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NUTRITIONAL, PHYSIOCHEMICAL, PASTING AND THERAPEUTIC ATTRIBUTES OF COMPOSITE FLOUR

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Composite flour technology denotes to the process of mixing wheat flour with other cereals or legumes to accomplish better quality of available raw material, impart nutritional and functional characteristics. Composite flour prepared by mixing wheat and legumes flour increase the fiber content that results in reduction in cholesterol level and helpful for diabetics. Wheat flour is deficient in amino acid lysine, so high protein composite flours were incorporated in the formulation of product to enhance the nutritional value of wheat flour. It was concluded that composite flour has better nutritional, physiochemical, pasting and therapeutic characteristics than wheat flour alone.
Keywords: wheat, sorghum, millet, composite flour, Nutritional, therapeutic effect.

INTRODUCTION

The studies related to the composite flours having legumes and cereals have been conducted worldwide to investigate their medicinal and therapeutic role. In developing countries there is a demand to significantly increase protein quantity and quality in the diet through dietary interventions and decrease protein malnutrition. The biological, chemical, technological, and sensory characteristics of composite wheat flour have been studied. However the literature related to current study has been reviewed under the following headings:

***Cereal grains: Nutritional aspects*: T**he word "cereal" originates from the Ceres, the name of the earliest Roman goddess of the harvest. Cereals belong to the family *Gramineae* and are defined as edible monocots. Foods made from cereal grains not only provide complex carbohydrates but are also excellent source of energy. Important micronutrients of cereals are vitamins of B group (thiamine, riboflavin, niacin and pyridoxine), minerals, phytochemicals and antioxidants. These micro nutrients participate a significant task in the enzyme systems of body, facilitate in energy utilization and growth processes. They contain low lipid contents and less fat soluble vitamins such as A, D, E and K. (Slavin, 2004).

The whole grain comprises of bran (13-17%), a germ portion (2-3%) and 80-85% endosperm (Sramkova *et al*., 2009). The composition of these portions varies according to the type of cereal. Bran that is the outer most layer of a grain contain a higher amount of micro and macronutrients such as fiber, minerals and different flavonoids. The germ is also rich source of lipids, vitamins B & E. The endosperm contains starch mainly amylose and amylopectin and non starch polysaccharides (Marquart *et al*., 2002). Food containing multi grains are the rich source of all the three portions of whole grains including endosperm, germ and bran. The bran portion of whole grains has significant importance in the health benefits of eating these grains (Franz and Sampson, 2006).

Cereals are known to have a positive influence on the general state of the humans. Nutritional experts paid more attention to oat and barley. Besides their accessibility, these cereals are interesting due to their relatively high contents of soluble non-starch polysaccharides (fibrous material). Cereal products have significant effect on both children and adults health. These are an important source of minerals like magnesium, zinc, calcium and iron. Magnesium and zinc providing 27% and 25% of adult intake on the average respectively. Cereals products are naturally low in sodium so it can be added during processing of products. Whole grain cereals are also good source of iron which is intrinsic component of haemoglobin meant for carrying oxygen to body cells (Mckevith, 2004).

Cereal foods act as "filler" and may help in weight management. Cereal foods are bulky in nature and provide no or little energy to body. By avoiding sugary and fatty food it becomes easy to consume more cereals foods. Cereals are a richest source of health promoting substances. The protective effect in the development of cardiovascular disease due to reduced level of total and LDL cholesterol and increase in HDL cholesterol was demonstrated (Newby *et al*., 2003). It also confirmed the correlation between whole grain nutrition and reducing cancer, while a diet containing whole grains may reduce cancer risk by 30 %

(Liu *et al*., 2003). There is an opposite linkage between the consumption of cereal food and body mass index which means that increasing consumption of cereals reduced the values of body mass index and at the same time it promotes the weight loss. Hence, cereals take first place in our diet due to many positive health effects (Rakicka *et al*., 2013).
Modern life style with less physical activity has accelerated health problems in both developed and developing countries. One of these health problems, obesity is a contributory factor in the development of type-II diabetes and cardiovascular diseases. These risks can be reduced by the intake of whole grain diets with high dietary fiber content and low glycemic index (Behall and Hallfrisch, 2006). The regular diet from whole grains has significant impact on human nutritional aspects like blood lipids profile, insulin level, dietary fiber and micronutrients intake (Jacobs *et al*., 2002). Over 3 billion people are micronutrient malnourished currently (Welch, 2005). However, knowledge about sufficient consumption of whole grains and mechanisms by which favorable effects are imparted is not clear yet (Slavin., 2003). USDA has introduced a recommendation for whole grain in its publication to increase the consumption of grains in daily diet (USDA, 2000).

PHYSIOCHEMICAL CHARACTERISTICS OF WHEAT, CHICKPEA, SORGHUM AND MILLET

***Physiochemical characteristics of wheat*:** Wheat is a top crop in the world and is mainly utilized for the preparation of chapatti or roti in Pakistan. It is estimated that 80% of the total wheat produced in Pakistan is used in the form of chapattis or rotis which is staple diet for the people. However, wheat protein is lacking in some essential amino acids i.e lysine and it contribute towards malnutrition among the masses. Wheat is considered as excellent food for building health. Wheat has many medicinal attributes as it contains gluten and starch which provides energy. Outer bran contains roughage which is not digestible but it helps to keep the bowel movements easy. The inner bran contains minerals and phosphates; germ contains vitamin E and B. (Kumar *et al*., 2011).
Wheat germ contains essential vitamins and their absence can lead towards heart disease but wheat germ is removed during refining process. As minerals and vitamins are lost during refining process so, it has resulted in constipation and some other widespread nutritional and health disorders related to digestive system. Wheat germ and bran constitutes the whole wheat, which protects against heart disease, ischaemic, diverticulum known as a colon disease and constipation, diabetes, obesity and appendicitis. So, it has emerged as most important cereal because it is used in bread making than other cereal crops due to the quantity and quality of its dominant protein known as gluten (Marquart *et al*., 2002). Whole wheat bran and germ are major components that are widely accepted as a significant ingredients in low glycaemic index (GI) foods. The α-glucosidase inhibitory action of bran and germ was identified. Various studies have been made on the glycaemic index of wheat bran and whole wheat; still the results are confusing and contradictory particularly as the whole wheat and wheat bran has unknown mechanism for glycaemic control. Whole grain and wheat kernels have a lower GI value i.e 63 than white wheat bread that have GI 100. The whole wheat flour chapati showed low glycaemic index as it contains wheat bran and germ, the whole grain components that are distinguished for its lower glycaemic response. Studies have also shown that the alpha-amylase inhibitors present in wheat, which can hold up cooking temperature, are effective in falling blood glucose response. All these factors lowered the GI of chapattis prepared by whole wheat flour (Liu *et al*., 2012).
In Pakistan wheat varieties have been found to contain on an average moisture 9.69 to 10.35%, protein 9.57 to 14.3%, crude fat 1.47 to 2.93%, ash 1.48 to 2.03% and crude fiber 0.98 to 1.43%, respectively (Anjum *et al*., 2008). In another study, proximate analysis in different wheat varieties exist in Pakistan contain on an average 7.02-8.26% moisture, 10.76-14.03% protein, 1.74-2.53% fat, 2.14-2.54% fiber, 1.10-1.89% ash and 72.62-75.17% NFE (Huma, 2004). Wheat contains moisture (10.81%), protein (13.73%), fat (1.4%), fiber (1.40 %) and 0.78% ash content (Gomez *et al*., 2008). Singh *et al*. (2003) showed that wheat flour has moisture (12.0%), protein (9.6%) and ash contents (0.48%), respectively. Shahzadi *et al*. (2005) showed that wheat flour has moisture (11.08%), crude protein (13.31%), crude fat (1.68%), crude fiber (2.05%), ash (1.35%) and NFE (81.92%). The proximate composition of wheat flour and fine semolina showed that wheat flour contain moisture content 12.68%, fat 1.24%, ash 0.6%, protein 10.50% and NFE 74.43% whereas semolina contain 14.12% moisture, 0.75%fat, 0.46% ash, 10.03% protein and 74.64% NFE (Senthil *et al*., 2002). Akhtar *et al*. (2008) reported that whole wheat flour has 8.83% moisture, 11.88% protein, 2.24% crude fat, 2.68% crude fiber, 1.62% ash and 72.72% NFE (Akubor and Badifu, 2004). Crude protein content ranges from 11.82- 14.10 % in different wheat flour samples (Randhawa, 2001).
Cereals contain 1.5 to 2.5% minerals. Wheat is considered as rich in phosphorus. Sodium and potassium are important minerals for health care. The potassium contents are high in wheat (200-1200mg/100g), also have Ca (100 to 200 mg/100g), Mg (100 to 200mg/100g), Fe (1 to 5 mg/100g) and Zn (1 to 5mg/100g) (Bergman *et al*., 1999). In addition to these, wheat also contain a large number of other elements in minute quantities. Wheat is a significant source of selenium that is an essential micronutrient for anticancer, antioxidant, and antiviral effects (Dewettinck *et al*., 2008).
Wheat starch pasting appear to be one of the key factors determining the qualities of wheat products and its physiochemical characteristics were affected by amylose and amylopectin and other components present such as phenolic compounds and polysaccharides (Funami *et al*., 2005).
No doubt wheat is considered as a good source of calories and nutrients, but it is considered as nutritionally poor, as cereal proteins are deficient in essential amino acids. Legumes contribute significantly towards protein, mineral

and vitamin B-complex requirements of people in developing countries. For that reason supplementation of wheat flour with inexpensive staples i.e pulses helps in improving the nutritional quality of wheat products (Sharma *et al*., 2012).

***Physicochemical composition of chickpea*:** Chickpea has moisture content 7.3%, crude protein 24.0%, crude fat 5.2% and ash 3.6%. Minerals content in chickpea were found as follow: sodium 101mg, potassium 1155mg, iron 3mg, zinc 3.4mg, phosphorus 251mg and magnesium 4.6 mg/100g, respectively (Iqbal *et al*., 2006). On an average, chickpea varieties have been found to contain 18.4-29% protein, 4.5-6.6% fat, 3-9% fiber, 2.6-3.5% ash and 59.5-65.45% carbohydrate (Boye *et al*., 2010). Likewise Alajaji and El-Adawy (2006) observed that chickpea contain protein (17-22%), fat (6.48%), crude fiber (3.82%) and carbohydrates (50%).

Chung *et al*. (2008) reported that chickpea flour contain 20.7-25% protein, 6.5-7.1%, fat 7.4-7.6% moisture content. In desi and kabuli type cultivars, proximate composition showed desi type cultivars contain ash (2.7-3.1%), fat (3.1-4.1%), protein (16.1-21.3%), fiber (7.8-12.7%) and 63-66.9% carbohydrates (Kaur and Singh, 2005). In another explanation it has been found that chickpea contain moisture 9.70%, crude protein 21.47%, crude fat 4.59%, crude fiber 3.43% and ash 2.74%, respectively. Whole flour of chickpea reported to contain protein (21%), fat (1.6%), fiber (4.4%), ash (3.4%) and carbohydrate (63.4%). Whole chickpea is rich protein, fiber, vitamins and essential minerals i.e Ca and Fe. The black gram seeds reported to contain 21% protein, 1.6% fat, 4.4% crude fiber, 3.45% ash and 63.4% total carbohydrate. Whole gram is an important source of protein, fiber, vitamins and essential minerals i.e Ca and Fe (Girish *et al*., 2012). The flour of bengal gram contained 11.08% moisture, 0.41% ash, 18.98% protein, 4.96% fat and 64.57% total carbohydrate (Sultana *et al*., 2014).

The chickpea contain 17 to 22% protein, 6.48% fat, 50% available carbohydrates and 3.82% crude fiber contents on dry basis. The carbohydrates is considered as slow digestible, therefore eliciting low glycaemic responses. Thus chickpea seeds play a significant role as a low glycaemic functional ingredient in a healthy diet (Shirani and Ganesharance, 2009).

Legumes are good source of minerals and vitamins. Mineral contents in legumes show that lentils and beans have more content of iron 122µg/g and 48-44µg/g of zinc. The minerals in legumes generally range from 1.5 to 5.0µg/g Cu, 0.05 to 0.60µg/g Cr, 18.8 to 82.4µg/g Fe, 32.6 to 70.2µg/g Zn. Chickpea is a rich source of iron (4.6 to 6.7mg per 100 g), zinc (3.7 to 7.4mg to100 g), calcium (93.4 to 197.4mg per 100 g), magnesium (125.1 to 158.7mg per 100 g) and potassium (732.2 to 1125.5mg per 100 g). (Thavarajah and Thavarajah, 2012). Minerals constituents of desi chickpea are sodium (96mg/100g), potassium (1236mg/100g), iron (3.7mg/100g), zinc (5.7mg/100g) and magnesium (4.3mg/100g), respectively (Haq *et al*., 2007). Calcium was the abundant mineral element content 177.94mg/100g in desi cultivar and 187.25mg/100g in kabuli cultivar after Mn, Fe, Na, Zn, Mg and Cu. Cu was found in lower quantity, ranging from 0.58-0.7mg/100g (Singh *et al*., 2010).

The chromatographic profile of raw chickpea sugars i.e ribose, fructose, glucose and galactose (monosaccharides), maltose and sucrose (disaccharides) and raffinose and stachyose (oligosaccharides) were identifed and quantifed. In all of them, monosaccharides represented only 2-8% of the total sugar content and the main sugar was fructose (contributes 3.21% of the total). Among disaccharides, sucrose is the main one (about 28% of the total sugar content) after maltose. In raw chickpea samples, glucose (0.065, 0.020g/100g), fructose (0.196, 0.056 and 0.288g/100g) and sucrose (2.28, 1.09 and 3.25g/100g) were identified. In some samples traces amount of glucose were identified (Mata *et al*., 1999).

The water activity (aw) and pH are the parameters that support or inhibit the growth of microorganisms in foods (Hathorna *et al*., 2008). Water activity is the sign of water availability and was in the range of 0.38 to 0.44 in chickpea. These values were lower than the level at which microorganisms can grow (about 0.61). Chenoll *et al*. (2009) reported that water activity for Spanish chickpea was 0.45.

Pasting properties of chickpea were reported as pasting temperature (71.8^{0}C), peak viscosity (755cP), breakdown (ND^B), setback (320cP) and final viscosity (1068cp) (Chung *et al*., 2008). Gomez *et al*. (2008) reported that whole chickpea have pasting temperature 79.1^{0}C, peak viscosity (936 cP) and breakdown (49 cP).

Physicochemical composition of sorghum

Sorghum kernel just like other cereals, contains three anatomical parts: pericarp (outer layer), endosperm (storage tissue) and germ (embryo). Proximate composition of sorghum is affected by environment and genetics but it is well adapted that the fiber is highly concentrated in pericarp, whereas protein, fat and ash are mostly concentrated in the germ. The endosperm is comprised of starch as the major portion with small amounts of protein, fat and fiber are also present (Dykes and Rooney, 2006). Seed coat or testa is present beneath the pericarp and in certain types of sorghum phenols and tannins are concentrated in this component. The endosperm consists of the aleurone layer, peripheral, corneous & floury areas and it depends upon arrangement of protein and starch (Rooney and Waniska, 2000).

Moreover, sorghum exhibits direct mutagenic effect, antioxidant activity and DPPH radical-scavenging activity. Utilization of sorghum has been related to minimize the occurance of gastrointestinal tract cancer particularly esophageal cancer (Isaacson, 2005). Sorghum has phytochemicals, such as phenolic compounds which are getting fame because of their numerous health benefits. Unfortunately sorghum and its products have been studied to restricted level for their antioxidant potential (Awika *et al*., 2003).

The commercial sorghum showed higher protein and ash content as compared to sorghum hybrids (Liu *et al.,* 2012). Sorghum showed highest concentration of protein (12.1%)

and millet (8.8%). It was affirmed that storage protein increased by high nitrogen fertilization. Generally, storage proteins in cereals are normally deficient of amino acids particularly lysine which are thought to be vital for the human nutrition, therefore, some other dietary source need to be added for lysine (Ragaee *et al*., 2006).

Moisture content in sorghum was ranged from 10.88-11.05% (Mwithiga and Sifuna, 2006). The red sorghum varieties were significantly higher in total ash content as compared to white sorghum varieties. Sorghum had the total ash content ranged from 1.8 to 1.9%. These contain free lipids ranging from 2.0 to 4.1%, bound lipids ranging from 0.1 to 0.56%. and contains higher fat content which makes 3% of overall fat content. Composition of fat in sorghum may be comparable with corn oil and concentration of palmitic, oleic and linoleic acids as 14%, 31% and 49% respectively (Ragaee *et al*., 2006).

Numerous studies have revealed that cereals and legumes are rich in resistant starch and accessible glucose contents may be categorized to lower glycemic index. Sorghum and millet contained higher resistant starch and ranged from 1.8% in sorghum and 2.0% in millet, respectively. Sorghum contains protein content ranged from 11 to 13% but occasionally high values are observed. Protein content and composition are affected by genotype, soil fertility, temperature, water availability and environmental conditions during grain maturity. Main fractions of protein in sorghum are glutelin, kafirins (prolamins) (Englyst *et al*., 2003).

Nutritional quality of sorghum is primarily dictated by its chemical composition and occurance of anti-nutritional factors like phytic acid (Badau *et al*., 2005; Fombang *et al*., 2005) Components of sorghum particularly its protein is not as much as digestible than other cereals for human and monogastric animals because of antinutritional factors like phytic acid and tannins (Shawrang *et al*., 2011).

Phytic acid is an abundant plant component that consists of 1 to 5% by weight of cereals. For many years, it was considered that phytic acid is an antinutrient factor because of its property to interact with certain minerals starch and protein, and decrease their bioavailability in humans (Kruger *et al*., 2012). Cereal based diet with staple sorghum, rice, maize and millet is used in developing countries, such a diet have greater amount of compounds which hinder non-heme iron absorption like phytic acid and polyphenols (Park *et al*., 2006). As starch can express differences in properties from even the same plant cultivar and species therefore understanding and analyzing the pasting properties of each hybrid or variety is important. A group of researchers showed the pasting properties of sorghum in their work and peak viscosity & set back of sorghum flour was recorded 120 RVU & 117 RVU. (Beta *et al*., 2000).

Rao and Rao (1997) reported that bread made from wheat-sorghum composite flour at 15% level of substitution was acceptable and similar to that of control (pure wheat flour). Sudha *et al*. (2013) replaced wheat flour with fenugreek at level of 0, 5, 7.5 and 10%. This flour was used in the formation of paratha. The L*, a* and b* values of paratha enriched with fenugreek (12.5%) were showed as 52.1, 3.1 and 27.4 respectively while as concentration of fenugreek were increased upto 25%, value of L*, a* and b* were showed as 48.6, -1.6 and 23.9 respectively.

Physiochemical composition of millet **:** Moisture content in millet was reported 10.16% (Lawal, 2009). The moisture content is influenced by the method and extent of drying. Ash content in millet ranged from 1.6-2.4%. The wheat flour showed significantly low ash content as compared to both sorghum flour (WSF) white and sorghum red (RSF) flour (Yousif *et al*., 2012). Ash content in millet was reported as 0.32% (Lawal, 2009) whole grain cereals are expected to contain higher level of total ash or mineral content than refined flour. Sorghum and millet had the total ash content ranged from 1.8 to 1.9% (Ragaee *et al*., 2006). For millet, lipids are categorized into free lipids ranged from 5.6 to 7.1% which are extractable with petroleum ether and bound lipids ranged from 0.6 to 0.9% which are extracted with butanol. Millet contains triglycerols as main component of lipid and remaining are free fatty acids, esters, sterols and hydrocarbons (Lovis, 2003). Crude fiber in millet ranged from 2.6 to 4.0%. The sorghum white flour (WSF) showed significantly higher level of total dietry fiber as compared to both red soghum flour (RSF) and wheat flour (WF) (Yousif *et al*., 2012).

Dietry fiber is considered as resistant starch represented by the fraction of starch, which escape digestion and do not take part in the absorption through small intestine of healthy humans. Numerous studies revealed that cereals and legumes rich in resistant starch and accessible glucose contents may categorized to lower glycemic index (Englyst *et al*., 2003). Sorghum and millet contained higher resistant starch 1.8% in sorghum and 2.0% in millet, respectively. Sorghum contained 1.4% of soluble and 19.6% insoluble dietry fiber. Millet had significant levels of insoluble (13.5%) dietry fiber. Millets and sorghum contained total dietry fiber including resistant starch from 15% in millet and 21% in sorghum (Yousif *et al*., 2012).

It has been reported that low concentration of total dietry fiber such as in sorghum 11% and millet may be due to variation in genotypes. The dietry fiber components of sorghum may categorize as cellulose and pentosan. Therefore, the concentration of cellulose ranged from 1.19 to 5.23% and pentosan ranging 2.51-5.57% in sorghum (Ragaee *et al*., 2006). Crude protein content investigated in the ten genotypes was ranged 8.5-15.1%. It was obvious from proximate and dietry fiber analysis that wheat flour had significantly higher in protein content than that of sorghum flour and white flour had higher protein than sorghum red flour (Yousif *et al*., 2012).

Sarker (2015) reported the pasting properties of raw millet flour as peak viscosity 755cP, peak time 9 min and final viscosity 1555cP. Vijayakumar and Mohankumar (2009) reported pasting properties of millet composite flour at level of 10, 20 and 30%. Peak viscosity (2161, 1913 and 1641cP), breakdown viscosity (686, 696 and 588cP), setback viscosity (1524, 1447 and 1525cP), peak time (5.73, 5.60 and 5.47min), pasting temperature (83.85, 83.85 and 85.65º

C) and setback (30, 39 and 57%). Ogori *et al*. (2013) reported in their research work that soaked and malted blend of millet grains flour has total titrable acidity 0.61+0.05, total sugars (2.02), reducing sugars (1.17), energy value (401Kcal).

COMPOSITE FLOUR TECHNOLOGY

Composite flour technology refers to the process of mixing wheat flour with cereals and legumes flour to make valuable use of raw material for the production of high quality food products. Cereal grains combination have been employed for the production of different food items. In addition to being rich protein source, whole cereals are being accepted as containing therapeutic/medicinal attributes. The composite flour technology plays a significant role in completion of deficiency of essential nutrients in wheat. The studies on the composite flours consisting wheat and legumes have been done in different parts of the world to explore their therapeutic and medicinal value (Butt *et al*., 2011). There is a demand to substantially increase protein quality and quantity in the daily diet of common masses through food habits in developing countries. Various research works are carried out to study the effect of enrichment on wheat flour. The chemical, technological, biological and sensory characteristics of enriched wheat flour for the preparation of bakery products were also studied (Khan, 2009). Factors affecting the selection of components to be used in the production of composite flour include easy availability of material, culture acceptability and provision of improved nutritional quality (Okpala and Chinyelu, 2011).

Wheat flour is deficient in amino acid lysine, so high protein composite flours are incorporated in the formulation of product to enhance the nutritional value of wheat flour. The research work on development and evaluation of composite flour for missi roti/chapati were carried out to develop the nutritious flours from various food commodities like wheat flour, chickpea, soybean and methi leaves powder to make good quality chapaties. Four types of bends were prepared in different ratios which are 'A'wheat flour: chickpea flour (80:20). 'B' wheat flour: full fat soy flour (90:10) 'C' wheat flour: chickpea flour: soy flour (80:10:10) and 'D' wheat flour: chickpea flour: soy flour: methi leaves powder (75: 10: 10: 05). The proximate composition of composite flours revealed that it contain proteins 11.8 to 15.37%, fat 1.53 to 3.45%, fiber 1.24 to 2.05%, ash 2.08 to 2.70%, respectively and carbohydrates 65.99 to 74.2%. These results showed that soy flour or chickpea flour alone or in combination, both increased the amount of protein significantly. Calcium, phosphorus and iron were found to increase on supplementation of chickpea, soy flour and methi powder. Iron was high in methi supplemented blend. All these blended flours were found to have good sensory quality characteristics of chapaties as compare to control. The supplementation of 5% methi powder increased the nutritional quality of flour particularly in terms of higher intake of minerals (calcium and iron) and fibers (Kadam *et al*., 2012).

Protein content of composite flour for wheat with 5% chickpea was 13.37%, with 7.5% it was 13.59% and with 10% chickpea it was 13.78%. Means for crude fat is higher in flour having chickpea @ 10% (1.93%) than that of flour having chickpea @ 7.5% (1.85%). Crude fiber and ash also increased as the concentration of chickpea increase (Shahzadi *et al*., 2005). The chemical composition of composite flour (85% wheat flour+15% chickpea flour) were found as: moisture 9.1%, ash 1.9%, fat 2.6%, crude protein 15.6% and carbohydrates 70.6%. Similarly composite flour (70% wheat flour + 30% chickpea flour) showed moisture 9.5%, ash 2.5%, fat 3.1, protein 17.2% and carbohydrates 71.2%, respectively (Hefnawy *et al*., 2012).

Hallen *et al*. (2004) has studied the wheat flour replacement with cowpea in a standard bread formulation, germinated cowpea flour and fermented cowpea flour at levels of 5%, 10%, 15%, and 20%. These blended flours were studied for ash, protein, gluten contents and α- amylase activity as well as color, farinograph and extensograph characteristics.

Barley flours replaced wheat flour at substition levels of 5, 10, 15 and 20% into to check the effect on functional, baking and organoleptic attributes of bread. Studies revealed that higher level of barley flour, decrease in dough mixing time and value of sedimentation, gluten contents and flour capacity for water absorption. The breads prepared from above blend depicted difference in loaf volume, loaf weight, and sensory characteristics. The higher levels such as 10% of defatted and full-fat soy flour or 15% of barley flour, increase the acceptability of the product because of compressed texture of the crumb and the appealing flavor (Dhingra and Jood, 2002).

Sultana *et al*. (2014) reported that thickness of chapatti containing 80% atta, 5% jackfruit seed flour, 10% brown seed flour and 5% Bengal gram flour were found (0.29cm) followed by the control (0.28 cm) that was 100% whole wheat flour and 0.24cm of chapatti having 45% atta, 25% white jackfruit seed flour, 20% brown seed flour, 10% bengal gram flour and 0.27cm of chapatti containing 55% atta, 15% white jackfruit seed flour, 15% brown seed flour, 15% bengal gram flour.

Beswa (2008) showed that composite flour bread was made in which 64% wheat flour, 30% millet-sorghum flour and 6% soya flour was used. This composite flour have high water absorption and bread made from this flour reported to have heavy texture. A slight grittiness was observed but flavor was acceptable. He reported that moisture and protein content of wheat-millet composite flour at 10% level of substitution (12 & 11.26%), at 20% (12 & 10.81%) and at 30% (12.4 &10.48%) respectively, was observed. The peak force was found to be minimum and ranged 1.43kg to penetrate the cookies from combination of sorghum and millet flour while the cookies (control) prepared from wheat needed highest force to puncture. It was found that texture of cookies having a fraction of wheat flour showed improved performance than those prepared from 100% of millet or sorghum. Also, they did not spread therefore, exhibited an inferior character of grain and were compact and dense (Rai *et al*., 2011).

Mineral content in wheat, sorghum and millet was determined. Wheat, sorghum and millet contain Ca (41, 28 and 20mg/100g), Fe (3.3, 4.4 and 68mg/100g), K (370, 350, 430mg/100g) and Mg (113, n.d and 162 mg/100g), respectively (Charalampopoulos *et al*., 2002). The composite flour containing kodo and barnyard millet flour, defatted soy flour and whole wheat flour of four various combinations was prepared and studied the effect of millet flour blend on characteristics of composite flour. Millet flour added at level of 10, 20 and 30%. The level of moisture content enhanced as the level of substation increased from 10 to 30% millet flour (12% to 13.2%) while protein content raised from 13.8% to 15.6%. Similarity fiber and fat content were observed as (3.9, 4.2, 5.3%) and (3.78, 3.9, 4.05%), respectively by incorporation of 10, 20 and 30% millet flour. Total sugars, reducing and non reducing sugars were also identified. Total sugars were 4.1, 3.9 and 3.6 in 10, 20 and 30% millet flour respectively with reducing sugars as (1.1, 0.9 and 0.65g/100g) and non reducing sugars (3.0, 3.0 and 2.95g/100g) (Vijayakumar and Mohankumar, 2009).

Belino *et al*. (2015) reported energy (Kcal/100g) in rice, chickpea and wheat flour. Energy in 100g of rice flour was 358 Kcal, in chickpea flour 356 Kcal and in whole wheat flour 377 Kcal was recorded. Energy value in different cultivars of whole sorghum were recorded as: F1000/K (384.7Kcal/100g), F1000/F (364.2Kcal/100g), PL-3 (368.7Kcal/100g) and PL-4 (366.6Kcal/100g). Shahidi and Chandrasekara (2013) reported nutrient composition and energy value (Kcal) in different cereals. He showed energy in wheat, maize, sorghum and maize as 348, 358, 329 and 336 Kcal/100g respectively.

The sensory score for sorghum: millet flour was highest and was observed low for wheat (control) flour. In accordance with these findings it was observed that the cookies derived from sorghum showed excellent palatability (Ciacci *et al*., 2007). It was investigated that cookies prepared from 58 to 67% of sorghum had satisfactory sensory attributes (Rodrigues *et al*., 2009). However, when the level of sorghum flour was increased the sensory score for taste, flavor, texture and overall acceptability was decreased. The effect of sorghum flour was found significant on sensory attributes like color, appearance and order of cookies. The results have indicated that the cookies prepared from sorghum flour using different levels with 5% defatted soy flour were generally accepted by panelists at 10% level of sorghum flour with high acceptability (Mridula *et al*., 2007).

Dhingra and Jood (2004) replaced wheat flour with full-fat, defatted soybean and barley flours at the rate of 5, 10, 15 and 20% to check the effect of composite flour on baking, functional and organoleptic characteristics of bread. The 10% of full-fat and defatted soy flour or 15% of barley flour increase the acceptability of the product. Composite flour of soybean and cassava flour were prepared on a replacement level of (CF/SF, 100:0, 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70, 20:80 and 0:100) and biscuits weights decreased with increased in soybean flour. The color, taste, texture, flavor and overall acceptability of biscuits prepared from above blend were not different. More scores were given by the judges to biscuits evaluated at 50% level of soybean flour (Akubor and Ukwuru, 2003).

There are different sorghum and millet varieties that are utilized in a variety of ways. The light color and plain flavor of food type millet and sorghums afford a valid improvement in functionality to millet and sorghum. They are gluten-free and their slow hydrolysis makes them suitable for coeliacs, diabetics and ethnic groups. They could in fact be up graded on the base of health claims concerning slow digestibility for diabetics and high antioxidants (Carson *et al*., 2000).

***Pasting and textural properties of composite flour*:**A viscous mass having continuous phase of solubilized amylose or amylopectin and a discontinuous phase of granule ghosts and fragments is known as paste. Pasting refers to change in the starch upon further heating after gelatinization has occurred, including further swelling and leaching of polysaccharides from the starch granule and increase in viscosity which occurs with the application of shear forces (Chung *et al*., 2008).

The BVA (Brabender viscoamylograph) and RVA (Rapid viscoanalyzer) have been commonly used to observe the pasting characteristics of pulse starches. The pasting curve of pluse starches have been determined at different concentrations and by using BVA or RVA. Therefore, it is difficult to make a meaningful comparison of the data. Most pulse starches show the absence of peak viscosity, high pasting temperature, increasing viscosity during the holding period and a high set back. The pasting characteristics of pulse starches may reveal their high amylose content, the presence of only trace quantities of lipid complexed amylose chains, strong interaction between starch chains (amylose-amylose and amylose- amylopectin) within the native granule and the orientation of amylose chains relative to one another. The pasting properties are also influenced by the chain length of amylose and amylopectin (Hoover *et al*., 2010).

Understanding of the rheology of pulse starches has come largely from studies using the BVA and RVA; in which measurements are made under non-laminar flow conditions and the starch paste is subjected to both thermal and mechanical treatments, thus making it difficult to relate viscous behavior to only one of these parameters. There is need to expand the use of rheometers; in which thermal treatments are separated from shear effects, to determine the rheological characteristics of pulse starches under well defined flow regimes (Doutch *et al*., 2012). Gelencser *et al*. (2008) observed that resistant starches did not gelatinize using the standard RVA method. The chemical modification of starches results in a considerable change in the rheological properties (Singh *et al*., 2007).

Goode *et al*. (2005) use RVA to study the effects of different concentrations of malt and barley adjunct. It is helpful not only in detecting the major viscosity changes during starch gelatinization, but also the minor viscosity changes which occur during the proteolytic and saccharification steps. Fundamental and empirical measurements are the two major properties of cereal flours. Ragaee and Abdel-Aal (2006) reported that RVA is useful in formulating cereal blends with certain pasting properties. There are no considerable negative effects on acceptability of bread by replacement of wheat flour, with 15% of rye, barley, and millet or sorghum whole grain. Gomand *et al*. (2011) analyzed the rye and wheat starches are same. The rye starches differ from the wheat in high crystalline, lower pasting temperature and gelatinizaion, lower breakdown and peak viscosities.

Leon *et al*. (2010) analyzed twenty chickpea varieties for their genetic diversity in seeds for physical, hydration and cooking properties. He also studied composition, pasting and gel textural characteristics for their flours. The pasting properties e.g pasting temperature, peak viscosity, breakdown, final viscosity and setback ranged between 75.0 to 87.1^{0}C, 564 to 853 cP, 32 to 123 cP, 573 to 969 cP, and 84 to 185 cP respectively. Amylose content ranged from 28.26-52.82%. Amylopectin content ranged from 36.2 to 43.24%, 36.44 to 38.68%, 14.86 to 18.22% and 4.95 to 6.9% respectively.

***Carbohydrates composition of composite flour*:** The starch present in the grains of wheat vary from 60 to75% of the dry weight of the grain. Starch is present in the form of granules in kernel of cereals. Wheat has 2 types of starch granules first one is 25 to 40um large lenticular and second one is 5 to 10um small spherical. Ater pollination, during the 1st 15 days the lenticular granules are formed. The small granules appear 10-30 days after pollination, representating 88% of the total of granules. Basically starch is a polymer of glucose. Chemically, amylose and amylopectin are two types of polymers. Amylose is a linear and α-1, 4 linked glucose polymer with a degree of polymerization of 1,000 to 5,000 glucose units. The structure of amylose polymer is linear, but the amylopectin is branched. Amylopectin is more branched than amylose. Amylopectin has a molecular weight of about 108. The proportion of amylose to amylopectin is comparatively constant (about 23). Amylopectin is a larger polymer of glucose (degree of polymerization 105 to 106) in which α-(1, 4) linked polymers of glucose are connected by 5 to 6% α (1, 6) linkages. Normally starch present in wheat contains of amylose (20 to 30%) and 70 to 80% amylopectin (Sramkova *et al*., 2009).

The carbohydrates in millet are mainly starch. Starch degradation can occur in the presence of cereal amylases (Muralikrishna and Nirmala, 2005). The pearl millet carbohydrate content is 67.5g/100g, which is lesser than sorghum, rice and wheat, but more than maize (NIN, 2003). The germ in pearl millet occupies greater proportion (17.4%) of the total kernel as compared to the germ of sorghum (9.8%). This dissimilarity indicates that pearl millet contains more protein and oil comparable to sorghum but starch proportion is low as compared to sorghum. Starch constitutes approximately 56 to 65% of the kernel 20 to 22% of the starch is amylose; range of free sugars is 2.6 to 2.8% of the grain. The principal sugar in main types of millet (i.e. pearl, finger, foxtail, and proso millets) is sucrose. Finger millet has a total carbohydrate content ranging from 72-79.5%. Starch comprises between 59.4 and 70.2% of the carbohydrate content of millet with the majority of this being amylopectin. For instance, about 80-85% of starch is amylopectin and 15-20% making up the amylose content (Singh and Raghuvanshi, 2012). The free sugars in millet include glucose, fructose and sucrose. Sucrose is the main sugar found in the highest amounts in millet, ranging from 60 to 68% of the total free sugars. The total free sugars in pearl millet range from 2.16-2.78%. Glucose and fructose content range from 3.2 to 6.3% of the total sugars in pearl millet (Sarker, 2015).

Sorghum contains starch as their major constituent among carbohydrates, while others like pentosans, hemicellulose, cellulose and soluble sugar are present in small amounts. Standard sorghum varieties have 23 to 30% amylose, whereas waxy varieties have fewer than 5% amylose. Soluble sugars in alcoholic extract of whole wheat flours and glucose (0.09%), fructose (0.08%), sucrose (0.62%), maltose (0.56%), raffinose (0.03%) and total sugars (1.38%) were found. (Revanappa, 2009).

***Diabetes mellitus and digestibility of different cereals and legumes*:** Diabetes mellitus is a diseases characterized by high blood glucose levels (hyperglycemia) that results from defects in insulin secretion and action of insulin or both. Insulin is a hormone that is secreted through the beta cells of the pancreas, which is required to utilize digested food glucose as a source of energy. Chronic hyperglycemia is linked with microvascular and macrovascular complications that can lead to blindness, visual impairment, kidney disease, nerve damage, heart disease, amputations, and stroke. There are two most common types of diabetes; type 1 and type 2 diabetes. The body does not produce insulin in type 1 diabetes and daily insulin injections are required. About 700,000 people in the United States have type 1 diabetes; this is about 5 to 10% of all the diabetes mellitus cases. Type 1 diabetes is commomly occurred during childhood or early adolescence and it affects about 1 in 600 children. There is failure to produce sufficient insulin and insulin resistance in Type 2 diabetes. Reduction in food intake, increased physical activity and eventually oral medications or insulin managed high blood glucose levels. More than 15 million adult Americans are affected with Type 2 diabetes, 50% of whom are undiagnosed. It is typically diagnosed during adulthood. The number of children having type 2 diabetes has increased worldwide due to increasing incidence of childhood obesity and concurrent insulin resistance (Loghmani, 2005).

There is evidence that healthy plant based diets can be beneficial to those with type 2 diabetes. Millets have been shown to have a low effect on blood glucose levels based on low starch digestibility. In comparison to rice and wheat, consumption of a whole finger millet diet produces the lowest plasma glucose levels, with the rice diet producing the highest effect on blood glucose (Kumari and Sumathi, 2002).

Glycemic index studies involving biscuits made with foxtail millet-refined wheat composite flour and burfi made with a foxtail millet-gram flour mix showed that both the biscuits and burfi were low GI products and were able to significantly reduce serum glucose levels compared to baseline (Singh and Raghuvanshi, 2012). Another study using a composite flour of millet and legumes (bengal, green and black gram) lowered blood glucose levels in healthy subjects (Shobana *et al*., 2007). There are studies examining the effects that composite flours containing millet have on blood glucose levels (Kumari and Sumathi, 2002) However, there is limited research on the *in vivo* and *in vitro* starch digestibility of 100% whole grain millet products. Whole grain products have been shown to have lower glycemic index values compared to refined products. Whole grains are high in dietary fibres and resistant starch, which can delay carbohydrate absorption, leading to lower starch digestibility (Hernot *et al*., 2008; Kumari and Sumathi, 2002).

After ingestion, starch is hydrolyzed by amylases and α-glucosidases before absorption and entering blood circulation. Phenolic acids can work as non-competitive inhibitors of amylase and α-glucosidase, regulating glucose uptake in the body. Prevention of carbohydrate absorption after intake is an approach for decreasing postprandial hyperglycemia (Shobana *et al*., 2009).

Starch is the major components in sorghum and it slowely digested than other cereals i.e maize. Starch granules of sorghum are packed tightly and surroundings by protein bodies that are fixed in protein matrix which lower starch gelatinization during cooking therefore limits starch digestibility. Less starch digestibility is not desirable in livestock feeding but it have great importance for making food having less rapidely digested starch and therefore have low glycaemic index (GI). After meal, low glycaemic index food induce a small elevation in level of blood glucose and therefore decrease the hazard of type 2 diabetes (Yousif *et al*., 2012).

***Conclusion*:**The chemical composition of cereals depicts that it contain moisture content (11-14%), carbohydrates mainly starch 56-74%, fiber (2-13%), protein (8-11%), while minor components are lipids 2-4% & minerals 1-3%. Sorghum contains phytochemicals including phenolic acids, anthocyanins and tannins which significantly affect human health. Millets have hypocholestrolemic, hypoglycaemic, anticataractogenic and nephrorotective properties. Functional foods are foods that supply some particular health benefits besides basic nutrients. So it is concluded that consumption of foods with high fiber content has been recommended to conquer health problems such as diabetes, hypertension, colon cancer and cardiovascular diseases.

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