Celiac disease is one of the most common lifelong disorder for which the only treatment is strict dependence over a gluten-free diet. It is an immune chronic condition with genetic transmission primarily affecting small intestine after the ingestion of gluten protein available major with wheat, rye, barley and other interbreed species. Celiac is strongly associated with specific HLA (Human leucocyte antigen) class-II genes where HLA-DQ2 and HLA-DQ8 allele is the region for disease development.

Gluten protein is the responsible protein to trigger immune response on ingestion in celiac patients. Solubility as one of the parameter of protein classification where, two sub-fraction of gluten i.e. gliadin and glutenin are soluble and insoluble in aqueous alcohol respectively. These fractions consist of numerous, closely related polypeptides that are rich in amino acids namely glutamine and proline. Gliadins are mainly monomeric proteins with molecular weights around 28,000–55,000 and are further sub classified as α, β, γ and ω-type (Yadav and Singh, 2011). Similarly glutenin consist of both high molecular weight subunits (67,000–88,000) and low molecular weight subunits (32,000–35,000) which are connected by intermolecular disulphide bonds. Non-covalent bonds such as hydrogen bonds, ionic bonds and hydrophobic bonds bind gliadin and glutenin to provide structure and physical properties to gluten. Gliadins and glutenins contain domains with numerous repetitive sequences rich in these amino acids. Humans inherently lack endopeptidases required to cleave bonds between proline and glutamines. This incomplete digestion of gliadin by digestive enzymes leads to the generation of polypeptides, which are immunogenic to patients genetically susceptible to celiac disease. Therefore, alternate of true cereals may be used for those patients which includes; coarse cereals and pseudocereals as of prime importance with their high nutrition capacity and
with wildly and widely grown capability. Foxtail millets (*Setaria italica*) and Amaranth are such examples of coarse and pseudocereals respectively recognized with the status of gluten free nutritious grain but underutilized. So there is need to introduce range of gluten free products as the demand for these products is increasing worldwide with the increase in the number of individuals diagnosed with celiacs.

The available information related to celiac disease, gluten free foods, ingredients and their effects are reviewed in this chapter with suitable sub-headings.

**2.1. Celiac status in India and world**

Sharma and Mandot (2018) as per their prospective and observational study over 201 patients in the Department of Paediatrics, Geetanjali Medical College and Hospital, Udaipur, Rajasthan. These patients were interviewed along with their parents and evaluated on the basis of clinical symptoms of diarrhea, abdominal pain and multivitamin deficiency. All the subjects were found positive for t-TGA test (>10au/ml) with prevalence level of 23.9%. So, the belief of celiac disease (CD) as the only mean by genetically related food intolerance, worldwide is broadened with chances of development after birth as well in severely malnourished children too.

Burkhardt et al, (2018) differentiate the wheat allergy, celiac disease and gluten sensitivity. Though wheat is the most commonly consumed, wheat allergy is rare compared to other food allergies with estimated prevalence of less than 0.5% in general population. Gliadin and glutenin are the most common allergens affecting GI tract (vomiting, colic, diarrhea), skin (urticaria, eczema), respiratory tract (upper respiratory, asthma), or multiple systems (anaphylaxis). Wheat allergy manifestations are mostly IgE –mediated. Celiac disease is due to prolamines (gluten in wheat, secalin in rye, hordein in barley and avenin in oats) mediated mal-absorption disorder. The
age for onset of symptoms varies widely, but usually within 6 months of introducing cereal grains into the diet. It may be delayed by several factors (nutrient deficiencies, infection, systemic stress, or malignancy) from late childhood to adulthood. Lowest reported occurrence was in Southeast Asia and the highest (5.6%) in African Saharawi children. As of the known pathogenesis enzyme resistant proline rich gluten fragment become deamidated by transglutaminase, this deamidated gluten than recognized by antigen cells (HLA-DQ2 and DQ8) and is presented to T-cells. In 2011, a panel of experts defined gluten sensitivity as a clinical entity, other than celiac disease and wheat allergy, induced by the ingestion of gluten and causing intestinal and/or extra-intestinal symptoms with its prevalence (0.5% to 6%) in different populations with undiagnosed mechanism. Reported symptoms vary widely, including GI symptoms (such as bloating, abdominal pain, diarrhea or nausea) and/or extra-intestinal manifestations (such as tiredness, muscle or joint pain, headache, or depression).

First Indian celiac patient was detected by Walia and associated doctors in 1966, when ten children patients (6 male and 4 females) agreed to undergo their clinical examination viz. haemogram, microscopical and bacteriological testing of stools. All these stunted growth child suffering from diarrhoea during second to third year of their life, when they were introduced to solid food after milk. Diarrhoea was not suggested by any of parasitic infection or infestation as suggested by clinical tests. So they were accessed differently after feeding them on to a strict gluten free diet for about 12 weeks and examined clinically and biochemically. Results revealed that all the patients were anaemic with stunted growth and the passage of stools with the characteristic of steatorrhea was observed.

Makharia et al, (2011) estimated the prevalence of celiac in North indian community through cross sectional study over urban and rural population of Delhi, India. Among 12573 contacted
population, 10488 (83.4%) agreed to participate, based on screening, 5622 (53.6%) were screen positive. Out of it 2167 (38.5%) were agreed for serological testing (anti-tissue transglutaminase antibody test). The overall prevalence of celiac disease was 1.04% that defines that every one individual in 96 is celiac in North Indian community.

A comparative investigation on Indian aged population by Ramakrishna et al, (2016) was accessed to diagnose celiac prevalence among 23,331 healthy participants of Northern, north eastern and southern people was carried out. They were screened for celiac disease using Ig-A anti-tissue transglutaminase antibody test followed by confirmation through ELISA in Ig-A positive respondents. ELISA positive patients were then also screened for their dietary pattern. Age-adjusted prevalence of celiac among northern, north eastern, and southern India was found to be 8.53/1,000, 4.66/1,000, and 0.11/1,000 respectively. Dietary pattern of daily wheat intake is the main concern that is highest in northern (455 g) compared to north eastern (37 g) and southern part (25 g) of India. On the other side daily rice intake showed an inverse pattern against celiac.

Chishty and Singh, (2017) compared the nutritional status of celiac children with those that are non-celiac in the age group of 7-12 years. Non-celiac respondent children were from first and second-degree siblings of the affected children just to cope-up with similar family and environment conditions. Non-celiac children were comparatively taller than children with celiac disease. The haemoglobin and serum iron were significantly lower in celiac than non-celiac group (p < 0.01). The protein intake was higher in non-celiac children and the difference was highly significant (p < 0.01).
Bhattacharya et al, (2009) screened 400 children (6 months to 12 years of age) through anti-tissue transglutaminase (tTG) antibody assay and Endoscopic duodenal biopsy in anti tTG positive respondents. Four subjects were diagnosed with celiac disease and hence confirmed prevalence in 1% of northern community patients.

Ludvigsson et al, (2012) conducted population based study in north America between 2000-2010 and diagnosed 249 individuals. It was reported that prevalence of celiac is increasing from 11.1 in 2000–2001 to 17.3 in 2008–2010 as diagnosed after symptomatic examination through diarrhoea and weight loss.

Swedish children were diagnosed for celiac disease or gluten enteropathy by Carlsson et al, (2001) through questionnaire based research about regarding food and feed ingredients to infants. The risks of celiac disease were reduced in children aged <2 y if they were still being breast-fed when dietary gluten was introduced. This effect was even more pronounced in infants who continued to be breast-fed after dietary gluten was introduced. The risk was greater when gluten was introduced in the diet in large amounts than when introduced in small or medium amounts. In older children, these risk factors were of minor importance.

Fasano and Catassi, (2001) worked on diagnosis spectrum of celiac disease and characterized it by damage of the small intestinal mucosa caused by gliadin fraction of wheat gluten and similar alcohol-soluble proteins (prolamines) of barley and rye in genetically susceptible subjects. Presence of gluten in diet causes damage to the internal mucosal lining, whereas its elimination results in full mucosal recovery. In addition to the classical gastrointestinal form, a variety of other clinical manifestations of the disease have been described, including atypical and asymptomatic forms. Therefore, diagnosis of CD is extremely challenging. Serologic tests
developed in the last decade provide a non-invasive tool to screen the general population for celiac atrophy. However, the current gold standard for the diagnosis of CD remains histologic confirmation of the intestinal damage in serologically positive individuals. Only the keystone treatment against it is to eliminate gluten from diet throughout lifetime.

Tack et al, (2010) screened a small celiac patients group (2-5%), and concluded that celiacs fail to improve clinically and histologically even after elimination of dietary gluten. This complication is referred to as refractory celiac disease, imposes serious risk of developing a virtually lethal enteropathy-associated T-cell lymphoma. Environmental factors such as gluten introduction at childhood, infectious agents and socio-economic features, as well as the presence of HLA-DQ2 and/or HLA-DQ8 haplotypes or genetic variations in several non-HLA genes contribute to the development of celiac disease. Besides adherence to the gluten free diet, various other alternative treatment modalities worked to modify dietary components, enzymatic degradation of gluten and inhibition of intestinal permeability and modulation of the immune response as an alternative.

2.2. Gluten free foods

In 2000, the Codex Alimentarius Commission of the World Health Organization and the Food and Agriculture Organization described gluten free foods with a gluten level not exceeding 20 ppm and consisting of, or made only from ingredients which do not contain any prolaminés from wheat or any Triticum species, such as spelt, kamut or durum wheat, rye, barley, oats, or their crossbred varieties (Hischenhuber et al, 2006).

Li, (2009) studied the effects of blue corn and guar gum on cookie quality. Increased levels of blue corn flour and guar gum reduced the cookie spread. Cookies’ texture was associated with the
amount of gum and water in the dough. Addition of guar gum allows more water in the cookie, with softer texture. The brightness was inversely related to the blue corn flour %.

Gluten is meant for its texturizing properties to the baked goods. Removal of gluten requires finding other flours from beans, rice and the “ancient grains” like amaranth, millet, quinoa and sorghum which do not have gluten. Cookies from 100% sorghum or pearl millet were produced by Badi and Hoseney, (1976), but these were described as “tough, hard, gritty and mealy”. Improvements were sought via various additions (wheat flour lipids, unrefined soybean lecithin, hydration of flour and increasing dough pH) and the authors concluded that the lack of polar lipids in sorghum is partly responsible for the lower quality of cookies when compared to those from wheat.

A gluten free formulation in terms of biscuit based on buckwheat flour with various hydrocolloids viz. guar gum, gum acacia, xanthan gum and gum tragacanth in fixed concentration of 1g/100g level were tested by Kaur et al, (2015) in comparison with refined wheat flour biscuit. It is revealed significantly (p<0.05) that incorporation of gums influenced various quality parameters i.e. water absorption capacity, oil absorption capacity and emulsion activity. Gums incorporated preparations had higher values of moisture content, thickness, weight and diameter but need little fracture strength. Sensory observation for wheat biscuits like most by the sensory panel members than buckwheat flour as per hedonic basis but incorporation of gums to buckwheat flour improved the sensory score for final baked biscuits. Xanthan gum addition favors the baking characteristics (color, flavor, appearance and overall acceptability) in biscuit development significantly amongst all the other hydrocolloids utilized.
This research was undertaken by Banusha and Vasantharuba, (2014) to emphasize much on the utilization of gluten free flours i.e. rice, maize, sorghum and pearl millets to develop gluten free cookies and characterize against wheat cookies as control counterpart. Blend of rice and maize has the highest spread factor and least with rice and sorghum blend. Proximate composition yielded high (% crude fat, % crude protein, % ash and calorific value) in pearl millet and sorghum blended cookies compared to wheat cookies. All the combinations when subjected to sensory panels followed the liking preferences as pearl millet & sorghum > rice & sorghum > maize & sorghum > rice & maize > maize & pearl millet > rice & pearl millet > control cookies.

Schober et al, (2003) studied the effect of low fat, high fat and microencapsulated high fat dairy powder alongwith vegetable fat in comparison with palm oil over the three differently combined multigrain gluten-free biscuits. These were than evaluated against the wheat (W) counterpart. Three mixes of brown rice flour (R), corn starch (C), potato starch (P), Soya flour (S), Buckwheat flour (B) and millet flakes (M) were studied: RCPS in the percentage 70, 10, 10, 10 RPBM (50, 30, 10, 10) and (25, 25, 25, 25). Biscuits were tested for water activity, moisture, texture (snap test), diameter, thickness and color (L* value). Cluster analysis revealed that RCPS was most similar to W with regards to all parameters measured and RCPS also showed best overall acceptability in sensory testing. Three fat powders were studied for use instead of palm oil: high and low fat dairy powder (HFP, LFP) and microencapsulated high fat powder based on vegetable fat (ME). HFP and ME yielded biscuits of comparable texture to palm oil, LFP resulted in much firmer biscuits attributed to lower fat, higher protein and total sugar content.

Caponio et al, (2008) evaluated the quality of lipid fraction in gluten free baked market samples of biscuit and snacks. The results showed that the fatty fraction of gluten-free biscuits present in
mean amounts of 15% have poor nutritional quality as indicated with high fat level of triacyl glycerol oligopolymers (0.46%), oxidized triacylglcerols (0.80%) as well as in some cases high level of oleic acid trans isomers (up to 9.39%). They all are meant to have negative effect on health and this should be seriously taken in account because the limited choice of food products in the diet of celiacs induces a high consume of packaged gluten-free products, such as snacks and biscuits.

Gambus et al, (2009) observed the nutritional values from gluten free confectionery products (control sample) in comparison with the gluten free products supplemented with linseed meal, amaranth and/or buckwheat (test sample). Both the products were analyzed for physico-chemical (volume, textural analysis: hardness, cohesiveness, chemical components) and organoleptic quality. Samples that were supplemented with linseed meal, amaranth and/or buckwheat flours had enhanced nutritional quality. A significant rise was observed in the protein content and dietary fiber, and in the case of linseed meal also α-linolenic acid. All of the supplemented gluten-free confectionery products contained more macro-elements and micro-elements (K, P, Mg, Ca, Fe, Mn, Zn and Cu), as compared with the controls. Similarly, amaranth incorporation in gluten free test samples raises the amino acid profile.

Barca et al, (2010) formulated and evaluated gluten free cookies using raw and popped amaranth flour. Among all the preliminary trials, best cookies recipe had 20% of raw amaranth flour and 13% of whole-grain popped amaranth flour. On examination, the gluten content in baked sample was 12 ppm with high nutrients as of amaranth. Functionality of amaranth incorporated dough was acceptable although hydrocolloids were not added in its basic preparation.
2.3 Pre-processing of selected flours

Foxtail millet (*Setaria italica*) is the second most widely planted species of millet, and the most important in East Asia. It has the longest history of cultivation among the millets, having been grown in China since sometime in the sixth millennium BC. The worldwide production of foxtail millet was 27.92 million hectare cultivated in total area of 32.18 million hectare in 2013; India alone contributed 11.44 million tons production of millets from a total cultivated area of 9.66 million hectare and stood as top most producers around the globe in millet production (Hariprasanna, 2017). Other names for foxtail millet include Italian millet, German millet, Chinese millet, and Hungarian millet. In India, it is assigned with common names within different geographical territory and pronounced as Korralu (Telugu), Navane (Kannada), Kangani (Hindi).

Taylor and Duodu, (2017) in collaborated experiments for sorghum and millet grains found that they are phytochemically rich with a range of phenolics. However, the types and amounts vary greatly between and within species. Application of pre-processing treatments i.e. Dehulling and decortications, malting, fermentation and thermal processing dramatically affect the quantity of phenolics present, most generally reducing them. Thus the levels of Phytochemicals in sorghum and millet foods and beverages are usually considerably lower than in the grains. These phenolics governs the better health in terms of cardiovascular efficiency, lower cholesterol and upgraded immune system and also through utilization of sorghum and millet based lactic acid bacteria-fermented products to have probiotic effects related to their unique microflora.

Nazni and Devi, (2016) presented a study with the objectives to find out the processing effects (boiling, pressure cooking, roasting and germination) on functional, nutritional, anti-nutritional and pasting properties of foxtail millet. Physical properties of unprocessed millets, chemical,
functional, anti-nutritional and pasting properties of both unprocessed and processed millets were analysed using standard techniques. Physical characteristics such as thousand grain weight, thousand grain volumes, hydration capacity and index, swelling capacity and index and cooking quality of the selected two unprocessed millets were considerably differed from each other. As per the concluded part for these two selected varieties in response to different processing methods, germination reduces the anti-nutritional factors while roasting significantly increases the nutritional compounds. The improved functional and pasting properties of the selected two millets were observed in the germinated and roasted millet flours.

Mishra et al, (2014) explored bioactive components (phytochemical and antioxidants) in underutilized cereals (foxtail millet) and compare them with true cereal (wheat). Total polyphenolic content (Folin-Ciocalteu reagent) and antioxidant activity (DPPH) quantified as 210 mg GAE/100g and 115.42 mg GAE/100g for foxtail millet and wheat flour respectively. Similarly, % radical scavenging activity by DPPH for foxtail millet and wheat flour quantified as 43.78% and 31.46% respectively. Proximate composition follows the same pattern where foxtail millet confirms the status to supercede the wheat in functionality and nutrient capacity both.

Agrawal et al, (2013) determined functional properties of malted and unmalted flour prepared from foxtail millet (kangni). The grains were soaked in triple the volume of water at 25±2⁰C for 6, 12, 18, 24, 30 h. It was clearly depicted in the results that moisture uptake increased gradually till 18h and then it became static. Moisture absorbed after soaking for 30h reported to be high (32.40%) in kangni, so moisture intake by grains is found to be directly proportional to the soaking time. Steeped seeds were then allowed to germinate at 25±2⁰C, 90% relative humidity with varying time intervals i.e. 24h, 48h, and 72h. It was observed that 96% of grains were
germinated whereas rootlets size under the same conditions grown to 18mm in length. It was concluded after malting that water absorption capacity decreases as in comparison with unmalted one. After malting, significant reduction was shown in bulk density by 20% of kangni flour.

Two millet varieties Ashana and Dembi studied by Mohamed et al, (2010) and analysed for their antinutrients after storage period of 30 and 60 days before and after application of cooking method. Phytic acid and polyphenols contents were assayed for all treatments. Storage results evidenced no change in phytate and polyphenols. Moreover, dehulling of the grains reduced more than 50% of phytate and polyphenols of both cultivars. Cooking of raw, whole and dehulled flour significantly (p ≤0.05) reduced phytate and polyphenols contents for both cultivars. Cooking resulted in reduced polyphenolics and phytate significantly (p ≤0.05) for the whole and dehulled flour of both cultivars. Dehulling alone significantly (p ≤0.05) decreased Ca and P content and slightly decreased Fe content.

Sharma and Niranjan, (2017) investigated the characteristic changes occurring in foxtail millet due to germination. There was a significant difference with respect to nutritional, anti-nutritional and pasting properties of foxtail millets in response processing application. It was inferred that germination lowers the tannin in foxtail millet flour 0.26mg/g to that of 0.36 mg/g in raw foxtail millet flour. Peak viscosity values of pasting properties decreases tremendously from raw foxtail millet (521 cP) to germination (116 cP). Crude protein, crude fiber content of raw foxtail millet grain 6.8 g/100 g and 4.9 g/100 g increased to 12.6 g/100 g and 5.1 g/100 g respectively after germination. Increase in protein was attributed mainly to protein synthesis owe to new microbial cell inclusion while germination. Crude fat level reduction to 2.6 g/100g after germination from
2.9 g/100 g values of raw foxtail millet attributed mainly to its utilization by growing embryo and utilization of germ proportion.

Coulibaly and Chen, (2011) evaluated foxtail millet through soaking and germination pre-treatment. One day soaking and 8 days germination increased soluble sugars from 0.99±0.06% in raw sample to 12.99±0.02% in the treated sample on 8th day. An elevation in amylase activity was recorded from first to third day (0.015 ±0.001 to 0.027±0.002 µg/mg) and a rise was also seen in phytase activity from first to seventh day (19.61±0.61 to 70.02±0.13 µg/mg). No change had been observed in proteins during germination (11.9±0.056% in raw sample to 12.13±0.032% on first day and 11.78±0.18% on eighth day of germination). Total soluble solids increased drastically from raw (0.99±0.07%) to the eight days’ germinated sample (12.99±0.022%). The mineral level elevated with germination i.e. Phosphorous (669.73mg/g). The vitamin C was maximum on eighth day i.e. 4.98 mg/g. Total phenolic content had decreased from 0.97±0.085mg/g to 0.11±0.001mg/g. Germination reduced fat content of foxtail millet significantly with time. It was measured to be high in raw samples i.e. 4.095±0.013% followed with decreasing pattern right from the beginning of germination (3.99±0.065%) and reached to 3.49±0.013% on eighth day. Decrease in fat during germination may be due to the action of lipolytic enzymes could be owing to fat catabolism for energy production which finally contributed to seed growth. This reduction brought an increase in palatability of millet food products. It reduced the possibility of development of free fatty acids, which occur mainly due to the action of lipase, causing bitterness.

Singh and Hathan, (2014) operated foxtail millet flour on the basis of selected series of pre-processing treatments and then analysed physico-chemically. Treated samples in comparison with
untreated (control group) evaluated for its proximate composition, phenolic constituents, antioxidant capacity, minerals value and for antinutrients (phytates and tannins). Raw grains were compared with pearled and germinated grains and were also evaluated against rootlets flour obtained after germination. Results revealed that raw grains have high protein and fiber (12.57±1.22mg/g and 10.21±1.67mg/100g), raw grains were phytate prominent (4.80±0.89g/100g); whereas pearled flour samples are the richest source of polyphenols (28.02±1.67mg/100g). Divalent cations (Iron, Calcium, Zinc) estimated through atomic absorption spectroscopy were also present in significant amount in germinated grains. Emerged rootlets grab the status with richest antioxidants (98.05±7.09 trolox eq. µg/g) obtained after drying and milling of germinated rootlets.

Mature and dried coconut kernel or meat is known as copra. The dried kernel is the chief commercial product from coconut, which is mainly used for oil extraction. Copra normally has oil content varying from 65 to 72%, copra meal is left behind after oil extraction. It is cheaper source of both protein and fiber as 22.2 % and 11.65 %, respectively. A study was conducted by Tasker et al, (1961) on the supplementary value of a low-cost protein food based on a blend of peanut, copra meal and chick pea flours to maize-topioca diet.

Aruna et al, (2017) reported that copra meal flour can provide not only value added income to the industry but also a nutritious and healthy source of dietary fiber. Copra meal flour play a role in controlling cholesterol and sugar levels in blood and prevention of colon cancer.

Moorthy and Viswanathan, (2009) explored the nutritive value of copra meal (coconut meal). The crude protein content of extracted coconut meal (ECM) was 22.75%. Amino acid profile evaluated for lysine and methionine content in ECM were 0.59 and 0.34 %, respectively. The
critical amino acids, lysine (0.59%) and methionine (0.34%) were lower in ECM compared to values given in National Research Council (1994) for other vegetable protein sources, which are commonly used in livestock feed like soybean meal (2.69 and 0.62%) sunflower meal (1.00 and 0.50%) and groundnut meal (1.54 and 0.54%). Comparable crude fiber content (12.11%) makes it more advantageous to be used in human diet.

Thongsook and Chaijamrus, (2014) worked on to the modification of physiochemical properties of copra meal using acid hydrolysis to improve its potential utilisation as source of food fibres or low-calories bulk ingredients. Although it is a good source of dietary fibre (DF), but its high water-holding capacity (WHC) restricted it as an active ingredient for development of various food products. Acid hydrolysis using 0.5% HCl significantly reduced swelling capacity (SC) and water retention capacity, whereas bulk density (BD) and soluble DF content of modified CM significantly increased. Monosaccharide composition profile, gel penetration profile and FT-IR spectra indicated the destruction of CM matrix structure. This destruction increased compactness of the structure and lessened the ability of CM to hold water. Substituting modified CM for wheat flour in bread and cookies significantly improved bread and cookies qualities compared with the use of the untreated CM.

Sindhuja et al, (2005) developed composite cookies with amaranth flour proportion (Amaranthus gangeticus). Its incorporation resulted in little reduction in water absorption capacity from 58.0 to 56.5%, considerable reduction in Farinograph stability from 3.0 to 1.5 min and increase in the mixing tolerance index from 40 to 120 BU of the dough.

Anamika and Vishakha, (2017) conducted a sensory study for amaranth fortified biscuits. Recipe was standardized and subjected to organoleptic evaluation by a panel of semi-trained judges
using 9-point Hedonic Scale. The mean score of organoleptic evaluation was 6.91±0.06. That was revealed that it was liked moderately by panel members. Incorporation of amaranth flour improved the color of the cookies from pale cream to golden brown. The cookies became crispier which is evident from the reduction in the breaking strength value from 6.2 to 4.02 kg. Considering the color, taste, flavour, surface appearance of the cookies, 25% incorporation of amaranth flour was found to be optimum. 0.5% combined addition of glycerol mono stearate (GMS) and soy lecithin further improved the textural and shelf stability of the cookies.

Chauhan et al, (2015) worked on to develop gluten free cookies from raw and germinated amaranth grain flour. Pre-treatment of germination decreases fat (6.68 g to 4.7 g/100 g) and carbohydrate (62.41 g–60.70 g/100 g) while an increase in protein (15.05 g to 16.5 g/100 g), total dietary fibre (9.52 g to 12.9 g/100 g) and antioxidant activity (10.23 g to 14.71 g/100 g) was observed. Raw amaranth flour cookies showed the highest spread ratio, followed by germinated amaranth flour and wheat flour cookies. Germinated amaranth cookies exhibited highest antioxidant activity (21.43 g/100 g) and total dietary fibre (13.97 g/100 g) as compared to raw amaranth and wheat flour cookies. Thus its incorporation could be the possible reason of selection for developed cookies with highest acceptability.

2.4 Composite biscuit

Sudha et al, (2007a) reported that the sensory scores for the appearance were decreased significantly with fat reduction. The surface of the control was smooth and as the fat level was reduced, especially at 60% and 70% levels, the surface was uneven and looked shrunk. The sensory parameters that were greatly affected by fat reduction were texture, taste and flavor. They became hard, developed dry mouthfeel, lacking the lubricity and moistness imparted by fat.
Seema et al. (2016) worked to enhance sensory appeal of multigrain cookies (Foxtail, barnyard and kodo millet) through seed germination technique. Analyses revealed that germinated flour blends contained highest proteins, total phenolics and possessed high *in-vitro* antioxidant activity, less fat and carbohydrate contents than raw flour blend. Germination imposed negative influence on pasting properties whereas functional properties were significantly improved. Raw minor millet flour blended cookies showed highest spread ratio, followed by cookies from germinated flour blends. Phenolic content (45.43 mg/100 g), DPPH activity (42.34%), dietary fibre (12.36 g/100 g) and nutritional value were highest in cookies with germinated flour followed by cookies prepared from raw minor millets and control. Sensory evaluation revealed that cookies of germinated foxtail, barnyard and kodo millets in the proportions of 70:20:10 respectively, were most acceptable, nutritious and were on desirable functional properties.

Daisy et al. (2017) developed nutraceutical biscuits using single and multiple blends of functional ingredients (foxtail millet flour, flaxseed flour, rice bran oil and carrot flour) and assess their suitability through sensory and physical characteristics. Acceptability trials were conducted by a semi-trained panel food science and nutrition and Horticulture concerned faculty against nine point hedonic scale. Three single blend formulations viz. SB1, SB2, SB3 and four multiple blend formulations namely MB1, MB2, MB3 and MB4 were developed under nutraceutical biscuits. Under each formulation, three products were developed at different level of incorporation 20% (A), 30% (B) and 40% (C) and were subjected to acceptability trials. Out of the three product prepared from SB1 formulation, SB1A (20% foxtail millet flour) exhibited highest scores for all the sensory attributes. Similarly out of the three products under MB1 formulation, MB1A (20% foxtail-millet flour +flaxseed flour) achieve highest sensory score.
Anju and Sarita, (2010) optimized the process parameters for biscuit development from foxtail millet and barnyard millet flour followed by sensory quality determination, nutritional value calculation and glycemic index evaluation by means of comparison with biscuits made from refined wheat flour as control sample. Three samples of biscuits prepared with 45% foxtail millet flour + 55% crude refined wheat flour, 45% barnyard millet flour + 55% crude refined wheat flour and 100% crude refined wheat flour (control). All the three types of biscuits were found to be acceptable by a trained panel and diabetic subjects. The shelf life study indicated that the biscuits made from foxtail millet flour can be successfully stored for a period of 60 days in a thermally sealed single polyethylene bag at room conditions. Moreover, foxtail millet flour had lowest GI of 50.8 compared to 68 for biscuits from barnyard millet flour and refined wheat flour thus suited best to the diabetics too.

2.5 Fat replacer

Forker et al, (2012) performed to replace fat (30% or 40%) singly (corn fiber, maltodextrin and lupine extract) or in combination thereof in biscuits. 30% baking fat replacement resulted in increased moisture in cookies, less spread and color affected drastically than reference biscuit. 40% replacement raises all these differences, but combined trial with 1:1 ratio (corn fiber:lupine extract) were on priority on sensory basis similar to reference sample.

Zoulias et al, (2002) prepared soft cookies with up to 35% fat replacement by fat mimetics, (polydextrose, maltodextrins, β-glucans, pectin and Simplesse) All formulations with fat replacement up to 23% showed properties similar to control cookies except hardness. Cookies with 35% fat replacement by polydextrose, a combination of polydextrose, maltodextrin and a combination of polydextrose, Simplesse each with 50% microparticulated whey proteins and
emulsifiers presented a greater hardness, but physical properties as well as flavor and general acceptance comparable to the control cookies.

Experiments were conducted by Chugh et al. (2013) to develop low-fat soft dough biscuits using carbohydrate-based fat replacers (maltodextrin and guar gum). A central composite rotatable design approach of response surface methodology was utilized for optimization purpose. Sugar (24–36%), composite fat (fat 10.5–24.5%, maltodextrin 10.4–24%, and guar gum 0.1–0.5%), ammonium bicarbonate (0.5–2.5%), and water (20–24%) were selected for production of low-fat biscuits. Resulted diameter and stress-strain ratio decreased significantly with increase in the amount of sugar. There was a significant decrease in spread ratio at high amount of water. Hardness was significantly affected by interactions of ammonium bicarbonate with sugar and fat. The optimum level of ingredients obtained for low-fat biscuits was sugar 31.7g, fat 13.55g, maltodextrin 21.15g, guar gum 0.3g, ammonium bicarbonate 2.21g, and water 21ml/100g flour. The fat level in the optimised low-fat biscuit formulation was found to be 8.48% as compared to 22.65% in control; therefore, the reduction in fat was 62.5%.

Savitha et al. (2008) studied the effect of replacement of 30% sugar with 0.05% sucralose and of different levels of maltodextrin (MD) on dough rheology and quality of biscuits. Replacement result of MD from 10 to 40% along with 0.05% sucralose influenced dough rheology. Objective evaluation of biscuits showed that the spread ratio of biscuits with 10% MD was 7.1, 20% MD was 7.8, 30% MD was 9.4 and 40% MD was 10.5, in comparison to control biscuits (9.9) with 30% sugar. The best overall quality score was reported for the control biscuits with 30% sugar, 69 out of the maximum score of 80, followed by 30% MD (65), 40% MD (60.5), 20% MD (54) and 10% MD (49.5).
Mosafa et al, (2017) develop biscuits based on whole oat flour (5–15%) maltodextrin (1–3%) and isomalt (10–20%) using Response Surface Methodology (RSM) as the optimization technique. On analysis, hardness, fracturability, penetration force and overall acceptability scores were determined. Results showed that increasing amount of whole oat flour and isomalt in biscuits lower the hardness and penetration force value, whereas, fracturability increased. Sensory characteristics in overall acceptability form increased to the level of oat flour (10%) after which it decreased. Maltodextrin addition works to raise the penetration force value, while hardness decreased. Resultant optimized formula containing 11.39% whole oat flour, 16.73% isomalt and 2.2% maltodextrin as the best proportion of these components. Optimized biscuit had improved protein (15.43%), ash (2.76%), carbohydrate (58.08%) and specially fibre (4.07%) in addition to acceptable textural characteristics.

2.6 Sugar replacer

Edyta et al, (2000) optimized the low sugar and fat cookies with the aid of polyols and polydextrose. The test cookies prepared with maltitol and lactitol were almost similar to that prepared with sucrose, sorbitol incorporated cookies had much acceptable values. In addition, lactitol and sorbitol improved the texture of low fat cookies too; softer and brittle. Mannitol arrests spread and impart unpleasant flavour and appearance to the baked cookies. Cookies with these polyols and fructose were less sweet than sucrose but supplementation with acesulfame-k increased sweetness and acceptability through improved perceived flavour.

Klug et al, (1992) explored the acesulfame-k heat stability at different baking temperatures and baking time. Evaluation of it was done through high performance liquid chromatography (HPLC) in baked and unbaked doughs. Recovery rate of acesulfame-k was independent of chosen baking
conditions correlated with unbaked doughs. Moreover, further extended study at varying pH and moisture investigation performed in acidic conditions too, but no decomposition of acesulfame-k could be detected.

Kutyla-Kupidura et al, (2016) designed a recipe by keeping in mind the sucrose substituted alternative sweeteners (xylitol, sucralose and acesulfame-k), applied separately or in blends. Textural and sensory parameters were analysed in comparison with sucrose sweetened cookies. Acesulfame-k as sole additive resulted in baked cookies resembled best in hardness to the sucrose sweetened cookies (control) whereas, the similar hardness was only be achieved when performed with blended proportion of sucralose and xylitol.

Mc Kemie, (2008) optimized reduced sugar oatmeal and chocolate chip cookies aimed to reduce simple carbohydrate and calorie consumption. Both the test samples were adjusted (100%) with sugar alternative blend (Splenda® Granular (sucralose + maltodextrin) and Isomalt). Control cookies were prepared with 100% granulated sugar. Using the multiple ingredient approach, three Splenda® Granular: Isomalt ratios were investigated: 30%:70%, 40%:60%, and 50%:50%. A trained descriptive panel evaluated sensory texture and flavors attributes. Overall, all blend ratios produced cookies with quality characteristics very similar to the controls. Sugar reduction was 30%; calorie, 4-7%.

2.7 Storage study of biscuits

Sahni and Shere, (2017) investigated shelf stability of fibre prone cookies stored in different packaging materials i.e. LDPE, PET jar, LDPE pouch in PET jar and metalized pouch over a storage period of 90 days. The samples were prepared with apple, carrot and beetroot pomace, evaluated on sensory basis. Cookies packed in LDPE pouch showed significant decrease in color
and appearance followed by PET jar as compared to other two packaging materials. Pronounced change in the color was observed in cookies with beetroot pomace powder. However, cookies packaged in metalized pouch showed least changes in color and appearance. Crispness of the control and oat cookies decreased in all packaging materials as compared to fibre rich cookies with pomace powders. Texture and crispness of cookies with beetroot pomace powder showed least changes as compared to other. Cookies packed in the LDPE pouch were on the least side for liking preferences as evidenced during 90 days of storage as compared to other packaging materials. Cookies with apple pomace powder stored in LDPE pouch showed least scores for taste as compared to cookies with carrot and beetroot pomace powder. Flavour score was highest in cookies with beetroot pomace powder. Cookies with pomace powders maintained better overall acceptability as compared to control and oat cookies.

Storage stability prediction for germinated fenugreek seeds powder fortified cookies was evaluated by Agrawal, (2017) at ambient atmospheric conditions for the storage capacity of 2 months. Basis of evaluation was physical (weight, diameter, spread ratio and thickness), chemical (peroxide value and free fatty acid value), sensory (9-point hedonic scale) and microbiological characteristics (total viable count and fungal count) packed in LDPE laminates. Obtained values (Peroxide and acid value) suggest their shelf stability and consumption over 2 months of storage in LDPE laminates at ambient conditions without appreciable quality loss.

Blackhall et al, (2002) describe a novel combination of Taguchi method and texture profile analysis (TPA) as a powerful problem-solving tool and predictive method to aid in manufacturing of food products. Taguchi methods are well known in the mechanical and electronic engineering environments but have not been applied to the difficult domain of food-product baking. The
success of this approach showed that the number of experimental factors and trials could be kept
to a cost-effective minimum and that the methodology could subsequently be applied to the full-
scale production plant process. Present study examined how this well-known method in
mechanical engineering circles could be applied to a different domain when used in a novel
combination with TPA, an important quality measurement tool used in the food sector. This
novel application resulted in reduced experiments in order to minimize production downtime
costs when applied within the actual plant. The research shows that combining these techniques
for the analysis of biscuit dough mix enabled the creation of an experimental methodology and
empirical models for four quality characteristics: dough-up time, viscous force, applied-force-
dependent-adherence ratio (AFDAR), and cohesiveness ratio; which give an indication of what
will happen when a specific factor is changed. This provided useful information about food
manufacturing processes and mixture rheology; especially with regard to how the ingredients
interact. The predictive models developed use discrete variables for the ingredients and were
tested to find the differences in their effects and were validated successfully against experimental
trials.

2.8 Market costs for gluten free products
Missbach et al, (2015) studied the nutrient composition and cost of 63 gluten free (GF) and 126
gluten-containing counterparts. A total of 63 packaged GF foods were included in the analysis
representing broad spectrum of different GF categories (flour/bake mix, bread and bakery
products, pasta and cereal-based food, cereals, cookies and cakes, snacks and convenience food).
Results showed that the protein content of GF products is >2 fold lower across 57% of all food
categories. On average, these products were substantially higher in cost, ranging from +205%
(cereals) to +267% (bread and bakery products) compared to gluten-containing products. In
conclusion, study reveals no predominant health benefits of consuming GF foods with their high price availability.

An exploratory study taken into consideration by Lambert and Ficken, (2016) using an amalgamation of two commonly used food basket (gluten free and gluten containing) These were designated as healthy food basket and modified (gluten-free) healthy food basket. Baskets were calculated on price difference basis for four common bread and cereal staples (per 100 g). Gluten-free healthy food basket was significantly more expensive compared to a gluten-containing healthy food basket and was considered unaffordable by common families. Compliance to a gluten-free diet may be more difficult for some families due to the significant price discrepancy of gluten-free items. Families on welfare with people who require a gluten-free diet are particularly vulnerable to food insecurity.

Fry et al, (2018) studied the price variations exists in gluten free diet as in comparison with the gluten containing alternatives and concluded that GF food is unlikely to offer healthier alternatives to regular foods, except for those who require a GF diet for medically diagnosed conditions, and it is associated with higher costs. Moreover, GF foods were rich in saturated fat, sugar and salt than regular foods, although this was not universally consistent, whereas fewer GF crackers contained high fat and sugar compared to regular foods. High salt content was found more frequently in GF than regular products. On average, GF products were 159% more expensive than regular (£0.44/100 g versus £1.14/100 g). GF items were also more likely to be lower in fibre and protein content than regular foods.
2.9 Gaps

From the data available till date, it has been inferred that celiac patients do not get the nutritious diet thus showed stunted growth in comparison with the non-celiac. Keeping in mind celiac status and present available foodstuffs in the market, foremost priority seems the selection of healthy and nutritious gluten free grains (pseudo-cereals and coarse grain) that provides the ample nutrients to the celiac patients. Along with utilization of gluten free grains, appropriate treatment of these grains (soaking, pearling and germination) may be explored to raise nutritional capacity and lower anti-nutrients and seems to be good in terms of sensory soothyness of treated grains. Use of saturated fats and refined sugars in bakery products pose serious threat to the consumer’s health. Hence a step may be put forward to replace these components with comparatively safe material such as maltodextrin and acesulfame-k for production of low calorie biscuits. Besides the use of alternative food grains, by products of other food industries such as copra meal flour may be selected that may boosts final product with nutrition and also helps in maintaining the cost effectiveness of product.