

Effect of slaughter age and muscle type on selected meat quality traits and fatty acid composition of Lindovskaya geese

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Summary

The study was conducted in order to determine how the slaughter age (SA) and muscle type (MT) affect technological properties and fatty acid composition (FAC) of meat among Linda geese reared under the breeder conditions. A total of 16 male geese were slaughtered in order to determine the technological properties and FAC of meat. It was determined that the effect of SA on pH₁₅ and pH₂₄ (TM), water holding capacity (WHC), cooking loss (CL), and drip loss (DL) of the thigh muscle was all statistically significant ($P < 0.05$). The effect of SA on pH₂₄, WHC, CL, and the 168th-hour DL of pectoral muscle (PM), was statistically significant ($P < 0.05$). Moreover, the effect of MT on pH₁₅, pH₂₄, WHC, CL and DL in the 12th week and on pH₁₅, pH₂₄, WHC and DL in the 16th week was found to be statistically significant ($P < 0.05$). Additionally, the effect of SA on monounsaturated fatty acid (Σ MUFA) of TM and polyunsaturated fatty acid (Σ PUFA) of PM and $\Sigma\omega$ -6 ratios was statistically significant ($P < 0.05$). Consequently, it was concluded that SA was better in the 12th week than the 16th week and PM was better than TM. The 16-week TM was better in terms of Σ MUFA, the 12-week PM was better in terms of Σ PUFA and $\Sigma\omega$ -6, and the 12-week TM was better in terms of $\Sigma\omega$ -3 amount and ω -6/ ω -3 ratio. Therefore, it can be recommended that 12-week-old Linda geese be selected in terms of selected meat traits and FAC of meat.

Keywords: fatty acid, Lindovskaya geese, meat quality, muscle type, slaughter age

Demanding healthier, higher quality, and better tasting animal products is gradually increasing. Goose meat is one such product, whereby its quality characteristics and fatty acid content are quite different from other meats of poultry. In Turkey, most geese are native breeds and as of 2017, there are 978.834 geese in Turkey (30). Geese from different breeds have been recently reared in Turkey as well, but their number is not known exactly. These breeds include primarily Emden, Toulouse, Chinese and Linda geese. Linda are the result of the breeding of Russian native geese reared in the Nizhny Novgorod with Chinese, Adler, Solnechnogorsk, and Gorky geese. Linda goose corresponds to more than 60% of Russia's goose population and has been acknowledged as a registered breed

since 1994. The Linda geese have heavy bodies and white feathers (25).

Many factors affect both meat quality and fatty acid composition (FAC) of poultry (34). Factors such as genetics, origin, sex, slaughter age, method of slaughter, slaughtering conditions, muscle type, breeding, and feeding as well as different methods used all affect the meat quality and FAC of geese (8, 12). In Turkey, several studies have been conducted in order to determine the meat quality and FAC of Turkish native geese species (26, 34). However, no study investigating the meat quality and FAC of Linda geese has been found to date.

This study was conducted in order to determine the effect of slaughter age (SA) and muscle type (MT) on selected meat quality traits and fatty acid composition

tion of the meat among Linda geese under the breeder conditions.

Material and methods

Location of the study, animals, and data collections.

The study was conducted in a private farm in the village of Kibriltli in the province of Burdur. Wing numbers were affixed to the goslings. The geese were reared and fed by breeders. The goslings were kept under 24 hours of light every day for the first week. From the second week onwards, the daily photoperiod was 16 hours of light and 8 hours of darkness. The pen temperature was 32-34°C in the first week, and then it was incrementally decreased by 3-5°C until it reached to 19-20°C by the 4th week. During this period, the goslings were fully feathered and were sent to graze. They were fed with vegetation having a feed value. Chick starter feed, triticale, corn product, and sugar beet were also given to the geese in addition to grazing. The nutrient content of the feed (in Tab. 1) was determined according to the method reported by the AOAC (4). The metabolizable energy level of the feed was calculated based on Titus and Fritz (31). The feed and water were given *ad libitum*. A total of 16 male geese, including 8 at 12 weeks of age and 8 at 16 weeks of age, were slaughtered, and the quality characteristics and FAC of meat were examined. The slaughtering was performed in the farm where the study was conducted.

The pH values of the muscles (*M. pectoralis major* and *M. peroneus longus*) were measured from a depth of 2.5 cm under the surface both 15 minutes and 24 hours after the slaughtering via a portable pH meter (Hanna Instruments HI 9024 microcomputer, Portugal) with spearhead glass electrode (HI 1230) calibrated at buffers pH levels of 4.01 and 7.01 at ambient temperature.

Cooking loss (CL) was determined 72 hours after the slaughtering process based on Honikel's technique (19). Once a meat sample was weighed for each goose (Precisa XB2200C, Labor Technique, Swiss made, 0.01 accuracy) and placed in a plastic bag, it was cooked in a water bath at 80°C for 1 hour. It was then taken from the water bath and cooled in cold water. The sample was removed from the bag, blotted dry, and weighed. CL was the weight difference between the precooked/blotted dry weight and the post-cooked weights and it was expressed as a percentage of the precooked weight.

Drip losses (DL) were determined 72 hours after the slaughtering process based on Bond and Warner's technique (9). DL values of the meat samples was calculated 3 days after slaughtering. The samples were then stored at

4°C for 3 days and re-weighed. The percentage of DL was calculated based on the ratio of the weight loss to the initial sample weight.

Water holding capacity (WHC) was determined based on a technique specified by Barton-Gade et al. (7). Muscle samples weighing approximately 5 g were placed between two pieces of filter paper (Whatman, 1 Qualitative Circles 110 mm Ø, Cat No 1001-110, GE Healthcare UK Limited, Amersham Place Little Chalfont, Buckinghamshire, HP7 9NA, UK, and Made in China) and pressed under a weight of 2.250 g for 5 min. WHC was expressed as the percentage value of weight loss of the 5 g meat samples.

In order to determine the fatty acid profile, meat samples (pectoral and thigh) were taken from the aged carcass (24 hours), packaged in plastic packages, and stored at -80°C until analyses at Burdur Mehmet Akif Ersoy University's Scientific and Technical Application and Research Center. The chemicals used in the analyses were Millipore Sigma products. The meat samples were homogenized using a PRO Scientific R200 homogenizer. During the centrifugation, Nüve 800R, Turkey model centrifuge was used. Analyses were performed in two parallels. The crude fat amount of the samples was determined using a BUCHI AG E-816 HE model hot extraction device according to AOAC 991.36 (3). The lipid extraction from the samples was performed based on modifications proposed by Christie (13) and Jeronimo et al. (20). 1 g of meat sample was weighed on a 50 mL plastic falcon, whereby 20 mL dichloromethane-methanol (2:1 v/v) was added and homogenized for 2 minutes. Afterwards, a 5 mL of 0.88% KCl solution was added and mixed with the vortex for about 1 minute, whereupon the centrifugation was performed at 1000 rpm for 10 minutes. Any impurities that were not lipid in the supernatant were removed. The lipid-containing liquid phase (subfraction) was removed, and the solvent in this phase was removed from the water bath at 30°C using nitrogen, and the lipids were extracted in pure form. The fatty acids of the lipid fraction were prepared according to IUPAC 2.301 (14). The Supelco® 37 Component FAME Mix fatty acid standard was used to identify the fatty acid profile. The following device, Shimadzu Gas Chromatography (Shimadzu GC-2025, AOC-20i Auto-injector), and the operation condition were used for the fatty acid profile analysis of the samples.

Statistical analysis. The data were statistically compared by using 17.0 version of Minitab statistical packaged software. Being applied to compare two independent groups, T-test was used in order to determine the effects of SA and MT on meat quality characteristics and FAC at significant level of P < 0.05.

Tab. 1. Nutrient composition of additional goose feeds in dry matter basis

Material	Dry matter %	Crude ash %	Ether extract %	Crude protein %	Crude fiber %	N free extract	Metabolic energy* (MJ/kg)
Starter feed	92.00	10.26	4.20	17.31	3.96	64.25	11.14
Triticale	93.17	1.45	2.17	10.85	1.95	83.55	12.19
Concentrate feed	97.69	38.22	21.17	15.12	1.51	23.95	9.87
Corn by-product	66.73	24.05	9.90	12.04	3.02	50.96	10.14

Explanations: Titus and Fritz (31); *ME (MJ/g) = 133.06 (crude protein) + 232.91 (ether extract) - 4.68 (crude fiber) + 122.77 (nitrogen free extract)

The Local Ethics Commission of Experimental Animals (Decision no: MAKU-HADYEK/2017-349) at Burdur Mehmet Akif University approved this study.

Results and discussion

Table 2 shows how the slaughter age and muscle type of the Linda geese affected the characteristics of its meat quality. It was determined that the effect of slaughter age (SA) on pH₁₅, pH₂₄, water holding capacity (WHC), cooking loss (CL) and the drip losses (DL) of the thigh muscle (TM) was statistically significant ($P < 0.05$). The effect of the SA on pH₂₄, WHC, CL, and the 168th-hour DL of the breast muscle (BM) was statistically significant ($P < 0.05$). As SA increased, pH₁₅ and pH₂₄ levels of TM and PM increased, while their WHC, CL, and DL values decreased. It was also found that the effect of MT on pH₁₅, pH₂₄, WHC, CL, and DL in the 12th week and on pH₁₅, pH₂₄, WHC, and DL in the 16th week was statistically significant ($P < 0.05$). In both weeks, TM was higher in terms of pH₁₅ and pH₂₄ values than PM. In contrast, the PM was higher in terms of WHC and DL values than TM.

Considering that no study examining the meat quality characteristics and FAC of Linda geese was found, the results of the study must be compared mostly with other breeds of geese reared both in Turkey and around the world. In this study, it was determined that the effect of SA on pH₁₅ of TM and pH₂₄ of TM and PM was significant. In a study conducted on the native goose breeds in Turkey, Kirmizibayrak et al. (21) reported that

the effect of the SA on pH₂₄ value of the TM and BM was statistically non-significant and Uhlirova et al. (32) reported that the effect of SA on pH₂₄ value of the BM in the Eskildsen Schwer and Czech geese was statistically non-significant. However, in the studies conducted on poultry other than geese, it has been reported that the pH value decreases with increasing SA and weight (1, 2, 6). The pH₁₅ values in this study were higher than the pH₁₅ (6.06-6.39) found by Sari et al. (26) in 14-week-old native Turkish geese and the pH₁₅ (6.56-6.61) found by Okruszek (22) in 24-week-old Suwalki and Kartuzy geese. Additionally, pH₂₄ value found in this study was higher than pH₂₄ value found by Sari et al. (26) for 14-week-old Turkish geese (5.76-6.15), by Yakan et al. (34) for 8-9 month-old mottled geese (5.74 and 5.76) and by Kirmizibayrak et al. (21) for 6-8 and 18-20 month-old native Turkish geese (5.74-6.04). These differences were associated with the differences in the breed, feeding, slaughter age, slaughter weight, slaughter conditions, processes applied after the slaughtering, and the measurement device for pH.

The most important criteria for consumers to buy meat are the sensory and nutritional quality, as well as price and product safety (21). WHC is the determining factor in the sensory quality. In the study, it was determined that the effect of SA and MT on WHC was significant. WHC of PM was higher than TM and WHC specified in the 12th week was higher compared to the value found in the 16th week. In other words, PM released more water than TM and the geese slaughtered in the 12th week released more water compared to the geese slaughtered in the 16th week. In this study, WHC determined for PM in the 12th and 16th weeks was higher than the values reported by Yakan et al. (34) for white and mottled geese (9.60 and 9.32% at the 72nd hour) and by Sarica et al. (27) for white and mottled male geese (3.63 and 3.78% at the 72nd hour). However, WHC of TM determined in the 12th and 16th weeks in this study was found to be lower than Sari et al.'s (27) values for 14-week old native Turkish geese (11.5-14.2%). These differences were associated with the differences in breed, care, feeding, and slaughter age.

The proteins in meat become denatured because of heat treatment, whereby a certain amount water is released as a result of this effect, which results in CL (19). In this study, it was found that CL of PM in the 16th week was lower than the values reported by Uhlirova et al. (32) for Eskildsen Schwer geese of the same sex and age (35.73%). The CL determined in the 12th week was higher than the value reported by the same researcher. CL of TM in the 16th week found in this study was similar to the values reported by Sari et al. (26) for the 14 week-old Turkish

Tab. 2. Effect of slaughter age and muscle type on selected meat quality characteristics of Lindovskaya geese

Characteristics	Muscle type	Slaughter age		P
		12 th week	16 th week	
pH ₁₅		*	***	
	Thigh muscle	6.86 ± 0.05	7.34 ± 0.09	***
	Pectoral muscle	6.70 ± 0.05	6.80 ± 0.08	ns
pH ₂₄		*	**	
	Thigh muscle	6.43 ± 0.05	7.09 ± 0.11	***
	Pectoral muscle	6.20 ± 0.06	6.68 ± 0.07	***
Water holding capacity %		*	***	
	Thigh muscle	11.69 ± 0.98	6.83 ± 0.31	***
	Pectoral muscle	14.40 ± 0.71	9.98 ± 0.60	***
Cooking loss %		*	ns	
	Thigh muscle	37.86 ± 0.56	32.29 ± 2.10	*
	Pectoral muscle	41.24 ± 1.30	30.95 ± 2.00	***
72 h Drip loss %		*	*	
	Thigh muscle	1.06 ± 0.07	0.82 ± 0.05	*
	Pectoral muscle	1.62 ± 0.18	1.15 ± 0.12	ns
168 h Drip loss %		*	***	
	Thigh muscle	1.13 ± 0.14	0.71 ± 0.04	**
	Pectoral muscle	2.01 ± 0.27	1.21 ± 0.08	*

Explanations: ns – non significant at $P > 0.05$; * – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$

Tab. 3. Effect of slaughter age and muscle type on fatty acid composition

Fatty acids	Muscle type	Slaughter age		P
		12 th week	16 th week	
Lauric acid – C12:0		*	ns	
	Thigh muscle	0.24 ± 0.04	0.18 ± 0.03	ns
	Pectoral muscle	0.12 ± 0.02	0.15 ± 0.02	ns
Miristic acid – C14:0		ns	ns	
	Thigh muscle	0.26 ± 0.03	0.29 ± 0.03	ns
	Pectoral muscle	0.20 ± 0.02	0.28 ± 0.02	*
Palmitic acid – C16:0		*	***	
	Thigh muscle	17.64 ± 0.34	18.90 ± 0.42	*
	Pectoral muscle	19.07 ± 0.54	21.22 ± 0.26	**
Palmitoleic acid – C16:1 (9)		**	*	
	Thigh muscle	1.05 ± 0.14	1.58 ± 0.11	*
	Pectoral muscle	0.50 ± 0.04	1.24 ± 0.11	***
Margaric acid – C17:0		**	*	
	Thigh muscle	0.16 ± 0.01	0.15 ± 0.01	ns
	Pectoral muscle	0.21 ± 0.01	0.18 ± 0.01	ns
Stearic acid – C18:0		ns	ns	
	Thigh muscle	12.39 ± 0.62	10.47 ± 0.57	*
	Pectoral muscle	13.00 ± 0.95	11.10 ± 0.46	ns
Elaidic acid – C18:1 (9t)		ns	ns	
	Thigh muscle	0.67 ± 0.07	0.46 ± 0.09	ns
	Pectoral muscle	0.55 ± 0.14	0.48 ± 0.05	ns
Oleic acid – C18:1 (9) ω-9		ns	ns	
	Thigh muscle	26.85 ± 1.74	31.99 ± 1.47	*
	Pectoral muscle	24.86 ± 3.72	30.75 ± 1.53	ns
Linoelaidic acid – C18:2 (9t, 12t)		ns	ns	
	Thigh muscle	0.35 ± 0.04	0.21 ± 0.04	*
	Pectoral muscle	0.34 ± 0.09	0.25 ± 0.03	ns
Linoleic acid – C18:2 (9, 12) ω-6		ns	ns	
	Thigh muscle	25.42 ± 0.36	22.43 ± 1.48	ns
	Pectoral muscle	24.95 ± 1.52	20.96 ± 1.25	ns
Arachidic acid – C20:0		**	ns	
	Thigh muscle	0.13 ± 0.01	0.11 ± 0.01	ns
	Pectoral muscle	0.21 ± 0.02	0.13 ± 0.01	**
Eicosenoic acid – C20:1 (11)		**	ns	
	Thigh muscle	0.24 ± 0.01	0.24 ± 0.01	ns
	Pectoral muscle	0.32 ± 0.02	0.23 ± 0.01	**
Alpha-Linolenic acid – C18:3 (9, 12, 15) ω-3		ns	ns	
	Thigh muscle	0.71 ± 0.05	0.84 ± 0.06	ns
	Pectoral muscle	0.57 ± 0.05	0.76 ± 0.06	ns
Eicosadienoic acid – C20:2 (11, 14) ω-6		***	ns	
	Thigh muscle	0.45 ± 0.03	0.34 ± 0.02	*
	Pectoral muscle	0.73 ± 0.06	0.35 ± 0.02	***
Behenic acid – C22:0		*	ns	
	Thigh muscle	0.33 ± 0.03	0.22 ± 0.02	*
	Pectoral muscle	0.48 ± 0.05	0.22 ± 0.02	***
Eicosatrienoic acid (dihomo-γ-linolenic acid) – C20:3 (8, 11, 14) ω-6		**	ns	
	Thigh muscle	0.20 ± 0.02	0.22 ± 0.02	ns
	Pectoral muscle	0.31 ± 0.03	0.26 ± 0.02	ns
Tricosanoic acid – C24:0		ns	ns	
	Thigh muscle	8.67 ± 0.92	7.55 ± 0.77	ns
	Pectoral muscle	9.46 ± 0.76	7.93 ± 0.62	ns
Nervonic acid – C24:1 (15)		ns	ns	
	Thigh muscle	1.97 ± 0.24	1.67 ± 0.17	ns
	Pectoral muscle	2.10 ± 0.17	1.61 ± 0.18	ns
Docosahexaenoic acid (DHA) – C22:6 (4, 7, 10, 13, 16, 19) ω-3		ns	ns	
	Thigh muscle	0.48 ± 0.10	0.42 ± 0.06	ns
	Pectoral muscle	0.37 ± 0.04	0.32 ± 0.06	ns
Total fatty acid		ns	ns	
	Thigh muscle	99.68	99.68	
	Pectoral muscle	99.72	99.67	
Unidentified		ns	ns	
	Thigh muscle	0.32	0.32	
	Pectoral muscle	0.28	0.33	

Explanations: as in Tab. 2.

geese. CL values determined in the geese slaughtered in both weeks were higher in this study compared to the values determined by Fernandez et al., (15) for Landes geese slaughtered at 13 weeks of age (19.2-20.5%). These differences may be associated with differences in breed, feeding style, slaughter age, slaughter weight, cooking temperature and cooking time.

In this study, it was determined that the effect of SA on the 72nd-hour DL of PM was insignificant, the effect of SA on DL of TM was significant, and DL decreased with increasing SA. Boz et al. (10) also obtained a similar result, indicating that the 72nd-hour and 168th-hour DL values of TM in both 12th and 16th weeks were lower compared to PM. All of the DL values obtained in this study were lower than those reported by Kirmizibayrak et al. (21), Sarica et al. (27), Sari et al. (26), and Boz et al. (10).

Table 3 shows how slaughter age and muscle type affected the fatty acid composition of the geese. It was revealed that the effect of SA on the myristic, palmitoleic, arachidic, eicosenoic, eicosadienoic and behenic acid ratios of PM was statistically significant ($P < 0.05$). The effect of the SA on the palmitoleic, stearic, oleic, linoelaidic, eicosadienoic, and behenic acid ratios of TM was also statistically significant ($P < 0.05$). Similarly, the effect of MT on the lauric, palmitic, palmitoleic, margaric, arachidic, eicosenoic, and eicosatrienoic acid ratios in the 12th week was statistically significant ($P < 0.05$). Likewise, the effect of MT on the palmitic, palmitoleic, and margaric acid ratios in the 16th week was statistically significant ($P < 0.05$).

Table 4 shows the effect of slaughter age and muscle type on the content of fatty acid type. It was established that the effect of SA on monounsaturated fatty acid (Σ MUFA) and polyunsaturated fatty acid (Σ PUFA) contents in total was statistically significant ($P < 0.05$).

The Σ UFA content of the goose meat was approximately 36% higher compared to its saturated fatty acid (Σ SFA) content. However, the effect of MT on fatty acid type was statistically insignificant in both weeks ($P > 0.05$).

Tab. 4. Effect of slaughter age and muscle type on fatty acid type content

Fatty acids	Muscle type	Slaughter age		P
		12 th week	16 th week	
ΣSFA		ns	ns	
	Thigh muscle	41.79 ± 1.48	39.54 ± 1.25	ns
	Pectoral muscle	44.83 ± 2.21	42.82 ± 1.03	ns
ΣUFA		ns	ns	
	Thigh muscle	57.89 ± 1.49	60.14 ± 1.25	ns
	Pectoral muscle	54.88 ± 2.22	56.85 ± 1.02	ns
ΣMUFA		ns	ns	
	Thigh muscle	28.82 ± 1.74	34.27 ± 1.51	*
	Pectoral muscle	26.23 ± 3.70	32.71 ± 1.57	ns
ΣPUFA		ns	ns	
	Thigh muscle	29.07 ± 0.42	25.87 ± 1.40	ns
	Pectoral muscle	28.65 ± 1.68	24.14 ± 1.24	*
Σω-6		ns	ns	
	Thigh muscle	26.07 ± 0.36	22.99 ± 1.47	ns
	Pectoral muscle	25.99 ± 1.58	21.56 ± 1.25	*
Σω-3		*	ns	
	Thigh muscle	1.19 ± 0.05	1.26 ± 0.09	ns
	Pectoral muscle	0.95 ± 0.07	1.08 ± 0.07	ns
ω-6/ω-3		*	ns	
	Thigh muscle	22.18 ± 0.95	19.06 ± 1.95	ns
	Pectoral muscle	28.09 ± 1.99	20.80 ± 2.26	*

Explanations: The trans isomers of DHA are not included in the calculation of the amount Σω-3; ns – non significant at $P > 0.05$; * – $P < 0.05$; ** – $P < 0.01$; *** – $P < 0.001$. Fatty Acids: ΣSFA – saturated fatty acid, ΣUFA – unsaturated fatty acid, ΣMUFA – monounsaturated fatty acid, ΣPUFA – polyunsaturated fatty acid, Σω-6 – Omega 6, Σω-3 – Omega 3

Tab. 5. Effect of slaughter age and muscle type on fat ratios

Fatty ratio %	Muscle type	Slaughter age		P
		12 th week	16 th week	
Wet weight		ns	ns	
	Thigh muscle	0.26 ± 0.10	1.04 ± 0.21	**
	Pectoral muscle	0.16 ± 0.07	1.34 ± 0.16	***
Dry weight		ns	ns	
	Thigh muscle	1.13 ± 0.43	4.38 ± 0.86	**
	Pectoral muscle	0.71 ± 0.29	5.53 ± 0.63	***

Explanations: ns – non significant at $P > 0.05$; ** – $P < 0.01$; *** – $P < 0.001$

The effects of slaughter age and muscle type on fat ratios were illustrated in Table 5. The fat ratios of TM and PM slaughtered during the 16th week increased on both dry and wet weight basis compared to those slaughtered during the 12th week ($P < 0.05$). This increase was approximately four times in the thigh samples, and approximately 8 times in the pectoral samples. There was no statistically significant difference between the

fat ratios of TM and PM in the geese slaughtered in the 12th week. The same situation was observed also in the geese slaughtered in the 16th week, but the fat ratio of PM in the 16th week was higher compared to the TM.

Linoleic acid, linolenic acid, and docosahexaenoic acid (DHA) are essential fatty acids and for this reason its determination in goose meat is important. In a study conducted by Geldenhuys et al. (16) on Egyptian geese slaughtered in November (summer) in Stellenbosch, South Africa, they found that the oleic acid was 40.38% and 35.91%, the linoleic acid was 16.43% and 14.94%, and the linolenic acid was 3.55% and 4.99% in PM and TM, respectively. They determined that the stearic acid in PM and TM was 10.07% and 10.57%, respectively. The oleic acid was 24.37% and 30.76%, the linoleic acid was 13.56% and 11.48%, and the linolenic acid was 10.63% and 13.15% in PM and TM, respectively among the geese slaughtered in July (winter). Stearic acid in PM and TM was 14.29% and 11.22%, respectively. On the other hand, in this study, it was determined that oleic acid was 24.86% and 26.85%, linoleic acid was 24.95% and 25.42%, α-linolenic acid was 0.57% and 0.71%, and stearic acid was 13.00% and 12.39% in PM and TM of the geese slaughtered in the 12th week, respectively; whereas, oleic acid was 30.75% and 31.99%, linoleic acid was 20.96% and 22.43%, α-linolenic acid was 0.76% and 0.84%, and stearic acid was 11.10% and 10.47% in PM and TM of the geese slaughtered in the 16th week, respectively. The oleic acid content of PM and TM of the ones slaughtered in the 16th week was lower than the value found in the summer, and this was similar to Geldenhuys et al.'s values determined in the winter (16). The linoleic acid content in both PM and TM of the geese slaughtered in the 12th and 16th weeks was significantly high, whereas the α-linolenic acid content was quite low. The stearic acid content was similar when compared with the ratios determined by Geldenhuys et al. (16) for summer and winter months in their study.

In their study, Arslan et al. (5) determined the weighted ΣUFA as oleic acid (52.99%), linoleic acid (11.77%), and palmitoleic acid (2.30%), and the ΣSFA as palmitic acid (21.85%) and stearic acid (7.39%) for meat of Turkish native geese slaughtered in the 12th week. Sari et al. (26) conducted a study with Turkish native geese reared to freely graze and then slaughtered them during the 14th week and determined an oleic acid content of 41.4% and 37.3%, an linoleic acid content of 12.4% and 12.7%, a palmitoleic acid content of 4.21% and 4.09%, an alpha-linolenic acid content of 2.38% and 2.29%, an arachidonic acid of 2.15% and 2.65%, an eicosapentaenoic acid (EPA) content of 0.67% and 0.73%, and docosahexaenoic acid (DHA) content of 0.42% and 0.64% in TM and PM, respectively. They determined that palmitic acid was 23.9% and 24.8%, and stearic acid was 9.8% and 11.5%, respectively in TM and PM. In a study conducted including female Polish native geese slaughtered during the 17th week,

Haraf et al. (18) determined the fatty acid profile of PM and TM as follows: oleic acid as 39.92% and 41.75%, linoleic acid as 15.01% and 14.51%, palmitoleic acid as 2.35% and 2.70%, linolenic acid as 1.50% and 1.28%, arachidonic acid as 4.12% and 3.99%, eicosapentaenoic acid (EPA) as 0.68% and 0.68%, docosahexaenoic acid (DHA) as 0.41% and 0.42%, and adrenic acid (C22:4, ω -6) as 0.80% and 0.82%, respectively. They also found the palmitic acid content as 21.67% and 20.50%, and stearic acid as 6.34% and 9.00%, respectively in PM and TM. In their study including Czech native geese slaughtered during 8th and 16th weeks, Uhlírova et al. (33) examined the fatty acid profile of TM of male and female geese from different genotypes and found that the oleic acid content was in the range of 37.17-38.88%, the linoleic acid content was in the range of 15.46-19.30%, the palmitoleic acid content was in the range of 2.46-2.73%, the linolenic acid content was in the range of 0.88-1.13%, the arachidonic acid content was in the range of 4.96-5.50%, the eicosapentaenoic acid (EPA) content was in the range of 0.02-0.03%, the docosahexaenoic acid content (DHA) was in the range of 0.80-0.93%, the clupadonic acid (C22:5) content was in the range of 0.44-0.48%, and the eicosanoic (C20:1) acid was in the range of 0.26-0.30%. They found that the palmitic acid content was in the range of 19.25-20.08%, the stearic acid content was in the range of 9.61-10.63%, and the myristic acid was in the range of 0.71-0.86% in TM.

In the present study, it was determined that the oleic acid and palmitoleic acid contents determined in both PM and TM were considerably lower compared to those reported by Arslan et al. (5), Haraf et al. (18), Sari et al. (26), and Uhlírova et al. (33) and the linoleic acid values were higher than the values found in the literature. The stearic acid values determined in the samples of the 12th week in this study were higher than those reported by Arslan et al. (5), Haraf et al. (18), Sari et al. (26) and Uhlírova et al. (33). Correspondingly, the DHA levels determined by Sari et al. (26) for TM and by Haraf et al. (18) for both TM and PM were similar to the results of the present study. In this study, an increase was found in the oleic acid and palmitoleic acid amounts determined in TM of the geese slaughtered in the 16th week versus the 12th week, and there was a decrease in the palmitic acid and stearic acid ratios as well ($P < 0.05$). The fact that the types and amounts of the fatty acids of both TM and PM were different from the previous studies was thought to be associated with the differences in the goose breeds, the feed content consumed by the geese, and the breeding methods.

The Σ MUFA content in both TM and PM of the geese slaughtered during the 16th week increased compared to the samples of the 12th week; likewise, their polyunsaturated fatty acid content decreased. In their study including Egyptian geese in Stellenbosch, South Africa, Geldenhuys et al. (16) found that while the Σ PUFA content of the meat of the geese slaughtered in November

(summer) was 25.998%, it was 35.263% in July (winter). They associated this situation with the fatty acid content of the feed. Okruszek et al. (23) determined the Σ SFA as 29.60%; Σ UFA as 68.8%; the Σ MUFA ratio as 42.9%; the Σ PUFA ratio as 25.9% in the PM in 17-week-old for White Koluda geese. In a study conducted by Haraf et al. (18) involving Polish native geese breeds, the researchers determined that Σ SFA ratios of PM and TM were 31.56% and 30.12%, Σ UFA ratios were 65.74% and 67.19%, Σ MUFA ratios were 43.21% and 45.50%, and Σ PUFA ratios were 22.53% and 21.70%. As is seen in Table 3, the Σ SFA, Σ UFA, Σ MUFA% and Σ PUFA ratios were significantly lower in the present study compared to those reported by Uhlírova et al. (33) (30.28-32.13%, 67.87-69.73%, 42.22-44.34%, and 23.65-27.51%, respectively), with the exception for the Σ PUFA ratio determined by Haraf et al. (18). The fact that this study and the other aforementioned studies are not parallel with one another may be associated with the differences in breed, the breeding environment, and the feed content consumed by the geese.

Edible oils such as sunflower seed, canola oil, and corn oil contain the ω -6 fatty acids at the rates of 15-66% and these acids are taken sufficiently into the body upon consuming these oils. The seed oils consumed for cooking do not contain DHA and EPA, although they substantially contain the alpha-linolenic being ω -3 fatty acids. The body can convert the alpha-linolenic acid into long-chain eicosapentaenoic (EPA) and docosahexaenoic (DHA) acid, however this conversion is quite limited (11). The alpha-linolenic acid can be converted into EPA only by 6%, or into DHA by 4% in the body (17). Hence, we need to take the long-chain ω -3 fatty acids directly with the foods we consume. Previous studies reported that EPA and DHA consumption was useful in terms of its protective effects against cardiovascular disease and decreasing triglyceride and LDL cholesterol levels of blood. Even though ω -6/ ω -3 ratio varies from person to person, the ratio required to be taken into the body should be 4-6/1 (28, 29). In the present study, the meat of geese slaughtered during the 16th week contained ω -3 fatty acids of 1.08% and 1.26%, in PM and TM tissues respectively. Haraf et al. (18) reported that for PM and TM, $\Sigma\omega$ -6 ratios were 19.93% and 19.32%, the $\Sigma\omega$ -3 ratios were 2.60% and 2.39%, and the ω -6/ ω -3 ratios were 7.72% and 8.76, respectively. As can be seen in Table 3, the $\Sigma\omega$ -6 and ω -6/ ω -3 ratios obtained in the present study were significantly higher, whereas the $\Sigma\omega$ -3 ratios were lower compared to those reported by Haraf et al. (18).

In a study conducted by Haraf et al. (18) involving 17-week-old Polish native goose breeds (KA and LU), the researchers found that the fat ratios of PM and TM were 2.68% and 3.52%, respectively; whereas Uhlírova et al. (33) found that the fat ratios of the TM of the male and female Czech geese slaughtered were 2.46-2.54% in the 8th week and 2.94%-2.87%, respectively in the 16th week. As the goslings grew, the fat ratio in their muscle

tissue increased. They stated that these ratios were rather lower than the fat ratios of PM and TM of Italian White and Koluda White breeds (2.54-3.93% pectoral, 4.16-10.52% thigh). Okruszek et al. (24) conducted a study involving 17-week-old Polish native geese (Ry: Rypinska and Ga: Garbonosa) that the average fat ratio of PM and TM in the Ry breed was 3.06% and 3.91%; whereas, it was 2.39% and 2.84%, respectively in the Ga breed. In this study, it was determined that the fat ratios in TM and PM of the geese slaughtered during the 16th week were 4.38% and 5.53%, respectively, which in turn was considerably higher compared to those reported by Okruszek et al. (24), Haraf et al. (18) and Uhlirva et al. (33). These differences may stem from differences in breed, care, feeding, slaughter age, slaughter weight, and the method of analysis used.

It was concluded that SA was better in the 12th week than the 16th week, and PM was better than TM in terms of the technological properties of the meat. In turn, it was concluded that the Linda geese should be slaughtered during the 12th week due to the technological properties of the meat. When considering the FAC, it was determined that MT did not bear any effect whatsoever on all of the fatty acid ratios of the geese slaughtered during both sets of weeks. It was concluded that TM of 16-week-old geese was better in terms of Σ MUFA, PM of 16-week-old geese was better in terms of Σ PUFA, and $\Sigma\omega$ -6, and TM of 16-week-old geese was better in terms of $\Sigma\omega$ -3 amount and ω -6/ ω -3 ratio. Therefore, it can be recommended that Linda geese be picked and slaughtered at the age of 12 weeks because of selected meat quality traits and FAC of the meat.

References

1. Abdullah A. Y., Matarneh S. K.: Broiler performance and the effects of carcass weight, broiler sex and postchill carcass aging duration on breast file quality characteristics. *J. Appl. Poult. Res.* 2010, 19, 46-58.
2. Abdullah Y. A., Marwan M. M., Haitham O. M., Sulaiman K. M., Majdi A. A. I.: Effects of strain on performance, and age at slaughter and duration of post-chilling aging on meat quality traits of broiler. *Asian-Australas. J. Anim. Sci.* 2010, 23, 1645-1656.
3. AOAC.: Official methods of analysis of AOAC International. 18th ed. Current through Revision 4, Gaithersburg, Maryland 2011.
4. AOAC.: Official methods of analysis of the association of official analytical chemists. 14th ed. Association of Official Analytical Chemists. Arlington 1990.
5. Arslan C., Cital M., Saatci M.: Effects of L-Carnitine administration on growth performance, carcass traits, serum lipids and abdominal fatty acid composition of geese. *Rev. Med. Vet.* 2004, 155, 315-320.
6. Atasoy F., Yakan A., Uğurlu M., Ünal N., Aksu T., Cengiz S.: Carcass composition, meat quality and antibody levels in male and female Broiler chickens reared on low dietary protein. *Ankara Üniv. Vet. Fak. Derg.* 2010, 57, 49-54.
7. Barton-Gade P. A., Demeyer D., Honikel K. O., Joseph R. L., Puolanne E., Severini M., Smulders F., Tornberg E.: Reference methods for water holding capacity in meat and meat product: procedures recommended by an OECD working group, 39th International Congress of Meat Science and Technology, Calgary, Canada 1993.
8. Berri C. (ed.): Breeding and quality of poultry, [in:] Mead G. C. (ed.): Poultry Meat Processing and Quality. CRC Press, Cambridge 2004, p. 21-33.
9. Bond J. J., Warner R. D.: Ion distribution and protein proteolysis affect water holding capacity of longissimus thoracis et lumborum in meat of lamb subjected to antemortem exercise. *Meat Sci.* 2007, 75, 406-414.
10. Boz M. A., Sarica M., Yamak U. S.: Production traits of artificially and naturally hatched geese in intensive and free-range systems – II: slaughter, carcass and meat quality traits. *Br. Poult. Sci.* 2017, 58, 166-176.
11. Burdge G. C., Calder P. C.: Conversion of alpha-linolenic acid to longer-chain polyunsaturated fatty acids in human adults. *Reprod. Nutr. Dev.* 2005, 45, 581-597.
12. Castellini C., Berri C., Le Bihan-Duval E., Martino G.: Qualitative attributes and consumer perception of organic and free-range poultry meat. *World's Poult. Sci. J.* 2008, 64, 500-513.
13. Christie W. W. (ed.): Preparation of lipid extracts from tissues, [in:] Christie W. W. (ed.): Advances in Lipid Methodology. Dundee: Oily Press 1993.
14. Dieffenbacher A., Pocklington W. D. (eds.): Standard methods for analysis of oils, fats and derivatives (IUPAC). 7th Ed. Blackwell Scientific, Oxford 1987.
15. Fernandez X., Lahirigoyen E., Auvergne A., Molette C., Bouillier-Oudot M.: The effect of stunning methods on product qualities in force-fed ducks and geese. 1. Carcass downgrading and meat quality. *Animal* 2010, 4, 128-138.
16. Geldenhuys G., Hoffman L. C., Muller N.: The fatty acid, amino acid, and mineral composition of Egyptian goose meat as affected by season, gender, and portion. *Poult. Sci.* 2015, 94, 1075-1087.
17. Gerster H.: Can adults adequately convert alpha-linolenic acid (18:3n-3) to eicosapentaenoic acid (20:5n-3) and docosahexaenoic acid (22:6n-3). *Int. J. Vitam. Nutr. Res.* 1998, 68, 159-173.
18. Haraf G., Woloszyn J., Okruszek A., Orkusz A., Werenska M.: Fatty acids profile of muscles and abdominal fat in geese of Polish native varieties. *Anim. Sci. Pap. Rep.* 2014, 32, 239-249.
19. Honikel K. O.: Reference methods for the assessment of physical characteristics of meat. *Meat Sci.* 1998, 49, 447-457.
20. Jeronimo E., Alves S. P., Prates J. A. M., Santos-Silva J., Bessa R. J. B.: Effect of dietary replacement of sunflower oil with linseed oil on intramuscular fatty acids of lamb meat. *Meat Sci.* 2009, 83, 499-505.
21. Kirmizibayrak T., Onk K., Yazici K.: Effects of age and sex on slaughtering and carcass characteristics of Turkish native geese reared in free range production conditions in Kars province. *Kafkas Univ. Vet. Fak. Derg.* 2011, 17, 41-45.
22. Okruszek A.: Effect of genotype on the changes of selected physicochemical parameters of geese muscles. *Europ. Poult. Sc.* 2012, 76, 155-161.
23. Okruszek A., Woloszyn J., Grajeta H., Haraf G., Orkusz A.: Changes in the fatty acid profile of intramuscular fat in goose meat packed in different atmospheres. *Europ. Poult. Sc.* 2015, 79.
24. Okruszek A., Woloszyn J., Haraf G., Orkusz A., Werenska M.: Chemical composition and amino acid profiles of goose muscles from native Polish breeds. *Poult. Sci.* 2013, 92, 1127-1133.
25. Reuter Ya S.: State and the main directions of work with the Lindsowlke geese. 17th International Conference of WPSA, Sergiev Posad, Russia 2012, p. 95-97.
26. Sari M., Onk K., Sisman T., Tilki M., Yakan A.: Effects of different fattening systems on technological properties and fatty acid composition of goose meat. *Europ. Poult. Sc.* 2015, 79.
27. Sarica M., Boz M. A., Yamak U. S.: Meat quality traits and some blood parameters of white and multicolor geese reared in backyard in Yozgat. *Anadolu Journal of Agricultural Science* 2014, 29, 147-153.
28. Simopoulos A. P.: The Importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. *Exp. Biol. Med.* 2008, 233, 674-688.
29. Stanley J. C., Elsom R. L., Calder P. C., Griffin B. A., Harris W. S., Jebb S. A., Lovegrove J. A., Moore C. S., Riemersma R. A., Sanders T. A.: The effects of the dietary n-6: n-3 fatty acid ratio on cardiovascular health. *Br. J. Nutr.* 2007, 98, 1305-1310.
30. Turkish Statistically Institute (T.S.I.): Animal Production Statistics 2018.
31. Titus H. W., Fritz J. C. (ed.): Percentage multipliers for computing metabolizable energy values, for chickens, of some feedstuffs used in the feeding of poultry, [in:] Danville I. L. (ed.): The Scientific Feeding of Chickens. 5th ed., Interstate 1971, p. 295-298.
32. Uhlirva L., Tumova E., Chodova D., Vlockova J., Ketta M., Volek Z., Skrivanova V.: The effect of age, genotype and sex on carcass traits, meat quality and sensory attributes of geese. *Asian-Australas. J. Anim. Sci.* 2018, 31, 421-428.
33. Uhlirva L., Tumova E., Chodova D., Volek Z., Machander V.: Fatty acid composition of goose meat depending on genotype and sex. *Asian-Australas. J. Anim. Sci.* 2019, 32, 137-143.
34. Yakan A., Aksu Elmali D., Elmali M., Sahin T., Motor S., Can Y.: Carcass and meat quality characteristics of white and multicolor geese under local breeder conditions. *Kafkas Univ. Vet. Fak. Derg.* 2012, 18, 663-670.

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