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Review Article

ANTINUTRITIONAL FACTORS IN SOYBEAN MEAL AND ITS DEACTIVATION

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Introduction

Soybean meal (*Glycine max* L.) is the principle protein source for monogastrics. It represents two-thirds of the total world output of protein feedstuffs, including all other major oil meals and fish meal (Oil World, 2010). Soybeans represent 55% of the total global production of oilseeds followed by rapeseed (14%), cottonseed (10%), peanut (8%), sunflower (9%), palm kernel (3%), and copra (1%). Globally, about 98 percent of soybean meal is used as animal feed. Compound of its amino acids is excellent for most species of poultry and when they are mixed with corn, usually only methionine can be limiting amino acid. Amount of protein in soybean meal may be affected by variety and method of oil extraction. Usually, meals containing higher rate of protein would be produced from sell-less seeds; although meals with lower percent of protein (44% of crude protein) would be produced from scaly seeds with higher rate of fiber and metabolizable energy.

Soybean Meal:

The soybean products used in animal feeding are full fat soybean meal, solvent extracted soybean meal, solvent extracted with high protein soybean meal, expeller processed soybean meal and soya hulls (Monari, 1996; Van Eys *et al*., 2004). Soybeans contain several anti nutritional factors (ANFs). Some ANFs of nutritional significance can be destroyed or inactivated by proper heat treatment (eg. Trypsin inhibitor) and some by supplemental enzymes (NSP enzymes, phytase), while others are unaffected by the methods applied now commercially.

Antinutritional Factor in Soybean Meal:

The ANFs present in the raw and processed soybean are protease inhibitors 45-60 mg/g CP and 4-8 mg/g CP; Lectins 50-200 mg/g and 50-200 mg/g; Glycinin 150-200 mg/g and 40-70

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mg/g; β-conglycin 50-100 mg/g and 10-40 mg/g; Saponins 0.5% and 0.6%; Oligosaccharides 14% and 15%; Phytic acid 0.6% and 0.6% (Van Eys *et al*., 2004).

Trypsin Inhibitors:

Trypsin inhibitors are Kunitz factor and Bowman-Birk factor (Winiarska-Mieczan, 2007) found in raw soybeans that inhibit protease enzymes in the digestive tract. They reduce trypsin activity (a protease enzyme secreted by the pancreas) and, to a lesser extent, chymotrypsin (Norton 1991), and, therefore, impair protein digestion by monogastric animals and some young ruminant animals (Leiner, 1994).

Feeding raw soybeans to monogastric animals like poultry and swine is not recommended as the presence of trypsin inhibitors and lectins will result in stunted growth, reduced feed efficiency and pancreatic hypertrophy (Leiner, 1994). Plant breeders have successfully developed lines of soybeans that are devoid of Kunitz inhibitors. This has reduced the amount of processing required to treat this type of soybean (Liener and Tomlinson, 1981). Eliminating the Bowman-Birk inhibitors from soybeans has proven to be more difficult (Livingstone *et al*., 2007) but progress is being made and commercial varieties devoid of trypsin inhibitors will likely be developed in the future. Trypsin inhibitors are sensitive to denaturation by heat treatment. The vast majority of soybean products used for livestock feeds are heat-treated in order to eliminate any anti-nutritional effects associated with feeding raw soybeans.

The activity of these inhibitors in soybean products may be decrease by toasted or heated processes. The right warming up of soybean and its products eliminate above 90% of antitrypsin activity. The animals of several species differently react on trypsin inhibitors in feeds. Goslings and chickens are more sensitive on the present trypsin inhibitors than piglets and calves. There are a new cultivars of soybean in which the level of trypsin inhibitors were reduced to 10mg/kg of seeds (Kulasek *et al*., 1995).

Lectins:

Lectins are glycoproteins capable to agglutinate erythrocytes and bind sugar components. Lectins are not broken down in the gut, attach to mucosa cells damaging the intestinal wall and reducing the absorption of nutrients (Pusztai, 1991).

Lectins are heat sensitive and are therefore only present at residual levels in soybean products. Heat treatment to inactivate antinutritional factors in soy products is less efficient for antigen than for trypsin inhibitors or lectins (Van Eys *et al*., 2004). The level of soy lectins can be estimated by measuring the hemagglutination activity.

Goitrogenic factors:

These, similarly, are glycosides belonging to the isoflavinic group, some of which like genistin; have goitrogenic activity resulting in enlargement of the thyroid gland and a reduction in the activity of thyroxine secreted by the thyroid itself.

Saponins:

Although they appear in low levels they can decrease feed palatability.

Rachitogenic factors:

These factors are associated principally with genistin (about 0.10% of raw soybeans) which interfere with calcification of bone. Turkeys are particularly sensitive.

Phytic acid:

Phytic acid complexes with certain minerals - such as calcium, phosphorus, magnesium, copper, iron and zinc - reducing their bioavailability. Levels of phytate in soybeans range from 1.0 - 2.3 percent.

Phytates and oligosaccharides are not destroyed by the heat treatment.

Antigens:

The two most important antigenic proteins in soybean are glycinin and β-conglycinin. The level of glycinin and β-conglycinin can be measured by a specific competitive inhibition ELISA using anti-soy globulin (Heppell *et al*., 1987).

Protein quality:

Protein quality is a function of the amino acid profile and the proportion of each amino acid that is available to the animal. When soybean meals are intended for monogastric feeding it is well known that proper heat processing has a dramatic positive effect on amino acid digestibility, consequence of the destruction of anti-nutritional factors. However, over-heating can result in a decrease in both concentration and digestibility of several amino acids, especially lysine. The reduction in digestibility is due to the Maillard reaction which binds free amino acids to free carbonyl groups (i.e., from carbohydrates). The Maillard reaction-end products are not bio-available for all livestock species.

Several methods used to determine protein quality of soybean products for monogastric species are urease index, KOH protein solubility, protein dispersability index (PDI) and nitrogen solubility index (NSI).

Urease Index:

The primary purpose of the urease assay is to determine if soybean meal has been sufficiently heated to destroy most of the anti-nutritional factors. Urease index values of 0.05 to 0.2 pH

rise are considered for properly processed soybean meal (Dudley-Cash, 1999). Values above 0.2 indicated under-heating and values below 0.05 indicated over-heating. But it is not useful to determine excessive heat treatment.

KOH protein solubility:

Raw soybean and well heat processed soybean products should have a protein solubility around 90%. KOH solubility is a good index for determining over processing of soybean meal, but it is not a sensitive index for monitoring under processing of soybean meal.

Protein dispersability index (PDI):

Determination of PDI is the best method of evaluating soybean for both under heating and overheating. The PDI method measures the amount of soy protein dispersed in water after blending a sample with water in a high-speed blender.

Nitrogen Solubility Index (NSI):

The water solubility of soybean protein can also be measured with a technique called Nitrogen Solubility Index.

The two methods differ in the speed and vigor at which the water containing the soybean product is stirred. In animal nutrition the PDI method is used.

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