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REVIEW ARTICLE **OPEN ACCESS**

Importance of black Soyabean, Post Harvest Technologies and its by-products- A review

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ABSTRACT

Soybean are regarded as the much consumed and important crop which provide complete protein with an affordable price. India being comprised of maximum vegetarian people sought protein in their everyday meal; soyabean comes to picture by serving the goal of replacing meat protein for people as whole. Soyabean has different seed coat colours, including black, brown, red, green and yellow, the only difference between the black and the other various colours lies in the seed coat where the black soyabean contain abundant anthocyanin pigments. Black soybean is also pondered as the miracle crop due to its nutritional values and potentials to develop as healthy functional food ingredients. Black soyabean provides many health beneficial effects such as anti-mutagenicity, anti-inflammatory properties, inhibition of low density lipoprotein oxidation and DNA damage reduction. Hence due to their various beneficial effects, black soybeans are increasingly sought in food and medicinal industries. There are many unit operations involved in post harvest handling and processing of black soyabean to prevent losses and to maintain the quality of the crop. Some of them include harvesting, threshing, drying, cleaning, packaging, storage, transport, dehulling, cracking, etc. Black soybeans are used for producing wide variety of products such as soymilk, tofu, soy sauce, natto, tempeh, soy oil, soy flour, texturized soy protein, black soy hull extract (anthocyanin), soy protein isolate, soy protein concentrate, etc. This paper goals is to renew and revive the potential of the forgotten or underutilised black soyabean crop having many functional and nutritional benefits calls out the researchers for a diverse expansion of importance of the seed crop to widen its uses and application in many ways.

Keywords: *Black soyabean, nutritional composition, health benefits, soy products*

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INTRODUCTION

Black soybean *Glycine max (L.) merr*. belongs to the family Papilionaceace is regarded to be well known as the black bean, soybean, horse bean or winter bean. This legumes is indigenous to East Asia and the main producers of soyabean in the world are United States, Brazil, Argentina, China and India. Soyabean is classified as an oilseed rather than a pulse and the English word soy is extracted from the Japanese pronunciation of shoyu which defined the Japanese word for soya sauce; also Dutch adapted of the same word soya. For centuries, soybean was used as milk, cheese, bread and oil and the crop has habitually been referred as the 'Cow of the field' or 'Gold from soil' [1]. However in Korea, black soybeans are required to prepare several different traditional fermented foods, including *meju* (soybean cake), *cheonggukjang* (soybean cook), *kanjang* (soybean sauce) and *doenjang* (soybean paste). In Indonesia, black soybeans are widely used as primal matter for the manufacture of soy sauce whereas in India, it is locally known as Bhat or Bhatmash grown in Kumaon region and in its bordering states and countries in the Himalayas. In China, India, Japan and Korea, black soybean has been customarily consumed as a medicine for a century as it contains a variety of substances that contribute positively to human health, including isoflavones. The medicine used by them is for detoxification, anti-inflammation and to improve the quality of red blood cells [22]. Soybean consisting of different seed coat colours including black, brown, red, green, and yellow is well known source of vegetable oil, protein and animal feed. The protein content of soybean is ponder as complete protein because it supplies adequate quantity

of the kinds of amino acids for building and repairing tissues required by the body. The only distinction between black and other types of soybeans is the black color of the hull which indicate that soy contains anthocyanin compounds, which occupies the top list with the highest antioxidant activity. Black soybean utilization is less favourable as compared to other types of coloured soyabean for a variation of processed food products, the only reason behind this is due to the black color hull and has a less desirable effects on various products as well as there is lack of information about the proper handling and processing. In order to avoid the losses and to maintain the quality of the forgotten and underutilised black soyabean, there are wide ranges of post harvest technologies that can be adopted through the process of harvesting, threshing, drying, cleaning, packaging, storage, transport, dehulling, cracking, etc. Black soybeans are profoundly used in making products such as soymilk, tofu, soy sauce, soy oil, natto, tempeh, texturised soy protein, soy flour, soy protein isolate, soy protein concentrate, black soya hull extract (anthocyanin), etc. Nowadays, trading of black soybean based foods is on the rise tremendously because of increasing consumer awareness of black soybean as a nutritious, healthy and functional food ingredient. The present paper aims to educate and revive the importance, nutritional benefits, units operation involved and the different by-products obtained from black soyabean.

Table 1: Nutritional value of soybeans (per 100 g)

Energy	**466 kCal**	**Energy**	**466 kCal**
Carbohydrates	30.2 g	Tyrosine	1.54 g
Sugars	7.3 g	Valine	2.03 g
Protein	36.49 g	Arginine	3.15 g
Trytophan	0.59 g	Histidine	1.1 g
Threonine	1.77 g	Alanine	1.92 g
Isoleucine	1.97 g	Aspartic acid	5.12 g
Leucine	3.31 g	Glutamic acid	7.87 g
Lysine	2.71 g	Glycine	1.88 g
Methionine	0.55 g	Proline	2.38 g
Phenylalanine	2.12 g	Serine	2.36g
Fat	19.94 g	Vitamin A	1 mg
Saturated	2.89 g	Vitamin B6	0.4 mg
Monounsaturated	4.4 g	Vitamin C	6.0 mg
Polyunsaturated	11.26 g	Vitamin K	47 mg
Water	8.54 g	Calcium	277 mg
Iron	15.7 mg	Potassium	1797 mg
Magnesium	280 mg	Sodium	2 mg
Phosphorus	704 mg	Zinc	4.9 mg

Source: USDA National Nutrient Database [21]

BLACK SOYABEAN NUTRITIONAL COMPOSITION

Black soyabean represent as one of the prosperous and economical sources of protein which are low in net carbohydrates, high in fiber and contain vitamin K, iron, magnesium, copper, manganese and riboflavin. According to Messina & Barnes, [10] black soyabean is reported to carry a very good source of proteins, carbohydrates, fibers and other components that have anti carcinogenic effects and helps in reduction of cholesterol. Soybeans contain between 35-40% protein as also shown in Table 1, on a dry weight basis according to Torres *et al.*, [19], with all of the essential amino acids except for methionine and tryptophan [26] which makes soy products almost equivalent in the quality of the protein to animal sources but with far less saturated fat and zero cholesterol [25]. Soybean reported to contain about 30-32% of soluble and insoluble carbohydrates with a number of minor constituents such as phospholipids, vitamins and minerals, trypsin inhibitors, phytic acid, saponins and isoftavones, which are thought to have beneficial biological effects in the diet by lowering blood cholesterol or even preventing cancer. Nielson, 2006 reported that the dietary fiber present in black soyabean reduces the toxic effect of microbial waste product of large intestine. Thus it lessens the risk of colon cancer and also helps to normalize blood lipids, thereby minimizing the risk of cardiovascular disease. Kirtikumari & Pandya, [5] found out the values of protein, carbohydrates and oil in black soyabean with seed coat was found to be 30g/100g, 31.85g/100g and 16.2g/100g respectively. The quantity of protein, carbohydrates and oil in black soyabean without hull was found to be 29.55g/100g, 30.35g/100g and 15.9g/100g respectively. The percentage of crude fiber with and without hull is 7.51% and 4.12%. Hence dehulling causes lesser loss of protein and carbohydrates and high in dietary fibers. Xu & Chang, [22] reported that compounds

that may have a health benefit for humans namely antioxidants and anthocyanins are found in tremendous amount in the seed coat than in the interior of the seed. Several authors such as Choung *et al*., [3]; Zhang *et al.,* [27] reported that seed coats or hulls obtained from black soybeans after dehulling are found to contain the greatest levels of anthocyanins of all pigmented soybeans.

IMPORTANCE OF BLACK SOYABEAN

Nutritionally, black soyabean are very alike to regular other soyabeans, though they are higher in some phytonutrients preferably antioxidants. According to the theory of customary Chinese medicine, the black soybean is sweet-warm, non-toxic, good for the kidney, the spleen and the heart, and has the effects of kidney tonifying and body building, dehumidification and damp clearing, as well as anti-aging. In addition, black soyabean improves the capillary circulation as well as have obvious anti fatigue effect [9]. The beneficial health effects of black soyabean as reported by many researchers includes effects specifically anti-mutagenicity, anti-inflammatory properties, inhibition of low density lipoprotein (LDL) oxidation and DNA damage reduction. Takahashi *et al.,* [19**]** reported that Japanese researchers lately found that the extract of black soybean had an inhibitory effect on low density lipoprotein (LDL) oxidation and also had a longer LDL oxidation lag time in comparison to yellow soybean. Black soybeans reduces the cholesterol level, inhibit growth of cancerous cells and also concluded that the people consuming black soybean in Japan was found to be less effected by pollution and from adverse effects of radiation. Li *et al.,* [9] reported that the black soybean hull extracts which is use mainly used for many biomedical research found many health effects such as to improve eyesight, stop bleeding, are diuretic and antiscorbutic, protect capillary vessel, promote the regeneration of erythrocytes of eyes, enhance the ability to adapt to the darkness, can obviously improve asthenopia and have obvious releasing effect on asthenopia suffered by teenagers, including blurred vision, bloated eyeball, ophthalmalgia, photophobia, xerotic eye and eyestrain. According to Chinese researchers [6, 28], clinical study of 36 patients in Japan demonstrated that intake of black soybean powder for six months improved ovulation and pregnancy by stimulated the growth of MCF-7 cells and increased the expression of estrogen receptor responsive gene in their study.

UNIT OPERATIONS INVOLVED IN POST-HARVEST PREPARATION, HANDLING AND PROCESSING OF BLACK SOYABEAN [20]

The main focus of post harvest operation is to avoid losses and maintain the quality and originality of the soyabean by subjecting to several operations once the soybeans are fully developed and ensure a continuous supply to processing industries or consumers. The post-production operations include the following:

Harvesting: The black soyabean are seasonal crop and takes 50 to 200 days to mature considering the variety, weather, latitude, etc. Harvesting time is one of the most important factors to check excessive yield losses. When about 85% of the pods have turned brown for a non shattering variety and 80% for shattering varieties, at that time the crop is suggested to harvest otherwise the crop can be harvested when the seeds contain moisture of 14-16% which is known as hard-dough stage. They are harvested mechanically over a relatively short period of time and if harvesting is delayed, losses in yield may occur from other causes.

Threshing: Threshing is an operation carried out manually with simple tools or with motor driven machines with care to prevent breakage of the beans or hulls which can reduce the quality and foster subsequent losses from the action of insects and post harvest diseases. This process mainly consists of separating the beans from the pods. The mature plants cut and stacked loosely and are allowed to dry in the open area under the sun for 2 weeks before threshing

Drying: After threshing, the moisture content of the beans at times are too high for guaranteeing conditions favourable for storage or for further processing or handling of the product. The only solution to this problem is to lower the moisture content by drying. Drying is considered as one of the critical phase in postharvest framework where the beans are rapidly dried until they reach the "safe-moisture" level. The safe moisture content required for storage of soyabean is 13-14%. Drying consists of rapidly drying the beans with the circulation of natural or artificial drying, natural drying consists of exposing the threshed beans to the sun by spreading in thin layers in the field for 1 to 2 weeks. The beans must be stirred frequently for uniform circulation of heated air during drying. Whereas artificial drying method comprised of exposing the beans to forced ventilation or circulation of air that is heated to certain degree in special equipment called dryers. There are two types of dryers: static or discontinuous and continuous dryers. The discontinuous dryer is relatively inexpensive and can treat only modest quantities of grain; it is better adapted to the needs of small and medium-scale collection centres and processing of products. The continuous dryers are high-flow dryers that require a more complex infrastructure, complementary

equipment and special planning and organization. One disadvantage of artificial drying is that it is fairly costly due to purchasing of equipment, energy consumption, care and maintenance.

Cleaning: Cleaning is an operations which consist of eliminating impurities from the grain mass. The simplest cleaning method consists of tossing the beans into the air and letting the wind carry off the lightest impurities but this method does not get rid of the heavier impurities. The cleaning is done several times in many stages of the post harvest system manually or by using machines such as air screen cleaners, screen cleaners, etc. in order to remove soil, insect, plant waste, weed seeds, gravel or broken soyabean which may cause contamination or may hamper machine if present for further processing.

Packaging: Soybeans are packed in bags of natural materials such as jute and cotton fibre or woven plastic bag and transported as break-bulk cargo or only bulk cargo.

Storage: Storage is a critical period of post harvest operations, the main motive is to conserve soybeans quality as long as possible and to make sure of its availability during its off season. The storage has to ensure deferred soybean use, to guarantee seed availability for the next harvest cycle. Therefore, a continuous supply of raw soybeans for processing industries is guaranteed. The supply and demand of soybean is balanced, thus stabilizing its market price.

Transport: It is especially important to transport the beans from the field to storage centres as soon as possible to avoid deterioration. The type of transport used to transfer soybeans depends on the quantity and distance travelled. Rail and ship are mostly prefer for large quantity of soybean and for over long distances.

Process: Soybean processing involves a series of steps to produce commodities for food, industrial and animal feed uses.

Cracking: Cracking is the breaking of the whole seed into several pieces to facilitate dehulling and flaking.

Dehulling: Dehulling is the process of removing the outer covering from grains or other seeds.

Hull: Hull is the tough exterior skin of a soybean. It is a major source of dietary fibre, the hull is processed to create a fibre additive for cereals, breads and snacks. Livestock feed is also manufactured from soybean hulls.

Degumming: Degumming is the elimination of phosolipids from vegetable oil by a water washing.

Flaking: Flaking is the transformation of dehulled oilseeds into thin flakes for solvent extraction or other processing.

SOME OF THE PROCESSED PRODUCTS OF BLACK SOYABEAN

1. **Soymilk:** Soymilk is one of the traditional drinks in the Eastern world, providing eight essential amino acids for human beings. [15]**.** Its appearance is off-white emulsion containing the water-soluble proteins and carbohydrates, and abundant oil of the soybeans. Soymilk contains lower sugar naturally than regular milk and hence promotes weight loss. The most important attribute of soymilk is its ability to improve lipid profile, it was also reported that regular intake of soymilk can significantly lower the blood concentration of triglyceride.
2. **Soyabean hull extracts (pigment-Anthocyanins):** Anthocyanins are groups of reddish or purple flavonoids that have been used widely as natural coloring agents in the food industry [2]. They have been idetified as health-promoting functional food ingredients due to their antioxidant activity [11-14]. Some researchers reported that anthocyanins are the primary pigments present in the seed coat of black soybean varieties [3, 7, 8, 24]**.** The black pigmentation of the black soyabean hull is largely due to accumulation of anthocyanins in the epidermis palisade layer of the seed coat [18]**,** which could be extracted or separated into anthocyanin-rich fractions for use as functional colorants or functional food ingredients. The black soybean hull extracts can be added to foods or drinks or made into all kinds of oral health care products and oral medicaments used by conventional methods of preparing traditional Chinese medicine preparations. The products can remarkably surpass the symptoms of osteoarthritis and also can stabilize or even reverse the degradation of cartilage of osteoarthritis.
3. **Soy sauce:** Soy sauce is a fermented soybean condiment produced by *Aspergillus oryzae* and/or *Aspergillus soyae* molds [16] which originated in China 2,500 years ago. The fermented soyabean was made into paste and then further pressed to extract or yield liquid. This savory seasoning sauce is now widely used in both Oriental and American cuisine. Specific types of soy sauce popularly common are Shoyu, Tamari and Teriyaki.
4. **Tofu:** Tofu appeared in American supermarkets in 1980s and are usually served as desserts and side dishes as well as ingredients of soup. The extracted soymilk was coagulated (by salt or acid) and pressed to form tofu. Tofu can be stored up to 1 year with novel pasteurization and packing techniques.

5. **Soy oil:** Soybean contains about 20 % oil and the extracted oil from soybeans are refined and blended for different applications, most of them are served as dietary oil. Soy oil contains no trans-fat and is low in saturated fat. In term of unsaturated fatty acid, according to Deckelbaum & Torrejon**,** [4], soy oil comprises 21 % of the monounsaturated oleate, 55 % of the polyunsaturated linoleate and 8 % of the polyunsaturated linolenate.
6. **Miso:** Miso is a traditional Japanese fermented product using soybeans, rice, and/or barley with salt and molds which has a rich flavors and healthful benefits [23].
7. **Natto:** Natto is a traditional Japanese soybean product fermented with *B. subtilis*. When properly prepared, it has a slimy appearance, sweet taste and characteristic aroma. It is more easily digested than whole soybeans and is found in Asian and natural foods stores.
8. **Tempeh:** Tempeh is a traditional fermented soybean cake obtained from black or yellow soybean fermented with *Rhizopus oligosporus*. Tempeh is one of the most popular fermented foods in Indonesia, New Guinea and Sumatra. Because of its meat like texture and mushroom-like flavour, tempeh is well suited to Western tastes. It is becoming a popular food for vegetarians in the United States and other parts of the world.
9. **Lecithin**: Lecithin is extracted from crude soybean oil through the refining process. It is used as a natural emulsifier, lubricant, animal feed, pharmaceuticals, paints, and other industrial applications. Lecithin is nature's best emulsifiers that help blend materials that do not mix spontaneously or easily when combined. Soy lecithin's are often used in many bakery applications such as bread, buns and tortillas as it can extend shelf life and softness of bread products.
10. **Textured soy protein (TSP)**: It is made from defatted soy flour and are sold in a dried, granular form. It is used as a meat extender or analogue and can be added to a meal to increase its protein content. It has a texture similar to ground beef or other meat products and must be rehydrated with boiling water before use. TSP contains about 70% protein and retains most of the beans dietary fiber
11. **Soy cheese**: Soy cheese is made from soymilk and it has creamy texture making it an easy substitute for sour cream or cream cheese.
12. **Soy fiber (okara, soy bran, soy isolate fiber)**: Soy fiber such as okara, soy bran and soy isolate fiber are high quality, inexpensive sources of dietary fiber obtained from soyabean. Okara is a pulp fiber by-product obtained from soymilk, although the content of protein is less still the quality remains high. Soy bran is the fiber made from the outer covering of the soybean which is removed during initial processing. Soy isolate fiber also regarded or well known as Structured Protein Fiber (SPF) is soy protein isolate in a fibrous form.
13. **Soy flour**: Soy flour is made from roasted soybean and is finally grounded into a fine powder to produce flour. There are three kinds of soy flour mostly available, they are a) Three-fourths of natural or full fat contains the natural oils found in the soybean. It is a good emulsifier, stabilizer and helps in homogenizing of milk for cakes. b) Three-fourths of defatted flour has oil removed during processing, it help in maintaining the balance of essential amino acids which is required for overall development in our bodies, it adds moistness and expand shelf life in the dough nut and also act as a good agent for surface sealing and protein fortification. c) Three-fourths of lecithinated flour consist of flour where lecithin are added to it.
14. **Soy protein concentrate (SPC) and Soy protein isolates (SPI)**: SPC comes from defatted soy flakes which contain about 70% protein; they are usually bland as they are produced by extraction of soluble carbohydrates (sugars). Whereas SPI is formed, when protein is removed from defatted flakes which contains 92% protein which is the greatest amount of protein in all soy products. SPI is known as the most highly refined soy protein and are used for their functional properties such as emulsification or foaming.
15. **Soybean meal**: Three-fourths of soybean meal comprise of livestock feed and a major protein product in the world. Around 90-95% of total output of soybean meal is being used for livestock feed in the world. Other three-fourths are considered safe ingredient for cattle and poultry as it contains minerals, vitamins and pack with all the required essential amino acids.
16. **Yuba**: Yuba are made by lifting and then drying the thin layer formed on the surface of cooling hot soymilk, it is reported to contain high protein and is commonly sold fresh, half- dried and dried form. It is commonly used in U.S. and Asian food stores.

CONCLUSION

Black soyabean are regarded as the new emerging foods that have good composition which is promising one for fighting hunger, malnutrition and guaranteeing food and nutritional health securities for mankind. Black soyabean are well known to be processed into a variety of food that is healthy and adapted to its purpose. Moreover the food and medicinal trade are increasingly focus or attentive in fruits and

vegetables as it contains high bioactive anthocyanins for the manufacture of supplements with preventative and therapeutic uses. Therefore most of these soy products serve the purpose as they are inexpensive, nutritious, easy to make and also serve as an alternative source to nourish. Being a versatile crop, widening the field of research and producing many health benefiting products is to be encouraged and entertained for future purpose.

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