CHAPTER I

INTRODUCTION

Pulses and cereals are the important primary source of nutrition and energy in human diet for long time across globe. They are also the important source of protein in daily diet for millions of people in the world. Cereals and pulses are the palatable seeds grains used as food stuff throughout the history by both humans and animals. The alternate name of pulses is “legumes” and is also known as “poor man’s meat due to its protein content (20-40%) and low cost as compared to meat. On the other hand cereals are known for their high carbohydrate or starch content (60-70%), therefore serve as good energy source (Manay and Shadaksharaswamy, 2008).

Cereals have been recommended for infants as first food source due to its good nutritional profile like vitamins, minerals, protein and energy. Each grain of both pulses and cereal is a potential seed and in turn is a potential plant. It contains all the complex biochemical substances and its own genetic information necessary to form a plant. Legumes are physiologically more complex as compared to cereals. Each grain can thus be considered as living entity and viable provided it has not been damaged. Once the grain structure is destructed or compartmentalized structure is affected, certain biochemical changes may occur which affects the viability of grain (Khetarpaul et al., 2005).

1.1. Cereals

Cereals are the grasses grown for their edible grains. They belong to family Gramineae/ Poaceae and are mostly monocotyledonous angiosperms. They are annuals mostly and one season yield one crop. Each grain acts as seed for next generation. Cereals are most common food for human consumption from long time. Globally, wheat and rice are the most vital crops, accounting for over 50% of the world’s cereal. Structural similarities between all cereals are almost same and
consist of an embryo, which is important for a grain to be a potent seed, and an endosperm, which is packed with nutrition for germ. Cereals are principal food and a chief source of carbohydrate, protein, B-complex vitamins and minerals for major population of world (Uwaghale et al., 2016). It contains both macro and micro nutrients. Cereals and cereal products are grouped with bread and other products to form a main part of meals. In the present scenario whole grain cereal, composite cereal flour and its products are in demand to fulfill the nutrition requirements.

1.1.1. Rice (*Oryza sativa*)

Rice refers to milled paddy, alternatively complete seed of rice is called paddy and contains one rice kernel. It belongs to grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice) of *Gramineae/ Poaceae* family. There are three sub species of paddy widely grown in the world. *Indica* or long grain rice is grown in warm climatic conditions of India, China, Pakistan, Thailand, Brazil and Southern U.S.A., *Japonica* is medium sized grain and is mostly cultivated in cold climate zone of Northern China, Korea, Japan and California. The *Javanica* or short grain rice is grown in Indonesia only (Kumar, 2009).

Asia is the larger producer of rice in world paddy production and gives more than 90% of the total world rice production. Paddy is the main produce of India and lodges about 37% of the crop producing land. Paddy provided more than 40% of food grains production of the country throughout 2000-01. It is the most popular cereal across globe and serves as a staple food in about 39 countries, which constitutes nearly half of the world’s population (Juliano, 1993). Most of the population of world depends fully or partially on rice. Globally rice contributes nearly 22% of total energy intake (Kainuma, 2004).

Paddy is rich in genetic variety and there are many varieties developed globally. In its usual less processed condition like polishing, rice comes in several shades which include brownish, reddish, purplish and even black tone. Non processed rice has a greater nutritional content than
processed white rice. In many cultures, it is a central part of the cooking items with different penchants on the subject of the taste, texture and color. For example, dry flakes of rice is portion of food in South Asia and Middle East. Many countries have characteristic rice methods for specific food preparation. Other than culinary various sweets food articles can also prepared from rice. The other common by-products of rice are rice husk, rice bran, rice flour, rice vinegar and rice soy milk etc (Perez et al., 1987).

Rice serves as a staple food for majority of population due to its nutritious value. As per FAO (2004) fact sheet, rice provides more dietary energy supply as compared to wheat. It is a great source of complex carbohydrates and is low in sodium and cholesterol. Rice is a good source of resistant starch, which reaches bowel in undigested form and promotes the growth of beneficial bacteria. Brown rice is rich in insoluble fibre and helps in maintaining the gastro-intestinal health. Gluten free quality of rice makes it suitable for gluten free food products. In addition rice is also excellent source of vitamin B group. Un-processed rice comprises a substantial quantity of dietary fibre. The protein of rice is rich in acidic amino acid like aspartic acid and glutamic acid whereas like other cereals rice is also not a good source of lysine (FAO, 2006).

1.1.2. Wheat (*Triticum aestivum*)

Wheat is a cereal grain belongs to family *Gramineae/Poaceae* and genus *Triticum*. Genus *Triticum* is divided into various species depending on the number of pair of chromosomes, i.e. diploid having 7 pairs, tetraploid having 14 pairs and hexaploid having 21 pairs. The origin of wheat is unclear, but is believed that it has been cultivated from prehistoric time. Emmer wheat is regarded as one of the ancestors of wheat grown today. Emmer (*Triticum dicoccum*) and einkorn (*Triticum monococcum*) were developed from a type of wild grass. Wheat is distributed throughout the world and is adapted to different climates and soils. As per the survey of FAO (2004) fact sheet, wheat is among the three major crops of world after maize and rice. Worldwide supplies of
wheat has raised 1.2 million tons during 2015-16 (on both beginning stocks and production). As per the **USDA, World Agricultural Supply and Demand Estimates (2016)**, wheat production across globe remains record high and is raised 0.5 million tons led by 0.5-million-ton increases for both Russia and Pakistan and a 0.3-million-ton increase for the European Union.

Depending on the type of climate, wheat is of two types: winter wheat and spring wheat. Wheat sown in late autumn and harvested in spring is known as winter wheat, whereas wheat sown in spring and harvested in early autumn is known as spring wheat. Wheat can also be classified on the basis of texture of endosperm: vitreous, which is steely, flinty and glassy and mealy, which is starchy and chalky. Wheat types can also be classified on the basis of product to be formed, as hard wheat for making bread and soft wheat for cookies or biscuits etc. Hardness and softness refers to the way in which endosperm breaks on milling. Hardness of wheat is due to relatively strong adhesion between starch and protein and yields coarse gritty flour. Soft wheat has relatively low protein content and yields fine flour. Wheat can be utilized for variety of products like bread, semolina, pasta, macaroni, beer and flakes (**Hruskova and Scve, 2009**).

The chemical composition varies widely depending upon the climatic and genetic factors. Wheat is good source of protein, carbohydrates and fibre. Proteins and carbohydrate each represents 16-20% of total dry matter of bran. The endosperm of wheat mainly consists of food reserves (energy-yielding starch) required for development of the plantlet. In addition to carbohydrates, the endosperm comprises fats, proteins and other major proteins of the wheat. These protein consists of gluten complex which in turn are constituted by gliadins and glutenins. Apart from these constituents the mineral and dietary fiber content of some wheat varities are quite low (**Belderok et al., 2000**). Germ is rich in proteins, lipids and minerals and lies at the end of grain. The amino acid composition of wheat is quite good with one half is the glutamine and proline of flour whereas; the levels of alanine, arginine, asparagine, glycine, lysine and threonine are
double (Cornell, 2003). Besides good nutritional value, wheat also have some medicinal importance. The most recent version of the USDA’s (2015) Dietary Guidelines recommend minimum 3 portions of whole grains daily for adults to keep in check both heart related diseases and minimizing cancer possibilities. Wheat embryo is rich in nutritional components like vit-E, magnesium, pantothenic acid, phosphorus, thiamin, niacin and zinc. Wheat is low in cholesterol but rich in para-aminobenzoic acid and ubiquinone (Shewry, 2009).

Wheat bran can be implemented for supplementation of dietary fiber which aids in prevention of colon and gastric tumor, Irritable Bowel Syndrome, reducing the risk of various disease like hemorrhoids, hypercholesterolemia, hypertension, breast cancer and gall-bladder related disease (Hadjivassiliou et al., 2003).

1.1.3. Triticale (Triticosecale wittmack)

Triticale (Triticosecale wittmack) is a man-made cereal as a result of cross between wheat (Triticum) and rye (Secale). Triticale is angiosperm monocot and belongs to family Gramineae/ Poaceae. It is an amphiploid hybrid (the plant is diploid for two genomes) of wheat (Triticum) and rye (Secale) by the incessant work of Scottish botanist A.S. Wilson, who produces the sterile hybrid. Further researches were completed by German scientist W. Rimpaud to make it a productive and potent hybrid. In the hybridization, wheat acted as the female parent and rye as pollen donor. Colichine is required during the cross to persuade polyploidy and thus make it capable to breed itself. Intercross between hexaploid wheat and hexaploid triticales have been made to get further improved hybrid as secondary triticales (Gustafson et al., 1991; Immonen, 1996). To provide more stability to the commercial triticales, progenies from the cross between tetraploid durum wheat and diploid rye to form hexaploid hybrid which is far more stable than octoploid triticales have been developed (Dendy and Dobraszczyk, 2001). Triticale exhibits the properties between wheat and triticale. It is taller than wheat but shorter than rye; grain size also
is between rye and triticale. All other properties like size of kernel, shape of kernel appearance, components distribution resembles the parent species. It could provide better results in association with progressive desertification, soil salinity and increasing acidity (Kulp and Ponte; 2000). Some varieties are genetically stable, resistant to soil contaminants and pest infestation. However storage problems related to Tribolium castaneum infestation are more prevalent due to soft grains.

Triticale shows physical attributes common to both of its source crops. There are few problems associated to its milling due to length of grain, with a deep crease and incomplete plumpness. Therefore milling yield is low as compared to wheat. Whole and processed triticale flours can be employed in the formulation and development of baking products, different bread types and soft wheat type products. Triticale can also be employed for making rye bread because of deficiency of gluten protein-related factors. Triticale flours forms weak dough due to lower gluten content, poorer strength and higher alpha-amylase activity. This type of dough is not suitable for preparation of wheat type leavened bread. But it can be utilized well in association with wheat. Triticale flour of good baking quality can be used to prepare wheat-triticale flour blends; the mixture with 30-50% triticale is able to make breads of a good quality compared to that of wheat (Naeem et al., 2002). Besides being used as food grain triticale is used as feed purpose for poultry, pig and for cattle, livestock grazing, cut forage (green chop), and whole-plant silage. Due to good alpha amylase activity triticale is suitable for malting and brewery process, but the only problem associated with malting and brewing is dark color and haziness of the final product, which is due to the high nitrogen and high proteolytic activity (Arendt et al., 2013).

Due to higher dietary fibre content triticale is good for managing blood sugar, ease in digestion and maintaining bowel health. Significant levels of iron, copper and folic acid content aid in improvement of metabolic activity and recovery of tissues. Minerals like manganese,
phosphorus and magnesium are all integral part of bone production and strength in the body (Wringley et al., 2017)

1.1.4. Pearl Millet (*Pennisetum glaucum*)

Millet is the group of small seeded grasses grown as fodder or cereal corps, of which pearl millet (*Pennisetum glaucum*) is the major crop grown worldwide. It belongs to Gramineae/Poaceae family and genus *Pennisetum*. Pearl millet was introduced to western world in 1850s, but the origin was reported much before 18th century in central tropical Africa. It was recognized as forage crop in the few regions of Africa. Cultivation of pearl millet as a food crop was done around 4000 to 5000 years ago along the southern region of the central highlands of the Sahara. The crop is widely dispersed through the semiarid tropical regions of Africa and to various regions of Asia (Board on Science and Technology for Interval Development, 1996). It is one of the most important cereals and most drought resistant crops among cereals and millets.

Plant is similar to maize as strong stemmed but comparatively compact head and small seeds. The kernel is tear shaped ranges from 1.5 to 2.5 mm and weigh up to 9 mg. The color of grain is slate grey with shiny surface. On storage there is a “mousy” odor associated with apigenin and flavonoids present in slate gray pearl millet variety. There is a misguided fact about the pearl millet to use as a fodder only, however the nutritional profile of pearl millet is comparable to all other major cereals like wheat, rice, maize and sorghum (Yadav and Rai et al., 2013). Protein content is higher in pearl millet depending on the variety with good balance of amino acid. The embryo of pearl millet is having much larger percentage contribution to total kernel therefore having higher fats and protein content. The grain is generally low in lysine, tryptophan and sulfur containing amino acid but has better leucine to isoleucine ratio and good source of methionine. Energy content is also high as compared to other major cereals and ranges from 350-380 Kcal/100g
The grain is also low in tannin content and small amount of other anti-nutritional factors.

Pearl millet serves as variety of foodstuff. It can be utilized as whole grain food, split grains or milled flour or a grain like rice and some cultivars can be consumed roasted. Pearl millet can also be processed to form fermented products like beer or traditional weaning food like Ogi. In mountainous regions of Nigeria the flour prepared from pearl miller is mixed with dehydrated dates and dried goat cheese. In India the milled flour is used to prepare cakes or chapattis. The grain is sometimes parched and eaten like popcorn. Green ears/kernel are roasted and consumed like vegetables. Due to easy and early growth crop is utilized as fodder to cattle and feed to poultry (Pelembe et al., 2003).

Pearl millet contains high amount of Iron and Zinc which may help to increase the haemoglobin levels. Pearl millet has high amylase activity with low fructose and glucose levels but enriched with Maltose and D-ribose sugars (Oshodi et al, 1999). Therefore it is considered to be the keystone in the managing of diabetes mellitus. Omega-3 fatty acids in pearl millet helps in prevention and treatment of cardiovascular diseases, diabetes, arthritis and certain types of cancer. Pearl millet is gluten free cereal grain and it keeps its alkaline properties even after being cooked which is best for people with wheat and gluten allergies (Nambiar et al., 2011).

1.2. Legumes or pulses

Legumes are the members of family leguminosae, which is composed of many species grown worldwide. It has wide range of uses from feed to fodder, green manure, silage and oil extraction. Major proportion of legumes is grown for green pods, seeds and dried beans. They are nutritionally important like cereals and have relatively good nutritional index and profile. Except bakery, they have been employed in variety of food stuff, but presently due to high nutritional status they are combined with some cereals to form composite flour which form good bakery products and
weaning food with better nutrition and sensory attributes. Legumes are consumed higher in those parts of the world, where animal proteins are scarce (Ofuya and Akhidue; 2005).

1.2.1. Chickpea (*Cicer arietinum*)

Chickpea (*Cicer arietinum*) belongs to genus *Cicer* and further placed in family *Fabaceae*, and subfamily *Papilionaceae*. It grows as herbaceous annual plant which branches from base as a small bush. It was believed to originate in south eastern turkey (Ladizinsky, 1975). The name is of Latin origin, derived from greek word “kikus” which means round, an illusion of seed which resemble the head of ram (Aries). Chickpea is also called garbanzo in Spanish, chana in Hindi and gram or Bengal gram in English (van der Maesen, 1987). It is a worldwide grown crop with major production area covered under India, Turkey and Pakistan. Being a legume, it shows characteristic feature of nitrogen fixation and thus requires optimum amount of phosphorus, potash, sulfur and other elements. Based on the seed size and color chickpea cultivars are of two type:

1.2.1.1 Macrosperma

The seeds of this cultivar are large with round or ram head and are cream in color. The plant is medium to tall in height with large leaflets and white colored flowers. These cultivars contains no anthocyanin and are also known as *kabuli* type.

1.2.1.2 Microsperma

Seeds of this cultivar are small in size and are angular as compared to macrosperma. The plants have small leaflets and purplish flowers, containing anthocyanin. These types are known as *desi* type.

The pod of chickpea begins at 5-6 days after fertilization. The number of pod varies from 30- 150 depending on the environmental conditions and genotype. Pod is 15-30 mm in length and each pod contains 1-2 seeds. Chickpea grains have a seed coat containing two cotyledons and an
embryo. Seed coat is comprises of two layers; outer testa and inner tegman and hilum. Embryo consists of two fleshy cotyledons, the pointed end at the axis is radical and feathery end is plumule. Seed attaches to the point called hilum and contains a small opening above it called micropyle (Frimpong et al., 2009).

Chickpea is a good source of carbohydrates and proteins. The protein quality of chickpea is relatively well than other legumes like pigeon pea, black gram and green gram. Albumins and globulin are the major constituents of chickpea; albumin contains most of enzymes and proteins of metabolic significance as compared to globulins. Chick pea protein has higher nutrition significance due to good amino acid profile, high digestibility and high biological value (Santiago and Areas, 2001). It contains all the essential amino acids in good quantity except sulfur containing amino acids. The major carbohydrates are starch, dietary fibre, oligosaccharides and simple sugars like glucose and sucrose. Chickpea is also good source of vitamins like riboflavin, niacin, thiamin, folic acid etc. Amount of lipids is lower, but unsaturated fatty acids like linoleic and oleic acid and stigmasterol constitutes the lipid profile of chickpea, which are nutritionally important. With the increased demands for pharmaceutical, food and cosmetic ingredients, the interest for the production of purified protein derivates from vegetable sources, such as concentrates, isolates and hydrolysates also increases (Tharanathan and Mahadevamma, 2003). Due to low lipid content, it is easy to obtain chickpea protein isolates, hydrolysates and concentrates of good quality.

Chickpea consumption is related to some health beneficial activities like beneficial in Cardiovascular Disease (CVD), Coronary Heart Disease (CHD) and Cholesterol Control, which is due to low cholesterol and low density lipoprotein-cholesterol. Due to higher amount of resistant starch and amylase chickpea or its products are helpful in maintaining diabetes and blood pressure (Kushi et al., 1999).
1.2.2. Kidney bean (*Phaseolus vulgaris*)

Beans are food legumes belong to genus *Phaseolus*, family *Leguminosae*, subfamily and *Papilionoideae*. These species has variety of life histories, growing nature, propagative systems, and adaptations, which makes it a versatile crop. Common bean or kidney bean is most common legume worldwide. Common beans also known *rajma* in India are kidney shaped hence their common name kidney bean. Bean plant is annual herb, with taproot system and nodules are also present to fix nitrogen. Fruit are 3-10 seeded, with ovoid to rounded outline and smooth surface. Fruit is an oblong legume, slightly flattened and curved with glabrous, long apiculate apex. Seed grain varies in color from reddish brown, grayish with dark spot or pink. Plant can be grown in variety of environmental conditions like dry-humid forest, intermediate dry conditions to deciduous tropical shrub. The largest producers of common bean are Brazil, USA, Mexico and China.

Like other beans, the common beans are high in their nutritional value with good amount of starch, protein, dietary fiber and are excellent source of iron, potassium, selenium, molybdenum etc. High fiber content of common beans prevent blood sugar levels to rise in diabetic patients, also the fiber of beans have property to lower cholesterol and aid in prevention of cardiac diseases. Trace mineral like molybdenum is a component of the enzyme sulfite oxidase, which is responsible for detoxifying sulfites, which are commonly presents as preservatives in food items. Fibre content also supports to digestive system and for colon bacteria (Tang, 2008).

In addition to the support to digestive system and the heart, soluble fiber helps maintaining blood sugar levels while providing energy at moderate rate. Thiamin is required for the synthesis of acetylcholine, which decreases during aging and its deficiency cause Alzheimer's disease.
Kidney beans are good source of thiamine and thus can be used in Alzheimer's disease treatment (Patel et al., 2008).

However contribution of nutrition through edible cereal and pulses to the consumer is limited due to presence of some toxic factors, enzyme inhibitors and factors which limits the digestibility. The presence of these anti-nutritional substances causes interference to digestibility and availability of nutrients. Multivariate techniques are currently applied by plant breeding experiments to lower the effect of these anti-nutritional factors and toxic components. In developing countries, foods are rarely modified at the household level to increase nutrient density to meet the needs of infants. The nutritional value of grain depends primarily on their nutrient content and presence/absence of anti-nutritional factors. Traditional infant foods like porridges made of raw cereals or tubers may be low in several nutrients including protein, vitamin A, zinc and iron; these nutrients are of special importance due to their impact on physical and cognitive development (Neumann et al., 2002). Therefore, timely the changes have been made to increase their nutritional availability and digestibility. Some of the common traditional methods include roasting, soaking and cooking. The cooking of presoaked seed appeared to be most effective method to reduce anti-nutritional factors significantly. Use of cooking and germination influences bio-availability and utilization of nutrient, enhancing digestibility and thus its nutritive value (Bakr, 1996).

Soaking, germination and fermentation can cause increment of nutritional profile, but soaking and germination has been targeted during the studies because of its better result and ease of processing as compared to fermentation. Germination is one of the best methods to be utilized in the improvement of nutritional profile of the seed grains and which will be used for the development of various food products. In the present scenario people are more health conscious so the germination of cereals is of great importance both from nutritional as well as health benefits.
point of view. It not only improves the nutritional profile of the seed grains but also reduces some anti-nutritional factors which reflects the beauty of this method. It also improves the bioavailability of the various minerals, vitamins and dietary fibers which are of immense significance from both health as well as nutritional point of view (Ramakrishna, 2006).

Various studies on pre-germination treatment shows improved germination rate and uniformity and quick seedling growth (Farooq et al., 2005; Thakur and Sharma, 2005). Pre-germination factors like soaking solution, soaking temperature, integrity of seed coat, water uptake mechanism of grain, germination temperature, relative humidity during germination etc play an important role for germination of seed. Despite of being soaking used as a method of inducing germination in some seeds, it can also be employed as a traditional process to enhance the nutritional quality of grains.

Keeping in view the above information regarding the use of cereal and legume crops worldwide, it is desirable to prepare the products from these grains, which should contain high nutritional value and digestibility. To fulfill this concept, a product should have been targeted which can serve as human food and fit for consumption of all caste-creed and age, therefore bakery product like cookies or biscuit could be an appropriate attempt. Bakery industry in India is the largest of the food industries with an annual turnover of about Rs.3000 crores. India is the second largest producer of biscuits after USA. The biscuits are quite popular in rural areas as well. Nearly 55% of the biscuits are consumed by rural sector. Therefore the study has been divided into following objectives:

1. Optimization and study the germination of selected cereals and pulses and its effect on Physico-chemical characteristics.
2. Development of Bakery products from composite flour of germinated cereals, pulses and millets, and their evaluation.
3 Characterization of developed bakery products.
4 *In-vitro* digestibility studies, amino acid profile and nutritional status of developed bakery products.

On the basis of research objectives, thesis is divided into various Chapters.

1. Chapter-I, comprises the general introduction about the elements of research
2. Chapter-II, gives the general review of literature
3. Chapter-III to VII, covers the different aspects of objective-I, like physico-chemical properties, functional properties, anti-nutritional factors and amino acid profiling of selected raw and germinated seed grains
4. Chapter-VIII, covers objective-II in detail, which deals with the optimization of product formulations
5. Chapter-IX covers objective-III in detail, which is about the characterization of developed optimized product.
6. Chapter-X covers objective-IV in detail, which deals with the in vitro digestibility studies, nutritional status and partial shelf life study of product.
7. Chapter-XI comprises of references.
8. Chapter-XII concludes the research in form of summary and conclusions.