Scientific Annals of Polish Society of Animal Production - Vol. 14 (2018), No 1, 23-36

Influence of the physical form of oat grain on the fattening results and carcass quality of White Kołuda geese

Eugeniusz Kłopotek[#]

National Research Institute of Animal Production, Kołuda Wielka Experimental Station, ul. Parkowa 1, 88-160 Janikowo; [#]e-mail: sekretariat.iz@onet.pl

The aim of the study was to examine the influence of the physical form of oat grain (whole, crushed or ground grain) on the fattening results, feed conversion and carcass quality of the W-33 strain of White Kołuda (Biała Kołudzka®) geese. A total of 90 hatchlings (45 ♂♂ + 45 ♀♀) were randomly selected for the experiment. All geese were fed in the same way until the age of 14 weeks, receiving KB-1, KB-2 and KB-3 compound feeds in the amount of up to 300 g/individual/day and grass forage ad libitum. At the end of the 14th week, the geese were divided into three feeding groups (15 ♂♂ and 15 ♀♀ in each) and in the period from weeks 15 to 17, a total of 21 days, they were fed only hulled oat grain of the Rajtar cultivar. Group I received whole grain, group II crushed grain, and group III ground grain. After the fattening was completed, 5 male and 5 female geese from each of the three experimental groups were selected for slaughter analysis. The birds receiving whole oat grain had the highest body weight, weight gain from the 15th to the 17th week of life, feed conversion and dressing percentage. Male geese had higher body weight, higher muscle tissue content, and lower adipose tissue content than females (P≤0.01). The two sexes did not differ significantly in dressing percentage or content of abdominal fat.

KEY WORDS: White Kołuda geese / fattening with oats / carcass analysis

Goose breeding and farming intensified in Poland after World War II, and especially after 1962, when it became possible to export goose meat. At that time White Italian chicks were purchased in Denmark, brought to Poland and placed at the Experimental Station in Kołuda Wielka. Shortly thereafter, the Kołuda Wielka Experimental Station became the only goose breeding farm in Poland, taking on the full responsibility for improving the domestic population of these birds. In 1993, geese bred in Kołuda Wielka were given the name of Biała Kołudzka (White Kołuda), which was approved by the Commission for recognition of breeding material of the Ministry of Agriculture, Forestry and Food Economy [1], and in 2001 the Patent Office of the Republic of Poland registered the trademark Biała Kołudzka® goose.

The genetic improvement programme for the White Kołuda goose covers two strains: the W-33 male strain and the W-11 female strain. In the male strain, breeding work is aimed at improving meat traits, while laying characteristics are improved in the female strain [12]. Currently, about 98% of the goose population in Poland derives its genotype from the White Kołuda goose from the breeding farm at the Kołuda Wielka Experimental Station.

Poland has been valued as a breeder and producer of geese for years, and the 'young Polish oat goose' is often referred to as one of the best export products of Polish agriculture. The trade name 'oat goose' derives from the fact that slaughter geese are fed only oats and water in the last three weeks of the fattening period. Oats, due to their specific chemical composition, with high fat content and a fatty acid profile that is beneficial to human health, increase the quality of goose meat and fat, as well as feather quality [9]. The meat has lower fat content than that of other poultry species.

The largest buyer of Polish goose meat is Germany, which purchases 95% of its export. Consumption of goose meat in Poland, although it is systematically growing owing to a widespread promotional campaign, is still small, amounting to around 300 g per capita per year. It is estimated that the growth trend will continue in the following years. Therefore, more extensive research should be conducted on the economic aspects of goose production in connection with raising the quality of goose meat.

Given that oat in the form of whole grain is commonly used in Poland in the last three weeks of fattening of slaughter geese, and due to the scarcity of scientific information in the available literature on this subject, a study was undertaken to determine what physical form of oat grain is optimal for feeding geese. The study analysed the influence of the physical form of oat grain (whole grain, crushed or ground) on the fattening results, feed conversion and carcass quality of the W-33 strain of White Kołuda geese.

Material and methods

The research was carried out at the Experimental Station of the National Research Institute of Animal Production in Kołuda Wielka in 2013-2014. A total of 90 White Kołuda goose chicks of the W-33 strain (45 birds of each sex) were randomly selected for the study. From hatching until the age of 14 weeks, the geese were reared and fed according to the system used in in Kołuda Wielka, using KB-1, KB-2 and KB-3 compound feeds in amounts of up to 300 g/chick/day, as well as ad libitum grass forage.

From hatching to the age of 14 weeks, the geese stayed for four weeks in a brooder and then in a goose house, in two adjacent pens, separate for each sex. The air temperature in the buildings, measured 1.5 m from the floor, was initially 25°C and the air humidity was 60-65%, gradually lowered to 19°C and 55-60%. The average body weight of the birds after hatching was 113.5 and 114.6 g for males and females, respectively, and after the age of 14 weeks, 5.8 and 5.5 kg.

At the age of 14 weeks, the geese were divided into 3 feeding groups (15 ♂♂ and 15 ♀♀ in each), which were placed in the same goose house, in three adjacent pens (30 birds each) measuring 3.9 x 4.0 m each, with access to an enclosed outdoor run. From weeks 15 to 17, a total of 21 days, they were fed exclusively with hulled common oat grain of the Rajtar cultivar (with continual access to water). Group I received whole grain, group II crushed grain, and group III ground grain.

The grain was crushed in a GZ-05 100 crushing mill (Zakład Innowacyjno-Wdrożeniowy GA-ZIN, 1985) and ground in a K1,13/0-1,3 grain mill (Fabryka Narzędzi Rolniczych JAROP, 1975).

After 14 and 17 weeks of life, the geese were individually weighed. The total oat consumption in the experimental groups was recorded as well.

After 17 weeks, 10 birds from each group (5 male and 5 female), with a body weight close to the average for the group, were randomly selected and killed by decapitation, after previous stunning and one-day fasting. After being plucked and gutted, the carcasses were cooled to +5°C and stored for about 24 hours. Next, slaughter analysis was performed on the left half of the chilled carcasses, determining the weight of the valuable cuts. The carcasses were dissected according to the procedure described by Ziołecki and Doruchowski [20]. The average hot and cold carcass weights and the weights of the valuable cuts were determined for each feeding group, broken down by gender. The dressing percentage was calculated for each experimental group and for the sexes, according to the following formula:

$$\text{Dressing pct.} = \frac{\textit{cold carcass weight with neck} + \textit{abdominal fat}}{\textit{body weight before slaughter}} \text{ x } 100\ (\%)$$

Chemical analysis of the oats was performed at the Central Laboratory of the National Research Institute of Animal Production. The content of dry matter, crude protein, crude fat, crude fibre and crude ash in the feeds was determined by analytical methods [14, 15]; neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) according to Van Soest [19]; and starch by polarimetry [16].

The results were analysed statistically using Statistica 6 PL software, by two-way analysis of variance (factor 1 – physical form of oat grain, factor 2 – sex). The statistical differences between means for the three feeding groups and the sexes were verified using the Tukey HSD test. In addition, the standard error of the arithmetic mean (SEM) was calculated as a measure of variation in the whole experiment, and the possible interaction between the experimental factors – the physical form of oats and the sex of the geese – was tested.

Results and discussion

Processing of oats, consisting of crushing and grinding, is associated with a small loss of grain particles, mainly the smallest ones, which may affect its chemical composition. The content of nutrients in the oat grain is given in Table 1.

The particle size in the various physical forms of oat was highly varied. Over 95% of the whole oat grain failed to penetrate sieves with 4 x 4 mm square mesh during 10 minutes of separation by shaking. The crushed oats were partially fragmented during processing. Kernels partially exposed from the seed hull were slightly crumbled. Over 78% did not fall through the 4 x 4 mm mesh during separation, 16.9% remained on sieves with 2 x 2 mm mesh, and 4.5% on sieves with 1 x 1 mm mesh. All of the ground grain penetrated through

Table 1
Dietary constituents (in 1 kg) and particle size of 3 physical forms of oat grain

Item	Physical form of oat grain		
	whole	crushed	ground
Dry matter (g)	900.3	895.4	904.9
Metabolic energy (MJ)	10.70	10.70	10.67
Crude protein (g)	106.3	107.6	112.1
Crude fat (g)	41.1	44.5	35.2
Crude fibre (g)	147.2	138.7	149.2
Crude ash (g)	30.5	31.9	31.3
NDF (g)	319.1	312.8	306.5
ADF (g)	147.2	138.4	149.2
ADL (g)	28.7	25.8	28.0
Starch (g)	359.1	371.2	329.8
Percentage of particles			
4.00 mm	95.5	78.6	–
2.00 mm	4.5	16.9	32.9
1.00 mm	–	4.5	36.9
0.50 mm	–	–	21.3
0.35 mm	–	–	8.9
less than 0.35 mm	–	–	–

sieves with 4 x 4 mm mesh, while 91.1% remained on sieves with mesh size from 2 x 2 mm to 0.5 x 0.5 mm. A small amount (8.9%) remained on sieves with 0.35 x 0.35 mm mesh size (Table 1).

Figure 1 shows the intake and conversion of the various physical forms of oats by geese in the three-week period. Oat consumption (in kg/bird) was highest in group I, which received whole oats, lower in group II, receiving crushed oats, and the lowest in group III, which was fed ground oats. Conversion of oats, expressed in kg/kg body weight, was the lowest in group I, which received whole oats, slightly higher in group II, which consumed crushed oats, and the highest in group III, which was fed ground oats (Figure 1). The use of ground oats caused difficulties in intake because the meal became stuck to the beak, re-

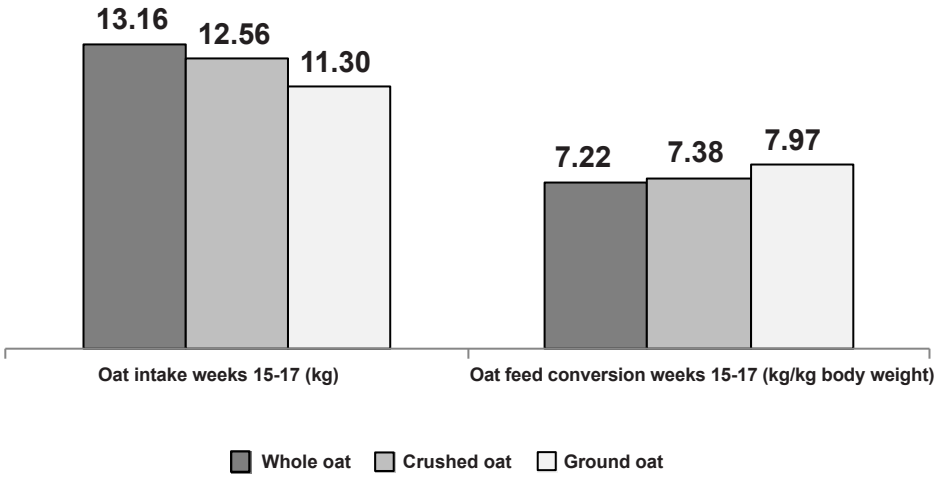


Fig. 1. Intake and conversion of different physical forms of oat grain by geese

sulting in the goose's constant reflex to rinse the beak with water, which explain the lower intake and inferior conversion of the grain.

The body weight of the geese at the ages of 14 and 17 weeks, i.e. before and after the oat grain feeding period, is presented in Table 2. At 14 weeks, the average body weight of the male geese was significantly higher than that of the females ($P \leq 0.05$). At the age of 17 weeks, the body weight of geese receiving whole oats was significantly higher than that of geese fed ground oats ($P \leq 0.05$). The average body weight of the male geese was highly significantly higher than that of the females ($P \leq 0.01$), but the interaction of the form of oat and sex was statistically non-significant. The highest weight gain in the period from weeks 15 to 17 (21 days) was noted in the group of geese fed whole oats, and the lowest in the group fed ground oats. There were no significant differences between the groups fed whole and crushed oats. Significant differences were shown between the two groups fed whole oats and crushed oats and the group fed ground oats, with a highly significant difference ($P \leq 0.01$) in body weight gain between geese fed whole and ground oats, and a significant difference ($P \leq 0.05$) between the geese fed crushed and ground oats. Weight gain in male geese was highly significantly higher than in females ($P \leq 0.01$). No statistically significant interaction was found between the form of the grain and the sex of the geese. Daily weight gains of geese receiving whole oats were also highly significantly higher than in geese receiving ground oats ($P \leq 0.01$) and significantly higher in geese receiving crushed oats compared to geese fed with ground oats ($P \leq 0.05$). The daily weight gains of male geese were highly significantly higher than in females ($P \leq 0.01$), while the interaction of oat grain form and sex was statistically non-significant.

Table 2
Body weight of geese before and after the oat feeding period

Physical form of oat grain	Sex	Number of birds	Mean body weight (g)		Weight gain (g)	Daily weight gain (g)
			week 14	week 17		
Whole oat grain	♂♂	15	5813	7833	2020	96.2
	♀♀	15	5440	7066	1627	77.5
	mean	30	5627	7450^{a}	1823^{A}	86.8^{A}
Crushed oat grain	♂♂	15	5787	7693	1907	90.8
	♀♀	15	5500	7000	1500	71.4
	mean	30	5643	7347	1703^{a}	81.1^{a}
Ground oat grain	♂♂	15	5700	7387	1687	80.3
	♀♀	15	5620	6767	1147	54.6
	mean	30	5660	7077^{b}	1417^{Bb}	67.5^{Bb}
SEM			51	73	50	2.4
Sex	♂♂	45	5767^{a}	7638^{A}	1871^{A}	89.1^{A}
	♀♀	45	5520^{b}	6944^{B}	1424^{B}	67.8^{B}
P value	form of oat grain		0.9647	0.0464	0.0005	0.0005
	sex		0.0172	0.0000	0.0000	0.0000
	interaction		0.4827	0.8913	0.7320	0.7320

a, b – values in columns for forms of oat (means) and sex of geese differ significantly (P≤0.05)
A, B – values in columns for forms of oat (means) and sex of geese differ highly significantly (P≤0.01)

In the present study, 17-week-old slaughter geese attained an average body weight of over 7 kg, regardless of the physical form of oat grain consumed. The birds' body weight was higher than in previous studies on fattening of slaughter geese. The birds used in the study were of the W-33 strain, selected for meat traits, which is of great importance in making comparisons with other strains, breeds and varieties. The body weight of the male geese was on average 7,638 g and that of the females was 6,944 g (Table 2). In a study by Bieliński et al. [5] on Italian White geese, one of the experimental groups of slaughter geese, fed ad libitum with KW-1, KW-2 and KW-3 concentrate feeds, followed by oats in the last two weeks, reached a body weight of 5.47 kg at the age of 17 weeks, and the total consumption of the compound feed and oat was 7.13 kg/kg body weight gain. The geese remained in the brooder until the 6th week and kept in enclosures with no run until the end of the fattening period.

Mazanowski [10], evaluating meat traits of goose crossbreds from experimental strains in comparison with White Kołuda geese, found that W-31 crosses (W-33 x W-11) at the age of 17 weeks reached a body weight of 6,554 g, significantly ($P \leq 0.05$) surpassing the other experimental groups. Consumption of compound feeds containing 10% oat from weeks 13 to 17 of life was 5,240 g/kg of body weight gain. In another study by Mazanowski [11], comparing the performance of oat-fattened 17- and 24-week-old crosses of geese from experimental strains and W-31 White Kołuda crosses, showed that the average body weight of the W-31 crosses at 17 weeks was 6,148 g. Weight gain in the oat fattening period in the last three weeks was only 487 g, while consumption of compound feeds and oats was 5,468 g/kg body weight gain. The geese were kept in a closed building without access to a run or pasture. The very low body weight gain is in marked contrast to the results of the present study, in which the group of geese fed whole oats from weeks 15 to 17 gained 1,823 g, the group fed crushed oats 1,703 g, and the group fed ground oats 1,417 g. The male geese gained on average 1,871 g, and the females 1,424 g (Table 2). The combined oat consumption per bird during the last three weeks was 13.16, 12.56 and 11.30 kg, respectively, for the experimental groups (Fig. 1).

The lowest weight gain in the group fed with ground oats in the present study can be explained by lower intake of this form compared to the whole and crushed oats.

Rosiński [17] evaluated the correlated effects of selection in meat traits of the W-11 and W-33 strains of White Kołuda geese in two experiments carried out in the same environmental conditions and using the same feed rations. The author found that the body weight of the geese at the age of 17 weeks ranged from 6.2 to 6.9 kg in the experimental groups, and the average body weight of the W-33 strain was significantly ($P \leq 0.05$) higher, by 304 g, than that of the W-11 strain. Concentrate feed consumption ranged from 4.69 to 4.98 kg/kg body weight gain, with the W-33 strain consuming 125 g less feed per kg weight gain. The environmental and feeding conditions in this experiment were similar to those described in the present study. The geese were kept in the same building with a controlled microclimate and access to runs; up to the 14th week they received concentrate feed and green forage, and from weeks 15 to 17 they ate only oats.

Bernacki [2] conducted a study to evaluate the effect of selection and combining abilities on performance traits in geese of four experimental strains and their crosses, which had undergone improvement in 1987-1998. Geese of the WD 02 strain (White Italian), from which the White Kołuda goose is derived, achieved average body weight gain of 647 g during the oat feeding period from weeks 15 to 17, with consumption as high as 13.9 kg oats/kg of body weight gain. Similar results were obtained by Mazanowski [10]. The differences in body weight, body weight gain and consumption of concentrate feed and oat per kg of body weight may have been the effect of many years of selection to improve the meat traits of the W-33 strain.

Rosiński [18] reported that the body weight of geese in the three-week oat feeding period increased from 1.2 to 1.4 kg, and the final body weight at 17 weeks reached up to 6.7 kg. A study by Biesiada-Drzazga [6] also showed that W-31 crossbreds (W-33 x W-11) at a similar age achieved an average body weight of 6,458.7 g, and in the three-week oat feeding period their weight gain was 974.2 g. An experiment by Bielińska et al. [4] showed that at the age of 17 weeks the body weight of male geese in three experimental groups was

similar, exceeding 7 kg, while female geese weighed about 1 kg less. In the present study, the difference in body weight between male and female geese was 694 g.

Pietrzak et al. [13] reported exceptionally high body weight at the age of 109 days in White Kołuda geese, especially males (7,623 g), fed until the age of 88 days on grower-type compound feeds produced from on-farm ingredients, and then for 21 days on oats. Feed consumption per kg body weight gain was 3.95 kg in males and 4.54 kg in females, and was more than 1 kg lower than in the group fed until day 88 on industrial compound feed and then on oats. Bernacki [2] reported that during fattening with oats the body weight of slaughter geese increases on average by 11–16%. In the present study, however, the body weight of geese fed for 21 days on whole oats increased by 32.4%, in those fed on crushed oats by 30.2%, and in those receiving ground oats by 25.0%, where 100% was the body weight of the geese at the age of 14 weeks.

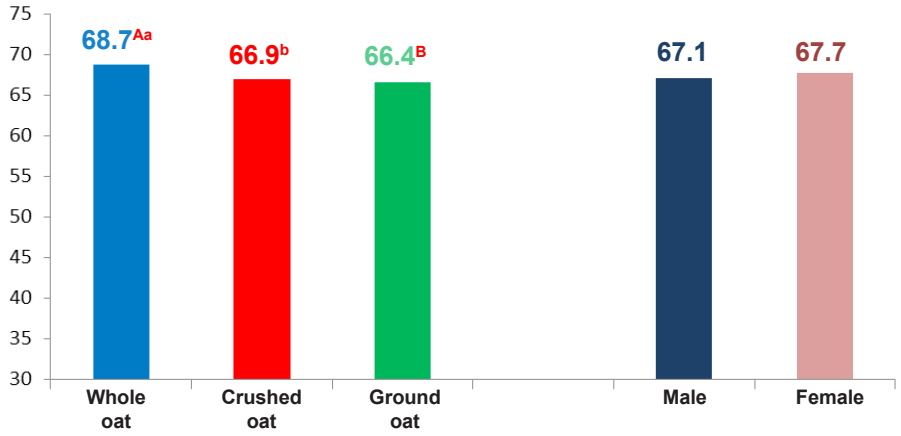
The results of the study indicate that the body weight of slaughter geese fed in the final period of life on oats depends on the genetic components used to cross the geese, the feeding system during the period from hatching to the age of 14 weeks, and then the physical form of the oat grain given to the geese between weeks 15 and 17. Oat feeding in the final fattening period, in comparison with the previous periods of the life of the geese, is distinguished by a low level of protein and a high level of energy (Table 1). This enriches the goose carcasses with abdominal fat and subcutaneous fat and beneficially affects the flavour of the meat during cooking.

The dressing percentage of the experimental geese is presented in Figure 2. The dressing percentage was higher in the group fed whole oats, and differed significantly from the group fed crushed oats ($P \leq 0.05$) and highly significantly from the group fed ground oats ($P \leq 0.01$). No significant differences were found between birds receiving crushed and ground oats or between the sexes. There was also no statistically significant interaction between the form of the grain and sex.

Analysis of the results obtained by researchers for the dressing percentage of 17-week-old geese of different breeds and varieties reveals systematic improvement over the years: from 62.2% in White Italian geese in a study by Bieliński et al. [5] to 65.2-68.5% in research by Biesiada-Drzazga [6] and by Bielińska et al. [3] in W-31 crossbreds.

The dressing percentage of the geese in this study ranged from 66.4% to 68.7% and was highest in the geese consuming whole oats and lowest for those receiving ground oats. As in research by Rosiński [17] and Biesiada-Drzazga [6], the females had a somewhat higher dressing percentage than the males.

Table 3 shows the results of the post-slaughter evaluation and carcass quality assessment of geese of both sexes fed with three forms of oats. The average slaughter weights of the birds in groups fed whole oats and crushed oats did not differ significantly, but were significantly higher than for the group of geese consuming the ground oats ($P \leq 0.05$). The average slaughter weight of the male geese was highly significantly higher than that of the females ($P \leq 0.01$). The highest hot and cold carcass weights were noted in the group of geese consuming whole oats, and were highly significantly higher than in group of geese consuming ground oats ($P \leq 0.01$), but not significant in relation to the group of geese fed crushed oats, while the geese receiving crushed oats had significantly higher hot and



a, b – values with different letters differ significantly (P≤0.05)
A, B – values with different letters differ significantly (P≤0.01)

Fig. 2. Dressing percentage of experimental geese (%)

cold carcass weights than those receiving ground oats (P≤0.05). Male geese had highly significantly higher hot and cold carcass weights than female geese (P≤0.01). There was no statistically significant interaction of the form of the grain and gender in these cases.

Table 4 shows the weight of edible cuts of the goose carcasses. The weight of the breast muscles in the group of geese consuming whole oats was higher than in the group fed ground oats, and the differences were statistically highly significant (P≤0.01). Similarly, the weight of the whole limb (without the foot) in the group of geese receiving whole oats was highly significantly higher than in the group consuming the ground oats (P≤0.01) and significantly higher than in the group consuming crushed oats (P≤0.05). In the group fed whole oats, the amount of abdominal fat was only significantly higher than in the group receiving crushed oats (P≤0.05), while there were no significant differences between the experimental groups in the percentage share of abdominal fat in the carcass.

The weights of the breast muscles, whole limb (without the foot), whole wing, and neck with skin were highly significantly higher in males than in females (P≤0.01), while the female carcasses contained more abdominal fat, but a significant difference was obtained for relative values with respect to the carcass weight (P≤0.05). The percentage share of the breast muscles and the whole limb in the carcass were not significantly different for the two sexes, but the male geese had a significantly higher percentage of wing weight in the carcass (P≤0.05) and a highly significantly higher percentage of neck with skin (P≤0.01) – Table 4.

Table 3
Characteristics of goose carcasses after slaughter

Physical form of oat grain	Sex	Number of birds	Body weight at slaughter (g)	Hot carcass weight (g)	Cold carcass weight (g)
Whole oat grain	♂♂	5	7518	5218	5166
	♀♀	5	6852	4758	4711
	mean	10	7185^{a}	4988^{A}	4939^{A}
Crushed oat grain	♂♂	5	7448	5011	4944
	♀♀	5	6840	4671	4618
	mean	10	7144^{a}	4841^{a}	4781^{a}
Ground oat grain	♂♂	5	7178	4797	4748
	♀♀	5	6586	4457	4399
	mean	10	6882^{b}	4627^{Bb}	4573^{Bb}
SEM			73	43	54
Sex	♂♂	45	7381^{A}	5008^{A}	4953^{A}
	♀♀	45	6759^{B}	4629^{B}	4576^{B}
P value	form of oat grain		0.0128	0.0004	0.0004
	sex		0.0000	0.0000	0.0000
	interaction		0.9292	0.6792	0.6856

a, b – values in columns for forms of oat (means) and sex of geese differ significantly (P≤0.05)
A, B – values in columns for forms of oat (means) and sex of geese differ highly significantly (P≤0.01)

In order to meet the expectations of consumers, greater emphasis has recently been placed on selection work to increase the weight of the limbs (thigh and shank muscles) in the White Kołuda goose. Less than 20 years ago, the weight of the breast muscles clearly exceeded that of the limbs (without feet), as shown by Mazanowski [10], Rosiński [17] and Bernacki [2]. These differences have now nearly disappeared, and in a study by Kłos et al. [8], the weight of the limb has even slightly surpassed that of the breast muscles. In our study, the weight of the limb muscles was slightly lower than that of the breast muscles, but the difference was not significant. Poultry companies suggest that this balance should be maintained, or even that the weight of the breast muscles should be slightly reduced or the weight of the thigh and shank muscles further increased. Given the quality of both types of muscles, breast and leg, I consider these suggestions unfounded. They seem to result from the taste preferences of goose meat consumers. Leg muscles in birds, including broiler chickens, contain more fat than breast muscles. This is true in geese as

Table 4
Edible carcass cuts in absolute values and percentages

Physical form of oat grain	Sex	Whole breast muscles[1]		Whole limbs (without feet)[2]		Whole wings[3]		Neck with skin		Abdominal fat	
		g	%[4]	g	%[4]	g	%[4]	g	%[4]	g	%[4]
Whole oat grain	♂♂	1196	23.2	1182	22.9	658	12.7	347	6.7	337	6.4
	♀♀	1132	24.1	1106	23.5	558	11.9	281	6.0	323	6.8
	mean	1164^{A}	23.6	1144^{Aa}	23.2	608	12.3^{b}	314	6.3^{b}	330^{a}	6.7
Crushed oat grain	♂♂	1152	23.3	1102	22.3	668	13.5	350	7.1	263	5.3
	♀♀	1084	23.5	1058	22.9	594	12.9	306	6.6	288	6.2
	mean	1118	23.4	1080^{b}	22.6	630^{a}	13.2^{a}	328	6.9^{a}	276^{b}	5.8
Ground oat grain	♂♂	1120	23.6	1078	22.7	636	13.4	340	7.2	269	5.6
	♀♀	992	22.6	1006	22.9	542	12.3	301	6.8	289	6.5
	mean	1056^{B}	23.1	1042^{B}	22.8	588^{b}	12.9	321	7.0	279	6.1
SEM		8	0.2	7	0.2	5	0.2	6	0.2	9	0.2
Sex	♂♂	1156^{A}	23.3	1120^{A}	22.6	654^{A}	13.2^{a}	346^{A}	7.0^{A}	289	5.8^{b}
	♀♀	1070^{B}	23.4	1056^{B}	23.1	564^{B}	12.4^{b}	296^{B}	6.5^{B}	300	6.5^{a}
P value	form of oat grain	0.0033	0.4732	0.0009	0.2884	0.0365	0.0072	0.4326	0.0336	0.0270	0.1109
	sex	0.0011	0.9474	0.0031	0.1298	0.0000	0.0041	0.0000	0.0270	0.5419	0.0405
	interaction	0.4722	0.1031	0.7568	0.7677	0.6848	0.5797	0.4427	0.5797	0.5926	0.7138

[1]Whole breast muscles = breast muscles + skin with subcutaneous fat
[2]Whole limb (without feet) = thigh and shank muscles + skin with subcutaneous fat + bones
[3]Whole wing = wing muscles + skin with subcutaneous fat + bones
[4]Percentage share of cut in cold carcass (weight of breast muscles, limb and wing of left half-carcass, doubled)
a, b – values in columns differ significantly ($P \leq 0.05$)
A, B – values in columns differ highly significantly ($P \leq 0.01$)

well, and thus the leg muscles are juicier and consumers perceive them as tastier. This view clashes with opinions on the health quality of individual parts of poultry meat, according to which meat with lower fat content is considered more desirable.

In comparison with the results of a study by Rosiński [17], performed on the W-33 goose strain, in the present study the abdominal fat content in the carcass was much higher. The females had a higher percentage of abdominal fat in the carcass than the males. It seems likely that the weight and age of the slaughtered geese have a significant effect on the percentage content of abdominal fat in the carcass. In the study cited above, the body weight of the W-33 geese at the age of 17 weeks ranged from 6,616.4 g to 6,871.0 g in both sexes, while in the present study it ranged from 6,767 g to 7,833 g (Table 2). An experiment by Gornowicz et al. [7] also showed that the content of abdominal fat in the carcass of protected native breeds, i.e. Kielce Landrace and Pomeranian, was significantly lower than in W-31 White Kołuda crossbreds, with very large differences in body weight at slaughter (Kielce Landrace: females 3,798 g, males 4,440 g; Pomeranian: 4,583 g and 5,853 g; White Kołuda: 6,483 g and 8,333 g). The study indicates that the weight of abdominal fat in the carcasses of geese increased with the slaughter weight of the geese, with a higher percentage of fat in the carcasses of male geese. The results of the present study show the reverse pattern (Table 4). In the groups receiving crushed and ground oat, the female geese, despite a pre-slaughter body weight about 600 g lower than in males, had more abdominal fat in the carcass, both in absolute values and as a percentage of the carcass weight. Only in the group receiving whole oats did the male geese have more abdominal fat in absolute values, but its percentage in the carcass was lower than in the females (Table 4).

In most poultry species, especially in waterfowl, including geese, fat deposition in the body cavity, in the adipocytes distributed there, may be a physiological vestige inherited from wild geese, which accumulated energy reserves for the winter, a period of insufficient food forcing birds to use energy stored in fat, but also to migrate over long distances to warmer climates.

Despite knowledge of the energy and protein requirements of geese on which breeding work and selection are carried out to reduce the amount of abdominal fat, in contemporary breeding of these birds controlled energy intake has not achieved the desired effect. The content of abdominal fat is known to be higher in females than males, despite their lower body weight. This may be due to their different hormonal profile, which causes oestrogen hormones in females to induce a response of greater deposition of subcutaneous and subcutaneous fat, as shown in the present study. This is also observed in mammals. It can be hypothesized that this is due to the need to expend a large amount of energy during the egg-laying period in early spring. There are no detailed studies linking the level of fat in the carcass with the hormone metabolism of birds.

Feeding of slaughter geese in the conditions of Poland, involving a three-week period using only oats, currently has the main goal of enriching the carcass with fatty acids that are released and permeate the meat tissue during cooking. Its original aim was to reduce the cost of goose fattening, as the price of oat grain was and is lower than that of other cereals.

To sum up, the best fattening results were achieved by feeding geese whole oat grain, slightly lower results with crushed oat, and significantly inferior results using ground gra-

in, as compared to whole and crushed oats. The higher slaughter weight of geese receiving whole and crushed oats, as compared to ground oats, resulted in higher weight of the breast muscles and limb muscles, with an increase in the weight of the skin and adipose tissue, but no significant differences in the content of muscle tissue. The physical form of oat grain had no significant effect on the relative values for the percentage of breast muscles and leg muscles in the weight of the carcass.

In summary, whole oat grain is the best physical form for use in fattening geese. Crushing the oats, and especially grinding them, interferes with their consumption by geese, resulting in lower body weight gains and lower weight of the most valuable carcass cuts (the breast and leg muscles).

REFERENCES

1. BADOWSKI J., 2013 – Hodowla gęsi w Instytucie Zootechniki Państwowym Instytucie Badawczym. Materiały konferencji „Polska rasa „gęś Biała Kołudzka®" – hodowla i chów". Wyd. K-PODR w Minikowie.
2. BERNACKI Z., 2001 – Kompleksowa ocena wpływu selekcji i zdolności kombinacyjnych na cechy użytkowe gęsi z rodów doświadczalnych i ich mieszańców. AT-R Bydgoszcz. Rozprawy nr 102.
3. BIELIŃSKA H., BADOWSKI J., KŁOS K., 2010 – Wpływ systemu żywienia gęsi Białych Kołudzkich® na wskaźniki wartości rzeźnej. XXII International Poultry Symposium PB WPSA. Olsztyn, 6-8 September 2010, 160-161.
4. BIELIŃSKA H., BADOWSKI J., SANDECKI R., KŁOS K., 2012 – Wpływ modyfikowanego systemu żywienia na wskaźniki wartości rzeźnej gęsi owsianych Białych Kołudzkich®. XXIV International Poultry Symposium PB WPSA. Kołobrzeg, 12-14.09.2012, 80-81.
5. BIELIŃSKI K., BIELIŃSKA K., SKARŻYŃSKI Ł., TRACZYKIEWICZ K., 1983 – Wpływ wieku na produkcyjność, użytkowość rzeźną oraz jakość mięsa i tłuszczu gęsi tzw. owsianych. ***Roczniki Naukowe Zootechniki*** 10 (1), 21-35.
6. BIESIADA-DRZAZGA B., 2008 – Porównanie masy ciała i składu tkankowego tuszek gęsi rasy Białej Kołudzkiej® rodu W11 i mieszańców międzyrodowych W31. ***Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego*** 4 (3), 245-253.
7. GORNOWICZ E., MOLIŃSKI K., LEWKO L., KŁOPOTEK E., SKOTARCZAK E., 2016 – Wpływ rasy na udział poszczególnych elementów w tuszce gęsi. Sympozjum „Postęp w Technologii Mięsa. Nauka – praktyce 2016" XLV Dni Przemysłu Mięsnego, Warszawa, 19 maja 2016, 37-38.
8. KŁOS K., SOKOŁOWICZ Z., BADOWSKI J., BIELIŃSKA H., 2010 – Określenie możliwości szacowania umięśnienia nóg gęsi Białych Kołudzkich® na podstawie pomiarów przyżyciowych. ***Roczniki Naukowe Zootechniki*** 37 (1), 55-62.
9. MAJEWSKA T., 2011 – Polska gęś owsiana – wczoraj, dziś i jutro. Materiały konferencyjne XXIII Międzynarodowe Sympozjum Drobiarskie PO WPSA. Poznań, 13-15.09.2011, 214-215.
10. MAZANOWSKI A., 1999 – Ocena cech mięsnych odchowywanych intensywnie mieszańców gęsi z rodów doświadczalnych w porównaniu z gęsią Białą Kołudzką®. ***Roczniki Naukowe Zootechniki*** 26 (1), 41-54.

11. MAZANOWSKI A., 1999 – Porównanie wyników tuczonych owsem 17- i 24-tygodniowych mieszańców gęsi z rodów doświadczalnych i gęsi Białych Kołudzkich®. ***Roczniki Naukowe Zootechniki*** 26 (1), 87-102.
12. MINISTERSTWO ROLNICTWA I ROZWOJU WSI, 2013 – Krajowa Strategia Zrównoważonego Użytkowania i Ochrony Zasobów Genetycznych Zwierząt Gospodarskich. 36-37. Wyd. Instytut Zootechniki – Państwowy Instytut Badawczy.
13. PIETRZAK D., MIERZEJEWSKA E., MROCZEK J., MICHALCZUK M., DAMAZIAK K., MAKARSKI M., ADAMCZAK L., 2013 – Wpływ żywienia i płci na wybrane wyróżniki jakości mięsa gęsi Białych Kołudzkich®. ***Zeszyty Problemowe Postępów Nauk Rolniczych*** 574, 49-56.
14. PN-EN ISO 771: 2000 – Śruta nasion oleistych. Oznaczanie wilgotności i substancji lotnych.
15. PN-EN ISO 665: 2004 – Nasiona oleiste. Oznaczanie wilgotności i zawartości substancji lotnych.
16. PN-R-64785: 1994 – Pasze. Oznaczanie zawartości skrobi metodą polarymetryczną.
17. ROSIŃSKI A., 2000 – Analiza bezpośrednich i skorelowanych efektów selekcji w dwóch rodach gęsi. ***Roczniki Akademii Rolniczej w Poznaniu. Rozprawy naukowe*** 309.
18. ROSIŃSKI A., 2003 – Hodowla i produkcja gęsi. Wyd. AR Poznań.
19. VAN SOEST J.P., 1994 – Nutritional Ecology of the Ruminant 2nd Cornell University Press, Ithaca, N.Y.
20. ZIOŁECKI J., DORUCHOWSKI W., 1989 – Metodyka oceny wartości rzeźnej drobiu. Wyd. własne. COBRD, Poznań.