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THE NUTRITIVE VALUE OF SOME WHEAT VARIETIES IN BROILERS

HRANIDBENA VRIJEDNOST NEKIH SORTI PŠENICE U HRANIDBI BROJLERA

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SUMMARY

The differences in the nutritive value of five, in Slovenia most frequently used wheat varieties for broiler chickens were investigated. The samples of wheat varieties Ana, Marija, Pinka, Rezka and Žitarka were obtained from the same location and were produced under equal agrotechnical conditions. The nutritive value was evaluated by chemical composition (crude nutrients; total, insoluble and soluble non-starch-polysaccharide fractions content; extract viscosity) and in a differential balance experiment on 48, twenty-five-day old, individually caged, male broiler chicks by measuring the energy value (AME_N), dry matter nutrient utilization and intestinal viscosity. The results of chemical analysis showed a relatively small degree of variability in most parameters observed. The results of the experiment on broilers demonstrated that the content of AME_N ranged from 13.21 and 14.25 MJ ME/kg dry matter, the utilization of dry matter between 74.2 and 79.9% and the intestinal viscosity between 2.1 and 4.0 mPa.s. In comparison to the average values, the most promising nutritive characteristics of broiler feed were observed in the wheat variety Marija (the lowest extract viscosity: -8%; the highest AMEN content: +4%; the most efficient dry matter utilization: +4.5; the lowest intestinal viscosity, -33%); contrary to that the variety Rezka turned out as the least favorable one (high extract viscosity: +7%; the lowest AME_N content: -3%; the least efficient dry matter utilization: -3%; the highest intestinal viscosity +27%).

INTRODUCTION

Wheat is an important source of energy in poultry diets. However, big differences in the nutritive value of different wheat varieties exist. In some samples of Australian wheat, Annison, 1991. found values of metabolisable energy for broiler chickens among 11.3 and 13.6 MJ AME/kg DM. It has been shown that the main reasons for the variability in the energy value of wheat and also other grains like barley and rye are the differences in the non-starch-polysaccharide (NSP) content and

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their solubility. For instance Annison, 1991. and Dusel et al., 1997. demonstrated that there is a high negative correlation between the AME of wheat and their soluble NSP content. The most important NSP in wheat are (soluble) arabi-noxylans, but the content of β-glucans can also be very high (Chesson, 1991.) and do also exhibit antinutritive activity (Annison and Choct, 1993). The normal arabinoxylan content in wheat is between 40 to 80 g/kg DM and the normal β-glucan content in wheat is between 5-8 g/kg DM whereas in other grains like barley and oats between 60 to 90 g arabinoxylan/kg DM and 40 to 60 g β-glucan/kg DM (Jeroch and Dänicke, 1995; Dusel et al., 1997).

Although the negative role of NSP is still not clearly understood, there are at least two very important factors that can play a considerable role in lowering the nutritional value of wheat and other cereals. The first is the restricted access of nutrients found in the endosperm. The second, even more important, is the influence of NSP on intestinal viscosity. Especially the viscous, high molecular weight NSP are of interest since their gel-forming properties are responsible for the overall anti-nutritive effect in broilers (Dänicke et al., 1999). Dissolved NSP are capable of creating viscous solutions, and thereby of reducing the diffusion rate of enzymes in the intestinal content, the diffusion of digested nutrients to the gut wall, and the intestinal rate of digesta transport (Wiesseman and Inborr, 1990; Bedford and Classen, 1992). This is associated with a reduced macronutrient digestion, a lower energy value and an impaired growth performance (Ward and Marquardt, 1987; Campbell and Bedford, 1992; Annison, 1993; Smits et al., 1997). Bedford and Classen, 1992 have shown that the performance of broilers is linearly related to the logarithm of intestinal viscosity.

As many experiments have shown, the addition of appropriate NSP-degrading enzymes (xylanases and β-glucanases) can significantly increase the nutritional value of wheat and other cereals. In experiments on broilers with two wheat samples Salobir, 1998 has shown that the samples differed not only in nutritive value, but also in response to different enzyme treatments (different xylanase and β-glucanase concentrations).

It is important to know, that the amount and the solubility of NSP vary between cereals and thus, their influence in the nutrition varies depending on genetic and environmental conditions (Campbell and Badford, 1992; Annisson, 1993).

Since the nutritional value of wheat varieties used in vivo in Slovenia was unknown, the aim of the present experiment was to specify the differences in the nutritive value of the five in Slovenia most frequently used wheat varieties for broiler chickens.

MATERIALS AND METHODS

The five most widely used Slovenian wheat varieties Ana, Marija, Pinka, Rezka and Žitarka were obtained from the 1997 harvest from the experimental farm Jable (Agricultural Institute of Slovenia) and were produced in equal agro-technical conditions.

The content of crude nutrients, starch and fibre fractions in wheat samples and diets, and N content of excreta were determined by standard procedures of the VDLUFA (Naumann and Bassler, 1993). The gross energy content of diets and excreta samples was determined by using an adiabatic bomb calorimeter (IKA Analysentechnik GmbH, Heitersheim, Germany). The dietary AME_N values were calculated with a correction for N retention, using the value 34.42 kJ/g of retained N (Hill and Anderson, 1958). The total and insoluble pentosans and NSP contents were analyzed according to GC-methods described by Dusel et al., 1997. The amount of pentosans was calculated from the arabynose and xylose content and the level of NSP as the sum of arabynose, xylose, mannose, glucose and galactose. The amount of soluble pentosans and NSP was calculated as a difference between the total and insoluble pentosans and NSP.

The viscosity of the wheat extract was determined according to Dusel et al., 1997 as follows: 1 g of ground wheat was extracted in a shaker with 2 ml of distilled water at 38 °C for 30 min, centrifuged by 9500 g, and the viscosity of supernatant was determined by a rotational cone and plate viscometer (model LVDVCP-II+, cone

CP-40; Brookfield Engineering Laboratories Inc., MA), maintained at 38 °C and at a shear rate 20 s^{-1}.

For the determination of the nitrogen corrected apparent metabolisable energy (AME_N) content of five wheat varieties, the differential method with total excreta collection was used. A total of 48, twenty-five-day old, individually caged, male broiler chicks weighing on average 1350 g (Ross) was used in balance experiments. Six dietary treatments were laid out. The animals in the first group received a basic diet (wheat 35,0%, barley 29,89%, soybean meal 23,64%, fish meal 6.0%, sunflower oil 2,0%, L-lysine 0.07%, limestone 1.75%, Ca-Na-phosphate 0.78%, salt 0.11%, vitamin/mineral premix 0.7%; 11.6 MJ ME/kg, 21.2% CP, 1.23% Lys, 1.25% Ca, 0.42% available P). The five experimental groups received a diet composed of 50% of the basic and 50% of one of the wheat varieties.

At the beginning of the balance period, the animals were weighed and randomly assigned to experimental groups. The animals were penned singly in metabolism crates, which allowed for the quantitative collection of excreta. Throughout the trial the animals were exposed to constant light and had free access to both food and water. The room temperature was between 22 and 24 °C.

The adaptation and total excreta collection period lasted for five days. The excreta were collected daily and frozen at -20 °C. Prior to the set-up of the balance period, the feed was withdrawn for eighteen hours so that the digestive tract could be emptied out. Eighteen hours before the last excreta collection, the feed was also withdrawn. After the last excreta collections, the animals were again fed ad libitum for 48 hours. After that, they were slaughtered and the gastrointestinal contents were analyzed.

The intestinal viscosity analysis was carried out according to Bedford and Classen, 1992. The total intestinal contents from gizzard to Meckel's diverticulum were collected, immediately homogenized and placed into microcentrifuge tubes, and then centrifuged at 9500 g for 8 minutes. The supernatant was withdrawn and the viscosity was determined by a rotational cone and plate viscometer (model LVDVCP-II+, cone CP-40; Brookfield Engineering Laboratories Inc., MA), maintained at 37 °C and at a shear rate 20 s-1.

Data from the broiler chicken experiment were analyzed by the General Linear Models (GLM) procedures (SAS, 1990) from SAS® software (Release 6.12), taking into consideration the wheat variety, as the only main effect, and live weight at the beginning of the balance period as covariable. Comparisons of wheat varieties were done by contrasts provided by the GLM procedure. The data are expressed as least square means (LSM). The least significant difference 0.05 was used to separate treatment means. The relation between chemical analysis of the wheat varieties and in vitro viscosity, intestinal viscosity and AME_N was assessed by regression analysis.

RESULTS AND DISCUSSION

The results of crude nutrient, non-starch-polysaccharide and pentosan content analysis are presented in Table 1. The results show that there was not a very high variability in the crude nutrient composition of all five samples. The results of NSP analysis did not show any important differences between wheat varieties. The mean content of total NSP was 114 g/kg DM with very small variability between 110.7 and 118.3 g/kg DM. The mean value was somewhat higher and the variability smaller than the value obtained in the study of Dusel et al., 1997, where the average value for 26 wheat samples (13 varieties, 2 locations) was 97 g/kg DM ranging from 75 to 114 g/kg DM. The same was also true for the soluble NSP content. The mean value of 46 g/kg DM was somewhat higher and the variation (41.9 to 49.6 g/kg DM) much smaller than in the above-mentioned study, where the average value was 33 g/kg DM ranging from 16 to 46 g/kg DM. The content of total pentosan did not show major differences between varieties (56.3 to 62.3 g/kg DM). The highest variation between varieties was found in the content of soluble pentosan (between 10.6 to 16.7 g/kg DM). The range is similar to those found in the study of Dusel et al., 1997.

Table 1. The crude nutrient, pentosan and non-starch-polysaccharide content, extract viscosity and weight of 1000 grains of five wheat varieties

Tablica1. Sadržaj sirovih hranljivih tvari, neškrobnih polisaharida i pentosana, viskoznost ekstrakta i težina 1000 zrna kod pet sorti pšenice

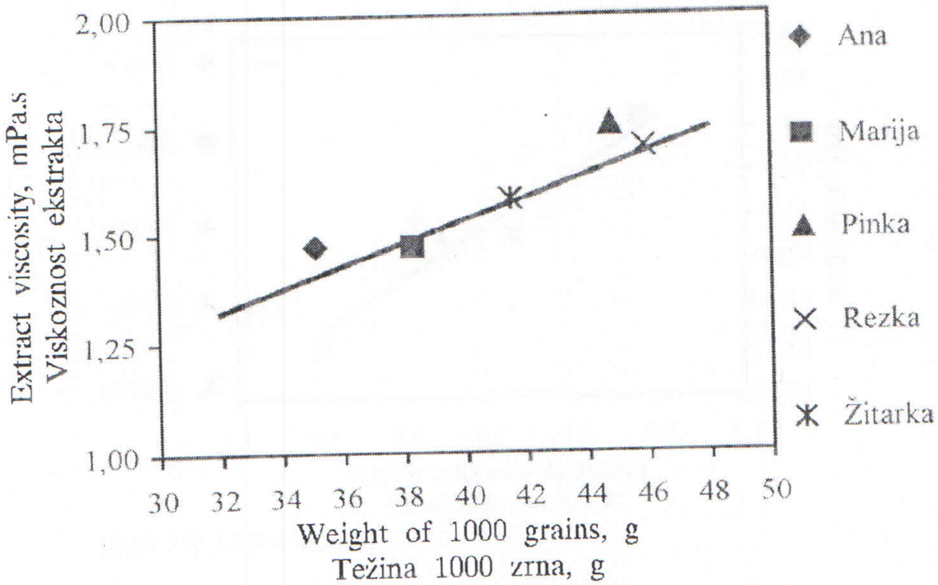
	Ana	Marija	Pinka	Rezka	Žitarka	Average Prosjek	CV, %
DM - ST, g/kg	894.1	896.2	894.5	894.1	890.8	893.9	0.2
CP - SB g/kg DM - ST	112.4	117.2	117.5	125.0	122.8	118.9	4.2
CF - SV g/kg DM - ST	12.7	13.8	13.2	11.8	13.6	13.0	6.1
CFa - SM, g/kg DM - ST	30.3	33.7	32.1	30.3	31.9	31.6	4.5
CA – Pepeo, g/kg DM - ST	17.7	19.2	17.7	19.0	19.4	18.6	4.5
NFE, g/kg DM - ST	827.0	816.2	819.5	813.9	812.3	817.8	0.7
Starch-Škrob, g/kg DM - ST	708.6	708.5	758.8	716.2	685.8	715.6	3.7
NDF, g/kg DM - ST	132.9	142.8	124.7	130.3	124.7	131.1	5.7
ADF, g/kg DM - ST	29.5	31.5	29.5	27.5	31.8	30.0	5.9
ADL, g/kg DM - ST	8.8	9.2	7.3	7.6	9.6	8.5	12.0
Total NSP - Ukupni NSP, g/kg DM - ST	118.1	118.3	110.7	115.3	106.3	113.7	4.5
Soluble NSP - Topivi NSP, g/kg DM - ST	47.8	45.8	45.2	49.6	41.9	46.1	6.3
Total pentosan - Ukupni pentosan, g/kg DM - ST	60.0	62.3	56.3	61.0	53.8	58.7	6.0
Arabinose-to-xylose Arabinosa:ksiloza odnos	0.65	0.63	0.63	0.61	0.65	0.63	2.9
Soluble pentosan - Topivi pentosan, g/kg DM - ST	12.2	13.2	12.8	16.7	10.6	13.1	17.1
Soluble arabin.-to-xylo. ratio Topivi arabin-prema xylo.odnos	0.77	0.61	0.56	0.59	0.57	0.62	13.6
Extract viscosity - Viskozitet ekstrakta, mPa.s	1.47	1.47	1.75	1.70	1.58	1.59	8.6
Weight of 1000 grains Težina 1000 zrna, g	35.1	38.3	44.8	45.9	41.5	41.1	10.9

It has been shown in many studies (Rotter et al., 1989; Bhaty et al., 1991; Dusel et al., 1997) that the extract viscosity is a good predictor of soluble NSP and pentosan content. Since no bigger differences were observed in (soluble) NSP and pentosan content, the small variation in extract viscosity among varieties between 1.47 and 1.75 mPa.s was actually expected. The individual values and mean value of 1.59 mPa.s are comparable to other studies (Classen et al, 1995, Dusel et al. 1997). Because of the small variation in (soluble) NSP and pentosan content, extract viscosity and small sample number, the results of the regression analysis were not statistically significant. But they have a tendency of proving the well-known relationships. The relationship between soluble pentosan content and extract viscosity showed that the regression coefficient +0,23 mPa.s/g soluble pentosan was statistically insignificant (P<0,50), but comparable to the average value +0,3 mPa.s/g of soluble pentosan calculated from the mentioned survey of Dusel et al., 1997.

One of the parameters with the highest variation was the weight of 1000 grains (between 35.1 and 45.9 g/1000 grains). The values are on, average, rather higher than the obtained values of the 70 French samples included in the study of Metayer et al., 1993, where the influence of year and region was also studied. The regression analysis presented in Figure 1 shows that there is a very strong statistically significant relationship between the weight of 1000 grains and extract viscosity (b = 0,026 mPa.s/g weight of 1000 grains; P<0,02).

Figure 1. Relationship between weight of 1000 grains and extract viscosity of five wheat varieties

Slika 1. Odnosi između težine 1000 zrna i viskoznosti ekstrakta kod pet sorti pšenice



$y = 0{,}49 + 0{,}026\,x\ (R^2 = 0{,}88,\ P < 0{,}02)$

The results of the broiler chicken experiment in Table 2 show no significant differences in AME_N content among wheat varieties. The AME_N content varied in a relatively small range, from 13.21 and 14.25 MJ ME/kg DM. The variability obtained in some other studies was bigger (Annison, 1991, Nicol et al., 1993,). Among our samples there was actually no wheat variety with a very low energy value. The mean value was somewhat (4-5%) lower than that found for 70 French samples (Metayer et al., 1993) and for five German varieties (Dusel et al., 1997), but somewhat higher than observed in the study of Nicol et al. (1993).

The results of the intestinal viscosity measurement did not show dramatic differences between varieties. Although, in comparison to other studies (Dusel et al., 1997), the small sample number and the variation in AME_N and intestinal viscosity value was very low, the results proved the known negative effect of intestinal viscosity on energy content (b = -0,48 MJ AME_N /mPa.s; P<0,03).

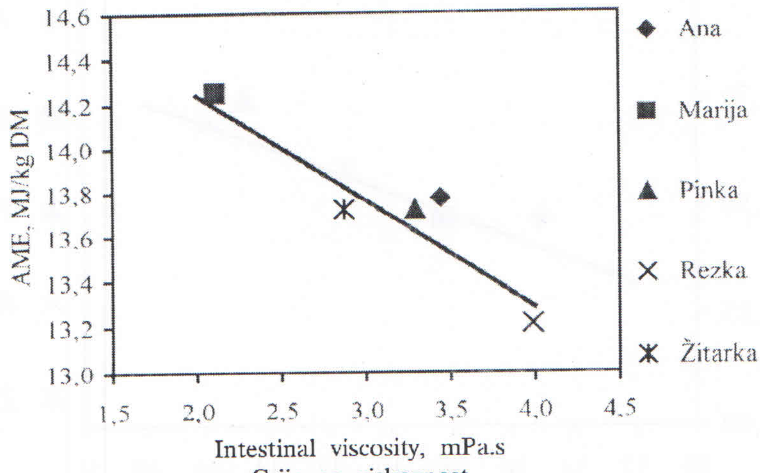
Table 2. The dry matter utilization, apparent metabolisable energy content of wheat varieties and intestinal viscosity in broilers fed experimental diets based on those wheat varieties

Tablica 2. Iskorištenje suhe tvari, sadržaj metaboličke energije kod pet sorti pšenice i viskoznost crijevnog sadržaja kod brojlera hranjenih krmnim smjesama na osnovi različitih sorti pšenice

	Ana	Marija	Pinka	Rezka	Žitarka	Average Prosjek	CV, %
DM utilization - Iskorištenje ST	76.40	79.85	77.13	74.19	74.82	76.48	2.9
AME_N, MJ/kg ST	13.77	14.25	13.72	13.21	13.66	13.72	2.7
Intestinal viscosity Crijevna viskoznost, mPa.s	3.44	2.11	3.29	3.99	2.87	3.14	22.3

Figure 2. **Relationship between intestinal viscosity and apparent metabolisable energy content of five wheat varieties**

Slika 2. **Odnosi između viskoznosti crijevnog sadržaja i sadržaja metaboličke energije kod pet sorti pšenice**

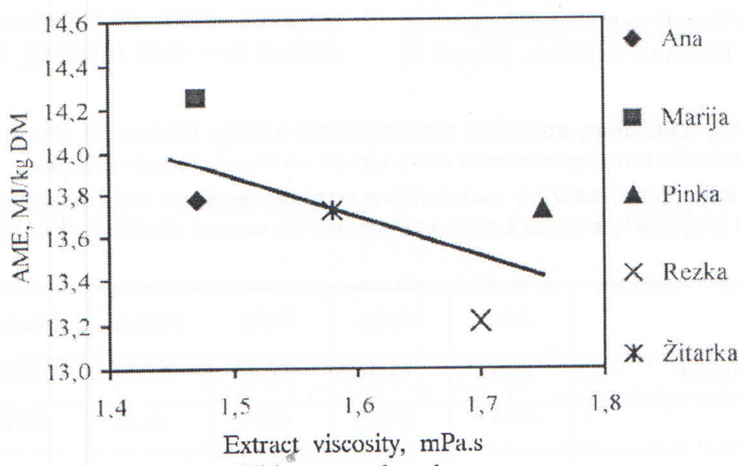


$y = 15,2 - 0,48\,x$ ($R^2 = 0,83$, $P < 0,03$)

The relation between parameters obtained by chemical analysis vs. energy content and intestinal viscosity was also calculated. In general, the correlation was very poor. The small sample number and quite a small variation in the observed parameters could again have caused this. The known relationship between extract viscosity and AME_N presented in Figure 3 was proven for investigated varieties only as a tendency (b = -1,88 MJ AME_N /mPa.s; P<0,22). The same was also true for the relationship between soluble pentosan content and AME_N.

Figure 3. **Relationship between extract viscosity and apparent metabolisable energy content of five wheat varieties**

Slika 3. **Odnosi između viskoznosti ekstrakta i sadržaja metaboličke energije kod pet sorti pšenice**



$y = 16,7 - 1,88\,x$ ($R^2 = 0,43$, $P < 0,22$)

Nicol et al., 1993 have shown in an experiment on young poultry that there is a strong negative correlation between AME and arabinose-to-xylose ratio in NSP. Although the range for arabinose-to-xylose ratio in our samples (Table 1) was comparable with the mentioned study, no significant relationship to energy value and intestinal viscosity could be established in our study.

In comparison to the average value, the most promising nutritive characteristics for broiler feed were observed in the wheat variety Marija (the lowest extract viscosity: -8%; the highest AME_N content: +4%; the most efficient dry matter utilization: +4,5; the lowest intestinal viscosity, -33%) contrary to that, the variety Rezka turned out as the least favorable one (high extract viscosity: +7%; the lowest AME_N content: -3 %; the least efficient dry matter utilization: -3%; the highest intestinal viscosity, +27%).

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SAŽETAK

U pokusu na pilićima-brojlerima istraživane su razlike u hranidbenoj vrijednosti pet, u Sloveniji najčešće upotrebljavanih sorti pšenice (Ana, Marija, Pinka, Rezka i Žitarka), koje su bile proizvedene pod jednakim uvjetima i na istoj lokaciji. Hranidbena vrijednost je ocjenjivana analizama kemijskog sastava (sirove hranjive tvari; sadržaja ukupnih, netopivih i topivih frakcija neškrobnih polisaharida, viskoznosti ekstrakta) i u pokusu na brojlerima u razdoblju rasta sadržajem metaboličke energije (AME_N), iskorištenja suhe tvari i viskoznošću crijevnog sadržaja. U pokus je uključeno 48 25-dnevnih muških pilića, razvrstanih u 2 individualne bilancijske kaveze. Rezultati kemijske analize pokazuju razmjerno malu varijabilnost u promatranim parametrima. Rezultati pokusa na brojlerima pokazuju, da se sadržaj AME_N kretao između 13,21 i 14,25 MJ ME/kg suhe tvari, iskorištenje suhe tvari između 74,2 i 79,9% i viskoznost crijevnog sadržaja između 2,1 i 4,0 mPa.s. U usporedbi s prosjekom sorti, u prehrambenom smislu najveću uporabnu vrijednost za hranidbu pilića imala je sorta Marija (najnižu viskoznost ekstrakta: -8%; najveću energetsku vrijednost: +4%; najveće iskorištenje suhe tvari: +4,5 i najmanju viskoznost crijevnog sadržaja: -33%); kao najmanje prihvatljiva pokazala se je sorta Rezka (razmjerno velika viskoznost ekstrakta: +7%; najniža energetska vrijednost: -3%; najniže iskorištenje suhe tvari: -3% i najveća viskoznost crijevnog sadržaja: +27%).