Praca oryginalna *Original paper*

Effect of hulless barley on body weight and chemical composition of hearts and livers in broiler chickens

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Summary

The purpose of the study was to determine whether replacing husked barley with hulless barley with a significantly lower share of crude fiber but a higher content of beta-glucans modifying the absorption of nutritional elements from the intestine can change the weight and the chemical composition of the heart and the liver in broiler chickens. The experiment was carried out on 162 Cobb broiler chickens reared in cages until the 42nd day of their lives, divided into three groups: one control group (K) and two experimental groups (I, II), 54 birds in each. Group K was fed mixtures with a share of wheat, group I – mixtures with hulless barley and group II – mixtures with husked barley. In starter mixtures of rearing the share of alternatively used crops was 45%, whereas its share in grower and finisher mixtures administered, respectively – 50%. The results of the study reveal that adding hulless barley to feed mixtures resulted in a statistically significant reduction in chickens' body weight and a lower weight of their breast muscles and legs, as well as in their lower share in the meat carcass. Adding hulless barley to the mixtures contributed to increasing the weight and share of the heart muscle. Hulless barley raised dry matter content in the heart by 9.5% and that of crude ash by 6.9%, in comparison with the chickens fed wheat. The type of barley significantly modified the weight of the chicken livers. The highest weight was noted in case of chickens fed husked barley, and the lowest in case of the addition of hulled barley. The difference amounted to 11%. Hulless barley used in the mixtures reduced the share of crude ash, total protein and crude fat, compared to their content in the livers of the chickens in the control group.

Keywords: broiler, barley, heart, liver, beta-glucans

Newly grown hulless barley is possible to use in larger amounts in poultry feeding due to a lower share of crude fiber, which increases its energetic value and seems to guarantee satisfactory production results of broiler chicken rearing (4, 7, 13, 16). It is also characterized by a share of non-starch polysaccharides (NSP) higher than in the husked type, particularly of beta-glucans (4, 7, 8, 16), and also a higher amount of protein and lysine, which makes it similar to wheat (1) as far as the content of digestible protein is concerned. Although depending to a certain extent on the structure of their particles, a characteristic property of beta-glucans is their bloating and forming sticky mucus in the presence of water. This leads to increasing the volume of stomach contents, lowering the rate of their passing through the digestive tract and also makes it difficult for the digestive enzymes to reach food particles. As a result, a feed containing an increased amount of NSP causes worse absorption of nutritional elements from the intestine in young poultry (17, 18).

In practice, the anti-nutritional effect of beta-glucans, bearing in mind a benefit for the main production output in broiler rearing, can be neutralized through using adequate feed enzymes (6, 9). It is still not known whether hulless barley, despite an addition of beta-glucanase, does not alter metabolic processes. Thus it cannot be excluded that hulless barley with an increased share of beta-glucans may also affect liver activity and, consequently, its weight. In the study performed by Zhou et al. (19) it is the glucans which must have been responsible for the increased liver weight in chickens. This view is confirmed by the results of the studies carried out by Brenes et al. (5) who, after using enzymes, observed a lower weight of

Tab. 1. Composition and nutritive value of the mixtures

Components	Group					
	Starter			Grower/Finisher		
	K Wheat	I* Barley hulless	II* Barley husked	K Wheat	I* Barley hulles	II* Barley husked
Maize	15.0	18.0	15.0	15.0	18.5	15.0
Wheat	45.0	–	–	50.0	–	–
Barley hulless	–	45.0	–		50.0	–
Barley husked	–	–	45.0	–	–	50.0
Soybean meal 46%	30.0	30.0	30.0	22.0	22.0	22.0
Fish meal 70%	2.0	0.5	2.0	3.5	2.0	3.5
Soya oil	3.5	2.0	3.5	4.5	2.5	4.5
Dicalcium phosphate	1.5	1.5	1.5	2.0	2.0	2.0
Limestone	1.5	1.5	1.5	1.5	1.5	1.5
NaCl	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin-mineral premix[a]	1.0	1.0	1.0	1.0	1.0	1.0
1 kg feed mixtures contain						
ME, MJ	12.93	12.92	12.84	13.27	13.19	13.17
Crude protein, %	21.72	21.89	21.77	19.67	19.99	19.72
Crude fibre, %	3.01	2.29	3.10	2.84	2.03	2.93
beta-glucans, g	0.71	1.77	1.87	0.78	1.96	2.07

Explanations: K – control group; I, II – experimental groups; * Avizyme 1100 (FinnFeeds Int., UK) was added at 0.1% of diets in place of wheat; [a] composition of premix/kg: vit. A 12 000 IU, vit. D_3 3000 IU, vit. E 20 mg, vit. K3 3 mg, vit B_1 2 mg, vit. B_2 6 mg, vit. B_6 2 mg, vit. B_{12} 0.015 mg, biotyn 0.05 mg, folic acid 1 mg, nicotinic acid 20 mg, D-calcium panthotenate 12 mg, choline chloride 200 mg, Mn 65 mg, Cu 6 mg, Fe 40 mg, J 0.5 mg, Se 0.1 mg, Co 0.2 mg

chicken livers. On the other hand, Nash and Lefrancois (12) did not observe any influence of barley on the weight of the liver, which may suggest a need to take up more studies.

For this reason, some studies have been initiated to examine the influence of the local type of hulless barley, Rastik, in feed mixtures on slaughter output and selected features of the heart and the liver: their weight, the content of dry matter, total protein, crude fat and crude ash in broiler chickens.

Material and methods

The experiment was carried out on 162 Cobb broiler chickens reared in cages until the 42nd day of their lives, in standard environmental conditions. One-day-old nestlings were randomly divided into three groups: one control group (K) and two experimental groups (I, II), with 54 birds in each (3 replications, 18 birds each). Group K was fed mixtures with a share of wheat, group I – mixtures with hulless barley and group II – mixtures with husked barley. In starter mixtures administered until the 14th day of rearing the share of alternatively used crops was 45%, whereas its share in grower and finisher mixtures administered, respectively, from days 15 to 35 and from days 36 to 42 was 50%. The animals in the experimental groups (I, II) were fed mixtures supplemented with Avizyme 1100 (FinnFeeds Int., UK), which contains protease, xylanase and β-glucanase. The composition and nutritional value of the mixtures are presented in table 1. Throughout the whole rearing period the chickens were given water and feed mixtures *ad libitum*.

On the last day of rearing the chickens in each group were weighed and 4 ♂ and 4 ♀ birds were selected from each group with their weight approximate to the average body weight for the given sex in the particular group. Slaughtered chickens were subject to a simplified dissection analysis (2) which delivered livers and hearts with pericardiac fat. Their natural weights having been determined, fat was separated from the heart muscle and each sample was weighed. On the basis of the dissection results the slaughter output was calculated, as well as the total share of the breast muscle and leg muscles, with the share of abdominal fat pad and giblets in chilled poultry meat.

The content of dry matter, crude ash, total protein and crude fat was determined in the hearts and the livers, with the use of standard AOAC methods (2).

The results obtained were analyzed statistically by ANOVA (Statistica PL), adopting 0.01 as a significant level ($P \leq 0.01$).

Results and discussion

The purpose of the study was to determine whether replacing husked barley with hulless barley with a significantly lower share of crude fibre but a higher content of beta-glucans that modifies the absorption of nutritional elements from the intestine can change the weight and the chemical composition of the heart and the liver in broiler chickens. The results obtained in the experimental groups fed barley were compared with the control group fed wheat.

On the 42nd day of rearing the body weight of broiler chickens fed a mixture with a share of hulless barley (group I) was significantly ($P \leq 0.01$) lower than the value of the body weight of the chickens in the two remaining groups which did not differ from each other (tab. 2). The conclusion is that better

Tab. 2. The effect of hulless barley on body weight and carcass characteristics of chickens

Group	Body weight (g)	Dresing percentage with giblets (%)
K – Wheat	$2005^{A} \pm 197$	71.5 ± 2.43
I – Barley hulless	$1902^{B} \pm 126$	69.1 ± 5.71
II – Barley husked	$2077^{A} \pm 169$	75.2 ± 4.74

Explanations: A, B – significant differences at $P \leq 0.01$

Tab. 3. Heart characteristics

Group	Sex	Heart weight (g)		Share of heart (%)		Circumcardiac fat (%)	Chemical composition (%)		
		with fat	without fat	with fat	without fat		Dry matter	Crude ash	Crude protein
K Wheat	♂	$9.57^{A} \pm 0.57$	$9.12^{A} \pm 0.84$	0.61 ± 0.04	0.58 ± 0.03	$4.72^{B} \pm 0.15$	20.34 ± 1.99	1.11 ± 0.09	16.10 ± 1.23
	♀	$8.27^{B} \pm 0.25$	$7.72^{B} \pm 0.44$	0.67 ± 0.03	0.62 ± 0.05	$6.80^{A} \pm 0.32$	21.93 ± 2.03	1.05 ± 0.07	16.14 ± 1.15
$\bar{x}$		8.92	8.42	0.64^{b}	0.60^{b}	5.76	21.14	1.08	16.12
I Barley hulless	♂	$10.40^{A} \pm 0.95$	$9.82^{A} \pm 0.72$	0.72 ± 0.05	0.68 ± 0.03	5.47 ± 0.23	23.05 ± 2.01	1.14 ± 0.85	16.32 ± 1.28
	♀	$7.92^{B} \pm 0.32$	$7.47^{B} \pm 0.53$	0.67 ± 0.03	0.64 ± 0.02	5.60 ± 0.31	23.63 ± 1.95	1.19 ± 0.92	16.36 ± 0.99
$\bar{x}$		9.16	8.65	0.70^{a}	0.66^{a}	5.53	23.34	1.16	16.34
II Barley husked	♂	$9.45^{A} \pm 0.73$	$8.87^{A} \pm 0.51$	0.61 ± 0.04	0.57 ± 0.03	6.13 ± 0.52	23.27 ± 1.92	1.08 ± 0.91	16.24 ± 1.32
	♀	$8.32^{B} \pm 0.56$	$7.85^{B} \pm 0.25$	0.63 ± 0.02	0.59 ± 0.04	5.60 ± 0.48	21.68 ± 1.83	1.13 ± 0.87	16.35 ± 1.51
$\bar{x}$		8.89	8.36	0.62^{b}	0.58^{b}	5.87	22.48	1.11	16.29
Effect of sex		*	*	ns	ns	*	ns	ns	ns
Effect of feed mixture		ns	ns	*	*	ns	ns	ns	ns

Explanations: a, b, A, B – means with different superscript letters differ significantly at $P \leq 0.01$; * $P \leq 0.01$; ns – not significant

effects are obtained by feeding chickens with husked barley (group II) rather than a hulless type, which may suggest that, despite its more favourable basic composition (4, 7), hulless barley loses in value as a result of the higher amount of beta-glucans (10, 16). However, this does not mean that administering hulless barley is pointless, but rather that it necessitates using feed enzymes. On the other hand, the influence of hulless barley on the slaughter properties of meat carcasses was not clear. No significant differentiation of slaughter productivity, the weight of the abdominal fat pad and its share in the meat carcass was observed (tab. 2). However, a negative effect of hulless barley on the weight of breast and leg muscles, as well as on the carcass's muscles, was noted, which had not been revealed in the studies by Pisarski (14) and Pisarski et al. (15).

Feeding broilers with mixtures in which husked barley (group II) was replaced with hulless barley (group I) led to alterations in the chemical composition of the chicken hearts (tab. 3). In case of the weight of the heart with fat and without pericardiac fat deposition it was noted that that the hearts of the birds fed hulless barley were slightly larger in comparison to the hearts of the birds given husked barley or wheat. A significant influence of the chickens' sex on the examined feature was observed. The heart weight in roosters was higher than in hens. The type of grain did significantly affect the percentage share of the heart in chilled meat carcass. Nevertheless, it can be observed that in roosters fed hulless barley the percentage share of the heart with pericardiac fat deposition was higher than its share in roosters administered husked barley and wheat.

Tab. 4. Liver characteristics

Group	Sex	Liver weight (g)	Share of liver in the body weight (%)	Chemical composition (%)			
				Dry matter	Crude ash	Crude protein	Crude fat
K Wheat	♂	$34.27^{A} \pm 2.8$	2.18 ± 0.1	26.63 ± 1.9	1.44 ± 0.9	20.87 ± 1.8	3.89 ± 0.1
	♀	$29.87^{B} \pm 2.1$	2.41 ± 0.2	26.63 ± 2.1	1.37 ± 0.8	21.87 ± 1.9	3.93 ± 0.2
$\bar{x}$		32.07^{ab}	2.30	26.63	1.41	21.37	3.91^{a}
I Barley hulless	♂	$34.22^{A} \pm 2.6$	2.37 ± 0.1	26.92 ± 1.7	1.43 ± 0.9	21.60 ± 1.7	3.50 ± 2.5
	♀	$29.52^{B} \pm 2.1$	2.53 ± 0.2	26.57 ± 1.6	1.35 ± 0.8	21.04 ± 1.6	3.75 ± 2.9
$\bar{x}$		31.87^{b}	2.45	26.74	1.39	21.33	3.62^{ab}
II Barley husked	♂	$39.60^{A} \pm 2.8$	2.54 ± 0.1	27.23 ± 1.6	1.42 ± 0.9	21.64 ± 1.6	3.31 ± 2.6
	♀	$31.72^{B} \pm 2.4$	2.38 ± 0.2	26.54 ± 1.9	1.48 ± 0.8	21.95 ± 1.9	3.27 ± 2.4
$\bar{x}$		35.66^{a}	2.46	26.88	1.45	21.80	3.29^{b}
Effect of sex		*	ns	ns	ns	ns	ns
Effect of feed mixture		*	ns	ns	ns	ns	*

Explanations: as in tab. 3

The study did not reveal a significant influence of the type of grain on the content of certain chemical components: total protein, crude ash and fat deposition of the heart (tab. 3).

The results of our own studies concerning the influence of hulless barley on the weight and chemical composition of the hearts cannot be confronted with other studies, since this is a new type of grain and, as such, has not been frequently tested, particularly regarding its influence on the chemical composition of broiler chicken hearts.

The experiments did not reveal any significant influence of the type of barley on the chemical composition of the chicken livers (tab. 4). The type of barley used affected the liver's weight. The liver weight in the chickens fed husked barley (group II) was statistically significantly higher by ca. 10% in comparison with the liver weights in the birds fed hulless barley (group I) and those given wheat. The weight of the liver was dependent to some extent on the chickens' sex, namely it was slightly higher in roosters than in hens however ($P \leq 0.01$). The share of the liver weight in the body weight of the chickens fed wheat, natural barley and naked barley was similar and did not reveal statistically relevant differences. However, its share was the highest in case of the chickens fed husked barley (group II). The results of our own studies regarding the share of the liver in the body weight differed from those observed by Bekta and Fabijańska (3), who, using large amounts of barley in feed mixtures for broiler chickens, noted a higher percentage share of the liver in the body weight. The results of our own studies concerning the increase of the liver weight and its share in the body weight correspond with the results observed by Kwiecień and Zięba (11). Changes in the absolute liver weight do not directly confirm the observations made by Brenes et al. (5); it is the increasing share of the weight of this organ that reflects the activity of beta-glucans.

The type of grain did not affect the content of dry matter, crude protein and crude ash in the livers (tab. 4). It was similar and its volume was within the limits of the statistical error. In case of the examined content of crude fat in the livers of the chickens fed mixtures with husked barley a lower content of these elements was noted in comparison with the control group.

In the experiments performed by Kwiecień and Zięba (11) using hulless barley, a slight, irrelevant decrease in dry matter content and a slight increase in protein and fat were observed, whereas in our own studies the situation was reversed.

Summing up, adding hulless barley to the mixtures resulted in a statistically significant reduction in the chickens' body weight, lower weight of breast and leg muscles and their lower share in the meat carcass. The addition of hulless barley used in the mixtures contributed to increasing the heart weight, its share in the chickens' body weight, as well as increasing the content of dry matter by 9.5% and of crude ash by 6.9%, compared to the chickens fed wheat. The type of barley significantly modified the weight of the chickens' livers. A higher weight was noted in the birds fed husked barley, the difference amounting to 11%. Hulless barley used in the mixtures reduced the content of crude ash, total protein and crude fat, in comparison to their content in the livers of the chickens in the control group.

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