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Chemical composition and nutritional value of different wheat cultivars for broiler chickens*

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ABSTRACT

The experiment was carried out on 90 Ross 308 broiler chickens (9 groups of 10 birds each) kept in individual cages. Nine diets based on Polish wheat (*Triticum aestivum*) cultivars: Zebra, Bryza, Vinjett, Torka, Rysa, Mikula, Turnia, Satyna and Bombona were prepared. The diets contained 732.6 g/kg wheat grain, soyabean meal, fish meal, lysine, methionine, vitamins and minerals. Broilers were provided experimental diets *ad libitum* from 14 to 42 days of age. Performance was measured, and on the last week of the experiment a marker was added to the diets, excreta were collected, analysed, and nutrient digestibility and metabolizable energy value were calculated. After completion of the experiment, jejunal digesta pH and viscosity were measured. Jejunal digesta viscosity was higher in birds fed diets with Bryza and Satyna cvs. than with the remaining cultivars, while apparent protein digestibility was 67.9% in birds fed diets with Rysa and Bombona cvs., and 84.6 on average, in birds fed diets with Zebra, Torka, Mikula, Turnia and Satyna cvs. Wheat cultivar neither influenced the AME_N value of diets, which averaged 12.5 MJ/kg, nor body weight gain, while the feed conversion ratio was 6% better, on average, in birds fed diets with cultivars of lower viscosity (Zebra, Vinjett, Torka and Turnia) in comparison with diets based on the remaining cultivars ($P<0.05$).

KEY WORDS: broiler chickens, wheat cultivar, apparent protein digestibility, AME_N, viscosity, jejunal digesta

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INTRODUCTION

At least several hundred wheat cultivars are used throughout the world, however, most of the technological parameters that describe the quality of seeds have been defined for human utilization (Carré et al., 2007). In Europe wheat is commonly used in poultry diets, but the nutritional potential of wheat cultivars in poultry feeding remains unknown. It is generally admitted that there is no problem when wheat is given to adult birds, but effects in broiler production are often unsatisfactory due to the variability of energy value between cultivars (McCracken and Quintin, 2000; Steenfeld, 2001; Pirgozliev et al., 2003; Carré et al., 2007). The content and physico-chemical characteristics of non-starch polysaccharides (NSP) can influence intestinal viscosity, nutrient digestibility and apparent metabolizable energy value (AME_N) in chickens (Mollah et al., 1983; Dusel et al., 1997; Pirgozliev et al., 2003).

The aim of the study was to determine the metabolizable energy value and nutrient utilization of diets based on different wheat cultivars in broiler chickens. Furthermore, the correlations between the content of different fractions of dietary fibre in wheat cultivars and characteristics of intestinal parameters (pH, viscosity), length of intestine and gizzard weight in chickens were determined.

MATERIAL AND METHODS

Nine Polish wheat cultivars: Zebra, Bryza, Vinjett, Torka, Rysa, Mikula, Turnia, Satyna and Bombona were used (Table 1). All wheat cultivars were grown on an experimental farm near Krakow (Poland) and harvested in the year 2005. Nine

Table 1. Nutrient composition (g/kg), gross energy (GE) content and the weight of 1000 grain (GW) of wheat cultivars

Item	Wheat cultivar								
	Zebra	Bryza	Vinjett	Torka	Rysa	Mikula	Turnia	Satyna	Bombona
Dry matter	864	868	861	861	875	859	863	861	862
Crude ash	16.7	16.2	16.2	14.5	15.7	18.5	14.8	15.6	15.8
Crude protein	118	120	120	102	132	117	106	104	126
Crude fat	14.2	13.9	16.9	9.1	22.6	10.3	19.6	10.7	15.3
N-free extractives	693	698	686	715	689	696	705	707	686
Crude fibre	22.0	19.4	23.0	20.5	14.9	17.4	17.2	23.6	19.0
ADF	33.2	43.4	36.5	30.8	30.4	42.1	26.4	32.6	28.6
NDF	112	131	103	94	101	126	105	135	96
IDF[1]	100	92	94	93	97	99	95	112	93
SDF[2]	15.9	16.2	16.0	19.1	16.0	20.9	14.7	8.8	16.7
GE, MJ/kg	15.9	16.0	15.7	15.7	16.4	15.7	16.0	15.7	15.9
GW, g	46	40	43	45	38	52	42	46	48

[1] - insoluble dietary fibre; [2] - soluble dietary fibre

experimental diets were prepared (Table 2). The diets were based on wheat grain and were supplemented with soyabean meal, fish meal, L-lysine, DL-methionine, vitamins and minerals to satisfy the nutrient requirements of broilers according to Smulikowska and Rutkowski (2005). The experiment was carried out on 90 Ross 308 broiler chickens (9 groups, 5 males and 5 females per group) aged 14 days with an average initial body weight of 430 g. The birds were kept in individual balance cages and fed experimental diets in mash form *ad libitum* from day 14 to 42 of life. Feed intake and body weight were measured in weekly intervals and body weight gain (BWG) and feed conversion ratio (FCR) were calculated.

Between day 33 and 42 of life the chickens were fed diets of the same composition (Table 2) but containing 3 g Cr_2O_3 per kg added as a marker on top

Table 2. Ingredients and nutrient composition of the experimental diets, g/kg

Item	Dietary treatment - wheat cultivar								
	Zebra	Bryza	Vinjett	Torka	Rysa	Mikula	Turnia	Satyna	Bombona
Component									
wheat	732.6	732.6	732.6	732.6	732.6	732.6	732.6	732.6	732.6
soyabean meal	150	150	150	150	150	150	150	150	150
fish meal	80	80	80	80	80	80	80	80	80
monocalcium phosphate	8	8	8	8	8	8	8	8	8
limestone	18	18	18	18	18	18	18	18	18
NaCl	3	3	3	3	3	3	3	3	3
L-lysine	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
DL-methionine	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
vitamin-mineral premix	5	5	5	5	5	5	5	5	5
Analysed									
dry matter	871	875	874	876	883	876	878	871	873
organic matter	811	816	814	815	824	818	819	812	813
crude ash	59.8	59.1	59.5	61.1	59.1	58.2	58.4	59.0	59.2
crude protein	203	203	206	204	215	193	196	195	210
crude fat	19.7	19.3	21.8	17.0	26.0	16.1	23.8	17.3	20.6
N-free extractives	567	575	565	577	567	589	582	579	564
crude fibre	20.5	18.2	21.3	17.3	15.4	19.5	17.1	21.8	18.9
ADF	34.3	41.8	36.7	40.8	32.3	32.6	29.3	33.9	30.9
NDF	97.5	115	90.9	108	90	84.7	92.5	114	85.8
IDF[1]	89.4	90.9	90.1	94.8	89.9	94.0	92.4	104	89.0
SDF[1]	12.2	10.8	11.7	11.6	10.5	14.0	11.8	15.3	18.7
GE, kcal/kg	16.0	15.9	16.1	16.0	16.4	15.9	16.1	15.9	16.1

[1,2] - see Table 1

of the diet. Feed intake was measured on a daily basis, and between day 38 to 41 excreta from each bird were collected twice a day, pooled, and kept frozen at -18°C until analysis.

Chemical analysis

At the age of 42 days all of the birds were weighed and sacrificed. After opening the abdomen the intestinal tract was exposed, the gizzard was excised and weighed, and the length of the jejunum and ileum was measured. The content of the jejunum (from the end of the duodenum to Meckel's diverticulum) was collected and pH was immediately measured with the use of a Mera Elwro N 517 pH-meter. The digesta was then centrifuged at 10000 *g* for 10 min at 4°C and the relative viscosity of the supernatant was immediately measured at room temperature using a Baker's "Jelmeter" viscosity pipette.

The apparent nutrient digestibilities were calculated from the ratio between the nutrients of interest and the marker in feed and excreta, respectively. Apparent crude protein digestibility was calculated using the α-amino nitrogen method (N-α-NH_2) (Barteczko et al., 1993).

The chemical composition of wheat grain, diets and excreta was determined according to AOAC (2000), while α-amino nitrogen in excreta was measured according to Barteczko et al. (1993). Neutral detergent fibre (NDF) and acid-detergent fibre (ADF) were determined according to Georing and Van Soest (1970) using the Ankom[220] (Ankom Technology) apparatus. Insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) were determined by an enzymatic method (Englyst and Cummings, 1988). The content of gross energy (GE) in diets and excreta was measured using a Parr adiabatic oxygen bomb calorimeter (KL-10, Precyzja, Bydgoszcz, Poland).

Statistical analysis

Data were evaluated statistically by one-way analysis of variance using SAS software (1996). Differences between treatment means were tested using Duncan's multiple range test.

RESULTS

The weight of 1000 grains was from 38 g in Rysa cv. to 52 g in Mikula cv. The content of basic nutrients, as well as detergent fibre fractions and dietary fibre fractions differed among cultivars (Table 1). The content of crude protein was highest in Rysa cv., lowest in Torka and Turnia cvs., while the content of crude fat was also highest in Rysa cv. and lowest in Torka cv. As all diets contained the same amount of wheat and remaining components, the nutrient content in the diets reflected that of the used wheat cultivars (Table 2).

There was no mortality during the experiment. The wheat cultivar used in the diets did not affect feed intake or BWG, while FCR was better on diets with Turnia, Zebra, Vinjett and Torka cvs., worse on diets with Satyna, Bombona, Bryza and Mikula cvs. (Table 3). The apparent protein digestibility of the diet with Satyna cv. was highest, followed by Torka, Turnia and Mikula cvs., while that of the diet with Bombona cv., lowest ($P<0.05$). The apparent digestibility of N-free extractives (NFE) did not differ among diets (Table 4). Nitrogen retention in chickens fed diets containing Bombona and Bryza cvs. was lower ($P<0.05$) than in chickens fed diets with Satyna, Turnia and Mikula cvs. ($P<0.05$). Apparent

Table 3. Performance of broiler chickens fed diets containing different wheat cultivars (14-42 day of age)

Item	Dietary treatment - wheat cultivar									
	Zebra	Bryza	Vinjett	Torka	Rysa	Mikula	Turnia	Satyna	Bombona	SEM
Initial body weight, kg	0.42	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.44	0.00
Body weight gain (BWG), kg	2.18	2.08	2.25	2.34	2.20	2.03	2.29	2.17	2.10	0.03
Feed intake, kg	4.71	4.76	4.85	5.03	4.88	4.65	4.86	5.01	4.83	0.04
FCR, kg feed/ kg BWG	2.15^{a}	2.28^{b}	2.15^{a}	2.15^{a}	2.21^{ab}	2.28^{b}	2.11^{a}	2.30^{b}	2.29^{b}	0.07

^{a,b} means in rows with different letters differ significantly at $P<0.05$

Table 4. Apparent total tract digestibility of dietary crude protein (ADP) and nitrogen-free extractives (ADNFE), nitrogen retention (NR), organic matter (OMR) retention (in %), apparent metabolizable energy (AME_N,MJ/kg) and energy metabolizability (AME_N/GE, %) measured in balance experiment

Item	Dietary treatment - wheat cultivar									
	Zebra	Bryza	Vinjett	Torka	Rysa	Mikula	Turnia	Satyna	Bombona	SEM
ADP	85.0^{d}	73.3^{b}	80.1^{c}	81.3^{cd}	69.6^{ab}	81.0^{cd}	81.1^{cd}	84.7^{d}	66.2^{a}	1.33
ADNFE	92.6	91.6	93.1	93.1	94.6	92.4	93.6	92.1	93.5	0.27
NR	52.2^{ab}	43.1^{a}	54.9^{ab}	51.1^{ab}	50.0^{ab}	59.5^{b}	59.8^{b}	58.9^{b}	42.9^{a}	1.76
OMR	77.2^{ab}	74.5^{a}	78.6^{ab}	81.4^{b}	81.0^{b}	79.6^{b}	81.4^{b}	77.4^{ab}	76.4^{ab}	0.63
AME_N	12.2	12.3	12.6	12.4	12.8	12.8	12.8	12.1	12.2	0.12
AME_N/GE	76.2	77.2	78.4	76.8	78.1	80.1	79.2	76.3	77.7	0.79

^{a,b} means in rows with different letters differ significantly at $P<0.05$

metabolizable energy and energy metabolizability did not differ among groups (Table 4).

The wheat cultivars used in the diets had no influence on gizzard weight, ileum length or jejunal digesta pH, while the jejunum was longer in birds fed diets with Bryza and Zebra cvs. in comparison with Mikula and Rysa cvs. (Table 5). The viscosity of jejunal digesta was higher in birds fed diets with Bryza and Satyna cvs. in comparison with diets containing Turnia, Bombona, Vinjett and Zebra cvs. (P<0.01). The performance data were not significantly correlated with the content of dietary fibre in wheat or with the viscosity of digesta.

Table 5. Effects of diet on pH and viscosity (in mPas·s) of jejunal digesta, length of jejunum and ileum (cm) and gizzard weight, g

Item	Dietary treatment - wheat cultivar									
	Zebra	Bryza	Vinjett	Torka	Rysa	Mikula	Turnia	Satyna	Bombona	SEM
Jejunal digesta										
pH	5.98	6.13	5.90	5.99	6.02	5.94	5.95	6.20	5.97	0.03
viscosity	3.07^{A}	4.69^{B}	2.92^{A}	3.11^{A}	3.04^{A}	3.58^{AB}	2.70^{A}	4.61^{B}	2.70^{A}	0.19
Jejunum, cm	112^{b}	113^{b}	104^{ab}	109^{ab}	102^{a}	101^{a}	111^{ab}	106^{ab}	108^{ab}	1.05
Ileum, cm	78.1	74.6	73.3	76.4	70.2	71.1	73.7	74.4	71.4	0.91
Gizzard, g	34.6	38.1	38.6	35.7	34.9	33.4	37.2	35.5	36.9	0.43

^{a,b,A,B} means in rows with different letters differ significantly at: ^{a,b} P<0.05; ^{A,B} P<0.01

DISCUSSION

Wheat AME values were shown to range in Australia from 10.5 to 15.5 MJ/kg (Mollah et al., 1983), in Canada from 11.9 to 14.4 MJ/kg (Classen et al., 1995), while in Europe some authors found no difference in the AME of different wheat cultivars (Steenfeldt, 2001; Pirgozliev, 2003). According to (Classen et al., 1995) the soluble non-starch carbohydrate (NSP) fraction has a negative relationship with AME of different wheat genotypes and mostly affects digesta viscosity. Carré et al. (2002) reported that in broilers, high digesta viscosity negatively affected lipid and starch digestibility, while the digestibility of protein of different wheat cultivars was similar. Carré et al. (2007) stressed that the viscosity of wheat in the chicken digestive tract results from a combination of several variables, among others from the physico-chemical characteristics of soluble NSP, endogenous xylanases, activity of proteinaceaous inhibitors, and technological treatment (grinding, pelleting).

In the current study no significant differences in AME_N value between diets based on different wheat cultivars were found, similarly as in experiments by Steenfeldt (2001) and Pirgozliev (2003). The viscosity of jejunal digesta was significantly different between groups. In chickens fed diets with Zebra, Vinjett, Torka, Rysa, Turnia and Bombona cvs. jejunal digesta viscosity was lower (from 2.7 to 3.1 mPas·s, respectively) than in chickens fed Bryza and Satyna cvs. (4.65 mPas·s, on average). The range between wheat cultivars reported by Campbell et al. (1995) was much greater - from 4.5 to 33.2 mPas·s. In the current study, FCR in groups fed diets with 4 wheat cultivars of lower viscosity (Zebra, Vinjett, Torka and Turnia) was 6% better than on the remaining 5 cultivars. Viscosity problems connected with feeding wheat are less common than with barley or rye (Svihus et al., 2000) and can be reduced by xylanase supplementation (Choct et al., 1999). In the current study, lower apparent protein digestibility of wheat cvs. also resulted in worse FCR.

Campbell et al. (1995) found a negative relationship of soluble NSP content and digesta viscosity with AME value, while Dusel et al. (1997) found a high correlation between IDF content in diets and intestinal viscosity in chickens, but in the present experiment neither correlation achieved statistical significance. Hetland and Choct (2003) claimed that the IDF fraction stimulated growth of the gizzard in chickens, but this was not confirmed in the present study. Modern broilers genetically selected for high feed efficiency may not show optimal digestibility of nutrients when fed on wheat diets, so the nutritional potential of wheat cultivars in poultry feeding should be investigated. It seems, however, that viscosity in the broiler chicken intestinal tract as well as nutritional value of different wheat cultivars cannot be predicted by analysis of particular dietary fibre or detergent fibre fractions.

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