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CHEMICAL COMPOSITION AND NUTRITIONAL EVALUATION OF SOYBEAN MEAL

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Abstract

Soybean represent the most important protein source for poultry and swine rearing but its producing in Romania and even in Europe is at a quite low level face to demands. To obtain complete mixed fodders are recurred imports from other world countries where are cultivated different soybean sorts under different pedo-climatic conditions, fact which made that products entered on Romanian market to present a great variability regarding chemical and nutritional features. In the current paper we analysed from chemical and nutritional point of view the quality of 10 soybean lots imported from Brazil. Besides basic chemical analysis were effectuated analysis to determine content in amino acids which allow a further protein nutritional evaluation by calculating chemical indices, essential amino acidsindex, protein efficiency rate, biological value and nutritional index. Proteins' nutritional evaluation from analysed soybean meal was realised using as etalon egg protein, amino acids requirements for swine, for broiler chickens and adult persons. Chemically speaking analysed soybean meal had values into limits imposed by literature (90.1% DM, 41.24% CP, 2.47% CF, 4% CA, 4.8% Ash and 37.59% NES). Nutritional evaluation show that analysed soybean meal lots had a good content in protein and even more, a good content in amino acids. This conclusion resulted because EAAI was>0.70, PER was>2.7 and P-BV was>70%.

Key words: *soybean meal, nutritional evaluation, amino acids, biological value.*

INTRODUCTION

Known and cultivated with thousands years ago, soybean was considered, in origin areas from Asia, as a "holy" plant. Idolizing from those ages was transformed during time into an incontestable recognition of its value among plants with an agricultural importance and not only, making that soybean to be considered as "plant of the future" being presented nowadays on all continents. Soybean crop was imposed by its remarkable value being utilised as fodder, oleaginous source, protein source and raw material source for certain industries. Soybean is the leguminous whit the highest content in essential amino acids, which are into a better equilibrium, in comparison with other leguminous and with some animal products (Stan et al., 2005; Halga et al., 2005; Pop et al., 2006).

In according with Stoica (2001), soybean "plant of the future", as it is characterized by experts' in human nourishment have a high protein content (32-35%), fat (16-20%), non-nitrogenous extractive substances (24-30%) and a not such higher content in crude cellulose (8-9%). Protein from soybean is mainly composed by glycine, which due to its features is quite similar with milk casein. Can be soluble in phosphohydric environments and could be re-synthesised in acid environment.

Soybean meal represent the most important protein source for poultry and swine rearing but unfortunately in Romania and even in Europe it is a quite low level face to consumption. To obtain complete mixed fodders are recurred imports from different world areas (USA, Argentina, China, Brazil) where are cultivated different soybean sorts in different pedo-climatic conditions fact which made that products entered on Romanian market to present a great variability regarding chemical and nutritional features.

Literature which has tables with nutritive values for raw fodder material (NRC, 1994; FEDNA, 2010; Rostagno et al., 2011) present generally nutritive value for soybean meal and amino acids profile but without having in view the influence of sort, provenance area or processing conditions on chemical composition (Serrano et al., 2012).

In establishing of recipes for mixed fodders beside crude protein content is taking in account also amino acids content, parameters which are quite variable function of source and implicitly by sort(Irish et al., 1993; Dudley-Cash, 1997). In this context, was proved that many factors could affect chemical composition of soybean meal such as gene-type (Cromwell et al., 1999; Palacios et al., 2004), soil type, latitude, localization and environmental conditions (van Kempenet al., 2002; Goldflusetal., 2006; Thakuret al., 2007), source and origin country (Waldroupet al., 1985; Parsons etal., 1991; Karr-Lilienthal et al., 2004; de Coca-Sinova et al., 2008). Having in view the above mention things by the current paper we aimed to analyse from chemical and nutritional point of view several soybean meal imported from Brazil, by one of the largest importers from Romania.

MATERIALS AND METHODS

Analyses were effectuated on soybean meal samples imported from Brazil. The analysed material was constituted by 10 samples which were gathered from 10 imported lots of soybean meal. From each lot was gathered a number of samples and after that was formed an average sample in according with Regulation (EU) nr. 691/2013 (Murariu et al., 2013).

Chemical composition was established as follows: determination of dry matter was realised using AOAC nr. 925.30 method (AOAC, 1990; Benţea et al., 2015;Lazăr et al., 2015), and water content was the difference in according with the formula:Water(%) = 100% – DM(%); protein content was calculated by multiplication of total nitrogen content with 6.25, and for determination of total nitrogen was utilised Kjeldah method in according with AOAC nr. 925.31 method (AOAC, 1990; Szakacs et al., 2016;Lazăr et al., 2014a); content in lipids was determined by Sohxlet method in conformity with AOAC nr. 925.32 method (AOAC, 1990;Benţea et al., 2013; Lazăr et al., 2014b); content in total mineral substances was realised by samples' carbonization and after that their calcinations in according with AOAC 900.02 method (Lazăr et al., 2013); non-nitrogenous extractive substances were calculated by difference in according with the formula:NES(%) = 100% – (Water% + Ash% + CP% + CF%) (Stoica et al., 2001; Dolişet al., 2018).

Determination of amino acids was done by liquid chromatography which presumed the detachment of amino acids from protein molecule by utilisation of acid hydrolysis. Aminoacidsare determined after derivation of samples ortophtalaldehide and detection at 338 µm. Method wasrealised in conformity with SR EN ISO 13903:2005 standard, calculus for concentration being made by rating of drops' area to calibration curve.

The results of analysis were processed being statistically calculated position and variation estimators (arithmetic mean, standard deviation of mean S and variation coefficient V%) (Sandu, 1995; Doliş et al., 2017; Lup et al., 2017).

For determination of soybean meal energetic value was realised the calculus of caloricity using the theoretical formula based on quantity of gross energy liberated at burning of 1 g of proteins, fats and carbohydrates in calorimeter bomb, in concordance with the relation: GE (kcal/100 g) = 5.70 kcal x g proteins + 9.50 kcal x g fat +4.2 kcal x NES (Stoica et al., 2001; Halga et al., 2005; Simeanu, 2017).

Quality of proteins was appreciated with chemical methods which evaluate their value on the basis of content in essential amino acids. At the end of amino acids determination, appreciation was done by calculating the chemical indexes, relating amino acids of studied protein to the ones from etalon protein (Stoica et al., 2001; Marin et al., 2013; Simeanu, 2015; Mierliţă et al., 2018):

$$CI = \frac{\text{content in amino acid A of studied protein}}{\text{content in amino acid A of etalon protein}} \times 100.$$

The nutritional values were referred to the whole egg protein amino acid standard (Standard 1: Lysine - 7, Methionine+Cysteine - 5.7, Threonine - 4.7, Isoleucine - 5.4, Tryptophan - 1.7, Valine - 6.6, Leucine - 8.6, Histidine - 2.2, Phenylalanine+Tyrosine - 9.3;

EAA=51.2 g/16 g N (NRC, 1989)), the standard for mature human (Standard 2: Lysine - 5.5, Methionine+Cysteine - 3.5, Threonine - 4, Isoleucine - 4, Tryptophan - 1, Valine - 5, Leucine - 7, Phenylalanine+Tyrosine - 6; EAA=36 g/16 g N –(FAO/WHO, 1991; FAO, 2007; Murariu et al., 2018)) and to two different standards for animal feeding. The protein usability for animal feeding was estimated on the basis of standard for 20-50 kg growing pigs (Standard 3: Lysine - 7, Methionine+Cysteine- 3.6, Threonine - 4.5, Isoleucine - 4, Tryptophan - 1.2, Valine - 5.2, Leucine - 8, Histidine - 2.5, Phenylalanine + Tyrosine - 8; EAA=44 g/16 g N (Boisen et al., 2000; Marin et al., 2016; Mierliţă et al., 2018)) as well as the standard for 6-8 weeks chicken broilers (Standard 4: Lysine - 4.7, Methionine+ Cysteine - 3.3, Threonine - 3.8, Isoleucine - 3.4, Tryptophan - 0.9, Valine - 3.9, Leucine - 5.2, Histidine - 1.5, Phenylalanine+Tyrosine - 5.8; EAA=32.5 g/16 g N (NRC, 1994; Murariu et al., 2013; Mierliţă et al., 2018)).

After calculation of chemical indexes for essential amino acids we calculated Oser index (Oser, 1959) or EAAI (*Essential AminoAcid Index*) (Sujak et al., 2001; Kotlarz, 2011; Simeanu, 2015, Simeanu et al., 2017):

$$EAAI = \sqrt[n]{CI1 \times CI2 \times CI3 \times \dots \times CIn}.$$

Protein efficiency ratio (PER) of soybean meal was calculated according to the equations developed by Alsmeyer et al., 1974: PER = 0.06320 [X_{10}] - 0.1539, where X_{10} = Threonine + Valine + Methionine + Isoleucine + Leucine + Phenylalanine + Lysine + Histidine + Arginine + Tyrosine.

Biological value (BV) was calculated in conformity with the method described (Oser, 1959; Marin et al., 2017; Mierliţă et al., 2018), in according with the following relation:

$$BV = 1.09 (EAAI) - 11.7.$$

Nutritional index (NI) for analysed soybean meal was calculated in according with the formula described by Crisan and Sands (Crisan et al., 1978; Mierliţă et al., 2018):

$$NI (\%) = \frac{EAAI \times \% \text{ protein}}{100}.$$

RESULTS AND DISCUSSIONS

Chemical composition and urease activity of analysed soybean mean are presented in Table 1. The obtained results show the fact that analysed soybean meal have a chemical composition close to the one presented in literature (Halga et al., 2005; Valencia et al., 2008; 2009; Stefanello et al., 2016) (Table 1).

Table 1.Chemical quality indicators of soybean meal

Trait	Means (%)	±Mean error	V%	Min.	Max.
Water	9.9	0.05	1.69	9.60	10.20
Dry matter	90.1	0.05	0.19	89.80	90.40
Organic matter	85.3	0.07	0.26	84.90	85.67
Gross energy (kcal/kg)	4290	6.82	0.54	4250.66	4329.34
Proteins	41.24	0.21	1.59	40.50	42.40
Lipids	2.47	0.02	2.74	2.31	2.54
Crude fibre	4.00	0.05	3.69	3.72	4.15
Crude ash	4.80	0.05	3.06	4.60	5.08
Calcium	0.38	0.01	7.41	0.33	0.41
Phosphorous	0.65	0.01	5.42	0.61	0.70
NES	37.59	0.16	1.34	36.81	38.21
Urease activity (mg N/g)	0.042	0.001	5.95	0.04	0.04

Speaking about dry matter content could be observed that the obtained value was 90.1±0.05%; being quite good and placed into the limits founded in consulted literature (88-92.1%).

Protein content of analysed soybean meal wasn't a very good one because the value of 41.24±0.21% even if was into the limits imposed by literature (40.4-43.5%), was placed at the lower side of the interval.

Speaking about proteins the analysed soybean meal wasn't one with a very good quality but regarding crude fat content we noticed that the obtained value 2.47±0.02% is with around 60% higher that the one reported by Halga et al. (2005), which made that analysed soybean meal to have a good energetic value (4290 kcal GE/kg).

Also, at those energetic value also contributes non-nitrogenous extractive substances which had a value of 37.59±0.16%, with around 20% higher than the values founded in consulted literature.

About crude cellulose content, the analysed soybean meal had only 4±0.05% while the values from literature are higher (4.48-6%).

Urease activity index was very low 0.042±0.001 mg N/g, value which indicates a correct applied thermal treatment to soybean grains in order to inhibit the anti-nutritional factors. The value of variation coefficient of only 5.95% indicates a constant process for obtaining a good quality soybean meal in the processing unit.

Chemical analysis for studied soybean meal continued with determination of amino acids content, which is presented in Table 2.

Table 2.Amino acids content of soybean meal

Aminoacids	**Mean (g/100 g)**	**±Meanerror**	**V%**	**Min.**	**Max.**
Tryptophan	0.558	0.009	5.37	0.512	0.611
Threonine	1.644	0.026	5.01	1.524	1.760
Isoleucine	1.911	0.032	5.26	1.791	2.071
Leucine	3.153	0.029	2.89	3.024	3.316
Lysine	2.635	0.043	5.19	2.427	2.815
Methionine	0.536	0.008	4.78	0.506	0.584
Phenylalanine	2.180	0.029	4.28	2.031	2.319
Valine	2.040	0.019	3.01	1.968	2.137
Histidine	1.148	0.009	2.48	1.107	1.198
Arginine	2.928	0.036	3.85	2.794	3.137
Glycine	2.048	0.021	3.25	1.913	2.135
Serine	2.378	0.021	2.80	2.273	2.451
Tyrosine	1.489	0.021	4.55	1.412	1.627
Cysteine	0.657	0.008	3.99	0.618	0.687
∑AA essential	19.389	-	-	-	-

Sum of essential amino acids in case of analysed soybean meal samples was 19,389 g/100 g, value which is with 1.2% higher than sum of essential amino acids presented by Steffanelo et al, in 2016 but with 6.6% lower than the value reported by Halga et al., in 2005.

Nutritional values of proteins from analysed soybean meal (EAA, CS, EAAI, BV and NI) were calculated based on nutritional standards for broiler chickens aged 6-8 weeks (NRC, 1994, Mierliţă et al., 2018) and nutritional standard for rearing of swine with a corporal mass between 20 and 50 kg (Boisen et al., 2000; Mierliţă et al., 2018). The analysed soybean meal was compared with standards based on nutrients necessary for adult (FAO/WHO, 1991; Simeanu, 2015; Simeanu et al., 2017; Mierliţă et al., 2018).

Content in essential amino acids related to protein content (in g/16 g N equivalent with g/100 g protein) of studied soybean meal and chemical indexes calculated function of mentioned standards are presented in Table 3.

Table 3. Amino acids content andchemical indexesfor studied soybean meal

Aminoacids (g/16 g N)		Chemicalindexes			
		Standard 1	*Standard 2*	*Standard 3*	*Standard 4*
Tryptophan	1.353	79.59	135.31	112.75	150.34
Threonine	3.986	84.82	99.66	88.59	104.91
Isoleucine	4.631	85.77	115.79	115.79	136.22
Leucine	7.645	88.90	109.22	95.57	147.03
Lysine	6.389	**91.28**	**116.17**	**91.28**	**135.95**
Methionine + Cystine	2.893	**50.75**	**82.65**	**80.36**	**87.66**
Phenylalanine + Tyrosine	8.899	95.69	148.32	111.24	153.43
Valine	4.947	74.95	98.93	95.13	126.84
Histidine	2.784	126.53	-	111.35	185.58
EAA	43.527	-	-	-	-

Protein from analysed soybean meal is characterized by a low value in comparison with animal origin protein. This fact is confirmed in the current study by content in exogenous amino acids (EAA) which is 43.527 g/16 g N, value with around 15% lower than content in amino acids in hen egg which was taken as standard (NRC, 1989; Mierliţă et al., 2018; Simeanu et al., 2017).

Calculation of chemical indexes by relating to standard protein from egg show the fact that the most reduced chemical index is the one for methionine and cystine (50.75%) and the highest one for histidine (126.53%); otherwise, chemical index for histidinewas the only one which passed the level of 100.

In case of calculation of chemical indexes by relating to standard protein for chicken broilers aged 6-8 weeks, we observed that only in case of methionine and cystinethe value was under the level of 100. This fact enlighten that tio-amino acids from soybean meal became limitative in chicken broiler rearing so it must be utilised synthetic methionine and cystine to balance the amino acids share.

The same aspect was observed also in case of chemical indexes calculated by relating to standard protein for piglets with 20-50 kg corporal mass where chemical index for methionine and cystine was 80.36 – the lowest value from all chemical indexes calculated for swine. At this animals' breed and category was observed that are more amino acids which not fulfil the demands fact which impose that soybean meal to be used in mixture with other fodder raw materials so to be well covered the requirements. For this category of swine is imposed utilisation of synthetic amino acids (L-Lysine, DL-Methionine and L-Threonine) in making of mixed fodders.

Sulphuric amino acids are limitative also in case in which such a soybean product will be used in adult human nourishment. From this reason is mandatory that soybean products to be used in human nutrition only in association with those foods which have a better content in methionine, such as rice.

Nutritional value for protein from analysed soybean meal is presented in Table 4.

After applying the formulas for appreciation of proteins' nutritional value from analysed soybean meal we observed, once more, that this one represent a good protein source for chicken broilers (EAAI=133.64%, P-VB=133.96 and NI=55.11%).

Analysed soybean meal could be a good protein source for pigs with a corporal mass between 20 and 50 kg because calculated values were lower than the ones calculated for chickens with 25.55% for EAAI%, 27.78% for P-VB and with 25.54% for NI%. This fact is due to the lower content in sulphuric amino acids ($CS_{Met+Cys}$=80.36).

Regarding the comparison with standard for adult persons, we observed that this soybean product covered well the necessary for amino acids – EAAI%=11.58 and P-BV=109.92.

Table 4. Proteins' nutritional values of studied soybean meal

Specification		*Standard 1*	*Standard 2*	*Standard 3*	*Standard 4*
P-PER	2.859	-	-	-	-
EAAI (%)	-	84.36	111.58	99.49	133.64
P-BV	-	80.25	109.92	96.74	133.96
Nutritional index (%)	-	34.79	46.02	41.03	55.11

[1]Based on egg standard (NRC, 1989);
[2]Standard based on nutrient requirement for mature human (FAO/WHO 1991);
[3]Standard based on nutrient requirement for growing pigs 20-50 kg (Boisen et al., 2000);
[4]Standard based on nutrient requirement of 6-8 weeks chicken broilers (NRC, 1994);
P-BV - Predicted-Biological Value; P-PER - Predicted-Protein Efficiency Ratio.

Having in view the above presented values we could affirm about analysed soybean meal that have a good content in protein, and more over, a good content in amino acids. This conclusion could be generated because, nutritional a protein source with a good value is when essential amino acids index (EAAI) is>0.70, protein efficiency rate (PER) is>2.7 and predicted biological value (P-BV) is>70% (Mierliţă, 2018). Even if analysed soybean meal had a good protein and essential amino acids content, however couldn't be utilised in nourishment of young animals without addition of synthesis amino acids.

CONCLUSIONS

Research realised on 10 imported soybean meal lots shown that chemically speaking the analysed soybean meal had values into limits imposed by literature (90.1±0.05% DM, 41.24±0.021% CP, 2.47±0.02% CF, 4±0.05% CC, 4.8±0.05% C.Ash and 37.59±0.16% NES), and lots were very homogenous (V%=0.19-7.41). Urease activity index was very low 0.042±0.001 mg N/g, value which indicate a correct thermal treatment applied to soybean grains to inhibit anti-nutritional factors.

Appreciation of proteins' nutritional value from analysed soybean meal shown, once more, that this one represent a good protein source for chicken broilers aged 6-8 weeks (EAAI=133.64%, P-VB=133.96 and NI=55.11%) and a good protein source for pigs with a corporal mass between 20 and 50 kg because the calculated values were lower that the ones calculated for chickens with 25.55% for EAAI%, 27.78% for P-VB and with 25.54% for NI%.

This fact is due to the lower content in sulphuric amino acids ($CS_{Met+Cys}$=80.36). Even if analysed soybean meal had a good content in proteins and essential amino acids, however couldn't be utilised in nourishment of young animals without addition of synthesis amino acids.

Regarding the comparison with standard for adult persons, we observed that this soybean product covered well the necessary for amino acids – EAAI%=11.58 and P-BV=109.92.

Having in view the above presented values we could affirm about analysed soybean meal that have a good content in protein, and more over, a good content in amino acids because essential amino acids index (EAAI) is>0.70, protein efficiency rate (PER) is>2.7 and predicted biological value (P-BV) is>70%.

REFERENCES

Alsmeyer, R.H., Cunningham, A.E., Happich, M.L. (1974). Equations predict PER from amino acid analysis, *Food Technol.*, 28, 34-40.

AOAC. (1990). *Official Methods of Analysis of the AOAC*, 15th edition. Arlington, VA, USA: Association of Official Analytical Chemists.

Benţea, M., Şara, A., Creţa, C., Toma, A.A. (2013). The Effects of Some Additives on Production Performances in Laying Hens. *Bulletin UASVM - Animal Science and Biotechnologies*, 70(1), 122-127.

Benţea, M., Șara, A. (2015). Nutritive Traits and the Use of Guar meal in the Nutrition of Farm Animals. *Bulletin UASVM Animal Science and Biotechnologies*, 72 (2), 245-246.

Boisen, S., Hvelplund, T., Weisbjerg, M.R. (2000). Ileal amino acid profiles as a basis for feed protein evaluation, *Livest. Prod. Sci.*, 64, 239-251.

Crisan, E.V., Sands, A. (1978). *Biology and cultivation of edible mushrooms*. New York, USA: Hangeri Academic Press, 137-142.

Cromwell, G.L., Calvert, C.C., Cline, T.R., Crenshaw, J.D., Crenshaw, T.D., Easter, R.A., Ewan, R.C., Hamilton, C.R., Hill, G.M., Lewis, A.J., Mahan, D.C., Miller, E.R., Nelssen, J.L., Pettigrew, J.E., Tribble, L.F., Veum, T.L., Yen, J.T. (1999). Variability among sources and laboratories in nutrient analyses of corn and soybean meal. *J. Anim. Sci.*, 77, 3262-3273.

de Coca-Sinova, A., Valencia, D.G., Jimenez-Moreno, E., Lázaro, R., Mateos, G.G. (2008). Apparent ileal digestibility of energy, nitrogen, and amino acids of soybean meals of different origin in broilers. *Poult. Sci.*, 87(12), 2613-2623.

Doliş, M.G., Simeanu, C., Usturoi, Al., Simeanu, D. (2017). Research Regarding Chemical Composition and the Digestibility of the Mulberry Leaves from Eforie Variety. *Revista de Chimie*, vol. 68, no. 1, 151-156.

Doliş, M.G., Boişteanu, P.C., Usturoi, M.G., Simeanu, D., Bodescu, D., Nacu, G., Usturoi, Al., Simeanu, C. (2018). Research on Digestibility of the Mulberry Leaf from the Kokuso 21 Variety in Relation to the Dynamics of the Chemical Content. *Revista de Chimie*, vol. 69, no. 2, 439-444.

Dudley-Cash, W.A. (1997). Soybean meal quality varies widely in many parts of the world. *Feedstuffs*, 69, 15–17.

FAO/WHO (1991). Protein quality evaluation. Report of Joint FAO/WHO Expert Consultant, *FAO Food Nutrition paper*, 51, 19-21.

FAO (2007). Protein and amino acid requirements in human nutrition. Report of Joint WHO/FAO/UNU Expert Consultation. *WHO Technical Report Series*, 935.

Fundacion Espanola DesarrolloNutricion Animal (2010). *Normas FEDNA de composicion y valor nutritivo de alimentos para la fabricacion de piensoscompuestos*. In: De Blas, C., Mateos, G.G., Rebollar, P.G. (Eds.), 3rd edition. Madrid, ES: FEDNA.

Goldflus, F., Ceccantini, M., Santos, W. (2006). Amino acid content of soybean samples collected in different Brazilian statesharvest 2003/2004. *Braz. J. Poult. Sci.*, 8, 105–111.

Halga, P., Pop, I.M., Avarvarei, T., Popa, V. (2005). *Animal nutrition and feeding*. Iaşi, RO: Alfa Publishing House.

Irish, G.G., Balnave, D. (1993). Poor performance of broilers fed diets containing soybean meal as the sole protein concentrate. *Aust. J. Agric. Res.*, 44, 1467-1481.

Karr-Lilienthal, L.K., Merchen, N.R., Grienshop, C.M., Flahaven, M.A., Mahan, D.C., Fastinger, N.D., Watts, M., Fahey Jr., G.C. (2004). Ileal amino acid digestibility by pigs fed soybean meals from five major soybean-producing countries. *J. Anim. Sci.*, 82, 3198-3209.

Kotlarz, A., Sujak, A., Strobel, W., Grzesiak, W. (2011). Chemical composition and nutritive value of protein of the pea seeds - effect of harvesting year and variety, *Vegetable Crops Research Bulletin*, 75, 57-69.

Lazăr, M., Ancuţa, A., Lazăr, R., Paşca, S. (2013). Morphological aspects of some organopathies in wild rabbits (*Lepus europaeus*) from north Moldavia. *Lucr. Ştiinţ. USAMV Iaşi*, vol. 56(15),157-164.

Lazăr, M., Şindilar, E.V., Paşca, S., Lazăr, Gh., Boişteanu, P.C. (2014a). Roe deer (*Capreolus capreolus*) age-dentition-trophy correlation. *Lucrări Ştiinţifice USAMV Iaşi – seria Medicină Veterinară*, vol. 57, nr. 3-4, 309-313.

Lazăr, M., Lazăr, R., Diaconu (Găină), N., Boişteanu, P.C. (2014b). Researches regarding the characterization of the nutritional profile of wild boar (*Susscrofaferus*). *Bulletin UASVM Animal Science and Biotechnologies*, 71(2), 291-292.

Lazăr, M., Boişteanu, P.C., Lazăr, Gh., Lazăr, R. (2015). Research on nutritive values on roe deer (*Capreoluscapreolus*) meat. *Lucr. Ştiinţ. USAMV Iaşi*, vol. 58(1), 47-54.

Lup, F., Pop, I.M., Simeanu, D., Vicas, S., Simeanu, C., Mierliţă D. (2018). Research Regarding Fatty Acid Profile and Health Lipid Indices in the Lambs Meat of Employing Feed Supplemented with Different Vegetable Oils. *Revista de Chimie*, vol. 69, no. 1, 222-227.

Marin, M., Diniţă, G.,Nicolae, C.G., Marin, I. (2013). Metabolic usage of essential amino acids in the reproductive laying turkey organism. The 1st Global Virtual Conference (GV-conf 2013), Zilina, Slovakia, April 8-12, 2013. *Proceedings of GV - The 1st Global Virtual Conference (GV-conf 2013)*, 1, 665-668.

Marin, M., Hodoşan, C., Nicolae, C.G., Diniţă, G., Drăgotoiu, T., Nistor, L. (2016). Researches regarding the chemical composition and gross energy of sorghum in comparison to other forages for feeding cattle and pigs. *Scientific Papers. Series D - Animal Science*, LIX, 95-98.

Marin, M., Hodoşan, C., Diniţă, G., Nicolae, C.G. (2017). The influence of the chemical composition of maize, barley and peas hybrids on the digestibility of compound feed for pigs. *AgroLife Scientific Journal*, 6(2), 127-132.

Mierliţă, D., Simeanu, D., Pop, I.M., Criste, F., Pop, C., Simeanu, C., Lup, F. (2018). Chemical Composition and Nutritional Evaluation of the Lupine Seeds (*Lupinusalbus L.*) from Low-Alkaloid Varieties. *Revista de Chimie*, 69(2), 453-458.

Murariu F., Murariu O.C. (2013). Variation of amino acid content in *Longissimus dorsi* and *Triceps brachii* muscles in Karakul sheep according to age and muscle region, *Current Opinion in Biotechnology*, 24, S55-S56.

Murariu, O.C., Murariu, F, Boişteanu, P.C., Lazar, R. (2013). Research regarding the chemichal composition and nutritional value of ovines meat according to age, sex and breed, *Current Opinion in Biotechnology*, 24, S52.

Murariu, O.C., Işan, E., Robu, T., Irimia, L., Dicu, L., Raţu, R., Murariu, F. (2018). Evaluation of thepresence of the pesticide residuesand it s metabolitesfromrawmaterialsused as sources for ensuring a healhy nutritions for athletes. *Proceedings of ICU 2018, Ed.Learning.it 2018*, 185-193.

NRC (National Research Council) (1989). *Recommended Dietary Allowances*, *Protein and Amino Acids*, 10th edition. Washington DC, USA: National Academy Press.

NRC (National Research Council)(1994). *Nutrient Requirements of Poultry*, 9th rev. edition. Washington DC, USA: National Academy Press, 19-34.

Oser, B.L. (1959). An integrated essential amino acid index for predicting the biological value of proteins, In A.A. Albanese (Ed.), *Protein and amino acid nutrition*. New York, USA: Academic Press, 295-311.

Palacios, M.F., Easter, R.A., Soltwedel, K.T., Parsons, C.M., Douglas, M.W., Hymowitz, T., Pettigrew, J.E. (2004). Effect of soybean variety and processing on growth performance of young chicks and pigs. *J. Anim. Sci.*, 82, 1108–1114.

Parsons, C.M., Hashimoto, K., Wedekind, K.J., Han, Y., Baker, D.H. (1991). Effect of overprocessing on the availability of amino acids and energy in soybean meal. *Poult. Sci.,*71, 133–140.

Pop, I.M., Halga, P., Avarvarei, T. (2006). *Animal nutrition and feeding*. Iaşi, RO: TipoMoldova Publishing House.

Regulation (EU) nr. 691/2013 of Commission from 19 July 2013 for modification of Regulation (EC) nr. 152/2009 regarding sampling and analyzing methods. *Official Gazette of European Union* L 197/1 from 20.07.2013.

Rostagno, H.S., Albino, L.F.T., Donzele, J.L., Gomes, P.C., Oliveira, R.F., Lopes, D.C., Ferreira, A.S., Barreto, S.L.T., Euclides, P.F. (2011). Tabelasbrasileiras para aves e suínos. In: *Composicão De Alimentos E ExigênciasNutricionais*, 3rd edition. Viosa, Minas Gerais, BR: UFV Publishing House

Sandu, G. (1995). *Experimental models in animal husbandry*.Bucureşti, RO: Coral Sanivet Publishing House, p. 74.

Serrano, M.P., Valencia, D.G., Mendez, J., Mateos, G.G. (2012). Influence of feed form and source of soybean meal of the diet on growth performance of broilers from 1 to 42 days of age. *Poult. Sci.*, 91, 2838-2844.

Simeanu, C., Simeanu, D., Popa, A., Usturoi, Al., Bodescu, D., Doliş, M.G. (2017). Research Regarding Content in Amino-acids and Biological Value of Proteins from Polyodon spathula Sturgeon Meat. *Revista de Chimie*, 68(7), 1063-1069.

Simeanu, D. (2015). *Human nutrition*. Iaşi, RO: "Ion Ionescu de la Brad" Publishing House, p. 46.

Stan,Gh., Simeanu, D. (2005). *Animal nutrition*. Iaşi, RO: Alfa Publishing house.

Stefanello, C., Vieira, S.L., Rios, H.V., Simões, C.T., Sorbara, J.O.B. (2016). Energy and nutrient utilisation of broilers fed soybean meal from two different Brazilian production areas with an exogenous protease. *Animal Feed Science and Technology*, 221, 267-273.

Stoica, I., Stoica, L. (2001). *Basis of animal's nutrition and nourishment*. Bucureşti, RO: Coral Sanivet Publishing House.

Sujak, A., Kotlarz, A., Strobel, W. (2006). Compositional and nutritional evaluation of several lupine seeds.*Food Chem.*, 98, 711-719.

Szakacs, A.R., Matei, S., Ştefănuţ, L., Moni, Z., Macri, A.M. (2016). Effects of Pre and Probiotic on Growth Performance and Haematological Parameters in Pigs, *Bulletin UASVM Veterinary Medicine*, 73(2), Cluj Napoca, Romania.

Thakur, M., Hurburgh, C.R. (2007). Quality of US soybean meal compared to the quality of soybean meal from other origins. *J. Am. Oil Chem. Soc.*, 84, 835-843.

Valencia, D.G., Serrano, M.P., Lázaro, R., Latorre, M.A., Mateos, G.G. (2008). Influence of micronization (fine grinding) of soya bean meal and full-fat soya bean on productive performance and digestive traits in young pigs. *Animal Feed Science and Technology*, 147, 340-356.

Valencia, D.G., Serrano, M.P., Lázaro, R., Jiménez-Moreno, E., Mateos, G.G. (2009). Influence of micronization (fine grinding) of soya bean meal and full-fat soya bean on the ileal digestibility of amino acids for broilers. *Animal Feed Science and Technology*, 150, 238–248.

van Kempen, T.A.T.G., Kim, I.B., Jansman, A.J.M., Verstegen, M.W.A., Hancock, J.D., Lee, D.J., Gabert, V.M., Albin, D.M., Fahey Jr., G.C., Grieshop, C.M., Mahan, D. (2002). Regional and processor variation in the ileal digestible amino acid content of soybean meals measured in growing swine. *J. Anim. Sci.*, 80, 429-439.

Waldroup, P.W., Ramsey, B.E., Helwig, H.M., Smith, N.K. (1985). Optimum processing for soybean meal used in broiler diets. *Poult. Sci.*, 64, 2314-2320.