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The effect of sex and feed supplementation with organic selenium and vitamin E on the growth rate and zoometrical body measurements of oat-fattened White Kołuda® geese*

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Abstract: This experiment was carried out on 200 White Kołuda geese, 1 day old, randomly divided into 2 groups with 50 males and 50 females in each group. From the first day until week 13, birds from the control groups were fed basic feeds; in the experimental groups, feed was supplemented with 0.3 mg/kg of selenium and 100 mg/kg of vitamin E. Later on, all birds were fed for 1 week with 160 g of oat grain and 250 g of ground cereals per day, then with oat grain ad libitum.

The body weight of each bird was measured individually on days 1, 7, 14, 21, 35, 49, 63, 77, 91, and 112, and growth rates were calculated. On the last day of the experiment, live zoometrical measurements were taken.

On days 7, 14, 21, 35, and 63, the live body weights of geese from the experimental groups were significantly higher compared to those of the control groups ($P < 0.05$).

Feed supplementation positively affected the length of the body and width of the chest ($P < 0.05$). The thickness of skin with subcutaneous fat was significantly lower in the experimental groups ($P < 0.05$). Regardless of the feeding group, significant sex-based differences were observed in the majority of the evaluated live body measurements ($P < 0.05$).

Key words: Goose, selenium, vitamin E, growth rate, zoometrical measurements

Introduction

The effect of selenium and vitamin E on the metabolism and physiology of farm animals has been studied for many years. Most studies related to poultry concern the use of these supplements in chicken and turkey feeding, whereas those related to geese are relatively scarce. Existing research studies pertain mainly to the effect of selenium and vitamin E on the efficiency of egg production (1), egg quality (2,3), meat quality (4), and the concentration of selenium and vitamin E in the blood, liver, and kidneys (5).

Selenium and vitamin E play an important role as the components of oxidoreductive enzymes and cytochromes. Selenium supports the normal functioning of the immune, reproductive, and nervous systems, and prevents various diseases and plays a major role in the animal's growth. Moreover, it affects the activity of thyroid hormones and prostaglandin and is an antagonist to heavy metals (4).

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Vitamin E plays an active role in many metabolic processes. As an antioxidant, it prevents the oxidation of vitamin A, unsaturated fatty acids, and other lipids; it inhibits the formation of toxic peroxides of unsaturated fatty acids; and, by increasing the oxygen level, it supports the growth of muscles and facilitates the assimilation of oxygen by erythrocytes (6).

It is well known that selenium and vitamin E show compensative effects and that a deficiency of both elements in a diet is detrimental to the animal. Selenium deficiency leads to degeneration of the muscles, damages the liver and cardiac muscle, and weakens the immune and hormonal systems (7). Vitamin E deficiency, though quite rare, can cause muscular dystrophy.

Studies comparing the effect of organic selenium (selenium yeast, malt selenium) and inorganic selenium (sodium selenate, sodium selenite) revealed that organic selenium has a more positive effect on the growth rate and dressing percentage of broiler chickens (4,8).

The present study was undertaken in order to determine the effect of feed supplementation with organic selenium and vitamin E on the growth rate and live zoometrical body measurements of oat-fattened White Kołuda geese. It seems to be of great importance considering the crucial role of selenium and vitamin E in the human diet and the economic importance of Polish oat-fattened geese in poultry meat production.

Materials and methods

Birds and their treatment

The experiment was carried out on 200 previously sexed White Kołuda commercial geese, 1 day old, randomly divided into 4 groups. There were 2 sex-based control groups, I (50 males) and II (50 females), and 2 similarly sex-based experimental groups, III (50 males) and IV (50 females). From the first day of life, the birds from the control groups were fed with the basic feeds, while the rations in the experimental groups were supplemented with 0.3 mg/kg of selenium (300 mg of selenium yeast; Sel-Plex, Alltech Inc., USA) and 100 mg/kg of vitamin E (200 mg/kg of E-50 adsorbate; Rolimpex S.A., Poland). Commercial feeds were provided until week 13 (Table 1). After this time, birds from all groups were fed in the same way: for 7 subsequent days, each bird received 160 g/day of oat grain and 250 g/day of ground cereal (barley and wheat), then, up to day 112 of life, oat grain ad libitum. The consumption of the supplied feeds was tracked in every group and the food conversion ratio (FCR) was calculated.

Geese in all groups were reared semiintensively; during the first 3 weeks, goslings were kept indoors,

Table 1. The chemical composition of the basic (control) feeds used to rear the White Koluda geese.*

Ingredients	Starter (Weeks 0-3)	Grower (Weeks 4-8)	Finisher (Weeks 9-13)
ME [MJ]	11.9	11.7	11.7
Dry matter [%]	88.0	88.2	88.9
Crude proteins [g/kg]	235	187	108
Crude fiber [g/kg]	37	50	102
Raw fat [g/kg]	289	256	379
Calcium [g/kg]	9.59	5.20	1.46
Phosphorus [g/kg]	7.30	5.05	0.10
Selenium [mg/kg]	0.251	0.192	3.90
Vitamin E [mg/kg]	69.1	53.6	22.7

*Feed analyses were made by the Local Feed Laboratory in Lublin, Poland.

under controlled environmental conditions (temperature, light program, humidity). Later, until week 16 of life, the birds were kept in an open house with free access to a grass field, in accordance with instructions for meat goose management (9). Additionally, vitamin-mineral mixtures Polfasol and Polfamiks were provided with water or feeds.

Evaluated parameters

Body weight was measured individually on electronic balances (Axis B3 and Axis AD10) at days 1 (5 h after hatching, accurate to 1 g), 7, 14, 21, 35, 49, 63, 77, 91, and 112 (accurate to 5 g) in order to evaluate the growth rate. The growth rate (t_w%) for particular periods was calculated according to the following equation, described by Świerczewska (10):

$$t_w\% = \frac{(W2 - W1)}{\frac{1}{2}(W1 + W2)} \times 100\%,$$

where W1 is body weight at the beginning of the particular period and W2 is body weight at the end of the particular period.

On the final day of the experiment, the following live body measurements were taken (11): length of body (with neck); length of trunk, sternum crest, forearm, and shank; circumference (with morphometric tape, accurate to 0.1 cm), width and depth of chest (12,13); thickness of shank and skin with subcutaneous fat (with VISA-type slide caliper, exact to 0.1 mm) (14); and depth of breast muscles (estimated with needle sampler) (15).

The feed consumption per bird of every supplied feed (commercial mixtures, ground cereals, and oat grain) and FCR for cumulative feeds were calculated, as well.

Statistical analysis

The obtained data were analyzed with ANOVA and the significance of differences was evaluated with Duncan's multiple range test. Analyses were performed using the Statistica 7.1 (StatSoft, Inc.) data analysis software system.

Results

Body weights and growth rates

The body weight of 1-day-old male chicks varied from 99.6 g to 162.2 g in the control group and from 104.5 g to 153.9 g in the experimental group, while female-chicks in the same groups ranged from 105.0 g to 140.8 g and from 93.5 g to 152.2 g, respectively. Existing differences were not significant (Table 2).

Table 2. The effect of sex and feed supplementation with organic selenium and vitamin E on the body weight (g) of oat-fattened White Kołuda geese in subsequent days of rearing period (n ♂ = 50; n ♀ = 50; ♂ + ♀ = 100; $\bar{x}$ ± SD).

Group	Sex	SD	Day of rearing period									
			1	7	14	21	35	49	63	77	91	112
Control	♂	$\bar{x}$	124.19	423.83 ^{a,1}	1112.84 ^{a}	1999.56 ^{a}	3620.00 ^{a}	4848.07 ^{a}	5340.00 ^{a}	6196.02 ^{a}	6155.06 ^{a}	7003.07
		SD	± 12.02	± 123.14	± 146.20	± 236.57	± 332.32	± 391.71	± 399.68	± 490.71	± 553.67	± 597.31
	♀	$\bar{x}$	123.14	410.88 ^{a}	1027.15 ^{a}	1788.02 ^{a}	3240.65 ^{a}	4319.69	4722.00 ^{a}	5531.37	5540.16	6271.47
		SD	± 9.18	± 55.79	± 136.43	± 257.33	± 281.36	± 305.35	± 289.11	± 410.71	± 421.11	± 436.05
	♂♀	$\bar{x}$	123.67	417.49 ^{a}	1070.91 ^{a*,2}	1896.04 ^{a*}	3434.46 ^{a*}	4589.50 ^{a*}	5038.06 ^{a*}	5870.76 ^{a*}	5854.15 ^{a*}	6645.05 *
		SD	± 10.68	± 59.21	± 147.18	± 267.64	± 361.25	± 439.52	± 466.75	± 561.15	± 579.85	± 638.35
Experimental	♂	$\bar{x}$	125.56	462.97 ^{b}	1188.86 ^{b}	2124.24 ^{b}	3833.38 ^{b}	5029.45 ^{b}	5725.20 ^{b}	6413.95 ^{b}	6411.33 ^{b}	7174.65
		SD	± 10.94	± 49.63	± 129.16	± 206.65	± 301.32	± 363.59	± 349.67	± 438.59	± 501.47	± 717.82
	♀	$\bar{x}$	127.72	443.06 ^{b}	1105.25 ^{b}	1903.87 ^{b}	3393.40 ^{b}	4446.64	5021.00 ^{b}	5668.63	5671.26	6329.87
		SD	± 12.78	± 55.31	± 113.75	± 182.05	± 329.45	± 384.19	± 444.44	± 527.04	± 537.26	± 629.17
	♂♀	$\bar{x}$	126.64	453.02 ^{b}	1147.06 ^{b*}	2014.06 ^{b*}	3613.39 ^{b*}	4738.05 ^{b*}	5373.52 ^{b*}	6041.29 ^{b*}	6041.30 ^{b*}	6752.26 *
		SD	± 11.88	± 53.23	± 128.16	± 223.15	± 384.10	± 473.55	± 532.17	± 610.70	± 636.88	± 794.43

[1]Mean values in columns within sex with different superscripts differ significantly: a, b ($P \leq 0.05$).
[2]Significant differences in columns between males and females within group: * ($P \leq 0.05$).

From the first week of the rearing period until the end of fattening, the birds from the experimental groups were heavier compared to those in the control groups; however, only at days 7, 14, 21, 35, and 63 were the differences found to be significant ($P < 0.05$). At days 49, 77, and 91, only the differences between males were significant ($P < 0.05$). Additionally, from the second week of growth, significant differences were observed in the body weight of males and females assigned to both groups ($P < 0.05$). Although differences between the control and experimental groups were not significant on the day of slaughter, males in the experimental group were characterized by the highest weights (7175 g on average), while females of the control group had the lowest body weights (6271 g on average) (Table 2).

The fastest growth rate was observed during the first week of age, particularly in males of the experimental group (114.38%), and it was significantly higher ($P < 0.01$) when compared to males of the control group (108.68%) (Table 3). With continued fattening, the weight gains were lower, and, as a consequence, the growth rate decreased (Table 3). Between days 49 and 63 of rearing, the growth rate of birds from the experimental groups was higher than that seen from the control groups ($P < 0.01$). In the next evaluated period (days 63-77), however, this difference was reduced by a faster growth rate in the control groups. On the day of slaughter, the body weights of males and females of the control group were similar to the respective sex of the experimental group (Table 2). Between days 77 and 91 of life, the body weights of males from both groups decreased and a negative growth rate was therefore noted during this period (Table 3).

Feed consumption and FCR

The consumption of commercial feeds provided up to week 13 of rearing averaged 29.1 and 29.5 kg for males and 21.5 and 21.9 kg for females of the control and experimental groups, respectively. The consumption of ground cereals amounted to 2.64 kg for males and 1.96 kg for females of the control group, while in the experimental groups, consumption was found to be 2.07 and 1.53 kg, respectively. During 3 weeks of oat-fattening, males consumed 6.09 and 7.01 kg of oat grain in the control and experimental

Table 3. The effect of sex and feed supplementation with organic selenium and vitamin E on the growth rate (%) of oat-fattened White Kołuda geese in subsequent days of rearing period (n ♂ = 50; n ♀ = 50; ♂ + ♀ = 100; $\bar{x}$ ± SD).

Group	Sex	$\bar{x}$ / SD	1-7	7-14	14-21	21-35	35-49	49-63	63-77	77-91	91-112
Control	♂	$\bar{x}$	108.68 [A,1]	89.69	57.10	57.85	29.07	9.72 [A]	14.79 [A]	−0.75	12.91
		SD	± 9.98	± 7.20	± 6.18	± 8.59	± 5.21	± 3.03	± 2.10	± 5.47	± 5.50
	♀	$\bar{x}$	106.44 [a]	85.67	52.96	58.54 [a]	28.64	9.03 [A]	15.70 [A]	0.14	12.44 [a]
		SD	± 9.56	± 6.64	± 10.72	± 8.10	± 3.84	± 2.97	± 3.40	± 4.47	± 3.46
	♂♀	$\bar{x}$	107.55	87.64**	55.01*	58.19	28.86 [A]	9.38 [A]	15.24 [A]	−0.32	12.68 [a]
		SD	± 9.78	± 7.17	± 8.97	± 8.13	± 4.56	± 3.00	± 2.84	± 5.00	± 4.60
Experimental	♂	$\bar{x}$	114.38 [B]	87.86	56.64	57.50	27.09	13.01 [B]	11.30 [B]	−0.12	11.03
		SD	± 5.34	± 6.86	± 4.41	± 4.34	± 5.01	± 3.61	± 3.61	± 3.66	± 5.40
	♀	$\bar{x}$	110.07 [b]	85.68	53.14	56.20 [b]	26.95	12.13 [B]	12.06 [B]	0.03	21.41 [b]
		SD	± 6.16	± 5.50	± 2.95	± 4.13	± 4.86	± 4.76	± 4.16	± 3.01	± 3.71
	♂♀	$\bar{x}$	112.2**,[2]	86.78	54.91**	56.86	27.02 [B]	12.57 [B]	11.68 [B]	−0.05	10.98 [b]
		SD	± 6.13	± 6.29	± 4.13	± 4.27	± 4.91	± 4.23	± 3.89	± 3.34	± 4.61

Evaluated rearing periods (in days) span columns 1-7 through 91-112.

[1]Mean values in columns within sex with different superscripts differ significantly: A, B (P ≤ 0.01); a, b (P ≤ 0.05).
[2]Significant differences in columns between males and females within group: ** (P ≤ 0.01); * (P ≤ 0.05).

groups, respectively, while females in these groups consumed 4.5 and 5.19 kg of oat grain, respectively. In both groups, males consumed significantly more of every feed when compared to the females (P < 0.05); however, the differences between treatment groups were not significant. Similar tendencies were observed in relation to the FCR calculated for all consumed feeds (commercial mixtures, ground cereals, and oat grain). Regardless of treatment, the average was determined to be 5.4 kg for males and 4.5 kg for females.

Zoometrical live body measurements

The results of live zoometrical body measurements are presented in Table 4. It can be seen that, in general, feed supplementation with selenium yeast and vitamin E positively affected the majority of the recorded parameters, although only measurements of the body length (with neck) and the width of the chest were significantly higher (P < 0.05) (Table 4). Contrary to the above, the thickness of skin with subcutaneous fat was higher in the control groups (P < 0.05), and no differences between sexes were seen. In both of the feeding groups, the majority of male measurements were higher (P < 0.05) compared to those of the females. Any sexual dimorphism was observed in relation to the thickness of the breast muscles.

Discussion

It is well known that during the first days of life, chicks utilize nutritive ingredients necessary for metabolic functions both from the yolk sac (15,16) and from the feed supplied (17). Selenium levels in the tissues of newly hatched chicks depend on the level of the mineral found in the feed provided to the reproductive flock. The goslings used in the present experiment originated from a flock fed with commercial feeds. The lack of differences in body weight on the day of hatching, both within groups and sexes, indicates a good foundation of gosling quality. They were 1-2 g heavier than the goslings studied in our previous experiment (18), which could be related to the age of the parent flock and/or to the size and biological value of the hatching egg.

Starting from day 7, the body weights of experimental geese were significantly higher than those of the control groups (P < 0.05). This may indicate the positive effect of improved antioxidant defense by increased levels of selenium and vitamin E in the experimental diets. Nevertheless, the differences

Table 4. The effect of sex and feed supplementation with organic selenium and vitamin E on zoometrical measurements of oat-fattened White Kołuda geese (n ♂ = 50; n ♀ = 50; ♂ + ♀ = 100; $\bar{x}$ ± SD).

Group	Sex	SD	Length (cm) of:					Chest			Thickness (mm) of:		
			Body	Trunk	Sternum	Forearm	Shank	Circumference (cm)	Width (mm)	Depth (mm)	Breast muscles	Shank	Skin with subcutaneous fat
Control	♂	$\bar{x}$	61.5 ^{a,1}	35.4	19.1	19.6	8.4	47.3	15.49 ^{a}	15.66	2.9	11.4	26.8 ^{a}
		SD	± 2.7	± 1.6	± 0.8	± 0.8	± 0.4	± 2.1	± 0.80	± 0.67	± 0.2	± 0.7	± 4.3
	♀	$\bar{x}$	57.2 ^{a}	33.5	17.8	18.5	7.9 ^{a}	45.7	14.97 ^{a}	14.93	2.9	10.9	22.2 ^{a}
		SD	± 1.6	± 1.1	± 0.7	± 0.6	± 0.4	± 1.8	± 0.70	± 0.59	± 0.2	± 0.5	± 4.1
	♂♀	$\bar{x}$	59.4 ^{a*,2}	34.5 *	18.4 *	19.0	8.2 ^{a*}	46.5 *	15.23 ^{a}	15.30 *	2.9	11.2 *	26.0 ^{a}
		SD	± 3.1	± 1.8	± 1.0	± 0.9	± 0.4	± 2.2	± 0.80	± 0.73	± 0.2	± 0.6	± 4.2
Experimental	♂	$\bar{x}$	62.8 ^{b}	34.9	19.1	19.5	8.5	47.7	16.95 ^{b}	15.67	2.8	11.5	22.1 ^{b}
		SD	± 1.9	± 1.5	± 0.8	± 0.7	± 0.5	± 2.1	±1.36	± 0.89	± 0.3	± 0.6	± 3.6
	♀	$\bar{x}$	58.5 ^{b}	32.8	17.8	18.5	8.2 ^{b}	45.4	15.71 ^{b}	14.80	2.8	11.2	21.9 ^{b}
		SD	± 2.6	± 1.8	± 1.0	± 0.9	± 0.5	± 1.8	± 1.15	± 0.86	± 0.3	± 0.5	± 3.3
	♂♀	$\bar{x}$	60.6 ^{b*}	33.9 *	18.5 *	19.0 *	8.3 ^{b*}	46.6 *	16.33 ^{b*}	15.23 *	2.8	11.4 *	22.0 ^{b}
		SD	± 3.2	± 2.0	± 1.1	± 0.9	± 0.5	± 2.2	± 1.40	± 0.98	± 0.3	± 0.6	± 3.4

[1]Mean values in columns within sex with different superscripts differ significantly: a, b (P ≤ 0.05).

[2]Significant differences in columns between males and females within group: * (P ≤ 0.05).

in the final body weights were not significant. The average body weight of 9-week-old geese (5340 g in control and 5725 g in experimental males; 4722 g in control and 5021 g in experimental females) was higher than the finding of 4154 g obtained by Shalev and Pasternak (19). In the present experiment, regardless of group and sex, body weights measured on day 91 of rearing (which varied from 4209 to 7298 g) were higher than those obtained on day 105 of fattening (4941-5140 g) in our previous experiment (18). The average body weights of 16-week-old oat-fattened White Kołuda geese in this study (6752 g in the experimental group and 6645 g in the control group) were also higher in comparison to the results described by Mazanowski (13) for geese of the same line (5835 g) and of quadruple crosses with White Kołuda (5720-5990 g) (20). The well-pronounced sexual dimorphism observed by other researchers (21,22) for body weight was also seen in the present experiment, despite the diets supplied.

Among poultry species, geese are characterized by having the highest initial growth rate up to week 3 of age (23,24), a fact that was confirmed in our study. During the first week of rearing, the growth rate of males in the experimental group (114.4%) was higher than that of those in the control group (108.7%), but in both cases it was lower than in the experiment of Michalik (25), which found a rate of 119.4% for both sexes. Contrary to the findings of other authors (12,24) in similar experiments, the growth rate of males was higher during the first 3 weeks in comparison with the rate stated for females ($P < 0.01$ and $P < 0.05$, respectively). With every subsequent week of rearing, the growth rate declined progressively, and by the last week, the total rate amounted to 11.0% for experimental and 12.9% for control males. Payne and Southern (8) and Yoon et al. (26) described the positive effect of organic selenium addition on selenium concentrations in broiler chicken tissue, but not on growth performance. In our previous study carried out on Japanese quails, we also failed to observe any significant improvement in the body weight gain, growth rate, or age of female maturity as a result of feed supplementation with organic selenium (27).

The decrease in body weight and body growth rate observed in the present experiment during summer weeks (when ambient temperatures were around 30 °C) was lower in the group supplemented with selenized yeast and vitamin E, which may suggest that the addition of organic selenium caused an increase in the birds' resistance to heat stress. Similar observations were made by Sahin and Kucuk (28) in relation to Japanese quails kept at permanent heat stress. In our earlier investigations, a much higher decrease in the body weight of geese (by 120-710 g for males and 60-650 g for females) was observed to be caused by high ambient temperatures (18).

Almost all of the live body measurements taken from 16-week-old geese fed a diet enriched with selenium and vitamin E were better than those of geese reared on the basic feeds. The body and sternum length were similar to those reported by Mazanowski (29) for progeny crosses of White Kołuda with Graylag and Slovakia geese. Significantly higher dimensions of body and shank length of geese from the experimental group ($P < 0.05$) can positively affect the content of breast and leg muscles (21). Moreover, a lower thickness of skin with subcutaneous fat was found in the selenium-enriched group (22 mm versus 26 mm), which may fulfill the consumers' demand for lower fattiness in the goose carcass. Saatci and Tilki (30), evaluating the native Turkish geese, described lower parameters of final body weight and zoometrical measurements at the age of 16 weeks than those of the White Kołuda line, a disparity that is probably caused by the genotype of the birds. However, Saatci and Tilki concluded that the body length and chest circumference at week 8 of age correlated the closest with live body weight. Similarly, in our experiment, the birds with the highest body length were characterized by the highest live body weights.

It is well known that selenium activates the secretion of thyroid hormones (7) and plays an important role as a component of oxidative enzymes and cytochromes (17). The present experiment further indicates that an increased selenium level in the diet positively affects the growth rate and development of particular parts of the goose body. At the same time, it decreases the negative effect of heat stress that occurs when geese are reared outside at high ambient temperatures. However, as was documented in our previous investigations, the addition of selenium and vitamin E has no influence on the share of breast and leg muscles or on the slaughter yield of commercial geese (31).

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References

1. Payne, R.L., Lavergne, T.K., Southern, L.L.: Effect of inorganic versus organic selenium on hen production and egg selenium concentration. Poult. Sci., 2005; 84: 232-237.
2. Pappas, A.C., Acamovic, T., Sparks, N.H.C., Surai, P.F., McDevitt, R.M.: Effect of supplementing broiler breeder diets with organic selenium and polyunsaturated fatty acids on egg quality during storage. Poult. Sci., 2005; 84: 865-874.
3. Utterback, P.L., Parsons, C.M., Yoon, L., Butler, L.: Effect of supplementing selenium yeast in diets of laying hens on egg selenium content. Poult. Sci., 2005; 84: 1900-1906.
4. Choct, M., Naylor, A. J., Reinke, N.: Selenium supplementation affects broiler growth performance, meat yield and feather coverage. Br. Poult. Sci., 2004; 45: 677-683.
5. Li, J., Wang, X.: Effect of dietary organic versus inorganic selenium in laying hens on the productivity, selenium distribution in egg and selenium content in blood, liver and kidney. J. Trace Elem. Med. Biol., 2004; 18: 65-68.
6. Surai, P.F.: Effect of selenium and vitamin E content of the maternal diet on the antioxidant system of the yolk and the developing chick. Br. Poult. Sci., 2000; 41: 235-243.
7. Arthur, J.R.: Selenium biochemistry and function. Proc. 9th Intern. Symp. Trace Elements in Man and Animals, Ottawa, Canada, 1997; 1-5.
8. Payne, R.L., Southern, L.L.: Comparison of inorganic and organic selenium sources for broilers. Poult. Sci., 2005; 84: 898-902.
9. Czechlowska, T., Bielińska, H.: Technology of rearing and fattening of White Kołuda goose. IZ, ZZD Kołuda Wielka, 1993; 5-28 (in Polish).
10. Świerczewska, E.: Utilization of meat-type chicken. In: Potemkowska, E. Ed. Technology of Industrial Poultry Production. PWR i L, Warsaw. 1983; 369-374 (in Polish).
11. Mazanowski, A., Bernacki, Z., Kisiel, T.: Meat traits and meat chemical composition of crossbred derived from ganders of Kartuska or Graylag ancestry and Astra G geese. Ann. Anim. Sci., 2004; 2: 239-245.
12. Biesiada-Drzazga, B., Grużewska, A.: Analysis of growth and body composition of White Kołuda W31 geese to 10th week of age. Zesz. Nauk. Przegl. Hod., 2004; 72: 71-77 (in Polish, with English abstract).
13. Mazanowski, A.: Evaluation of meat traits of intensively reared goose hybrids from the experimental strains in comparison with White Kołuda geese. Rocz. Nauk. Zoot., 1999; 26: 41-54 (in Polish, with English abstract).
14. Adamski, M.: Meat traits and correlations between body measurements and carcass tissue composition of duck strain A44. Acta Sci. Pol. Zoot., 2004; 3: 3-16 (in Polish, with English abstract).
15. Bochno, R., Brzozowski, W., Lewczuk, A., Wawro, E.: Analysis of effect of measurement of breast muscles thickness with needle catheter on body gain and content of tissue components in goose carcass. Zesz. Nauk. Drob., 1984; 1: 73-78 (in Polish, with English abstract).
16. Wertelecki, T., Łukaszewicz, E., Jamroz, D.: Development of goslings obtained after goose insemination with fresh or frozen-thawed semen. Med. Wet., 2002; 56: 890-894 (in Polish, with English abstract).
17. Surai, P.F., Karadas, F., Pappas, A.C., Sparks, N.H.C.: Effect of organic selenium in quail diet on its accumulation in tissues and transfer to the progeny. Br. Poult. Sci., 2006; 47: 65-72.
18. Łukaszewicz, E.: Growth rate and slaughter value of goslings obtained after geese insemination with fresh or frozen-thawed White Kołuda gander semen. J. Poult. Sci., 2006; 43: 78-83.
19. Shalev, B.A., Pasternak, H.: Genetic-economic evaluation of traits in a goose meat enterprise. Br. Poult. Sci., 1999; 40: 221-226.
20. Mazanowski, A.: Rearing performance of four-strain crossbreds produced using White Kołuda and regional varieties of geese. Ann. Anim. Sci., 2000; 27: 65-83.
21. Rosiński, A.: The analysis of direct and correlated selection effects in two geese strains. Rocz. AR Poznan, 2000; 309: 5-107 (in Polish, with English abstract).
22. Smalec, E.: Differentiation of geese from genetic gene pools in relation to their performances and polymorphism of blood plasma proteins. COBRD Zeszt. Nauk. Drob. Poznan, 1991; 3: 1-87 (in Polish, with English abstract).
23. Knizetova, H., Hyanek, J., Veselsky, A.: Analysis of growth curves of fowl. III. Geese. Br. Poult. Sci., 1994; 35: 335-344.
24. Janiszewska, M.: Changes in body weight and tissue components of White Italian geese during the rearing period. Acta Acad. Agric. Tech. Olst. Zoot., 1993; 37: 1-39 (in Polish, with English abstract).

25. Michalik, D.: Comparison of food utilisation by different species of young slaughter bird. Acta Acad. Agric. Tech. Olst., 1994; 39: 34-38 (in Polish).

26. Yoon, I., Werner, T.M., Butler, J.M.: Effect of source and concentration of selenium on growth performance and selenium retention in broiler chicken. Poult. Sci., 2007; 86: 727-730.

27. Łukaszewicz, E., Jerysz, A., Małaniuk, P.: Effect of feed supplementation with organic selenium and vitamin E on growth rate and maturation of Japanese quails (*Coturnix Japonica*). Rocz. Nauk. AR we Wrocławiu, 2006; LIV: 87-97 (in Polish, with English abstract).

28. Sahin, K., Kucuk, O.: Effects of vitamin E and selenium on performance, digestibility of nutrients, and carcass characteristics of Japanese quails reared under heat stress (34 °C). J. Anim. Physiol. Anim. Nutr., 2001; 85: 342-348.

29. Mazanowski, A.: Effect of reciprocal crossbreeding of hybrid ganders or White Kołuda geese and Graylag with Slovakia geese on meat characteristics of progeny. Ann. Anim. Sci., 2001; 28: 59-76.

30. Saatci, M., Tilki M.: Zoometrical body measurements and their relation with liveweight in native Turkish geese. Turk. J. Vet. Anim. Sci., 2007; 31: 47-53.

31. Łukaszewicz, E., Adamski, M., Kowalczyk, A.: Correlations between body measurements and tissue composition of oat-fattened White Kołuda geese at 17th week of age. Br. Poult. Sci., 2008; 49: 21-27.