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Nutritional Value of Soybean Meal

Teresa Banaszkiewicz
Siedlce University, Natural Faculty, Poland

1. Introduction

Protein feeds in the European Union (EU) cover only 25% demand for protein, what oblige the particular members to import feeds with a high protein content, where the main place have soybean meal. The share of this feed in total quantity of feeds utilization in EU is about 9%. Yearly consumption of soybean meal in EU is about 32mln ton, from what 5.6% it falls on Poland (Rynek Pasz, 2010). Poland, as another countries, is importer of protein feeds, mainly soybean meal. The utilization of high protein feeds in Poland in the season 2010/2011 is estimated on about 3.5mln ton (Rynek Pasz, 2010), from what in country is produced about 1.6mln ton, in this about 1.2mln ton of rapeseed meal,180thou. ton legume seeds and 18thou. ton of fish meal (Rynek Pasz, 2010). Remaining part of feeds must be imported. Import of high protein feeds estimated on about 2.5mln ton, from this about 2mln ton this is soybean meal, which in the most (1.4mln ton) is imported from the Argentine (Rynek Pasz, 2010).To 2003 year, import of animal meals to Poland was evaluated on about 300thou. ton, which were covered about 30-40% demand of protein need to production mixtures for poultry and pigs. In results of prohibition applying the animal meals import decreased to 70thou. ton (Rynek Pasz, 2010).

Feed	2006/2007	2007/2008	2008/2009	2009/2010 (estimated)	2010/2011 (prognosis)
Soybean meal	1852	1969	1679	1810	1970
Rapeseed meal	540	512	624	861	840
Sunflower meal	207	140	310	502	400
Legume seeds	168	224	195	227	240
Animal meals	23	26	29	30	30
Percentage of soybean meal,%	66.8	69.7	60.5	52.6	55.5

Table 1. Utilization of high protein feeds in Poland, thou. ton (Rynek Pasz, 2010)

In Poland does not write down deficit of protein for ruminant generally, however in feeding of non ruminant animals care, similarly in another countries of UE, this deficit is defined on about 1mln ton (Prusiński, 2008). This deficit of protein is covered by soybean meal (Judziński, 2007). In results of prohibition applying the animal meals, the consumption of soybean meal increased. Till to 2000 year, Poland imported about 900thou. ton of soybean

meal annually, but after prohibition of import and applying the animal meals in animal nutrition import of soybean meal increased to 1.3mln ton, and after 2006 year to about 2mln ton (Rynek Pasz, 2010). Lately in Poland also waste of another of vegetable high protein fodders increased: rapeseed meal to 840thou. ton, legume seeds to 240thou. ton ,whereas the quantity of animal meals decreased to 31thou. ton. Soybean meal is the basic component of fodder mixtures for poultry, in which make up about 70% high protein fodders. Participate of soybean meal in mixtures for particular of animal species shape as follow: the laying hens -20-25%; broiler chickens-25-35%; pigs-10-20% and cows efficiency above 7thou. liters -15% (Brzóska, 2009; Brzóska et al., 2009).This broadly utilization of soybean meal and soybean products be connected mainly with high content of proteins and its amino acid composition. In this description the information relating nutritional value of soybean and soybean meals for animals were introduced. Also the attention on possibility replacement the part of soybean meal by rape products (rape meal and rape cakes) was turned.

2. Production and nutritional value of soybean

The soybean (*Glycine max*) is grown as a commercial crop in over 35 countries as the major oilseed (Smith & Huyser, 1987). The fruit of soybean is simple or take the shape of crescent pod, length about 3-7cm, including 1 or 2seeds which mass of 1000 seeds take out 115-280g. On the fodder designed the seeds in mass about 180-200g.Unripe seeds are green , and mature have from light-yellow by green to brown colour. In practice are used seeds of different cultivars, what influence on colour and form of seeds. The soybean seeds of modern cultivars have spherical shape, and the yellow and green colour is the most desirable (Sikorski, 2007).The soybean products are use in food industry on whole world. The soybean seeds contain high quantity of protein and its amino acid composition is approximate to composition of animal proteins, therefore is often used as replacement component of meat protein. Soybean seeds are used in oil industry. About 90% of soybean seeds make up cotyledons and 8% there are hulls. In the cotyledons are accumulated proteins and fats , the main components of seeds. In the cotyledons also are accumulated carbohydrates and anti-nutritional factors. In result of separation of this components or their extraction were obtained different soybean products used in people and animals feeding.

2.1 Production of soybean seeds and meal

The world production of the soybean seeds in 2009/2010 season carried out about 260.6mln ton (Rynek rzepaku, 2010) and the same importance producers of seeds and soybean meal are USA, Brazil , Argentine as well as China, which produced about 87% total quantity of soybean seeds. The main exporters of the soybean seeds are USA (about 44%), Brazil (about 33%) and Argentine (about 11%) and main importer are China (about 38%).

On direct consumption is appropriate about 10% of harvest and about 90% of soybean seeds is use as feeds for animals. The production of soybean meal on world is amount over 160mln ton (Rynek Rzepaku,2010) and main exporters are Argentine -about 37%, Brazil-about 29% and USA- about 8%.

The soybean seeds are subjected of different processing (Berk, 1992), so the oil industry supplies many kinds of by-products (cakes, expellers, oilseed meal), which are used in animal nutrition. After preliminary processes of type the cleaning ,smashing, dehulling , conditioning , flaking, boiling or toasting of soybean seeds, the oil is extracted from seeds by mechanical method or by solvent extraction. Most of all wide spread is solvent extraction.

In results of this process the raw oil and defatted flakes are obtained. In order to elimination of anti-nutritional substances the flakes subjected on high temperature (toasted) and the soybean meal is obtained. To the obtained flakes, sometimes the hulls are added back and obtained soybean meals contained different quantity of protein and fiber. When the hulls does not add, the high protein products are obtained ,which used mainly in poultry nutrition. The other meals containing more or less of hulls application are used in nutrition of another animals (Van Eys et al.2004).

Country/Region	Production, mln ton
United States of America	94.8
Brazil	68,0
Argentina	54.5
China	14.5
India	9.1
Paraguay	6.7
Other	13.00
Total	260.6

Table 2. Production of soybean seeds (Rynek rzepaku, 2010)

Raw oil obtained in results of fat separation is the most important product, but quantitative most of all, the soybean meal from raw or dehulled and extracted solvent is obtained. Considerably less the soybean meal is obtained by the mechanical press. Before processing of raw soybean seeds are dehulled and obtained by-products contained protein which composition of amino acids are similar to animal protein. About 46% of soybean by-products are appropriate to poultry, 32% to swine, about 9% to dairy and beef cattle respectively. Remaining part is use in nutrition of pets and aquaculture.

2.2 Chemical composition and nutritional value of seeds and soybean meal

Nutrients content in soybean products are the basic element to optimization diets and estimation of total quantity nutrients give to animals. Knowledge about composition of feeds let to forecast animal performance results. Soybean meal is the best vegetable protein source considering on quantity as well its quality. From among legume seeds, the soybean seeds content the most of crude protein and the best of amino acid composition. Content of crude fiber (about 6%) is lower in comparison to another vegetable high protein feeds.

2.2.1 Basal nutrients

Soybean seeds contain to 40% of crude protein and about 20% of fat, and soybean meal characterized higher content of crude protein- about 40-49%. Soybean meal standardized on 44 and 49% of protein there is on the feed market . The protein of soybean contains the considerable quantity of lysine (6.2g/16gN), but value of protein is limited by methionine and cystine content (2.9g/16gN). With regard on high protein content, the soybean meal is mainly use in poultry and pigs nutrition. In mixtures for poultry content of soybean meal can approximate to 40%.

Generally soybean seeds content 5,6-11.5% of water, ranges for crude protein is from 32 to 43,6%, for fat from 15.5 to 24.7%, for crude ash from 4.5 to 6.4%, for neutral detergent fiber

(NDF) from 10 to14,9%, acid detergent fiber (ADF) from 9 to 11,1%, carbohydrates content from 31.7 to 31.85% on a dry matter basis (Ensminger et al., 1990; NRC, 1998; Poultry Feeding Standards,2005).

Nutrient	Soybean seeds % of DM	Soybean meal		SBM(Banaszkiewicz, 2000)%
		44% CP, % of DM	49% CP, % of DM	
Crude protein	37.08	43.8-49.9	52.8-56.3	44.40
Crude ash	4.86	5.6-7.2	5.2-9.1	6.65
Crude fat	18.38	0.55-3.0	1.0-3.3	2.18
Crude fiber	5.12	4.3-7.2	3.1-4.1	6.75
NDF	12.98	12.3-18.9	7.4-12.2	15.51
ADF	7.22	8.9-11.9	5.2-6.7	9.5
N-free-extractive	24.00	34.3	33.2	31.82
Starch	4.66	5.51	5.46	6.3

Table 3. Basic nutrients in soybean seeds and products (Van Eys et al.2004; ENV/JM/MONO (2001)15)

The soybean contain very little of starch (4.66-7%) and quite a lot of hemicellulose and pectins. Protein of soybean products characterized much quantity of lysine, tryptophane, isoleucine, valine and threonine however sulphuric amino acids are less than in protein of rape products (Ensminger et al. 1990; NRC, 1998; Poultry Feeding Standards,2005). Content of essential amino acids of soybean products shown in table 4.

Amino acids	Soybean seeds, % of DM	Soybean meal 44%CP, % of DM	SBM, g/16g N (Banaszkiewicz, 2000)
Arginine	2.45-3.1	3.49-3.78	6.79
Cystine	0.45-0.67	0.66-0.75	1.57
Histidine	1.0-1.22	1.21-1.32	2.58
Isoleucine	1.76-1.98	2.15-2.78	4.24
Leucine	2.2-4.0	3.66-3.92	8.21
Lysine	2.5-2.66	2.99-3.22	6.49
Methionine	0.5-0.67	0.6-0.69	1.50
Phenylalanine	1.6-2.08	2.35-3.0	4.93
Threonine	1.4-1.89	1.89-2.03	3.99
Tryptophan	0.51-2.44	0.66-0.75	1.05
Valine	1.5-2.44	2.24-2.67	5.22

Table 4. Content of essential amino acids of soybean products, [ENV/JM/MONO (2001)15]

Nutritive value of soybean protein is limited by sulphur amino acids and tryptophane. Soybean is characterized the highest digestibility of protein, lysine and methionine. The amino acids content in soybean protein are good supplemented of grain protein and covered requirement of animals.

Amino acids	Soybean meal	Canola meal	Sunflower meal
Crude protein	82	79	79
Arginine	88	89	90
Lysine	85	81	80
Methionine	83	86	90
Threonine	76	80	73
Cysteine	75	77	92

Table 5. Apparent ileal digestibility coefficients of amino acids,% (Ravindran et al. 2005)

According Banaszkiewicz (2000) the nutritive value of soybean protein obtained by chemical methods was lower than rape cakes.

Specification	SBM
Chemical Score(CS) - related to total egg protein	53
CS- related to egg albumin	42
Essential Amino Acids Index (EAAI) - related to total egg protein	81
EAAI- related to egg protein	80
Limiting amino acids- related to total egg protein	Met, Cys, Trp
Limiting amino acids- related to egg albumin	Met, Cys, Trp

Table 6. Nutritive value of soybean meal protein (Banaszkiewicz, 2000)

The mean value of protein of rape cakes obtained by CS index was adequately 60 and 57 and by EAAI- 81 and 82.

Lipid fraction of the soybean seeds contain about 99%of triglycerides, in which content of polyunsaturated fatty acids (linoleic and linolenic) and unsaturated – oleic acid is high. In the lipid fraction of soybean seeds the fatty acids content about 80%, from what about 50% it is the linoleic acid. The range in fatty acid composition in soybean seeds and oil shown in table 6.

Fatty acids	Soybean seeds% of DM	Soybean oil%
Palmitic	1.44-2.31	7-12
Stearic	0.54-0.91	2-5
Oleic	3.15-8.82	19-34
Linoleic	6.48-11.6	48-60
Linolenic	0.72-2.16	2-10
Arachidic	0.04-0.7	< 1.0

Table 7. Fatty acid composition of soybean seeds and oil (ENV/JM/MONO (2001)15)

The concentration of mineral components in the soybean seeds depend on different factors and the most of all on origin, conditions of tillage, variety and technological process. The soybean products contain the considerable quantities of phosphorus. In the region of

intensive animal production the phosphorus content in the fecal excretion is limiting. The phosphorus content in the feeds influence on the its excretion.

Mineral components	Soybean seeds	Soybean meal		SBM Banaszkiewicz(2000)
		Mechanical extracted (cakes)	Solvent extracted 44% CP	
Ca	2.62	2.96	3.12	2.71
P	5.70	6.64	6.37	5.14
Mg	2.80	2.84	2.72	2.27
K	15.93	20.28	19.85	6.66
Na	0.29	0.33	0.18	0.30

Table 8. Content of minerals in seeds and soybean products, g/kg (Van Eys et al.2004)

The content of vitamins in soybean seeds and products shown in table 9. Soybean full fat contain 31 mg/kg of vitamin E ,soybean meals only about 3mg/kg and soybean expeller 6.6mg/kg. The big differences between soybean full fat and another soybean products occurs.

Vitamins	Soybean meal solvent	Soybean meal dehulled solvent	Soybean expeller	Soybean full-fat
E, (mg/kg)	3.0	3.3	6.6	31.0
Thiamin, (mg/kg)	1.7	1.7	1.7	6.6
Riboflavin, (mg/kg)	3.0	2.6	4.4	2.64
Pantothenic acid, (mg/kg)	13.3	13.2	13.8	15.6
Biotin, (µg/kg)	320	320	320	286
Folic acid, (µg/kg)	450	700	450	3542
Niacin, (mg/kg)	59.8	20.9	36.7	22.0

Table 9. Content of vitamin in seeds and soybean products
(http://www.soymeal.org/sbmcomposition.html)

Content of metabolizable energy in soybean seeds for poultry is about 15 MJ/kg DM and for pigs about 17MJ/kg DM. The metabolizable energy content for poultry in the soybean meal is about 9MJ/kg DM and for pigs about 13MJ/kgDM. Jiang (2003) collected soybean meal samples and appreciated the ME value of these soybean meals no relationship were found between the ME and crude protein or crude fat, but ME content was lower for higher crude fiber.

2.2.2 Anti-nutritional factors in soybean

Protease inhibitors

The nutritive value of soybean is limiting mainly by trypsin and chymotrypsin inhibitors, pectins and the protein about immunology activity. The most important there are the trypsin inhibitors - the Kunitz inhibitors and the Bowman-Birk inhibitors (Winiarska – Mieczan,2007). In animal cause they lowering the nitrogen retention, decreasing of performance results and increasing of metabolic nitrogen excretion.

Protease inhibitors (the Kunitz inhibitor and Bowman –Birk inhibitor) are active against trypsin and chymotrypsin (Liener, 1994). These inhibitors interfere with the digestion of proteins resulting in decreased animal growth. Activity of trypsin inhibitor range from 100 to 184 TUI/ mg of protein (Kakade et al.1972). The limit of activity for soy products is to 0.4 urease units. Thacker & Kirkwood (1990) report a range for trypsin inhibitors of 21.1 to 31.1 mg/g. 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). Chickens fed diets containing soybean seeds, where TIA level was low, characterized of better growth, and heating these seeds increased its growth yet, what was probably resulting of further decreasing TIA and inactivation of lectins and immunogenic proteins.

Lectins

Lectins (hemaglutinins) are proteins that bind to carbohydrates. In raw soybean can decrease growth and cause increase mortality rate in animals. The level of the lectins in soybean can vary from 37 to 323 HU /mg of protein (Kakade et al.1972). In soybean meal content of lectins joining carbohydrates carried out since 0.2 to 3.1g/kg and there are mainly agglutinating lectins (Fasina et al 2003; Maenz et al.1999). This strong influence of lectins practically disappearance after autoclaving.

Phytoestrogenes

Soybean contain a isoflavones. This compounds have got biochemical activity, including estrogenic, anti-estrogenic and hypocholesterolemic effects. Total isoflavones content ranged from 160.8 to 284.2 mg/100g (Hoeck et al.2000). The isoflavones in soybean and soy products have three types: daidzein, genistein and glycitein in three isomers and three forms. Totally, there are 12 isomers of isoflavones in soybean. The concentrations of total daidzein , genistein and glicitein carried out of 20.2-206 mg, 31.5-268 mg and 10.9-107 mg per 100g raw seed respectively (Douglas, 1996;Wang & Murphy, 1994). These compounds have been implicated in reproduction in animals fed diets containing large amounts of soybean meal (Schutt, 1976). On negative influence of izoflavones on broilers show results obtained by Payne et al.(2001), but a little of quantity of this components in feed for chickens have beneficial anti-carcinogenic effects (Messina & Barnes, 1991). The isoflavones content is greatly influenced by many factors. The soybean products are mainly source of isoflavones which executing important consideration in prevention of neoplasmic diseases and reduced the risk diseases of circulation tract (Radzikowski,2004). The interest of role and utilization of isoflavones increase in animal production, because was proved the influence on immunological tract and improvement of performance results and quality of trait (Payne et al.2001; Kerley & Allee,2003).Lee et al. (2003) show the total content of isoflavones in Korean soybean cultivars range from 110 to 330mg/100g of feeds.

Stachyose and raffinose

The stachyose and raffinose are low molecular weight carbohydrates. These compounds are present in toasted soybean meal, as well as in raw soybean seeds (Padgette et al.1996).The raffinose content of soybean seeds ranges from 0.1 to 0.9g/100g on fresh weight basis and stachiose is from 1.4 to 4.1g/100g (Douglas, 1996; Hymowitz et al.1972).

Phytates

Phytic acid chelates calcium, magnesium, potassium ,iron and zinc rendering them unavailable to non ruminant animals. A lot of phytates in diets decrease availability of this minerals, mainly calcium, phosphorus and zinc. The phytates decrease also activity of enzymes (pepsin, trypsin and amylase) as well as availability of protein , amino acids , starch and energy (Sebastian et al.1998;Ravindran et al.2000). Phytates influence on decrease of feed consumption by chickens as well as their growth (Shan& Davis,1994). Liener (2000) estimated that two-thirds of the phosphorus in soybean is bound as phytate and unless freed is mostly unavailable to animals. Phytic acid is present in soybean and most soybean products at level 1-1.5g/100g of the dry matter.

Allergens

The allergenic effect is attributed to the globulin fraction of soybean proteins. In the soybean seeds the globulins comprise about 85% (80-90%) of total protein (Shinbasaki et al.1980).The most important allergens of soybean are GLY 1 and GLY1B - glicynine and beta-conglicynine (Świderska- Kiełbik et al. 2005). Soybeans contain several antigenic proteins which can stimulate the immune system sensitive of calves, pigs and human (Pedersen,1988). These proteins are not sensitive on temperature. The denaturation of beta-konglicinine needs of temperature about 75^{o}C. Allergens were ascertained also in lecitine of soybean, which is described as occupational allergens at the bakers. The allergic activity can also show tryptase inhibitor present in soybeans. According Moroz & Yong (1980) the heating increase allergenic proprieties of soybean. Now appeared reports on small quantities of soy protein in meat of chickens fed diets contained 25% of soybean seeds (Świderska- Kiełbik et al. 2005).

Pectins

They are very important anti-nutritional substances (Pusztai,1991). They components belong to sensitive substances on high temperature. They answer for agglutination in alimentary tract and mitosis. The thermal processing is little effective to this soy antigens.

Micotoxins

Most mikotoxins in soybean products there is the ochratoxins (mushrum‹s products of Aspergillus ochraceous or Penicyllium varrucosum) and zearalenon as product of Fusarium graminearum. They come into being during storage in bad conditions (high moisture and temperature >20^{o}C). These products show estrogenic activity which can cause disturbance in reproduction. The particular sensibility on zearalenon is observed at pigs. The level of these substances over 1 ppm caused problems in reproduction. The afla-micotoxins in soybean products occur rather seldom.

Oligosaccharides

Oligosaccharides are substances can cause of flatulent problems, decrease of digestibility of nutrients and hypertrophy of intestines (Salgado et al.2002). They can also influence on quantity of microorganisms in intestines (Rubio et al. 1998). The reaction of animals on anti-nutritional substances in soybean depend on animal species and age. The adult ruminants are not sensitive on these substances , whereas the decrease of growth of chickens , pigs, calves and rats were observed, when raw soybean was given. In the feeding of this animals should been used of heated and toasted products. The level of TIA in this products should not exceed 10 mg/kg. Reaction of hens and adult of pigs on raw soybean seeds is less,

therefore in mixtures for this animals can use a little quantity raw soybean products without fear decrease of this performance.

Specification	Soybean seeds (Hanssen,2003; Peisker,2001)	Soybean meal 44%CP (Hanssen,2003; Peisker,2001)	Soybean meal
Oligosaccharides,%	14	15	50-60g/kg[Coon et al.,1990; Kocher et al. ,2002]
Stachiose,% Rafinose,%	4-4.5 0.8-1	4.5-5 1-1.2	
Trypsin inhibitor,mg/g CP Chymotrypsin inhibitor	45-60	4-8	1-8mg/g [Peisker,2001] 10.7mg/g[Douglas et al.,1999] 30.3mg/g[Douglas et al.,1999]
Lectins, ppm	50-200	50-200	0.22-3.1g/kg chelated of sugar, in it0.01-0.87aglutinin[Maenz et al.,1999;Fasina et al.,2003]
Saponins,%	0.5	0.6	600mg/kg[Peisker,2001]
Glicynina mg/g Beta konglicynina,mg/g	150-200 50-100	40-70 10-40	- -
Phytic phosphorus,%	0.6	0.6	8.9g/kg[Glencross&Carter,2007]11.2mg/kg[Refstieetal.,1999] 19.9mg/kg[Glencross,2004]

Table 10. Content of anti-nutritional substances in soybean

2.3 Technological processes improved nutritional value of seeds and soybean products

Raw soybean seeds as well as the soybean products contain many anti-nutrient factors, which decrease their nutritional value and conduct to depression of animals performance and worsening of this health (Liener,1994).Adequate heat processing inactivate these factors. The soybean requires the processing in aim to elimination of anti-nutrient factors particularly in non ruminants feeding. Before of purchase the soybean meal should to be testing , if it was toasted (Van Eys et al.2004) . During to heat of soybean seeds (100-105^{o}C) follow the changes in protein structure and decomposition of trypsin inhibitors. In result of this process the availability of lysine, methionine and cystine increase. Under the heat the trypsin inhibitors are inactivating. The effectiveness of these process depend on temperature and time of working , moisture of seeds as well as the degree of their crumbling. The use of too high temperature cause decrease of protein and some amino acids availability, especially lysine. The measured heating of seeds prevent of decomposition protein in rumen of ruminants, while too strong heating decrease of this utilization also at ruminants. Use of optimal temperature and time of its working can increase of digestibility and availability of protein and amino acids.

The results in table 11 shows that the digestibility of amino acids (lysine, methionine and threonine) increased as the result of autoclaving at 121^{o}C for 0-18 minutes. This improvement in digestibility was the result of the destruction of anti-nutritional factors by the heat treatment.

Autoclave time (minutes)	Lysine	Methionine	Threonine
0	73	65	64
9	78	70	68
18	87	86	82

Table 11. Effect of autoclaved of raw soybean seeds on digestibility of amino acids in chickens,% (Anderson-Haferman et al.,1992)

The excessive hot processing can decrease content digestibility and availability of amino acids. It regards mainly lysine, which can bind in non available products with carbohydrates.

Autoclave time at 121°C(minutes)	Lysine	Cystine	Methionine	Threonine
Digestibility coefficients,%				
0	91	82	86	84
20	78	69	86	86
40	69	62	83	84
Concentration of amino acids ,%				
0	3.27	0.70	0.71	1.89
20	2.95	0.66	0.71	1.92
40	2.76	0.63	0.71	1.87
Concentration of available amino acids,%				
0	2.98	0.57	0.61	1.59
20	2.30	0.46	0.61	1.65
40	1.90	0.39	0.59	1.50

Table 12. Effect of autoclaved of soybean meal on digestibility, concentration and available of amino acids ,% (Dudley-Cash n.d.; Parsons et al., 1992)

The data show on reduction in concentration of lysine and cystine as a results of autoclaved for up to 40 minutes. There was little or no effect this process on methionine and threonine. Under heated soybeans have reduced amino acid digestibility, which reduces growth performance. In the result of processes with high temperature the reduction in protein quality was observed.

The anti-nutrient substances such protease inhibitors, lectins, pectins, urease, lipooxygenases and anti-vitamin substances are decomposed in high temperature or in fermentation processes (Liener,2000). In soybean the anti-nutrients sensitive substances there are trypsin inhibitors, pectins and goitrogenes substances(Liener, 2000).Some substances no destruction in use of temperature: faintly digested of carbohydrates, saponins, estrogens, cyjanogens and phytates (Liener,2000). The utilization of soybean products by animals depend at remainder of anti-nutritive substances. Protein dissolvent is correlated with gain of poultry and pigs (Araba & Dale, 1990).

Protein dissolvent in raw of soybean seeds and soybean products subjected of strong heating should to be about 90%. With protein dissolvent below 72% the decrease of animal performance was observed. These meals are necessary thermal prepared. The urease index does not change much in the first minutes of heating and next suddenly decrease. The

soybean protein quality for ruminants depend from quickly of destruction in rumen and intestine digestibility.

Autoclaved120^{o} C (minutes)	Body gain of chickens, g	Feed efficiency kg/kg	PDI(protein dissolvent), %	Urease index (change pH)
0	450a	1.79	86.0	0.03
5	445a	1.87	76.3	0.02
10	424a	1.83	74.0	0
20	393b	1.89	65.4	0
40	316c	2.04	48.1	0
80	219d	2.55	40.8	0

Table 13. Effect of autoclaved on performance, protein dissolvent and urease activity (Araba and Dale,1990)

Product	PDI,%	Trypsin inhibitor activity, mg/g	Pectins mg/g	Antigens, mg/g
Soybean flour non toasted	90	23.9	7.3	610
Soybean flour slightly toasted	70	19.8	4.5	570
Soybean flour toasted	20	3.1	0.05	125
Concentrate of soybean extracted	6	2.5	<0.0001	<0.02

Table 14. Concentration of anti-nutritional factors in soybean products subjected to technological processes (Huisman & Tolman,1992)

Species	Soybean meal mechanical extracted	Soybean meal solvent- extracted 44%CP	Soybean meal solvent- extracted 48%CP
Pigs :			
- digestible energy ,kcal/kg	3394	3446	3776
- metabolizable energy, kcal/kg	2986	3210	3299
- net energy, kcal/kg	1903	1955	1992
Poultry:			
-apparent metabolizable energy for hens, kcal/kg	2179	2208	2464
- apparent metabolizable energy for chickens, kcal/kg	1929	1973	2147
Ruminants:			
- net energy for cows,kcal/kg	1706	1748	1826
- net energy for beef cattle,kcal/kg	1838	1847	1993

Table 15. Energy value of soybean meal obtained different technologies (Van Eys et al.2004)

In before rumen soybean meals are strong destruction and making up of source protein for microorganisms, but the part of protein which no destruction is nonsufficient for ruminants with high production. Energy value of soybean products depends on technique processes, which influence on chemical composition, digestibility and availability of nutrients.

The most suitable methods for protection of soybean proteins before destruction in rumen is thermal processing. The soybean products are sensitive on oxygenation, because contains the high of unsaturated fatty acids, mainly linoleic . The fatty acids composition is very important trait of fats from nutritional consideration. Lately in soybean oil the level of palmitic , stearic and oleic acids increased and linoleic and linolenic decreased.

2.4 Another high protein feeds as part of substitute of soybean meal

The withdrawal the animal meals from mixtures improved the microbiological quality of mixtures (the decrease of the Salmonella occurrence for poultry),but it simultaneously yet more worsened the balance of protein in the animals feeding, increase of prices of high protein feeds and demand on soybean meal. Soybean meal is the dominating protein feed in poultry feeding. As soybeans are only grown in North and South America, most countries have to import it. About choice of soybean meal to mixtures decide the high protein and amino acids content and accessibility big consignment of homogenous nutritional value of its feed. Increase price of soybean meal and deficiency protein source coerce to look for alternative source of protein. According Święcicki et al. (2007) is possibility of partial replacement of imported soybean meal using of protein from domestic sources (rape products and legume seeds).

Lately in Poland increased area of rapeseed cultivation from 550 to 750th.ha. This is bound up with program the component to fuel production. In 2010 in Poland the rapeseed crops nursed about 2.72mln.ton what supply about 0.5mln ton of protein. The polish cultivars and foreign registration in Poland are crossbreeding cultivars, non GMO. The Polish cultivars contain 2-3 time less of glucosinolates then foreign.

Lately in Poland was processed about 1.6mln ton of rape seeds and obtained about 700thou.ton of rapeseed meal. On the feed market increase supply rape cakes products which remaining after extraction of oil from rapeseed without chemical process. This is connected for extraction of oil, mainly to produced of bio-components by ecological methods (Nystrom et.al.1996). Lately rape cake production increased, as different technologies of processing rapeseed oil are preferred as more environment friendly. Low glucosinolate rape products are appropriate alternatives to soybean meal as a vegetable protein source in broiler diet. The rape meal contain abort 35% of protein, and about 2-3% of fat. In dependent on efficiency of press to extraction of oil the rape cakes contains 28-32% of protein and from 9 to 16% of fat.

Banaszkiewicz (2000) published that rapeseed is characterized by high protein (21-22%), fat (above 40%), total phosphorus (6-8g·kg^{-1}) and gross energy content (26-27MJ·kg^{-1}). About 75% of total phosphorus is the phytate form. Rapeseed contains about 8% crude fiber and 20% N-free extracts. The non-starch polysaccharides in rapeseed oil meal contain up to 35% dry matter. Total non-starch polysaccharides in rapeseed products contains about 200g (Knudsen ,1997) and have negative effect on nutrients digestibility, mainly crude fat and amino acids. Amino acid composition of rapeseed protein is beneficial:6g Lys; 2g Met; 4.6g Thr and 1.2g/16g N of Trp (Banaszkiewicz,2000).

Specification	SBM	Rape seeds	RSM	Rape cakes
Dry matter,%	92	93	92.5	92.37
Crude ash,%	6.5	5.3	7.2	5.57
Crude protein,%	44	22.5	36.5	28.82
Crude fat,%	1.9	42	2.4	25.98
Crude fibre,%	6.7	8.2	6.7	8.49
NDF,%	14.5	24.5	29.5	25.3
ADF,%	9.5	20.5	22.5	19.7
N-free-extracts,%	15.5	15.5	33.9	23,51
Lysine,g/100gCP	6.3	6.0	5.5	6.11
Methionine+ Cystine,g/100gCP	3.1	4.6	4.3	3.97
Threonine,g/100gCP	3.7	4.5	4.2	4.72
Tryptophan,g/100gCP	1.2	1.2	1.2	1.45
Ca, g/kg	3.2	3.4	6.3	5.9
P, g/kg	5.8	7.3	11.2	8.35
Mg, g/kg	2.5	2.8	4.6	3.26
Na, g/kg	0.4	0.2	0.4	0.16
Metabolizable energy, MJ/kg:				
pigs	13	19	11	15
poultry	9	16	8	13.5
ruminants	11.5	17	9	14.3

Table 16. Comparison of chemical composition and energy value soybean meal and rape products (Krasucki & Grela, 2004; Strzetelski,2006; Banaszkiewicz ,2000)

The digestibility of some amino acids in rape meal is less than that of soybean meal (Jondreville et al.2000). Digestibility of rapeseed and rape cake proteins for poultry is 70% and 76% respectively (European Table of Energy Values, 1986) and of rapeseed meal protein - 80% (Pastuszewska et al.,1987). Digestibility of rapeseed and rape cake fat is 90-98% (European Table of Energy Values, 1986). Fat digestibility stated by Banaszkiewicz (1995) was about 60-70%. Digestibility of N-free extracts ranges from 37 to 68% (Smulikowska et al.,1997) and 22-32% (European Table of Energy Values, 1986).

Amino acids	Soybean meal	Rapeseed meal
Protein	88.4	73.6
Lysine	90.5	70.7
Threonine	86.8	73.2
Methionine	93.0	86.0
Cystine	87.4	77.7
Tryptophan	89.4	74.8
Arginine	94.6	83.9

Table 17. True intestine digestibility of protein and amino acids,% (Jondreville et al.2000)

The rapeseeds products are limited by the nutritionally unfavorable substances such as glucosinolates, sinapin, tannin, phytate (Ciska & Kozłowska, 1998), but also by high content of dietary fiber and non starch polysaccharides (Kocher et al.2000).Rape products are characterized by low available energy and phytate phosphorus of about 25% (Nwokolo &

Bragg,1980). A study by Kocher et al. (2001) showed that rape meal (CM) can replace SBM in broiler diets even at high inclusion levels without any loss in performance, but according Bell (1993) the level of indigestible carbohydrates increased compared with soybean meal. The fiber is restrictive component to digestibility of protein, fat, absorption amino acids and fatty acids.

Nutrient	Soybean seeds	Soybean hulls	Rape seeds	Rape hulls
Dry matter	92.0	91.0	91.5	87.5
Crude ash	5.5	5.1	4.2	4.0
Crude protein	42.8	12.1	22.5	14.2
Crude fat	18.8	2.1	40.1	9.9
Acid Detergent Fiber	10.0	50.0	16.8	47.7

Table 18. Chemical composition of soybean and rape seeds and its hulls,% (Banaszkiewicz, 2000; Ensminger et al.,1990)

Soybean hulls contain about 12% of crude protein and rapeseed hulls about 14%. In the hulls are high of acid detergent fiber (ADF), about 50% in soybean hulls and 47.7% in rapeseed hulls compared to 10% in soybean seeds and 16.8%in rape seeds. Obtained of tree-000 of cultivars in Poland is advanced.

The nutritive value of rapeseed feeds may be improved by enzyme addition (Lesson & Caston, 1996; Kocher et al., 2001). Addition of carbohydrates to the basal wheat-rapeseed diet, may influence the nutritive value of rapeseed meal, but an inclusion of rapeseed meal to replace SBM, and an addition of Roxazyme G or Ronozyme VP to canola meal diets did not significantly affect broiler performance, but the mortality in birds fed canola meal diet was significantly reduced compared with the mortality in birds fed soybean meal (Kocher et al., 2001).

Dietary treatment	Group	Body weight g/bird	Feed intake g/bird	Feed conversion (FCR)g/g gain	Mortality %
Soybean meal	Control	1979	3520	1.779	4.1a
Canola meal	Control	1987	3525	1.779	1.2b
Canola meal	Enzyme A	2017	3579	1.775	2.9a
Canola meal	Enzyme B	2024	3603	1.781	2.8a

a,b. – means in rows followed by different letters are significantly different ($p \leq 0.05$)

Table 19. Growth performance and mortality of broiler chickens fed soybean and canola diets (Kocher et al. 2001)

Further improvement of nutritive value of diets can be obtained by the combined introduction of enzymes. Wu et al. (2004) reported that the combined addition of phytase and xylanase to wheat-based diets significantly increased the value of AME. Banaszkiewicz et al. (2009) reported that the rape cake from Kaszub cultivar supplemented with enzyme could partially replace soybean meal in wheat-based diets without any detrimental effects on chickens performance.

Supplementation with enzyme preparations can degrade dietary fiber and improve digestibility of crude fat and protein (Mikulski et al., 2000). Banaszkiewicz et al. (2009) reported that the simultaneous application of phytase and xylanase to wheat-soybean –rape diets significantly increased digestibility of crude protein, fat, fiber and N-free extracts.

Specification	Groups				SEM
	(SBM)	(RC XY)	(RC FYT)	(RCXY+FYT)	
Body weight at 1 day, g	40	40	41	40,5	1.92
Body weight at 21 day, g	672	692	679	672	9.92
Body weight gain 1-21days, g	631	649	633	628	11.27
Feed/gain ratio, kg/kg 1-21 day	1.55a	1.59a	1.67b	1.62ab	0,02

a,b. – means in columns followed by different letters are significantly different (p≤ 0.05)
SEM- pooled standard error of mean

Table 20. Body weight gain and feed efficiency of broilers (Banaszkiewicz et al.2009)

Groups	Digestibility, %				
	Crude protein	Crude fat	Crude fiber	N-free extracts	Crude phosphorus
(SBM)	88.20a	87.43a	18.06c	82.4a	57.93a
(RC XY)	87.92ab	71.24b	42.76a	79.15b	54.18a
(RC FYT)	85.82c	65.89c	37.67b	76.48c	50.10a
(RC XY+FYT)	86.30bc	67.24c	46.58a	79.49b	55.91a
SEM	0.37	2.28	2.90	0.63	1.25

a,b. – means in columns followed by different letters are significantly different (p≤ 0.05)
SEM- pooled standard error of mean

Table 21. Apparent digestibility of nutrients in experimental diets (Banaszkiewicz et al.2009)

Digestibility of protein in the control group (soybean meal) was about 88% and for diets containing rape cakes was significant higher and ranged from 85.8 to 87.9%. The highest digestibility of fat for control –soybean group was found- about 87%, when for groups contained rape cakes was from about 66 to 71%. Partial replacement of soybean meal with rape cakes supplemented with an enzyme preparations containing phytase or xylanase individually or in combination had not statistical effect on digestibility of crude phosphorus (Banaszkiewicz et al.,2009). The rape cakes with regard on high protein and fat may be good substitution of imported soybean meal particularly in mixtures where animal products (meat - bone meal and fats) were applied. Use of rape cakes on fodder aims maybe limited import of soybean even about 30-40% i.e. (about 500-600 thou. ton) a year (Strzetelski 2006).

3. Conclusion

The soybean meal characterized the highest content of protein and amino acids and its good point are big consignments on homogenous nutritional value. In the regard of big quantity of soybean meal in mixtures the small difference in nutritional value in this feed may have influence on balance of nutrients in diets and animal performance. Rapeseed may be one alternative to soybeans. If 25% of soybean meal in mixtures for poultry was replace by rapeseed meal the quantity of imported soybean meal may decrease of about 0.18-0.2mln ton. On the ground of investigations conducting with rape cakes were ascertained that rape cakes can replace about 15-20% of soybean meal, but efficiency of rape product will be at about 15-20% worse. The lower intestine digestibility of amino acids for rape cakes (70-75%) than for soybean meal (90-92%) is this cause. The rape products can completely replace soybean meal in fattening pigs and cows. It is possibility of replacing soybean meal by

domestic feeds in mixtures for poultry, mainly for broiler chickens at level of 300 thou. ton, in mixtures for pigs -180 thou. ton and for cattle 20 thou. ton. In general domestic high protein feeds can replace about 500 thou. ton of soybean meal what make about 25% of imported soybean meal. In connection with low utilization of fat from rape cake, the investigations relating of its utilization should be conducted. One ought to limit of variability in chemical composition and nutritive value of rape cake. In the regard of increasing interest of rape cultivation one should expand a system of small oil mill. These ought decrease cost of transportation of materials and products and influence of higher utilization of rape cake in animal nutrition. In Poland obtained about 3mln ton of rapeseeds. If the take cognizance of that from 100kg of rapeseeds are obtained the 40kg oil and 60kg rape meal or rape cakes, it is possible to production of about 1.8 mln ton of feeds with high protein content and about 0.6 mln ton of crude protein.

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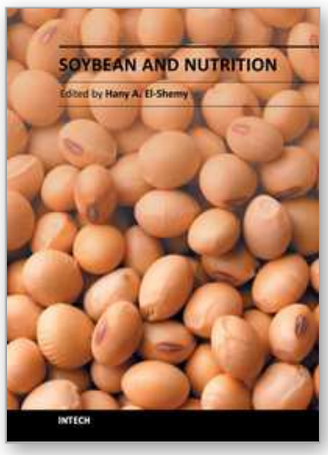

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Worldwide, soybean seed proteins represent a major source of amino acids for human and animal nutrition. Soybean seeds are an important and economical source of protein in the diet of many developed and developing countries. Soy is a complete protein and soy-foods are rich in vitamins and minerals. Soybean protein provides all the essential amino acids in the amounts needed for human health. Recent research suggests that soy may also lower risk of prostate, colon and breast cancers as well as osteoporosis and other bone health problems and alleviate hot flashes associated with menopause. This volume is expected to be useful for student, researchers and public who are interested in soybean.

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University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
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www.intechopen.com

InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
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