Journal of Microbiology, Biotechnology and Food Sciences

Vršková et al. 2013 : 2 (Special issue 1) 2079-2086

REGULAR ARTICLE

PROTEIN QUALITY EVALUATION OF NAKED OAT (*AVENA NUDA* L.) AND BUCKWHEAT (*FAGOPYRUM ESCULENTUM* MOENCH) BY BIOLOGICAL METHODS AND PDCAAS METHOD

Martina Vršková[*1], *Emília Bencová*[1], *Vladimír Foltys*[1], *Michaela Havrlentová*[2], *Iveta Čičová*[3]

Address: Ing. Martina Vršková, PhD.,

[1]Animal Production Research Centre Nitra, Institute for Nutrition, Hlohovecká 2, 951 41 Lužianky, Slovak Republic.

[2]Plant Production Research Centre Piešťany, Biology of Plants, Bratislavská cesta 122, 921 68 Piešťany, Slovak Republic.

[3]Plant Production Research Centre Piešťany, Gene Bank of the Slovak Republic, Bratislavská cesta 122, 921 68 Piešťany, Slovak Republic.

[*]Corresponding author: vrskova@cvzv.sk

ABSTRACT

The aim of this paper was to determine the protein quality of naked oat (*Avena nuda* L.) and buckwheat (*Fagopyrum esculentum* Moench) by traditional biological methods [Protein Efficiency Ratio (PER), Net Protein Utilization (NPU), Biological value] and the protein digestibility-corrected amino acid score (PDCAAS). As an animal model we used growing rats at the age of 21 days and at average body weight 83 g. The tested feeds represented the only nitrogen source in the experimental diets, and the tested nitrogen substances were 10 % of the feed ration in dry matter. We found higher values achieved in growth, feed conversion and crude protein intake in the group fed buckwheat. Buckwheat achieved higher biological value. Oat achieved a higher digestibility, which was also influenced by higher PDCAAS. Buckwheat achieved higher biological protein value. Isoleucine was the limiting amino acid in both tested feeds. Other parameters of the evaluation of protein quality (PER, NPU) had minimal differences.

Keywords: rat, oat, buckwheat, biological methods, PDCAAS

INTRODUCTION

Access to sufficient food of adequate quality to maintain normal body structure and function throughout life is essential for maintaining of health. Protein is an essential component of a healthy nutrition, which allows the growth and maintenance of 25 000 proteins encoded in the human genome, as well as other nitrogen compounds, which together form the body system dynamic structural and functional elements, and thus provide nitrogen cycle in the environment **(WHO, 2007)**. Proteins perform many functions in the body, for example: building function, regulation of metabolism, transport of nutrients, synthesis of enzymes and hormones, immune response, and many others **(Keresteš *et al.*, 2011)**.

From the above mentioned it follows that it is necessary to assess the quality of protein, whether vegetable or animal origin. For many years, bioassays, predominantly using growing rats, were the preferred approach to assessing the nutritional quality of proteins **(Schaafsma, 2005)**. Values are expressed in parameters Protein Efficiency Ratio (PER), Net Protein Utilization (NPU) and biological value (BV). These methods, however, did not take into account the composition of amino acids in humans. Accordingly, experts from FAO/WHO derived comparative method known as protein digestibility-corrected amino acid score (PDCAAS), which is now accepted as a standard procedure for assessing the quality of protein. These experts concluded that protein quality could be assessed adequately by expressing the content of the first limiting essential amino acid in a test protein as a percentage of the content of the same amino acid in a reference pattern of essential amino acids. This reference pattern was based on the essential amino acid requirements of preschool-age children **(WHO, 2007)**.

Cereals are the world's most important crops and cereal products are the most important food. Cereals have low content of protein and composition of essential amino acid is non-balanced **(Asgar *et al.*, 2010)**. The most important "bread" cereal is wheat (*Triticum aestivum* L.), which contains gluten, that causes health problems in some people and can cause illness - celiac disease **(Gálová *et al.*, 2010)**. As the solution is the use of minor cereal species so-called pseudocereals **(Moudrý *et al.*, 2005)**. For example buckwheat has high content of protein (9.7 – 15%) and starch. Compared to conventional cereals it has almost

optimal representation of the essential amino acid composition and is similar to the structure of amino acids in legumes **(Michalová and Čejka, 1996)**.

The objective of our study was to determine and compare the quality of protein in naked oats (*Avena nuda* L.) variety Tatran and buckwheat (*Fagopyrum esculentum* Moench) variety Špačinská by biological methods (PER, BV, NPU, UP) and method PDCAAS.

MATERIAL AND METHODS

Feed

Experimental feeds naked oat (*Avena nuda* L.) variety Tatran and buckwheat (*Fagopyrum esculentum* Moench) variety Špačinská were offered us by PPRC in Piešťany. Tested feeds represented the only source of nitrogen in the experimental diets. Crude protein (CP) of feeds made up 10% of the ration is dry matter (Table 1). Analysis of nutrients in feed, feces and urine were performed according to the Commission Regulation EC no. 152 (2009). The content of amino acids after acid hydrolysis 6M-HCl and methionine and cystine after oxidation hydrolysis was determined in an automatic amino acid analyzer AAA 400 (fy Ingos Praha).

Table 1 Composition of feed mixture (% of dry matter)

Test crops	**amount equivalent content of 10% crude protein**
sucrose	10%
mineral-vitamins premix	5.2%
oil	5%
cellulose	to about 4% including fiber of feed
starch	up to 100%

Animals and methods used

The quality of protein in selected alternative crops we investigated by the biological methods (protein digestibility, protein efficiency ratio - PER, biological value - BV, net protein utilization - NPU) in accordance with the standard method by **Eggum (1973)** and **Heger et al. (1990)**. In each group, eight Wistar male rats (Velaz, Ltd., Prague) were weaned

at 21 days of age, the average body weight 83 g. The animals were housed individually in metabolic stainless steel screen-bottom cages, with standard temperature and humidity, with 12 hour light-dark cycle. Animals were given free access to water and feed and records of weekly food consumption and body weights were kept. Standard 23/2009 digest of laws for the care and use of laboratory animals was followed.

Protein digestibility-corrected amino acid score (PDCAAS) was calculated using the following formula:

$$\text{PDCAAS} = \frac{\text{mg of first limiting amino acid in 1 g test protein}}{\text{mg of the same amino acid in 1 g reference protein}} \times \text{digestibility of protein (\%)} \times 100$$

This reference model is based on protein amino acid requirements for preschool children **(WHO, 2007)**.

RESULTS AND DISCUSSION

The content of crude protein in cereals is generally low, which is confirmed by our results in the naked oat (*Avena nuda* L.) variety Tatran 125.4 g/kg and buckwheat (*Fagopyrum esculentum* Moench) variety Špačinská 146.6 g/kg. **Rychlík (2004)** reported values by 1.5% higher in oat compared with our results. Similarly **Bíro *et al.* (2010)** found higher values for oats. **Sant'Ana *et al.* (2011)** found in oat as many as 18.13% crude protein content. When compared with other authors dealing in this particular field **Moudrý *et al.* (2005)** and **Petrikovič *et al.* (2000)** mentioned values of crude protein fluctuating by 2% up and down. **Kováčiková (2010)** found the lowest content of CP in buckwheat by 5% lower compared to us.

In testing these crops on animal model, we found higher increase of body weight by 9% in group with buckwheat feeding. This group had higher CP intake and feed conversion too (Table 2). Indigestible part of CP in feeds was reflected in the amount of nitrogen excreted in urine and feces. The group of rats fed oat excreted more nitrogen in urine, second group in feces, which was reflected in the final protein digestibility of crude protein, which was higher in oat. **Petrikovič *et al.* (2000)** found this parameter in oats and buckwheat higher (82% and 78%) than we did. Higher digestibility of buckwheat (74%) found **Moudrý *et al.* (2005)**. The difference in the excretion of nitrogen in urine and feces was also reflected by a higher

biological value of proteins in buckwheat by 6%. Differences in other endpoints (PER, NPU) were negligible.

Table 2 Observed parameters of quality protein

Feed		**oat**	**buckwheat**
Parameters		$\bar{x} \pm s_x$	$\bar{x} \pm s_x$
Increase body weight	g	107.64 ± 21.88	118.78 ± 18.13
Feed conversion	g	3.64 ± 0.40	4.06 ± 0.42
Intake CP	g	40.04 ± 4.95	44.02 ± 3.90
Secreted N in urine per day	mg	80.13 ± 16.21	71.63 ± 18.05
Secreted N in feces per day	mg	67.83 ± 15.73	99.61 ± 10.77
Protein digestibility	%	74.36 ± 3.54	68.97 ± 4.42
BV	%	80.30 ± 8.32	86.33 ± 7.88
PER	%	2.67 ± 0.29	2.69 ± 0.25
NPU	%	59.80 ± 7.79	59.77 ± 8.87

Legend: $\bar{x}$ - mean, s_x-standard deviation, BV - biological value, PER - protein efficiency ratio, NPU - net protein utilization

In table 3 we showed the amino acid composition of the tested feeds. Limiting amino acid was isoleucin in both of them. **Moudrý *et al.* (2005)** found leucine as limiting acid in buckwheat. We explain the discrepancy by changing the values used in the reference protein in preschool children, stating **WHO (2007)**. Higher PDCAAS was calculated at 71.11% in oat, buckwheat compared to 55.41%. PDCAAS value was affected by higher crude protein digestibility in oat by 6%.

Table 3 Composition of amino acids in dry matter of tested feeds (g/kg DM) and value PDCAAS

Amino acid (g/kg DM)	**oat**	**buckwheat**
aspartic acid	8.02	7.41
threonine	4.30	3.15
serine	5.33	4.25
glutamic acid	21.45	13.46
proline	5.75	2.17
glycine	5.13	4.64
alanine	4.71	3.29
valine	4.50	3.40
isoleucine	2.97	2.49
leucine	7.02	5.07
tyrosine	3.16	1.91
phenylalanine	4.84	3.60
histidine	2.30	2.09
lysine	5.91	6.32
arginine	6.58	8.40
cystine	2.25	1.78
methionine	1.46	1.28
PDCAAS (%)	71.11	55.41

Legend: DM – dry mater

CONCLUSION

Based on tests of naked oat and buckwheat by biological methods, we can conclude that the differences in the content of crude protein between the various types of cereals and in species are great, depending on the location of cereal cultivation, fertilization and weather. We found higher values achieved in growth, feed conversion and CP intake in the group fed buckwheat. Oat achieved a higher digestibility, which was also influenced by higher PDCAAS. Buckwheat achieved higher biological protein value.

Acknowledgments: This article was created by the implementation of departmental research and development project "Efficient use of feed in terms of reducing costs and improving the quality of primary livestock products" under the support of the Ministry of Agriculture of the Slovak Republic.

REFERENCES

ASGAR, M.A. – FAZILAH, A. – HUDA, N. – BHAT, R. – KARIM, A.A. 2010. Nonmeat Protein Alternatives as Meat. Extenders and Meat Analogs. Comprehensive Reviews in *Food Science and Food Safety*, vol. 9, p. 513-529. doi: 10.1111/j.1541-4337.2010.00124.x

BÍRO, D. – GÁLIK, B. – ŠIMKO, M. – JURÁČEK, M. – ROLINEC, M. – ŠEVČÍK, P. – KURUC, M., 2010. Comparison of Cereal Grain Energy Value Detected by Different Methods. In *Acta fytotechnica et zootechnica*, vol. 3, p.64-66.

COMMISSION REGULATION EC no. 152, 2009. z 27. januára 2009, ktorým sa stanovujú metódy odberu vzoriek a analýzy na účely úradných kontrol krmív.

EGGUM, B.O. 1973. A Study of Certain Factors Influencing Protein Utilization in Rats and Pigs. Beretn.Report, In *Nat. Inst. Anim. Sci.*, vol. 406, 173 p.

GÁLOVÁ, Z. – POLÓNIOVÁ, Z. – CHŇAPEK, M. – KEČKÉŠOVÁ, M. – PÁLENČÁROVÁ, E., 2010. Nutritive Quality of Cereals, Pseudocereals and Leguminous from the Point of View Coeliac Agens. In *Risk factors of food chain (*Proceeding of the work X international scientific conference), 13.-14. september 2010, Nitra: SUA, p. 91-95, ISBN 978-80-552-0436-9.

HEGER, J. – SALEK, M. – EGGUM, B.O., 1990. Nutritional Value of Some Czechoslovak Varieties of Wheat, Triticale and Rye. In *Animal Feed Science and Technology*, vol. 29, p.89-100.

KERESTEŠ, J. – MAČEK, J. – TÓTH, Z. et al. 2011. Zdravie a výživa ľudí. CAD PRESS, Bratislava, 1037 p. ISBN 978-80-88969-57-0.

KOVÁČIKOVÁ, E. 2010. Potravinová banka dát. [cit. 2012-06-25]. Available at: http://www.pbd-online.sk/.

MICHALOVÁ, A. – ČEJKA, L. 1996. Variabilita agronomických a nutričních znaků v genofondech pohanky, prosa a laskavce – možnosti jejího využití. Sborník. *Alternativní a maloobjemové plodiny pro lidskou výživu.* VÚRV, Praha. p. 37-50.

MOUDRÝ, J. – KALINOVÁ, J. – PETR, J. – MICHALOVÁ, A., 2005. Pohanka a Proso. Ústav zemědělských a potravinářských informací : Praha, 206 p. ISBN 80-7271-162-8.

PETRIKOVIČ, P. – SOMMER, A. – ČEREŠŇÁKOVÁ, Z. et al., 2000. Výživná hodnota krmív, II. časť. VÚŽV Nitra – ÚVZ, Nitra, ISBN 80-88872-12-X.

RYCHLÍK, A.J., 2004. Strava jako lék. Jáhly, kroupy, kukuřice, ovesné vločky, pohanka a sója v naší kuchyni. Nakladatelství Lípa ve Vizovicích, 224 p. ISBN 80-86093-78-6.

SANT'ANA, R.C.O. – MENDES, F.Q. – PIRES, CH.V. – OLIVEIRA, M.G.A., 2011. Influence of Lipid Extraction from Different Protein Sources on In Vitro Digestibility. In *Ciênc. agrotec.*, vol. 35, no. 4, p. 758-764.

SCHAAFSMA, G., 2005. The Protein Digestibility-Corrected Amino Acid Score (PDCAAS)—A Concept for Describing Protein Quality in Foods and Food Ingredients: A Critical Review. In *Journal of AOAC International*, vol. 88, no. 3, p. 988-994.

STANDARD 23/2009 Digest of laws for the care and use of laboratory animals.

WHO, 2007. Protein and Amino Acid Requirements in Human Nutrition: Report of a joint. FAO/WHO/UNU expert consultation, 270 p. ISBN 92 4 120935 6.