

# The Role of Soybean in Sustainable Poultry Nutrition: Review

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**Abstract:** The increased meat demand is a driver of poultry production which is expected to make up 39% protein source by 2030. This is because of its nutritional value, and also because there are no religious or cultural barriers hindering the production and consumption. The banning of animal products as a source of protein in the nutrition of animals in the EU, necessitates an alternative protein source. Soybean is considered as a source of plant protein in sustainable poultry production because it is relatively cheap and affordable. However, there is a high demand of soy products due to its relevance in both human and animals. The purpose of this work is to review the role of soybeans use as a major protein source in poultry nutrition. This work also focus on the prediction of future challenges in utilisation of soybean in animal diet such as Increase in price of feed ingredients due to competition between animal agriculture industries and bio-fuel industries, Demands of environmental regulations regarding animal feed production, due to nitrogen waste and phosphorus removal into the surroundings as a result of the use of soybean.

**Keywords:** Soybean, poultry, nutrition, protein, utilization, challenges.

## I. INTRODUCTION

The global demand for meat in the past 20 years was 173 million tonnes, of which 23% was poultry. The annual meat demand today is 285 millions tonnes globally, with 35% (approximately 100 million tonnes) from the poultry industry as shown in figure 1.1 (Rabobank, 2011). The increase in meat demand is the main driver for the increase in poultry meat production, making it the meat of choice globally. Consumers readily accept poultry meat due to its availability, versatile nature and its nutrient contribution in the diet (Garnaut, 2011). Compared to other meat, globally it is popular due to its low price, nutritional value and lack of religious or cultural barriers hindering the production and consumption (Magdelaine, *et al.*, 2008).

In anticipation of the need for a secure global food supply, there is the need to increase meat production by 40% and 70% by 2030 and 2050 respectively, to meet rising world population (OECD-FAO, 2009). Therefore, poultry meat is expected to become the most consumed meat type representing 39% of protein source consumed by 2030 (Rabobank, 2011). The efficiency of poultry meat production could possibly be the reason for the growth forecast (Garnaut, 2008).

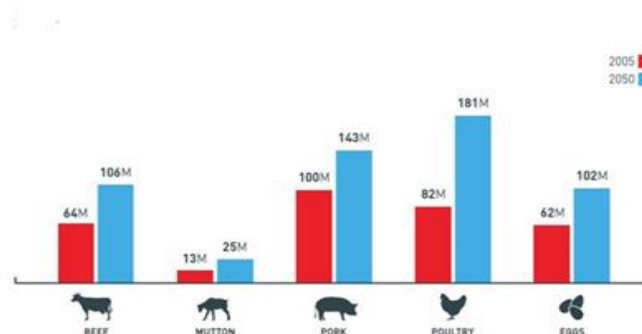


Figure 1: Global demand for meat 2005-2050 (FAO, 2009)

### Sustainable Protein source in poultry

Protein in the feed is an important component that contributes to high feed cost in poultry nutrition (Skinner, *et al.*, 1992). Plant protein specifically constitutes the second largest portion of poultry feed next to cereals but significantly contributes to dietary costs as it is an essential requirement. Plant and animal products are the most commonly known protein source in poultry production; the source of poultry protein supplied is dependent on the amount of essential amino acid, digestibility and level of ANFS (Scanes, *et al.*, 2004).

### Roles of plant protein feedstuffs in Poultry Nutrition

The ban on the use of protein from animal sources in poultry production in some countries, and the cost of its inclusion in feeds (TSER 999/2001; ABPR 1774/2002), necessitates the need to consider other alternatives. The use of plant protein sources is therefore a viable option that could be used in solving this issue. However, the choice of plant protein also depends on its source. Plant proteins are sometimes deficient in certain essential amino acids (Scanes, *et al.*, 2004), and a significant variation in the individual amino acid content of plants has also been reported. The use of plants as the only protein source may not be sufficient in meeting the nutritional requirement of an animal. Synthetic amino acid has been proved to increase the efficiency of feed conversion, lowering production feed cost and limiting the excretion of nitrogen (Cmiljanic, *et al.*, 2005). Synthetic amino acids have therefore been used to improve the utilisation of plant proteins with the benefit of reducing the cost of animal feed, and maximising meat production (Han and Lee, 2000).

### Soybean as ingredient for poultry feed

Soybean (*Glycine max*) is globally accepted as a high plant quality protein source for human and animal consumption as shown in figure 1.2. It is widely accepted due to its protein content and supply of amino acids; is relatively cheap and affordable; is available and abundant all year round and can be utilised in poultry diets if properly processed. Similarly, much focus has been on the use of soybean as a major source of protein that can be substituted for animal protein sources. However, it is deficient in some amino acids such as methionine, therefore the use of synthetic amino acids and enzymes help in improving its nutritional value (Liener, 1994).

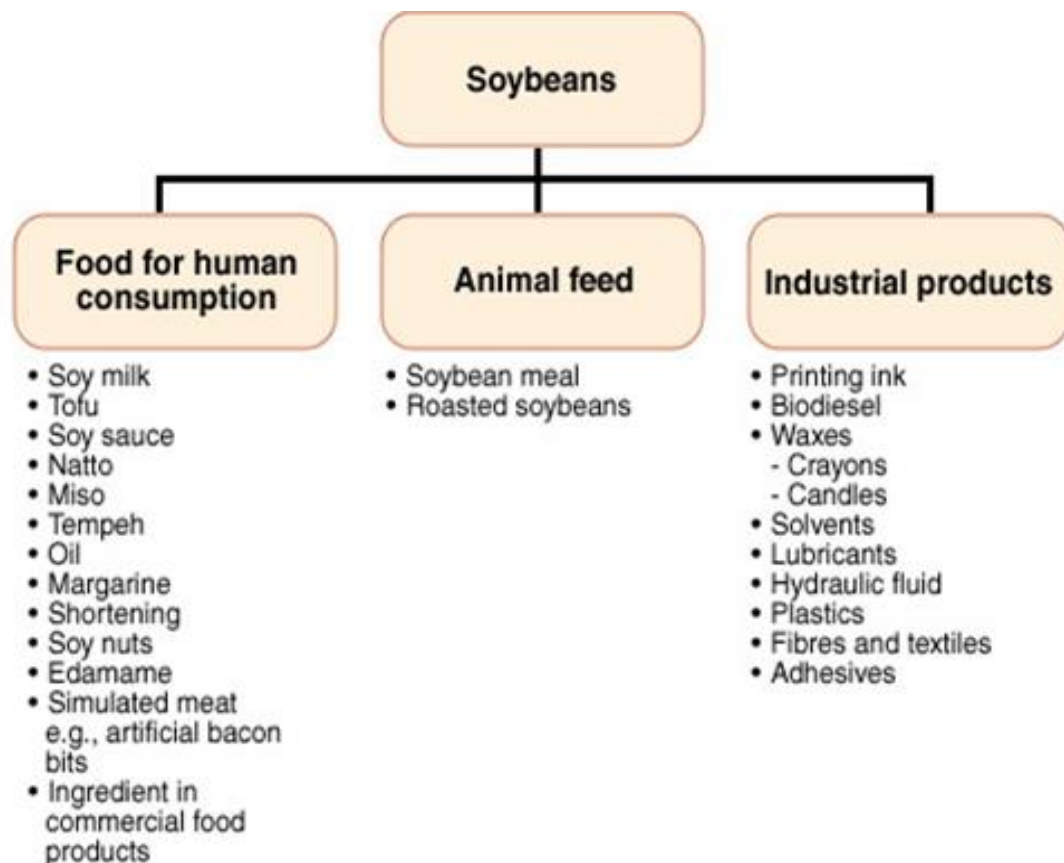


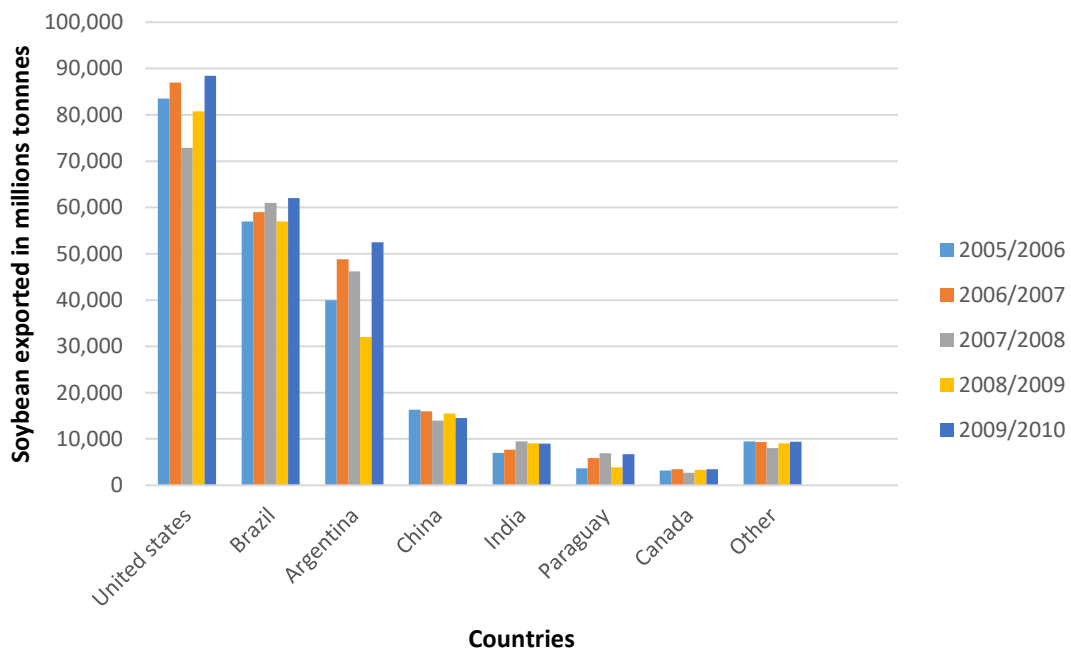
Figure 2. Global use of soybean in human and animal. SCCA (2007)

### Global soybean trend (production and consumption of soybean)

Soybean is a leguminous crop produced annually; it is known to originate from Asia. However, some European countries, as well as Argentina, Brazil and USA are known to be the highest soybean producers in the world (FAO, 2016). In 2016, the United States of America and Brazil were the world leading soy producers and exporters, with 42% and 26% as shown in table 1.1 and figure 1.4 respectively (FAO/USDA, 2016).

**TABLE 1. WORLD SOYBEAN SUPPLY (MILLION TONNES) AND DISTRIBUTION, BY COUNTRY  
FAO/USDA (2016)**

Major producing countries	2012	2013	2014	2015	2016/2017
United states	82,790	91,389	106,877	106,000	106,857
Brazil	65,848	81,724	86,760	96,000	96,500
Argentina	40,000	49,389	53,397	56,000	56,800
China	13,010	11,950	12,154	11,700	11,785
India	14,666	11,950	10,528	9,100	7,125
Paraguay	4,344	9,086	9,997	9,000	9,200
Canada	5,086	5,358	6,048	6,200	6,371



**Figure 3: Global soybean export. FAS/USDA (2009)**

### The processing of soybean products for animal feed

Different methods are used in processing soybean into different protein products. Anti-nutritional factors are eliminated or reduced by using different processing methods to improve the nutritional value for animal use. Processing methods have been used to improve the quality of the products, but the improvement depends on the method used (Araba, 1990); heating process has been identified as the only method that affects the protein quality of soybean. Although, Several processing method of grains such as bio- refinery has been proved to be effective in soybean processing, this is effective in deactivating the anti-nutritional factors, animal feed and fuel production (Burton, *et al.*, 2014) Anti-nutritive factors (trypsin inhibitors and lectins) can be rendered inactive when conditions such as moisture content, heating temperature and heating time are properly used (Araba 1990). However, using high processing temperature could denature the amino acid and protein content (Hurell, 1990; Parsons *et al.*, 1992).

### Full- fat soybeans

Full-fat soybeans are processed without the extraction of oil. They are produced using different methods such as extrusion (wet or dry), roasting or toasting, autoclaving or cooking and micronizing to deactivate the anti-nutritional factors (Dei, 2011). However, the impact of the above-mentioned processing methods on the value of the nutrient depends on the deactivation level of the anti-nutritional factors (Gu, *et al.*, 2010). Although defatted soybean meal is commonly used in poultry nutrition, there is an increase in the use of full-fat soybean in poultry feed formulation, due to the reduced quantity of anti-nutritional factors (Gu *et al.*, 2010). Similarly, full-fat processed soybean is considered good for poultry nutrition because of the fat content leading to high energy compared with solvent extracted soybean (Willis, 2003). Woodworth, *et al.* (2001) reported that the digestible and metabolised energy in full-fat soya is greater than in extracted soybean meal.

### Soybean meal

Soybean meal is the most common plant protein source used in formulating poultry feed. It has about 40-48% crude protein, depending on the process of oil extraction and the quantity of the hulls removed. It has a well-balanced amino acid profile compared to other oilseed plants and is considered favourable in poultry feed formulation (Ravindran, 2013). Nutritionally, plant protein sources are not balanced in some essential amino acids which could affect the supply of some amino acids for growth and performance in poultry. Animal protein source contain all the essential amino acids needed by the body, but are expensive, therefore animal protein is used to supplement plant-based protein rather than being used as the main source for commercial broiler production (Denton *et al.*, 2005; Akhter, *et al.*, 2008). Plant proteins are generally deficient in some essential amino acids such as methionine, therefore, animal protein sources such as fish meal and synthetic amino acids are in used in supplementing the deficient amino acids (Pear, 2002; Denton *et al.*, 2005).

### Soybean protein concentrates

The production of soybean protein concentrates is by the removal of carbohydrates. It can be achieved by ethanol extraction or enzyme degradation. Soybean protein concentrates are used in replacing milk in calves when dry and also as a pre-starter in piglets in the powdered form, due to the reduced oligosaccharides and antigenic content (Graham, *et al.*, 2002).

### Soy bean oil

The production of soybean oil is primarily for consumption by humans. However, it is now used as a dietary fat source as a result of high levels of energy feed by poultry production industries and nutritionists. This is because it is highly digestible and contains a high level of metabolisable energy compared to other sources of plant fats and oils. Soybean oil is used to formulate feed –grade fat for young turkeys and broilers to enhance consumption of feed (Sell, *et al.*, 1978). It is high in unsaturated fatty acid which increases its energy value, and is used by animals as an energy source (Huyghebaer, *et al.*, 1988). The high level of fatty acids in the soybean meal increases the independent energy effect required to improve reproduction of dairy cattle (Lucy, *et al.*, 1990 and Kerly and Allee, 2003). This is as a result of the role of linoleic acid content in soybean oil during reproduction (Staples *et al.*, 1998).

### Chemical composition of common soybean products used

Genetically, there are different biotypes of soybean which have different chemical composition (Gu, *et al.*, 2010), and soybean processing methods can also result in different chemical composition in soybean products as shown in Table 1.5 and this can affect the nutrient supply. Therefore, soybean can improve performance in monogastric animals when the anti-nutritive factors are eliminated, or the feed is properly formulated. To determine the use of soybean and the effect on growth performance, bioavailability, nutritive level and anti-nutritive factors should be considered (Gu, *et al.*, 2010).

**TABLE 2: PERCENTAGE COMPOSITION OF SOME SOYBEAN PRODUCT USED IN ANIMAL FEED. NRC (1994), INRA (2004), PEISKER (2001)**

	Full –fat soy	Soybean meal	Soy protein concentrate	Soy protein isolate
Dry matter	89.4	87.6-89.8	91.8	93.4
Crude protein	37.1	43.9-48.8	68.6	85.9
Crude fibre	5.1	3.4-6.3	1.7	1.3
Ether extract	18.4	1.3-5.7	2.0	0.6
Ash	4.9	5.7-6.3	5.2	3.4
NDF	13.0	10.0-21.4	13.5	-

ADF	7.2	5.0-10.2	5.4	-
ADL	4.3	0.4-1.2	0.4	-
Starch	4.7	3.3-7.0	-	-
Total sugars	-	9.1-9.3	-	-
Gross energy	20.95	17.22-17.41	17.89	22.45
Lysine	2.34	2.85-3.50	4.59	5.26
Methionine	0.52	0.62-0.80	0.87	1.01
Cystine	0.55	0.68-0.77	0.89	1.19
Tryptophan	0.49	0.56-0.74	0.81	1.08
Calcium	0.26	0.27-0.31	0.24	0.15
Phosphorus	0.57	0.64-0.66	0.76	0.65
Linoleic acid	9.7	0.6-2.9	-	-
Urease activity	2.0	0.05-0.5	<0.05	<0.05
Trypsin inhibitor mg/g	45-50	1-8	2	<1
Glycin (ppm)	180.000	66.000	<100	-
B-conglycinin (ppm)	>60.000	16.000	<10	-
Lectins ((ppm)	3.5000	10-200	<1	0
Oligosaccharides (%)	14	15	3	0
Saponins (%)	0.5	0.6	0	0

### Anti-nutritive factors

Anti-nutritive factors are natural compounds that affect nutrient utilisation and result in causing harmful effects to the performance of animals. Anti-nutritional factors in soybean have a negative impact on the nutritional quality, and those anti-nutritional factors of importance such as lectins and trypsin inhibitors can be eliminated or reduced by heating. The anti-nutritive factors (trypsin inhibitors) cause the enlargement of the pancreas and also hinder animal growth (Liener, 1994). Lectin also affects animal's growth by blocking the nutrient absorption. Lectin, trypsin inhibitors and other anti-nutritional factors of less importance can be eliminated using different processing methods (Araba 1990). For example, the anti-nutritive factors present in soybean, that inhibits the activities of protein enzymes such as lectins and trypsin inhibitors (Liener, 1994), can be destroyed by heat. However, such processing methods could negatively affect its nutritive quality.

Other anti-nutritive factors of less importance such as tannins, phytoestrogen, goitrogens, phytate, saponins and oligosaccharides are reduced by a small amount of heat-stable factors (Liener, 1994) with the exception of oligosaccharides. High amounts of phosphorus have been determined in soybean meal, but it occurs mainly in the form of phytic acid. Consequently, an increase of 50% phosphorus retention and 42% reduction in phosphorus excretion has been reported because of phytase use (Lei *et al.*, 1993), which has a negative effect on nutrient utilisation. Heat-stable anti-nutritive factors are of a lesser amount in soybean, and cannot cause problems when used as a feed ingredient. However the nutritive value of soybean protein concentrates has been improved when oligosaccharides are removed (Liener, 1994).

### Soybean utilisation in animal production

Species of farm animal feed contain and consume soybean includes poultry, aquatic animals, cattle and pigs are shown below.

**Table 3: Soybean utilisation in animal production. (USDA 1999/2000)**

Species	Millions metric tonnes	Percent of total
Poultry- broilers	12.36	44
Poultry – layers	1.88	7
Swine	6.69	24
Cattle-beef	3.45	13
Cattle-dairy	1.61	6
Pet animals	0.74	3
Aquaculture	0.18	1
Other	0.65	2
Total	27.56	100

**Future challenges in utilisation of soybean in animal diet**

1. Increase in price of feed ingredients due to competition between animal agriculture industries and bio-fuel industries, for instance, soybean meal and maize as by-products of ethanol and production of biodiesel (Kerley and Allee, 2003).
2. Demands of environmental regulations regarding animal feed production, due to nitrogen waste and phosphorus removal into the surroundings as a result of the use of soybean
3. Increase in the demand for oil from vegetables for biodiesel may lower the soybean production, favouring other oil-producing seed crops, with high production per hectare.
4. Pressure to improve the genetic make-up of soybean, with the aim of improving the nutritional value (Kerley and Allee, 2003).

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