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# Soybean as a Feed Ingredient for Livestock and Poultry

H.K. Dei
*Department of Animal Science, Faculty of Agriculture, University for Development Studies, Tamale, Ghana*

## 1. Introduction

The need to meet animal protein demand of ever growing world population, currently at approximately 6.8 billion (US Census Bureau, 2010), is set to increase at an even greater rate as the economies of developing countries improve and their growing affluent populace alter their dietary habits. This means production of soybean, which is used extensively as animal feed, must increase beyond current production level of about 246 million metric tonnes (FAS/USDA, 2009).

Soybean (*Glycine max,* L) is not only a source of high quality edible oil for humans, but also a high quality vegetable protein in animal feed worldwide. Its universal acceptability in animal feed has been due to favourable attributes such as relatively high protein content and suitable amino acid profile except methionine, minimal variation in nutrient content, ready availability year-round, and relative freedom from intractable anti-nutritive factors if properly processed. Also, attention has been focused on soybean utilisation as an alternate protein source in animal diets due to the changing availability or allowed uses of animal proteins coupled with relatively low cost.

Despite soybean's pivotal role in animal production, it cannot be fed raw because there are a number of anti-nutritive factors (ANFs) present that exert a negative impact on the nutritional quality of the protein. The main ANFs are protease inhibitors (trypsin inhibitors) and lectins (Liener, 1994), which fortunately can be destroyed by heat treatment. The trypsin inhibitors cause pancreatic hypertrophy/hyperplasia with consequent inhibition of growth, while lectins inhibit growth by interfering with nutrient absorption (Liener, 1994). The elimination of these ANFs and those of less significance can be achieved through various processing methods. These methods have different impact on the nutritional quality of the products derived such as full-fat soybeans, soybean meal and soybean protein concentrates. Of these, soybean meal has been the major ingredient in both poultry and livestock diets.

This chapter discusses soybean production and consumption, primary soybean products and their nutritional value for feeding animals, anti-nutritive factors present and ways of eliminating them, and utilisation in animal feeds as well as future challenges of using soybeans as a major source of animal feed.

## 2. Soybean production and consumption

Soybean (*Glycine max,* L) is an annual crop that belongs to the Fabaceae or Leguminosae family. It originated from East Asia, but now grown over a wide geographical area worldwide with United States of America, Brazil and Argentina being the leading producers (Table 1). It is used primarily for production of vegetable oil and oilseed meal for animal feeding. The surge in the use of soybean meal in feeding animal as replacement protein source for animal protein feeds has been the main driving force in soybean production.
Table 1 shows the major soybean producing countries and their relative supplies. Generally, there has been an increase of supply with a slight depression in most producing countries between 2006 and 2008 cropping seasons. The US and China tend to consume virtually what they produce, while Argentina and Brazil are major exporters with exports largely to the EU (Table 2).

| Major producing countries | 2005/06 | 2006/07 | 2007/08 | 2008/09 | 2009/10 October |
|---|---|---|---|---|---|
| United States | 83,507 | 87,001 | 72,859 | 80,749 | 88,454 |
| Brazil | 57,000 | 59,000 | 61,000 | 57,000 | 62,000 |
| Argentina | 40,500 | 48,800 | 46,200 | 32,000 | 52,500 |
| China | 16,350 | 15,967 | 14,000 | 15,500 | 14,500 |
| India | 7,000 | 7,690 | 9,470 | 9,100 | 9,000 |
| Paraguay | 3,640 | 5,856 | 6,900 | 3,900 | 6,700 |
| Canada | 3,161 | 3,460 | 2,700 | 3,300 | 3,500 |
| Other | 9,512 | 9,337 | 8,004 | 9,090 | 9,413 |
| World Total | 220,670 | 237,111 | 221,133 | 210,639 | 246,067 |

Source: FAS/USDA (2009)

Table 1. World soybean supply (million tonnes) and distribution.

| Countries | 2009/10 | | 2010/11 | |
|---|---|---|---|---|
| | Production | Consumption | Production | Consumption |
| China | 37.42 | 35.82 | 41.71 | 40.36 |
| US | 37.31 | 27.22 | 35.41 | 27.58 |
| Argentina | 27.13 | 0.70 | 29.95 | 0.60 |
| Brazil | 24.41 | 12.80 | 25.42 | 13.38 |
| EU | 9.85 | 31.49 | 9.77 | 32.30 |
| India | 4.85 | 2.85 | 6.08 | 3.08 |
| Others | 20.58 | 49.60 | 21.30 | 51.20 |
| World Total | 161.63 | 159.77 | 169.64 | 167.89 |

Source: FAS/USDA (2009)

Table 2. World soybean meal production and consumption outlooks for 2010/11 in million tonnes.

## 3. Primary soybean products for animal feeding

Figure 1 shows a schematic processing of soybeans into various high quality protein products. The processes involved either reduce or eliminate the ANFs in the beans and improve the nutritional value substantially for all classes of animals. Several steps involved in processing these products can have either positive or negative effect on the quality of the protein depending on the conditions used in processing. The heat applied in processing is identified as the single most important factor that affects soybean meal protein quality. Proper processing conditions such as moisture content, heating time and temperature inactivate ANFs such as trypsin inhibitors and lectins, which results in improved performance when fed to monogastric animals (Araba, 1990). High processing temperatures of oilseeds has deleterious effects on proteins and amino acids due to formation of Maillard reaction products (Hurell, 1990) or denaturation (Parsons *et al.*, 1992).

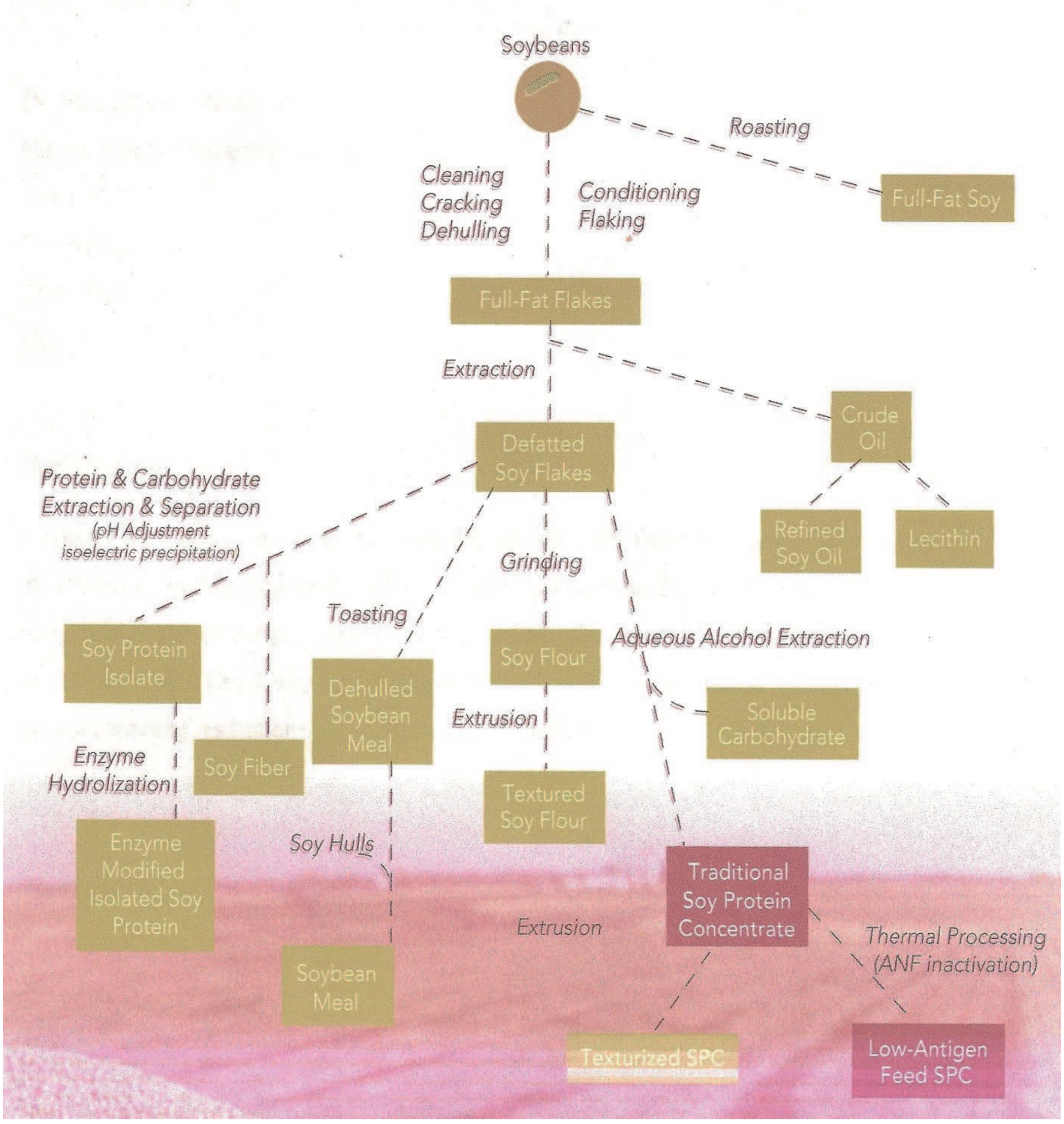


Fig. 1. Processing of soybeans into soybean products (USSEC, 2008).

### 3.1 Full-fat soybeans

These are whole soybeans in which the oil is not extracted. These products are produced by a variety of processes such as extruding (dry or wet), cooking/autoclaving, roasting/toasting, micronizing and jet-sploding to inactivate the ANFs. All of these processes have a different impact on the nutritive value of the products depending on heat damage or degree of inactivation of ANFs. Normally, soybeans are processed into defatted meals for feed formulation, particularly for poultry and pigs. However, the amount of full-fat soybeans used has been increasing in the livestock industry due to development of new varieties with limited number or levels of ANFs (Gu *et al*., 2010). Also, properly processed full-fat soybeans are a valuable feed ingredient for animal feeding because of their high energy content.

### 3.2 Soybean meal

Soybeans yield 18.6% of oil and 78.7% of soybean meal with the rest being waste (FEFAC, 2007). The oil can be extracted either mechanically or by solvent means. There are two main types of soybean meal. The dehulled soybean meal and soybean meal, depending on whether the testa (seed coat) is removed or not. Both products vary in their nutrient composition, but are quite high in protein content with a good amino acid balance except methionine, low in fibre, high in energy, and have little or no anti-nutritive factors when properly processed.

The amino acid profile of soybean meal is close to that of fishmeal, except methionine (INRA, 2004). This deficiency can easily be corrected in monogastric diets using synthetic source of methionine. Also, soybean meal is superior to other vegetable protein sources in terms of crude protein content and matches or exceeds them in both total and digestible amino acid content (Table 3a). Soybean meal protein digestibility in poultry is approximately 85% (Woodworth *et al*., 2001), ranging between 82% and 94% for individual amino acid digestibility. Among the vegetable protein sources, soybean meal is used to meet the animal's requirement for limiting amino acids in cereal-based (e.g. maize) diets (Table 3b), because it is usually the most cost-effective source of amino acids (Kerley and Allee, 2003).

The carbohydrates in soybean meal are incompletely digested by colonic microbiota in monogastrics (Kerley and Allee, 2003). Thus removal of raffinose and stachyose improved metabolisable energy content by 12% (Graham *et al*., 2002).

### 3.3 Soybean protein concentrate (SPC)

SPC is produced from the defatted flakes by the removal of the soluble carbohydrates. This can be achieved by two methods, either by ethanol extraction or enzymatic degradation (Figure 1). SPC is valuable as milk replacer feed for calves and as piglet pre-starter feed. This is because it contains only traces of the heat-stable oligosaccharides and the antigenic substances (Table 5). In milk replacer feed, it has been largely substituted for dried skim milk; whilst in pig starter feeds it can replace dried skim milk, whey powder and fishmeal.

### 3.4 Soybean oil

Soybean oil is produced primarily for human consumption. However, it has become a useful source of feed-grade fat for animals due to a need to formulate high-energy diets for modern breeds. Feed-grade soybean oil is popularly used in high energy diets, particularly for

| | Soybean | Canola | Cottonseed | Palm kernel | Peanut | Sunflower |
|---|---|---|---|---|---|---|
| Crude protein | 43.0 | 36.2 | 39.6 | 13.2 | 45.2 | 32.8 |
| Amino acid | | | | | | |
| Lysine | 90.7 | 78.6 | 62.8 | 58.9 | 78.1 | 80.4 |
| Methionine | 90.6 | 88.6 | 71.9 | 83.7 | 85.6 | 91.2 |
| Cystine | 82.1 | 73.1 | 70.9 | 66.6 | 78.5 | 79.2 |
| Threonine | 84.1 | 77.6 | 67.2 | 69.2 | 83.8 | 83.7 |
| Tryptophan | 87.9 | 80.0 | 80.3 | - | 75.6 | - |
| Arginine | 91.1 | 90.6 | 85.3 | 88.6 | 89.6 | 93.1 |
| Isoleucine | 91.2 | 89.0 | 72.8 | 81.0 | 89.3 | 88.9 |
| Leucine | 90.7 | 94.1 | 74.8 | 85.0 | 89.7 | 88.7 |
| Valine | 88.9 | 87.8 | 76.3 | 80.1 | 88.9 | 85.8 |
| Histidine | 88.5 | 88.5 | 64.1 | 80.3 | 85.4 | 86.1 |
| Phenylalanine | 91.6 | 91.6 | 84.0 | 85.3 | 92.3 | 90.8 |

Source: Ajinomoto Heartland Lysine LLC Revision 7 (2006)

Table 3a. True digestibility (%) of essential amino acids in common oilseed meal proteins for poultry.

| Amino Acid[1] | Soybean meal (475.0 g/kg CP) | Palm kernel meal (200.0 g/kg CP) | Maize (85.0 g/kg CP) |
|---|---|---|---|
| Arginine | 73.3 | 135.0 | 44.7 |
| Histidine | 26.9 | 23.0 | 27.1 |
| Isoleucine | 44.6 | 32.0 | 34.1 |
| Leucine | 78.7 | 60.0 | 117.6 |
| Lysine | 62.3 | 36.0 | 30.6 |
| Methionine | 14.1 | 20.0 | 21.2 |
| Cystine | 15.2 | 15.0 | 21.2 |
| Phenylalanine | 49.3 | 39.0 | 44.7 |
| Threonine | 39.4 | 35.0 | 34.1 |
| Tryptophan | 15.6 | 10.0 | 7.1 |
| Valine | 46.7 | 57.0 | 47.0 |

[1]Data are adapted from Elkin (2002).

Table 3b. Comparative amino acid composition (g/kg protein basis) of soybean meal with palm kernel meal and maize.

poultry, because of its high digestibility and metabolisable energy content compared with other vegetable fats/oils (Table 4a). It is used widely in rations for broiler chickens and growing turkeys as a feed-grade fat to increase energy density of feeds and improve efficiency of feed utilisation (Sell *et al*., 1978). The high energy value of soybean oil is attributed to its high percentage of (poly) unsaturated fatty acids (Table 4b), which are well absorbed and utilised as a source of energy by the animal (Huyghebaert *et al*., 1988). Also, the high polyunsaturated fatty acids (PUFA) in soybean oil appears to have an energy independent effect on improving reproduction in dairy cattle (Lucy *et al*., 1990; Kerley and Allee, 2003), and this has been attributed to the role of linoleic acid in reproduction (Staples *et al*., 1998).

| Source | Digestibility (%) | | Metabolisable energy (MJ/kg) | |
|---|---|---|---|---|
| | 3-4 weeks | >4 weeks | 1-3 weeks | 7.5 weeks |
| Soybean oil | 96[+] | 96[+] | 38.5* | 38.5* |
| Corn (maize) oil | 84[+] | 95[+] | - | 41.3[#] |
| Lard | 92[+] | 93[+] | 30.8*** | - |
| Beef tallow | 70[+] | 76[+] | 30.9* | 32.9* |
| Menhaden oil | 88[+] | 97[+] | 35.9[#] | 37.6[#] |
| Palm oil | 74** | - | 27.7* | 32.3* |
| Sunflower oil | 85**** | 88**** | - | 40.4[#] |

[+]Leeson and Summers (2001), *Wiseman and Salvador (1991), ** Zumbado *et al.* (1999), ***Huyghebaert *et al.* (1988), ****Ortiz *et al.* (1998), [#]NRC (1994)

Table 4a. Comparison of digestibility and metabolisable energy values of triglycerides in broiler chickens fed soybean oil and selected dietary fats/oils.

| Fatty acid | Soybean oil[2] | Palm oil[2] | Sunflower Oil[3] | Corn Oil[4] | Tallow[2] | Lard[5] | Poultry oil[4] |
|---|---|---|---|---|---|---|---|
| Lauric acid (C12:0) | 1 | 3 | - | - | 2 | - | - |
| Myristic acid (C14:0) | 2 | 14 | - | - | 23 | 16 | 6 |
| Palmitic acid (C16:0) | 161 | 488 | 60 | 112 | 249 | 224 | 232 |
| Palmitoleic acid (C16:1) | 6 | 1 | - | - | 39 | 21 | 71 |
| Stearic acid (C18:0) | 61 | 55 | 64 | 21 | 206 | 177 | 64 |
| Oleic acid (C18:1) | 251 | 364 | 284 | 269 | 405 | 461 | 430 |
| Linoleic acid (C18:2) | 452 | 73 | 581 | 579 | 66 | 80 | 179 |
| Linolenic acid (C18:3) | 66 | 2 | 1 | 8 | 10 | 21 | 6 |
| Arachidic acid (C20:0) | - | - | 6 | 5 | - | - | 2 |

[1]Values may not total 1000 g due to trace amounts of other fatty acids not reported or rounding of figures
[2]Wiseman and Salvador (1991), [3]Ortiz et al. (1998), [4]Waldroup et al. (1995), [5]Huyghebaert et al. (1988)

Table 4b. Comparison of fatty acid composition of soybean oil with selected dietary fats/oils (g/kg total fatty acids)[1].

## 4. Chemical composition of commonly used soybean products in animal diets

There are variations in the reported chemical composition of soybean products that can be attributed to differences in processing methods (Table 5). Also, genetic variations have been observed in the soybean biotypes of *Glycine* (Yen *et al.*, 1971; Gu *et al.*, 2010), which may vary in their chemical compositions. The use of soybean products in non-ruminant diets can give reasonable performance only if diets are formulated correctly or their anti-nutritive factors removed. In this regard, nutrient levels, bioavailability, and anti-nutritive factors and their effects on animal performance must all be considered in determining the usefulness of any of the soybean products as a feed ingredient. Table 5 shows composition of some soybean products commonly used in animal feed. It is clear that soybean is a source of high protein content and quality as well as energy with little or no ANFs. It appears the quality of soybean proteins improves when subjected to multiple processing procedures. This is shown by increases in concentrations of limiting essential amino acids such as lysine and methionine for monogastric animals (Table 5). However, the cost of such improved products may limit their use in animal feeds.

| | Full-fat soybean | 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 (MJ/kg) | 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 (pH-rise) | 2.0 | 0.05 - 0.5 | <0.05 | <0.05 |
| Trypsin inhibitor (mg/g) | 45-50 | 1 – 8 | 2 | <1 |
| Glycinin (ppm) | 180.000 | 66.000 | <100 | - |
| β-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 |

Data are adapted from NRC (1994), INRA (2004), Peisker (2001)

Table 5. Per cent composition of some soybean products used in animal feed.

### 4.1 Anti-nutritive factors

Anti-nutritive factors are natural compounds in feedstuffs that impair utilisation of nutrients with consequent undesirable effects on animal performance. The ANFs in soybeans exert a negative impact on the nutritional quality for animals (Table 6). Fortunately, those ANFs with significant impact such as trypsin inhibitors and lectins are easily destroyed by heat. Of lesser significance are the anti-nutritional effects produced by relatively heat stable factors, such as goitrogens, tannins, phytoestrogens, oligosaccharides, phytate, and saponins (Liener, 994). Heat stable ANFs with the exception of oligosaccharides and the antigenic factors are low in soybeans and not quite likely to cause problems under practical feeding conditions. The removal of the oligosaccharides and antigens in the manufacture of soybean protein concentrates further improves the nutritional value.

| Anti-nutritional factor | Mode of action | Method of detoxification |
|---|---|---|
| Protease inhibitors | Combines with trypsin or chymotrypsin to form an inactive complex and lower protein digestibility<br>Causes hypertrophy of the pancreas<br>Counteracts feedback inhibition of pancreatic enzyme secretion by trypsin | Heat treatment<br>Germination<br>Fermentation |
| Lectins (Phytohaemagglutinins) | Agglutinates red blood cells | Heat treatments |
| Anti-vitamin factors (rachitogenic factor and anti-vitamin B12 factor) | These factors render certain vitamins (e.g. vitamins A, $B_{12}$, D, and E) physiologically inactive | Cooking<br>Supplementation of vitamins |
| Goitrogens | Enlargement of the thyroid | Heat treatment in some cases<br>Administration of iodide |
| Metal-binding factors (phytate) | These factors decrease availability of certain minerals (e.g. P, Cu, Fe, Mn, Zn) | Heat treatment<br>Addition of chelating agents<br>Use of enzymes |
| Saponins | Bitter taste, hemolyze red blood cells | Fermentation |
| Estrogens | Cause an enlargement of the reproductive tract | |
| Cyanogens | Cause toxicity through the poisonous hydrogen cyanide | Cooking |
| Oligosaccharides | Impair digestion (e.g. intestinal cramps, diarrhoea, and flatulence) | Ethanol/water extraction |
| Antigens (glycinin and β-conglycinin) | Cause the formation of antibodies in the serum of calves and piglets.<br>Prevent proliferation of beneficial bacteria in the GIT | Ethanol/water extraction |

Sources: Liener (1977), Ensminger and Olentine Jr (1978), Peisker (2001)

Table 6. Anti-nutritive factors in soybeans.

Soybean meal contains high levels of phosphorus, but much of it is present in a complex form due to the presence of phytic acid. However, the use of phytase can increase phosphorus retention by 50% and reduction in excretion by 42% (Lei *et al*., 1993).

## 5. Utilisation of soybean in animal production

The major farmed animal species diets containing soybean include poultry, pigs, cattle and aquatic. The global animal feed production by species a decade ago included pigs (31%), broiler (27%), dairy cattle (17%), beef cattle (9%), layer (8%), aquatic (5%) and 3% of others (Hoffman, 1999). Thus soybean meal is used relatively more in some types of animal feed than in others. The major aim is to provide high quality protein to poultry and pigs.

Of all plant protein sources, soybean cultivation alone occupies most land needed for production of animal products. For example, soybean meal is used extensively in animal compound feed in the United States (Table 7a) and European Union (Table 7b). The annual EU livestock consumption alone demands soybean acreage of 5.0 million hectares in Brazil and 4.2 million hectares in Argentina (Table 7c).

| Species | Million metric tons | 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 |

Source: United Soybean Board (1999/2000)

Table 7a. Utilisation of soybean meal by livestock in the United States

| Type of animal compound feed | Production volume (1,000 tonnes) | Estimated soy bean meal content (%) | Volume of soybean meal in compound feed (1,000 tonnes) |
|---|---|---|---|
| Cattle – meat | 12,148 | 13.9 | 1,683 |
| Cattle – dairy | 27,852 | 10.4 | 2,893 |
| Pigs | 51,440 | 28.8 | 14,815 |
| Poultry – broilers | 30,929 | 36.8 | 11,389 |
| Poultry – layers | 15,532 | 22.4 | 3,477 |
| Other animals (e.g. sheep, goats, ducks, etc) | 9,522 | 16.6 | 1,577 |
| Total | 147,423 | 24.3 | 35,834 |

Source: PROFUNDO (2008)

Table 7b. Soybean meal used in types of animal compound feed in the European Union-27.

| Livestock product | Soybean Equivalent[1] (1,000 tonnes) | Acreage (ha) | Country of origin | Soybean Equivalent (1,000 tonnes)[1] | Acreage (ha) |
|---|---|---|---|---|---|
| Beef and veal | 1,557 | 595,519 | United States | 2,102 | 781,256 |
| Milk | 621 | 237,642 | Canada | 463 | 182,290 |
| Pork | 10,341 | 3,956,061 | Argentina | 11,450 | 4,240,559 |
| Poultry meat | 7,934 | 3,035,314 | Brazil | 12,789 | 4,995,608 |
| Eggs | 3,247 | 1,242,109 | Paraguay | 585 | 263,553 |
| Cheese | 1,156 | 442,402 | Uruguay | 53 | 26,319 |
| Other products | 2,764 | 1,057,330 | Other countries | 180 | 76,791 |
| Total | 27,620 | 10,566,377 | Total | 27,621 | 10,566,377 |

Source: PROFUNDO (2008) 1,000 tonnes of soybean meal = 771 tonnes of soybeans.

Table 7c. Soybean acreage needed for livestock consumption in the European Union-27 and by country of origin.

## 6. Future challenges of soybean utilisation in animal diets

Future challenges confronting soybean utilisation in animal diets have been discussed by Kerley and Allee (2003). The major challenges include the following:

- Increased demand for vegetable oil for biodiesel production may in turn reduce overall production of soybean in favour of other oilseed crops that produce more oil per acre. For instance, soybean produces about 36 litres of oil per acre compared to 72 litres of safflower, 84 litres of sunflower and 108 litres of canola (United Soybean Board, 2011). Even though the nutritional values of meals from these oilseeds are lower than that of soybean, the increased value of the oil may shift production to these crops at the expense of soybean.
- Competition between the bio-fuel industry and animal agriculture has increased the prices of feed ingredients with consequent increase in feeding cost. Also, by-products from ethanol and biodiesel production (e.g. distillers dried grains with soluble) are now competing with maize and soybean meal for their place in animal diets.
- Demands on animal production exerted by environmental regulations as a result of nitrogen waste, malodour and excretion of phosphorus into the environment by the use of soybean in diets.
- Pressures to improve nutritional value of soybean through breeding to modify aspects such as anti-nutritive factors, fatty acid profile, and oligosaccharide or protein synthesis in order to allow greater levels of soybean meal in animal diets.

## 7. Conclusion

Soybean is the major vegetable protein source in the animal feed industry. Its universal acceptability in animal feed is as a result of important attributes such as relatively high protein content and suitable amino acid profile except methionine, minimal variation in nutrient content, ready availability year-round, and relative freedom from intractable anti-nutritive factors if properly processed, limited allowable uses of animal proteins in feed and its relatively low cost. Therefore, its production and consumption will continue to grow as a preferred source of alternate high quality protein in animal diets.

Commonly used soybean products as protein source in animal feed are soybean meal, full-fat soybean and soybean protein concentrates, which are obtained through various heat processing methods that reduce anti-nutritive factors present such as trypsin inhibitors and lectins. Of these products, soybean meal is most preferred due to its relatively low cost. It is used extensively in feeds for poultry, pigs and cattle.

Soybean is also a major source of vegetable fat in animal feed. Feed-grade soybean oil is popularly used in high energy diets, particularly for poultry, because of its high digestibility and metabolisable energy content compared with other vegetable fats/oils.

Soybean production and utilization for animal feed is bound to face future challenges as a result of increased demand of vegetable oil for biofuel production; of which soybean is less competitive. There is also increased research to use co-products from biofuel production as substitutes for soybean meal in animal diets. Thus, there is a need to overcome these and other challenges in order not to jeopardise cheap meat production for ever increasing world population.

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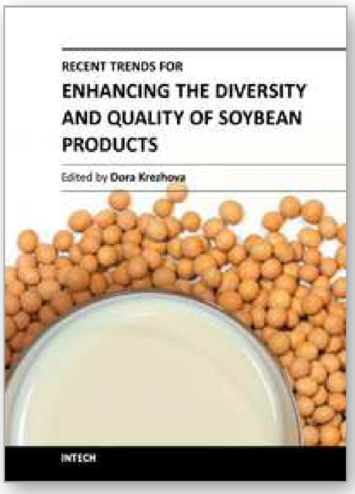


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This book presents new aspects and technologies for the applicability of soybean and soybean products in industry (human food, livestock feed, oil and biodiesel production, textile, medicine) as well as for future uses of some soybean sub-products. The contributions are organized in two sections considering soybean in aspects of food, nutrition and health and modern processing technologies. Each of the sections covers a wide range of topics. The authors are from many countries all over the world and this clearly shows that the soybean research and applications are of global significance.