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REVIEW ARTICLE

Nutritional significance of cereals and legumes based food mix- A review

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ABSTRACT: Tertiary processed foods are commercially formulated foods designed for the ease of consumption. These foods are mainly formulated using the refined flour which are lacking in one or more nutrients. Whole cereals and legumes found to possess immense nutritional potentials which could complement one another if accurately processed and combined. Therefore, it is essential to formulate composite blends and carry out scientific research to ascertain the nutritive adequacy of the cereal and legumes for possible use as tertiary foods. The present study is therefore a part of an exploratory work towards this goal. The study emphasis on formulation of tertiary processed foods with application of processing and drying methods using multicereals and legume combination. Successful utilization of cereals and legumes with added functionality in snack food sector will definitely open up new dimensions to the food industries.
Keywords: Cereals, Legumes, Processing, Mix and Food.

INTRODUCTION

The growing third world population requires more protein and good nutrition for the better lifestyle. The cheapest source of protein and nutrients are those that are derived from underutilized plant materials present abundantly in the developing countries. It is more evident that plant nutrients are the best alternative to proteins derived from animal source. The importance in terms of nutritional composition, health benefits, processing and utilization of cereals and legumes for the food product development was reviewed under the following heads.

1.1 Nutritional significance of cereals and legumes based food mix
1.2. Health benefits of cereals and legumes
1.3. Processing of cereals and legumes for formulation of food

1.1. Nutritional significance of cereals and legumes based food mix

The utilization of cereals and legumes by the human race offers them an essential place in global nutrition which plays a vital part in the conventional food practice of many provinces all over the world. Cereals and legumes reside a significant position in human nutrition particularly in the dietary pattern of low economic population from budding countries are said to be the best combination for delivering good nutrients. National Health and Medical Research Council report states that cereals including barley, maize, wheat, rice, oats, sorghum, rye and millet and the foods prepared out of the cereals supply more than 56 percent of the energy and 50 percent of the protein to the human population (National Health and Medical Research Council, 2003). Foods prepared out of whole cereals contain increased concentration of phytochemicals along with other vitamins and minerals (Slavin, 1999). In addition to this, a smaller percentage of population used cereals like sorghum and other millets and their food products have received the attention in new food formulations as they are proved to be the good and comparable sources of proteins and other functional components (Duodu, Taylor, Belton and Hamaker 2003; Pathak, Srivastava and Grover, 2000). They also hold considerable levels of a extensive range of phenolic compounds (Dykes and Rooney, 2006). Like cereals, legumes which are considered as poor man's meat are also excellent sources of dietary complex carbohydrates (starch and dietary fiber), protein, minerals and B vitamins (Tharanathan and Mahadevamma, 2003).The legumes that are generally consumed by the people including red gram, green gram, black gram, green peas proved to contain good nutritional profile ensuring health benefits. They contain low fat, high protein, dietary fiber and good amount of micronutrients and phytochemicals. (Anderson *et al.,* 1999 and Messina, 1999). After few mechanical processes like steel cutting, rolling or flour making, most of the cereals can be eaten as whole, refined or as breakfast foods which may add required nutritional profile like high fiber, low fat and retention of some micronutrients. Legumes which have some anti-nutritional factors like phytates, tannins and cyanogenic agents need specific processing techniques to make them suitable for consumption (Reddy and Pierson, 1983). Geil, P.B. and Anderson,

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J.W. (1994) reported that intake of legume in the diet was a tremendous mode to increase dietary fiber consumption. Though the cereals and legumes are unique in their individual nutrient composition, health benefits and other functional properties, cereals are poor source of the essential amino acid lysine which is abundant in pulses. On the other hand, methionine is complemented by cereal protein which is less in legume (Iqbal *et al.,* 2006). Hence, the overall protein quality, nutritional value and health promotion further more increases when cereals and legumes are combined together as composite mix, weaning food mix, supplementary food mix and other ready to cook flour mix.

New composite mix and weaning or supplementary food mix are being introduced by emerging food industries and also by the health professionals and nutritionists in order to combat with the deep rooted food insecurity, malnutrition and certain diseases in infants, children and adults. These food mix prepared by combining cereals and legumes are economical which contain locally available ingredients to improve the overall food and nutritional quality (Almeida-Dominguez *et al.,* 1993). Ahmed *et al.,* (2008) formulated six mix using flours of soyabean and wheat at different ratios. Soyabean was treated with heat for 5, 10 and 15 min before milling into powder and blended with wheat flour at the proportion of 95:5 or 90:10. Further 3g of milk powder and 5g sugar were added to all the mix and analyzed for nutritional composition. The processed mix contains 12.52 - 13.63 g of protein, 4.58 - 4.88 g of fat, 1.47 - 1.57 g of ash and 72.69 - 73.72 g of carbohydrates. Two types of mix were made up of finger millet, lima bean and peanut at the proportion of 65:25:15 were formulated and analyzed by Geetha and Suja (1996). The result revealed that the mix possessed higher content of fat (6.8 g), protein (12.80 g), ash (1.10 g), iron (2.5 mg), phosphorous (283 mg) and calcium 260 mg for every 100 g of finger millet when compared to rice based mix (12.20 g, 5.9 g, 0.9 g, 0.5 mg, 205 mg and 63 mg/100g respectively). Ijarotimi *et al.,* (2006) developed and analyzed the nutritional quality of multi mix consisted of sorghum and pigeon pea at different combinations of 90:10, 80:20, 70:30, 60:40 and 50:50 respectively. With the increment in ratio of pigeon pea an increased content was noted in crude protein and crude fibre with a decrease in carbohydrate content. Mix possessed 12.7 - 21.9 g protein, 2.3 - 2.6 g fat, 1.4 - 2.2 g crude fibre, 5.8 - 6.5 g ash and 58.3 - 71.8 g carbohydrates.

Apart from this, incorporation of cereals and legumes along with leafy vegetables, nuts and oil seeds have remarkable effect on the nutritional and functional properties of composite mix. Utilizing wheat, pearl millet, bengal gram and amaranth leaves in the proportion of 4:1:1:4:4 for low cost weaning foods were formulated by Dahiya and Kapoor (1994). They revealed that the mix with wheat possessed an increased carbohydrate and protein content, while those with pearl millet contain more of fat, ash and crude fibre. Depending upon the nature of the pulses the values of energy varied. The mix possessed 11.7 - 12.7 % protein, 5.0 - 5.98 % crude fat, 1.26 - 1.61 % crude fibre, 5.3 - 6.1 % moisture, 1.9 - 2.2% ash, 72.5 - 73.7g carbohydrates and 388–392 kcal of energy per 100 g. Similarly, Gahlawat and Sehgal (1994) formulated and developed the mix using cereals, green gram and jaggery at the ratio of 70:30:25 and they were evaluated for their proximate composition. It revealed that the mix possessed 1.0 - 1.87 g fat, 2.9 - 3.7 g ash, 10.2 - 13.7 g protein, 1.0 - 1.27 g crude fibre, 14.42 - 15.53 mg iron and 357–374 kcal of energy per 100 g. Solanki (1986) reported that mix formulated using wheat, bengal gram, peanut and sesame seeds in varying proportion using various processing methods resulted in increased protein and energy content. Similarly the weaning mix prepared by using pearl millet or barley with roasted amaranth, green gram and jaggery in different ratio found to contain 5.90 - 6.03 g moisture, 9.84 - 9.95 g protein, 416 - 441 kcal energy, 3.77 - 4.32 g ash, 17.75 - 19.42 mg iron and 150 - 190 mg calcium (Gupta and Sehgal, 1991).

Incorporation of starchy vegetables and tubers has found to be increased in the carbohydrate and protein content of supplementary food mix which meets nutritional requirements of malnourished and underweight children. Evaluation of nutritional composition of the composite mix made up of 20 % maize, 50 % sweet potato, 25 % soyabean and 5 % peanut revealed to possess 14 - 25 % protein, 6.41 % fat, 2.39 % ash, 67.36 % carbohydrate, 59.6 mg calcium, 187.5 mg phosphorous and 2.4 mg iron/100 g. The mix had decreased iron values when compared to commercial weaning mix (Idowu *et al.,* 1993). Nnam (2000) used maize, sorghum, cowpea, soyabean, yam, coco yam and sweet potato in the proportion of 65:30:05 (cereal: legume: starchy staple) for the formulation of eight multi mix. There was an increment in the protein, fat, crude fibre and iron in the mix. Kshirnagar *et al.,* (1994) formulated and analysed four weaning foods made up of finger millet, peanut, green gram and skimed milk powder in varying proportion of 35:35, 10:20 with or without addition of 5% barley malt. The mix contain 370 - 381 kcal energy, 20.8 - 21.7 % protein, 3.5 - 3.7 % fat, 3.1 - 3.7 % ash and 1.64 - 1.79 % crude fibre. Lysine and methionine content of the malted (1.93 and 7.69 g/16g N) barley (1.89 and 7.58 g/16g N) were comparatively higher than roasted mix (1.82 and 7.31 g/ 16g N) and mix formulated without 5% of barley malt (1.85 and 7.46 g/ 16 g).

Traditional processing methods like sprouting, popping or puffing of cereals and legumes are still used in the preparation of food mix and gained special attention among consumers as they are economical and simple. Naikare and Mabesa (1993) formulated supplementary mix from blends of roasted rice and germinated green gram at the ratio of 100:0, 80:20, 60:40, 50:50, 40:60, 20:80 and 0:100. The mix was fortified with roasted sesame and carrot powder of 5g each. The evaluated mix consist of 17.2 % protein, 4.9 % fat, 2.54 % minerals, 1.01 % dietary fibre, 65.5 g carbohydrate, 346 mcg ß– carotene per 100 g. Baskaran *et al.,* (2001) formulated eight composite mix using popped cereals (40 % finger millet, pearl millet or sorghum, wheat), legumes (20 or 10 % defatted soy flour or 10 % bengal gram dhal), jaggery (30 %) and vegetable fat (5 %). The mix was enriched with vitamins and minerals and evaluated for nutrient composition and dietary fibre. They revealed that mix possessed 10.4 - 12.5 g protein, 4.2 - 5.9 g fat, 10.0 - 13.0 g dietary fibre, 1.8 - 3.6 g ash, 64 - 67 g carbohydrates and 340 - 398 kcal of energy. The mix could meet 1/3rd RDA for children and were well within PAG

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recommendations of protein. Proso millet based malted and popped convenience mix with soyabean and peanut flours in the proportion of 70:15:15 were formulated and developed by Srivastava *et al.,* (2001). They found that the nutrient content of popped mix has significantly higher amount of energy 336 kcal/100g, protein 15.98 g and fat 5.43 g when compared to the malted mix. A millet based weaning food using malted flours of barnyard millet (30 %) and foxtail millet (30 %), roasted soy flour (25 %) and skim milk powder (15 %) were formulated by Thathola and Srivastava (2002). Results indicated that the weaning mix possessed 18.3%, 4%, 9%, 0.4% and 60.8 % of protein, total ash, crude fat, crude fibre and carbohydrates respectively. Multi vitamin–mineral mixture was fortified to the weaning mix to meet PFA standards.

As observed from number of research findings, it is evident that the composite mix and weaning food mix prepared out of cereals and legumes incorporating vegetables, nuts and oil seeds have tremendous nutritional value. The health promoting components such as dietary fiber, micro nutrients and phytochemicals may reduce the risk of malnutrition in children and other health risk factors. This composite mix also ensures high organoleptic and sensorial qualities suitable for all individuals targeting low cost food mix formulations with high nutritional significance.

1.2. Health benefits of cereals and legumes

There is emerging support that whole cereals and legumes occupies vital function in the avoidance of chronic diseases which was pointed out by research put forth by Trowell and Burkitt (1975). It was evidenced by Toussaint-Samat (1994) that cereals and legumes were eaten by the human hunter-gatherers in ancient times and appeared in a number of myths and legends. People who consume whole cereals and legumes had shown better nutritional status and health benefits (Cleaveland *et al.,* 2000). Several studies have shown a contrary association between the consumption of cereals and legumes and the reduction of the degenerative diseases. Hence the usage of cereals and legumes in different proportions in the product will provide good nutrition. Itagi (2012) opines that the consumption of whole cereals has increased concentration of dietary resistant starch, fiber and oligosaccharides. They also contain antioxidant which includes minerals and phenolic compounds which play vital role in prevention of various diseases. Legumes are rich and efficient source of protein, complex carbohydrates (dietary fiber), minerals and vitamin while cereal grains provide important amount of proteins, carbohydrates and selected micronutrients (Salunke *et al.,* 2005).

Cereals and legumes provide positive health responses when they are properly positioned in the daily diet (Kushi *et al.,* 1999). In addition, work carried out by Kaur *et al.,* (2011) revealed associations between the utilization of legumes and declining prevalence of numerous diseases for examples aging, cancer, diabetes and cardiovascular diseases. Hu (2003) reported that the consumption of large amount of whole grain cereals showed lower risk of CHD and stress among people. Supplementation of whole grain in the diet lowers the atherogenic LDL cholesterol fraction while protecting anti-atherogenic HDL cholesterol levels. This is mainly due to the high soluble content of storage polysaccharide in legumes (Anderson and Gutafson, 1988, Anderson *et al.,* 1999, Joanne slavina, 2007 and Duane, 1997). Intake of whole grain will protect against cancer, CVD, diabetes and obesity because of the phytochemicals present in it.

According to IFIC (2009) and Gambus *et al.,* (2009), the mineral present in the buckwheat contain dietary compounds which show sound effects on health. Magnesium helps in boosting the immune function, bone health, normal muscle and nerve function. The potassium contributes to diminish the threat of stroke and high blood pressure. Zinc in the buckwheat helps in maintaining healthy skin, prevent diabetes and reduces the risk of atherosclerosis (Desikachar, 1975 and Chakrabiorty *et al.,* 2009).

Cereal fibers has consistently lowered the risk of diabetes and helpful in the management of people who have already developed type 2 diabetes mellitus (Willet *et al.,* 2002). Among cereals, finger millet and kodo millet are good source of antioxidant as phenolics, tannins and phytates. These millets play a vital role in defensive mechanism involving oxidative stress and sustaining glucose levels in the *in vivo* study conducted on type II diabetes (Prashant *et al.,* 2005). An exploring research conducted by Wolever *et al.,* (1987) concluded that supplementation of bean diet found to have glycaemic indices lesser than that of white bread (GI=100). The resistant starch content present in the legume and their low starch digestion rate released the glucose into the blood stream in slow rate, which resulted in reduced glycemic index in comparison with other foods (Tovar *et al.,* 1992). The resistant starches are probiotic and act as a substrate for microbiological fermentation (Topping *et al.,* 2001, Annelisse *et al.,* 2011 and Machado *et al.,* 2008).

Intake of diet high in whole cereals showed a positive association with lower body mass index, eventually a decrease in waist circumference and reduced risk of being overweight (Biglari *et al.,* 2008). A weight control strategy involves extremely complex physiological and psychological relations. The researches stated that there is no solitary food item that will have a continuous impact on weight control but rather a sequence of lifestyle and diet modifications. Legumes have shown positive contribution to weight control due to the comparative low glycemic index and high resistant starch. According to the report of National Health Nutrition examination survey 1999 to 2002, subjects who consumed legumes frequently in their diet showed a positive effect on the lower systolic blood pressure, waist circumference and body weight. (Leathwood *et al.,* 1988 and Ludwing *et al.,* 1999). The water soluble dietary fibers present in oats shows significant result in reduction of blood cholesterol (Krichevsky, 2001) which in turn reduced the risk of high blood pressure (Kim *et al.,* 2004 and Filipcev, 2011).

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Jacobs (1998) reported that cereals and its products show beneficial effects in reducing the risk of cancer. In addition the relationship between cereal intake and different type of cancer has been evidenced by several researchers. High intake of whole grains and legumes showed positive association in reducing the risk of cancer, particularly gastric cancer and colorectal cancer. Among cereals, sorghum fractions possess high antioxidant activity which offers similar health benefits commonly associated with fruits. Antioxidant properties present in food stop inflammation, cell damage, cancer, aging and atherosclerosis (Biglari *et al.,* 2008). Legumes have the effects of cancer prevention may not be entirely linked to dietary fiber, but due to phenolic and other non–nutritive compounds (Oomah *et al.,* 2006). Polyphenols from legumes may perhaps perform as antioxidants, hindering the formation of free radicals that eventually lead to the deterioration of biological molecules. These naturally occurring phenolic compounds are predominantly present in the seed coat and possess antimutagenic and antioxidant activities (Apariclo - Fernandey *et al.,* 2005; Carador – Martinzed *et al.,* 2002; Shahidi *et al.,* 2001; Dinelli *et al.,* (2006) and Tsuda *et al.,* 1993). Ibrahim *et al.,* (1987) said that cowpea is one of the most basic cultivated legumes in the world used as a food component because of its low cost gluten free property significant amounts of protein, calories and some B vitamins. Bazzano *et al.,* (2003) stated that utilization of legumes have been associated to decrease the risk of diabetes, obesity and have an inhibitory role in the reduction of coronary heart diseases.

1.3. Processing of cereals and legumes for formulation of food

Whole cereals and legumes remains the chief source of energy in the human diet as stated by Estrada *et al.,* (2004). In general, raw cereals and legumes possess anti-nutritional factors than the processed forms of cereals and legumes. In order to include the cereal and legumes in diet, it is necessary to process before incorporating in the food products (Hajos and Osagie, 2004). Several researches evidenced that biological food processing techniques namely germination, soaking, hydrothermal treatment and fermentation increases the bioavailability of the cereals and legumes. Addition of microbial enzyme during formulation seems to be the best efficient techniques for absolute degradation throughout processing (Martin - Cabrejas *et al.,* 2000). Afify *et al.,* (2011a, 2012 a, b) reported that cereal and legume processing contribute to alleviate of micronutrient deficiencies. Among different processing of cereal and legumes, substrates fermented by lactic acid bacteria enhanced the health properties. (Santhosh *et al.,* 1999). FAO (1990) and Singh *et al.,* (2000) stated that millets form the staple food for a huge sector of the population in India. Utilization of millet as food is still habitually restricted to the conventional consumers and population in lower economic strata.

Soaking and germination were older methods of processing the cereals and legumes. This type of processing offers the advantage of saving energy and reduces the flatulence producing oligosaccharides (Hajos and Osagie, 2004). Cereals and legumes were used for the formulation of food products. The cereals and legumes contains anti-nutritional components such as phytates, tannins, cyanogenic agents which interfere with the reduction of nutritional levels and affect the bioavailability and digestibility of protein and carbohydrates (Reddy and Pierson, 1983). This type of processing will enhance the utilization of legumes and serve as potential food source for infants, children pregnant, lactating women and old age (Muhammed *et al.,* 2010). Ascorbic acid is the important factor which is increased by 1.5 fold on sprouting the cereals and legumes. Minerals such as copper, iron, potassium and zinc are also observed to be increased during sprouting (Plaza *et al.,* 2003). Hotz and Gibson (2007) reported that nutritional characteristics and sensory properties of milled grains are improved by processing technology.

Traditional processing enhanced the bioavailability of micronutrients in the plant based diet. Decortications of hydrothermally processed millet had shown comparative changes in the nutrient contents of the finger millet which was soaked, steamed and dried (Dharmaraj Usha and Malleshi, 2011). Hydrothermal pre-treatment processing improved the functional properties and decreased the cooking time without affecting the nutritional composition of pigeon pea (Tiwari *et al.,* 2008). Goyal and Khetarpaul (1995) formulated cereals and legume blends from fermented rice and defatted soya flour in the ratio of 40:60, 50:50, 60:40 and mixed in the butter milk. On comparison, the result showed that fermentation had significantly improved the zinc solubility (2.28 %) and zinc absorption of intestinal segment (1.16 %).

According to the research carried out by Esenwah and Ikenebomeh, (2008) investigated the processing techniques like soaking, boiling, sprouting, autoclaving, roasting and dehulling has shown enhanced nutritional quality and destroyed the anti-nutrients present in them. Germination was one of the widely used methods for cereal and legumes to improve their deliciousness and nutritional value by breaking down of certain antinutrients namely phytate and protease inhibitors. During germination α-amylase and ß-amylase were produced which delivered more energy. Germination has increased the mineral extractability and thereby it paved the way for alleviating micronutrient deficiencies in population subsisting on these processed foods (Mamiro *et al.,* 2001). The results indicate that germination of pearl millet at 30°C for 48 hrs has decreased the phytate content and increased the extractability to 100 percent. Jain *et al.,* (2009) reported that germination, soaking, presoaked cooking beans hold a good potential for improving the nutritional value of lablab bean by reducing its anti-nutritional factors such trypsin inhibiters and phytic acid and thereby enhancing its utilization. Vijayaraghavan (1981) reported that the germination is a traditional and most popular practice all over the world. Addition of germinated legumes in the diet showed an increment in the nutrient contents. During germination increased enzyme activity is observed

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in the oven baked seeds. Apart from that starch, major biopolymeric components of legumes are partially modified to resistant starch due to processing (Tharanathan and Mahadevamma, 2003).

The effect of sprouting on phytic acid and HCL extractability of mineral content in pearl millet was studied by Kumar and Chauhan (1993) and Cheryan (1980). Sprouting before cooking leads to better nutritional value in terms of calcium and phosphorus availability. Nattress (1987) revealed that the nutritious weaning food formulated using wheat, millet, garbanze bean, mung bean and sesame was acceptable when served with banana and palm sugar. He concluded that germination of cereals and legumes made the product more acceptable.

Fermentation was the most simple and economic way of improving their nutritional value, sensory parameters and functional properties as reported by Blandinob *et al.,* (2002). Chandrasekhar (2010) who reported that fermented grain were used by majority of the people in traditional period. Elimination of anti-nutrients or toxic compounds depends on type of pulses and the processing techniques. The unfermented cereal legume blends contained high amount of phytic acid than the fermented cereals and legume blends. Effect of fermentation of cereal and legume on the availability of zinc was studied in vitro assay by Agte *et al.,* (1997).

CONCLUSION

One of the chief challenges of nutritionists is to diminish human sufferings due to nutritional stress as Indian population suffers from food and nutritional insecurity. Utilization of multicereals composite mix in the development of product has proven to possess immense functional properties in terms of amino acid composition, fatty acids composition, phytochemicals, vitamins and minerals. The developed tertiary processed foods will be superior to the products formulated using refined flours and offer broader spectrum for people who wish to improve the nutritional quality of their diet. With the drive for ready to eat and ready to cook foods in modernization era, the formulated value added tertiary products utilizing multicereals and legume will provide healthy lifestyle. Successful utilization of cereals and legumes with added functionality in snack food sector will definitely open up new dimensions to the food industries.

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CONFLICTS OF INTEREST
"The authors declare no conflict of interest".