JMBFS
Journal of Microbiology, Biotechnology and Food Sciences
International peer-reviewed scientific online journal
Published by Faculty of Biotechnology and Food Sciences

CHEMICAL COMPOSITION AND AMINO ACID PROFILE OF GOOSE MEAT (UKRAINIAN LARGE GRAY AND LARGE WHITE BREEDS) IN SEMI-INTENSIVE SYSTEM OF GROWING

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https://doi.org/10.55251/jmbfs.9828

ARTICLE INFO

Received 21. 1. 2023
Revised 19. 4. 2023
Accepted 3. 5. 2023
Published 1. 6. 2023

Regular article

OPEN ACCESS

ABSTRACT

Large gray and Large white geese breeds were created in Ukraine and are widespread. At the same time, the nutritional value of their meat is insufficiently studied. Therefore, this work aimed to study and compare the chemical composition and amino acid profile of the muscles of the chest and thighs of geese of these breeds in semi-intensive growing. The study used 20 heads of geese of both sexes of the Large gray and Large white breeds, which were raised under similar housing and feeding conditions. Muscle samples were analyzed following current regulations in Ukraine, harmonized with relevant international standards. Studies have shown no significant differences in the muscle content of males and females of these breeds in terms of moisture, protein and ash, but a more significant difference in fat content was observed. In the thighs of females of Large gray geese fat content was higher than in the thighs of males of this breed by 0.29% ($P<0.05$). At the same time, in females of the Large white breed, on the contrary, higher fat content than in males (by 0.27%) was observed in the chest muscles ($P<0.05$). The chest muscles of both males and females of both breeds had more moisture and more crude protein than the thigh muscles. In contrast, the thigh muscles had a higher fat content ($P<0.05$). As for protein, the muscles of the chest and thighs contained all the essential amino acids. However, the amino acid profile of male and female proteins of the same type in different muscle types, both within one breed and between breeds, differed slightly in the content of some amino acids, with the statistically reliable ($P<0.05$) difference in some of them. Comparison of the amino acid profile of chest and thigh muscle proteins of both breeds of geese with the reference protein (FAO/WHO, 2013), showed that the muscle protein of geese of Large gray and Large white breeds contains a sufficient amount of all essential amino acids. The essential amino acid indices of the chest and thigh muscle proteins were similar for both breeds and were approximately 1.8-fold higher than the reference protein index. These data indicate the high nutritional value of meat of both goose breeds and the feasibility of their further use for meat production in Ukraine.

Keywords: meat, goose, amino acid, nutrition

INTRODUCTION

Amino acids need to the organism of man and animals for the synthesis of proteins, formation of new cages and fabrics. Impossibility of synthesis of certain albumen as a result of absence or deficit of separate amino acids results an organism in violations of him normal work. All squirrel consists of 20 amino acids, 8 from that is not synthesized in an organism or synthesized with insufficient speed. Such amino acids are considered irreplaceable and must come in an organism with a meal **(Almeida *et al*., 2021)**.

Squirrel, and with them amino acids, come in the organism of man with the different food products of both vegetable and animal origin. By advantage of natural proteins of animal origin, as a rule, amino acid composition is more balanced. The amount of amino acids in meat of bird depends first of all on a kind and breed of bird **(FAO, 2013)**. Thus, meat must be the inalienable constituent of ration of man. The special attention it follows to spare feed of bird of children meat different age with the aim of providing of them growing organism by irreplaceable amino acids, and also fat acids, row of vitamins and microelements **(Korish & Attia, 2019; Haščík *et al*., 2019; Gumulka & Poltowicz, 2020; Čech *et al*., 2021)**.

Geese are valued primarily for their ability to fatten on cheap (pasture) feed and a wide range of products obtained: meat, fat, feather and fluff raw materials, large fatty liver **(Mel'nyk *et al*., 2015)**.

The digestive system of geese is adapted to the consumption of large amounts of roughage with high fiber content. Therefore, grazing them or feeding them green and succulent fodder saves a significant amount of grain and thus to reduce competition for this resource with other poultry species **(Wang *et al*., 2010; Liu and Zhou, 2013; Wang *et al*., 2014; Jin *et al*., 2014; He *et al*., 2015; Li *et al*., 2017)**.

Goose meat is characterized by high taste, rich in protein, essential amino acids, fat, vitamins and minerals and is a valuable food product **(Biesalski, 2005; Magdelaine *et al*., 2008; Bogosavljević-Bošković *et al*., 2010)**.

The nutritional value of meat is usually based on parameters such as protein content, amino acid profile, fat content and its fatty acid composition **(Straková *et al*., 2002; Magdealine *et al*., 2008; Okruszek *et al*., 2013)**.

The quality of poultry meat largely depends on the genetic characteristics of poultry, their feeding system and environment **(Romanov, 1999; Berri, 2000; Wężyk *et al*., 2003; Bihan-Duval, 2004; Wood *et al*., 2008; Liu and Zhou, 2013)**.

The chemical composition and amino acid profile of goose meat has been studied in a number of studies **(Galina, 2012; Yakan *et al*., 2012; Okruszek *et al*., 2013; Geldenhuys *et al*., 2015; Li *et al*., 2020; Haraf *et al*., 2018 and 2021; Grishina, 2016; Song *et al*., 2017; Boz *et al*., 2019; Gumulka & Poltowicz, 2020)**. According to these researchers, there were also significant differences in mentioned parameters depending on the genotype of birds, their type of feeding and housing system.

Extensive, semi-intensive and intensive fattening technologies for geese are used **(Mel'nyk *et al*., 2015; Kozák, 2021)**. However, recently the demand for intensive fattening geese has been declining, while the demand for semi-intensive and extensive fattening geese is increasing, which provides free-range keeping of birds while grazing, spending much of their lives in pastures, or feeding large amounts of greens and succulent feed. Geese kept on pastures and fed a variety of feeds meet the requirements of an ecological product. This is important because more and more consumers want to know how their food is produced and prefer organic production that takes into account animal welfare **(Okruszek *et al*., 2013; Boz *et al*, 2019)**.

In Ukraine, goose breeding has a long tradition, favorable conditions and one of the largest flocks in Europe **(Wężyk, 2004)**. The most common breeds of geese in Ukraine are the Large gray and Large white geese, created at the Institute for Poultry farming of the National Academy of Agrarian Sciences of Ukraine. Geese of both breeds are well adapted to the climatic conditions of Ukraine and the local fodder base, they are in great demand in industrial enterprises, farms and homesteads **(Mel'nyk *et al*., 2015)**.

The Large Gray breed of geese was created by direct and reverse crossing of local Romen and Toulouse breeds with subsequent selection of the best hybrid combinations and their selection by live weight, meat forms, viability and fertility. Live weight of adult males' averages 7 kg, females 6 kg. Geese of the Large gray and Rhenish White breeds were used as a source of genetic material in the creation of the Large white Breed. Large white geese were obtained by reproducibly crossing them and then selecting the desired genotypes. Live weight of adult males increased to 7.2 kg, females 6.5 kg **(Ryabokon′ *et al*., 2005)**.

To determine the future prospects of the Large gray and Large white geese in Ukraine and the areas of work with them, it is important to know the nutritional value of their meat, including chemical and amino acid composition. However, there are no relevant data in the scientific literature on these genetic resources. Thus, the aim of this work was to study and compare the chemical composition and amino acid profile of the chest and thigh muscles of geese of the Large gray and Large white breeds in semi-intensive growing.

MATERIALS AND METHODS

The work was carried out at the Institute of Animal Husbandry of the National Academy of Agrarian Sciences of Ukraine.

The place of the experiment

Analysis of the basic chemical composition of muscles and determination of their amino acid profile was carried out in the laboratory of quality assessment of feed and animal products of the Institute of Animal Husbandry of the National Academy of Agrarian Sciences of Ukraine.

Experimental animals

The experiment used 20 heads of each of two goose breeds - Big Gray and Big White, 17-week-old. The population of each breed was half male and half female. Both breeds have related genetic origins and similar characteristics and are included in the Catalog of Pedigree Poultry Resources of Ukraine **(Ryabokon′ *et al*., 2005)**. They are widely used in Ukraine for meat production (Tab. 1).

Table 1 The main economically useful characteristics of the Large gray and Large white breeds of geese **(Ryabokon' *et al*., 2005)**

Characteristics	**Breed**	
	Large gray	**Large white**
Feather color	Mostly gray	White
Live weight of adult birds, kg:		
males	7,0	7,2
females	6,0	6,5
Egg-laying per 1 cycle, pcs. eggs	44-47	46-48
Mass of eggs, g	155-170	170
Offspring of goslings, %	74	75

Day old goslings for breeding were obtained from the State Breeding Poultry Enterprise "Rozdolne" of Kharkiv region.

Semi-intensive technology was used to raise goslings from the age of 24 hours to 17 weeks. Growing of young birds was carried out in the spring-summer-autumn period (May-September), which was divided into 4 parts: 1st – from one day to 3 weeks of age; 2nd – from 4 weeks to 8 weeks of age; 3rd - from 9 weeks to 14 weeks of age; 4th – from 15 weeks to 17 weeks of age.

During the first period, the goslings were raised on litter in a poultry house without walking areas on the base of the State Poultry Research Station of NAAS. Young animals of each breed were placed in separate sections at a density of 4 heads/m^2, feeding and watering field – 4 cm/head. The microclimate in the poultry house was controlled in accordance with the requirements of current regulations of Ukraine. The birds were fed to their heart's content with complete compound feed with a crude protein content of 20% according to the Guidelines for the standardization of poultry feeding **(Bratyshko *et al*., 2019).**

During the light period of the day, goslings from 3 to 8 weeks of age were let out for grazing calculating 2 m^2/head, placing density in the poultry house was reduced to 3 heads/m^2, and the field of feeding and watering was increased to 10 cm/head. At the same time, chopped alfalfa greens was given without limits, and the feeding of compound feeds was limited in comparison with the norms, and the protein content in the diet was reduced to 18%.

From 9 weeks to 14 weeks of age, young birds were raised and fed in the same way as in the previous period, but the placing density in the poultry house was reduced to 2 heads/m^2, the walking area was increased to 4 m^2/heads, and the feeding field was reduced to 15 cm/head, the crude protein content in compound feed was 15%. From the age of 14 weeks, the poultry was fed a grain mixture of wheat, corn and oats in equal parts by mass. Technological parameters of breeding geese were the same as in the previous period.

Rations

The scheme of poultry feeding is shown in table 2, the composition and nutritional value of feed – in table 3, green mass – in table 4.

Table 2 Scheme of feeding geese according to age

Fattening periods	**Concentrated fodder**	**Daily giving of concentrated fodder, g/head**	**Green and succulent feed**	**Daily giving of green and succulent feed, g/head**
1-3 weeks	Complete compound feed with a crude protein content of 20%	Without limits	-	-
4-8 weeks	Complete compound feed with a crude protein content of 18%	200-240	Chopped alfalfa green mass	Without limits
9-14 weeks	Complete compound feed with a crude protein content of 15%	220	Chopped alfalfa green mass	Without limits
15-17 weeks	Grain mixture (wheat, corn, oats)	Without limits	-	-

Table 3 Nutritional value of complete compound feed for goslings

Components	**Age of goslings, weeks**		
	1-3	4-8	9-14
Composition of compound feed, %			
Corn	18.0	25.0	15.0
Wheat	47	40.0	25.0
Oat	-	3	7.5
Barley	-	-	23.0
Wheat bran	-	4,0	10.0
Sunflower meal	10.0	12,0	12.0
Fodder yeast	5.0	3,0	-
Fishmeal (60% RP)	5.5	3,0	2.0
Soybean meal (42% RP)	8.0	6,0	-
Herbal flour	3.0	-	-
Chalk, limestone, shell rock	1.2	1,8	3.2

Tricalcium phosphate defluorinated	1.2	1,0	1.0
Salt	0.1	0.2	0.3
Vitamin and mineral premix	1.0	1.0	1.0
Nutrition of compound feed			
Exchange energy, MJ/kg	11.73	11.73	11.65
Crude protein	20.1	18.1	15.0
Crude fiber	4.5	4.9	4.9
Crude fat	2.0	2.6	3.47
Calcium	1.2	1.2	1.6
Phosphorus	0.8	0.7	0.7
Sodium	0.27	0.28	0.30
Lysine	0.98	0.90	0.55
Methionine	0.45	0.45	0.34
Cystine	0.34	0.32	0.18

Table 4 Nutritional value of alfalfa green mass

Indicators	Values of indicators
Dry substance, %	25-35
Exchange energy in 1 kg of feed, MJ	0.209-0.293
The green mass contains, %	
Protein	17.3
Lysine	0.79
Methionine	0.22
Tryptophan	0.27
Methionine+cystine	0.43
Crude fat	2.4
Crude fiber	24
Calcium	1.22
Phosphorus	0.26
Sodium	0.23

At the age of 17 weeks, all birds were weighed on electronic scales with accuracy of ±1 g and slaughtered. 12 hours before slaughter, we stopped feeding with free access to water. Immediately before slaughter, the geese were stunned with a *Sprut* hand-held device. Slaughter was performed by cutting the throat. Subsequently, the carcasses of poultry were subjected to primary processing by the technology of full gutting (exsanguination, scalding, plucking, gutting).

Preparation of samples

The gutted carcasses were placed in a refrigerator, where they were cooled at a temperature from 2 to 4°C for 24 hours. After a 24-hour cooling period, samples of the pectoralis major and biceps femoris without intramuscular fat, skin, and subcutaneous fat were taken from the left side of the carcasses. The samples were packaged under vacuum and stored at - 80°C for further analysis of the chemical composition (moisture, nitrogen, crude lipids and ash) and determination of the amino acid profile.

Estimation of amino acid composition of protein in chest and thigh muscles of geese

Based on the analysis of amino acid content, the completeness of the amino acid profile and the nutritional value of proteins in the muscles of the chest and thighs of geese were determined. To do this, we compared the essential amino acid profile (EAA) of the test muscles and the amino acid profile of reference protein the adult human **(FAO / WHO, 2013)**, and calculated the essential amino acid index (EAAI) of the muscle.
Assessment of muscle amino acid profile was performed according to FAO/WHO **(2002)** method as the ratio of the content of individual essential amino acids in the tested muscles to their content in the reference protein for an adult (formula 1). The essential amino acid with the lowest percentage of the reference profile was considered to be the limiting amino acid and this percentage was taken to estimate the amino acid profile of the test muscles as a whole.

$$AAS = \frac{\text{g of amino acid in 100 g of test protein}}{\text{g of amino acid in 100 g of requirement pattern}} \times 100\% \quad (1)$$

The Index of Essential Amino Acids (EAAI) was calculated as the geometric mean of the content of some amino acids in goose muscle samples and their content in the reference protein (Oser, 1959) (formula 2):

$$EAAI = 100 \times \sqrt[n]{\frac{Lys_p}{Lys_s} \times \frac{Tr_p}{Tr_s} \times \ldots \times \frac{Val_p}{Val_s}} \quad (2)$$

where the index p refers to the sample of the tested protein, s – to the reference protein and n – to the number of amino acids (taking into account the pairs Met + Cys and Phe + Tyr as one).

Research methods

The contents were determined in the muscles:
- fat: according to the Soxhlet method following DSTU ISO 1443: 2005 (ISO 1443: 1973, IDT) **(2007)**;
- moisture: by drying the samples to constant weight at 105 °C according to DSTU ISO 1442: 2005 (ISO 1442: 1997, IDT) **(2007)**;
- nitrogen: according to the Kjeldahl method according to DSTU ISO 937: 2005 (ISO 937: 1978, IDT) **(2007)**. To determine the protein content, the nitrogen content was multiplied by a factor of 6.25;
- ash: according to DSTU ISO 936: 2008 (ISO 936: 1998, IDT) **(2010)**.

Analytical studies to determine the content of amino acids in muscle samples were performed by liquid chromatography using an automatic amino acid analyzer brand AAA-339 M made in the Czech Republic, in accordance with the requirements of ISO-13903.

Statistical Analysis

The experiment was completely randomized. All data were subjected to one-way analysis of variance for genotypes of geese (GG and GW), males and females and muscle type (thigh and chest) using application software for «Microsoft Excel 2007». The difference in values between the options was considered reliable at P≤0.05.

RESULTS

Live weight of males of both breeds exceeded 6 kg, females 5.5 kg, which corresponded to their normative indicators and the potential of other breeds of geese of this type **(Yakan *et al*., 2012; Okruszek *et al*., 2013; Haraf *et al*., 2018)**. Live weight of geese at the end of the fattening period (17 weeks of age) is shown in table 5.
Significant differences in live weight between males and females of each breed have been recorded. The live weight of males of the Large gray breed was greater than the live weight of females by an average of 604 g (P<0.001), live weight of males of the Large white breed was more than the live weight of females of this breed by 637 g (P<0.001). There were also significant differences in live weight of males and females between breeds. Thus, the live weight of males of the Large white breed was greater than the live weight of males of the Large gray breed, on average by 271 g (P<0.01), females by 218 g (P<0.05).

Table 5 Live weight of geese at 17 weeks of age (n=10)

Genetic group	Gender	N animal	Live weight, g	
			Mean (x̄)	Standard error
Large gray breed	Males	10	6234^{ab}	47.91
	Females	10	5650^{b}	53.46
Large white breed	Males	10	6505^{a}	57.75
	Females	10	5868^{ab}	64.11

Note: ^{a,b}Means within a row with different superscripts differ significantly, *p ≤0,05*)

The results of the general chemical analysis of muscle samples of geese of both breeds are shown in table 6. The results of the analysis did not show significant differences between males and females of some breeds in the content of moisture, protein and ash in the same type of muscles (chest or thighs). More significant differences between them were observed in fat content. In the thighs of female geese of the Large gray breed fat content was higher than in the thighs of males of this breed by 0.29% (P<0.05). At the same time, in females of the Large white breed, on the contrary, higher fat content than in males (by 0.27%) was observed in the pectoral muscles (P<0.05).

Table 6 Chemical composition of the muscles of the chest and thighs of domestic geese (M±m, n=10)

Components	The average value of the indicator, %			
	Males		Females	
	Chest muscles	Thigh muscles	Chest muscles	Thigh muscles
Large gray breed				
Moisture	74.44±0.19^{a}	73.00±0.15^{b}	74.36±0.14^{a}	73.25±0.17^{b}
Protein	21.66±0.12^{a}	20.77±0.14^{b}	21.83±0.11^{a}	21.07±0.10^{b}
Fat	3.09±0.09	3.98±0.06^{b}	3.21±0.08	4.27±0.07^{a}
Ash	1.27±0.08	1.25±0.05	1.29±0.08	1.24±0.06
Large white breed				
Moisture	74.86±0.17^{a}	73.57±0.19^{b}	74.66±0.21^{a}	73.7±0.18^{b}
Protein	21.90±0.12^{a}	21.03±0.10^{ab}	21.75±0.08^{ab}	20.94±0.08^{b}
Fat	2.95±0.07^{b}	3.72±0.09^{ab}	3.22±0.07^{a}	3.84±0.08^{ab}
Ash	1.26±0.07	1.21±0.04	1.34±0.04	1.28±0.04

Notes: ^{a,b}Means within a row with different superscripts differ significantly, *P≤0,05*

Interbreeding differences were observed only by the content of crude protein in the muscles of the thighs of males, which was higher by 0.26% (P<0.05) in males of the Large white breed, and by the content of fat in the muscles of the thighs of females, which was greater by 0.43% in females of the Large gray breed (P<0.05). The most significant differences in the geese of both breeds were observed in the chemical composition of the chest and thigh muscles. Chest muscles in both males and females of both breeds had higher humidity (min74.36-max74.86%) and higher crude protein content (min21.66-21.90%) than thigh muscles (min73.0-max73.7% and min20.77-max21.07%, respectively) (P<0.05). In contrast, the thigh muscles had a higher fat content (min2.95-3.22% in the chest muscles and min3.72- max4.27% in the thigh muscles, respectively) (P<0.05).

Goose protein contained a number of nonessential_amino_acids (NEAA) and all essential amino acids (EAA) (Tab. 7). Processing of the results showed that although the quantitative content of some amino acids in the chest and thigh muscles of male and female geese of both breeds had some differences, but within one breed these differences were insignificant.

Slightly greater differences in amino acid profile were observed between breeds of geese – Large gray and Large white. The chest muscles of Large white males contained more leucine, valine, and methionine (P<0.05). In total, the amount of essential amino acids in the chest muscles of males of the Large white breed exceeded this indicator of the Large gray breed by 0.73 g/100 g of protein.

Higher levels of leucine and isoleucine (P<0.01) were also observed in the chest muscles of Large white females. In contrast, the chest muscles of Large gray females contained more valine and tyrosine (P<0.01). The amount of essential amino acids in the chest muscles of Large white females was 0.66 g/100 g of protein in the chest muscles of Large gray females.

The interbreeding differences in the amino acid profile of the thigh muscles of males and females were even less than those of the chest muscles. Only a higher content of isoleucine in the thigh muscles of males was observed (P<0.001). In general, the content of essential amino acids in the thigh muscles when comparing males of different breeds was higher in males of the Large white breed by 0.55 g/100 g of protein, and when comparing females – in the Large gray breed, but the difference was insignificant – 0.13 g/100 g

Significantly greater differences were observed in the amino acid profile of the chest muscles and thigh muscles in both breeds of geese. In males of the Large gray breed in chest muscles the content of aspartic amino acid, proline (P<0.001) and alanine (P<0.005), as well as EAA – leucine (P<0.005), lysine, threonine and histidine (P<0.01), as well as isoleucine (P<0.001) was significantly higher than in the thigh muscles.

In contrast, male thigh muscles had higher levels of NEAA – glutamic amino acid and arginine (P<0.001); EAA – valine and cystine (P<0.001), phenylalanine and tryptophan (p <0.01). In females of the Large gray breed, as in males, the chest muscles contained more: NEAA – aspartic amino acid, proline (P<0.001) and alanine (P<0.01); EAA – leucine (P<0.001), lysine, threonine and histidine (P<0.01), tyrosine (P<0.05). Female thigh muscles had higher levels of: NEAA – glutamic amino acid and arginine (P<0.001); EAA – valine, phenylalanine, tryptophan and cystine (P<0.001). The total amount of EAA in the muscles of the chest and thighs in both males and females of the Large gray breed per 100 g of protein did not differ significantly.

Table 7 Amino acid composition of the muscles of the chest and thighs of domestic breeds of geese, g/100 g of protein (M±m, n=10)

Components	The average value of the indicator (x)			
	Males		Females	
	Chest muscles	Thigh muscles	Chest muscles	Thigh muscle
Large gray breed				
NEAA				
Ala	5.36±0.14^{a}	4.92±0.07^{b}	5.27±0.08^{a}	4.89±0.07^{b}
Arg	8.39±0.13	9.99±0.11	8.27±0.10^{b}	10.05±0.11^{a}
Asp	6.71±0.09	5.1±0.05	6.57±0.09^{a}	5.08±0.09^{b}
Glu	14.03±0.14^{b}	15.15±0.08^{a}	13.96±0.15^{b}	15,04 ± 0.08^{a}
Gly	3.0±0.06	3.07±0.06	3.03±0.07	3.03 ± 0.05
Pro	5.16±0.14^{a}	4.14±0.05^{b}	5.07±0.10^{a}	4.18 ± 0.05^{b}
Ser	4.07±0.10	4.11±0.05	4.07±0.09	4.14 ± 0.05
EAA				
Cys	1.02±0,05^{b}	1.36 ± 0.06^{a}	1.04 ± 0.04^{b}	1.33 ± 0.05^{a}
His	3.67±0,08^{a}	3.30 ± 0.06^{b}	3.58 ± 0.07^{a}	3.25 ± 0.06^{b}
Ile	4.26±0,06^{a}	3.62 ± 0.06^{ab}	4.22 ± 0.05	4.19 ± 0.04^{b}
Leu	10.35±0,15^{b}	9.81 ± 0.10^{b}	10.41 ± 0.12^{a}	9.74 ± 0.09^{b}
Lys	10.07±0,12^{a}	9.3 ± 0.12^{b}	10.11 ± 0.07^{a}	9.17 ± 0.09^{b}
Met	3.06±0,05^{b}	3.11 ± 0.05	3.16 ± 0.06	3.20 ± 0.07
Phe	4.86±0,07^{b}	5.72 ± 0.06^{a}	4.86 ± 0.06^{b}	5.63 ± 0.11^{a}
Thr	5.05±0,08^{a}	4.70 ± 0.06^{b}	5.02 ± 0.05^{a}	4.67 ± 0.06^{b}
Trp	0.96±0,06^{b}	1.25 ± 0.03^{a}	1.01 ± 0.05^{b}	1.29 ± 0.03^{a}
Tyr	3.48±0,06	3.4 ± 0.06	3.55 ± 0.04^{a}	3.35 ± 0.07^{ab}
Val	5.21±0,12^{b}	6.27 ± 0.06^{ab}	5.16 ± 0.07^{ab}	6.36 ± 0.07^{a}
∑EAA	51.99	51.84	52.14	52.18
Large white breed				
NEAA				
Ala	5.29 ± 0.11	5.05 ± 0.07	5.36 ± 0.07^{a}	5.01 ± 0.08^{b}
Arg	8.31 ± 0.10^{b}	9.82 ± 0.09^{a}	8.19 ± 0.08^{b}	9.96 ± 0.05^{a}
Asp	6.72 ± 0.06^{a}	5.24 ± 0.10^{b}	6.64 ± 0.09^{a}	5.13 ± 0.05^{b}
Glu	14.11 ± 0.09^{b}	15.07 ± 0.07^{a}	14.04 ± 0.12^{b}	15.17 ± 0.08^{a}
Gly	3.05 ± 0.09	3.16 ± 0.07	3.09 ± 0.04	3.14 ± 0.06
Pro	5.21 ± 0.12^{a}	4.11 ± 0.08^{b}	5.02 ± 0.09^{a}	4.09 ± 0.08^{b}
Ser	4.08 ± 0.09	4.01 ± 0.07	3.97 ± 0.06	4.03 ± 0.07
EAA				
Cys	1.06 ± 0.03^{b}	1.37 ± 0.03^{a}	1.06 ± 0.05	1.32 ± 0.05
His	3.56 ± 0.07^{a}	3.18 ± 0.04^{b}	3.68 ± 0.08^{a}	3.27 ± 0.04^{b}
Ile	4.34 ± 0.05	4.17 ± 0.05^{a}	4.44 ± 0.04^{a}	4.12 ± 0.05^{ab}
Leu	10.75 ± 0.07^{a}	9.68 ± 0.09^{b}	10.88 ± 0.09^{a}	9.55 ± 0.03^{ab}
Lys	10.25 ± 0.12^{a}	9.44 ± 0.09^{b}	10.21 ± 0.07^{a}	9.33 ± 0.08^{b}
Met	3.22 ± 0.05^{a}	3.22 ± 0.05^{a}	3.29 ± 0.05	3.15 ± 0.05
Phe	5.00 ± 0.08^{b}	5.54 ± 0.10^{a}	4.90 ± 0.04^{b}	5.63 ± 0.09^{a}
Thr	5.20 ± 0.05^{a}	4.79 ± 0.06^{b}	5.09 ± 0.05^{a}	4.72 ± 0.06^{b}
Trp	1.02 ± 0.06^{b}	1.29 ± 0.02^{a}	1.11 ± 0.05	1.24 ± 0.04
Tyr	3.40 ± 0.07	3.30 ± 0.05	3.33 ± 0.05^{b}	3.22 ± 0.04^{b}
Val	4.94 ± 0.06^{ab}	6.41 ± 0.07^{a}	4.81 ± 0.05^{b}	6.50 ± 0.07^{ab}
∑EAA	52.72	52.39	52.80	52.05

Notes: ^{a,b}Means within a row with different superscripts differ significantly, *p ≤0,05*

Similar differences in the amino acid composition of the chest and thigh muscles were observed in the Large white geese. Male chest meat contained more: NEAA – aspartic amino acid and proline (P<0.001); EAA – leucine, lysine, threonine and histidine (P<0.001).

At the same time, the male thigh muscles had a higher content of NEAA – glutamic amino acid and arginine (P<0.001); EAA – valine, cystine (P<0.001), phenylalanine and tryptophan (P<0.01). Female chest muscles contained more aspartic amino acid, proline (P<0.001) and alanine (P<0.01); EAA – leucine, lysine, isoleucine, threonine and histidine (P<0.001).

Instead, the thigh muscles contained more: NEAA – glutamic amino acid and arginine (P<0.001); EAA – valine and phenylalanine (P<0.001). The total amount of EAA in the chest and thigh muscles of males and females of the Large white breed did not differ significantly, although (except for the thigh muscles in females) it was slightly higher than in the Large gray breed: in the chest muscles of males, respectively, 52.72 and 51.99; male thigh muscles 52.39 and 51.84; chest muscles of females 52.80 and 52.14; thigh muscles of females 52.05 and 52.18.

Comparison of the amino acid profile of chest and thigh muscle proteins of both breeds of geese with the reference protein **(FAO/WHO, 2013)** (Tab. 8). Comparison of the amino acid profile of proteins in chest and thigh muscles of both geese breeds with the standard protein **(FAO / WHO, 2013)** (Tab. 8). that goose muscle protein contains enough t amount of all essential amino acids (indexes from 121 to 229. It indicates that they can be a good source in human nutrition and classified (according to FAO, 2013) to the category of products with high protein levels.

Table 8 Estimation of the profile of essential amino acids of the muscles of the chest and thighs of geese in comparison with the reference protein and the index of essential amino acids (n = 10)

Amino acids	Amino acid profile of the reference protein (FAO/WHO, 1991), g/100 g of protein	Evaluation of the EAA profile compared to the reference protein			
		Males		Females	
		Chest	Thigh muscles	Chest	Thigh muscles
Large gray breed					
AAS (%)					
His	1.9	193	174	188	171
Ile	2.8	152	129	151	150
Leu	6.6	157	149	158	148
Lys	5.8	173	160	174	158
Met+ Cys	2.5	163	179	168	181
Phe+ Tyr	6.3	132	145	133	143
Thr	3.4	149	138	148	137
Trp	1.1	87	114	92	117
Val	3.5	149	179	147	182
∑Essential	33.9	51.99	51.84	52.14	52.18
EAAI	100	148	150	148	153
Large white breed					
AAS (%)					
His	1.9	187	167	194	172
Ile	2.8	155	149	159	147
Leu	6.6	163	147	165	145
Lys	5.8	176	163	176	161
Met+ Cys	2.5	171	184	174	179
Phe+ Tyr	6.3	133	140	131	140
Thr	3.4	153	133	150	139
Trp	1.1	93	117	101	113
Val	3.5	141	183	137	186
∑Essential	33.9	52.72	52.39	52.80	52.05
EAAI	100	150	152	152	152

Essential EAA indices of goose muscle proteins were also calculated (Tab. 8). The EAAI indices of goose muscle proteins were estimated to be approximately by 1.8-time higher than the EAAI of the standard protein. Both males and females of the Great Grey and Great White Goose breeds had higher EAAIs (2-5 units) in the thigh muscles. Cross-breed differences in EAAI indices of the same type of muscle were insignificant. EAAI indices (1-2 units) are slightly higher in the same type of muscles, except for the thigh muscles in females of the Great White breed. In contrast, the thigh muscles of the Great Grey females had an EAAI index over the Great White female females by 1 unit. However, these differences were too small to draw any conclusions about the benefits of a particular geese breed.

Obviously, this issue requires further study.

DISCUSSION

Amino acids play an important role in the vital functions of a body and are crucial for human health. All proteins are primarily the building blocks in the body and are needed to build the skeleton, muscle growth and connective tissue **(Solano, 2020; Lopez & Mohiuddin, 2021; Simakhina & Naumenko, 2020; Posey *et al*., 2021)**.

The leading role of amino acids in the processes of biosynthesis of chemical regulators of physiological processes - hormones and neurotransmitters has been proved **(Simakhina & Naumenko, 2020; He, W. & Wu, 2020; Sarkar *et al*., 2021).**

Researchers point to the important role of essential amino acids in achieving full genetic potential. The role of amino acids is well known in including essential ones, in DNA and protein synthesis, proteolysis and metabolism of glucose and lipids, maintenance of endocrine status, male and female fertility, skin health and recovery, acid-base balance, antioxidant reactions and detoxification of endogenous and endogenous detoxification, xenobiotics, maintaining adequate immune status **(Hou, Yin, & Wu, 2015; Solano, 2020)**

Protein synthesis in the body does not occur in the absence or lack of at least one of the essential amino acids, and food is used only as a source of energy or accumulates in fat **(Simakhina & Naumenko, 2020).**

Amino acid deficiency in food leads not only to growth inhibition and wrong physical development, but also to cardiovascular dysfunction, decreases immunity and reduces resistance to metabolic and infectious diseases in humans **(Hou, Yin, & Wu, 2015; Li, He, & Wu, 2021)**.

Consequence of the insufficient intake of essential amino acids and/or a lack of protein synthesis in human body may develop clinical symptoms such as depression, anxiety, insomnia, fatigue, weakness **(Lopez & Mohiuddin, 2021)**.

The quality and safety of poultry meat directly depends on the epizootiological welfare of poultry **(Paliy *et al*., 2018a)**, as well as a number of other environmental factors **(Paliy *et al*., 2018b; Bogach *et al*., 2021)**. Compliance with all necessary veterinary, sanitary and technological measures is an integral part of poultry farming **(Paliy *et al*., 2021a, b)**. Hygiene of production must be strictly observed while processing poultry carcasses and meat of other farm animals **(Rodionova *et al*., 2021)**.

To date, very little research has been conducted on the chemical composition of muscles in Ukrainian Large gray and Large white geese. Of these, we can note the work of **Ivko *et al.* (2009)**, which determined the content of moisture, protein and fat in the chest muscles of adult geese of the Large white breed and obtained indicators in the range, respectively, min72.16-max73.85%, min16.85-max20.14%, min2.88-max3.54%. This is less than in our studies, however, probably due to the older age of the poultry.

According to other data **(Grishina, 2016)**, the chest muscles of geese obtained from crossing males of Large gray breed and females of Pereyaslav breed at the age of 63 days contained 73.85% moisture, 19.63% crude protein 5.46% fat and 1.06% ash, thigh muscles, respectively, 71.44%, 19.36%, 8.02% and 1.06%. The author did not note any significant differences between the muscles of the chest and thighs in terms of ash content. This is largely consistent with our research, but the moisture and crude protein content in the chest and thigh muscles of the Large gray and Large white geese was slightly higher than in the author's research.

Galina (2012) studied the chemical composition of the muscles of the chest and thighs (both males and females) of geese of Italian and Kuban breeds and their hybrid combinations in intensive growing. It was found that at 9 weeks of age the chest muscles of females had a higher moisture content max76.07%, at the same time, a lower protein content max20.91%, fat max2.19% and ash max1.11%.

Similar differences were found in the chemical composition of the thigh muscles, which had a higher moisture content in females but less protein and ash than in males. Our studies did not confirm significant differences between males and females in moisture and protein in the same type of muscle, which, however, can be explained by a large difference in the age of geese (9 and 17 weeks), but agree with the author's research on differences in chemical composition of chest and thigh muscles. Certain differences in chemical composition were also observed between some breeds and hybrid combinations of geese, which, however, were not statistically significant.

The data on the protein content in the chest muscles and thigh muscles of the Great Grey and Great White geese obtained by us during the experiment are close to the results of the research of **Okruszek *et al*. (2013)**. This group of researchers studied similar indicators in 17-week-old female geese of the Polish aboriginal breeds Rypińska and Garbonosa. Our data are also coincide with the results of studies by **Boz *et al*. (2019)** goose meat of Turkish aboriginal breeds. According to the results of their research, the content of protein and fat in the chest muscles is min21.85-23.56 and min3.72-5.69, respectively, and in the thigh muscles – min21.21-max22.79 and min3.22- max5.30.

As in our studies, **Okruszek *et al*. (2013)** and **Haraf *et al*. (2021)** did not note significant interbreeding differences in protein content in the same type of goose muscle. Significantly greater differences between breeds in all studies were observed for fat content.

Unfortunately, the available literature does not contain data on the amino acid composition of geese of the Large gray and Large white breeds, which indicates that such studies are unlikely to be conducted.

If we compare our data with the known amino acid profile of other goose breeds with similar characteristics, such as the above-mentioned Polish aboriginal breeds Rypińska and Garbonosa **(Okruszek *et al*., 2013; Haraf *et al*., 2018)**, Kartuska, Suwalska, Lubelska and Kielecka **(Haraf *et al*., 2021)**, we can note its similarity in the content of most amino acids except lysine. Lysine content (g/100 g of protein) in chest muscles (min13.24-max14.48) and thigh muscles (min 12.44-max13.38) of females in Polish goose breeds of Rypińska and Garbonosa, thigh muscles of goose breeds Kartuska, Suwalska, Lubelska and Kielecka (min11,53-max13,44) was significantly larger than in similar muscles of goose in Ukrainian breeds (in chest muscles, respectively, min10,11-max10,21; in thigh muscles min9.17-max9.33%), which, however, does not indicate the superiority of the former above the latter, but the necessity for further researching in this area. At the same time, despite the slightly higher content of lysine in the muscles of Polish goose breeds, the total amount of essential amino acids was the similar. It was in the range of min51.76-max55.63 in Polish goose breeds and min51.84-max52.80 in Ukrainian goose breeds respectively.

Both in our studies and in the studies of other authors, there are significant differences in the amino acid profile of the same type of muscle between different breeds of geese. Yes, **Gumułka & Połtowicz (2020)**, who studied the amino acid profile of the chest muscles of Polish breeds of geese Zatorska and White Koluda noted that the chest muscles of the breed Zatorska were characterized by higher content of some essential (Glu, Asp, Ala) and essential amino acids (Val, Thr). Their thigh muscles were characterized by smaller content Gly, Lys and Leu essential amino acids and larger Pro and Ile acids than in White Koluda. Instead, **Geldenhuys *et al*. (2015)**, who studied the amino acid profile of the chest muscles of both sexes of Egyptian geese, did not note significant differences between them, but found a significant effect on the amino acid composition of the muscles. These differences were attributed to differences in seasonal feeding. There were no significant differences in the amino acid profile of the chest and thigh muscles depending on the sex of **Boz *et al*. (2019)**. At the same time, they found quite significant differences in this profile for different breeds of geese.

The sum of the NAC and the NAC index of the chest muscles and thigh muscles of the Great Grey and Great White breeds of geese obtained in our study exceed similar values for the standard protein by about 1.8 times and agree with similar values for other breeds of geese with similar characteristics **(Okruszek *et al*., 2013; Haraf *et al*., 2018 and 2021)** and indicate their high nutritional value. However, it is advisable to continue research in this direction to clarify the data obtained. Another important issue is the study of the amino acid profile of the muscles and the fatty acid profile of fat of these breeds of geese, depending on the technology of breeding and type of poultry feeding.

CONCLUSIONS

The muscles of the chest and thighs of the Large gray and Large white breeds of geese raised under similar housing and feeding conditions did not differ significantly in chemical composition and amino acid profile, although there were some differences between them. Significant differences were observed in the chemical composition and amino acid profile of the chest and thigh muscles within each breed, which can be explained by different types of protein.

Estimation of the content of essential amino acids (AAS) in the muscles of the chest and thighs of geese of both breeds compared to their content in the standard protein (FAO, 2013) according to FAO/WHO (2002) shows that they contain sufficient amounts of all essential amino acids. It indicates the high nutritional value of goose meat of these breeds. This is also confirmed by the general index of essential amino acids of goose meat, which is about 1.8 times higher than the same index of the reference protein.

Acknowledgments: the authors of the work express their sincere gratitude to the director of State Poultry Research Station NAAS for the opportunity to conduct research.

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