*Helianthus annus* the botanical name for sunflower seeds; it is a member of the genus *Helianthus* and family *Asteraceae* (National Sunflower Association 2011). The seeds produced by sunflower are widely considered as seeds with a good nutritive value and are easily available all over India (Philips *et al.* 2005). The metabolic disorders like diabetes, CVD, fatty liver etc. these days are creating a menace. Hence, countering the epidemic requires development of strategies like the formulation and effective implementation of evidence based policy, reinforcement of health system, and treatment with the use of both conventional and innovative techniques. Many studies have been done on sunflower seeds, its health benefits, processing, and nutritive value. Thus the topic of the present study has been reviewed under the following headings

2.1 Sunflower seeds and its composition

Sunflower (*Helianthus annus* L.) with a good stability and an opulent PUFA content makes it world's leading oilseed crops. After the soybean oil it’s the sunflower oil that ranks second in world in the vegetable oil production. Whole sunflower kernels can be incorporated into human food formulations (Robertson *et al.* 1975). Tocopherols are the most important compounds having antioxidant activity in sunflower seeds (Velasco *et al.* 2002). Amongst the oilseed crops sunflower has been claimed to be very important and in the world ranks amongst one of the best vegetable oils with a very novel nutritional quality. Generally about ninety percentile of fatty acids are unsaturated in the general sunflower oil composition. They are linoleic and oleic fatty acids. Palmitic, stearic and small quantities of myristoleic, myristic, arachidic, behemic, palmitoleic along with other fatty acids contribute to remaining 10%.

A research was conducted by Katherine *et al.* (2001) on the usually consumed seeds and nuts in United States regarding the quantification of phytosterols. Acid hydrolysis followed by alkaline saponification of the lipid extracts was done. With the help of capillary GC-FID and GC-MS the free sterols were analysed as trimethyl derivatives. Amongst all, the phytosterol content was found to be highest in wheat germ and sesame seeds about (400-413
mg/100g) whereas Brazil nuts were reported with the lowest (95 mg/100 gm). Pistachios and sunflower seed kernels the most commonly consumed snack foods in US were also reported with good amounts of ranging from 270-289 mg/100gm.

The sunflower genotypes and the content of tocopherol and phenols was investigated in the same by Zilic et al. (2010). In this study, the tocopherol (α, β, γ) and the phenolic compound content along with the DPPH radical scavenging activity were analyzed in the seeds and kernels of 3 sunflower hybrids. With the help of HPLC method, 6 different phenolic compounds were identified. The most opulent phenol was found out to be Chlorogenic acid which showed a strong correlation with the total phenols (r=0.93). Other major phenolics found have been ferulic acid, rosmarinic acid, caffeic acid, rutin, and myriceti. Now as compared to the seeds the total tocopherols were found out to be substantially higher in the kernels (P<0.05) in all the sunflower hybrids. The concentrations of tocopherols in sunflower seeds and kernels ranged from 200.56 to 220.04μg/g and from 255.52 to 268.49μg/g respectively, where α-tocopherol had been found to be most abundant amongst the sample. Accordingly, it was deduced that sunflower kernels had a higher DPPH scavenging activity, and a higher nutritive value than sunflower seeds.

The effect of powdered safflower seed and sunflower seeds on total cholesterol level in the rats that were fed on high fat and high cholesterol diets was studied by Moon et al. (2001). A high cholesterol diet (1%, weight/weight) or diet high in cholesterol augmented with the powder of sunflower seeds (5% weight/weight; SSP) or extract of sunflower seeds and ethanol (0.15% weight/weight; SSE) or water extract with safflower seeds (0.5% weight/weight; SSW) were administered to male rats for a time period of about 5 weeks. It was found that all the compositions of the safflower seed considerably reduced the concentration of total cholesterol; on contrary the SSE and SSW supplementations that lowered the plasma triglyceride concentration. In the SSW group the plasma hepatic cholesterol contents were found to be considerably lesser with regard to the control group, on contrary in both the cases the triglyceride hepatic content had been found to be markedly lesser. It was also analysed that, the hepatic HMG-CoA functions had been considerably raised in the two groups SSE and SSW groups in comparison to the remaining both groups. As per the results it becomes indicative that the SSE and SSW administration had proven to
be potent improvising the risk of arthrosclerosis in the rats which were administered with diets high in cholesterol.

Flaxseeds, wheat germ, sunflower seeds, buckwheat along with twenty eight plant products were selected and their total phenolic content and antioxidant activities were analysed by Veliogulu et al. (1998). Folin-Ciocalteu method was used to determine the phenolic content. Phenolic content was determined to be varying from 168 to 10549 mg/100 g of dry product. β-carotene bleaching method had been utilised to evaluate the antioxidant activity of the methanolic extract being expressed as AOX (log A$_470$/min), A4 (percent inhibition relative control), ORR (Oxidation Rate Ratio), and ACC (Antioxidant Activity Coefficient) varied from 0.05, 53.6, 0.009, and 51.7 to 0.26, 99.1, 0.46, and 969.3, respectively. Amongst the antioxidant activities and the total phenolic content the correlation coefficient came out to be statistically significant.

The outcome of intake of different types of fat on cholesterol levels in the blood serum was investigated by Bronte et al. (1956). 2 European men with high serum cholesterol initially along with 1 Cape Coloured man and 5 Bantu men with low serum cholesterol level initially were given diets added with several fats and oils. The diet of the 2 Europeans comprised of 50 g of fat daily mainly from the animal origin whereas the diet of the 6 Non Europeans comprised of a low fat content. The serum cholesterol and serum lipoprotein were recorded along with the cholesterol content of the faeces. It was found out that beef muscle, beef drippings, butter, and hydrogenated groundnut oil caused a raise in the serum cholesterol levels.

A cross over double-blind study was directed by Barham et al. (1998) to analyse the effects of sunflower seeds and whole flax seeds on the lipid profile of the post-menopausal women as a part of their diet. 38 postmenopausal women were selected with mild, moderate or severe hypercholesterolemia. They were randomly assigned the 6-week period with two regimens: flaxseeds or sunflower seeds. Either treatment provided to the subjects comprised of 38 g in breads and muffins. After six weeks of supplementation a two week washout phase was conducted. Post the washout phase the subjects were switched. The Blood samples were collected at the start and then 6, 8 and 14$^{th}$ week of the study. For both the treatments significant reductions ($p<0.01$) in total cholesterol were recorded (6.9 and 5.5% for flaxseed
and sunflower seed, respectively). The cholesterol lowering effects of the sunflower and flax seeds were attributed to the presence of α-linolenic acid or the linoleic acids, the non-protein constituents in the seeds along with total and soluble fiber.

### 2.2 Effect of food processing (roasting) on the quality attribute of sunflower seeds

Roasting is a common cooking method that incorporates dry heat method, usually practised at 140-400°C. This method of cooking prepares food with radiating heat and also by convicing heat through forced air (Singh et al. 2016). This is basically a short time and a high temperature procedure (Mayer et al. 1985). Roasting results into drying that further leads to a reduction in the moisture content. The moisture diffusion occurring at a high temperature causes puffing and hence a crisp texture. With the decrease in the moisture content the shelf life of food, seeds or grains increases as the water activity is also decreased. The colour, flavour and odour evolved during roasting in the food product give a characteristic appearance and taste to it (Sharma et al. 2011).

One appliance that is nowadays found in majority of houses is the Microwave oven. The microwaves are used widely by masses these days for reheating as well as cooking certain foods. The principle used by microwaves is heating through interaction of electric component of the electromagnetic field with the polar molecules. As and by the polar molecules strive to position in the oscillating field the heat is generated (Burfoot et al. 1990). The microwave provides many advantages for industrial as well as home cooking, thawing, baking, pasteurization, sterilization, tempering and blanching (Decareau et al. 1985). Microwave energy works instantaneously with penetration and heating of food (Mudgett et al. 1989; Watanabe et al.1998).

The roasting of sunflower seeds was performed in a study by Fozia et al. (2005). 10 g of sunflower seeds were placed uniformly in pyrex-petri dishes. They utilised a consumer-model microwave oven for the experiment. The roasting was conducted for 5, 10 and 15 min at 2450 MHz frequency (oven adept of generating 500 W and medium power setting). Once the roasting was completed the sunflower seeds were kept at an ambient temperature to cool, post to which they were intensively mixed before the crushing and oil extraction. In another study, Farooq et al. (2005) studied the impact on the sunflower seed composition of microwave heating. They also explored the oxidative stability changes, Fatty Acid distribution and
tocopherol content of the sunflower oil. Two varieties KL-39 and FH 330 of sunflower seeds were taken and extracted with n-hexane. In their experiment, a significant difference ($P<0.05$) in the oil content of seeds was observed. However, content of protein and fiber depicted no change in the oilseed residue. Although, a significant ($P<0.05$) decrease in the tocopherol amount was found but still around 76-81% of $\alpha$-tocopherol was detected in it even after 15 min of roasting. Microwave heating in regard to the FA composition lead to decrease in linoleic acid 17-19% and an increase in oleic acid 16-42%, while the content of palmitic and stearic acid remained unaffected.

In an experiment Yoshida et al. (1999) analysed the oxidative stability and the tocopherol content in the oils prepared from soybean conducted roasting of whole soybeans. 12.0 cm diameter pyrex-petri dishes were taken. The beans were placed uniformly in a single layer. Next they covered the petri dishes, and placed them in the microwave oven on its glass rotating plate (model R-5550; Sharp, Osaka, Japan). In turntable mode, beans were roasted for six, eight, twelve and 20 minutes respectively. To prepare a full fat soy flour without any burnt odour roasting for about 6-10 min was found to be favourable.In another study to analyse the functional and antioxidant properties of chick pea (Cicer arietinum), post to its exposure to the microwave roasting (Jogihali et al. 2017) performed the roasting of chickpeas seeds. The seeds were soaked in water for 45 minutes at room temperature (Ratio being; water: seeds =2:1). Post to this they were air-dried in open for 10 minutes. The treated chickpeas at different powers (450, 600 and 900W) for 5, 10 and 15 minutes were then roasted in microwave oven. Post to this the roasted and non-roasted chickpeas were converted to a flour using hammer mill.

2.3 Antioxidant potential of sunflower seeds

Antioxidants are considered to be additives in the food industry as they play a major role in reducing oxidation of food components, specifically that of lipids. The process of oxidation results in deterioration of the quality of food as well as its shelf life (St Angelo et al. 1996). The antioxidants are treated to be of a high importance even in the living organisms since they interfere and hence prevent the formation of excessive free radical in cells. These free radicals if present in excess may cause degradation and deterioration of the biologically important molecules and thus result in progression of various diseases. It is the oxidative processes that results in onset of various infectious diseases, diabetes, cancer, rheumatoid
diseases, arthritis, eye issues, respiratory diseases, atherosclerosis etc. (Temple et al. 2000). Among various plant products, the eminent sunflower seeds have been found out to possess a high antioxidant potential. In comparison to other vegetables oils, sunflower oil was found out to be rich in α-tocopherol (Schmidt et al. 2005).

Antioxidant activity and the phenolic compound profiles of six fractions (I-VI) of sunflower seed extract was analysed by Magdalena et al. (2012). The HPLC-MS (ESI) analysis method was applied for the qualitative and quantitative analysis of the fractions for its phenolic compounds profiles. In terms of their ability to scavenge DPPH and ABTS and also in terms of their ability to reduce Fe³⁺ferricyanide complex to the ferrous form which was expressed as TEAC, EC50, and the reducing power values the antioxidant activity of the fraction were studied respectively. Their experiment showed a pragmatic result as in a positive correlation was obtained between the antioxidant activity and the phenolic content of the individual fraction.

The antioxidant activities and total phenolics of 28 plant products, including sunflower seeds, flaxseeds, wheat germ, buckwheat and several fruits, vegetables and other medicinal plants were determined by Velioglu et al. (1998). The total phenolic content, determined according to the Folin-Ciocalteu method varied from 169 to 10548 mg/100g of dry product. Antioxidant activity of methanolic extract evaluated -carotene bleaching method expressed as AOX (Δ log A₄₇₀/min), AA (percent inhibition relative to control), ORR (Oxidation Rate Ratio) and AAC (Antioxidant Activity Coefficient) ranged from 0.05, 53.7, 0.009 and 51.7 to 0.26, 99.1, 0.46 and 969.3 respectively. The correlation coefficient between total phenolics and antioxidative activities was statistically significant. In a similar study, Bolivar et al. (2009) aimed to check the antioxidant activity (TAC) at different germination states (dormant, imbibed and 7d sprouts) for 13 edible seeds. Selected seeds included mungbean, alfalfa, fava, fenugreek, mustard, wheat, broccoli, sunflower, soybean, radish, kale, lentil and onion. Sunflower seed sprouts had higher TAC on a DB(40202 µg Trolox g⁻¹) compared to other seeds.

In another study conducted by Paulina et al. (2013) aimed at investigating the effect of germination on the phenolic acids and flavonoids profile, as well as antioxidant activity (AA), in selected edible seeds of mung beans, radish, broccoli and sunflower. Germination increased the total phenolic (TP) and flavonoid (TF) levels, as well as the AA of the seeds,
and influenced the profile of free and bound phenolic compounds. Among the samples, mung bean was characterised by lowest levels of TP and TF, as well as AA, evaluated using ABTS, DPPH and FRAP assays. Sunflower and radish sprouts were the most rich in phenolic compounds.

Phenolic compound profiles and antioxidant activity of six fractions (I–VI) acquired from the extract of sunflower seeds was analyzed by Karamac et al. (2012). For the quantitative and qualitative estimation of phenolic content of fractions the HPLC-MS (ESI) analysis method was put to use. The evaluation of the antioxidant activity of the fractions was done in reference to their potential to scavenge ABTS and DPPH along with their ability to reduce ferricyanide complex to ferrous form. It was expressed as EC50, TEAC respectively. Good correlation was shown amongst the antioxidant activity as well as the phenolic content of the fractions.

2.4 Relationship between diet and diseases

It has been recorded during the last few years that a bad diet is directly proportional to the progression of certain metabolic disorders and chronic diseases as like cardiovascular disease, cancer, cataract, diabetes mellitus, hypertension, obesity etc. (Willet et al. 1998). The records depict that a daily diet regime that consists of ample vegetables, fruits, plant foods, legumes with non-processed foods in it decreases the development of such chronic diseases considerably. It was forwarded by Jacobs et al. (1998) in their study that vegetables, fruits and minimally processed foods form protective foods that make a shield against the progression of the various chronic diseases.

In another study Scoztek et al. (2013) reviewed and identified the major contributing factors of diabetes, cardiovascular disease (CVD), chronic diseases of respiratory system, malignant cancer to be unhealthy nutritional practices and adverse lifestyle. In accordance to the WHO guidelines, it was forwarded that a healthy lifestyle would require replacing saturated fatty acids (SFA) with polyunsaturated fatty acids (PUFA) along with elimination of the trans-fatty acids from diet and reducing the consumption of simple carbohydrates. Present study reviewed the current evidences and the most appropriate type of dietary fat for preventing arteriosclerosis was discussed. Increased intake of PUFA in the diet in both America and Northern Europe resulted in n-6 PUFAs being dominant in diets in comparison
to n-3 PUFAs. The resultant non-proportion led to increase in mortality due to CVD in these countries. It was analysed that in contrast to the above, the conventional Mediterranean diet that yielded a PUFA n-6/n-3 ratio of 2:1 proved to be more beneficial. Also it was added by the recent studies that the idea of replacing the SFAs with carbohydrates could not reduce the risk or arteriosclerosis. Also, substituting carbohydrates with MUFA gave ambiguous findings but only the PUFAs and that too n-3 was found to reduce the risk of IHD (Ischemic Heart Disease). Till now the debate about n6 and n3 goes on. However, its noteworthy that adopting a Mediterranean diet pattern might help reduce the risk of IHD.

In a study conducted by Nicolosi RJ et al. (2004), the diets which were higher in PUFA i.e. polyunsaturated an their relation with cholesterol in the blood serum levels was evaluated. In contrast, meal plans with elevated quantities of MUFA and saturated fats did not lead to any such decrease. The given study had been conducted to analyse the impact of meal plans with high- or mid-linoleic oil in comparison to the high-linoleic containing sunflower oil on oxidation of LDL which would lead to progression of cardiac diseases on earlier stages in the hamsters with a raised serum cholesterol levels. The hamsters were given a high cholesterol diet consisting of 10% sunflower oil (mid- oleic), or sunflower oil (high linoleic) (wt/wt), olive oil (high oleic) in addition to cholesterol 0.4% (wt/wt) for a period of 10 weeks. After completion of 10 weeks, only the animals that had been fed with first group showed considerable decrease in the serum levels of LDL (a decrease of about 17%) in comparison to the second group. Hamsters fed upon third group showed considerably raised levels of serum triglycerides (an increase of about 41%) in comparison to the fourth group. Amount of the serum LDL in the animals administered with the fourth group were significantly higher (+77%) in comparison to hamsters given either the olive oil (high-oleic) or sunflower oil (high linoleic). As per the LDL oxidation parameter measurements the animals fed on the third and second group had notably an extended lag phase (ranging from an increase of 66% to145%). With regard to the sunflower oil (high linoleic), the ester of the aortic cholesterol ester had been found to be decreased by 13% and 34% in the sunflower oil (mid oleic) and Olive oil group (high oleic).

The LDL atherogenicity was studied by Juan et al. (1996). For the study about 18 subjects were selected as volunteers. The subjects were given a diet with 31% of its calories coming from the sunflower oil for 3 weeks which was then changed to a diet in which 30.5% of calories were obtained from the olive oil for an additional 3 weeks. The LDL after SFO
(Sunflower oil) displayed the ratio of fatty acids as $(18:2 + 18:3 + 20:4)$ to $(16:0 + 16:1 + 18:0 + 18:1)$ of $1.06 \pm 0.11$ compared to $0.73 \pm 0.06$ after the OO (Olive Oil) period. The LDL levels were found to be significantly lower after SFO than as compared to after OO. Against the expectation, the LDL oxidation catalysed by copper was significantly less than period of SFO intake in comparison to the period of OO intake. The result obtained could also be contributed to the larger size of the SFO-LDL. Thus, it was found that the LDL properties: oxidizability, circulation, along with the intima proteoglycans affinity, alteration in the atherogenesis, was found to be directed in the favourable condition with intake of natural antioxidants and linoleic acid in the diet.

Functional foods and its properties were studied by Claire et al. (2002). They forwarded it to could be certain group of foods that are whole, enriched, enhanced or fortified. The functional foods have been known to consist of certain medicinal value in addition to its usual nutritional profile or they are considered to boast certain health properties apart from their nutritional abundance (e.g., vitamins and minerals), when they are consumed in adequate quantities as part of their diet on a regular basis. Correlating the intake of certain foods considered to be functional foods with health benefits should be established on some scientific evidences. The study was conducted on the normal people taken as subjects. Although many claimed to be functional foods with sufficient amount of data for back-up but still all foods available in market and claiming to be functional foods are not. The given study on the basis of certain proofs on their role categorized a number of foods that were considered to be functional. These foods have become mightily explored & broadly popular field of nutritional research these days. Nevertheless, special consideration should be given to the fact that the functional foods should not considered as a magic wand against improper lifestyle and habits.

In another study conducted by Rui et al. (2005) the intake of nuts on a regular basis was found to be directly lower the risk of diabetes type 2 and cardiovascular disease. The authors studied in the Multi-ethnic study of atherosclerosis the relation between the consumption of nuts and seeds along with C-reactive protein, interleukin-6, and fibrinogen. A cross-sectional study was done and it incorporated around 6080 participants from US with their age ranging from included 6,080 US participants aged 45–84 years with ample background study of their diet and biomarkers. The consumption of nuts and seeds was categorised as 5 or more times per week, 1-4 times per week, less than once a week, rare or
never. After certain adjustment in age, gender, income, education, race/ethnicity, physical activity, drinking, smoking, use of dietary supplements mean biomarkers were as follows interleukin-6—1.25, 1.24, 1.21, C-reactive protein—1.98, 1.97, 1.80, and 1.72 mg/litre and fibrinogen—343, 338, 338, and 331 mg/dl (p < 0.01). Further changes in hypertension, lipid levels, diabetes and medication use furnished identical results. Secondary changes in the BMI mildly enhanced intensity of the union delivering statistical significance at borderline. Frequent consumption of seeds and nuts was found to be linked with lower inflammatory marker levels.

It was investigated by Kathleen et al. (2007) that diet influenced the prevailing risk factors for cardiovascular diseases (CVDs). In lieu of the study, intake cholesterol rich foods along with the total dietary fat, particularly Trans-fats and saturated fats was recommended in moderation. Dietary fats were allowed mainly from plant sources and fatty fish, providing polyunsaturated (including omega-3) and monounsaturated fatty acids. Whole grains, legumes, vegetables, fruits, and other fiber-rich sources, were used as the carbohydrate source rather than sugars. Although vitamins such as E, C, and some B vitamins have been correlated with decrease in CVD risk, data supports foods rich in these nutrients than the use of supplements. Dietary minerals such as calcium, potassium and magnesium have been found to be favourable for heart health, on contrary the risk of hypertension decreases with the reduction corresponding with reduced risk of CVD. In contrast, the data present has been quite powerful to advocate the association of healthy body weight management and cardiovascular health. In general, diets based mainly of plant origin and less processed foods, along with an active lifestyle were found to be helpful in heart health. A similar study conducted by Levya et al. (2010) demonstrated the utilisation of nutritional interventions to prevent the advent of cardiovascular diseases (CVD). One such nutritional strategy was increased usage of omega (ω)-3 fatty acids to produce considerable cardiovascular benefits. Amongst the rich sources of ω-3 fatty acids marine food products are one. Apart from marine products flaxseed is also one plant based ω-3 fatty acid source. As per the results acquired from various epidemiological investigations, experimental studies and clinical trials consumption of ALA (alpha-linolenic acid) has been found to be beneficial in CVD.

The effects of essential fatty acids on health and in chronic diseases was analysed by Artemis et al. (1999). It was forwarded that the diets of human beings evolved have ever since consisted of around similar quantities of n-3 and n-6 essential fatty acids, but in the last century there has been a relative increase in the intake of n-6 fatty acids. In the western diets
nowadays the proportion of n-6 to n-3 fatty acids instead of the prescribed 1-2:1 ranges from ≈20–30:1. The high intake of n-6, as per the study’s lead to a shift in the anatomical condition to prothrombotic which is designated by an increase in vasopasm, blood viscosity, decrease in bleeding time and vasoconstriction. The omega 3 Fatty acids on the other hand possess antithrombotic, anti-inflammatory, antiarrhythmic, vasodilatory and hypolipidemic properties. The n–3 fatty acids is known to prevent HTN, type 2 diabetes, coronary heart disease along with rheumatoid arthritis, renal disease, Crohn’s Disease, Ulcerative Colitis in certain patients.

2.5 Product Development

2.5.1 Cookies

From a very long time cookies as snack foods have played a vital role in life of human as antiquity and are very much relished by large section of society. The percentages of its ingredients might differ but in the end the final product is always expected to be same- sweet, crunchy and nutty. Cookies have a lower moisture content and hence they are protected from microbial spoilage and provides longer shelf life. The incorporation of sunflower seeds flour may be a very good option for its easy administration due to its wide acceptability by masses.

In a study conducted by Pasha et al. (2011) mung beans were used to develop high protein cookies (100:0, 95:5, 90:10, 85:15, 80:20, 75:25). It was found that there was an increase in the ash, crude fiber and the protein content as the percentage of mung beans was increased. Also, it was found that the thickness of the cookies along with the above parameters was increased. In a similar study Mishra et al. (2012) blended soybean flour and maize flour to develop the cookies in the ratio of 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90 and 0:100. It was found that the cookies with highest percentage of soy flour were high in crude fiber, ash, protein and fat in comparison to the cookies containing high maize flour content which showed a high carbohydrate content. The cookies containing ninety percentile of maize flour and ten percentile of soy flour attained highest in sensory quality attributes.

In a similar study conducted by Aziah et al. (2012) legume flour was incorporated to develop cookies. Three formulations had been developed (1) control with 100% wheat flour (2) wheat flour 50% + moong bean 35% + corn starch 15% (3) wheat flour 50% + chick pea
35% + corn flour 15%. Significant difference (p<0.05) were obtained in total carbohydrates, crude fiber, protein and ash content in the cookies. It was deduced that the sensory attributes of cookies incorporated with legumes were better than the control. Another study conducted by Chilungo (2013) used Cassava flour and Pigeon Pea flour in different percentage. The flours were blended in the ratio wheat flour: Cassava flour: Pigeon pea flour (90:5:5, 80:10:10, 70:15:15). 100% wheat flour cookie was used as the control. An increase in the protein as well as the fiber content was observed when the content of pigeon pea flour and cassava were raised. Cookies with the highest content of cassava and pigeon pea flour had highest cookie weight, diameter and spread ratio whereas the control ranked lowest in all.

2.5.2 Biscuits

Hesham et al. (2007) developed biscuits incorporated with germinated and non-germinated legume seed flour or mushrooms. Germinated and non-germinate legume flour along with mushroom flour was blended with wheat flour in the percentile of 5, 10 and 15 respectively. As per the results dough developing time and water absorption capacity increased whereas the dough stability and tolerance index decreased in the flour blend of 10 and 15 percentile. In a similar study, Masur et al. (2008) developed high protein biscuits supplemented with Bengal gram. Wheat biscuits with added Bengal gram flour with 10, 15, 20, 25 percent level along with modifications in water, fat and baking powder to improve the nutritional and textural quality of biscuits were made. The diameter (cm) and height (cm) were found to be constant with 15% incorporation of Bengal gram flour. It was found that supplementation of Bengal gram flour in about 15-20% level improved the dough texture, sensory parameters and protein quality.

A study performed by Banurekha and Mahendran (2009) developed biscuits incorporated with soybean flour as a protein supplemented cereal snack food. In the percentage of 5,10,15,20 and 25 the soybean flour and wheat flour was thoroughly blended. It was found that protein, fat and calorie of wheat-soybean biscuits increased as the per cent of soybean flour increases. But there was a decrease in the moisture and ash content of the biscuits as the soybean flour per cent was increased. Similarly, Abu-Salem and Abou- Arab (2011) prepared biscuits supplemented with Bambara groundnut. Wheat flour and the Bambara groundnut flour were blended thoroughly at a percentile 5, 10, 15, 20, 25, and 30 per cent. The biscuits made from 100 per cent were used as control. It was found that the
mean quality score of the decrease as groundnut flour increases. Thickness and diameter increases as groundnut flour increases.

2.5.3 Physicochemical Composition of Biscuits and Cookies

High protein biscuits were developed from Bengal gram in a study conducted by Masur et al. (2008). Wheat biscuits with Bengal flour tried at 10, 15, 20, and 25 per cent levels along with modifications in water, fat and baking powder were made to improve the nutritional and textural quality of biscuits. It was reported that the height of the biscuits remained constant with increasing levels of Bengal gram flour up to 20 per cent and also the diameter remains constant (58.5) at different levels up to 15 per cent of Bengal gram flour. But the spread factor and spread ratio decreased with increasing ratio of Bengal gram flour. Another study was conducted on similar lines where Mishra et al. (2012) prepared cookies from blended flour of soybean and maize flour in different proportion (100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80, 10:90 and 0:100) and the cookies were assessed for the physical and chemical attributes. It was seen that the cookies’ weight reduced gradually from 16.3 to 4.9 with the rising fraction of soy flour and the spread ratio reduced significantly from 7.1 to 6.7 with increase in the concentration of maize flour. The protein content of the cookies was also found to reduce from 39.3 to 9.9 % with the increase in maize flour proportion. The fat, crude fiber and ash content reduced from 27 to 16 per cent, 4.2 per cent to 2.1 per cent and 7.08 to 4.58 per cent respectively.

The result of utilisation of protein pea isolate (decorticated) on basal baking attributes of the biscuits made from wheat was studied by Hassan et al. (2009). Decorticated pigeon pea isolate (DPPI) was incorporated with wheat flour at protein levels of 15, 20 and 25 per cent respectively. There was a decrease in the gluten quantity and increase in water absorption, dough development time and dough stability. Also an increase in the protein and the ash content is found along with decrease in the carbohydrate and the calorific value. Another study conducted by Kohajdova et al. (2013) studied the suitability of pea flour in cracker biscuits production. Refined wheat flour are substituted with different levels of pea flour (0, 10, 20 and 30%). The evaluation on rheological properties and physical characteristics found that addition of pea flour result in increased absorption of water and dough development time whereas dough stability was decreased. It was also found that there was a decrease in the
volume index, width and spread ratio and an increase in thickness. It was observed that pea flour had considerably higher protein (21.46%) and ash (3.11%) content than wheat flour.

2.5.4 Phytonutrient Composition of Biscuits and Cookies

The antioxidant activity (AOA) of frequently consumed pulses, cereals, legumes and millets in India was studied by Sreeramulu et al. (2009). AOA assessed by DPPH radical scavenging assay, ferric reducing antioxidant powder (FRAP) assay. It was observed that the finger millet and rajmah has highest FRAP ranged from 16.21 to 47.71 moles/g and DPPH scavenging activity 1.73 and 1.07. Finger millet and black gram dhal has the highest TPC ranged from 373 to 418 mg/100gm, respectively.

The nutrient composition of cereal (wheat) bambara and groundnut based cookies was analysed Maduke et al. (2013). Wheat flour and Bambara groundnut flour were used in ratio 70:30 to provide 10 per cent protein. It was observed that higher Zinc and iron (5.51 and 12.82 mg/100mg) were found in Bambara groundnut-wheat cookies as compared to the wheat cookies. Another study performed by Zhang et al. (2014) studied the selected dietary polyphenols in a cookie model for its antioxidant and anti-glycation activity. Five dietary polyphenols named epicatechin, naringenin, chologenic acid, quercetin and rosmaric acid were selected for the cookie fortification. The increase in the antioxidant capacity was not as per the expectations since the antioxidant capacity was considerably decreased by thermal degradation during the baking process.

2.5.5 Organoleptic Evaluation

Hemenda and Mohamad (2010) prepared a cake fortified with 5 per cent and 10 per cent of chick pea and soybean. Sensory evaluation was performed using a 5-point semi structure scale method in terms of appearance, colour, cell uniformity, firmness, odour, taste, and overall acceptability. It was found that addition of soy flour blend at 5 per cent and 10 per cent levels to wheat flour had no adverse impact on sensory attributes of the end product. In another study, Gratin et al. (2010) developed school children snacks based on baked fermented legumes and cereals. Cakes were prepared by substituting 20 per cent of the refined wheat flour and kidney bean flour, brownies with 30 per cent of pigeon pea flour and cookies with 30 per cent of black eyed pea flour using fermented and non-fermented
legumes. The sensory evaluation of the products using the hedonic scale of 7 points observed that the product was higher than 5 in the attribute, taste, colour and overall acceptability.

Similar study was conducted by Howard et al. (2011) where they analysed pasta supplemented with the peanut flour for its formulation optimisation as well as the ingredient functionality and formulation optimization. Peanut flour substituted with durum wheat flour at a level of 30 per cent, 40 per cent, and 50 per cent. And also carrageenan were added at a level of 2.4 per cent, 2.65 per cent and 2.9 per cent and the drying temperature (60, 70 and 88ºC) were used respectively on final pasta product. The sensory evaluation were done where the values of colour lightness varied from 42.43 to 64.01, decreasing (becoming darker) with an increase in drying temperature along with increase in the peanut flour level. The content of moisture varied from 56.24 per cent to 68.37 per cent and the values reduced as the drying temperature increased. The pasta was found to be light in colour, softer in texture and higher in moisture when dried at 60ºC with 30 % of peanut flour in it in comparison to the other relative varieties with higher percentile of peanut flour and dried at a higher temperature.