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Soybean: A novel food grain for human health: A review

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Abstract
Malnutrition among under-five children is a major health problem in India. Nearly 30 percent of humanity is currently suffering from one or more of the multiple form of malnutrition. Therefore various preparations based on cereal-pulse combination are of paramount important to improve the protein quality of Indian diet. Due to high cost of non-vegetable protein and their inaccessibility by the poorer sections of population, cereal and legume assumes significance as a cheap and concentrated source of proteins in Indian diets. Soybean is most important, because of content of high amount of protein (40 percent). The proteins present in soy meet the amino acid needs of body, both for adults and children. Soybean is extensively used for extraction of edible oil. The residual defatted cake is good source of protein. The utilization of soybean oil cake in different low cost food products can useful in controlling malnutrition condition of developing countries.

Keywords: Composite flour, defatted soybean, malnutrition, protein, soybean

Introduction

A condition resulting from inappropriate nutrition regarded as malnutrition. It includes both inadequate and excessive dietary intakes of nutrients and/or calories. Insufficient protein intake causes kwashiorkor in children, and a diet deficient in all nutrients causes marasmus. Over nutrition can lead to toxicity and obesity. Protein Energy Malnutrition (PEM) continues to be the major nutritional problem resulting from under nutrition that affects children in most of the developing world. The most recent estimates show that more than one billion people worldwide are undernourished (FAO, 2009) [10]. Protein malnutrition is a serious problem in India due to cereal based dietary pattern. Malnutrition among under-five children is a major public health problem in India. This is reflected by the fact that the prevalence of under-weight children in India is among the highest in the world and is nearly doubles that of Sub-Saharan Africa. Currently, an estimated 149.6 million children under five year of age i.e. 26.7 percent of the world's children in this age group are still malnourished when measured in terms of weight for age. It was reported that under-weight among under-five children ranged from 39 to 75 percent, stunting from 15.4 to 74 percent and wasting from 10.6 to 42.3 percent in different parts of the country (Kumar *et al.*, 2015). Each year approximately 2.3 million deaths among 6-60 months aged children in developing countries are associated with malnutrition, which is about 41 percent of the total deaths in this age group.

Food and Agricultural Organization suggested that to meet the recommended dietary allowances of infants, preschool children, adolescent girls, pregnant and lactating women, low cost supplementary foods could be processed domestically by simple, inexpensive processing technology. The requirement of supplementary foods is increasing to reduce malnutrition. Supplementary food should be such, if taken in small quantity, could provide necessary amount of nutrients. They should be made in form of ready-to-eat snacks, baked, drinks etc. Therefore various preparations based on cereal-pulse combination are of paramount important to improve the protein quality of Indian diet.

Cereals constitute the most suitable vehicle for delivering proteins to at risk populations because of their wide spread consumption, stability and versatility. In developing countries where a single cereal is often the primary staple, they contribute 70 to 90 percent of the total dietary protein. To augment the protein quality, the concept of cereal-legume complementation by blending cereal and legume flours can be applied (FAO/WHO, 1994) [11]. It is admitted that the nutritional quality of cereals and the sensorial properties of their products are inferior or poor in comparison with milk and milk products.

The reasons are lower protein content, deficiency of certain essential amino acids (lysine), low starch availability, presence of anti-nutrients (phytic acid, tannins and polyphenols) and the coarse nature of the grains.
Due to the high cost of proteins of animal origin and their inaccessibility by the poorer section of the population, the grain legume assumes significance as a cheap and concentrated source of proteins in Indian diets. The legume proteins significantly enhance the protein content and helps to improve the biological value of cereal flours due to presence of high essential amino acids especially lysine. Different food grain founds good source of protein among that soybean is most important, because of content of high amount of protein about 40 percent.
Soybean is derived from seeds *Glycine max* (L) merr of family- Legumiodae or Fabaceae. Taxonomically, the soybean belongs to the order, Fabales, the family, Fabaceae, the subfamily, Faboidae and the genus Glycine. In China it has been used for 5,000 years as a food and a component of drugs. The five largest soybean producing countries are USA, Brazil, Argentina, China and India. The total world production of soybean in 2015 estimated about 319.7 million tones. Global soybean production current year forecasted 314 million tones. Production of soybean in India at the present time is restricted mainly to Madhya Pradesh, Uttar Pradesh Maharashtra and Gujarat. It is also grown on a small acreage in Himachal Pradesh, Punjab and Delhi.
Soybean is known as the "Golden bean" or the super legume of the twentieth century. Kadam *et al.* (2012) [15] stated that legumes have been known as "a poor man's meat". They supply protein, complex carbohydrates, fiber and essential vitamins and minerals to the diet, which are low in fat and sodium and contain no cholesterol. Soybean has more than two times the amount of most of the minerals, especially calcium, iron, phosphorus and zinc, than any other legume and very low sodium content. In addition to being a rich source of nutrients, soybean has a number of phytochemicals (isoflavones), which offer health benefits along with soy protein though they do not have any nutritional benefits. Soybeans contain two primary isoflavones called genistein and diadzein, and a minor one called glycitein. Soy protein and isoflavones together contribute to a number of health benefits such as, cancer prevention, cholesterol reduction, combating osteoporosis and menopause regulation.
Soybeans have been thus far considered as a source for crude oil for edible and industrial purposes, and the protein-rich (more than 50 percent) meal is seen as a protein source for animal feed. In recent years, however, there has been increasing interest in utilization of soy meal as a protein source for human foods. This is in view of the easy and abundant availability of this quality protein at relatively low cost. Soybean is crushed into oil and defatted meal and meal is usually used as an animal feed and smaller percent is further processed into food ingredient including soy flour, concentrate, isolate and textured protein (Jideani, 2011) [13].

Soybean a novel food
Dixit *et al.* (2011) [9] reported epidemiological importance of soybean in prevention of several diseases. Past several years of clinical and scientific evidences have revealed the medicinal benefits of the soy components against metabolic disorders (cardio-vascular diseases, diabetes and obesity etc.) as well as other chronic diseases (cancer, osteoporosis, menopausal syndrome and anemia etc.). Many of the health benefits of soy are derived from its secondary metabolites, such as, isoflavones, phyto-sterols, lecithins, saponins. Jooyandeh (2011) [14] studied that soy products do reduce the risks of developing various age-related chronic diseases and epidemiologic data strongly suggest that populations that regularly consume soy products have reduced incidence and prevalence of the aforementioned age-related conditions and diseases than populations that eat very little soy. Kanchana *et al.* (2015) [16] stated that some of the natural medicinal plants are so common that we use them in daily life without knowing their medicinal importance. Glycine max (L.) Merr is the best example of it. The plant is commonly known as soy bean which is eatable. Bruised leaves applied to snake bites, Flowers used for blindness and corneal opacities. Green bean hulls chewed to a pulp are applied to smallpox ulcers, corneal ulcers and excoriations in children from urine, dried sprouts believed to be beneficial for hair growth and curative for ascites and rheumatism. Lokuruka (2010) [18] reported that whole soy foods are good sources of dietary fiber, B-vitamins, calcium, and omega-3 essential fatty acids. Singh *et al.* (2008) [29] stated that soybeans as food are very versatile and a rich source of essential nutrients. They are also an excellent source of good quality protein, comparable to other protein foods, and suitable for all ages. Soybeans provide an alternative source of protein for people who are allergic to milk protein. Soy protein is highly digestible (92 to 100 percent) and contains all essential amino acids. Verma *et al.* (2014) reported that consumption of soy foods may contribute to a lower incidence of coronary artery disease, type 2 diabetes mellitus, certain cancers such as breast and prostate and ensure a better bone health, relief of menopausal symptoms, as well as weight control.

Composition of Soybean
Bhise and Kaur (2013) reported that the defatted sunflower meal had 2.56 percent moisture, 2.53 percent fat, 43.38 percent protein, 13.07 percent fiber and 32.54 percent protein digestibility. The defatted soybean meal had 2.70 percent moisture, 2.26 percent fat, 52.86 percent protein, 3.29 percent fiber and 56.33 percent protein digestibility. The defatted flaxseed meal had 2.61 percent moisture, 2.71 percent fat, 38.24 percent protein, 12.24 percent fiber and 43.77 percent protein digestibility. Mustakas (1971) reported that full fat soybean meal contains protein (41 percent), fat (20.5 percent), ash (5.3 percent), carbohydrate (25.2 percent) and fiber (2.8 percent) while defatted soybean meal contains protein (50.5 percent), fat (1.5 percent), ash (5.8 percent), carbohydrate (34.2 percent) and fiber (3.2 percent). Singh *et al.* (2014) [28] investigate physical properties of soybean cultivated in NEH region of India. Major, minor and intermediate mean diameters of soybean seeds were 8.88±0.55 mm, 4.68±0.32 mm and 6.46±0.36 mm, respectively. Geometric mean diameter was 6.45±0.35 mm. Mean roundness of the seeds was 0.66±0.02, while mean sphericity of the seeds in their natural rest position was 0.73±0.02. Bulk density, true density, porosity, thousand seeds weight and angle of repose were 749.50±1.59 kg/m3, 1171.80±115.02 kg/m3, 34.62±9.00 percent, and 177.55±3.04 g and 25.82±1.88º, respectively. Warle *et al.* (2015) carried out germination of soybean under controlled condition and its soaking and germination time was finalized for the best results. It was found that the germination of soybean reduced the carbohydrate content from 22.1 to 17.9 percent, starch 12.23 to 10.21 percent, amylopectin 6.2 to 4.4 percent, ash content from 4.95 to 4.59 percent, fat 24 to 10 percent, falling number 341 to 98 and oil absorption capacity 3.45 to 3.26 percent respectively. The germination of

grains increased the moisture content from 10 to 11 percent, total sugar 3.55 to 5.6 percent, reducing sugar 0.45 to 0.61 percent, nonreducing sugar 3.1 to 4.99 percent, protein content 29.09 to 34.99 percent, amylose content 5.8 to 6.4 percent, water absorption capacity 120.4 to 123.4 percent, particle size 0.091 to 0.094 µm and water solubility index 16 to 28 percent respectively.

Strategies for reduction of content of anti-nutritional content of soybean

Carrao-Panizzi *et al.* (1999) [6] concluded that differences in isoflavone contents between IAS 5 and BR-36 are maintained in soymilk and whole cooked soybean grains, despite the processing treatments. The aglucone genistein is formed in the soymilk in reduced amounts and does not affect flavor. Pre-soaking treatment of grains intensifies beany flavor in the soymilk reducing the perception of astringency, which is caused by genistein. When whole soybeans grains are cooked under pressure, malonyl glucosides are converted to the correspondent conjugated glucosides (daidzin and genistin). Deshpande and Bal (2005) [7] reported that cooking characteristics of full fat and defatted soya flakes were performed using different cooking treatments, viz., normal boiling, cooking with additive salts, pressure cooking to explore the feasibility of using such flakes in the preparation of broth. The results indicated that the optimum cooking time of soya flakes can be successfully reduced from 142 min by normal boiling to 69 min by pre-heating and boiling in 1 percent sodium bicarbonate (NaHCO3) and 11 min by pre-heating and pressure cooking in 1 percent NaHCO3 for the preparation of good-quality broth thus reducing time and energy in cooking considerably. Destro *et al.* (2013) [8] reported soybean is one of the richest sources of protein; however, its prolonged cooking time makes its use more difficult. Soy dhal with sodium carbonate and sodium bicarbonate, at the 0.5 percent, 0.75 percent and 1 percent concentrations, reduced cooking time significantly. Abd El-Hady and Habiba (2003) [1] studied the effects of soaking in water for 16 hr and extrusion conditions including barrel temperature (140 ^{0}C and 180 ^{0}C) and feed moisture (18 and 22 percent) on anti nutrients, total and phytate phosphorus and protein digestibility of whole meal of four kinds of legumes (peas, chickpeas, feba and kidney beans) were investigated. The results obtained indicated that the soaking and extrusion significantly decreased anti nutrients such as phytic acid, tannins, phenols, a-amylase and trypsin inhibitors. Izadi *et al.* (2013) reported that beany flavor in soymilk could be reduced with hot water blanching and grinding at temperature above 80 °C. LOX activity gradually decreased by hot water treatment with time, and with the decrease of LOX activity, the 5 beany odor-active compounds and 3 nonbeany aroma-active compounds was significantly decreased. Sharma *et al.* (2013) studied that effects of soaking and cooking methods on physicochemical characteristics, nutrients and anti nutrients in twenty soybean genotypes were studied. Batches of seeds were soaked for 18 hr in distilled water, 1 percent citric acid and 2 percent sodium bicarbonate solutions at room temperature and then boiled in water. Raw soybean genotypes exhibited 36.5-43.2 percent protein, 20.7-22.2 percent oil, 2.5-8.3 percent total soluble sugars, 1.1-10.4 percent sucrose, 11.1-18.8 mg/g tannins, 14-36.2 mg/g phenols, 5.1-24.5 mg/g phytate, 30-102.5 mg/g trypsin inhibitor activity and 9.3-27 mg/g saponin. Soaking in distilled water and/or different solutions followed by cooking resulted in significant reductions in the levels of protein, oil and anti nutrients and enhanced the carbohydrates in soybean seeds. Cooking of soaked seeds resulted in higher losses of anti-nutrients in comparison to unsoaked seeds. Among the various treatments, soaking in 1 percent citric acid solution followed by cooking for 30 min resulted in maximum reduction in most of the anti-nutrients studied.

Composite flour technology

Cereal grains and legumes play significant role in supplying the nutrients, as well as providing over 70 percent of the daily energy requirements. The composite flour technology refers to the process of mixing wheat flour with cereals and legumes to make use of local raw material to produce high quality food products in an economical way. Bolarinwa *et al.* (2015) [5] prepared malted sorghum-soy composite flour which is mixed with wheat flour. Substitution of malted-sorghum flour with 40 percent soy flour resulted in notable increased in protein content. Thus, the composite flour products would be nutritionally advantageous to Africa, where many people can hardly afford animal protein. Noorfarahzilah *et al.* (2014) [21] reported that blending of wheat flour with various sources of tubers, legumes, cereals and fruit flour in different percentages to produce variety of food products. It was found that composite flour used to produce food products is still able to maintain similar characteristics to products made from full-wheat flour. The positive effects of the use of composite flour can be seen in the final product related to the functional and physicochemical properties and health benefits of raw blended flour along with percentage blending. Nwanekezi (2013) [22] concluded that composite flour containing 80 percent or less wheat flour can no doubt be used to make good quality bread provided the wheat flour in the composite flour has high quality and quantity (14 percent or more) of protein. Also, it is possible to bake good quality biscuits and cakes from composite flour having equal blends of wheat flour and local food flour as wheat flour containing as low as 6 – 7 percent Protein could be used for making them. Oluwamukomi *et al.* (2011) [24] reported that cassava (Manihot palmata) and soybean were processed into flours and used to substitute wheat flour as composite flour. The wheat flour (WF) was substituted by cassava flour (CF) at levels of 0, 10, 20, 30, 40, 50, 60, and 70 percent; while the resulting composite flours at levels above 40 percent were replaced with 10 percent soy flour (SBF) to increase their protein levels for biscuit production. Shahzadi *et al.* (2005) [26] prepared composite flour by blending commercial wheat flour "resultant atta" with various legumes i.e. lentil, chickpea and guar gum in different proportion to study their rheological and baking performance and conclude that blending of various legumes particularly the guar gum with wheat flour improves rheological and sensory attributes of chapaties.

Value addition with soybean

Arshad *et al.* (2007) [2] studied the replacement of wheat flour with defatted wheat germ (DFWG) at levels of 0–25 for its effect on functional and nutritional properties of cookies. The crude protein content of DFWG was as high as 27.8 percent with a highly valuable amino acid profile, rich in essential amino acids, especially lysine (2.32 g/100 g). Bashir *et al.* (2012) reported the fortification of durum wheat semolina was done by the combination of chickpea flour and defatted soy flour at levels (0,0) percent containing only semolina as control, (10,6) percent, (14,10) percent and (18,14) percent respectively. A novel legume fortified pasta product was successfully produced and it was observed as the concentration of legumes was increased the cooking time also increased. The cooking quality of the pasta was enhanced by steaming. Ndife *et al.* (2011) [20] reported that the physico-chemical analyses results obtained showed an increase in the range of 11.0 percent for moisture, 4.37 percent for protein, 2.40 percent for fat, 2.35 percent for crude fiber, 0.85 percent for ash and a decrease in carbohydrate and energy contents by 20.92 and 44.60 percent respectively and concluded that a substitution of 10 percent soy flour into wheat flour gave the bread with the best overall quality acceptability. Ogunmodimu *et al.* (2015) [23] studied that, the snacks produced with soybean flour substitution up to 20 percent were nutritionally superior to that of the control chewy products. Senthil *et al.* (2002) [25] studied that by blending soya flour ranging from 20 to 40 percent level with wheat flour did not affect the sensory quality of the products. The products had high protein and ash content. The rheological studies indicated that the amount of water required for making dough increased and the strength of the dough decreased with increasing level of soya flour in the formulation. Incorporation of soya flour up to the level of 40 percent did not affect the color during deep fat frying but there was a significant difference in textural properties. Suleiman *et al.* (2008) [30] studied the supplementation of 5, 10 and 15 percent of de hulled and defatted soy flour (DDSF) in biscuits to increase their protein content. Proximate analysis was determined for the DDSF which contained 7.4 ± 0.14 percent moisture, 6.7 ± 0.16 percent ash, 60.6 ± 0.64 percent protein and 25.3 ± 0.3 percent carbohydrate. Varma and Pathak (2015) studied that incorporation of soybean and different type of millets (bajra, sana, ragi, jowar, etc.) for therapeutic uses has been well recognized. They are having high protein, fiber, micronutrients, antioxidants and high energy density. Zaker *et al.* (2012) [34] standardize the levels of defatted soy flour in composite flour for biscuit preparation. The defatted soy flour was incorporated in the traditional recipe to replace wheat flour at levels defatted soy flour by 0, 10, 20, and 30 percent in preparation of biscuits. Sugar was replaced by the Stevia and Date paste while traditional shortening was replaced by olive oil. The prepared biscuits were evaluated for its physical, sensorial and nutritional properties. Result of sensory (appearance, color, flavor, texture, taste, and overall acceptability) evaluation of biscuits showed that 20 percent addition of defatted soy flour had higher overall acceptability, taste, texture and flavor. The nutritional value of the biscuit as determined through nutrient analysis-moisture (2.7), Protein (13.53), Fat (17.74), ash (1.75), and total energy (462.30) with 20 percent of defatted soy flour was comparable to control (wheat flour) biscuit.

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