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Meat traits and meat chemical composition in hybrids of Graylag (*Anser anser* L.) with White Kołuda and Slovakian geese*

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Evaluated were the meat production traits of hybrid males and females derived from four-way (three-breed) crossing of Graylag (Gr), White Kołuda (WK) and Slovakian (Sl) geese. Parental males and females were similar within a group, but differed between groups in the direction (type) of crossing the parents. The greatest values of meat production traits, except for meat and fat content of carcass, were characteristic of 12- and 24-week-old SlGrWKSl'SlGrWKSl hybrids (group II). The direction (type) of crossing was shown to affect the values of meat traits in the hybrid geese. This trend was conspicuous in 24-week-old offspring of four-way crosses. WKGrSlSl'WKGrSlSl hybrids (group III) reflected a positive effect of WK males, while SlWKGrSl'SlWKGrSl (group IV) a negative effect of Sl males on body dimensions of the offspring. Good results of body weight, weight of carcass with neck, dressing percentage and elements content of carcass were achieved by 24-week-old hybrids of both sexes from group I (GrWKSlSl'GrWKSlSl) and group II (SlGrWKSl'S1GrWKSl). The weight of breast and leg muscles was significantly and positively correlated with all the body dimensions analysed. Per cent of breast and leg muscles was significantly and positively correlated only with breast bone length and thickness of skin with subcutaneous fat. Simple correlation coefficients between carcass elements and body dimensions in the offspring of four-way crosses justify using them to raise hybrid Graylag geese. When compared to the other Polish geese breeds and varieties, breast muscles of hybrid Graylag geese contained less water, protein and fat and more ash, while leg muscles contained similar per cent of water, slightly less protein, and more fat and ash.

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KEY WORDS: carcass / crossing / goose / hybrids / meat quality

Research carried out for several years in Poland on hybrids with Graylag geese aimed at improving muscling and dressing percentage with simultaneous decreasing of fat content of carcasses and maintaining a relatively high body weight [Mazanowski and Chełmońska 2000, Mazanowski *et al*. 2002, Mazanowski and Dziadek 2003]. A component of four-breed cross were three-breed crosses of White Kołuda × Graylag × Slovakian, crossed again with Slovakian males or females [Mazanowski and Dziadek 2002].

Slovakian geese were used due to their very good muscling, low carcass fatness and fine-fibred meat [Smalec 1991]. The idea of crossing with Slovakian geese was based upon Wężyk [1984] and Pingel [1990] and later supported by Romanov 1999] who pointed to the effect of genotype on the quantity and quality of meat and fat in geese. Other factors largely affecting the quantity, quality and flavour of geese meat are age at slaughter and maintenance conditions, including feeding regimen [Jeroch and Schubert 1977, Stevenson 1985, Hrouz 1988, Schneider 1988].

Many experiments with geese showed wide differences in dressing percentage and slaughter value as well as in nutritive and technological value of meat as related to genotype, crossing type, age and sex of geese [Puchajda and Faruga 1980, Fortin *et al*. 1983, Schneider 1988, Mazanowski and Chełmońska 2000, Mazanowski *et al*. 2002, Mazanowski and Dziadek 2003].

Four-breed hybrids with Graylag geese can easily adapt to the conditions of semi-intensive and intensive rearing, which allows them to be further used for production of commercial crossbreds [Mazanowski 2001, Mazanowski and Dziadek 2003]. In addition, Slovakian geese show very good reproductive parametres [Smalec 1991]. Therefore, if they could improve the reproductive traits of crossbreds and simultaneously not to affect their meat production traits, the economic importance of using them for crossing may be significant.

The aim of the present study was to evaluate meat production traits and meat chemical composition in four-breed geese hybrids having the share of Slovakian goose increased as a result of their repeated crossing with three-breed hybrids of White Kołuda, Graylag and Slovakian geese, and to determine the effect of type (direction) of crossing parental geese on the meat production traits of their offspring.

Material and methods

The crossing experiment was carried out in 2002 at the Waterfowl Breeding Farm Dworzyska belonging to the National Research Institute of Animal Production, Cracow, Poland. Meat production and meat composition traits were studied in hybrid males and females derived from crossing of Graylag (Gr), White Kołuda (WK) and Slovakian (Sl) geese. Parental males and females were similar within a group, but differed among groups in the direction of crossing the parents. Four final hybrids (group I-IV) were

obtained, further referred to as:

I – GrWKSlSl'GrWKSlSl
II – SlGrWKSl'SlGrWKSl
III – WKGrSlSl'WKGrSlSl
IV – SlWKGrSl'SlWKGrSl

where:

Gr – Graylag goose;
WK – White Kołuda goose;
Sl – Slovakian goose.

Exemplary crossing and mating scheme used in creating group I hybrids (both sexes) is presented below.

F_2 male Gr'WK × female Sl male Sl × female Sl male Gr'WK × female Sl male Sl × female Sl

↓ ↓ ↓ ↓

F_3 male GrWK'Sl × female Sl male GrWK'Sl × female Sl

↓ ↓

F_4 male GrWKSl'Sl × female GrWKSl'Sl

↓

F_5 male/female GrWKSlSl'GrWKSlSl

In each group, 10 males and 10 females were reared until 24 weeks of age. The birds were kept indoors on rye straw bedding with no access to outside runs until week 6 of age, and then outdoors in partially roofed pens from week 7 to 24. Birds in all the groups were given the same complete mixed ration to week 6 of age, a feed containing 90% mixed ration and 10% oats (18.4% crude protein and 2830 kcal metabolizable energy per kg) from week 7 to 12, and then a feed containing 80% mixed ration and 20% oats (17.6% crude protein and 2801 kcal metabolizable energy per kg) from week 13 to 24. From week 2 to the end of rearing, birds were given, in separate feeders, chalk, gravel and poultry mineral mixture mixed at a 1 : 4 : 1 ratio by volume.

Males and females were individually weighed at week 12 and 24 of age. At week 12, the length of forearm and keel were tape-measured, and the thickness of breast muscle was determined with a needle catheter 4 cm from the beginning of keel and 2.5 cm off, parallel to its edge.

Measurements of 12-week-old geese were used to estimate the weight of meat (Y) and fat (U) by multiple regression equations. For birds derived from Graylag geese the following equations [Wawro *et al*. 1985] were used:

$$Y = 0.223\ X_1 + 18.915\ X_2 + 60.178\ X_3 - 113.944,$$
$$U = 0.279\ X_1 - 63.252\ X_2 + 623.302,$$

where:

X_1 – body weight (g);

X_2 – forearm length (cm);
X_3 – breast muscle thickness (cm).

The weight of meat and fat allowed determining their content (%) of carcass.

Five males and five females aged 24 weeks of each group were dissected. Their body weights were close to the male and female group means. In the chosen birds the length of trunk with neck, trunk, sternum and shank, and circumference of chest and shank were tape-measured. Calipers were only used to measure chest depth and a needle catheter to measure the thickness of breast muscles.

After plucking and cooling for about 20 hours, the breast muscles, leg muscles, skin with subcutaneous fat and abdominal fat were separated from the carcass. Dissection was performed following the procedure of Ziołecki and Doruchowski [1989]. The results were used to calculate the correlation coefficients between carcass weight with neck, dressing percentage, weight and per cent of breast and leg muscles, total skin with subcutaneous fat and abdominal fat, and body dimensions of the geese at 24 weeks of age.

Breast and leg muscles were analysed for pH, water holding capacity (WHC) and water, protein, fat and ash contents.The pH was determined 15 min *post mortem* (pH_{15}) and after 20 h carcass cooling (pH_{24}) with a spear tip electrode combined with a pH-meter CP-401 (ELMETRON). The electrode was placed at an angle of 45° halfway through the muscle, and pH values were read from an LCD display with an accuracy of 0.01. WHC was determined according to Grau and Hamm [1952]. To determine the meat chemical composition, breast muscles as well as leg and lower thigh muscles from the same leg were taken from each carcass-side and then analysed individually. Breast and leg muscles were minced separately and homogenized in a food processor (Cucina HR 2831/6, PHILIPS). Chemical composition of breast and leg muscles (water, protein, fat, ash) was determined with routine procedures.

The results were analysed statistically (mean values, standard error of means, analysis of variance, evaluation of significant differences, correlation coefficients) with a package of statistical computer programmes developed at the National Research Institute of Animal Production [Kiełczewski 2002].

Results and discussion

Twelve-week-old geese from group II had the greatest body weight and those from group IV the smallest (Tab. 1). Greatest breast bone length was also found in group II, while the thickness of breast muscles was greater in groups I and II than in groups III and IV. No significant differences were found within groups in the thickness of breast muscle between males and females. Meat weight in 12-week-old males and females, calculated by means of the multiple regression equations, was the greatest in group II and the smallest in group IV. Weight of fat was greater in groups I and II than in groups III and IV. Meat content of carcass was highest in group IV and significantly ($P<0.05$) lower in the other groups. Significant differences were also found in meat content of carcass between males

Table 1 Means and their standard errors (SE) for body weight, body dimensions and dressed carcass, meat and fat weight in [illegible]-week-old geese hybrids

Trait	I (n=10)		II (n=10)		III (n=10)		IV (n=10)		males (n=[illegible])		females (n=[illegible])		I–IV (n=[illegible])	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Body weight (g)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Meat weight (g)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fat[1] weight (g)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Meat content of carcass (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fat[1] content of carcass (%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Breastbone length (cm)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Breast muscle thickness (cm)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[a,b,c] Within rows means bearing different superscripts differ significantly at P ≤ 0.05

[**] Significant difference between males and females (P ≤ 0.05)

[1] Including skin

n – number of birds

and females when data for groups were pooled. Fat content was higher in groups I and II than in groups III and IV, with no significant differences between sexes. The lowest SEs for meat traits were found in group I. SlGrWKSl'SlGrWKSl hybrids (group II) at the age of 12 weeks were characterized by the greatest body weight and meat weight, which were accompanied by fairly high fatness. In males and females, breast bone length and thickness of breast muscles with skin were the greatest. The worst results were noted in group IV in SlWKGrSl'SlWKGrSl hybrids. The greatest value of meat traits, except meat and fat content of carcass, was shown in 12-week-old hybrids from group II.

In an experiment with three-breed hybrids of geese the greatest body weight (4982 g) of 17-week-old offspring geese was found in SlWKGr, while the lowest (4480 g) in WKGrSl hybrids [Mazanowski and Chełmońska 2000]. Mazanowski *et al*. [2002] did not find any significant differences in body weight between 12-week-old groups of progeny, derived from three-way crossbreds of White Kołuda, Graylag and Slovakian geese. Body weight of the birds averaged 4226 g. Four-way SlGrWKSl hybrids of both sexes had the highest body weight (4323 g) and WKGrSlSl hybrids the lowest (4174 g) – Mazanowski and Dziadek [2002]. These experiments confirmed that the direction (type) of crossing of White Kołuda, Graylag and Slovakian geese had an effect on the body weight of 12- and 17-week-old birds. This is also confirmed in the present experiment, in which the progeny of four-way SlGrWKSl crosses had the highest values of meat traits.

The longest trunk with neck and shank was found in 24-week-old birds from group III (Tab. 2). Trunk of the same length was also found in group II, and similar breast bone length in birds of all the groups ($P<0.05$). Chest circumference was lowest in group IV. Shank circumference did not differ significantly between the hybrid groups. Chest depth and thickness of breast muscles were greater in groups I and II than in groups III and IV. SEs of body measurements were small. When group data were pooled, body measurements of males differed ($P<0.05$) from those for females except, however, for breast muscle thickness. Between the 24-week-old hybrids, no significant differences were found in breast bone length and shank circumference. Geese from group III (WKGrSlSl'WKGrSlSl) were characterized by the longest trunk with neck, trunk, legs and greatest chest circumference. Birds from group IV (SlWKGrSl'SlWKGrSl) showed the smallest body dimensions. It is assumed that group III hybrids showed a positive effect of White Kołuda males, while those from group IV a negative effect of Slovakian males on body dimensions of the offspring.

Three-breed crosses designated as GrWK'Sl, Sl'GrWK, WKGr'Sl and Sl'WKGr did not differ at week 24 of age in length of trunk with neck, trunk and breast bone [Mazanowski and Chełmońska 2000]. In another study [Mazanowski 2001] length of trunk with neck in 24-week-old hybrids did not differ significantly between the groups, while the greatest trunk length (35.1 cm) was characteristic of Sl'GrWK, and the greatest chest circumference (49.9 cm) was found in Sl'WKGr hybrids. In 24-week-old four-way crosses [Mazanowski and Dziadek 2002] no significant differences were found within groups between birds for length of trunk with neck and for chest circumference. The

Table 1. Means and their standard errors (SE) for body dimensions in 14-week-old geese hybrids

Trait	Group of hybrids													
	I (n=10)		II (n=10)		III (n=10)		IV (n=10)		males (n=20)		females (n=20)		I–IV (n=40)	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Length (cm)														
trunk with neck	57.8[b]	0.44	57.9[ab]	0.44	59.1[a]	0.44	58.4[ab]	0.57	60.4	0.71	56.1	0.76	58.1**	0.14
trunk	38.7[b]	0.38	39.4[a]	0.35	39.7[a]	0.38	38.2[b]	0.32	39.6	0.18	38.1	0.30	38.9**	0.17
breastbone	16.5	0.17	16.6	0.19	16.7	0.18	16.8	0.19	17.2	0.17	16.1	0.16	16.6**	0.11
shank	8.0[b]	0.17	8.1[b]	0.06	8.4[a]	0.06	8.1[b]	0.17	8.4	0.07	7.9	0.07	8.1**	0.05
Circumference (cm)														
chest	39.7[a]	0.41	40.1[a]	0.32	39.4[a]	0.35	38.2[b]	0.19	40.1	0.32	38.6	0.18	39.4**	0.14
shank	5.1	0.07	5.1	0.07	5.2	0.06	5.1	0.07	5.2	0.02	5.0	0.04	5.1**	0.02
Chest depth (cm)	13.8[a]	0.17	13.8[a]	0.17	13.5[b]	0.09	13.1[c]	0.09	13.8	0.04	13.2	0.09	13.6**	0.05
Breast muscle thickness (cm)	1.6[a]	0.17	1.4[b]	0.06	1.7[bc]	0.06	1.1[c]	0.07	1.4	0.04	1.2	0.04	1.4	0.07

[a,b,c] Within rows means bearing different superscripts differ significantly at P ≤ 0.05

** Significant difference between males and females (P ≤ 0.05)

n – number of birds

best result for trunk length was obtained by SlGrWKSl and WKGrSlSl hybrids, and the worst by SlWKGrSl. This also confirms the effect of direction (type) of crossing on body dimensions in geese. In the present study, these effects were more evident in the offspring of four-way crosses.

Body weight of 24-week-old geese of both sexes and weight of carcass with neck were the lowest in group IV (Tab. 3) where the lowest were also SEs for both traits. Moreover, significant differences were noted between sexes. Dressing percentage was significantly ($P>0.05$) greater in groups I and II than in III and IV. Per cent of breast muscles was the greatest in group I and the lowest in group III, while per cent of leg muscles was the greatest in group IV. There were also significant differences between males and females in the content of leg muscles weight of carcass. Group IV showed the lowest per cent of skin with subcutaneous fat and the lowest weight of abdominal fat in carcass. Within remaining groups the content of these elements was greater with no inter-group differences. Body weight, weight of carcass and skin with fat, did not differ significantly between hybrids of groups I, II and III. Per cent of breast muscles was the greatest in group I and the lowest in group III. Poorest results in terms of body weight and other meat production traits were noted in group IV (SlWKGrSl'SlWKGrSl), apart from the significantly lower fat content of carcass and lower content of abdominal fat. Good results in terms of body weight, weight of carcass with neck, dressing percentage, and percentage of carcass elements, were obtained by 24-week-old hybrids of both sexes from groups I and II.

In another study in which the dissection results in 24-week-old three-way crosses with Graylag goose were analysed [Mazanowski 2001], the greatest body weight (5364 g) was found in SlWKGr, and the lowest (4476 g) in WKGrSl hybrids, in which also the lowest weight of carcass was ascertained. Dressing percentage (65.4%) and percentage of breast muscles (22.1) did not differ significantly between the groups and the per cent of breast muscles was lowest in SlWKGr hybrids. In four-way hybrids, no significant differences were found in dressing percentage and percentages of breast muscles (21.6%) and skin with subcutaneous fat (21.6%). Significant differences were only noted in percentage of leg muscles [Mazanowski and Dziadek 2002], which was dependent to a greater extent on the direction (type) of crossing.

The offspring of three-way crosses by GrWKSl and WKGrSl ganders [Mazanowski *et al*. 2002] showed the best rearing performance and good reproductive parametres. The greatest body weight and carcass weight were characteristic of GrWKSl'GrWKSl, and the lowest fatness of WKGrSl'WKGrSl hybrids. These hybrids did not differ significantly in terms of dressing percentage and per cent of breast and leg muscles. A study by Mazanowski and Dziadek [2003] showed that 24-week-old SlGrWK'SlGrWK and SlWKGr'SlWKGr hybrid geese had high both body and carcass weight, and high dressing percentage. GrWKSl'GrWKSl hybrids were characterized by high body weight and higher per cent of breast and leg muscles than in the other groups.

The weight of breast and leg muscles was highest in geese of both sexes from group II, and the lowest in geese from groups III and IV. Meat content of carcass was

Table 3. Means and their standard errors (SE) for body weight, dressing percentage and carcass elements in 14-week-old goose hybrids

Trait	Group of hybrids													
	I (n=10)		II (n=10)		III (n=10)		IV (n=10)		males (n=20)		females (n=20)		I–IV (n=40)	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Body weight at slaughter (g)	4791[a]	120.18	5066[a]	86.66	5007[a]	90.46	4726[b]	72.11	5068	58.14	4510	71.79	4794**	46.96
Weight of carcass with neck (g)	1018[a]	91.08	1140[a]	64.10	1990[a]	56.09	1601[b]	40.16	1116	44.96	1766	47.41	1940**	71.57
Dressing percentage	61.0[a]	0.66	61.1[a]	0.15	59.8[b]	0.11	60.1[b]	0.15	61.4	0.11	61.1	0.11	61.1	0.11
Breast muscles of carcass with neck (%)	11.4[a]	0.18	11.1[ab]	0.11	10.4[b]	0.41	11.1[ab]	0.16	10.8	0.15	11.1	0.15	11.1	0.17
Leg muscles of carcass with neck (%)	15.1[b]	0.15	15.5[b]	0.11	15.6[b]	0.11	16.1[a]	0.19	16.0	0.16	15.4	0.18	15.7**	0.17
Skin with fat of carcass with neck (%)	11.5[a]	1.11	11.5[a]	0.95	11.0[a]	0.98	19.4[b]	0.76	11.4	0.56	11.8	0.81	11.1	0.49
Weight of abdominal fat (g)	155.4[a]	15.14	190.4[a]	16.18	171.7[a]	11.11	101.1[b]	10.75	151.6	8.94	157.1	10.51	155.4	6.09

[a,b]Within rows means bearing different superscripts differ significantly at P ≤ 0.05

**Significant difference between males and females (P ≤ 0.05)

n – number of birds

highest in group IV. Significant differences were ascertained between males and females in the total weight of breast and leg muscles (Tab. 4). The weight and per cent of skin with subcutaneous fat was significantly higher in groups I, II and III than in group IV. SEM was lower in group IV than in the other groups.

The investigated hybrid males and females were of the same origin, but differed only in the direction (type) of crossing the parents. This is why the simple correlation coefficients (*r*) between weight of carcass with neck and carcass components and body dimensions in 24-week-old birds were calculated for all individuals pooled (Tab. 5). Significant and positive correlation coefficients were found between weight of carcass with neck, or weight of breast and leg muscles and all body dimensions. Weight of skin with subcutaneous fat was positively and significantly correlated with trunk length, chest circumference and depth, and thickness of breast muscles, while dressing percentage with chest circumference and breast muscles depth and thickness. Per cent of breast and leg muscles was positively correlated only with breast bone length. No significant differences were noted for breast bone length between the groups, which may serve as an important indicator for breeders in their selection programmes, especially so that the per cent of skin with subcutaneous fat was negatively correlated only with breat bone length. Per cent of skin with subcutaneous fat was positively correlated with chest circumference and thickness of breast muscles.

In a study on three-way hybrids of Graylag goose [Mazanowski 2001] found were significant and positive simple *r* values also between weight of carcass with neck or weight of breast and leg muscles and selected body dimensions. Weight of skin with subcutaneous fat was significantly and positively correlated only with length of trunk with neck and chest circumference. Per cent of leg muscles of carcass was negatively and significantly correlated with chest circumference. Similar relations were found by Mazanowski *et al*. [2002] for the offspring of three-way hybrids of Graylag geese.

In four-way hybrids with Graylag [Mazanowski and Dziadek 2002] significant and positive correlation coefficients were found between body weight, weight of carcass with neck, weight of breast and leg muscles, and length of trunk with neck, shank length and chest circumference. The breast muscles content of carcass was positively and significantly correlated with chest circumference, while per cent of skin with fat - negatively and significantly with most of the body dimensions. Earlier, Mazanowski and Dziadek [2003] found in 24-week-old Graylag crosses significant and positive correlations between weight of breast muscles and breast bone length, chest circumference and thickness of skin with fat. Weight of breast and leg muscles was significantly and positively correlated with body dimensions. Per cent of breast and leg muscles was significantly and positively correlated only with breast bone length and thickness of skin with subcutaneous fat. Negative and mostly significant correlations were found between skin with fat content of carcass and carcass dimensions. Correlation coefficients given by Faruga *et al*. [1982] for body dimensions and carcass elements can be used to estimate the values of some traits in geese, especially length of trunk with neck, shank circumference, sternum length and body weight. Simple correlation

Table 4. Means and their standard errors (SE) for muscle and fat content of carcass in [illegible]-week-old geese hybrids

Trait	Group of hybrids													
	I (n=10)		II (n=10)		III (n=10)		IV (n=10)		males (n=20)		females (n=20)		I–IV (n=40)	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
Breast and leg muscles (g)	1109[ab]	15.69	[illegible]	[illegible]	1075[b]	[illegible]	979[a]	19.19	[illegible]	[illegible]	1011	15.66	1078**	11.70
Skin with fat and abdominal fat (g)	[illegible]	67.88	910[a]	55.98	880[a]	[illegible]	608[b]	71.89	816	[illegible]	[illegible]	[illegible]	810	[illegible]
Breast and leg muscles (%)	16.7[ab]	[illegible]	16.6[ab]	[illegible]	16.0[b]	0.66	17.6[a]	0.15	16.8	0.19	16.7	[illegible]	16.7	0.15
Skin with fat and abdominal fat (%)	26.1[a]	[illegible]	27.9[a]	[illegible]	21.7[a]	[illegible]	21.5[b]	1.01	[illegible]	0.69	[illegible]	0.98	[illegible]	0.60

[a,b] means in rows bearing different superscripts differ significantly at P≤0.05
**significant differences between males and females (P≤0.05)
n – number of birds

Table 5. Correlation coefficients between weight of carcass with neck, carcass elements and body dimensions in 14-week-old goose hybrids (n=[illegible])

Correlated traits (cm)	Traits – correlation coefficients					
	carcass with neck (g)	breast and leg muscles (g)	skin with fat (g)	dressing percentage	breast and leg muscles (%)	skin with fat (%)
Trunk with neck length	0.559**	0.594**	0.175	-0.050	0.016	-0.115
Trunk length	0.708**	0.724**	0.161**	0.106	-0.050	0.015
Breastbone length	0.716**	0.476**	-0.164	-0.010	0.118**	-0.419**
Shank length	0.506**	0.485**	0.169	0.168	-0.115	0.008
Chest circumference	0.915**	0.918**	0.670**	0.481**	-0.177	0.115**
Shank circumference	0.518**	0.614**	0.198	0.174	0.068	-0.110
Chest depth	0.727**	0.771**	0.497**	0.119**	-0.080	0.190
Breast muscle thickness	0.681**	0.617**	0.658**	0.660**	-0.157	0.475**

**P ≤ 0.05
n – number of birds

coefficients between carcass elements and carcass dimensions in three- and four-way crosses and in their offspring are similar for particular pairs of traits. This justifies their use in breeding geese with Graylag ancestry.

Breast muscles in geese of both sexes showed higher pH_{15} and pH_{24} in groups I and II than in III and IV (Tab. 6). WHC of breast muscles was greatest in geese from groups I and II. Highest content of water was found in breast muscles of geese from group III. Water content of breast muscles of females was significantly higher than in males. Breast muscles contained more protein in groups I and III than in II and IV, the muscles of the latter two containing more fat. Ash content in breast muscles was similar in all the groups, but higher in males than in females.

Faruga and Majewska [1978] found pH_{24} of breast muscles in Polish geese aged 2 to 4 years to range from 5.7 to 5.8, similar to the present study, but water content was higher (73.3 to 73.5%). Protein content found in the present study was slightly lower, that of fat similar, and that of ash markedly higher than reported by Faruga and Majewska [1978]. Puchajda and Faruga [1980] analysed the meat chemical composition in 24-week-old White Kołuda, Kartuzy, Suwałki, Zator and Biłgoraj local geese and found the pH_{24} of breast muscles to be 5.8 in geese of both sexes. Water content averaged 72.1%, protein 22.8%, fat 4.2%, ash 1.2%. Rosiński [2000] found in the *pectoralis maior* muscle of 17-week-old White Kołuda males and females the following mean values: pH_{24} – 5.8, water – 74.6%, protein – 22.6%, fat – 4.1%, and ash – 1.0%. In the present study differences were found in chemical composition of breast muscles as related to the origin of the geese. Compared to White Kołuda and other Polish geese, breast muscles of hybrid Graylag birds contained less water, protein and fat and more ash.

Leg muscles of geese of both sexes did not differ in pH_{15} between the groups, while pH_{24} was higher in groups I and II than in III and IV. WHC of leg muscles was greater in groups I and II than in groups III and IV. Water content was the highest in group III and the smallest in group IV. Leg muscles of group IV hybrids contained most protein, more in males than in females of all the groups. Fat and ash content was similar in all the groups (Tab. 7).

Puchajda [1991], who compared 17-week-old Biłgoraj and White Kołuda geese, found small differences between breast and thigh muscles in pH and chemical composition. Breast muscles and thigh muscles showed pH of 5.9. Breast muscles contained 73.9% water, 21.3% protein, 2.6% fat and 1.2% ash, while thigh muscles 72.5%, 19.7%, 4.7% and 1.1%, respectively. In the present study, thigh muscles contained as much water, slightly less protein and more fat and ash than in that reported by Puchajda [1991].

It is concluded, on the basis of results presented here, that the highest indicators of meat production traits except for per cent of meat and fat, is characteristic of 12- and 24-week-old hybrid geese from group II (SlGrWKSl'SlGrWKSl). The effect of the direction (type) of crossing on the value of meat traits of hybrid geese was found more conspicuous in the offspring of four-way crosses. In hybrids from group III (WKGrSlSl'WKGrSlSl) a positive effect of White Kołuda males, while in group IV (SlWKGrSl'SlWKGrSl) a negative effect of Slovakian males on the body dimensions

Table 6. Means and their standard errors (SE) for pH, water holding capacity and chemical composition of breast muscles in 14-week-old geese hybrids

Traits	Group of hybrids													
	I (n=10)		II (n=10)		III (n=10)		IV (n=10)		males (n=20)		females (n=20)		I–IV (n=40)	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
pH_{15}	6.0[c]	0.07	6.0[c]	0.07	5.9[b]	0.05	5.8[a]	0.04	5.9	0.02	5.9	0.07	5.9	0.02
pH_{24}	5.8[bc]	0.04	5.8[c]	0.07	5.7[a]	0.07	5.7[a]	0.07	5.8	0.02	5.8	0.07	5.8	0.02
Water holding capacity (%)	19.5[b]	0.56	19.1[b]	0.47	21.9[a]	0.69	21.6[a]	0.28	20.4	0.18	21.1	0.16	20.8	0.26
Water (%)	70.4[b]	0.14	70.1[b]	0.15	71.1[c]	0.15	69.9[a]	0.16	70.1	0.17	70.7	0.16	70.4**	0.10
Protein (%)	21.5[c]	0.12	20.9[a]	0.15	21.2[b]	0.10	20.9[a]	0.17	21.1	0.17	21.2	0.17	21.1	0.09
Fat (%)	1.2[a]	0.10	4.7[c]	0.18	1.2[a]	0.12	4.7[c]	0.15	1.7	0.14	1.8	0.12	1.8	0.17
Ash (%)	4.8	0.15	4.5	0.16	4.6	0.10	4.8	0.10	5.0	0.16	4.1	0.16	4.7**	0.11

a,b,c – Means in rows not sharing the same superscript differ significantly at P ≤ 0.05

**Significant difference between males and females (P ≤ 0.05)

n – number of birds

Table 7. Means and their standard errors (SE) for pH, water holding capacity and chemical composition of leg muscles in 17-week-old geese hybrids

Trait	Group of hybrids													
	I (n=10)		II (n=10)		III (n=10)		IV (n=10)		males (n=20)		females (n=20)		I–IV (n=40)	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
pH1	6.[illegible]	0.06	6.[illegible]	0.05	6.1	0.0[illegible]	6.1	0.0[illegible]	6.1	0.05	6.1	0.0[illegible]	6.1	0.0[illegible]
pH24	6.1^{a}	0.0[illegible]	6.0^{a}	0.0[illegible]	5.8^{b}	0.0[illegible]	5.9^{b}	0.0[illegible]	6.0	0.19	5.9	0.0[illegible]	5.9	0.01
Water holding capacity (%)	16.7^{b}	0.[illegible]5	16.7^{b}	0.59	$11.[illegible]^{a}$	0.[illegible]	19.9^{a}	0.11	1[illegible].5	0.[illegible]1	1[illegible].5	0.16	1[illegible].5	0.1[illegible]
Water (%)	7[illegible].[illegible]	0.16	7[illegible].[illegible]	0.11	7[illegible].0	0.1[illegible]	7[illegible].1	0.11	7[illegible].[illegible]	0.19	7[illegible].5	0.16	7[illegible].5	0.11
Protein (%)	19.[illegible]	0.1[illegible]	19.1	0.1[illegible]	19.[illegible]	0.1[illegible]	19.9	0.15	20.0	0.11	19.0	0.1[illegible]	19.5	0.0[illegible]
Fat (%)	5.1	0.15	5.1	0.11	[illegible].5	0.10	5.0	0.11	[illegible].[illegible]	0.10	5.1	0.19	5.0	0.1[illegible]
Ash (%)	1.1	0.11	1.1	0.1[illegible]	1.1	0.1[illegible]	1.1	0.11	1.9	0.09	1.1	0.11	1.1	0.11

a, b, c – means within rows not bearing the same superscript differ significantly at P ≤ 0.05

* Significant difference between males and females (P ≤ 0.05)

n – number of birds

of the offspring was found. Promising body weight, weight of carcass with neck, dressing percentage, and elements content of carcass, were obtained by 24-week-old hybrids of both sexes from groups I and II.

Weight of breast and leg muscles was significantly and positively correlated with body dimensions. Breast and leg muscles content was significantly and positively correlated only with breast bone length and thickness of skin with subcutaneous fat. Simple correlation coefficients between carcass elements and body dimensions in the offspring of four-way crosses justify their use for breeding geese with Graylag ancestry.

Breast muscles of hybrids with Graylag geese contained, compared to the muscles of other Polish geese, less water, protein and fat and more ash, while leg muscles contained much water, slightly less protein, and more fat and ash.

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Cechy mięsne i skład chemiczny mięsa mieszańców gęsi gęgawych (*Anser anser L.*) z białymi kołudzkimi i słowackimi

S t r e s z c z e n i e

Oceniono cechy mięsne mieszańców samców i samic, po gęsiorach będących poczwórnymi mieszańcami gęsi gęgawych (Gr), białych kołudzkich (WK) i słowackich (Sl), krzyżowanych z podobnymi

poczwórnymi mieszańcami. Samce i samice w grupach różniły się od siebie tylko kierunkiem krzyżowania komponentów rodzicielskich.

Stwierdzono, że największe wartości cech mięsnych, z wyjątkiem procentowego udziału mięsa i tłuszczu w tuszce, cechują 12- i 24-tygodniowe gęsi mieszańce SlGrWKSl´SlGrWKSl (grupa II). Wykazano wpływ kierunku krzyżowania na wartość cech mięsnych ocenianych mieszańców, co wystąpiło wyraźnie u 24-tygodniowego potomstwa. U mieszańców WKGrSlSl´WKGrSlSl (grupa III) zaznaczył się dodatni wpływ samców WK, a u SlWKGrSl´SlWKGrSl (grupa IV) ujemny wpływ samców Sl na wymiary ciała potomstwa. Dobre wyniki pod względem masy ciała i masy tuszki z szyją oraz wydajności rzeźnej, a także procentowego udziału elementów w tuszce, uzyskały 24-tygodniowe mieszańce obojga płci – GrWKSlSl´GrWKSlSl (grupa I) i SlGrWKSl´SlGrWKSl (grupa II). Mieszańce te najlepiej nadają się do hodowli.

Masa mięśni piersiowych i mięśni nóg była istotnie i dodatnio skorelowana ze wszystkimi badanymi wymiarami ciała. Natomiast procentowy udział mięśni piersiowych i nóg w tuszce, był w podobny sposób skorelowany tylko z długością mostka i grubością skóry z tłuszczem podskórnym. Współczynniki korelacji prostej stwierdzone między elementami tuszki a wymiarami ciała potomstwa mieszańców poczwórnych, świadczą o możliwości wykorzystania tych zależności w hodowli prowadzonej z udziałem gęsi gęgawych i słowackich.

Mięśnie piersiowe mieszańców z dziką gęsią gęgawą, gęsią białą kołudzką i gęsią słowacką zawierały, w porównaniu z mięśniami gęsi krajowych ze stad zachowawczych, mniej wody, białka i tłuszczu, a więcej popiołu, podczas gdy mięśnie nóg miały tyle samo wody, nieznacznie mniej białka, ale więcej tłuszczu i popiołu. W dalszej pracy należy zwrócić baczniejszą uwagę na budowę i skład chemiczny mięsa.