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Soybeans (*Glycine max*) and Soybean Products in Poultry and Swine Nutrition

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1. Introduction

Soy is a legume and has been successfully cultivated around the world. Today, the world's top producers of soy are the United States, Brazil, Argentina, China and India. According Brazilian Association of Vegetable Oil Industries (Abiove), the Brazil is responsible for some 28 percent of the world's soybean production, with the estimate of a production of 57 million tons. The Brazil is the world's second largest producer and exporter of soybeans, soybean meal and soybean oil. The soybean complex, which gathers the productive chain of soybean, soybean meal and soybean oil, is the main item in the country's Trade Balance. Other activity that involves the use of soy products (oil) is the production of biodiesel.

In fact, so much in the Brazil as in most of the countries of the World, the soy represents one of the largest oilseeds of the world and to main source of vegetable protein for the poultry and swine feeding.

2. The nutritional composition of the soybeans and soybean products used in the feeding of poultry and swine

Soybeans and soybean products are now used widely in animal feeding. The crop is grown as a source of protein and oil for the human market and for the animal feed market. Soybean meal is generally regarded as the best of plant protein source in terms of its nutritional value. Also, it has a complementary relationship with cereal grains in meeting the amino acids (AA) requirements of farm animals. Consequently, it is the standard to which other plant protein sources are compared (Blair, 2008).

Soybeans provide an excellent source of both energy and protein for poultry and swine. As with any ingredient, their usage rate depends upon economics, although in the case of soybeans such economics relate to the relative price of soybean meal and of supplemental fats. Soybeans contain about 38% crude protein, and around 20% oil (Leeson & Summers, 2008). However, soybeans contain compounds that inhibit the activity of the proteolytic enzyme trypsin. They also contain other antinutrients, including hemagglutinins or lectins, which contribute to reduce nutrient use. Nutritional composition of the soybeans and soybean products is affecting by percentage of anti-nutritional factors (ANFs), variety genetic, efficiency of the oil-extraction process and the amount of residual hulls present, the heat processing and other factors.

2.1 Anti-nutritional factors (ANFs) and nutritional quality

The nutritional quality of soybean products for poultry and swine feeding is determined not only by the quantity of nutrients (protein, amino acids, fat and others), but mainly by nutrients availability for the animals. According Durigan (1989), anti-nutritional factor whole substance is synthesized by normal plant metabolism, which may result from different mechanisms to reduce the efficiency of utilization of the diet. The ANFs present in soybean can to affect the nutrients availability for poultry and swine.

Most of the ANFs present in the raw soybeans, as protease inhibitors and lectins is heat-labile, but others as phytic acid and polysaccharides non starch (PNS) only decrease with enzyme addition in diet, because poultry and swine has no ability to produce enzymes to degrade the PNS.

From Liener (1994), soybeans contain some heat-labile protease inhibitors and hemagglutinins. Soy also contains factors that are relatively heat-stable, though of lesser significance, such as: Goitrogens: substances that cause goiters, an enlargement of the thyroid gland; Tannins: complex plant compounds that are often bitter or astringent; Flatus-producing oligosaccharides: carbohydrates of small molecular weight that cause flatulence (gas); Phytates: which bind minerals preventing absorption; Saponins and Antivitamins.

This ANFs of soybean can cause inhibition of growth, decreased feed efficiency, goitrogenic responses, pancreatic hypertrophy, hypoglycemia, and liver damage in nonruminant animals depending on species, age, size, sex, state of health and plane of nutrition (Palacios et al., 2004)

2.1.1 Proteases inhibitors

Proteases inhibitors are substances that ability has to inhibit the activity of certain digestive enzymes (Durigan, 1989). They are polypeptides of 181 and 71 amino acid residues, respectively, which form well-characterized stable enzyme inhibitor complexes with pancreatic trypsin on a one-to-one molar ratio. The content of soya bean trypsin inhibitors varies in different varieties of soya bean and germination process (Bau et al., 1997). These are known as the Kunitz inhibitor and the Bowman-Birk inhibitor which are active against trypsin, while the latter is also active against chymotrypsin (Liener, 1994), because Bowman (1944) identified a protein in soy can inhibit trypsin and chymotrypsin and subsequently purified by Birk et al (1961), called Bowman-Birk inhibitor. It is a heat-stable protein, due to its large number of sulfur bridges. Later Kunitz (1945) identified and crystallized other protein, Kunitz trypsin inhibitor, which strongly inhibited the activity of digestive enzyme trypsin.

These protease inhibitors interfere with the digestion of proteins, resulting in decreased animal growth. Protease inhibitors stimulate protein synthesis and enzyme secretion from the pancreas. Inhibition of proteolysis, the presence of undigested protein in the intestinal tract, and a decreased release of amino acids in raw soy diets induce a compensatory reaction in the pancreas and a general stimulatory effect on other endogenous secretions

(Rackis & Gumbmann, 1981). The compensatory effect of the pancreas is effective since that the urease activity of the soy is in up to 0,20 (Butolo, 2010). The effect 8of hypertrophy of pancreas followed by a stimulation of its secretory activity can also result in an endogenous loss of the pancreatic enzymes, trypsin and chymotrypsin which are rich in the sulphur-containing amino acids, and thus accentuating the deficiency of methionine, being the first limiting amino acid in soybean (Johri, 2005)

Coca-Sinova et al. (2008) had evaluated the coefficient of apparent ileal digestibility (%) of DM, N, energy, and amino acids (AA) of the diet with different soybean meal (SBM) origin in broilers of 21 d of Age. They observed that digestibility coefficients were higher for SBM contained lower levels of TIA - trypsin inhibitor activity (1,8 mg/g), when compared with SBM with higher levels of TIA (4,8mg/g).

2.1.2 Lectins (haemagglutinins)

Lectins are glycoproteins with the ability to bind carbohydrate-containing molecules on the epithelial cells of the intestinal mucosa, with the property of agglutinating the erythrocytes of higher animals (Liener, 2000).) The cells of the intestine in the presence of lectin, tend to collapse by reducing the absorption (Butolo, 2010). According Fasina et al. (2004), when lectins are ingested by animals, they can be degraded by intestinal digestive enzymes or survive intestinal digestion and bind to enterocytes on the brush border membrane (BBM). However if bind, lectins may cause antinutritional effects such as disruption of the intestinal microvilli, shortening or blunting of villi, impairment of nutrient digestion and absorption, increased endogenous nitrogen loss, bacterial proliferation, and increased intestinal weight and size (Pusztai, 1993 cited by Fasina et al., 2004).

2.1.3 Goitrogens

The soybean and its products have been considered goitrogenic in humans and animals (Doerge et al., 2002)., because the acidic methanolic extract of soybeans contains compounds that inhibit thyroid peroxidase-(TPO) catalyzed reactions essential to thyroid hormone synthesis (Divi et al., 1997). Pigs feeding goitrogens (0.075% 1-methyl-2-mercaptoimidazole or .5% potassium thiocyanate) produced symptoms of hypothyroidism in a relative short period of time, usually 3 to 4 weeks with pronounced growth depression, but when the goitrogens were withdrawn from the diet, there was a marked increase in growth rate. The effects of goitrogens are more common in humans, mainly infants (Shepard et al., 1960), than in pigs, because the soybeans used in feed for pigs is generally thermally processed. the goitrogens of soybean can removed by heat treatment (Liener, 1970; Zhenyu et al., 2000).

2.1.4 Tannins

Tannins are complex plant compounds that are often bitter or astringent, they are naturally-occurring plant polyphenols which combine with proteins and other polymers such as cellulose, hemicellulose and pectin, to form stable complexes (Mangan, 1988). Egounlety et al. (2003) observed that the hulls were much richer in tannins than the whole soybean (2. 31 x 1.52 mg catechin equivalent/g). Soaking soybean for 12–14 h reduced the tannin content by 54.6%. No tannin was detected in dehulled and cooked and in fermented Soybean.

In contrast to the position with ruminant animals where tannins in the diet may have considerable benefits, and in plants where tannins give partial protection against predators, in simple-stomached animals, including man, tannins in the diet are generally undesirable, because they present effects as decrease of protein digestibility and reduction of the animal growth(Mangan, 1988).

2.1.5 Saponins

Saponins are steroid or triterpenoid glycosides, common in a large number of plants and plant products that are important in human and animal nutrition (Francis et al., 2002). Saponins have long been known to cause lysis of the erthrocytes when given in vitro. The hemolytic activity of saponins, coupled with this cholesterol inhibition effect, has been extensively used as a means of detecting and quantifying saponins in plant material. Such saponins activity results from their affinity for membrane sterols (Yoshiki et al., 1998).

Most listings of soybean antinutritional factors in the past included saponins, although with little or no justification. Toxicity was attributed to them simply by analogy with saponins from other sources that, in deed, are toxic (Anderson et al., 1995). Soyabean saponins did not impair growth of chicks when added at five times the concentration in a normal soyabean-supplemented diet (Ishaaya et al., 1969 as cited in Francis et al., 2002). Acording Yoshiki et al. (1998) no hemolytic activity in soybean saponin was observed, while 80% methanolic soybean extract had strong activity. As a result of detailed studies, the hemolytic compounds in soybean are indentified as linoleic acid and lipoxin, wich are secondary metabolitic products from lipoxigenase.

2.1.6 Antivitamins

There exists a fairly large category of natural substances that interfere with the utilization of certain minerals and vitamins. As examples, isolated soya-bean protein has been shown to interfere with the availability of such minerals as zinc, manganese, copper and iron as well as vitamin D (Liner, 1970) or other diverse but ill-defined factors appear to increase the requirements for vitamins A, B12, D, and E (Liner, 1994).

Raw soybean contains an enzyme lypoxygenase which catalyses oxidation of carotene, the precursor of vitamin A and can be destroyed by heating soybeans for 15 min at atmospheric pressure. Autoclaving of soybean protein or supplementation with vitamin D3 for about 8-10 times can eliminate the rachitogenic activity (Johri, 2005). Fisher et al. (1969) reported anti-vitamin E activity of isolated soy protein for the chick.

2.1.7 Olygosaccharides and polysaccharides non starch

Soybean carbohydrates make up approximately 35% of soybean (SB) seed and 40% of soybean meal (SBM) dry matter (DM). Approximately half of these carbohydrates are nonstructural in nature, including low molecular weight sugars, oligosaccharides, and small amounts of starch, while the other half are structural polysaccharides, including a large amount of pectic polysaccharides (Karr-Lilienthal et al., 2005). The fibre component of the grain consists primarily of nonstarchpolysaccharides (NSP) which in cereals form part of the cell wall structure. In legumes, NSP also play a role as an energy storage material. The role of fibre in monogastric diets has attracted much attention in recent years, due to the facts that (a) the soluble NSP elicit anti-nutritive effects (Choct, 1997). The components of non-digestible carbohydrates of a feedstuff are NSP, consisting of water insoluble cellulose and water soluble gums, hemicelluloses, pectic substances and mucilages (Mekbungwan, 2007) . Polysaccharides are plymers of monosaccharides joined through glycosidic linkages and are defined and classified in terms of the following structural (Choct, 1997). Choct et al. (1995)

showed that the addition of 40 g/kg NSP to a commercial broiler diet decreased the weight gain, feed efficiency and apparent metabolizable energy (AME) by 28.6, 27.0 and 21.2%, respectively.

According Smits & Annison (1996) the physicochemical properties of non-starch polysaccharides (NSPs) are responsible for their antinutritive activities in the poultry and swine. In particular, soluble viscous NSPs depress the digestibilities of protein, starch and fat. It is suggested that the gut microflora can mediate the antinutritive effects of soluble and viscous NSP. On the other hand, insoluble and non-viscous NSPs may have a beneficial effect. Hetland et al. (2004) reported that digestibility of starch is higher and digesta passage rate faster when a moderate level of insoluble fibre is present in the diet. The effect of insoluble fibre on gut functions stems from its ability to accumulate in the gizzard, which seems to regulate digesta passage rate and nutrient digestion in the intestine. NSP content of soybean meal is approximately 61 and 103 g kg-1 (dry matter basis) for soluble NSP and insoluble NSP, respectively (Bach Knudsen, 1997).

Choct et al. (2010) reported in review that non-digestible oligosaccharides can be fermented throughout all sections of the gastrointestinal tract including the large intestine, and the effects are most variation depends of specie. Soy oligosaccharides increased microbial activities as indicated by the increased volatile fat acids (VFA) contents and can cause intestinal disorder.

The α–galactoside family of oligosaccharides cause a reduction in metabolizable energy with reduced fiber digestion and quicker digesta transit time. Birds do not have an α-1:6 galactosidase enzyme in the intestinal mucosa (Leeson & Summers, 2008). Enzyme addition in diet for poultry and swine is most utilized for improve the nutritional value of soybean products. Zanella et al. (1999) found better body weight gain for broilers fed soybean meal (45% CP), extruded soybeans (38% CP) and roasted soybeans with addition of blend enzyme (xylanase, protease and amylase) ,when compared to without enzyme..

2.1.8 Phytate

Three terminologies, namely phytate, phytin and phytic acid, are used in the literature to describe the substrate for phytase enzymes. The most commonly used term, phytate, refers to the mixed salt of phytic acid (myo-inositol hexaphosphate; IP6). The term, phytin, specifically refers to the deposited complex of IP6 with potassium, magnesium and calcium as it occurs in plants, whereas phytic acid is the free form of IP6 (Selle & Ravindran, 2007). Historically, phytates have been considered solely as antinutrients because they are known as strong chelators of divalent minerals such as Ca^{2+}, Mg^{2+}, Zn^{2+} and Fe^{2+}. Moreover, phytates are also capable of binding with starch and proteins while preventing their assimilation through the digestive system (Afinah et al., 2010). The soybean meal present 0.34% of phytate the soybean has 0.34% of phytate which represents approximately 60% of the amount of total phosphorus (Kornegay, 2000). To improve the utilization of phosphorus and other nutrients complexed to phytate has been used in the enzyme phytase in diets for poultry and pigs. In Brazil more than 50% of poultry diets were formulated using phytase.

2.2 Soybean processing

Soybean processing is useful and necessary to destroy or remove undesirable constituents, make nutrients more accessible or to improve palatability. However, processing toward these ends also leads to changes in the composition of the various soybean materials compared with whole soybeans. These changes may be intentional, as in the case of heating to diminish trypsin inhibitor activity (Anderson et al.,1995). Although exist other options for reducing the antinutritional effects of soybean products, the cheaper and more efficient is heat-processing (Pusztai et al., 1997).

The most common procedures have involved a combination or extraction, cooking and fermentation. With soybeans, moist-heat treatment is particularly effective in reducing trypsin inhibitor activity below biological threshold levels, as determined by short-term animal bioassay. With present day manufacturing processes, residual trypsin inhibitor activity in edible-grade soy protein products is about 5-20% of the activity originally present in raw soybeans (Rackis & Gumbmann, 1981).

The heat necessary to destroy trypsin inhibitors and other hemagglutinins found in raw soybeans is dependent upon exposure time, and so high temperatures for a shorter time period are as effective as lower temperatures for longer times (Leeson & Summers, 2008).

In the 1930's, soybeans were mechanically processed using hydraulic or screw presses, which squeezed out the oil of the heated or cooked soybeans. In the late 1940's and early 1950's, most of the industry converted to the solvent-extraction process, which removes more oil from the soybean. Today, more than 99 percent of the U.S. processing capacity is using the solvent extraction process produced in large crushing facilities that produce meals of consistent high quality (Johnson & Smith, sd).

According Soybean Meal INFOcenter, the soybean products appear with the initial processes that included cleaned and dehulled and other three processes is used to separate the soybean oil from the protein meal. The first is solvent extraction, which is the one used most commonly around the world, uses hexane to leach or wash (extract) the oil from flaked oilseeds. This method reduces the level of oil in the extracted flakes to one percent or less. After this continuous pressing is performed at elevated temperatures, using a screw press to express the oil from ground and properly conditioned soybeans. The pressed cake is reduced to between 4 percent and 6 percent oil content by this method. At the end, dydraulic or batch pressing, this is an intermittent pressing operation carried out at elevated temperatures in a mechanical or hydraulic press after the soybeans have been rolled into flakes and properly conditioned by heat treatment. It is the oldest known method of processing oilseeds. According Butolo (2010), the industrialization flow for obtaining soybean oil, soybean meal or full fat soybean is divided into four distinct phases, which are shown in Figure 1.

A great processing variety exists, in table 1 sowed the composition of soybean feed ingredient products.

The quality of soya meal is the result of many factors, including bean variety, origin and storage. The various processing steps employed from the time the bean is received can affect the quality of the resulting meal and oil obtained. Heat treatment of the meal is essential to optimize its protein quality. The variables of moisture, temperature and time are interrelated and are important to achieve proper cooking conditions. The magnitude of these variables must be determined for each plant, preferably using a biological assay for evaluation. Many in vitro tests designed to measure protein quality in soya have been proposed and evaluated (Wright, 1968). Simple crude protein or amino acid assays provide information on the protein, but do not provide useful information on the quality of the protein. Chemists have used trypsin inhibitor analyses, urease activity, protein solubility in potassium hydroxide, protein solubility in water and dye binding methods to assay for protein quality (Johnson & Smith, nd).

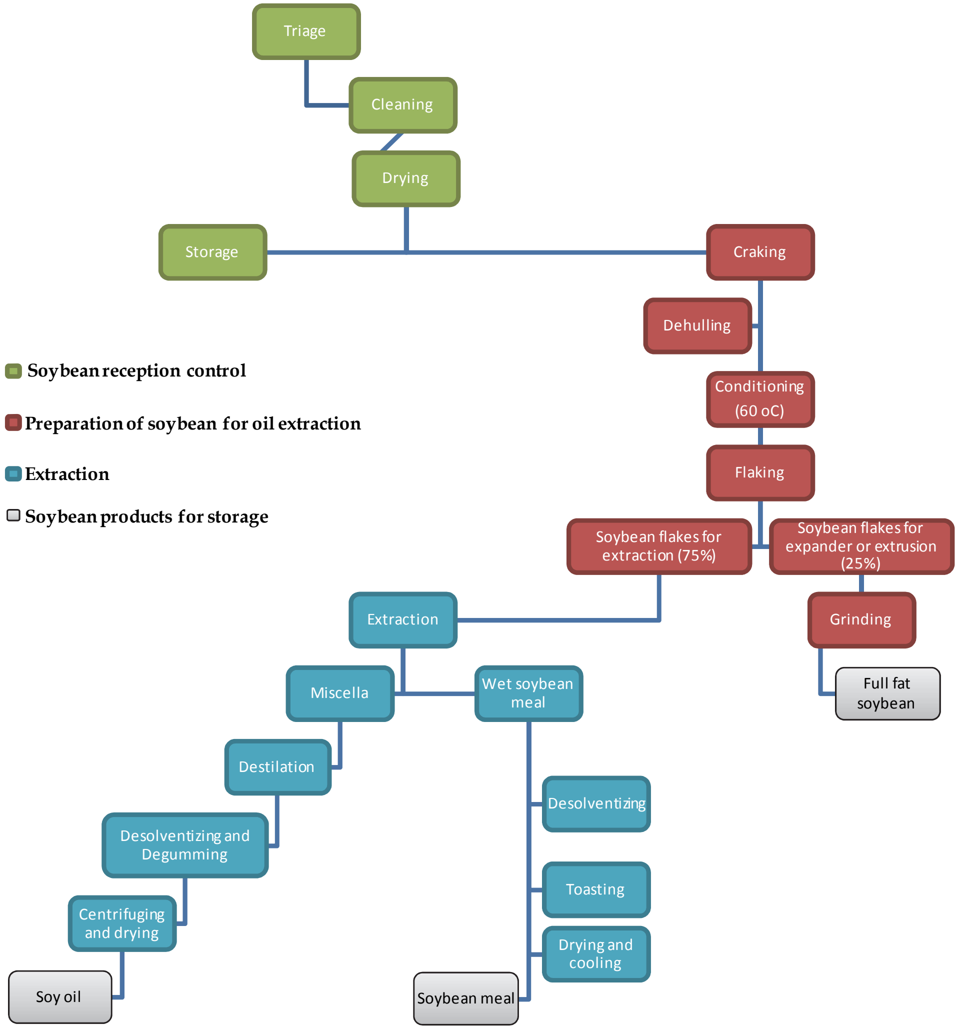

Fig. 1. The simple flowchart of soybean processing (Adapted of Butolo, 2010).

Inadequate heating fails to completely destroy the ANFs, which may have a detrimental impact on animal performance, while excessive heating reduces the availability of lysine via the Maillard reaction and possibly, to a lesser extent, of other amino acids (Caprita et al. 2010). While processed beans should be periodically tested for trypsin inhibitor or urease levels, a simple on-going test is to taste the beans. Under-heated beans have a characteristic 'nutty' taste, while over-heated beans have a much darker color and a burnt taste. The problem with overheating is potential destruction of lysine and other heat-sensitive amino acids (Leeson & Summers, 2008).

Nutrient profile	**Full-fat extruded soybean**	**Soybean meal (48%)**	**Soybean protein concentrate**	**Soybean Hulls**	**Soy oil**
Dry matter (%)	90.47	88.21	89.88	88.80	99.60
Gross energy (Kcal kg^{-1})	4938	4164	4495	3854	9333
Starch (%)	6.70	3.00	-	-	-
Fat (%)	17.64	1.40	0.43	2.86	99.60
Crude fibre (%)	6.24	4.27	2.64	33.00	-
Crude protein(%)	37.00	47.90	62.92	13.50	-
Arginine(%)	2.71	3.50	5.32	0.81	-
Lysine (%)	2.23	2.92	4.07	0.89	-
Methionine + cystine (%)	1.08	1.37	1.90	0.39	-
Threonine (%)	1.47	1.86	2.60	0.51	-
Triptophan (%)	0.47	0.64	0.87	0.14	-
Calcium (%)	0.23	0.31	0.27	0.49	-
Av. Phosphorus(%)	0.17	0.21	0.27	0.05	-
Potassium(%)	1.67	2.11	2.18	-	-
Poultry					
Metabolizable energy (Kcal kg^{-1})	3429	2302	2677	871	8790
Dig. Arginine(%)	2.54	3.31	5.12	0.64	-
Dig. Lysine (%)	2.02	2.70	3.75	0.59	-
Dig. Methionine + cystine (%)	0.93	1.21	1.67	0.21	-
Dig. Threonine (%)	1.29	1.66	2.29	0.25	-
Dig. Triptophan (%)	0.43	0.58	0.79	0.09	-
Swine					
Digestible energy (Kcal kg^{-1})	4250	3540	4035	2370	8600
Dig. Arginine(%)	2.52	3.31		0.68	-
Dig. Lysine (%)	1.99	2.66		0.53	-
Dig. Methionine + cystine (%)	0.93	1.23		0.26	-
Dig. Threonine (%)	1.28	1.62		0.31	-
Dig. Triptophan (%)	0.40	0.57		0.09	-

Table 1. Nutrient profile of soybean products for poultry and swine nutrition (From Rostagno et al., 2005).

The most widely adopted method more economical and faster is the measurement of urease activity (urease test or urease index), however difficult the correlation of the protein solubility in KOH. Levels of the enzyme urease are used as an indicator of trypsin inhibitor activity. Urease is much easier and cheap to measure than is trypsin inhibitor and both molecules show similar characteristics of heat sensitivity. Two analytical methods for urease test were described, the first is based on ph difference in which 200 mg of sample (soybean or soybean product) is incubated in 10.0 ml of phosphate buffered urea solution at 300C for 30 minutes, after which the increase in pH units (ΔpH) from pH 7.00 is recorded (Palić et al. 2008; Butolo, 2010). The second is based a simple colorimetric assay in which urea-phenol-red solution is brought to an amber color by using either 0.1 N HCl or 0.1 N NaOH. About 25 g of soybean meal is then added to 50 ml of indicator in a petri dish. After 5 minutes, the sample is viewed for the presence of red particles. If there are no red particles showing, the mixture should stand another 30 minutes, and again if no red color is seen, it suggests overheating of the meal. If up to 25% of the surface is covered in red particles, it is an indication of acceptable urease activity, while 25 – 50% coverage suggest need for more detailed analysis. Over 50% incidence of red colored particles suggests an under-heated meal (Leeson & Summers, 2008). But urease index is not useful to determine excessive heat treatment since additional heating has no effect on the urease index (Caprita et al. 2010).

The KOH protein solubility test is based on the solubility of soybean proteins in a dilute solution of potassium hydroxide. The procedure involves the incubation of a sample with a 0.2% KOH solution for 20 min at room temperature. Following this incubation, the sample is centrifuged and the supernatant is analyzed for the protein concentration. The solubility of the protein, expressed as a percentage, was calculatedby dividing the protein content of the KOH extracted solution by the protein content of the original soybean sample (Caprita et al. 2010). KOH protein solubility is a better indicator of overprocessing than underprocessing of soybeans (Batal et al., 2000). In table 2 are shown the levels of urease activity and protein solubility in potassium hydroxide acceptable in most soybeans processing.

Protein Dispersibility Index (PDI) can be used to measure protein quality. According Butolo (2010) to determine the protein dispersibility index should be mixed 8g of soybean meal with 150ml water, then it is centrifuged to 8.500ppm for 10 minutes, filter and determining the soluble nitrogen by the Kjeldahl method. Batal et al. (2000) indicated that PDI demonstrates more consistent response to heating of soyflakes than did urease index or protein solubility in KOH, because the urease index is not linear and that it rapidly falls from approximately 2.0 units of pH change to near zero as SBM is heated contributes to the difficulty in determining a precise maximum acceptable.

Degree of soybean processing	Urease test (pH change)	KOH Protein solubility (%)
Under-processed	> 0.20	90
Normal	-	85
Adequately processed	0.05 - 0.20	77-80
Over-processed	-	< 77

Table 2. Globally accepted relation between the degree of soybean processing for urease activity and protein solubility in potassium hydroxide (from Palić et al. 2008; Butolo, 2010).

Nitrogen Solubility Index (NSI) is other methods can be used for determines protein quality. It uses a slow stirring technique. Nitrogen is extracted from the ground flour by placing approximately 1.5 g into a 200 ml beaker and adding 75 ml of 0.5% KOH. The sample is stirred 20 minutes at 120 rpm. PDI and NSI are a more consistent and sensitive indicator for monitoring both underheating and over-heating of SBM (Caprita et al. 2010).

It is very important whether the assessment process quality of soybeans for the animal is unlikely to have decreased performance.

2.3 Storage and genetic variety

The storage and genetic variation are factors that can alter the nutritional composition of soybean as well as the performance of monogastric animals. Narayan et al., (1988) found that chemical characteristics, moisture content, fat, water-soluble nitrogen (WSN), nitrogen solubility index (NSI), sugars, trypsin inhibitor activity, available lysine, pigment and lipoxygenase activity of seeds decreased during storage whereas non-protein nitrogen (NPN), extent of browning, free fatty acid (FFA) content and peroxide value are increased.

According Cromwell et al. (2002) the rate and efficiency of weight gain, scanned backfat and longissimus area, and calculated carcass lean percentage were not different ($P > 0.05$) for pigs fed diets containing conventional or genetically modified, herbicide (glyphosate)-tolerant soybean. For poultry, Taylor et al. (2007) concluded that the diets containing soybean meal produced from genetically modified (GM) glyphosate-tolerant were nutritionally equivalent to diets containing soybean meal produced from the control and conventional reference soybean varieties when fed to broilers.

Other genetically modified soybeans were study for Palacios et al. (2004) that compared the growth performance of chicks and pigs fed diets containing modified soybeans: Kunitz trypsin inhibitor-free (KF), lectin-free (LF), lectin and Kunitz trypsin inhibitor-free (LFKF), conventional soybeans (CSB), and commercially obtained, dehulled, solvent-extracted soybean meal (SBM). They verify that Chicks fed diets containing any of the raw soybean varieties gained less weight than did chicks and among the raw soybean treatments, there was a greater effect on growth performance by removing both lectins and Kunitz trypsin inhibitor (LFKF), than by removing each antinutritional factor separately. Feeding raw soybeans to chicks decreased average daily gain (ADG) by 49% for CSB, 37% for KF, 38% for LF, and 27% for LFKF compared with the ADG achieved by chicks fed SBM. For to pigs deprecreased ADG by 78% for CSB, 60% for LF, and 35% for LFKF compared with the ADG achieved by pigs fed the same variety but extruded. This results and others (Brune et al., 2010; Becker-Ritt et al., 2004; Vasconcelos et al., 1997) prove that variability in the amounts of these components (proteases inhibitors and lectins) can be affect by cultivars differences.

As observed, there seems great potential for reduction in content of anti-nutrients within GM soybeans, as studies have shown that the isogenic variant lacking the Kunitz trypsin inhibitor and other soybean variants low in Kunitz trypsin inhibitor are nutritionally superior to conventional raw soybeans but not as good as commercial soybean meal. Others genetic improvements in reducing the phytate-bound phosphorous, and reduction or elimination of oligosaccharide carbohydrates are the most important economical traits that are being researched

3. Soybean products for poultry and swine nutrition

3.1 Soybean meal and full fat soybean

Soybean meal is the most popular source of supplemental protein in livestock feeds (Table 3). That popularity derives from its nutrient content, its relative freedom from intractable antinutritional factors, and other issues (Pettigrew et al.2002).

Many studies are conducted comparing the inclusion of soybean meal with other soy products or other protein source, and where the animals fed soybean meal has a better perform in most cases. In general, full-fat soybeans may replace soybean meal in swine and poultry diets with similar performance anticipated. The decision on which soybean product to use needs to be based on the product's composition, availability and unit costs. Bertol et al. (2001) observed that substitution of 50% of soybean meal by full-fat extruded soybeans, texturized soybean protein and concentrated soybean protein in the weaning diet, promoted better performance, with additional 1 to 2 kg of body weight gains per piglet at the end of the nursery phase.

Protein Source	Million Metric Tons	Percent
Soybean meal	152.1	66.5
Rapeseed meal	30.7	13.5
Cottonseed meal	14.4	6.3
Sunflower meal	12.2	5.3
Palm kernel meal	6.1	2.7
Peanut meal	5.9	2.6
Fish meal	5.3	2.3
Copra meal	1.9	0.8
TOTAL	228.6	

* Soy Stats (2010)

Table 3. World Protein Meal Consumption*.

Micronizing is the name given to a cooking process that uses infrared rays to cook cereals and pulses at lower temperatures and for shorter times than other heating methods. Gas burners are used to generate the infrared rays that are absorbed by the products. The raw materials are passed under the burners on variable speed belts to achieve the desired level of "cook". The product is then passed through a roller mill to create flakes. These flakes can be used whole or ground into a meal (MMfeeds). The increase available energy and improve digestibility are both achieve due to the gelatinisation of starch molecules during the cooking process. Trindade Neto et al. (2002) observed that pigs fed micronized soybean takes more days to reach 50 and 90 kg of body weight when compared with those fed soybean meal.

3.2 Soybean hulls

Soybean hulls, due to their high fiber contents, are known to be poorly digested by non-ruminant animals. Recent studies, however, suggest that the hulls have potential as an alternative feed ingredient for swine and poultry. The soybean hulls can be included up to 10 and 12% for growing or finishing pig diets, respectively, replacing the wheat bran on a weight basis without any adverse effects on palatability of diets and animal performances (Chee et al., 2005). However, Moreira et al. (2009) not recommend the use of soybean hulls to piglets due reducing daily feed intake and daily weight gain for the animals fed feed containing soybean hull (15% inclusion in the diet) compared to the control feed without soybean hull.

Esonu et al. (2005) studing laying hens, found that inclusion of up to 20% soybean hulls, improves the Feed cost/dozen eggs, and when cellulolytic enzyme supplementation at 30% dietary level of soybean hull meal in layer diet could not significantly affect the performance of laying hens.

Currently, it is very common the use of soybean hulls in programmers of feed restriction and welfare of breeders and laying hens.

3.3 Soy protein isolates

Soybean protein concentrate (or soy protein concentrate) is the product obtained by removing most of the oil and water-soluble non-protein constituents from selected, sound, cleaned, dehulled soybeans. The traded product among 650 to 900 g/kg CP on a moisture-free basis. Soybean protein isolate (or soy protein isolate) is the dried product obtained by removing most of the non-protein constituents from selected, sound, cleaned, dehulled soybeans. Both soy protein concentrate and isolate have the potential to be used in poultry diets as a source of protein and AA (Blair, 2008). In Table 4 are showed broilers performance when feed with different soybean products in diets.

Protein source	Weight gain (g)
Casein	364 b
Soybean meal	405 a
Soy protein concentrate	356 b
Soy protein isolate	366 b

Batal & Parson (2003)

Table 4. Effect of protein sources on weight gain of chicks(week 0-3).

3.4 Soy oil

Soy oil has found many food uses due to its excellent nutritional qualities, widespread availability, economic value and wide-use functionality. Soy oil is a highly concentrated source of feed energy. Its caloric value is the major reason for its increased use.

Gaiotto et al. (2000) evaluated performance of broilers fed diets containing 4% supplemental fat from the sources: soybean oil (SOY4), beef tallow (TAL4), acidulated soapstock (SOAP4), mixtures 2%:2% (SOAP2/TAL2), (SOAP2/SOY2) and (SOY2/TAL2), and confirmed the superiority of soybean oil relative to the other fat sources fed to broiler and demonstrated that the quality of acidulated soapstock and beef tallow may be improved when used in 1:1 mixtures with soybean oil.

For laying hens Costa et al. (2008) evaluated soy and canola oil, and they observed better results for those characteristics were obtained as soybean oil increased. However, the egg mass conversion was negatively influenced by increase of canola oil. The addition of soybean oil promoted better performance as compared to canola oil.

For swine, Mascarenhas et al. (2002) evaluated the effects from two lipid sources (soybean oil and coconut oil) on performance from 60 to 100 kg boars and they observed that diets with coconut oil as lipidic source showed the best results of weight gain.

4. Conclusion

The benefits of the use of soybean and soybean products can be observed in the nutrition of poultry and swine, but it is very important to know the factors that affect the composition of the same ingredients for that may be included in adequate amounts without reducing animal performance.

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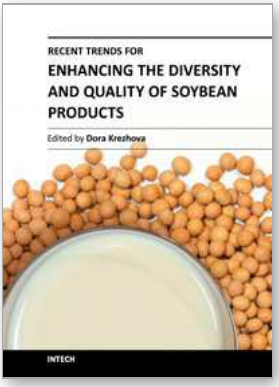

Recent Trends for Enhancing the Diversity and Quality of Soybean Products

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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.

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