USE OF DIFFERENT SOYBEAN PRODUCTS IN THE DIET OF DIFFERENT CATEGORIES OF ANIMALS

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Abstract

The soybean content 18 different amino acids necessary for all: humans and animals equally. It chemical content is approximately: 35-50% proteins, 18-24% oils, 34% carbohydrates, 5% minerals (K, P, S, Ca, F, Mg, Na), vitamins – A, B-complex, D, E, K. But except many positive characteristics it has one negative, it has not been used raw, thermal unprocessed, because of present of proteins, which bind the enzyme protease. So they avert activation of trypsinogen – that why they are called trypsin inhibitors which are really chemical block protease. With this blockade in mammals illeal stopped digest of proteins. That why soy must be thermal processed. There are different ways of processing of soybean and are produced many various products: full fat soybean semolina, soybean concentrate or isolate (depleted), soybean meal, flour and oil. One of the most used ways of processing is extrusion. With this process is make the various changes on nutritional content.

The content of that products determinate their usage: full fat soybean semolina is use in feeding of weaned piglets, calves and young chickens, but not more than 10%, soybean concentrate or isolate for bigger piglets only till 20% in feed, like how depleted semolina of soybean (and soybean meal) for growers, fish, shrimps, mother sows, hens, dairy cows, bulls with% of raw proteins till 44% with portion most till 20%.

Key words: soybean, varieties, extrusion, soybean products, feed, animals

INTRODUCTION

Today worldwide, for cultural type soybean, the scientific and professional community, most commonly used Latin name for soybeans is *Glycine Max (L.) Merrill*, which is determined by Richer and Morse (1948), cited by Hymowitz and Singh (1987), (Mihajlov, 2000). World Mayor soybean producers are United States, with areas of about 31 milion hectares (mil.ha), followed, Brazil with 23.5, Argentina 18, China 9, India 9, Paraguay 2.75 and the other states with 8.07 mil. ha. Highest obtained average yield of grain achieves United States with 2.89 t/ha, Argentina 2.78 t/ha, Brazil 2.77 t/ha, Paraguay 2.36 t/ha, in the other states 1.8 t/ha, China 1.69 t/ha and the least yields are obtained in India 0.98 t/ha, (Soya & Oilseed Bluebook, 2011). Windish (1981) described the efforts of pioneers in popularizing soybean cultivation. Hybrid cultivars were developed from imported cultivars during the 1940's. Since then, tremendous progress has been made and further selection and hybridization efforts have continued. Soybean meal has currently become the most important source of plant proteins in the diets of monogastric animals, especially for poultry. The multinational corporations involved in promoting poultry production all over the world using their hybrid chicks recommend similar dietary patterns relying heavily on soybean meal (Vohra & Kratzer, 1991). The processed grains of soybean, also can use for human nutrition, because of it good quality and composition. The soy's proteins contents eight essential amino acids which is necessary for nutrition of humans and animals, because they do not appear by natural way in their bodies. Different cultivars differ in amino acid profiles (Bajjalieh et al., 1980). Except for human nutrition, soybean is used in production of animal food, for feeds, but also and for green meal in combination with cereals – for production of green soybean flour and for silage. Soybean also has very big agrotechnical meaning.

In spite of many positive characteristics, soya has also one negative, soy's kernel cannot use raw, thermal unprocessed. In raw soybean are contain some proteins, which bind the enzyme protease and so they avert activation of trypsinogen, that why, they are called trypsin inhibitors which are really chemical block protease (Read & Haas, 1938; Ham & Sandstedt, 1944; Bowman, 1944; Ham et al., 1945; Kunitz, 1945; Borcher et al., 1947, 1948; Almquist & Merrit, 1952; Birk & Gertler, 1961; Birk et al., 1963; Liener & Kakade, 1980), cited by (Vohra & Kratzer, 1991). Trypsin inhibitors also included a few more protease inhibitors: hemagglutinin or lectins (Liener, 1951; Pallansch & Liener, 1953; Jaffe, 1980), cited by (Vohra & Kratzer, 1991), estrogens (Carter et al., 1955; Booth et al., 1960; Naim et al., 1974; Wada &Yuhara, 1964), cited by (Vohra & Kratzer, 1991), saponins (Wolf, 1966; Gestetner et al., 1966; Fenwick & Oakenfull, 1981), cited by (Vohra & Kratzer, 1991), and urease (Caskey & Knapp, 1944), is also present in raw soybeans, but it is doubtful whether they are deleterious to monogastric animals. With this blockade in mammal's duodenum, stopped digest of proteins, and result is state of weakness or death in animals because of lack of proteins in nutrition of these animals. Raw, fat-extracted soybean meal is tolerated by mature birds and does not cause any depression in egg production or hatchability (Carver et al., 1946), especially when it is supplemented with methionine (Fisher et al., 1957, 1958; Saxena et al., 1963; Summers et al., 1966; Waldroup et al, 1969) cited by (Vohra & Kratzer, 1991). However, full-fat soybeans are not as well utilized as fat extracted meal (Waldroup et al., 1985; Atteh & Leeson, 1985).

Initial studies on the nutritive value of soybeans were done on rats. Osborne & Mendel (1917), and Hayward et al. (1936), observed that full-fat or fat-extracted raw soybean meal inhibited growth of rats and growth inhibition was overcome in cooked or heat-processed soybeans. Pigs also grew better on diets containing heat – processed soybeans rather than raw soybeans (Robison, 1930; Vestal and Shrewsbury, 1932; Hayward et al., 1935). Similar results were reported for growing chickens (Wilgus et al., 1936; Hayward et al., 1937).

By the way of processing and characteristics, in the industry for production of ingredients for feed, mostly are produced two different types of soybean semolina: full fat and depleted, which have different use. Extruded soybean semolina is high value raw material in production of feed, characteristic by its high nutrition and biological value. It has been produced with extrusion, and offer maximum usage of proteins, fats and carbohydrates. During the extrusion antinutritients have been inactivate and harmless. Extruded soybean semolina (full fat and depleted) is protein-energetic additive in the nutrition of young animals which enzyme system of digestive organs is still unsatisfactory developed for complete usage of nutritients of plants feed, like and for animals in grower, for whom is ideal compound, which in spite source of proteins, should provide and big energetic value. Except this, the taste is better, the dispersion of the most delicate compounds in the meal is prevent, the need of using fats are eliminate, which bring many difficulties (precise dosing, homogenization etc.). Extruded feed based on soybean is very good also because of bigger percentage of utility and digestivity of proteins and fats. Soybean semolina is on the first place by content of Ca, P and carotene on 1 kg of feed, relate with other cereal meals. Average content of all 18 amino acids in soy's proteins if bigger in full fat soybean semolina, compare with depleted semolina, like all other sorts of feed produced from soya. Investigations are done with goal to determinate characteristics of full fat and depleted semolina produced by extrusion and to find their adequate usage in feed industry for various categories of animals.

MATERIALS AND METHODS

It has been analyzed samples of raw soybean grain of 5 varieties of soybean (3 foreign – Lana, Balkan and Gorshtak, and 2 domestic: Ilindenka and perspective line of soybean MMK), with aim for production of compounds for fodder feed. Of all 5 varieties, there were determinate characteristics (chemical composition) of raw soybean grain, also of full fat and depleted semolina of soybean. The process of preparation of soy grains for animal feed and for subsequent chemical analysis is conducted through the application of specific technological procedure„extruding". Extruding the term should be understood HT/ST (high temperature/short time), extrusion cooking (HT – high temperature, ST – short time), which means processing on the device in which is mixed the material, transported, heated, placed under pressure and is subject to mechanical friction in the cylinder of the extruder (Hrustic et al., 1998). The mentioned technological processes resulting in a gelatining starch components, denaturation of proteins, stretching or reconfigure the components and exothermic expansion of the extrudates. Extrusion cooking process that comes in the action of high temperatures (100-200°C) during the 1-2 minutes of the material / substrate, i. e. the substrate temperature progressively increased over the last 10-30 seconds until the optimum for achieving the desired effects (Riaz, 2007). At the same time, the material for extruding action and a relatively high pressure, which can range up to 25 MPa. The process may be dried (moisture content 30%) or wet, where the moisture content as low as 80%. Extrusion has for years provided the means of producing new and creative foods. One major advantage of extrusion cooking is the capability to produce a wide range of finished products with minimum processing times and by using inexpensive raw material (Riaz, 2000). Analyzes have been conducted in two ways in two different and independent laboratories: Ist with classical chemical analysis, which include: *determination of moisture, raw ash, raw proteins by Kjeldahl method, raw fiber, raw fats (oils) and activity of urease,* the second: by using the „NIR" analyzer.

RESULTS AND DISCUSSION

The results from classic chemical analyze are between regulation frames of different variety of soybean grains and soybean products. In the Table 1, are

Table 1. Results of classic chemical analyses of soybean grains

Parameters / Varieties	Moisture on input,%	Moisture (results of analysis),%	Crude ash,%	Raw proteins,%	Crude fibers,%
Balkan	9.60	7.82	4.82	35.97	12.12
Lana	8.10	6.63	5.15	36.13	15.49
Ilindenka	8.20	7.00	4.86	36.92	14.14
Gorshtak	8.20	6.59	4.34	34.40	15.16
MMK	7.50	6.43	5.18	34.43	14.45

Table 2. Results of analyse of proteins content in soybean grain, on NIR analyzer and by classic lab method

Varieties	Raw proteins in grains,%		
	On NIR analyzer	By classic lab method	Average
Balkan	34.99	35.97	35.48
Gorshtak	34.82	34.40	34.61
Ilindenka	34.77	36.92	35.84
Lana	34.74	34.40	34.57
MMK	34.35	34.43	34.39

presented results of classic chemical laboratory analyses on grains of the different soybean varieties.

Differences in the percentages of moisture grain from the time of receipt in the laboratory, to the period of analysis is between 1.07% and 1.78% lower values during the analysis of soybeans grains. Comparative results from the two ways of analysis of protein content in the grains of soybean are presented in Table 2.

The percentage of protein ranged from 34.61% in variety Gorshtak until 35.84% in the variety Ilindenka. The results from NIR – analyzer is something between classic with some differences – at Balkan is about 1%, like at Lana, at Ilindenka is about 2%, but at Gorshtak and MMK the results are very similar in the two ways of analysis.

Comparative results from both laboratories are presented in Table 3 and 4, where can see that there no bigger differences in results between the two laboratories', at depleted semolina.

Moisture content is between 3.5 till 5.8% (by regulation is max. 12); Raw ash is between 5.4 till 6.1% (by regulation is min. 8, but the results at both labs are very similar); Raw proteins are between 39.9 till 43.4% (by regulation is min. 38); Raw fiber is between 6.0 till 8.6% (by regulation is max. 9); Raw fats are between 11.7 till 17.7% (by regulation is min.12); Only the results for activity of urease are inappropriate at non sample. These results are just because that soybean is not quality thermal processed (short time to achieve working temperature at extruder and lower temperature at the process of extrusion of 125°C, because of small quantity of samples for production).

The results at full fat semolina are: Moisture content is between 3.0 till 5.2% (by regulation is max.8); Raw ash is between 4.9 till 5.7% (by regulation is min.

Table 3. Comparative results of classic chemical analyzes of soybean depleted semolina – make in lab of „Ovchepolka“ DOO Veles and „Nutriko“ Vranje

Parameters	Moisture, %мax		Ash % min		Proteins % min		Fiber % max		Activ. of urease max. 0.5mgN /g/min.	Fats % min	
Varieties/Lab.	N*	O*	N	O	N	O	N	O	N	N	O
Balkan	5.8	5.0	5.5	5.5	39.3	41.2	6.2	7.1	> 0.5	17.7	17.2
Gorshtak	4.6	3.5	5.2	5.4	40.8	40.4	8.0	6.6	> 0.5	12.8	12.0
Ilindenka	5.4	4.2	5.5	5.7	42.6	43.3	8.6	8.1	> 0.5	13.6	13.9
Lana	5.3	4.8	6.1	5.8	41.0	41.5	8.5	6.0	> 0.5	11.9	11.7
ММК	5.2	3.6	5.5	5.4	42.2	41.5	8.2	6.9	> 0.5	15.2	14.7
By the regulation	12		8		38		9		0.5	12	

N* - lab of „Nutriko“ Vranje; O*- lab of „Ovchepolka“ DOO Veles.

Table 4. Comparative results of classic chemical analyses of full fat soybean semolina – make in lab of „Ovchepolka“ DOO Veles and „Nutriko“ Vranje

Parameters	Moisture, %мax.		Ash % min.		Proteins % min.		Fiber % max.		Activ. of urease max. 0,5mg N	Fats % min.	
Varieties/Lab.	N*	O*	N	O	N	O	N	O	N	N	O
Balkan	4.8	3.3	5.2	4.9	38.0	39.1	7.1	6.5	> 0.4	18.1	18.0
Gorshtak	4.2	3.0	4.9	4.7	39.6	37.9	8.3	8.9	> 0.4	18.5	18.6
Ilindenka	4.6	3.7	5.2	5.1	40.7	39.0	7.4	7.1	> 0.4	17.7	17.9
Lana	4.2	4.2	5.7	5.4	39.8	37.9	12.8	8.3	> 0.4	16.6	16.9
ММК	5.2	3.0	5.4	5.1	42.2	40.8	8.2	7.3	> 0.4	15.2	15.7
By the regulation	8.0		5.5		38.0		4.5		0.4	17.0	

N* - lab of „Nutriko“ Vranje
O*- lab of „Ovchepolka“ DOO Veles

5.5); Raw proteins are between 37.9 till 42.2% (by regulation is min. 38); Raw fiber is between 6.5 till 12.8% (by regulation is max. 12); Raw fats are between 15.2 till 18.6% (by regulation is min.17 but the results at both labs are very similar). Only the results for activity of urease are inappropriate at non sample, because the previous mentioned reasons.

The average decrease of moisture in the processed (extruded full fat and depleted soybean semolina), grains of soybeans, compared to the moisture content in unprocessed grains, ranges from 2.8% to 4.5% for all varieties. The differences in the content of proteins in depleted soybeans semolina, compared with proteins in unprocessed grains, ranging between + 3.82% in the variety Balkan, to +6.76% higher protein content, in the variety Ilindenka in processed soybean grains. Reducing to the percent's of crude fibers in grains, compared with processed soybean grains, (extruded full fat and depleted soybean semolina), ranges from –5.92% of variety Balkan to –9.49% for variety Lana. Increasing to the percent of ash in processed soybean grains, compared with percent of ash in unprocessed soybean grains, ranges from +0.22% for variety MMK to +1.06% for variety Gorshtak.

The differences in the content of proteins in full fat soybean semolina, compared with proteins in unprocessed grains, ranging between +5.72% in the variety Balkan to +7.81% in the variety MMK, higher protein content in processed soybean grains. The reducing of percentage of fats in depleted soybeans semolina, compared with full fat semolina soybeans, ranges from –0.82 for variety Balkan to –6.6% for variety Gorshtak. The percent of fiber in full fat soybean semolina, compared with depleted semolina soybean, in some varieties is higher, (Lana +2.39%, MMK +0.36%, Gorshtak +2.27) and in some smaller, (Ilindenka –0.90% and Balkan –0.59%). For all varieties are measured smaller values to content of ash, (between –0.26% and –0.72%), in full fat soybean semolina, compared with depleted semolina soybean.

CONCLUSION

Processing of soybean is obligate process, which must be in front of any further use. Applying high temperature and high pressure in the process of extruding, contributes to the sterilization of soybean meal and thus these two products are suitable and recommended for nutrition, especially the young animal categories, in which the immune system is not fully developed.

Decreasing the percentage of moisture and increasing the percentage of protein and other positive chemical changes which take place in the process of extrusion, contribute to the two products, to be more economical and suitable for transport and manipulation in animal nutrition.

Percentage of proteins and fats, like and of the other compounds in the final product of processing soybean, except of the way of processing depend and from genetic characteristics of the varieties of soybean.

There is positive correlation between content of proteins and fats in soya kernel and the final products at all investigated varieties, in both laboratories like at results of NIR – analyzer.

In accordance with a number of scientific and professional recommendations and recipes for feeding animals, full fat soybean semolina should be recommended for use like compound in feed of early weaned piglets (ex. from Gorshtak) but not more than 10%, soya concentrate or isolate for older piglets but only till 20% in feed, like and depleted semolina (and meal), for mature animals with the percent of raw proteins till 44% in ratio till 20% (depleted semolina from MMK and Ilindenka.

During processing of soybean in various types of semolina should be attempt special attention, to find adequate parameters for production process (temperature, pressure, time of processing – often extrusion) to get the desired characteristics of semolina.

REFERENCES

Almquist, H. J., J. B. Merrit, 1952. Effect of soybean antitrypsin factor on growth of the chick. Arch. Biochem. Biophy., 35, 352-354.

Atteh, J. O., S. Leeson, 1985. Effects of increasing dietary levels of whole soybeans on performance, nutrient retention and carcass quality of broilers. Poultry Sci. (Abstracts)., 64, 58.

Bajjalieh, N., J. H. Orf, T. Hymowitz, A. H. Jensen, 1980. Response of young chicks to raw defatted, Kunitz trypsin inhibitor variant soybeans as sources of dietary protein. Poultry Sci., 59, 328-332.

Baker, K. M., H. H. Stein, 1963. Amino acid digestibility and concentration of digestabli and metabolizable energy in soybean meal produced from conventional,high-protein,or low-oligosaccharide varieties of soybeans and fed to growing pigs, J. Anim. Sci., 87, 2282-2290.

Birk, Y., A. Gertler, S. Khalef, 1963. A pure trypsin inhibitor from soybeans. Biochem. J., 87, 281-284.

Borcher, R., Ackerson, C.W., and Sandstedt, R.M., 1947. Trypsin inhibitor, 3. Determination and heat destruction of the trypsin inhibitor of soybeans. Arch. Biochem. 12:367-374.

Bowman, D. E., 1944. Fractions derived from soybeans and navy beans which retard tryptic digestion of casein. Proc. Soc. Exptl. Biol. Med., 57, 139-140.

Carver, J. S., J. McGinnis, C. F. McClary, R. J. Evans, 1946. The utilization of raw and heat treated soybean meal for egg production and hatchability. Poultry Sci., 25, 399 (Abstract).

Caskey, C. D., F. Knapp, 1944. Method for determining inadequately heated Soybean meal. md.Eng.Chem. (Anal. Ed.)., 16, 640-641.

Hayward, J. W., H. Steenbock, G. Bohstedt, 1936. The effect of heat as used in the extraction of soybean oil upon the nutritive value of the protein of the soybean oil meal. J. Nutr., 11, 219-234.

Hrustich, M., M. Vidich, Gj. Jockovich, 1998. Institute for crop and vegetable growing, Novi Sad „Soya Protein” Becej, 409.

Mihajlov, A., Lj., 2002. Productive and quality characteristics of soybean producing in Ovce Pole. Ph.D. thesys, University of „St. Cyril and Methodius” Faculty of Agriculture, Skopje.

Mihajlov, Lj., 2009. Guide for organic production of soybean. Ministry for agriculture, forestry and watereconomy of Republic of Macedonia. Soya – Organic production – reference books, ISBN 978-9989.

Nutrico Vranje. www.nutriko.rs

Osborne, T. B., L. B. Mendel, 1917. The use of soybeans as food. J. Biol. Chem., 32, 369.

Puvacha, N., 2011. Extrusion and micronisation in animal feed production, Master work, Agricultural faculty – Department for animal breeding, University in Novi Sad.

Pran, V., F. H. Kratzer, 1995. Evaluation of soybean meal determines adequacy of heat Treatment, Department of Avian Sciences, University of California, Davis U.S.A.

Ramsey, P.W., B. E. Helwig, N. K. Smith, 1985. Optimum processing for soybean meal used in broiler diets. Soyfoods Center, Lafayette, California Waldroup, Poultry Sci., 64, 2314-2320.

Riaz, M. N., 2000. Extruders in food applications. Technomic Publishing Co. Inc., Lancaster, Pennsylvania.

Riaz, M. N., 2007. Introduction to extrusion. In, Extruder and expanders. M. N. Riaz. (Ed). Agrimedia GmbH, Germany.

Smith, K. A., A. P. Belter, L. R. Anderson, 1956. Urease Activity in Soybean Meal Products, Northern Utilization Research Branch, Peoria, Illinois-reprinted from The Journal of the American oil Chemists‘ Society, August, issue Vol.XXXIII, 8, 360-363.

Stein, H. H., 2012. Soybean meal fed to pigs., University of Illinois, Urbana-Champaign.

Vohra, P., F. H. Kratzer, 1991. Evaluation of soybean and determines adequacy of heat treatment., Department of Avian Sciences University of California.

Windish, 1981. History of Soybeans in Illinois by William Shurtleff and Akiko Aoyagi. A Chapter from the Unpublished Manuscript, History of Soybeans and Soyfoods, 1100 B.C. to the 1980s – Copyright 2004.

Yugoslavian standard „Methods of investigations of fodder feed" − 1965. III. Yugoslavian office for standardization Belgrade.