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Nutritional Value Determination of Different Varieties of Oats and Barley Using Near-Infrared Spectroscopy Method for the Horses Nutrition

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***Abstract*—**In horse nutrition, the most suitable cereal for their rations composition could be defined as oats and barley. Oats have high nutritive value because it provides more protein, fiber, iron and zinc than other whole grains, has good taste, and an activity of stimulating metabolic changes in the body. Another cereal – barley is very similar to oats as a feed except for some characteristics that affect how it is used; however, barley is lower in fiber than oats and is classified as a "heavy" feed. The value of oats and barley grain, first of all is dependent on its composition. Near-infrared spectroscopy (NIRS) has long been considered and used as a significant method in component and quality analysis and as an emerging technology for authenticity applications for cereal quality control. This paper presents the chemical and amino acid composition of different varieties of barley and oats, also digestible energy of different cereals for horses. Ten different spring barley (n = 5) and oats (n = 5) varieties, grown in one location in Lithuania, were assayed for their chemical composition (dry matter, crude protein, crude fat, crude ash, crude fiber, starch) and amino acids content, digestible amino acids and amino acids digestibility. Also, the grains digestible energy for horses was calculated. The oats and barley samples reflectance spectra were measured by means of NIRS using Foss-Tecator DS2500 equipment. The chemical components: fat, crude protein, starch and fiber differed statistically ($P<0.05$) between the oats and barley varieties. The highest total amino acid content between oats was determined in variety Flamingsprofi (4.56 g/kg) and the lowest – variety Circle (3.57 g/kg), and between barley - respectively in varieties Publican (3.50 g/kg) and Sebastian (3.11 g/kg). The different varieties of oats digestible amino acid content varied from 3.11 g/kg to 4.07 g/kg; barley different varieties varied from 2.59 g/kg to 2.94 g/kg. The average amino acids digestibility of oats varied from 74.4% (Liz) to 95.6% (Fen) and in barley - from 75.8 % (Tre) to 89.6% (Fen). The amount of digestible energy in the analyzed varieties of oats and barley was an average compound 13.74 MJ/kg DM and 14.85 MJ/kg DM, respectively. An analysis of the results showed that different varieties of oats compared with barley are preferable for horse nutrition according to the crude fat, crude fiber, ash and separate amino acids content, but the analyzed barley varieties dominated the higher amounts of crude protein, the digestible Liz amount and higher DE content, and thus, could be recommended for making feed formulation for horses combining oats and barley, taking into account the chemical composition of using cereal varieties.

***Keywords*—**Barley, digestive energy, horses, nutritional value, oats.

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I. Introduction

THE implementation of a successful feeding program depends on an accurate assessment of the nutritional value of the feed, as well as an understanding of the nutrient requirements of the specific horse.

Horses are basically forage-eating animals and must have a regular and minimum amount of pasture or hay on a daily basis. However, maximum production, growth and work cannot be obtained on a total forage ration. Grains are included in these rations to add energy. Protein supplements and minerals are then balanced with forage and grain for a complete ration. Grains should be selected on a cost per unit of energy or total digestible nutrients basis. Most of the common grains may be fed to horses. Oats are bulky grains preferred by many owners. In general, they are the “safest” of all grains to feed, but are not as high in total digestible nutrients as most of the other grains. They are higher in fiber, and may be fed whole, except that they should be rolled or crimped for young foals. Oats weigh less per unit volume than other grains.

The oats are thoroughly investigated for their specific chemical composition and nutritional value. Due to its high nutritional value: good taste, dietary properties, promote metabolic changes in the body, they are used for human and animal nutrition [1]-[4]. The oats straw is soft, and the grain itself is precious, and therefore, it is desirable feed for horses.

The high protein content of oat and excellent chemical score of oat amino acids have prompted in recent years several investigations of this cereal crop.

The chemical analysis of the oat hydrolysate indicated that the oat groat proteins have an excellent amino acid balance, nutritionally superior to the other cereal grains [5]. The major proteins of oats are globulins, therefore in oats are higher fundamental amino acids content compared with the other cereals [6], [7].

Barley can be a substitute for corn. Corn and wheat have a slightly higher energy value compared with the barley. However, barley grain has higher crude protein content than

corn, lower compared with the field peas, but similar with the wheat and oats [8].

Barley can be included in the diets of ruminants, monogastric livestock, poultry and even fish [9]. However, certain aspects of animal nutrition set limits on the use of barley. The quality requirements of feed barley are related to grain composition and structure through the supply of essential amino acids, phosphorus and minerals, energy content and digestibility. Many requirements for feed barley are related to the polysaccharides present in the barley grain. Starch serves as the primary source of digestible energy for livestock; a high starch content is thus preferred in barley used as feed [10], [11]. The high starch content is also supported by the requirement of high grain weight for feed barley [12]. In ruminal feed, a high starch content and low content of insoluble or acid detergent fiber fraction are favored, because such a composition combined with high particle size after dry rolling has been associated with higher weight gain and a slower digestion rate without undesirable symptoms [9], [13].

For the optimization of equine diets, it is necessary to ensure the adequate, but not inordinately amounts of the indispensable amino acids and protein that are fed. Thus, a better understanding of whole body protein metabolism and the requirements for those irreplaceable amino acids probably to be limiting in equine diets is needed.

In making feed formulations for horses, it is important to know the exact amount of nutrients, because this factor is essential for their productivity, healthiness and the profitability of feeds. Application of the NIRS technique in cereal quality control is characterized by rapid development from prediction of major constituents in grains to prediction of functional properties of cereals that define its capability to meet the requirements of the intended purposes. Thus, the aim of this study was to determine the nutritional value of several oats and barley varieties, assessing their nutritional value according to NIRS method and to calculate the content of digestive energy for horses.

II. Material and Methods

A. Samples

Clean and uncontaminated samples of oats (n=5) and barley (n=5) were taken for nutritional value analyses. All cultivars were grown in experimental fields of Institute of Agriculture at LRCAF (Lithuania). The fertilization of oats was NPK 16-16-16, barley − NPK 17-10-14+11S 300 kg/ha, additional – ammonium nitrate 100 kg/ha.

B. Milling

Oats and barley samples were milled using a Laboratory Mill 120 (Perten Instruments AB, Sweden), with minor flow changes. Grains were poured into a plastic funnel mounted on a vacuum feed control and milled; a 1 mm homogeneous sample was collected in a nylon bag.

C. Chemical Analyses of Oat and Barley Samples

Different varieties of oats and barley, with their growth conditions known, were analyzed by the following methods: moisture, crude protein, crude fat, ash, crude fiber, starch and amino acids content, digestible amino acids and amino acids digestibility were determined with NIRS analysis. The reflectance spectra of barley and oats samples were measured by means of NIRS using a Foss-Tecator (DS2500) equipment on the milled grain samples. NIRS calibration models for starch and moisture content were developed using software, ISIscan Nova (Germany).

A horse's digestible energy (DE) was calculated by method of [14] (1):

$$\text{DE (MJ/kg DM)} = 8.86 + 0.05097 \times \text{Crude protein (g/kg)} - 0.0392 \times \text{ADF} - 0.0160 \times (\text{NDF-ADF}) + 0.197 \times \text{Crude fat} + 0.085 \times (100 - \text{Crude protein-NDF-Crude fat-Crude ash}) - 0.110 \times \text{Crude ash} \quad (1)$$

D. Statistical Analysis

The results of the experiment were analyzed using the one-way ANOVA test, and significant differences between groups were determined by Duncan's multiple range test. Statistica 8.0 for Windows™ software was used. Differences were considered significant at $P<0.05$.

III. Results and Discussion

The main components of the analyzed oats and barley samples were starch and crude protein (Table I). The starch content significantly differed between cereal grains types ($P<0.05$) with mean values ranging from 43.46% in oats to 59.79% in barley. The higher cold viscosity (CV) of starch was in oats (3.29%) than in barley (1.89%). Starch is the most abundant energy source for most domestic animals; to maximize starch utilization, high small intestinal digestibility of barley starch is desirable for mono-gastric animals. In ruminants, starch in cereals also serves as an important source of energy for microbial growth and has therefore great impact on the feed protein value [15]. Reference [16] found that hulless barley was characterized with significantly higher starch content.

The mean crude fat content present in this study ranged from 1.48% in barley to 4.66% in oats ($P<0.05$). For these cereal grains, variation between varieties was relatively high, with CV values ranging from 4.71% to 6.08%.

The crude protein content in oats and barley varied 4.10%−5.41% and 10.87%−14.89%, respectively. The mean crude protein content ranged from 10.03% in oats to 12.71% in barley ($P<0.05$). The CV of crude protein content was similar for the grains and ranged from 4.79% in oats to 5.51% in barley.

The protein content (16.91%–17.46%) was within the range (15%–20%) as reported by [17], [18].

The crude fiber content in present study in barley and oats varied 3.48%−4.89% and 6.76%−9.83% respectively. The mean crude fiber content ranged from 4.19% in barley to 8.44% in oats ($P<0.05$).

The data presented in this paper demonstrate clearly a notable variation of important components in oats and barley grain. The differences in chemical composition of different oats and barley types may be explained by genetic make-up

since all varieties were grown under the same environmental conditions. The results of the present study for composition of barley grain (Table I) are in agreement and comparable to those reported by [19], [20]. However, other researches [21] determined higher content of chemical components than presented in our studies. Variations in proximate composition, mainly in starch, crude protein, and fiber could affect the actual digestibility and digestible energy values of feed.

TABLE I
THE CHEMICAL COMPOSITION AND DIGESTIBLE ENERGY OF DIFFERENT OATS AND BARLEY VARIETIES FOR HORSES

		Moisture, %	Crude fat, %	Crude protein, %	Ash, %	Crude fiber, %	Starch, %	DE (MJ/kg DM)
Oats (n=5)	Mean	11.60	4.66[a]	10.03[a]	4.51	8.44[a]	43.46[a]	13.74[a]
	Min	11.17	4.10	8.83	4.12	6.76	38.93	13.44
	Max	12.23	5.41	11.71	4.88	9.83	48.07	14.19
	SD	0.17	0.22	0.48	0.13	0.65	1.43	0.13
	CV%	1.47	4.71	4.79	2.86	7.72	3.29	0.95
Barley (n=5)	Mean	7.95	1.48[b]	12.71[b]	3.32	4.19[b]	59.79[b]	14.85[b]
	Min	6.98	1.29	10.87	2.75	3.48	55.90	14.31
	Max	8.89	1.78	14.89	3.89	4.89	62.20	15.08
	SD	0.35	0.09	0.70	0.20	0.25	1.12	0.14
	CV%	4.39	6.08	5.51	6.03	5.98	1.86	0.94

Notes: SD - standard deviation; CV-coefficient of variation;
Means within a column not showing a common superscript letter are significantly different between grain types; a, b – P<0.05.

The digestible energy of oats for horses range from 13.44 MJ/kg DM to 14.19 MJ/kg DM; barley from 14.31 MJ/kg DM to 15.08 MJ/kg DM. The mean digestible energy content ranged from 13.74 MJ/kg DM in oats and to 14.85 MJ/kg DM in barley (P<0.05). Variation within grains was very similar in oats (CV 0.95%) and barley (CV 0.94%). These results are the same as [22], [23], which claim that digestible energy of oats for horses is from 11.92 MJ/kg to 13.39 MJ/kg and digestible energy of barley for horses is from 14.7 MJ/kg to 15.4 MJ/kg.

The variation in digestible energy content observed, particularly for barley and oats, may be of significance for the formulation of livestock diets, because cereals are major dietary ingredients and the largest contributor to dietary energy. Further studies using animals are warranted to determine whether the observed variation in digestible energy content is also reflected in digestible energy and metabolizable energy value of the respective cereals [24].

The present study showed the differences in the content of amino acids of analyzed grain of oats and barley varieties (Table II). The higher protein content in barley is accompanied by lower contents of the essential amino acids, particularly lysine and threonine that are the most limiting amino acids in cereals' protein for monogastric animals [25], [26].

There are 22 standard amino acids, but only 10 amino acids are essential. The primary amino acids are needed for protein synthesis, several can be made by the tissues of the body, while, lysine, methionine, threonine, tryptophan, valine, isoleucine, leucine, phenylalanine, histidine and arginine are the essential amino acids that must be made available through dietary sources.

TABLE II
AMINO ACIDS CONTENT IN DIFFERENT OATS AND BARLEY VARIETIES

		Lys	Met	Thr	Trp	Val	Ile	Leu	Phe	His	Arg
		g/kg									
Oats (n=5)	Mean	0.44[a]	0.18	0.35	0.18[a]	0.53[a]	0.34	0.54	0.50	0.22[a]	0.71[a]
	Min	0.42	0.16	0.32	0.16	0.48	0.30	0.42	0.44	0.19	0.68
	Max	0.46	0.20	0.39	0.19	0.60	0.40	0.73	0.59	0.26	0.76
	SD	0.01	0.01	0.01	0.01	0.02	0.02	0.05	0.03	0.01	0.02
	CV%	2.28	5.56	2.86	5.57	3.78	5.88	9.26	6.01	4.55	2.82
Barley (n=5)	Mean	0.33[b]	0.16	0.30	0.13[b]	0.44[b]	0.31	0.60	0.46	0.18[b]	0.42[b]
	Min	0.32	0.15	0.29	0.13	0.40	0.29	0.53	0.38	0.17	0.40
	Max	0.35	0.17	0.32	0.14	0.46	0.33	0.65	0.58	0.19	0.44
	SD	0.03	0.01	0.02	0.01	0.04	0.01	0.02	0.04	0.02	0.01
	CV%	9.10	6.25	6.67	7.70	9.06	3.24	3.36	8.71	11.13	2.36

Notes: SD - standard deviation; CV-coefficient of variation;
Means within a column not showing a common superscript letter are significantly different between grain types; a, b – P<0.05.

The mean Lys content ranged from 0.33 g/kg in barley to 0.44 g/kg in oats (P<0.05). The CV for the content of Lys in protein was especially high in barley (9.10%). The Trp content in barley and oats varied 0.13−0.14 g/kg and 0.16−0.19 g/kg, respectively. The mean Trp content ranged from 5.57 g/kg in oats to 7.70 g/kg in barley (P<0.05).

The studied oat samples were rich in non-essential amino acids such as glutamic acid (Glu), arginine (Arg) and proline

(Pro) and essential amino acids such as leucine (Leu), valine (Val) and phenylalanine (Phe), as previously reported [27], [28]. Significant and considerable differences between grains were also detected in the Val, His and Arg content.

The mean Val content ranged from 0.44 g/kg (CV 9.06%) in barley to 0.53 g/kg (CV 3.78%) in oats, the mean His content from 0.18 g/kg (CV 11.13%) in barley to 0.22 g/kg (CV4.55%) in oats and the mean Arg content from 0.42 g/kg (CV 2.36%) in barley to 0.71 g/kg (CV 2.82%) in oats. Also [29] detected the contents in barley: lysine – 4.11 g/100g, methionine – 1.91 g/100g, threonine – 3.70 g/100g. Whereas, in barley [30] detected: lysine –3.7 g/100g DM, methionine – 1.0 g/100g DM, valine – 3.8 g/100g DM, leucine – 7.1 g/100g DM.

TABLE III
DIGESTIBLE AMINO ACIDS CONTENT IN DIFFERENT OATS AND BARLEY VARIETIES

		Lys	Met	Thr	Trp	Val	Ile	Leu	Phe	His	Arg
		g/kg									
Oats (n=5)	Mean	0.32[a]	0.16	0.28	0.15[a]	0.45[a]	0.31	0.51	0.48	0.18	0.64[a]
	Min	0.31	0.14	0.25	0.14	0.41	0.27	0.40	0.42	0.16	0.61
	Max	0.34	0.18	0.32	0.16	0.52	0.37	0.69	0.57	0.22	0.70
	SD	0.01	0.01	0.01	0.01	0.02	0.02	0.05	0.03	0.01	0.02
	CV%	3.13	6.26	3.58	6.67	4.43	6.45	9.79	6.25	5.56	3.13
Barley (n=5)	Mean	0.25[b]	0.13	0.23	0.11[b]	0.34[b]	0.26	0.54	0.42	0.15	0.36[b]
	Min	0.24	0.13	0.22	0.10	0.31	0.25	0.47	0.34	0.14	0.35
	Max	0.27	0.14	0.24	0.12	0.35	0.28	0.59	0.52	0.15	0.38
	SD	0.01	0.02	0.01	0.02	0.04	0.01	0.02	0.02	0.01	0.01
	CV%	4.01	15.38	4.36	18.16	11.76	3.84	3.68	4.76	6.65	2.79

Notes: SD - standard deviation; CV-coefficient of variation;
Means within a column not showing a common superscript letter are significantly different between grain types; a, b – P<0.05.

The amino acid composition of oat affects the quality of proteins and their amino acid properties [24], [31].

The mean digestible Lys content (Table III) ranged from 0.25 g/kg in barley to 0.32 g/kg in oats (P<0.05). The digestible Trp content in barley and oats varied 0.10−0.12 g/kg and 0.14−0.16 g/kg, respectively. The mean digestible Trp content ranged from 0.11 g/kg in oats to 0.15 g/kg in barley (P<0.05).

The mean digestible Val content ranged from 0.34 g/kg in barley to 0.45 g/kg in oats (P<0.05). The higher CV of digestible Val was 11.76% in barley. The higher differences were detected in the digestible Arg. The mean digestible Arg content ranged from 0.36 g/kg in barley to 0.64 g/kg in oats (P<0.05). Significant and considerable differences between grains were detected in the Met digestibility, Val digestibility and Arg digestibility content (Table IV).

TABLE IV
AMINO ACIDS DIGESTIBILITY CONTENT IN DIFFERENT OATS AND BARLEY VARIETIES

		Lys	Met	Thr	Trp	Val	Ile	Leu	Phe	His	Arg
		%									
Oats (n=5)	Mean	74	91[a]	79	85	86[a]	90	94	96	85	91[a]
	Min	73	90	78	84	85	90	93	95	84	90
	Max	77	91	81	87	87	91	95	97	86	92
	SD	0.75	0.24	0.63	0.58	0.40	0.37	0.37	0.40	0.40	0.37
	CV%	1.00	0.26	0.81	0.68	0.46	0.40	0.38	0.42	0.48	0.41
Barley (n=5)	Mean	76	86[b]	76	82	77[b]	85	89	90	82	86[b]
	Min	75	85	75	81	77	84	89	89	82	86
	Max	77	86	76	82	78	85	90	90	83	87
	SD	0.32	0.24	0.20	0.24	0.24	0.20	0.20	0.24	0.20	0.24
	CV%	0.42	0.29	0.26	0.30	0.30	0.24	0.22	0.26	0.25	0.28

Notes: SD - standard deviation; CV-coefficient of variation;
Means within a column not showing a common superscript letter are significantly different between grain types; a, b – P<0.05.

The mean Met digestibility content ranged from 86% in barley to 91% in oats, the mean Val digestibility content from 77% in barley to 86% in oats and the mean Arg digestibility content from 86% in barley to 91% in oats.

IV. CONCLUSIONS

In this study the variation in chemical composition, nutritional value and digestible energy between individual samples of oats and barley used for horse's nutrition were observed. The higher nutritional value and chemical composition was found in oats, but in barley were higher crude protein, starch, Leu digestible, Lys digestibility contents and digestible energy for horses.

Considering the high nutritional value of the investigated grain, creating the rations for horses, oats and barley can be used in combination.

REFERENCES

[1] T. S. Brand and J. P. Merwe, "Naked oats (Avena nuda) as a substitute for maize in diets for weanling and grower-finisher pigs", *Animal Feed Science and Technology,* vol. 57, pp. 139-147, 1996.

[2] Å. Lia, H. Andersson, N. Mekki, C. Juhel, M. Senft and D. Lairon, "Postprandial lipemia in relation to sterol and fat excretion in ileostomy subjects given oat bran and wheat test meals", *American Journal of Clinical Nutrition*, vol. 66, pp. 357-365, 1997.

[3] P. Peltonen-Sainio, M. Kontturi and A. Rajala, "Impact dehulling oat grain to improve quality of on-farm produced feed", I. Hullability and associated changes in nutritive value and energy content", *Agricultural and Food Science*, vol. 13, pp. 18-28, 2004.

[4] D. M. Peterson, "Oat – a multifunctional grain", In: P. Peltonen-Sainio, M. Topi-Hulmi (Eds.), *Proceedings, 7th International Oat Conference*, *Agrifood Research Reports* 51. MTT Agrifood Research, Jokioinen, Finland, 2004, pp. 21-26.

[5] E. K. Arendt and E. Zannini, "Oats. Cereal grains for the food and beverage industries", *Cambridge: Woodhead Publishing*, pp. 243-282, 2013.

[6] C. Klose and E. K. Arendt, „Proteins in oats; their synthesis and changes during germination: A review", *Critical Reviews Food Science Nutrition*, vol. 52, pp. 629-639, 2012.

[7] E. Bartnikowska, "Przetwory z ziarna owsa jako źródło ważnych substancji prozdrowotnych w żywieniu człowieka" (Oat grain preparations as a source of important health-related substances in human nutrition). *Biul. Inst. Hod. Aklim. Rośl.,* vol. 229, pp. 235-245, 2003.

[8] J. Rowe, W. Brown and S. Bird, "Safe and effective grain feeding for horses", *Rural Industries Research and Development Corporation*, Kingston, ACT, Pub. Vol. 01, no. 148, 2001.

[9] T. Blake, V. C. Blake, J. G. P. Bowman and H. Abdel-Haleem, "Barley feed uses and quality improvement", In: *Ullrich SE, ed. Barley: Production, Improvement, and Uses. West Sussex*, UK, pp. 522-531, 2011.

[10] S. L. Fairbairn, J. F. Patience, H. L. Classen and R. T. Zijlstra, "The energy content of barley fed to growing pigs: characterizing the nature of its variability and developing prediction equations for its estimation", *Journal of Animal Science*, vol. 77, pp. 1502-1512, 1999.

[11] D. Solà-Oriol, E Roura and D. Torrallardona, "Feed preference in pigs: relationship with feed particle size and texture", *Journal of Animal Science,* vol. 87, pp. 571-582, 2009.

[12] B. K. Baik, "Processing of barley grain for food and feed", In: *Chemistry and Technology,* eds. P. R. Shewry and S. E. Ullrich, Barley: St. Paul: AACC International, 2014, pp. 233-268.

[13] L. M. M. Surber, J. G. P. Bowman, T. K. Blake, D. D. Hinman, D. L. Boss and T. C. Blackhurst, "Prediction of barley feed quality from laboratory analyses", *Proceedings of Western Section of American Society of Animal Science,* vol. 51, pp. 454-457, 2000.

[14] J. D. Pagan, "Measuring the digestible energy content of horse feed", In: J. D. Pagan (ed). *Advances in Equine Nutrition*. Nottingham University Press, Nottingham, 1998, pp. 71-76.

[15] B. Svihus, A. K. Uhlen and O. M. Harstad, "Effect of starch granule structure, associated components and processing on nutritive value of cereal starch", *A review. Anim. Feed Sci. Technol.,* vol. 122, pp. 303-320, 2005.

[16] P. Åman and C. W. Newman, "Chemical composition of some different types of barley grown in Montana", *Journal of Cereal Science,* USA, vol. 4, pp. 133-141, 1986.

[17] G. S. Robbins, Y. Pomeranz and L. W. Briggle, "Amino acid composition of oat groats", *J. Agr. Food Chem*., vol. 19, pp. 536-539, 1971.

[18] S. D. McMullen, "Oats", In: *Handbook of Cereal Science and Technology*. K. J. Lorenz, K. Kulp (eds.), Marcel Decker Inc., New York, 1991, pp. 199-232.

[19] V. Grove, J. Hepton and C. W. Hunt, "Chemical Composition and Ruminal Fermentability of Barley Grain, Hulls, and Straw as Affected by Planting Date, Irrigation Level, and Variety", *Professional Animal Scientist*, vol. 19, pp. 273-280, 2003.

[20] B. K. Baik and S. E. Ullrich, "Barley for food: characteristics, improvement, and renewed interest", *Journal of Cereal Science*, vol. 48, pp. 233-242, 2008.

[21] M. U. Makeri, I. Nkama and M. H. Badau, "Physico-chemical, malting and biochemical properties of some improved Nigerian barley cultivars and their malts", *International Food Research Journal*, vol. 20, no. 4, pp. 1563-1568, 2013.

[22] NRC, "Nutrient Requirements of Horses", *5th Revised Edition. National Academy press,* D. C. Washington, 1989, pp. 58.

[23] D. Sauvant, J. M. Perezaand G. Tran, "Tables of composition and nutritional value of feed materials: pigs, poultry, cattle, sheep, goats, rabbits, horses, fish", D. Sauvant, J.M. Perez and G. Tran (Eds), *Wageningen Academic Publishers*, Wageningen and INRA Editions, Versailles, 2004.

[24] M. Rodehutscord, C. Rückert, H. P. Maurer, H. Schenkel, W. Schipprack, K. E. B. Knudsen, M. Schollenberger, M. Laux, M. Eklund, W. Siegert and R. Mosenthin, "Variation in chemical composition and physical characteristics of cereal grains from different genotypes", *Archives of Animal Nutrition*, vol. 70, no. 2, pp. 87-107, 2016.

[25] E. Jacyno, "Nutritive value of barley varieties and feed mixtures containing them in pigs feeding", *Ph .D. dissertation, Agricultural University in Szczecin, Poland*, 1989.

[26] R. K. Newman and C. W. Newman, "Barley: Genetics and nutrient composition", In: *Barley for Food and Health: Science, Technology, and Products.* John Wiley and Sons, Inc. Publication, New Jersey, 2008, pp. 56-94.

[27] T. Georgieva and P. Zorovski, "The content of non-essential amino acids in the grains of winter and spring varieties of oats (Avena sativa L.) under the conditions of Central Southern Bulgaria", *Agro-knowledge J.*, vol. 14, no. 1, pp. 105-113, 2013.

[28] W. Biel, E. Jacyno and M. Kawecka, „Chemical composition of hulled, dehulled and naked oat grains", *S. Afr. J. Anim. Sci*., vol. 44, pp. 189-197, 2014.

[29] M. Åssveen, "Amino acid composition of spring barley cultivars used in Norway", *Acta Agriculture Scandinavica Section B-Soil and Plant Science*, vol. 59. pp. 395-401, 2009.

[30] M. Bleidere, "Amino acids composition of spring barley genotypes with different protein content", *Acta Biol. Univ. Daugavp.* vol. 11, no. 1, 2011.

[31] W. Biel, K. Bobko and R. Maciorowski, "Chemical composition and nutritive value of husked and naked oats grain", *Journal Cereal Science,* vol. 49, no. 3, pp. 413-418, 2009.