Eurasian Journal of Food Science and Technology 2020; Vol: 4, Issue: 1, pp: 41-53

Nutritive potentials of Soybean and its significance for humans health and animal production: A Review

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Abstract

Nutrition matters for every living thing and a complete diet with balanced nutrients is a canonic right for humans and animals. Agricultural products possess a substantial position to fulfill the requirements of both animals and humans. The soybean being a part of the Leguminosae family is a very renowned paltry source of protein in consecrated nature. Due to unique nutritional potentials, the usage of soybean in humans and livestock is very frequent. Soybean averts humans from different diseases and boosts up the milk, meat and wool production in animals. Besides many benefits, the soybean also begets some health upsbot and disasters. So this article particularizes the absolute composition, nutrition value, emoluments and drawbacks of soybean and permits the different researchers to explore more about soybean.

Keywords: Soybean, Golden Bean, Nutrition, Livestock, Human health.

Review article

INTRODUCTION

Agriculture is a very vast field for funding the economy of the world and provides beneficial foodstuff to humans. The animal production industry is an ultimate part of agriculture which yields many products for human nutrition and welfare. Globally, livestock contributes 40% value of agricultural productivity and secure food for more than 1.3 billion people like it is the fastest emergent part of the agricultural economy (FAO, 2017). With the provision of a row of food items, the animals also need a balanced and accurate diet for survival and management as humans required. In the animal industry, the feeding of animals is very obligatory for the production of meat, milk, egg, fiber and other fecund products. de Visser et al. (2014) reported that the European population acquires their major portion of protein from animals as 59% of the diet and other portions from cereals, vegetables, and pulses. So that is the reason the animals' protein and other animal products have symbolical importance in nutrition. In the living population (humans and animals) the nutrition affects health, welfare, physical fitness, and emotions and averts different diseases by providing natural immunity. Pond et al. (2004) stated that optimum animal production needs an equilibrium between all energy transfiguration and nutritional balance. The balanced nutrition of animals can be obtained by different vegetable meals, crops, fodder, crops residues and concentrate feeding either in plain or treated form.

Among the vegetables, the soybean and its products are cheap and the richest source of protein for the whole animal industry especially to accomplish the protein requirement. The soybean is a yellow vegetable protein grain that originates from China and spread all over the world as a cheap source of vegetable protein (nearly 48 to 50 %) with low-fat contents (Garcia et al., 1997). Belloque et al. (2002) reported that soybean use in animals is very communal due to its nutritional and functional possessions especially as meat extenders in animals. The use of soybean and its products is very common in the present generation due to its economical values and high nutritive values. The uncontrolled increase of the human population demands a high quantity and quality of nutrition from agricultural fields.

Ali et al. (2020) reported that the human population is expected to increase up to 9 billion in 2050, which will fashion a very austere pressure on the animal production industry in respect of food requirements. So to overcome the pressure of food scarcity, scientists are working to generate new varieties of animal feed and new breeds of animals with high production. Good human health is trusting on the consumption of milk, meat, egg, fruits and vegetables because they are the vital source of some indispensable and basic nutrients along with phytochemicals that decrease the risk of chronic disease. Soybean is also very eminent in use for compensating the nutrition value directly for humans and indirectly for humans through animal feeds. Yin et al. (2011) stated that the United States is on top number according to global soybean production with 206.4 tons in 2007 and Brazil, Argentina, China, and India are in descending order respectively. Asian countries are using soybean as tofu while other countries are highly using it as feeding for animals and it is also the most researched ingredient and most important part of animal nutrition. By keeping the excellent role of soybean and its products in animals and human nutrition fields, this review paper will give a trivial depiction about the significance of soybean nutritive values and its commercial uses for humans, animal production and health. We will try to describe every aspect of soybean and its products on the animal nutrition and production industry, which will be very helpful for the improvement of the human diet and uplift the economy.

Nutritional potentials and composition of Soybean

The *Leguminosae* family (beans, peas, lentils, peanuts, soybean, and fava beans) possesses high nutritional value and the soybean is a fundamental part of the household. *Leguminosae* family also called a *Fabaceae* family produces pod with seeds and 12,000-18,000 species are present in the *Leguminosae* family. These species contain climbers, shrubs, herbs, and trees but only a limited amount of plants is used as human feed and as forage for livestock. Legumes are thought to be the first plant cultivated by humankind as humans are consuming legumes as staple food back to as far as 5500 BC and it remained staple food in the world for over 10,000 years (Kouris-Blazos and Belski, 2016). Maximum legumes consumed by humans are grain legumes or food legumes known as peas, broad beans, lentils, soybean, lupins, sprouts, mung bean, green beans, and peanuts. Whereas only about 40 legumes are noteworthy in forage production includes alfalfa, clovers, trefoils, soybean, etc.

The legumes are valued cheap and a better alternative for meat, after cereals legumes are considered as the second most important food worldwide because they can be a good source of oil and traditional food (Maphosa et al., 2017). Soybean scientific name Glycine max and is the most important warm-season crop in the leguminous family. It is not only important as a protein source but also important as an oil crop (Yamaguchi, 2012). Wild soybean (Glycine soja) can be found in East Asia regions of the world but Glycine max is a cultigen from the same region (Dovring, 1974). It is cultivated in the different regions of the world especially for grain in Asia, South and North America. The production purpose of soybean is not only restricted for human consumptions or oil production nevertheless it is also grown to produce forage for grazing, haying and ensiling. Due to its high protein content, it can use alone or in a mixture to feed the livestock (Chang et al., 2012; Touno et al., 2014; Spanghero et al., 2015). With this point, soybean production was increased because soybean meal was used as a replacement protein source for the animal protein feeds (Dei, 2011).

Soybean is also called as the 'Golden Bean', it is an important food source in human food and animal feed. A single soybean seed on a dry weight base contains about 40% protein and 21% oil. Soybean with protein and oil content contains other major and minor components like phospholipids, vitamins and minerals. On the other side, soybean has biological active or minor substances such as trypsin inhibitors, phytates, oligosaccharides. The soybean has 5 most abundant fatty acids in the triacylglycerol of soybean. These are unsaturated fatty acids of linoleic acid (C18:2) and linolenic (C18:3), palmitic (C16:0), saturated fatty acids of oleic (C18:1) and stearic (C18:0) acids. These fatty acids could vary in type, composition and distribution which affect their nutritional quantity, flavor, oxidative stability, melting point, crystallization form and processing characteristics (Yadav, 1996). The soybean has minor components that include phospholipids, un-saponifiable material (tocopherols, phytosterols, hydrocarbons), trace metals and free fatty acids. The phospholipids are the main component in the soybean seed membrane lipid account in a total of 1-3% or 05-1.5% of soybean seed (Wang et al., 1997). Among this 1-3% phospholipids, there are also major and minor phospholipids such as phosphatidylcholine (35%), phosphatidylethanolamine (25%), and phosphatidylinositol (15%) are the major phospholipids whereas 5-10 % phosphatidic acid and the rest is a composite of all the minor phospholipid compounds (Liu, K., 1997).

In moisture-free soybean, the carbohydrates content is 35%, therefore, it is the third abundant component in the soybean seed and soybean carbohydrate has less importance than the soybean protein and oil content. Soybean seed contains about 11-25% soluble carbohydrates and these soluble carbohydrates are made from 15-20 different sugars (Obendorf et al., 2008) in which sucrose 1.1–7.4%, raffinose 0.1–1.4% and stachyose 1.2–6.9% is the most abundant (Obendorf et al., 2008; Kumar et al., 2010). With proteins, lipids and carbohydrates as major components soybean also contain minor nutrients which include phytate, phenolics and other minerals. It has 5% ash content, ash contains the major minerals as sulfates, phosphates, and carbonates. Among all the mineral potassium concentration is high following magnesium, sulfur, calcium, chloride, and sodium along with other minor minerals silicon, iron, zinc, manganese, copper, molybdenum, fluorine, chromium, selenium, cobalt, cadmium, lead, arsenic, mercury, and iodine.

Whole cultivated soybeans constitute major parts hulls, cotyledons, hypocotyl and plumule. Cotyledon of soybean comprises 90% with the highest percentage of both protein and oil. Hull comprises 8% of cultivated soybean, whereas hypocotyl is the only 2 percent. This composition of soybean and structure depends upon the variety, growing season, Drought, temperature, land, soil fertility, and agricultural practices (Kouris-Blazos and Belski, 2016). Proximate composition of a dry soybean seed contains approximately 40% protein and 20% oil which makes 60% of whole dry matter. Other remaining 40% dry matter is composed of main carbohydrates about 35% mainly poly-saccharides, stachyose (3.8%), raffinose (1.1%), sucrose (5.0%) and ash that is about 5% (Singh, 2010). Phosphatides, sterols, and other minor constituents are also present and this composition is not the same for the wet soybean.

Wet soybean contains protein and oil by about 35% and 17% respectively. Other carbohydrates and ash are 31% and 4.4% respectively. It has 13% water content to keep storage stability (Liu, 1997). Soybean seed proteins based upon the role can be classified into four classes like metabolic enzymes, structural (including ribosomal and chromosomal), membrane, and storage proteins (Krishnan, 2001). Metabolic enzymes and structural are considered as metabolic proteins and storage proteins are produced during soybean seed development. Soybean major protein part is considered as storage protein and it comprises the 65-80% of the total seed protein (Murphy, 2008). The storage protein of soybean is an exceptional source of dietary proteins for humans and animals excluding that this in sulfur-containing amino acids 13-conglycinin is very deficient (Fukushima, 1991).

Soybean and its products' worth in human nutrition and health

The practice of soybean in the human diet is healthy in response to prevent from different diseases like heart disease, obesity, blood cholesterol (Henley and McNiven, 1996) diabetes, kidney disease, and osteoporosis (Garcia et al., 1997). It contains the inhibitory activity of an angiotensin 1-converting enzyme (ACE) which very supportive to regulate water ratio and blood pressure and soybean is also a suitable diet for milk allergic infants.

Soybean can prevent some major diseases that happen in humans such as cancer because of isoflavones contains by soybean. Its high nutritional value is due to unsaturated fatty acids and these unsaturated fatty acids also have good effects on the human health like prevention of atherosclerosis, reduction of total and low-density lipoprotein (LDL) cholesterol and triacylglycerol levels in plasma, and suppression of inflammatory processes (Bahrami, 2009).

In soybean seed beside phospholipids, there are other minor components such as sphingolipids, glycosylceramide are the most abundant (Johnson et al., 2015). Both phospholipids and sphingolipids have convenient health effect as they both are bioactive components of soybean and the intake of sphingolipids can inhibit the development of colorectal and skin cancer, decrease plasma and liver cholesterol levels, and regulate immune cell function, whereas the consumption of phospholipids shows the reduction of serum cholesterol levels and fat accumulation in the liver of human body (Schmelz, 2000; Olivera and Rivera, 2005; Wang, 2008).

The soybean phytate is not available to humans and nonruminants animals as they have lacked the enzymes that synthesize the phytase enzyme (Oltmans et al., 2005). Some studies show that phytate also has some positive effects on the animals and humans and act as an anticarcinogen and an antioxidant by complexing iron and decreasing free radical generation and peroxidation of membranes (Ferry et al., 2002; Vucenik and Shamsuddin, 2003). Soybean isoflavones have a positive effect such as cholesterol-lowering effect making cardioprotective if they fed along with the soya proteins (Johnson et al., 2015). It has also suggested that isoflavones show a protective role against several cancers and osteoporosis (Weaver and Cheong 2005) but the link between soybean isoflavones and these diseases is still not clear.

Use of Soybean and its products in animal production Sector

Nutrition is a very mandatory part of animal production sector as it plays a dynamic role in milk production, animal health, disease resistance, good body score and proper growth of animals for intensification the economy of this sector (Kambara et al., 1993; Wallace et al., 1995). For example, lambs can enhance their resistance against Oesophagostomum columbianum and Trichostrongylus colubriformis by a decent supplementation of protein in nutrition. Soybean can also add up to the honey and pollen mixture, provided to bee larvae as feed to increase production and boosting of the immune system (Raghuvanshi and Bisht, 2010).

Soybean is a very rich source of protein as it's quite necessary for milk and meat production in the animal production industry. To compensate for the food need of the growing population, the use of new techniques and appropriate feed formulation for optimum growth of animals is very compulsory. During the feed formulation, the proper mix and balancing of diet nutrients according to the requirement of animals is the first goal. Soybean being a rich source of a cheap legume protein source is a basic component for a balanced animal diet.

Globally, in the animal feeds soybean meal (SBM) can be used as a major supplemental protein source. Fan et al. (1995) nominated the soybean meal as a superior source of protein and it gives almost 480 g/kg dry matter protein with excellent quality (Yamka et al., 2003). Soybean is the best legume for animal feeding and as a bypass protein source for dairy animals as it has the highest crude protein content (44.1%) shown from crude protein analysis and elevating milk production (Osti et al., 2013). The digestibility and composition of amino acid determine protein quality. It can be changed with the presence of different structural and non-structural components (carbohydrates) and processing conditions (Yamka et al., 2003). Due to its outstanding amino acid profile and elevated level of digestibility, soybean meal is a major protein source for animals. Along with the highest lysine digestibility (91%), soybean meal is a concentrated source of energy and protein with lower crude fiber than most of the other oilseed meals (Willis, 2003).

SBM (soybean meal) digestibility shows variability because of some unsuitable factors like the presence of oligosaccharides, tannins, phytate, lectins and trypsin inhibitors (Zuo et al., 1996). Due to its distinguished properties and a high source of nutrients, its use is very trendy nowadays in all fields of the animal production sector. Castro et al. (2007) specified that among all oilseed meals, the soybean meal is most useable for dairy animals of America and contains the highest quality of amino acids as compared to other oilseed meals. Several scientists (Mielke and Schingoethe,1981; Rafalowski and Park, 1982; Anderson and Wolf, 1984; DePeters et al., 1985; Drackley and Schingoethe, 1986) had elaborated about oilseed meals like soybean, cottonseed meal and sunflower meal are a big source of AA (amino acids) and fat for animals production (Ipharraguerre and Clark, 2005). Drackley and Schingoethe, (1986) also reported that feeding of extruded, heat-treated and roasted soybean with a mixture of sunflower meal give more balancing in a diet for rumen digestibility and increase milk production in dairy animals because this combination overcomes the shortage of lysine in sun-flower meal and methionine in soybean meal. This combination of diet increase milk production in early lactation of animals and enhance the amount of escape ruminal amino acid during feed digestibility.

The soybean meal is considered a high-value ingredient as compared to recent low glucosinolate rapeseed foodstuffs because it gives more balanced in essential amino acid contents. Koné et al. (2020) proposed a study on Guinea fowl by feeding soybean meal supplement partially substituted by 15% cashew nut (*Anacardium occidentale*) and 15 % hevea seed (*Hevea brasiliensis*) meal) separately and resulted with no adversative consequence on growth performance and carcass yield while cashew nut meal imposes a harmful consequence on performance like daily weight gain and feed conversion ratio. Digestible amino acids and protein absorption reduce by excessive feeding of soybean as it contains plant fibers and indigestible oligosaccharides that obstruct digestion enzymes and increase bacterial activity by resulting in the lower degradability of nutrients (Erdaw et al., 2018).

The use of fish meal affords a sympathetic pillar for balancing the ratio of amino acids when it mixes with soybean meal while its result is not very clear for sorghum, maize, oat and other cereals source of protein even it intensify the performance by mixing with soybean meal as compared to simple feeding of soybean meal. Fish growth and survival are enhanced by the use of soybean and maize in fish feed preparation (Solomon and Alasa, 2017). Krogdahl et al. (2000) stated that soybean meal (SBM)-encouraged enteritis in the distal intestine of the teleost Atlantic salmon (*Salmo salar L.*) and other salmonids may be considered a model for diet-related mucosal disorders in other animals and man.

For all types of the poultry industry, soybean meal is an ideal protein source and 50% of all soybean meal used in animal industries is consuming by the chicken meat industry as a major user (Willis, 2003). Soybean mixed with grain sorghum or corn provides a balanced source of essential amino acids except methionine needed by poultry. To increase energy density and to enhance the efficiency of feed utilization, oil extracted from soybeans is excessively used as feed grade fat to supplement soybean-based diets of broiler chickens and turkeys (Erdaw et al., 2016). Irish et al. (1993) reported that animal protein concentrates generate more abdominal fat content with a high rate of oily bird syndrome in broilers as compared to the soybean-maize protein source because it may help to enhance dietary amino acid balance.

The role of soybean against the production of pet feed is very significant as Linolenic acid and soybean proteins in full-fat soybean meal further improve the quality of mink's fur (Raghuvanshi and Bisht, 2010). Addition of fermented soybean reduced the serum insulin and leptin levels, indicating the effectiveness of fermented soybean addition as an anti-diabetic feed ingredient that alleviates hyperleptinemia in Rabbits (Sada et al., 2017).

In recent times, many nutritionists are focusing on soybean as a protein source for the Canine family. The use of soybean meal in canine food is very technical as it should not increase more than 150g/kg because it can decrease digestibility due to the presence of Oligosaccharide, soluble fiber and anti-nutritional contents (Yamka et al., 2003). Due to the high content of dietary fiber comprise of cellulose and pectin, soybean hulls have a huge potential to be used as a functional feed ingredient. Metabolizable energy intake in the diet and stereotypical and scratching behaviors of beagle dogs decreased by the addition of soybean hulls as a fiber source (Scheraiber et al., 2018).

The feeding of soybean meals and its other products is very up-to-the-minute nowadays for the feed of lactating animals. In dairy cow diets supplementation of soybean oil is effective in reducing saturated fatty acid and elevating the level of monounsaturated fatty acid content in milk (Park et al., 2020). The feeding heat-treated soybeans instead of soybean meal or raw soybeans, favored more milk (4.5 L/d), 3.5% FCM (4.0 L/d), and milk protein (0.09 kg/d) (Tiwari et al., 2018). Soybean lecithin oil in diets of lactating sow enhance the PC content along with phospholipid in milk and decrease the milk fat globule size. Soybean lecithin oil further improves the weaning weight of piglets, immunoglobulin plasma level, milk and colostrum (Shi et al., 2019). Replacement of soybean meal in lactating sow's diets by 10-15% fermented soybean remarkably elevates the nutrients digestibility and biological values and further enhance serum biochemical parameters along with the antioxidant activity of lactating sows and elevate the production performance of suckling piglets (Wang et al., 2016). By adding soybean oil, fat and energy content of diet increased which leads to the production of enriched fat CLA and TVA in milk compared with non-fat supplemented diet in goats. Miraj and Kiani, (2016) revealed that even though dry matter intake and growth rate decreased by the addition of 4% soybean oil in the diet, progesterone concentration and the number of goats with functional corpus luteum increased, indicating that soybean oil inclusion in diet stimulated puberty in prepubertal goats.

Worldwide, soybean supply two-third of the protein concentrates for animal feeds, over one-fourth of the fats and oils and three fourth of the total world trade in high protein meals. Untreated soybean meal feeding leads to intestinal morphological and physiological changes along with marked immune response in young piglets and calves (Peisker, 2001). In young animals preferably calves, milk proteins are replaced by soy proteins usually, 30% or less of the milk is replaced by soy proteins. In the United States round, about 70% of dairy herd replacement calves are being fed milk replacers (Endres, 2001).

Concerning disease resistance, soybean meal has a converse effect on parasites growth in young lambs as lower fecal egg counts were observed four weeks in Finn Dorset lambs with infection and no fecal egg counts in Scottish blackface lambs (Abbott et al 1991). Pond et al. (2004) denoted that supplementary soybean meals can intensify the immunity in animals, withstand power against infections (anemia, hypoproteinemia, and hypoalbuminemia), increase milk production and overall growth of animals.

The cultivation history and uses of soybean in the world are very old but in turkey (Black sea area), its cultivation had started after first World War as a first crop and production reached up to 10000-12000 tons, Later on, it was cultivated as a second crop in the Aegean and Mediterranean areas (Kibar and Öztürk, 2008). At present, the cultivation and uses of soybean for animal feed and human nutrition are very famous all over the globe due to its beneficial potentials. Now young farmers also need new techniques to formulated it with some others feeds for animal health improvement and better production. That is the reason for this subject, soybean is a very important legume protein and needs more research for its production, cultivation and uses as food and feed.

Some drawbacks of soybean

The feeding of protein source and balancing of nutrients in dairy feed is an art because nowadays is very common to feed protein for desire milk production and without pay any attention to its disasters like emissions of nitrogen in environment and impairment in animal reproductive performances (Nousiainen et al., 2004). Soybean seed contains storage proteins with some low-abundance proteins and these low-abundance proteins are accountable for the mobilization of stored nutrients also act as a defense against many micro-organisms and macro-organisms. These proteins also cause allergic symptoms like gastric reactions and atopic eczema in humans and animals due to some antimetabolic compounds present in these proteins (Herman, 2005).

In soybean, the isolated protease inhibitors are present as Bowman-Birk trypsin-chymotrypsin inhibitor and the Kunitz trypsin inhibitor along this other main protease inhibitor is a lectin and Protease inhibitor amount in the soybean seed at a considerable level can cause reduced digestibility or proteins and pancreatic hypertrophy in some animals whereas lectin disturbs the animal nutrient absorption system which inhibits the growth of the anima (Krishnan, 2001).

In soybean carbohydrates, raffinose and stachyose have gained the most attention because their presence is considered as antinutritional factors. They produce flatulence and abdominal discomforts in humans and animals (Liying et al. 2003). These factors especially flatulence is the major reason that is limiting the use of soybean as food. Raffinose and stachyose are galactooligosaccharides and mammals do not have the α-galactosidase enzyme required to hydrolyze galactooligosaccharides to D -galactose. When it is consumed by mammals it is not digested and these intact sugars go directly to the lower intestine where they get mobilized by the microorganisms that contain the enzyme results in flatulence producing gases such as methane, carbon dioxide and nitrogen, etc. (Kumar et al., 2010).

Besides its beneficial effects on human health still, soybean use as raw food is limited due to its antinutritional factors include isoflavones, trypsin inhibitor, phenolics and phytate (Sharma et al., 2014).

CONCLUSION

The maximum credit for a healthy life goes to appropriate and well-managed nutritional ingredients in diet and soybean has the unsurpassed name as a gigantic source of protein which encompasses more than 45% protein. The core determination of this review is to elaborate on the potential paybacks and some drawbacks of soybean and open the door for new researchers to find some new practices for optimal usage of soybean in the welfare of living things. The plant production sector can engender new varieties suitable for every region while animal production and health sectors can justify their work with appropriate use of soybean for meat, milk, fiber and wool production as well as for production of a healthy diet for human beings. This article delivers some universal subjects related to the practice of soybean that wishes unusual care to be solved. Overall soybean is the superlative source of protein for every living thing but its use needs some precise attention for high production and human health issues.

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