16	103.40	64.86	1.93	0.81	1.24
Soup										
Sunflower	5.08	11.08	8.72	130.04	0.36	64.33	187.46	1.29	1.31	24.20
Almond	5.28	12.44	7.24	137.04	0.50	54.33	151.46	1.30	1.01	17.23
Cashew nut	5.36	10.04	8.56	125.24	1.10	18.33	98.46	1.45	1.49	0.60
Melon	7.94	11.18	6.04	131.64	0.76	75.00	248.86	1.77	0.30	-
Bread rolls										
Sunflower	20.80	21.70	46.29	425.40	0.98	40.66	598.70	4.35	0.33	2.41
Poppy seeds	20.55	15.89	48.77	414.80	1.33	105.80	586.80	4.85	0.08	-
Sesame	20.38	17.09	46.65	422.56	1.07	99.16	593.70	4.56	0.81	0.01
Melon seeds	21.17	17.56	45.62	425.86	1.13	31.66	612.00	4.47	-	-
Cookies										
Sunflower	18.58	56.46	78.96	758.65	0.90	94.60	561.40	4.11	0.58	4.22
Almond	18.83	58.16	77.11	788.60	1.07	82.10	516.40	4.13	0.10	3.00
Cashew nut	18.93	55.16	80.06	892.60	0.97	37.10	506.40	4.31	2.11	0.10
Ground nut	19.50	53.46	81.01	885.30	1.42	27.10	481.40	3.48	0.45	0.80
Salted seeds										
Sunflower	19.80	52.10	17.90	620.00	1.00	280.00	670.00	5.00	5.06	36.33

prepared with sunflower, fried gram, cashew nut and ground nut respectively.

Dry roasted flavoured seeds

The costs of the products for dry roasted flavoured seeds with the incorporation of different flavours are estimated to be Rs.6.40/100gm.

Barfi

The variable cost of the products estimated to be Rs. 10.5/100gm, Rs. 76.5/100 gm, Rs. 46.5/100 gm and Rs. 14.5/100 gm for barfi prepared with sunflower, cashew nut, almond and coconut respectively.

Chikki

The variable cost of the products estimated to be Rs. 10.40/100 gm, Rs. 12.90/100gm, Rs. 20.90/100 gm and Rs. 13.40/100 gm for chikki prepared with sunflower, ground nut, water melon seeds and sesame respectively.

Marzipan

The variable cost of the products estimated to be Rs. 8.00/100 gm, Rs. 41.00/100gm, Rs. 10.50/100 gm and Rs. 18.50/100 gm for marzipan prepared with sunflower, cashew nut, ground nut and water melon respectively.

Cookies

The variable cost of the products estimated to be Rs.8.70/100 gm, Rs. 19.50/100gm, Rs. 36.00/100 gm and Rs. 20.75/100 gm for cookies prepared with sunflower, almond, cashew nut and ground nut respectively.

Table 23: Variable cost of the developed products using dehulled sunflower seeds and other seeds

	Products	Cost (Rs.)/100g
Namkeens	Sunflower seeds	7.83
	Fried gram	8.43
	Cashew nut	21.03
	Ground nut	8.83
Dry roasted flavoured seeds	Sunflower seeds	6.40
Barfi	Sunflower seeds	10.50
	Cashew nut	76.50
	Almond	46.50
	Coconut	14.50
Chikki	Sunflower seeds	10.40
	Ground nut	12.90
	Water melon seeds	20.90
	Sesame	13.40
Marzipan	Sunflower seeds	8.00
	Cashew nut	41.00
	Ground nut	10.50
	Water melon seeds	18.50
Cookies	Sunflower seeds	8.70
	Almond	19.50
	Cashew nut	36.00
	Ground nut	20.75
Bread rolls	Sunflower seeds	7.20
	Poppy seeds	10.30
	Sesame	7.80
	Water melon seeds	9.30
Pesto sauce	Sunflower seeds	17.51
	Walnut	26.11
	Ground nut	18.01
	Commercial product	19.91
Soup	Sunflower seeds	9.36
	Almond	16.56
	Cashew nut	22.56
	Water melon seeds	13.56
Salted seeds	Sunflower seeds	6.24

Bread rolls

The variable cost of the products estimated to be Rs.7.20/100 gm, Rs. 10.30/100gm, Rs. 7.80/100 gm and Rs. 9.30/100 gm for bread rolls prepared with sunflower, poppy seeds, sesame and water melon seeds respectively.

Pesto sauce

The variable cost of the products estimated to be Rs.17.51/100 gm, Rs. 26.11/100gm, Rs. 18.01/100 gm and Rs. 19.91/100 gm for pesto sauce prepared with sunflower, walnut, ground nut and commercial product respectively.

Soup

The variable cost of the products estimated to be Rs.9.36/100 gm, Rs. 16.56/100gm, Rs. 22.56/100 gm and Rs. 13.56/100 gm for soup prepared with sunflower, almond, cashew nut, and water melon seeds respectively.

Salted seeds

The costs of the products for salted seeds with the incorporation of different flavors are estimated to be Rs.6.24/100gm.

Discussion

V. DISCUSSION

When any new product is developed it is important to study the impact of different ingredients on the acceptability and storage or shelf life. Sunflower is an oilseed rich in poly unsaturated fatty acid. Rancidity is understandably an important aspect to be considered. Thus, the formative part of this research study concentrated on the effect of different types of oils and antioxidants in order to optimize the type of oil or antioxidants or combination to restrain the development of rancidity and promote shelf stability. One of the requirements of product development is variety. Thus, non fried products were also developed. The effect of using sunflower seeds in the products on its nutritive value and cost were also evaluated. These being important aspects of product development. Thus, the results obtained on "**Development of shelf stable products from sunflower seed kernels"** are discussed under following headings.

5.1 Effect of frying sunflower seeds in different types of oils on sensory and functional properties

5.2 Effect of different antioxidants on shelf life of fried sunflower seeds

5.3 Development and comparative evaluation of fried products

5.4 Development and comparative evaluation of non fried products

5.5 Shelf life studies of selected products

5.6 Nutrient composition of the developed products

5.7 Cost of production

5.1 Effect of frying sunflower seeds in different types of oils on sensory and functional properties

Oil provides several important attributes to the fried product that makes the fried food palatable and desirable to the consumers, these include texture, fried food flavour, mouthfeel and aftertaste (Gupta, 2005). Autoxidation reaction produces alcohols and acids, among others. Some of these are dibasic acids, i.e., they contain two carboxylic acid groups (- COOH). This is why oil expelled from a highly oxidized or rancid fried product can exhibit high free fatty acid content. The free fatty acid content in the fryer oil ranges from 0.25% to 0.40% for most snack food products (Gupta, 2005). In commercial deep-fat frying, oil is continously exposed to air and light for extended periods at temperatures approaching 180°C (Augustin and Berry, 1983). Under such conditions, both thermal and oxidative decompositions of oil may occur (Yeng, Grey, Archer & Bruce, 1998).products from lipid oxidation not only influence the quality and safety of the oil (Izaki, Yostikawa and Uchkawa, 1984) but also affect the acceptability of the fried product (Jacobson, 1991). In addition to all these, type of oil and presence or absence of antioxidants can also have effect on the parameters (Gupta, 2005). Therefore the results originating from this study are discussed in light of the evidences from scientific literatures in the following paragraphs.

Sensory characteristics

In the present study all oils were equally acceptable with palmolein showing better acceptability. Palmolein oil is being used increasingly in frying operations, and because of its inherent excellent frying properties, improves the frying quality of other vegetable oils when it is blended with them (Gupta, 2005). The present study showed that sunflower seeds fried with different oils such as sunflower, palmolein, vanaspathi and ground nut were acceptable, but seeds fried with palmolein oil showed good acceptability. Gulla and Waghray (2012) are of opinion that the flavour likability of fried food is dependent upon consumer perception and is affected by the type of oil used and the length of time the oil has been heated or used for frying. Kalra *et al* (1998) also stated that the frying medium plays an important role in the shelf life of a fried product.

In their study they reported that among the blends studied sesame-rice bran (20:80) and sesame-palmolein (20:80) scored the highest in all aspects of sensory attributes and overall acceptability. Common oils used in frying operations are sunflower, ground nut oil and palmolein (Nasirullah and Rangaswamy, 2005). Vanaspathi is used commonly while making Indian products (Sandhyarani, 2010). Therefore the evaluation of type of oil used for frying is very important. An attempt was made to decide which oil will have better appeal to fry sunflower seeds so that acceptable products can be made.

Functional properties

Study of Functional properties can be used to indicate the suitability of fried sunflower seeds. The functional properties broadly defined as those properties other than nutritional attributes that affects its utilization the overall functional property of a food system is a result of composite properties of individual protein components as they interact with one another and with non protein component also (Anwara *et al.,* 2009). The study of functional property is important as it necessary to know the different functions and behaviour of the oil while formulating different products.

Fat absorption: In the present study there was not much variation observed in fat absorption for sunflower seeds fried with different oils. It was noticed that fat absorption capacity for sunflower seeds fried with ground nut oil and vanaspati (10 ml/g) was more followed by palmolein (8.75 ml/g) and sunflower oil (8.66 ml/g). Gesellschaft(2008) reported that the amount of fat uptake in the deep-fryer was for potato chips or crisps ranging from 30-40%, for donuts 15-20% and for fried potatoes (french fries, chips) 6-12%.The greater part of oil uptake (80%) takes place after removing the fried foods from the fryer. In the present study the oil absorption for different oils ranged from 1.84 to 1.87%. The inherent fat content in the sample may be responsible for the lower oil absorption when compared to the other food systems, eg. Donuts and chips.

Volume expansion: No significant differences found in the volume expansion for sunflower seeds fried with different oils. However ground nut oil (1.87) showed increase in the volume expansion followed by palmolein and vanaspathi (1.85) and sunflower oil.

5.2 Effect of different antioxidants on shelf life of fried sunflower seeds

Products from lipid oxidation not only influence the quality and safety of the oil (Izaki, Yostikawa and Uchkawa, 1984) but also affect the acceptability of the fried product (Jacobson, 1991). Peroxidation is a problem in the storage of fried foods. In order to overcome the stability problems of oil and fats, synthetic antioxidants, such as butylated hydroyanisole (BHA), butylated hydroxytoluene (BHT), ter-butyl hydroquinone (TBHQ) have been used as food additives (Iqbal and Bhanger 2005, Suja *et al*. 2004, Krings *et al*. 2000), because they are effective and less expensive than natural antioxidants (Suja *et al*. 2004). Tocopherol inhibits free radical oxidation by reacting with peroxyl radicals to stop chain propagation, and with the alkoxyl radical to inhibit the decomposition of the hydroperoxides and decrease the formation of aldehydes (Frankel 1996). Citric acid has also been shown to possess some antioxidant activities through metal sequestering activity (Mahoney and Graft, 1986). Together with citric acid, rosemary and sage can exhibit a synergistic effect to retain the fatty acid composition of palm olein during repeated deep-fat frying (Irwandi, Che Man and Kitts, 1996). Therefore in the present study BHA, citric acid and vitamin E were the antioxidants selected. These were approved by FSSAI (2006).

In commercial deep-fat frying, oil is continously exposed to air and light for extended periods at temperatures approaching 180°C (Augustin and Berry, 1983). Under such conditions, both thermal and oxidative decompositions of oil may occur (Yeng, Grey, Archer and Bruce, 1998.

The parameters such as the sensory characters, moisture content, peroxide value, acid value and TBARS were used as indicators of rancidity.

Sensory characters

Oil and fat manufacturers normally treat refined oils with antioxidants to retard against undesirable changes during storage and frying operations and to prolong the shelf-life of the food fried in the oil. Presently, butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are two synthetic antioxidants commonly used in commercial cooking oils. However, with safety concerns identified for these synthetic antioxidants (Kitts, 1996), considerable interest in the use of natural antioxidants for frying purposes has occurred. Man and Tan (1999) reported the sensory evaluation of fried potato chips that there was no significant (P >0.05) difference in terms of flavor, odor, texture, and overall acceptability. There was no significant (P > 0.05) difference in sensory evaluation for rancid odor during storage periods.

In the present study the results obtained through the presence of rancidity was noticed in the 6th and 8th week of storage in the sunflower oil with the peroxide value of 12.13meq/kg with added vitamin E and 10.80 meq/kg for added citric acid. Hydroperoxide formation is higher for oils rich in PUFA (Kim *et al*., 2007). Considering this fact the peroxide values were expectedly lower for samples fried in palmolein and sunflower+vanaspati. Predictably the addition of all antioxidants brought slower acceleration of hydroperoxide formation. This effect was greater for BHA. The order of effectiveness was BHA> vitamin E> citric acid.

The oxidative stability of soybean oil was determined by the combination of headspace oxygen content and volatile compounds. The oil at the end of oxidation period could have a low peroxide value although the oil is highly oxidized and has a rancid flavor. Oil with a large amount of oxidized polymers could have a very low peroxide value. Oil with a low peroxide value and a large amount of oxidized polymers could have a very low flavour quality and stability during storage. Peroxide value could not be a reliable indication for the oxidative stability of oil at the later stage of lipid oxidation (Kim *et al*., 2007). Therefore TBARS method was also used along confirmation with peroxide value and rancidity assessment. Jaswir and Che Man (1999) reported that all three antioxidants (Rose Mary extract, BHA, citric acid) significantly (P<0.05) influenced the sensory attributes evaluated such as appearance, taste, crispiness, odour and overall acceptability.

The rancid flavour and chemically analysed indicators of rancidity are very often associated. Although some time one may precede the others. In some cases the rancid flavour is detected when the peroxide value is <20meq/kg. However according to Kim *et al*., 2007 rancid flavour may be present at a low peroxide value. Therefore, it is better to have a combination of methods to assess rancidity. In the present study the rancid flavour in samples was perceived in 6th and 8th week for sunflower oil without antioxidants, sunflower oil with vitamin E, and sunflower oil with citric acid samples respectively. This coincided with the peroxide values of 12.13, 13.93, 13.80 and 13.95 meq/kg respectively.

Moisture

Moisture is one of the critical factors responsible for the deterioration of quality of food during storage (Gupta, 2005). As the storage period increases moisture content also increases. In the present study it was noticed that there was a slight increase in the moisture content of fried sunflower seeds throughout the storage period. Moisture content gradually increased in all the samples during the storage period. The control samples stored for 4 months had the highest increase in the moisture content for all types of oil when compared to oils treated with antioxidants. The lowest increase in the moisture content was found in palmolein oil treated with 0.02% of BHA. Among the three treated oils(sunflower, sunflower + vanaspati and palmolein), sunflower seeds fried with palmolein oil showed less moisture content and among the antioxidants BHA offered better protection against oxidative stability throughout the storage period. Statistically there was a significant difference for the moisture content of stored fried sunflower seeds with different oils treated with different antioxidants throughout the storage period.

Similar results were reported by Waghray and Gulla (2010) in their study on butylated hydroxyanisole (BHA) to maximize the oxidative stability of a traditional Indian snack sev and boondi and they reported that the moisture content of the samples increased throughout the storage period and the samples treated with BHA showed less moisture content compared to the control. Amadi and Adebola (2008) studied the shelf life of garri, a Nigerian snack product and they reported that the moisture content in garri during storage increased with time. It must be noted that presence of moisture will accelerate formation of peroxides (Iskander *et al*., 1986). Peanut pastes with 2g H_2O / 100g added moisture had lower peroxide value (Abegaz *et al*., 2004). In the present study samples showed a slight increase in the moisture content. The moisture value ranged between (4.01 to 5.81%). During storage the moisture increased registered were from 4.43 to 5.81%, 4.21 to 5.10% and 4.04 to 4.66% for samples fried in sunflower oil, sunflower + vanaspathi and palmolein oil respectively. These moisture contents are quite low and it can be predicted that these moisture levels the hydroperoxide formation is also low. This is borne out by the peroxide values <20meq/kg throughout the study period.

Peroxide value

Peroxide value determined by an iodometric method (AOCS, 2004) measures only hydroperoxide (Hahm and Min, 1994; Shahidi and Wanasundara, 2002). The hydroperoxide content is expressed as peroxide value in milliequivalent of hydroperoxides per kg of oil. This is based on the reduction of the hydroperoxide group (ROOH) by the iodide ion (I–). Peroxide value measures only hydroperoxide, which is a transient product of oxidation.

Fresh oils usually have peroxide values below 10 meq/kg, and a rancid taste often begins to be noticeable when the PV is above 20 meq/kg (PFA 2005). A rancid taste often begins to be noticeable when the peroxide value is between 20 and 40 meq/kg. (Enujiugha and Akanbi, 2008).

The peroxide values of crude oil, degummed oil, refined oil, and bleached oil are 2.4, 10.5, 8.8, and 16.5 meq/kg oil, respectively (Jung et al, 1988). Storage changes in vegetable oil blends were measured by the peroxide formation, the final products of oxidation. Steady increase in the blends according to the extent of oxidation caused by the formation of hydro peroxides during fat oxidation was observed. Although peroxides are possibly not directly responsible for the taste and odour of rancid fats, their concentration as represented by the PV is often useful in assessing the extent to which the rancidity has advanced (Gulla and Waghray, 2011). In the present study the results of peroxide value indicates that all the oils without antioxidant at the end of the frying period had significantly higher peroxide value. Addition of different types of antioxidants such as BHA, vitaminE and citric acid oil caused significant lowering effect in the formation of peroxides in the oil. Palmolein oil treated with BHA indicated powerful antioxidant activity followed by vitamin E and citric acid. The order of effectiveness of antioxidants was BHA> vitaminE> citric acid.

Similar results were reported by Waghray and Gulla, (2010) that there was an increase in the peroxide value with the increase in storage period. The samples treated with BHA showed less peroxide value compared to control after two months of storage. Man and Tan (1999) reported that the order of effectiveness ($P < 0.05$) in inhibiting oil oxidation in RBD palmolein was oleoresin rosemary > BHA > sage extract > BHT > control. Rehman (2003) coated that addition of BHA and BHT retarded the development of rancidity in fried potato chips.

Acid value

Oil quality of sunflower is determined by fatty acid concentrations and vitamin in oil. Oleic and linoleic acid concentrations comprise fatty acids ranging from 85 to 90% in sunflower oil (Bozkurt and Karacal, 2001). Marmesat *et al.* (2005) reported the value of 0.10 per cent free fatty acid in high-oliec, high-palmitic sunflower oil. Hartman *et al.* (1999) reported that the value of per cent free fatty acid ranged between 0.28 to 1.05meq/kg in sunflower seed kernel oil.

FSSAI specification for acid value should not exceed more than 6 percent for vegetable oils. In the present study the values of acid values are within the range of FSSAI specifications. According to Demain (1990), acid values are used to measure the extent to which glyceride in the oil has been decomposed by lipase and other actions such as light and heat.

In the present study acid value gradually increased in all the samples during storage. The control samples stored for 4 months had the highest increase in acid value for all types of oil when compared to oils treated with antioxidants. The lowest increase increase in the acid value was found in palmolein treated with 0.02% BHA (1.50 mgKOH/g, 2.27 mgKOH/g, 3.33 mgKOH/g and 4.12 mgKOH/g) throughout the storage period. The order of effectiveness of antioxidants in inhibiting oil oxidation was BHA>vitaminE>citric acid.

Waghray and Gulla (2010) saw similar trends in their study that there was an increase in the acid value with the increase in storage period. The samples treated with BHA showed less acid value compared to control after two months of storage. The acid value increased gradually in all oil samples during storage. The lowest increase in acid value was found in oil samples stored for three months and treated with 0.02 % B.H.A (Iskander *et al.* 1986).

TBARS assay

The TBA test, which is used to assess frying oil degradation, increases during the frying process due to progressive hydrolytic reactions (Firestone, 1993; Fritsch, 1981; Gutierrez, 1998; Melton and Kim, 1994). This quantity could be used as an indicator to show whether the hydrolysis process is under control (Saguy et al, 1996). The high TBA value is not accepted in any commercial product because of the strong off-flavour caused by the degradation products (volatile and non-volatile compounds) of the free fatty acids during deep-frying (Gutierrez, 1998; Melton and Kim, 1994).Man and Tan (1999) reported the changes of sensory scores for rancid odour over time agreed with changes in TBA values for all oil systems.

All oils with antioxidants yielded lower TBA values than did the control throughout the storage period. Although each antioxidant offered protection, the oleoresin rosemary was most effective ($P < 0.05$) in retarding oxidation, followed by BHA, sage extract, and BHT. (Man and Tan, 1999).

Results in the present study indicated that TBA values of all the oils increased significantly throughout the storage period. Palmolein with BHA yielded lower TBA value than did the control throughout the storage period. Although each antioxidant offered protection, BHA was most effective in retarding oxidation, followed by vitamin E and citric acid. Therefore the present study confirms that addition of BHA to palmolein improves the oxidative stability when used as deep frying oil. The order of activity found for antioxidants in palmolein during deep fat frying of sunflower seeds was BHA>vitamin E> citric acid. Statistically there was a significant difference for the TBARS value of stored fried sunflower seeds with different oils treated with different antioxidants throughout the storage period.

Similar trend was found by Iskander *et al*., (1986) that the rate of increase in T.B.A values were higher in oil samples (either cottonseed or canola) treated with 0.01 % concentration of BHA than those treated with 0.02 % concentration. in another study among three oils of sesame (0.02%) percentages of antioxidants, the rate of increase in free fatty acid (FFA) of the oil containing 0.02% of BHA was found to be the lowest (0.1372) (Rahman *et al.*, 2008).

5.3 Development and comparative evaluation of fried products

Use of palmolein alone or with antioxidants especially BHA proved to be the most stable frying medium. These gave the peroxide value of <10meq/kg throughout the storage period of 18 weeks. Thus, palmolein oil was used to produce the fried snack with the higher potential for shelf stability.

When any new product is identified it is very important to study about the functional, shelf life and functional parameter which helps in the development of new product. Product development is an important step in popularising the any commodity. Therefore in present study attempts were made to develop the products like namkeen and dry roasted sunflower flavoured seeds.

Tobi (2010) reported the chemical changes in frying oil resulted in changes in the quality of fried food. The fatty acid composition of the frying oil is an important factor affecting fried food flavour and its stability; therefore, it should be low level of polyunsaturated fatty acid such as linoleic or linolenic acids and high level of oleic acid with moderate amounts of saturated fatty acid (Kiatsrichart *et al.,* 2003; Mehta and Swinbum, 2001).

Two products namely namkeen and dry roasted flavoured seeds were developed with sunflower and other seeds. Comparative evaluation was done for the sensory characteristics of namkeen made from sunflower and other seeds. Sensory attributes were determined for both the products.

Namkeens

Namkeens are popular Indian snack and can be prepared from a variety of ingredients. Vijaya *et al.* (2005) prepared and standardized rice flakes chiwda which were well accepted. Namkeens are the fried snacks and were prepared using sunflower seeds and other seeds such as cashew, roasted bengal gram and peanut. In the present study all the variations that were tried viz., namkeen with sunflower and other seeds were found to be highly acceptable. Products with cashew nut and sunflower had marginally higher scores for all the sensory characteristics. Faigmane (2002) prepared and evaluated namkeens for sensory qualities.

Dry roasted flavoured seeds

All the variations that were studied had good acceptability. Garlic flavour had higher acceptability than other recipes. Statistically significant differences were found between the recipes for the sensory attributes such as taste and over all acceptability. A study conducted by National sunflower association (1999) demonstrated that dry roasted samples were approaching the minimum fresh flavour score and had exceeded the maximum storage flavour score by 36 weeks. Cold storage, to prolonged shelf stability upto 36 weeks. Similar results were found by the expert sensory evaluation which was conducted every 12 weeks by a tasting panel evaluating the sunflower kernels in terms of fresh and storage flavours. The minimum acceptable fresh flavour score was determined to be 33, the maximum acceptable storage flavour score was 42.

5.4 Development and comparative evaluation of non fried products

Besides fried products it was thought that sunflower seeds can lend themselves to products that are traditionally made with other nuts and seeds. Therefore, to understand how versatile sunflower is, typical recipes from common nuts and seeds were selected. These were barfi, chikki, marzipan, cookies, pesto sauce, soup mix, bread rolls and salted seeds. This was done to understand how sunflower compares with its counter parts that are popular in the Indian cuisine.

Barfi

Barfi is a versatile Indian sweet which is originally made with concentrated milk and sugar. However, it is commonly made with legume flours, pulverised nuts and seeds. Example besan barfi, cashew barfi, almond barfi etc. In the present study all the variations that were tried viz., barfi with sunflower and other seeds such as cashew nut, almond and coconut were found to be highly acceptable. The mean scores of different recipes showed that the coconut barfi had higher mean score for overall acceptability (8.00). Sunflower barfi had a dark colour and this could be the reason for lower sensory scores compared to other samples.

Chikki

Chikki is a traditional Indian confection that is very popular. It is a jaggery based sweet, commonly containing groundnut, but also made from puffed bengal gram, sesame, puffed rice, coconut flakes, etc., either individually or in combination (Manay and Shadaksharswamy 1995). In the present study chikki prepared with sesame had marginally higher score for all the sensory characteristics. When analyzed statistically significant differences were found between the recipes for all the sensory attributes.

Gupta and Sharma *et al.* (2007) reported the chikki prepared using jaggery (brown sugar): sunflower kernel: sesame kernel in the ratio of 50:35:15 was the most acceptable product. The sensory term “overall acceptability” of the chikki is significantly correlated with instrumental cohesiveness, springiness and chewiness, which are desired quality attributes of the chikki.

Marzipan

Marzipan is a candy made of roasted nuts and sugar. In the present study all the variations that were tried viz., marzipan with sunflower and other seeds such as cashew nut, groundnut and melon seeds were found to be highly acceptable. There was no statistically significant difference between the products. Products with groundnut and melon seeds had marginally higher scores for all the sensory characteristics. Sunflower gave an acceptable product. It must be noted that marzipan is a product very similar to cashew barfi. While addition of sunflower in barfi resulted in dark product which affected its acceptability. In case of marzipan this problem was overcome as the product was masked by the addition of colour and garnishes. Thus, resulting in a highly acceptable product, when compare to barfi. Gupta *et al.* (2007) reported that the sugar and shelled seed proportions affect the textural characteristics of the product significantly. The highest values of hardness and chewiness were attained for the product with 70:30 sugar and shelled sunflower seed proportion respectively. The lowest values of hardness and chewiness were observed in 50:50 (sugar: shelled sunflower seed) proportion respectively. In our study the sample was found acceptable in the selected sugar and sunflower seed proportion.

Cookies

Variations in texture of cookies can be obtained by changing the type and amount of the main ingredient such as flour, fat and sugar. Several reports suggest that acceptable products can be obtained within a wide range of proportions of these ingredients (Zoulias et al., 2010; Hutchinson *et al*., 2010).

In the present study it was found that product with cashew nut had higher acceptability than the other recipes. Significant differences were found between the recipes for the sensory parameters like texture and overall acceptability. In the present study it was found that product with cashew nut had higher acceptability than the other recipes. Significant differences were found between the recipes for the sensory parameters like texture and overall acceptability

Bread rolls

Sunflower incorporation as flour even at 10% level of incorporation has been reported by Leelavathi *et al.* (1991). However, others have reported that it can be added upto 10% (Pawar and Machewad, 2004). Alternate approaches to incorporate sunflower with a better accepted product was attempted by Leelavathi *et al.* (1991) who successfully incorporated roasted sunflower grits at 30% level.

Since all the above types of incorporations were already tried, we attempted to incorporate sunflower seeds in a novel way. Investigator observed that breads with whole grain garnish were sold at a premium in stores. Therefore, in present study the sunflower seeds and other were used to dress the bread. The results indicated that in this form it was acceptable.

Pesto sauce

A sauce typically served with pasta contains crushed basil leaves, garlic, pine nuts, oliveoil, parmesan cheese, all crushed together. In the present study pesto sauce developed with peanuts, sunflower, and walnut were compared with the commercial product which is served as a control. The result revealed that there was a significant difference among the variations used in the development of pesto sauce for all the sensory attributes except texture and taste. According to Francesca et al (2008) main visual characteristics of pesto sauces, which are derived from its ingredients which are partly correlated with the concentration values of the main pigments. In present study it was found that commercial product had higher acceptability than the other recipes. Significant differences were found between the recipes for all sensory attributes except texture and taste. The pigments in sunflower and the polyphenols resulted in a darker product rendering a not very acceptable product.

Soup

Soup is a generally warm food that is made by combining ingredients such as vegetables with stock, juice, water, or another liquid and is served before a formal meal as an appetiser. Vaidehi *et al* (1996) developed products by incorporating pigeon pea in the traditional recipe. The products developed were soup, curry, playa and sambar and all products were accepted. Vidyashree (2003) developed four products viz., soup, playa, salad and sambar using five cowpea varieties. All the products were acceptable. Fresh fluted pumpkin soup was rated significantly ($P \leq 0.05$) higher for colour, taste, texture and flavour/aroma characteristics, while fresh gnectum vegetable soup was highly rated for taste, flavour/aroma and overall acceptability characteristics Mebpa *et al.* (2007). Indicating that indeed choice of ingredients plays a role in acceptability of products. In the present study there were no statistical differences between the products for the sensory parameters like appearance, texture and colour. It was found that the products with cashew nut had higher acceptability than the other recipes. Significant differences were found between the recipes for the sensory parameters like taste and overall acceptability.

Salted seeds

Salted seeds are very common poor man's snack in sunflower growing countries (Chakrapani, 1997). The results revealed that control had higher sensory score for overall acceptability (8.4) followed by onion, garlic+onion (8.2). The mean scores of salted seeds developed with garlic showed least over all acceptability (7.8). The result revealed that there was no significant difference among the variations used in the development of salted seeds for all the sensory attributes (Fig: 25). Highly acceptable product was developed reiterating the preference of this snack.

5.5 Shelf life studies of selected products

Shelf life studies of fried products

Impact of storage period on sensory attributes is an important criteria in deciding the product quality.

Namkeens

Lee and Resurreccion (2006) reported that consumer acceptance of fried rice flakes was affected by storage temperature and humidity conditions. Consumer acceptance and intensity ratings of fried rice flakes stored at temperatures of 23, 30, 35 and 40ºC and water activities (a_w) of 0.33, 0.44, 0.54, 0.67 and 0.75 were determined over time. Consumer acceptance ratings, including overall appearance, colour and texture were affected by storage water activity and time but not storage temperature. Consumer intensity ratings of crunchiness were affected by storage water activity and time but not storage temperature. Aroma acceptance, flavour acceptance and stale/ oxidized rancid intensity ratings of fried rice flakes were dependent on storage temperature, water activity and time. In the present study there was slight deterioration in the acceptability by the 4^{th} week. This could be attributed to the slight increase in moisture content.

Dry roasted sunflower flavoured seeds

Dry roasted flavoured seeds in present study stored in HDPE showed higher mean sensory scores for all the sensory attributes compared to PET jars throughout the storage period. Similar study carried out by National sunflower association (1999) reported that low oxygen packaging protects roasted sunflower seeds kernel form oxidative stability. Raghav *et al.* (1999) studied the storage stability of oil in different packaging materials. It was observed that storage of raw sunflower oil during storage, different packaging materials and heat treatment affected the colour, odour, free fatty acids and iodine value of oil. The airtight HDPE pouches with heat-treated oil were found to be the best packaging materials for storage of oil up to a period of 16 weeks.

Shelf life studies for non fried products

Effect of storage on sensory characteristics and rancidity for products barfi, chikki and cookies were studied. These are discussed in the following paragraphs.

Barfi

Moisture sorption data are useful in choosing suitable packaging material having a desirable water vapour barrier property in addition to determining the stability of the product (Chetana *et al*., 2004). Gupta *et al.,* (2007), reported that high percentage of unsaturated fat present in the product makes it susceptible to hydrolytic rancidity. The resulting increase in free fatty acid content coupled with mold growth limit its shelf life to 7–10 days in unpacked condition. In their study the samples were packed in flexible pouches of multilayer films in-package heat processing. A maximum of 75 days shelf life was obtained for heat-processed samples as against <15 and 45 days for air and vacuum packed samples respectively in both packaging materials. In the present study cashew nut scored higher mean score for over all acceptability followed by almond, coconut and sunflower in the 1st and 2nd week compared to rest. There was a significant difference for over all acceptability for all the treatments throughout the storage period.

Chikki

Pajin *et al.* (2006) reported the quality and shelf-life of a dragee product obtained by coating a confectionery sunflower kernel with sugar syrup. The product was packed in oriented polypropylene/oriented polypropylene; oriented polypropylene/metalized oriented polypropylene, polyester/polyethylene and kept at room temperature in daylight for 5 months. At the beginning of the experiment, the dragee product was in the category of excellent sensory quality in terms of its colour, smell, taste, mastication and structure. During the storage, these properties changed and the product lost its stability. The indicators of oxidative stability i.e., rancidity of peanut confections during storage was determined by peroxide value, instrumental volatile and descriptive sensory analysis. In the present study chikki made from sesame scored the higher mean score and had lower perceptible rancidity followed by peanut, melon and sunflower in the 1st and 2nd week compared to rest. There was a significant difference for appearance for 1st week, 3rd week and 4th week except 2nd week for all the treatments. Thus, sunflower seeds were not as stable as other seeds.

Cookies

Zoulias *et al.,* (2010) studied the effect of fat reduction in cookies on moisture content and shelf life. All fat-reduced, sugar-free cookies prepared in this study had higher values of moisture content and water activity than the control, but these values were below the upper limit that affects cookie shelf-life. Thus, cookies because of low water activity are considered a shelf stable product. Therefore, cookies were subjected to shelf life study. In the present study cookies made from cashew nut scored high mean scores followed by almond, peanut and sunflower. The developed cookies due to their lower water activity had a longer shelf life than the product barfi. However, cookies made with sunflower were also acceptable.

5.5 Nutrient composition of the developed products

Srilatha and Krishnakumari (2003) reported that incorporation of defatted sunflower cake in recipes at 10 and 20 per cent levels contributed a significant increase in protein and fibre values. There was 4.7 to 5.8 per cent increase in protein and 2.2 to 6.0 per cent increase in fat contents of the products containing 20 per cent cake. Among the recipes developed pakodi containing 10 per cent sunflower cake was most acceptable. In the present study the mean macronutrients were higher in the sunflower products for energy, cashew nut products for protein and ground nut for fat. The micronutrients were higher in the sunflower products compared to products prepared from other seeds.

5.6 Cost of production

The cost of the individual products from sunflower seeds alone per 100g was Rs. 7.83, 6.4, 10.50, 10.40, 8.00, 8.70, 7.20, 17.51, 9.36 and 6.24 for namkeens, dry roasted flavoured seeds, barfi, chikki, marzipan, cookies, bread rolls, pesto sauce, soup and salted seeds respectively. The production costs were higher for other products prepared from other seeds such as cashew nut, almond, walnut, ground nut, water melon seeds, poppy seeds sesame and coconut. Thus, inclusion of sunflower in the daily diet can be an economical way to diversify the diets.

Summary and conclusion

VI. SUMMARY AND CONCLUSION

6.1 SUMMARY

Sunflower is an important non-traditional crop which has gained popularity in India as a supplement to traditional oil seed crops. Studies on the foods product development aspects of sunflower seeds are limited in the country. The present study was conducted to evaluate and explore the possible uses of sunflower seed kernel. In the present study sunflower seed kernels were used along with other seeds such as almonds, cashew nuts, poppy seeds, walnuts, ground nuts and melon seeds to see if these costlier seeds could be replaced by sunflower seeds. Aim of the study was to develop shelf stable products. Since oxidative rancidity is a problem evaluation of frying medium as well as antioxidants was performed to identify the most effective frying system. Effects of frying with different types of oil such as palmolein oil, sunflower oil, ground nut oil and vanaspati was evaluated by treating the oils with antioxidants such as vitamin E, BHA, citric acid. Fried and non fried products were developed and evaluated for sensory characteristics. Shelf life of developed products was assessed. Cost of production of products was computed. Following are the salient findings of the study:

- Sunflower seeds fried with different oils showed that seeds fried with Palmolein oil showed good acceptability (appearance-7.00, texture-7.4, colour-7.2, taste-7.6 and over all acceptability 8.00) compared to other oils.

- The fat absorption for sunflower seeds fried with ground nut oil and vanaspati (10.0%) was more followed by palmolein (8.75 %) and sunflower oil (8.66%). Statistically there were no significant differences found in the volume expansion for sunflower seeds fried with different oils. However ground nut oil (1.87%) showed increase in the volume expansion followed by palmolein and vanaspathi (1.85%) and sunflower oil.

- Sunflower seeds were fried with the oils such as palmolein, sunflower oil and sunflower+vanaspathi and also treated with antioxidants such as vitamin E, BHA and citric acid and were stored for four and a half months.

- The fried seeds were evaluated for the presence of rancidity, moisture content, peroxide value, acid value and TBARS assay. Among the three treated oils, palmolein oil showed less moisture content, peroxide value, acid value and TBARS value compared to sunflower oil and sunflower + vanaspathi. Among the antioxidants BHA showed less moisture content, peroxide value, acid value and TBARS value compared to vitamin E and citric acid throughout the storage period.

- Two fried products namely namkeen and dry roasted flavoured sunflower and other seeds were developed and subjected to sensory evaluation. Products form were well accepted. The storage study of these products revealed that the products developed could be stored for four weeks in HDPE and plastic box at ambient temperature. Eight non fried products namely barfi, chikki, marzipan, cookies, bread, pesto sauce, soup and salted seeds made from sunflower and other seeds were developed. Products were well accepted.

- Three non fried products such as barfi, chikki and cookies were selected for storage study for four weeks in HDPE pouches. The storage study revealed that the products developed could be stored for one to four weeks.

- Nutrient composition of the developed products was computed. Addition of sunflower seed kernels brought about a slight increase in some of the nutrients (energy, calcium, phosphorous, iron, zinc and vitamin E) when compared to other seeds.

- The cost of the individual products from sunflower seeds alone per 100g was Rs. 7.83, 6.4, 10.50, 10.40, 8.00, 8.70, 7.20, 17.51, 9.36 and 6.24 for namkeens, dry roasted flavoured seeds, barfi, chikki, marzipan, cookies, bread rolls, pesto sauce, soup and salted seeds respectively. These prices were markedly lower than the corresponding products made from other seeds.

6.2 CONCLUSION

High proportion of PUFA in sunflower predisposes it to oxidative rancidity which is an important constraint in the shelf stability. The results of the study demonstrated that:

- Considering the chosen parameters to assess oxidative rancidity such as development of rancid flavour, moisture content, peroxide value, acid value and TBARS assay Palmolein oil was most suitable for deep fat frying operations for the development of shelf stable products.

- The antioxidants (BHA, vitamin E and citric acid) were effective in retarding the progression of rancidity. BHA was found to be most effective.

- Based on the above formative research palmolein oil was used to develop fried products namely namkeens and dry roasted flavoured seeds and were packed HDPE pouches and PET jars. It was demonstrated that the products were within the acceptable range of two to four weeks of storage. HDPE pouches were found to be the best packaging material.

- Among the 8 non fried snack products that were developed using sunflower seeds. Seven (barfi, chikki, cookies, marzipan, soup, bread rolls and salted seeds) were found acceptable. The order of acceptability was salted seeds > cookies > marzipan > barfi > chikki > soup >bread rolls. Pesto sauce was not acceptable. The product salted seeds was most shelf stable product and was found to be acceptable till the end of the storage period of 4 weeks, other products also had product specific shelf stability in the order of cookies>chikki>marzipan>barfi>bread>soup>sauce.

These results allow the ***overall conclusion*** that shelf stable product with the appropriate shelf stability could be made with sunflower seeds. Therefore, it can be concluded that sunflower seeds can be successfully incorporated in the development of shelf stable products which are less expensive compared to the products developed with other seeds and nuts. The inclusion of sunflower seed also improved the nutritive value of products especially energy, zinc and vitamin E. Thus, use of sunflower can enable the development of products of low cost, nutritious and shelf stable value added products.

Future line of work

Further research is needed on

- Packaging material to store the products for good shelf stability.
- Natural antioxidants to prevent the oxidative stability during storage.
- Identification of high oleic acid type sunflower varieties for the purpose of developing shelf stable value added products.
- Popularization of the developed products through transfer of technology.

Reference

VII. REFERENCES

ABEGAZ, E.G., KERR, W.L. AND KOEHLER, P.E., 2004, The role of moisture in flavour changes of model peanut confections during storage. *Journal of Food Science.,* **37**:255-225.

ADEBESIN, A. A., SAROMI, O.T., AMUSA, N.A. AND FAGADE, S.O., 2001, Microbiological quality of some groundnut products hawked in Bauchi, a Nigerian City. *The Journal of Food Technology in Africa.*, **6**: 53-55.

ADNAN, M., ARGOUDELIS, C.J., RODDA, E. AND TOBIAS, J., 1980, Lipid oxidative stability of reconstituted partially defatted peanuts. *Peanut science.*, **8**:13-15.

AHMED, E.M. AND ALI, M., 1986, Textural quality of peanut butter as influenced by peanut seed and oil content. *Peanut Sci.,* **13**:18-20.

ALLENDORF , M., SUBRAMANIAN, A. AND SAONA, L.R., 2012, Application of a Handheld Portable Mid-Infrared Sensor for Monitoring Oil Oxidative Stability, *J Am Oil Chem Soc* , **89:** 79–88

AMADI, J.E AND ADEBOLA, M.O**.,** 2008, Effect of moisture content and storage conditions on the storability of garri. *African Journal of Biotechnology.,* 24: 4591-4594.

ANJUM, F., ANWAR, F., JAMIL, A. AND IQBAL, M., 2006, Microwave roasting effects on the physico-chemical composition and oxidative stability of sunflower seed oil. *JAOCS.*, **83**(9):777-784.

ANONYMOUS, 2008, USDA National Nutrient Database for Standard Reference, Release 20.

ANONYMOUS, 2012, Project Directions Rep., AICRP on Sunflower and Castor, *Directorate Oilseed Res., Hyderabad*, pp. 16.

ANWARA, A.K., 2009, Nutritional composition, processing for value addition and anti calcifying properties of selected horse gram genotypes. Msc (agri) thesis, UAS, Bangalore, Karnataka.

ANWARA, F., ANWAR, T. AND MEHMOOD, Z., 2009, Methodological characterization of rice bran oil from Pakistan. *Grasas Aceites.,* **56**:126-127.

ANYASOR, G.N., OGUNWENMO, K.O., OYELANA, O.A., AJAYI, D. AND DANGANA, J., 2009, Chemical analysis of groundnut (Arachis hypogaea) oil. *Pakistan Journal of Nutrition.,* **8**(3):269-272.

AOAC.1980, Official methods of analysis, 13th edition, Association of official analytical chemists, Washington.DC.

AUGUSTIN, T.K. AND BERRY., 1983, Omega-3, Omega-6 unsaturated fatty acid composition of commercially available vegetable oils. *Ind. J. Nutr. Dietet.,* **29**:200-203.

BAJAJ, M., KAUR, A. AND SIDHU, J., 1991, Studies on the development of nutritious cookies utilizing sunflower kernels and wheat germ. *Plants Foods for Human Nutrition.,* 41:381-387.

BAX, M.M., GELY, M.C. AND SANTALLA, E.M., 2004, Prediction of crude sunflower oil deterioration after seed drying and storage processes. *JAOCS.*, **81**(5): 511-515.

BLIGH, E.G. AND DYER, W.J., 1959, Estimation of total lipids. *Can. J. Biochem Physiol.,* **37**:911.

BOZKURT, M.A. AND KARACAL, I., 2001, Quantitative relationship between nutrient contents and oil quality of sunflower seed. *J. Food Sci. Technol.,* **38**(6):635-638.

BUDIN, J.T. AND BREENE, W.M., 1993, Factors affecting the shelf stability of sunflower nuts. *JAOCS.,* **70**(5):493-496.

BUENDIA, M.O., APPOLONIA, B.L., 1986, Storage studies on confectionery sunflower kernels. *Cereal chemistry.,* **63**(2):85-88.

CANCOLAN, P., 1971, Chemical composition of sunflower seed hull. *JAOCS.,* **48**:629-632.

CANIBE, N., PEDROSA, M.M., ROBREDO, L.M. AND KNUDSEN, K.E.B, 1999, Chemical composition, digestibility and protien quality of 12 sunflower (*Helianthus annus* L.) cultivars. *J. Sci. Food Agric*., **79:** 1775-1782.

CHAKRAPANI, Y., 1997, Evaluation of sunflower genotypes for confectionery purpose, *MSC. (Agri.) Thesis,* University of Agricultural Sciences, Dharwad.

CHETANA, R., SRINIVASA, P. C. AND REDDY, Y.S., 2004, Moisture sorption characteristics of milk burfi, an traditional Indian sweet using sugar substitutes. European Food Research and Technology., 136-141.

CHEUNG. S.C.M., SZETO, Y.T. AND BENZIE, I.F.F., 2007, Antioxidant Protection of Edible Oils, *Plant Foods for Human Nutrition,* **62:** 39–42

CHOI, E. AND MIN, D.B., 2005, Chemistry and reactions of reactive oxygen species in foods. *J Food Sci.,* **70:** 142–R159.

CHOL, S.P., 2005, Stability and quality of fish oil during typical domestic application. *European Food Research and Technology,* 136-141.

CHRISTINE, M. S., SONG, Q. AND CSALLANY, A.S., 2010, The antioxidant functions of tocopherol and tocotrienol homologues in oils, fats, and food systems. *J. Am Oil Chem Soc.*, **87:** 469-481.

DARAMOLA, B. AND ASUNNI, O. A., 2006, Nutrient composition and storage studies on roselle extract enriched deep-fat-fried snack food. *African Journal of Biotechnology ,* **19:** 1803-1807

DAS, P., LAISHRAM, P.D. AND GOGOI, M., 2005, Nutrient composition of some nuts and oilseeds based recipes of Assam, India. *J. Hum. Ecol.,* **18**(2):161-165.

DEMAIN, M.J., 1990, Principles of Food Chemistry, 2nd Ed. *Van Nostrond Reinhold International Company Limited, London England.,* pp:37-38.

DENIS, L. AND VEAR, F., 1996, Variation of hullability and other seed characteristics among sunflower lines and hybrids. *Euphytica.*, **87**:177-187.

DREHER, M.L., SCHANTZ, R.M., HOLM, E.T. AND FRAZIER, R. A., 2006, Sunflower butter: Nutritional evaluation and consumer acceptance. *Journal of Food Science.,* **48**(1):237-239.

EBONG, P.E., OWU, E.U. AND ISONG, E.U., 1999, Influence of palm oil (*Elaesis guineensis*) on health, *Plant Foods for Human Nutrition, 53***:** 209–222

EDEM, D.O., 2002, Palm oil: Biochemical, physiological, nutritional, hematological, and toxicological aspects: A review, *Plant Foods for Human Nutrition,* **57:** 319–341

ENUJIUGHA, N.V. AND AKANBI, T.C., 2008, Quality evaluation of canned fermented oil bean seed slices during ambient storage. *African Journal of Food Science*., **2:** 4591 – 4594.

FAIGMANE, M.S., 2002, Sensory profiles and hexanal content of cracker-coated and roasted peanuts stored under different temperatures. *Journal of Food Processing and Preservation.*, **32**: 1-23.

FARAG, 1999, Effect of radiation and other processing methods on protien quality of sunflower meal. *J. Sci. Food Agric*., **79:** 1565-1570.

FARHOOSH, R., KENARI, R.E. AND POORAZRANG, H., 2009, Frying Stability of Canola Oil Blended with Palm Olein, Olive, and Corn Oils*, Am Oil Chem Soc,* **86:** 71–76.

FIRESTONE, 1993, Effect of heat processing on phenolic constituents and nutritional quality of sunflower flour. *J.A.O.C.S.,* **62**:1131-1134.

FISHER, R.A. AND YATES, F., 1963, Statistical tables for biological, agricultural and medical research. *Oliver and Boyd*, Edinburg.

FISK, D., WHITE, D.A., CARVALHO, A. AND GRAY, D.A., 2006, Tocopherol-an intrinsic component of sunflower seed oil bodies. *JAOCS.,* **83**(4):341-344.

FRANKEL, E. N., 1996, Antioxidants in lipid food and their impact on food quality. *Food Chemistry*, **57:** 51-55.

FRANKEL, E.N., 2005, Lipid oxidation, 2nd edn. PJ Barnes, Bridgewater, England, pp 165–183, 209–253.

FRITSCH, C.W., 1981, Measurements of frying fat deterioration: A brief review, *J. Am. Oil chem. Soc.,* **58:** 272–274.

FRITSCH, C.W., HOFLAND C.N. AND VICKERS, Z.M., 2006, Shelf life of sunflower kernels. *J. Food Sci..,* **62**(2):425-428.

GAJERA, H.P., KOPAPARA, M.B., PATEL, V. AND HANDPATEL, M.M., 2008, Influence of peanut butter on quality characteristics of biscuits. *J. Food Sci. Technol.,* **45**(4):373-375.

GATTA, C. AND PIERGIOVANNI, A.R., 1996, Technological and nutritional aspects in hyperproteic bread prepared with the addition of sunflower meal. *Food Chemistry.,* **57**:493-496.

GESELLSCHAFT, 2010, deep fat frying. 18th Ed: 298, 302, 315.

GHARACHORLOO, M., GHAVAMI, M., MAHDIANI, M. AND AZIZINEZHAD, R., 2010, The Effects of Microwave Frying on Physicochemical Properties of Frying and Sunflower Oils, *J Am Oil Chem Soc*, **87:** 355–360

GITANJALI, A. AND LAXMI, C., 2000, Microbiological and chemical changes during storage of groundnut meal. *Indian J. Agric. Biochem.*, **10**: 46-47.

GOPALAN, C., RAMASASTRI, B.V. AND BALASUBRAMANIAN, S.C., 2007, Nutritive value of Indian foods, National Institute of Nutrition., *ICMR Publication, Hyderabad.*

GOPIKA, C.M., 2009, evaluation of sunflower seed kernels for preparing shelf stable added value food products, *unpublished.*

GROSSO, N.R., RESURRECCION, A.V.A., WALKER, G.M. AND CHINNAN, M.S., 2007, Sensory profiles and hexanal content of cracker-coated and roasted peanuts stored under different temperatures. *Journal of Food Processing and Preservation.*, **32**: 1-23.

GUITERREZ, M.K., 1998, Evaluation of total tocopherol content of selected edible oils in Indian markets. *Ind. J. Nutr. Dietet.,* **34**:169-172.

GULLA, S. AND WAGHRAY, K., 2011, Effect of Storage on Physico-chemical Characteristics and Fatty Acid Composition of Selected Oil Blends. *J L S*, **3:** 35-46.

GULLA, S. AND WAGHRAY, K., 2012, Blending of oils: A case study on storage stability and sensory characteristics of a ready to eat extruded snack. *Journal of Nutrition*., 212- 258.

GUPTA, H., MEHTA, U. AND SANGHA, J., 1996, Characteristics of cookies and muffins supplemented with full fat sunflower grits. *Journal of Food Science and Technology.,* **33**:513-515.

GUPTA, K. M., 2005, frying oils, Bailey's Industrial Oil and Fat Products, Sixth Edition, Six Volume Set.

GUPTA, R. K., SHARMA, A. AND SHARMA, R., 2007, Instrumental texture profile analysis (TPA) of shelled sunflower seed caramel snack using response surface methodology. *Food Sci. Tech. Int*., **13**(7): 455-460.

GUPTA, R.K. AND DAS, S.K., 1999, Performance of centrifugal dehulling system for sunflower seeds. *Journal of Food Engineering.,* **42**(4):191-198.

GUPTA, R.K. AND SHARMA, A., 2007, Textural profile analysis of sunflower-sesame kernel confection. *Journal of texture studies.,* **38**:153-165.

HAHM, T.S. AND MIN, D.B., 1994, Analyses of peroxide values and headspace oxygen. *AOCS*., 144–148.

HARTMAN, L., ANTONIASSI, R. AND FREITAS, S.P., 1999, Characterization of five sunflower varieties cultivated in Brazil. *B. Ceppa, Curitiba.,* **17**(2): 145-152.

HEGAZY, N.A., MEKAWY, A.A. AND HASSONA, 1991, Influence of different levels of peanut hull flour on physical and sensory evaluation of low calorie cakes. *Egypt Nahrung*., **35**(8): 821-826.

HOLLIDY, R. AND PHILLIPS, K., 2001, Health benefits of sunflower seed kernel. *Cereal Foods World.,* **46**:205-208.

HOUHOULA, D.P., OREOPOULOU, V.P. AND TZIA, C., 2002, A Kinetic Study of Oil Deterioration during Frying and a Comparison with Heating, *JAOCS,* **79:** 133–137

HUTCHINSON, P.E., BAIOCCHI, F. AND VECCHIO, A.J., 2002, Effect of emulsifiers on the texture of cookies. *Journal of Food Science.,* **42:** 401 - 445

IQBAL, S. AND BHANGER, M. I., 2005, Stabilization of sunflower oil by garlic extract during accelerated storage. *Food Chemistry*, *Article in press*.

IRWNANDI, R.T., CHE MAN. AND KITTS, D.B., 1999, Quality and storage stability of crude palm oil and its blends. *The Ind. J. Nutr. Dietet.,* **32**:238-249.

ISKANDER, M.H., DAWOOD, A.A. AND HATOUR, F.S., 1986, Effect of storage conditions on the stability and fatty acid composition of sunflower oil. *J. Agric. Res.,* **3:** 879 – 892.

IZAKI, T.R., YOSTIKAWA, K. AND UCHKAWA., 1984, Studies on the physico-chemical characteristics of some vegetable oils during heating and frying. *J. Food Sci. Technol.*, **35**: 432-434.

JACOBSON, G.A., 1967, Quality control of commercial deep fat frying. *Food Technology*., **2:** 43 – 48.

JACOBSON, H.T., 1991, Colorimetric determination of total tocopherols in palm oil, olein and stearin. *J.A.O.C.S.,* **65**:258-261.

JASWIR, I. AND CHE MAN, Y.B., 1999, Use optimization of natural antioxidants in refined, bleached, and deodorized palm olein during repeated deep-fat frying using response surface methodology. *J Am Oil Chem Soc.*, **76:** 341–348.

JUNG, M.Y., YOON, S.H. AND MIN, D.B., 1988, Effects of processing steps on the contents of minor compounds and oxidation of soybean oil. *J Am Oil Chem Soc.*, **66:**118–120

KALOGIANNI, E.P., KARASTOGIANNIDOU, C. AND KARAPANTSIOS, T.D., 2009, Effect of the Presence and Absence of Potatoes under Repeated Frying Conditions on the Composition of Palm Oil, *J Am Oil Chem Soc.*, **86:** 561–571.

KALRA, C.L., SEHGAL, R.C., NAGENDER, A., LAL, M. AND BERRY,S.K., 1998, Preparation, quality standards and storage of mathi- a traditional savoury product. *J food sci. technol*., **35**(1): 25-29.

KARAKAYA, S. AND SIMSEK, S., 2011, Changes in Total Polar Compounds, Peroxide Value, Total Phenols and Antioxidant Activity of Various Oils Used in Deep Fat Frying, *J Am Oil Chem Soc,* **88:** 1361–1366

KIATSRICHART, S., BREWER, M.S., KEITH, R., CADWALLADER, AND WILLIAM, E., 2003, Pan-Frying Stability of NuSun Oil, a Mid-Oleic Sunflower Oil, *JAOCS,* **80:** 479–483

KIM, J.H., HAHM, T.S. AND MIN, D.B., 2007, Hydroperoxide as a Prooxidant in the Oxidative Stability of Soybean Oil, *J Amer Oil Chem Soc.*, **84:** 349–355

KITTS, A.E., 1996, Physicochemical studies on oils from five selected Nigerian plant seeds. *Pak. J. nutr.,* **6**:75-78.

KOH, S.P., ARIFIN, N., TAN, C.P., YUSOFF, M.S.A., LONG, K. AND LAI, O.M., 2011, Deep Frying Performance of Enzymatically Synthesized Palm-Based Medium- and Long-Chain Triacylglycerols (MLCT) Oil Blends. *Food Bioprocess Technol.*, **4:**124–135

KRINGS, U., SAHARTY, Y. S. E., ZEANY, B. A. E., PABEL B. AND BERGER, R. G., 2000, Antioxidant activity of extracts from roasted wheat germ. *Food Chemistry,* **71:** 91-95.

LAKE, R.J. AND SCHOLES, P., 1997, Quality and Consumption of Oxidized Lipids from Deep-Frying Fats and Oils in New Zealand, *JAOCS,* **74:** 1065–1068

LEE, C.M. AND RESURRECCION, A.V.A., 2006, Consumer acceptance of roasted peanuts affected by storage temperature and humidity conditions. *Lebensm. Wiss. U. Technol.*, **39**: 872-882.

LEELAVATHI, K., RAO, H.P. AND SASTRY, S.M.C., 1991, Studies on the utilization of sunflower kernels in bakery products. *J. Food Sci. Technol.,* **28**(5):280-284.

LOH, S., CHEW, S.M. AND CHOO, Y.M., 2006, Oxidative Stability and Storage Behaviour of Fatty Acid Methyl Esters Derived from Used Palm Oil, *JAOCS,* **83:** 947–952

LUSAS, E.W., 1985, Sunflower seed protein. In New Protein Foods:Altscul, A. M., Wilcke, H. L., Eds: *Academic Press Inc*: *Orlando, F. L.,* pp 393-433.

MADHUSUDHAN, K.T., SHAMANTHAKA, M.C. AND SRINIVAS, H., 1986, Effect of roasting on the physico-chemical properties of sunflower proteins. *Journal of Food Science.*, **19**:292-296.

MAHONI, N, T. AND GRAFT, K., 1986, Effect of moisture content in the dehulling capacity of sunflower seeds. *Information Technologica.,* **12**(1):3-8.

MAKHOUL, H., GHADDAR, T. AND TOUFEILI, I., 2006, Identification of some rancidity measures at the end of the shelf life sunflower oil. *European Journal of Lipid Science and Technology.,* **108**(2):143-148.

MAN, Y.B.C. AND TAN, C.P., 1999, effects of natural and synthetic antioxidants on changes in refined, bleached, and deodorized palm olein during deep-fat frying of potato chips, *JAOCS* **76:** 331–339

MANAY, N.S. AND SHADAKSHARSWAMY, M., 1995, Food facts and principles, pp.420-424, *New Age International Publishers (P) Ltd.,* New Delhi, India

MARMESAT, S., MANCHA, M., RUIZ-MENDEZ, M.V. AND DOBARGANES, M.C., 2005, Performance of sunflower oil with high levels of oleic and palmitic acids during industrial frying of almonds, peanut, and sunflower seeds. *JAOCS.*, **82**(7): 505-510.

MATHEWS, A.R., MAHADEVIAH, M., GOWRAMMA, R.V. AND KRISHNAMURTHY, M.N., 1998, Packaging of raw groundnut oil in tin-free steel cans. *J. Food Sci. Technol.*, **35**: 435-437.

MEBPA, H.D, EBOH, L AND BANGIO, D.E.B., 2007, Effects of processing treatments on the nutritive composition and consumer acceptance of some Nigerian edible leafy vegetables. *African journal of food agriculture nutrition and development.,* 2158- 2245.

MEHTA, K.L. AND SWINBUM, A.S., 1991, Methods for measuring changes in deep fat frying oils. *Food Technol*. **45** (2): 75 – 80.

MELTON, K.L. AND KIM, D.G., 1994, Chemical composition and oxidative stability of safflower oil prepared with expeller from safflower seeds roasted at different temperatures. *J. Food Sci.,* **69**:33-38.

MERRILL, L.I., OSCAR A. P., LYNN V. O. AND MICHAEL L. D., 2008, Oxidative stability of conventional and high-oleic vegetable oils with added antioxidants. *J Am Oil Chem Soc.*, **85:** 771-776.

MIKOLAJCZAK, K.L., SMITH, C.R. AND WOLFF, I. A., 1970, Phenolic and sugar components of Armavirec variety sunflower (*Helianthus annus*) seed meal. *J. Agr. Food Chem.,* **18**(1):27-32.

MILLER, N., PRETORIUS, H.E. AND VAN DER RIET, W.B., 1986, The effect of storage conditions on mould growth and oil quality of confectionery and high-oil sunflower seeds. *Journal of Food Science.,* **19**:101-103.

MIN, D.B. AND BOFF, J.M., 2002, Chemistry and reaction of singlet oxygen in foods. *Comp Rev Food Sci. Food Saf*., **1:** 58–72.

MIN, D.B. AND CHOE, E., 2003, Effects of singlet oxygen oxidation on the flavor of foods and stability of vitamins. *J Food Sci Biotech.,* 582–586.

MOHARRAM, Y.G., MOUSTAFA, A.Y. AND OSMAN, O.A., 1981, Studies on wet dehulling of Egyptian sesame seeds by lye solutions. *Journal of Food Science.,* **14**:137-140.

MURTHY, N.K. AND SHOBANA, S., 1997, Evaluation of total tocopherol content of selected edible oils in Indian markets. *Ind. J. Nutr. Dietet.,* **34**:169-172.

NAGARAJ, G., 1995, quality and utility of oilseeds. DOR, Hyderabad, pp. 23-27.

NAGHSHINEH, M., ARIFFIN, A., GHAZALI, H.M., MIRHOSSEINI, H. AND MOHAMMAD, A., 2010, Effect of Saturated/Unsaturated Fatty Acid Ratio on Physicochemical Properties of Palm Olein–Olive Oil Blend, *J. Am. Oil. Chem. Soc.,* **87:** 255–262

NARASIMHAMURTHY, K. AND RAINA, P.L., 1998, Studies on the physico-chemical characteristics of some vegetable oils during heating and frying. *J. Food Sci. Technol.*, **35**: 432-434.

NARASIMHAN, S., RAGHUVEER, K.G., ARUMUGHAM, C., BHAT, K.K. AND SEN, D.P., 1986, Oxidative rancidity in groundnut oil-evaluation by sensory and chemical indices and their correlation. *J. Food Sci. Technol.*, **23**: 273-278.

NARWAR, W.W., 1996, Lipid. In: Fennema OR (ed) Food chemistry, 3rd edn. Marcel Dekker, New York, pp 225–320

NASIRULLAH AND RANGASWAMY, B.L., 2005, Oxidative stability of healthful frying oil medium and uptake of inherent nutraceuticals during deep frying. *J Am Oil Chem Soc.*, **82:** 753–757.

NEFF, W.E., WARNER, K. AND ELLER, F., 2003, Effect of γ tocopherol on formation of non-volatile lipid degradation products during frying of potato chips in triolein. *J Am Oil Chem Soc.*, **80:** 801–806.

NINFALI, p., ALUIGI, G., BACCHIOCCA, M. AND MAGNANI, M., 2001, Antioxidant Capacity of Extra-Virgin Olive Oils, *JAOCS,* **78:** 243–247

NOLASCO, S.M., AGUIRREZABAL, L.A.N. AND CRAPISTE, G.H., 2004, Tocopherol oil concentration in field-grown sunflower is accounted for by oil weight per seed. *JAOCS.*, **81**(11): 1045-1051.

NOLASCO, S.M., AGUIRREZABAL, L.A.N., LUQUEZ, J. AND MATEO, C., 2006, Variability in oil tocopherol concentration and composition of traditional and high oleic sunflower hybrids (*Helianthus annus* L.) in the Pampean region (Argentina). *GRASAS Y ACEITES.*, **57**(3):260-269.

NOR, F, M., MOHAMED, S., IDRIS, N. A. AND RAZALI ISMAIL, 2009, Antioxidative Properties of Curcuma longa Leaf Extract in Accelerated Oxidation and Deep Frying Studies, *J. Am. Oil. Chem. Soc.*, **86:** 141–147

NORMAND, L., ESKIN, N.A.M. AND PRZYBYLSKI, R., 2001, Effect of Tocopherols on the Frying Stability of Regular and Modified Canola Oils, *JAOCS* **78:** 369–373

NORMAND, L., ESKIN, N.A.M. AND PRZYBYLSKI, R., 2006, Comparison of the Frying Stability of Regular and High-Oleic Acid Sunflower Oils, *JAOCS,* **83:** 331–334.

OZCAN, M.M., 2006, Determination of the mineral composition of some selected oil-bearing seeds and kernels using inductively coupled plasma atomic emission spectrometry (ICP-AES). *GRASAS Y ACEITES.,* **57**(2):211-218.

PAJIN, B., LAZIC, V., JOVANOVIC, O. AND GVOZDENOVIC, J., 2006, Shelf life of a dragge product based on sunflower kernel depending on packaging materials used. *International Journal of Food Science and Technology.,* **41**(6):717-721.

PAJIN, B.S. AND JOVANOVIC, O.L., 2003, Dragee product based on sunflower., *BIBLID,* **34**:13-20.

PARSKOVA, P., JORDANOV, J., RESURRECCION, A.V.A., MOON, W., FLORKOWSKI, W.J., CHINNAN, M.S. AND BEUCHAT, L.R., 2001, Consumer acceptance of American peanut products by Bulgarian consumers. *Peanut Science.*, **28**: 44-48.

PAWAR, V.D. AND MACHEWAD, G.M., 2004, Oraganoleptic quality of bread enriched with high protein products from sunflower meal. *J. Food Sci. Technol.,* **41**(6):672-674.

PAWAR, V.D., PATIL, J.N., SAKHALE, B.K. AND AGARKAR, B.S., 2001, Studies on selected functional properties of defatted sunflower meal and its high protein products. *J. Food Sci. Technol.,* **38**(1):47-51.

PRAVEENA, B., SRINIVAS, C.V.S. AND NAGARAJ, G., 2000, Quality of some Indian sunflower genotypes and utilization of cakes in snack foods. *Helia.,* **23**(33):121-128.

PREVENTION OF FOOD ADULTRATION ACT 2003, 18th Ed: 298, 302, 315.

PRZYLSKI, R. AND ESKIN, N.A.M., 1994, Canola oil: physical and chemical properties. *Food Technology.,* **82**(7): 505-510.

PURDY, R.H., 1996, Oxidative stability of high oleic sunflower and sunflower oils. *J. Am. Oil. Chem. Soc.,* **62**:523-525.

RAGHAV, P.K., GROVER, P.C. AND THAPAR, V.K., 1999, Storage stability of sunflower (*Helianthus annus*) oil in different packaging materials. *J. Food Sci. Techno.,* **36**(3):259-255.

RAGURAMULU, N., MADHAVAN NAIR, K. AND KALYANA SUNDARAN, S., 2003, A laboratory techniques, NIN, *ICMR publications.*, Hyderabad.

RAHMAN, M., GRAY, K, O. AND JACOBSON, G.A., 2008, Quality control of commercial deep fat frying. *Food Technology,* **21**(2): 43 – 48.

RAMA PRASAD, C., SUBRAMMANIAN, R. AND VENUGOPAL, P., 1992, Omega-3, Omega-6 unsaturated fatty acid composition of commercially available vegetable oils. *Ind. J. Nutr. Dietet.,* **29**:200-203.

RAMADAN, M.F., 2010, Rapid antiradical method for screening deep fried oils, *J. Verbr. Lebensm*, **5:** 47–50

RECCOBENE, I.C., FERNANDEZ, M.B. AND NOLASCO, S.M., 2001, Effect of moisture content in the dehulling capacity of sunflower seeds. *Information Technologica.,* **12**(1):3-8.

REDDY, B. K., UPPAR, D.S., VYAKARANAHAL, B.S., NADAF, H.L., RAVI HUNJE AND HIREMATH S.M., 2007, Integrated nutrient management in sunflower hybrid seed production (KBSH-1). *Karnataka J. Agric. Sci.,* **21**(2): 171-175.

REHMAN, Z.U., 2003, evaluation of antioxidant activity of methanolic Extract from peanut hulls in fried potato chips, *Plant Foods for Human Nutrition,* **58:** 75–83.

ROMERO, A., CUESTA, C., FRANCISCO, J. AND MUNIZ, S., 1998, Effect of Oil Replenishment during Deep-Fat Frying of Frozen Foods in Sunflower Oil and High-Oleic Acid Sunflower Oil, *JAOCS ,* **75:** 161–167.

ROSARIO, R.D. AND FLORES, D.M., 1981, Functional properties of flour types on mung bean flours, *J. Sci. Food Agric.*, 32:172-180.

RUIZ, G.M., POLVILLO, M.M., JORGEB, N., RUIZ MENDEZ, M.V. AND DOBARGANES, M.C., 1999, Influence of Used Frying Oil Quality and Natural Tocopherol Content on Oxidative Stability of Fried Potatoes. *JAOCS.*, ***76*****:** 421–425.

SAGUY, I.S., SHANI, A., WEINBERG, P. AND GRATI, I., 1996, Utilization of jojoba oil for deep fat frying of foods. Lebensm.-wiss. U-Technol. **29:** 573 – 577.

SAN JAUN, E.M., EDRA, E.V., EVANGELINE, N., FADRIGALAN, LUSTRE, A.O. AND RESURRECCION., 2005, Consumer based optimization of peanut-chocolate bar using response surface methodology. *Journal of Food Processing and Preservation.,* **29**: 208-227.

SANDHYA RANI, A.K., YELLA REDDY, S. AND CHETANA, R., 2010, Quality changes in *trans* and *trans* free fats/oils and products during frying*, Eur Food Res Technol*, **230:** 803–811.

SASTRY, M.C.S. AND SUBRAMANIAN, N., 1985, Effect of heat processing on phenolic constituents and nutritional quality of sunflower flour. *J.A.O.C.S.,* **62**:1131-1134.

SEN, M. AND BHATTACHARYYA, D.K., 2000, Nutritional quality of sunflower seed protein fraction extracted with isopropanol. *Plant Foods for Human Nutrition.,* **55**: 265-278.

SEPPANEN, C.M., SONG, Q. AND CSALLANY, A.S., 2010, the Antioxidant Functions of Tocopherol and Tocotrienol Homologues in Oils, Fats, and Food Systems, *J. Am. Oil. Chem. Soc.*, **87:** 469–481.

SHAHBAZ, A. AND HASSAIN, F., 2000, Oil yield and fatty acid composition of spring sunflower. *Pak. J. Biol. Sci.,* **12**:2063-2064.

SHAHIDI, F. AND WANASUNDARA, U.N., 2002, Methods for measuring oxidative rancidity in fats and oils. *Food lipids*, 2nd edn. 465–488.

SHEPPARD, A.J. AND RUDOLF, T.S., 1991, Analysis of peanuts and peanut products for total lipids, fatty acids and proximates. *Peanut Science.*, **15**: 51-54.

SHIELA, P.M., SREERAMA, Y.N. AND GOPALA KRISHNA, A.G., 2004, Storage Stability Evaluation of Some Packed Vegetable Oil Blends, *JAOCS,* **81:** 1125–1129

SISMAN, C.B. AND DELIBAS, L., 2004, Storing sunflower seeds and quality losses during storage. *Central European Agriculture.,* **5**(4):239-250.

SRILATHA, K. AND KRISHNAKUMARI, K., 2003, Proximate composition and protein quality evaluation of recipes containing sunflower cake. *Plant Foods for Human Nutrition.,* **58:** 1-11.

SRINIVASAN, P.V., 2005, Impact of trade liberalization on India's oilseed and edible oil sector: Reporter prepared for Indira Gandhi Institute of Development Research (IGIDR) Economic research service (ERS)/USDA project: *Indian agricultural markets and policy,* **2**:1-35.

SRIPAD, G., PRAKASH, V. AND NARASINGA RAO, M.S., 1982, Extractability of polyphenols of sunflower seed in various solvents. *J. Biosci.,* **4**(2):145-152.

SUJA, K. P., ABRAHAM, J. T., THAMIZH, S. N., JAYALEKSHMY, A. AND ARUMUGHAN, C., 2004, Antioxidant efficacy of sesame cake extract in vegetable oil protection. *Food Chemistry*, **84:** 393-400.

TARMIZI, A.H.A AND ISMAIL, R., 2008, Comparison of the Frying Stability of Standard Palm Olein and Special Quality Palm Olein, *J. Am. Oil. Chem. Soc.,* **85:** 245–251

TOBI, M.N., 2010, Comparative Study of Stability Measurements for Two Frying Oils: Soybean Oil and Refined Palm Oil. Advance *Journal of Food Science and Technology*., 22-27.

VAIDEHI, M.P., GOWRAMMA, T.S., ANNAPURNA, M.B., VIJAYALAKSHMI, D. AND GEETHA., 1996, Pigeon pea (*Kajanus kajana*), products and their nutritive value (traditional and newer recipes from India). Division of rural science, UAS, Bangalore.

VALENZUELA, A., SANHUEZA, J. AND NIETO, S., 2002, Effect of synthetic antioxidants on cholesterol stability during the thermal-induced oxidation of a polyunsaturated vegetable Oil. *JAOCS.,* **79:** 325–328.

VASISHTHA, A.K., BAJPAI, M. AND SINGH, C., 1992, Variations in the characteristics and oil compositions in different genetic varieties of sunflower. *Journal-of-the-Oil-Technologists'-Association-of-India.,* **24**(1): 9-14.

VENKATESH, A. AND PRAKASH, V., 1993, Functional properties of the total proteins on sunflower (*Helianthus annus* L.) seed-effect of physical and chemical treatments. *J. Agric. Food Chem.,* **41**(1):18-23.

VIDYASAGAR, K., ASWATHNARAYANA, K.G., GHOSH, S.R. AND KAMESHWAR RAO, G., 1964, Studies on storage of packed rations in groundnut candy bar. *J. Food Sci.*, **1**(4): 68-71.

VIDYASHREE, K.M., 2003, Variation in seed size uniformity among cowpea genotypes. *USA Crop-Science.,* **31(5**):1324-1327.

VIJAYA, M., IYER, L. AND SINGH, V., 2005, Functional properties of wheat and chickpea composite flours, Food Australia., **49**: 27-31.

VILLIERS, J.B.M., DU TOIT, L.J., MILLER, N. AND PRETORIUS, H.E., 1986, The behaviour of decorticated sunflower seeds stored under favourable and unfavourable conditions. *Journal of Food Science.,* **19**:472-476.

WAGHRAY, K. AND GULLA, S., 2010, Butylated hydroxyanisole (BHA) to maximize the oxidative stability of snacks: A case study with sev and boondi. *J Hum Ecol.*, **32**(2): 97-99.

WARNER, K. AND FEHR, W., 2008, Mid-Oleic/Ultra Low Linolenic Acid Soybean Oil: A Healthful New Alternative to Hydrogenated Oil for Frying*, J. Am. Oil. Chem. Soc.,* **85:** 945–951

WILLS, R.B.H., KABIRULLAH, M. AND HEYHOE, T.C., 1984, Enrichment of biscuits with sunflower protein. *Food Sci. and Technol.,* **17**:205-208.

YENG, K., GREY, ARCHER, L.T. AND BRUCE., 1998, Oxidative stability of high oleic sunflower and sunflower oils. *J. Am. Oil. Chem. Soc.,* **62**:523-525.

YOSHIDA, H., HIRAKAWA, Y. AND ABE, S., 2001, Roasting influence on molecular species of triglycerols in sunflower seeds (*Helianthus annus* L.). *Food Res. Int.,* **34**:613-619.

YOSHIDA, H., HIRAKAWA, Y. AND ABE, S., 2002, Influence of microwave roasting on positional distribution of fatty acids of triglycerols and phospholipids in sunflower seeds (*Helianthus annus* L.). *Eur. J. Lipid Sci. Technol.,* **103**:201-207.

YOSHIDA, H., HIRAKAWA, Y. AND MIZSUSHINA, Y., 2002, The content of Tocopherols and oxidative quality of oils prepared from sunflower (*Helianthus annus* L.) seeds roasted in a microwave oven, *European Journal of Lipid Science and Technology.,* **104**:116-122.

YOUSUF ALI KHAN, R., LAKSHMINARAYANA, T., AZEEMODDIN, G., ATCHYUTA RAMAYYA, D. AND TIRUMALA RAO, S.D., 1979, Shelf life of sunflower oil and groundnut oil. *J. Food Sci. Technol.*, **16**: 90-92.

ZOULIAS, E.I., OREOPOULOU, V. AND KOUNALAKI, E., 2010, Effect of fat and sugar replacement on cookie properties. *Journal of the science of food and agriculture.,* **82:** 1673-1644.

ZVEREV, L.V., PRUDNIKOV, S.M., VITYUK, B.Y., DZHIOEV, T.E. AND PANYUSHKIN, V.T., 2001, Determination of main fatty acids in sunflower-seed oil by a nuclear magnetic relaxation technique. *Journal of Analytical Chemistry.,* **56**(11):1029-1031.

Annexures

ANNEXURE-I

Score card

Name of the judge : Date:

Name of the product:

Directions:

1. Rinse the mouth between samples
2. Place the numerical score in the space provided
3. Comments should justify the numerical score and must be brief
4. Evaluation of the food products must be brief

Score system

Quality characters	Products / genotypes			
	A	B	C	D
Appearance				
Texture / consistency				
Color				
Flavor				
Taste				
Overall acceptability				

Note: Please give scores between 1 and 9

9 – Like extremely

8 - Like very much

7 – Like moderately

6 – Like slightly

5 – Neither like nor dislike

4 – Dislike slightly

3 – Dislike moderately

2 – Dislike very much

1 – Dislike extremely

Comments:

Signature

ANNEXURE II

Namkeens

Ingredients	Weight (gm)
Dehulled sunflower seeds/fried gram/cashew nut/ground nut	20
Rice flakes	100
Raisins	5
Palmolein oil	22
Chilli powder	1
salt	2

Dry roasted flavoured seeds

Ingredients	Weight (gm)
Dehulled sunflower seeds	100
Spice mix	8

Barfi

Ingredients	Weight (gm)
Dehulled sunflower seeds/ cashew nut/ almond/ coconut	100
Icing sugar	100
Vanilla essence	1-2 drops

Marzipan

Ingredients	Weight (gm)
Dehulled sunflower seeds/ cashew nut/ almond/ melon seeds	50
Icing sugar	100
Almond essence	1-2 drops

Chikki

Ingredients	Weight (gm)
Dehulled sunflower seeds/ ground nut/melon seeds/ sesame	50
Fat	5
Jaggery	100

Cookies

Ingredients	Weight (gm)
Dehulled sunflower seeds/ cashew nut/ almond/ ground nut	25
Icing sugar	50
Maida	100
Margarine	40

Pesto sauce

Ingredients	Weight (gm)
Dehulled sunflower seeds/ walnuts/ ground nut/ commercial	10
Basil leaves	40
Olive oil	15
Cheese	10
Salt	2

Soup

Ingredients	Weight (gm)
Dehulled sunflower seeds/ cashew nut/ almond/ melon seeds	20
Tomato powder	5
Garlic salt	5
Oregano	1
Parsley	1
Salt	2

Bread rolls

Ingredients	Weight (gm)
Dehulled sunflower seeds/ poppy seeds /melon seeds/ sesame	10
Maida	50
Sugar	10
Margarine	10

Salted seeds

Ingredients	Weight (gm)
Dehulled sunflower seeds	100
Salt	30

ANNEXURE III

Sensory evaluation form for stored added value food products from sunflower and other seeds

Name:

Date:

Name of the product:

Directions:

- Place the numerical score in the space provided.
- Rinse the mouth between samples
- Suggestions/comments for improvement must be brief.

Hedonic score:

Excellent-5 : Good-4 : Neither good or bad-3 : Poor-2 : Very poor-1

***Absence of rancidity:** Not perceived-5 : Traces detected-4 : Present-3 : Moderately rancid-2 : Extremely rancid-1

Quality Characteristics	Products		
	XYZ	XYD	XYS
Appearance			
Texture			
Colour			
Taste			
Overall acceptability			
*Absence of rancidity			

Remarks:

Signature

ANNEXURE-IV

Estimation of total lipids (Bligh and dyer method)

In this method, a mixture of chloroform and methanol (2:1V/V) was used. The tissue (about 1 g wet weight) was first ground in a pestle and mortar with about 10 ml of distilled water. The pulp was transferred to a conical flask (250ml capacity) and 30ml of chloroform – methanol mixture was added and mixed well.

For complete extraction, it was kept overnight at room temperature, and in dark. At the end of the period, 20 ml chloroform and 20 ml of water was added. The resulting solution was subjected to centrifugation, and three 3 layers were seen. A clear lower layer of chloroform containing all the lipids, a colored aqueous layer of methanol with all water soluble material and a thick pasty interface were seen.

The methanol layer was discarded and the lower layer was carefully collected by filtering through glass wool. The organic layer was taken in a pre- weighed beaker or vial and carefully evaporated. The sample was kept in warm water (around 50°C).

When the solution was free of organic solvents, the weight was taken again. The difference in weight gives the weight of the lipids. The results were expressed in terms of milligrams of total lipids per gram of the sample.

ANNEXURE–V

Determination of Peroxide value

Principle: In the oxidative rancidity, oxidation of fat due to the combination of oxygen with unsaturated fatty acids takes place and results in the formation of compounds with a peroxide structure. These are detected by the liberation of iodine from an acid solution of potassium iodide. There is another type of rancidity caused by the action of lipase of fat. This rancidity is called hydrolytic rancidity, which is caused by the formation of low molecular weight fatty acids like butyric acid, caproic acid and caprylic acids. This can be estimated by alkali titration method mentioned under acid value of ghee and is expressed in terms of butyric acid.

Reagents:

1. Acetic acid- chloroform mixture (Composed of glacial acid and chloroform in the ratio of 2:1)
2. Saturated potassium iodide solution
3. N/1000 sodium thiosulphate
4. Starch indicator

Procedure:

0.5 to 1 g of clear melted fat was weighed accurately in the boiling flask. To this 30 ml of acetic acid- chloroform mixture was added and fat was dissolved. 1ml of saturated potassium iodide was added. After 5min 100 ml of distilled water was added. The liberated iodine was titrated against N/1000ml sodium thiosulphate. When the end point is approached 1ml of freshly prepared starch was added and titration was completed till the blue colour disappears. Blank was carried out using all the reagents without the oil. Calculation:

$$\text{Peroxide value of oil (meq/kg of sample)} = \frac{\text{(Titre-blank)} \times N \times 1000}{\text{Wt of oil (g)}}$$

ANNEXURE–VI

Determination of Acid value

Principle: The acid value is the number of milligram of KOH required to neutralise the free acid in 1 g of the substance**.**

Reagents:

1. A mixture of equal volume of alcohol (95%) and ether
2. 1% phenolphthalein in alcohol
3. 0.1 N KOH

Procedure:

About 10gm of the oil was weighed accurately into a 250ml conical flask to which was added 50 ml of a mixture of equal volume of alcohol and ether previously neutralised after the addition of 1 ml of phenolphthalein solution. The contents were warmed in a water bath until the substance is completely dissolved. The solution was titrated with 0.1 N KOH with constant shaking until a pink colour persists for 15 sec. The ttre value in ml (a) was noted.

$$\text{Acid value} = \frac{a \times 0.00561 \times 1000}{\text{Weight in g of substance}}$$

ANNEXURE VII

Thiobarbituric acid reactive substances (TBARS) assay

Principle:

Malondialdehyde, formed from the breakdown of polyunsaturated fatty acids, serves as a convenient index for determining the extent of the peroxidation reaction. Malondialdehyde has been identified as the product of lipid peroxidation that reacts with thiobarbituric acid to give a red species absorbing at 535 nm.

Reagent:

Stock TCA-TBA-HCL reagent: 15% w/v trichloroacetic acid: 0.375% w/v thiobarbituric acid; 0.25 N hydrochloric acid. This solution may be mildly heated to assist in the dissolution of the thiobarbituric acid.

Procedure:

One gm of fat sample was dissolved in 10 ml of carbon tetrachloride, to which 10 ml of TBA reagent was added. The tubes were immersed in the boiling water bath for 30 min and cooled. The absorbance was determined at 535 nm against a blank that contained all the reagents minus the lipids. The malondialdehyde concentration of the sample was calculated using the following formula:

$$\text{mg of malondialdehyde per 100g 0f sample} = \frac{0.4189 \times \text{OD of samlpe} \times 100}{1 \times \text{Wt of sample} \times 1000}$$

ANNEXURE–VIII

Preparation cost of namkeens using sunflower and other seeds

Ingredients used	Cost /kg (Rs)	Sunflower		Fried gram		Cashew nut		Ground nut	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	20	0.80	-	-	-	-	-	-
Fried gram	70	-	-	20	1.40	-	-	-	-
Cashew nut	700	-	-	-	-	20	14	-	-
Ground nut	90	-	-	-	-	-	-	20	1.8
Rice flakes	30	100	3	100	3	100	3	100	3
Raisins	110	5	0.55	5	0.55	5	0.55	5	0.55
Palmolein oil	60	22	1.32	22	1.32	22	1.32	22	1.32
Chilli powder	150	1	0.15	1	0.15	1	0.15	1	0.15
Salt	8	2	0.016	2	0.016	2	0.016	2	0.016
Electricity	-	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	7.83	-	8.43	-	21.03	-	-
Yield	-	150	-	150	-	150	-	150	8.83

Preparation cost of dry roasted flavored seeds using sunflower and other seeds

Ingredients used	Amt (Rs.)/kg	Sunflower	
		Cost/kg (Rs)	Cost (Rs)
Dehulled sunflower seeds	40	20	0.8
Barbeque sauce	450	8	3.6
Electricity	-	-	1
Labour cost	-	-	1
Total cost	-	-	-
Yield	-	28	6.4

Preparation cost of marzipan using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower		Cashew nut		Ground nut		Melon seeds	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	50	2	-	-	-	-	-	-
Cashew nut	700	-	-	50	35	-	-	-	-
Ground nut	90	-	-	-	-	50	4.5	-	-
Melon seeds	250	-	-	-	-	-	-	50	12.5
Icing sugar	40	100	4	100	4	100	4	100	4
Electricity	-	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	8	-	41	-	10.5	-	18.5
Yield	-	150	-	150	-	150	-	150	-

Preparation cost of barfi using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower		Cashew nut		Almond		Coconut	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	100	4	-	-	-	-	-	-
Cashew nut	700	-	-	100	70	-	-	-	-
Almond	400	-	-	-	-	100	40	-	-
Coconut	80	-	-	-	-	-	-	100	8
Icing sugar	45	100	4.5	100	4.5	100	4.5	100	4.5
Electricity	-	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	10.5	-	76.5	-	46.5	-	14.5
Yield	-	200	-	200	-	200	-	200	-

Preparation cost of Chikki using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower		Ground nut		Melon seeds		Sesame	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	50	2	-		-	-	-	-
Ground nut	90	-	-	50	4.5	-	-	-	-
Melon seeds	250	-	-	-	-	50	12.5	-	-
Sesame	100	-	-	-	-	-	-	50	5
Jaggery	50	100	5	100	5	100	5	100	5
Fat	280	5	1.4	5	1.4	5	1.4	5	1.4
Electricity	-	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	10.40	-	12.9	-	20.9	-	13.4
Yield	-	155	-	155	-	155	-	155	-

Preparation cost of Sauce using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower		Walnut		Groundnut		Commercial	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	10	0.4	-	-	-	-	-	-
Walnut	900	-	-	10	9.0	-	-	-	-
Groundnut	90	-	-	-		10	0.9	-	-
Commercial	280	-	-	-		-	-	10	2.8
Basil	40	40	1.6	40	1.6	40	1.6	40	1.6
Olive oil	700	15ml	10.5	15	10.5	15	10.5	15	10.5
Cheese	300	10	3.0	10	3.0	10	3.0	10	3.0
Salt	8.0	2.0	0.016	2.0	0.016	2.0	0.016	2.0	0.016
Electricity	-	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	17.51	-	18.01	-	18.01	-	19.91
Yield	-	77	-	77		77	-	77	-

Preparation cost of Soup using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower		Almond		Cashew nut		Melon seeds	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	20	0.8	-	-	-	-	-	-
Almond	400	-	-	20	8.0	-	-	-	-
Cashew nut	700	-	-	-	-	20	14	-	-
Melon seeds	250	-	-	-	-	-	-	20	5.0
Tomato	600	5.0	3.0	5.0	3.0	5.0	3	5.0	3.0
Garlic	50	5.0	0.25	5.0	0.25	5.0	0.25	5.0	0.25
Oregano	1000	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Parsley	2300	1.0	2.3	1.0	2.3	1.0	2.3	1.0	2.3
Salt	8.0	2.0	0.016	2.0	0.016	2.0	0.016	2.0	0.016
Electricity	-	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	9.36	-	16.56	-	22.56	-	13.56
Yield	-	34	-	34	-	34	-	34	-

Preparation cost of bread using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower		Poppy seeds		Sesame		Melon seeds	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	10	0.4	-	-	-	-	-	-
Poppy seeds	350	-	-	10	3.5	-	-	-	-
Sesame	100	-	-	-	-	10	1	-	-
Melon seeds	250	-	-	-	-	-	-	10	2.5
Maida	30	50	1.5	50	1.5	50	1.5	50	1.5
Sugar	30	10	0.3	10	0.3	10	0.3	10	0.3
Margarine	300	10	3.0	10	3.0	10	3.0	10	3.0
Electricity	-	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	7.2	-	10.3	-	7.8	-	9.3
Yield	-	80	-	80	-	80	-	80	-

Preparation cost of Cookies using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower		Almond		Cashew nut		Ground nut	
		Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)	Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	25	1	-	-	-	-	-	-
Almond	400	-	-	25	10	-	-	-	-
Cashew nut	700	-	-	-	-	25	17.5	-	-
Ground nut	90	-	-	-	-	-	-	25	2.25
Fat	300	40	1.2	40	1.2	40	1.2	40	1.2
Sugar	30	50	1.5	50	1.5	50	1.5	50	1.5
Maida	30	100	3	100	3	100	3	100	3
Electricity	30	-	1	-	1	-	1	-	1
Labour cost	-	-	1	-	1	-	1	-	1
Total cost	-	-	8.7	-		-	-	-	-
Yield	-	215	-	215	-	215	-	215	-

Preparation cost of Salted seeds using sunflower and other seeds

Ingredients used	Cost / kg (Rs)	Sunflower	
		Qty. used (g)	Cost (Rs)
Dehulled sunflower seeds	40	100	4
Salt	8.0	30	0.24
Electricity	-	1	1
Labour cost	-	-	1
Total cost	-	-	6.24
Yield	-	130	-