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The effect of the production system and slaughter age on meat quality in pheasants*

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In this study the nutritional composition, fatty acid content, total and index values of fatty acids were analyzed in breast and thigh meat of pheasants (male-female mixed) reared in intensive and free-range production systems at the 14, 16 or 18 weeks of age. The experimental material consisted of skinless breast and thigh meat. Analyses were carried out on a total of 24 samples with 2 replicates from skinless breast and thigh meat samples obtained from slaughtered (male-female mixed) pheasants that were grown for 14, 16, or 18 weeks in free-range and intensive systems. Following slaughter of the pheasants, breast and thigh meat samples were frozen at -18 / -22°C until analysis. The effect of the production system (PS) on the nutrient composition of breast and thigh meat was non-significant (P>0.05). The C20:2 level in breast meat was higher in meat produced using the intensive system, while C15:0, C17:0, and C20:1 contents were higher in thigh meat produced in the free-range system (P<0.05). The C18: 2n6c, C22: 1n9, C22: 6n3, PUFA, ∑n-3, and ∑n-6 levels were lower and that of C20:2 was higher in breast meat at 14 weeks of slaughter age (P<0.05). Dry matter and crude ash ratios were higher in thigh meat at 18 weeks of age (P<0.05). In this study it was observed that the production system and slaughter age had no effect on meat quality traits except for some traits in breast and thigh meat of pheasants. However, considering the meat quality traits of pheasants it was determined that the meat has high nutritional value and low fat content, although its high saturated fatty acid content should also be taken into account.

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Pheasants are raised for various reasons, including commercial purposes such as meat and egg production, as a hobby, and for the supply of game to hunting grounds [Yamak 2015, Yamak *et al*. 2016]. The goal of breeding for meat production is to produce high carcass weight and ensure meat quality [Cetin and Kırıkcı 2000]. Because of its unique qualities, including low fat and cholesterol levels, high protein content, taste and aroma, pheasant meat is highly sought after, especially in Europe [Sarica *et al*. 1999, Kuzniacka *et al.* 2007]. It is also included in special feast menus and is appropriate for people on a diet.

As the world population grows, forests are being destroyed to support this growth. The destruction of forests to obtain agricultural and grazing lands, fuel supply and timber, followed by agricultural spraying and fertilization, leads to increased environmental pollution, culminating in an extreme and rapid threat to the natural habitats of pheasants [McGowan and Garson 1995, Cetin and Kırıkcı 2000]. Therefore, pheasant breeding is important not only for the supply of game materials, but also as an alternative production system. Expanding pheasant breeding in different production systems is a promising source of income. Meat obtained from domesticated game birds is of importance in human nutrition. There have been regular studies attempting to develop and revive pheasant breeding [Strakova *et al.* 2006, Yamak *et al.* 2016]. In these previous studies it was reported that broiler pheasants (both wild and domestic) should be studied in different feeding and production systems [Severin *et al.* 2006]. However, many consumers prefer the meat of animals bred using alternative methods to those bred in the conventional production system. Consumers consider meat produced in open production systems to be more delicious, nutritious and healthy [Sokolowicz *et al*. 2016]. Modern consumers prefer foods with low fat and cholesterol contents for a healthy and quality meal [Horbańczuk *et al.* 1998, Nuernberg *et al*. 2011].

Regarding production, live-carcass weight and meat quality characteristics are also taken into consideration for marketing purposes [Górska-Horczyczak *et al*. 2017]. Pheasant meat has a greater nutritional value, higher quality protein, lower fat content and higher essential oil and amino acid contents than chicken, duck and goose meat [Tucak *et al*. 2004, Adamski and Kuzniacka 2006, Strakova *et al*. 2006, Dordevic *et al.* 2010, Franco and Lorenzo 2013].

Meat quality is a complex characteristic affected by genetic and environmental factors and it may vary considerably between individual poultry species [Cooper *et al*. 2008, Horbanczuk *et al.* 2007, Yamak *et al.* 2016]. In particular, meat quality characteristics of poultry may change depending on genetic factors, production system and region, slaughter age, sex, feeding, slaughtering process, meat type and cuts [Sarica *et al.* 1999, Sokolowicz *et al.* 2016, Boz *et al.* 2017]. There are fewer studies on meat quality in domesticated game birds, such as pheasant and partridge, compared to the other poultry species [Horbańczuk and Wierzbicka 20016]. There are no studies on the quality characteristics of nutrients and fatty acids in different production systems in pheasants.

The objective of the present study is to evaluate effects of the production system and slaughter age on the nutrient composition and fatty acid contents in pheasants.

Material and methods

This study was carried out on pheasants bred at the Ondokuz Mayıs University Faculty of Agriculture Research Farm in Samsun, Turkey. Approval for all procedures was obtained from the Ondokuz Mayıs University Experimental Animals Ethics Committee.

After hatching, 200 1-day-old chicks were used in the experiment. Chicks were randomly allocated to pens belonging to either an intensive or "free-range" production system interspersed within windowed poultry houses, with four pens per system and 50 chicks per pen. Each group was housed in a 3.5×3.5 m pen covered with 0.5×0.5 cm wire mesh to contain the birds with one round feeder and one round drinker. All birds were fed ad libitum using the same commercial layer chicken diet based on corn and soybean meal (190 g CP and 11.72 MJ ME, 10.0 g lysine, 4.00 g methionine, 11.0 g Ca, 6.00 g P per kg) until 12 weeks of age, and with the layer chicken developer diet (160 g CP, 11.30 MJ ME, 3.50 g methionine, 7.20 g lysine, 10.0 g Ca, 4.00 g P per kg) from 12 weeks until the end of the experiment. Water was also provided *ad libitum*. The pens were interspersed in windowed poultry houses. In the four indoor pens wood shavings (8 cm thickness) were used as litter, which was not replaced during the study period. Infrared heaters were used for heating and incandescent bulbs for lighting. For the first 3 d, chicks were kept under continuous light. Between days 3 and 14 the light was gradually decreased to 20 h/d, which was maintained until 6 weeks. At this time, natural lighting (approximately 14 h/d) was applied until slaughter. Upon 6 weeks of age, birds in the outdoor "free-range" system were given 24h access to outdoor pens of 14 × 3.5 m accessible through a single doorway of 50×90 cm.

An 8h fasting period was applied prior to slaughter; only water was provided during this period. Birds were slaughtered in a semi-automated slaughtering house. Scalding (1 min at 56°C), plucking, cold-water chilling, vent opening, eviscerating and air chilling were performed using the slaughter lines. Analyses were carried out on a total of 24 samples with 2 replicates from skinless breast and thigh meat samples obtained from slaughtered (male–female mixed) pheasants that were grown for 14, 16, or 18 weeks in free-range and intensive systems. After slaughter, pheasant breast and thigh meat samples were kept in the freezer at -18/-22°C until analysis.

The method of Gokalp *et al.* [2010] was adopted to determine the nutritional composition of the samples. The AOAC 996.01 method was used to assay fatty acid methyl esters (FAME) [Satchithanandam et al. 2001]. Oil (0.1 g) obtained by the ether extraction method was mixed with 10 mL n-hexane. Next, 0.5 mL of 2 N methanolic potassium hydroxide solution was added and the mixture was stirred again. After 1–2 hours in a dark environment 1 µL of the upper phase was injected into a gas chromatograph. The fatty acid composition was analyzed using a flame ionization detector (FID) and a Restek RTX-2330 capillary column (60 m, 0.25 mm i.d., 0.1 µm film thickness, Bellefonte, PA (USA) in a Shimadzu gas chromatograph (model QP2010 Plus). After the column temperature was kept at 100°C for 3 minutes, it was increased to 240°C at a rate of 4°C per minute. It was kept for 18 minutes at the final temperature. The injection temperature was 250°C and the detector temperature was 255°C. Helium was used as the carrier gas and the flow rate was adjusted to 0.64 ml/min. The injection split ratio was set to 1:80. The LabSolution software was used to control the GC-FID system.

The 37 Component FAME mix (Supelco) was used as a standard. The FAME peaks were determined by comparing the retention times and chain lengths specified in the standard. Of the 37 total fatty acids in the standard, those that could not be detected in all samples and those that were below a certain value were not included in the results. In the total and index values, calculations were made for all the fatty acids. The international abbreviations of fatty acids in this study are given below.

Myristic acid (C14:0), pentadecanoic acid (C15:0), palmitic acid (C16:0), palmitoleic acid (C16:1), heptadecanoic acid (C17:0), stearic acid (C18:0), oleic acid (C18:1n9c), linoleic acid (C18:2n6c), cis-11-eicosenoic acid (C20:1), linolenic acid (C18:3n3), cis-11,14-eicosadienoic acid (C20:2), behenic acid (C22:0), erucic acid (C22:1n9), cis-11,14,17-eicosatrienoic acid (C20:3n3), cis-13,16-docosadienoic acid (C22:2), cis-4,7,10,13,16,19-docosahexaenoic acid (C22:6n3) DHA. Saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA), poly-unsaturated fatty acids (PUFA), and total unsaturated fatty acids (TUFA).

In this study, the atherogenic index (AI) and thrombogenic index (TI) were calculated according to Ulbricht and Southgate [1991] and Peiretti and Meineri [2008]; the nutritive value and desirable fatty acid (DFA) indexes were calculated according to Caneque *et al*. [2005] and Boz *et al*. [2019], while the hypocholesterolemic/hypercholesterolemic (h/H) index was calculated according to Ahmed *et al.* [2015].

AI (atherogenic index) = (C12:0 + (4*C14:0) + C16:0)/∑TUFA,

TI (thrombogenic index) = (C14:0 + C16:0 + C18:0)/[(0.5*MUFA) + (0.5*∑n6) + (3*∑n3) + (∑n3/∑n6)],

NV (Nutritive value) = (C18:0 + C18:1)/C16:0,

DFA (desirable fatty acids) = (C18:0 + TUFA),

h/H (hypocholesterolemic/hypercholesterolemic) = [(sum of C18:1 cis-9, C18:2n6, C20:4n6, C18:3n3, C20:3n6, C20:5n3, and C22:6n3)/(sum of C14:0 and C16:0)].

The present study was conducted in a 2 x 2 factorial design with 2 production system, and 2 slaughter age treatments. Data were analyzed via a factorial ANOVA (Bootstrap Analysis of ANOVA) using the GLM procedure in SPSS (Version 20). The model used for the statistical analyses of nutrient composition, fatty acid composition, total fatty acid and index values was:

$$y_{ij} = \mu + P_i + S_j + (PS)_{ij} + e_{ij}$$

where:

y_{ij} – the dependent variable;

μ – the overall mean;

P_i – the fixed effect of i-th production system (i = intensive and free-range);

S_j – the fixed effect of slaughter age (j = 14, 16, and 18 weeks of age);

$(PS)_{ij}$ – the interaction of the production system x slaughter age;

e_{ij} – the residual error term.

The Duncan test was performed for the comparison of slaughter age means. A level of P<0.05 was considered statistically significant.

Results and discussion

Nutrient Composition

The effect of the production system on the nutrient composition of breast and thigh meat was found to be insignificant (P>0.05, Tab. 1). While slaughter age did not affect breast meat nutrient composition (P>0.05), dry matter and crude ash ratio were higher in thigh meat at 18 weeks of age (P<0.05). The effect of the PS x age interaction on breast and thigh meat composition was not significant (P>0.05).

Table 1. Breast and thigh meat nutrient composition (%)

Production system	Age	Breast meat				Thigh meat			
		dry matter	crude protein	crude fat	crude ash	dry matter	crude protein	crude fat	crude ash
Intensive	14	27.40	23.18	0.53	1.06	24.65	20.29	0.46	0.94
	16	27.17	23.95	0.22	0.97	23.84	19.41	0.84	0.81
	18	27.51	23.58	0.36	1.02	25.60	20.38	1.53	1.12
Free range	14	26.95	23.11	0.18	1.14	24.15	18.85	0.72	0.98
	16	26.99	24.12	0.29	1.08	24.36	19.68	0.48	0.76
	18	28.13	24.10	0.58	1.23	25.96	19.50	1.20	1.09
SEM		0.1735	0.1860	0.0660	0.0330	0.2588	0.4004	0.1551	0.0425
Production system p-value		0.996	0.595	0.874	0.073	0.697	0.518	0.624	0.701
intensive		27.36	23.57	0.37	1.02	24.70	20.02	0.95	0.96
free range		27.36	23.78	0.35	1.15	24.82	19.34	0.80	0.94
Age p-value		0.230	0.200	0.463	0.431	0.009	0.938	0.120	0.001
14		27.18	23.14	0.35	1.10	24.40^b	19.57	0.59	0.96^b
16		27.08	24.04	0.26	1.03	24.10^b	19.54	0.66	0.78^c
18		27.82	23.84	0.47	1.12	25.78^a	19.94	1.36	1.11^a
Production system by age p-value		0.448	0.815	0.263	0.687	0.409	0.784	0.625	0.654

SEM – standard error of mean.
^{abc}Differences in superscript letters within "columns" represent significant differences between groups.

Meat quality characteristics greatly affect the attitude of consumers when buying meat and meat products [Hofbauer *et al*. 2010]. The nutritional value of meat obtained from game birds can be calculated based on the nutrient composition and fatty acid content. The chemical composition, including protein, fat and ash, is associated with important economic properties for poultry, as they are associated with meat production yield [Nuernberg *et al.* 2011]. Consumers prefer meat with a low fat content [Sokolowicz *et al*. 2016]. In their study Tucak *et al*. [2008] reported higher nutrient levels, whereas Hofbauer *et al.* [2010] reported similar nutrient composition values compared to those obtained in the present study. Tucak *et al.* [2008] found that the water content of breast meat in pheasants (female-male mixed) both hunted and farm-grown was 71.77-72.43%, protein content was 25.11-25.57%, fat content was 0.96-1.69% and ash amounted to 1.12-1.16%, respectively. In thigh meat water content amounted to 71.58-74.50%, protein content was 20.71-22.32%, fat content was 2.11-6.81% and ash value was 1.09-1.15%. Hofbauer *et al.* [2010] reported water content in breast meat both in hunted and farm-grown pheasants to be 71.83-71.85%, while protein content was 25.66–25.03%, the fat level was 0.35-0.52% and ash content was 1.39-1.30%, while the analogous values in thigh meat were 75.28-74.20%, 22.60-23.56%, 1.16-0.84%, and 1.32-1.39%, respectively. Severin et al. [2007] found higher dry matter and fat contents, lower protein content and similar ash content in thigh and breast meat when compared to the results of the present study. Vecerek *et al*. [2005] showed that the nutrient composition in breast and thigh meat varied depending on the slaughter age. Kokoszynski *et al*. [2018] determined higher dry matter, protein and fat levels in breast and thigh meat at week 16 compared to the present study results. Only the thigh meat dry matter and crude ash level increased in the present study. In general, body and muscle composition changes are thought to occur with age, including increases in protein, fat, and dry matter contents [Aberle *et al*. 2001]. The results of this study are in line with the proposed hypothesis.

Fatty Acid Composition

The C20:2 content in breast meat was higher in meat produced using the intensive system, while those of C15:0, C17:0, and C20:1 were higher in thigh meat produced in the free-range system ($P<0.05$, Tab. 2 and 3). While C22:6n3, C22:1n9, and C18:2n6c levels were lower at 14 weeks of age, that of C20:2 was higher in breast meat ($P<0.05$). In thigh meat the C16:1 content was higher at 14 weeks of age and that of C18:0 at 16 weeks of age ($P<0.05$). The effect of the PS x age interaction on C20:2 in breast meat was found to be significant ($P<0.05$).

The fat composition and content in meat play an important role in meat quality [Nuenberg *et al.* 2011], since fat and fatty acid compositions affect eating quality and nutritional value of meat [Öz and Çelik, 2015]. The amount of fat in human nutrition is very important for energy production, absorption of fat-soluble vitamins and essential fatty acids, especially for infants [Can *et al.* 2009].

Similarly to the present study, Nuernberg *et al.* [2011] found high levels of C16:0, C18:0, C18:1n9c and C18:2n6c fatty acids in breast and thigh meat both in wild and farmed pheasants. In addition, Kokoszynski *et al*. [2014] reported that the C18:0, C18:1, and C18:2 fatty acid levels were higher in breast and thigh meat of 16-week-old slaughtered pheasants. In addition, Kokoszynski *et al.* [2018] measured the C16:0, C18:0, C18:1n9c, and C18:2n6c fatty acid contents in breast and thigh meat in 16-week-old slaughtered pheasants. In particular, C16:0 and C18:2n6c levels were

Table 2. Pheasant breast meat fatty acid profile (%)

P	A	Fatty acids														
		C14:0	C15:0	C16:0	C16:1	C17:0	C18:0	C18:1n9c	C18:2n6c	C20:1	C18:3n3	C20:2	C22:0	C22:1n9	C20:3n3	C22:2	C22:6n3
I	14	1.04	3.69	25.02	3.69	0.35	24.84	23.07	12.84	0.43	0.24	0.40	1.03	1.63	0.10	0.77	0.24
	16	0.91	2.64	29.53	2.64	0.25	20.34	25.02	14.11	0.38	0.24	0.14	0.32	2.29	0.11	0.80	0.41
	18	1.13	2.52	28.14	2.52	0.48	17.54	29.77	15.67	0.42	0.22	0.11	0.28	1.82	0.12	1.11	0.27
FR	14	1.13	3.51	26.40	3.51	0.57	16.84	33.73	12.70	1.05	0.27	0.08	0.38	1.12	0.13	0.81	0.16
	16	1.03	2.12	29.33	2.12	0.30	24.05	20.43	14.08	0.61	0.19	0.17	1.01	2.29	0.24	0.84	0.40
	18	0.85	3.85	26.83	3.85	0.27	12.23	34.21	17.25	0.80	0.25	0.08	0.36	1.59	0.10	0.46	0.38
SEM		0.045	0.017	1.150	0.269	0.053	1.829	2.260	0.766	0.115	0.016	0.031	0.150	0.166	0.017	0.102	0.033
P p-value		0.867	0.526	0.988	0.684	0.869	0.390	0.454	0.781	0.139	0.905	0.011	0.901	0.441	0.177	0.442	0.918
I		1.03	0.20	27.57	2.95	0.36	20.91	25.95	14.21	0.41	0.23	0.22	0.55	1.92	0.11	0.89	0.31
FR		1.01	0.18	27.52	3.16	0.38	17.71	29.46	14.68	0.82	0.24	0.11	0.59	1.67	0.16	0.70	0.32
Age p-value		0.613	0.230	0.589	0.205	0.411	0.261	0.293	0.047	0.722	0.730	0.022	0.620	0.046	0.176	0.991	0.048
14		1.08	0.23	25.71	3.60	0.46	20.84	28.40	12.77^{b}	0.74	0.26	0.24^{a}	0.71	1.38^{b}	0.12	0.79	0.20^{b}
16		0.99	0.16	29.43	2.38	0.28	22.20	22.73	14.09^{ab}	0.50	0.22	0.15^{ab}	0.67	2.29^{a}	0.18	0.82	0.40^{a}
18		0.99	0.18	27.49	3.19	0.37	14.89	31.99	16.46^{a}	0.61	0.24	0.10^{b}	0.32	1.71^{ab}	0.11	0.78	0.33^{ab}
P x Age p-value		0.170	0.181	0.927	0.334	0.322	0.406	0.415	0.891	0.806	0.691	0.007	0.268	0.790	0.152	0.424	0.495

P – production system, A – age, I – intensive, FR – free range, SEM – standard error of mean.
[ab]Differences in superscript letters within "columns" represent significant differences between groups.

Table 3. Pheasant thigh meat fatty acid profile (%)

P	A	Fatty acids														
		C14:0	C15:0	C16:0	C16:1	C17:0	C18:0	C18:1n9c	C18:2n6c	C20:1	C18:3n3	C20:2	C22:0	C22:1n9	C20:3n3	C22:2	C22:6n3
I	14	0.82	0.85	25.98	5.11	0.17	13.87	27.55	19.49	0.47	0.25	0.15	0.66	3.52	0.69	0.34	0.53
	16	0.73	0.95	24.59	3.62	0.20	16.77	28.06	19.12	0.39	0.27	0.14	0.58	4.24	0.44	0.25	0.61
	18	0.75	0.11	23.92	3.10	0.21	12.70	33.76	20.05	0.44	0.28	0.14	0.51	2.95	0.16	0.23	0.40
FR	14	0.78	0.13	27.05	4.94	0.23	12.48	32.81	16.54	0.62	0.29	0.12	0.59	1.50	0.22	0.31	0.27
	16	0.80	0.14	23.88	2.67	0.23	15.93	27.07	20.28	0.65	0.29	0.17	0.66	3.91	0.33	0.67	0.70
	18	0.82	0.11	26.78	4.11	0.20	13.33	30.03	19.13	0.61	0.24	0.13	0.49	2.46	0.50	0.21	0.47
SEM		0.021	0.007	0.582	0.358	0.007	0.652	1.042	0.568	0.037	0.011	0.011	0.043	0.398	0.076	0.055	0.061
P p-value		0.567	0.010	0.395	0.896	0.049	0.666	0.928	0.468	0.012	0.812	0.811	0.975	0.264	0.602	0.146	0.786
I		0.77	0.10	24.83	3.82	0.19	14.45	29.79	19.56	0.43	0.27	0.15	0.59	3.57	0.43	0.27	0.51
FR		0.80	0.13	25.90	3.91	0.22	13.91	29.97	18.65	0.63	0.27	0.14	0.58	2.62	0.35	0.40	0.48
Age p-value		0.829	0.495	0.348	0.046	0.517	0.047	0.242	0.467	0.918	0.832	0.807	0.535	0.271	0.802	0.102	0.236
14		0.80	0.11	26.52	5.02^{a}	0.20	13.18^{b}	30.18	18.02	0.55	0.27	0.14	0.63	2.51	0.45	0.33	0.40
16		0.76	0.12	24.24	2.96^{b}	0.22	16.35^{a}	27.57	19.70	0.52	0.28	0.16	0.62	4.07	0.38	0.46	0.66
18		0.79	0.11	25.35	3.60^{ab}	0.20	13.01^{b}	31.90	19.59	0.53	0.26	0.14	0.50	2.70	0.33	0.22	0.43
P x Age p-value		0.591	0.061	0.501	0.569	0.115	0.776	0.213	0.412	0.728	0.543	0.672	0.830	0.633	0.166	0.089	0.430

P – production system, A – age, I – intensive, FR – free range, SEM – standard error of mean.
[ab]Differences in superscript letters within "columns" represent significant differences between groups.

lower in the present study, whereas those of C18:0 and C18:1n9c were similar. The amounts of the C16:0, C18:0, and C18:1 fatty acids in pheasant meat were higher than the fatty acids in meats obtained from various other animal species (turkey, cattle, sheep, horse, and pig) [Chernukha 2011].

Total fatty acid and index values

The effect of the production system on breast and thigh fatty acid total and index values was not significant (P>0.05, Tab. 4-7). The PUFA, ∑n-3, and ∑n-6 levels were lower in breast meat at week 14 of slaughter age (P<0.05). Other properties did not change depending on slaughter age (P>0.05). The effect of the PS x age interaction on total fatty acids and index values was non-significant (P>0.05).

The interest in fatty acids is mainly aimed at understanding their role in affecting human and animal health. Human health is associated with the fat composition of consumed meat [Nuenberg *et al.* 2011]. The relationships between the dietary fat content and composition and lifestyle diseases, especially coronary heart diseases, are well known. Therefore, the relationship between fat in the diet, its composition and health is taken into consideration when developing guidelines by different nutrition and health organizations [WHO 2003].

Total and index values (PUFA, MUFA, SFA, MUFA/SFA, PUFA/SFA, AI, TI, nutritive value, h/H, and DFA) are widely used for nutritional and health evaluation purposes. In contrast to SFA, a high MUFA value decreases LDL cholesterol and the total/HDL cholesterol ratio [FAO/WHO 2009]. Although unsaturated fatty acids positively affect health, they undergo autooxidation more easily than SFAs [Mottram

Table 4. Pheasant breast meat fatty acid total values (%)

Production system	Age	Total fatty acids						
		SFA	MUFA	PUFA	TUFA	n-3	n-6	n-9
Intensive	14	52.95	32.64	14.40	47.04	0.59	12.84	24.70
	16	51.83	32.35	15.81	48.16	0.76	14.11	27.31
	18	47.93	34.60	17.46	52.06	0.62	15.67	31.60
Free range	14	46.28	39.53	14.19	53.72	0.56	12.73	34.90
	16	56.66	27.41	15.92	43.33	0.83	14.08	22.72
	18	40.83	40.63	18.53	59.17	0.74	17.25	35.89
SEM		2.406	2.078	0.746	2.406	0.043	0.766	2.167
Production system p-value		0.573	0.556	0.844	0.573	0.548	0.777	0.466
intensive		50.90	33.20	15.89	49.09	0.66	14.21	27.87
free range		47.92	35.86	16.22	52.07	0.71	14.69	31.17
Age p-value		0.340	0.356	0.037	0.340	0.041	0.050	0.313
14		49.62	36.08	14.30^{b}	50.38	0.58^{b}	12.79^{b}	29.80
16		54.25	29.88	15.87^{ab}	45.75	0.80^{a}	14.09^{ab}	25.02
18		44.38	37.62	18.00^{a}	55.62	0.68^{ab}	16.46^{a}	33.74
Production system by age p-value		0.574	0.493	0.942	0.574	0.767	0.894	0.414

P – production system, A – age, I – intensive, FR – free range, SEM – standard error of mean.
^{ab}Differences in superscript letters within "columns" represent significant differences between groups.

Table 5. Pheasant thigh meat total fatty acid values (%)

Production system	Age	Total fatty acids						
		SFA	MUFA	PUFA	TUFA	n-3	n-6	n-9
Intensive	14	41.67	36.83	21.49	58.33	1.47	19.52	31.11
	16	43.03	36.09	20.88	56.97	1.32	19.15	32.36
	18	38.26	40.46	21.27	61.73	0.84	20.05	36.75
Free range	14	41.43	40.81	17.75	58.57	0.78	16.54	34.40
	16	41.84	35.68	22.48	58.16	1.32	20.31	31.06
	18	41.81	37.49	20.69	58.18	1.21	19.13	32.52
SEM		0.589	0.855	0.674	0.590	0.119	0.569	0.763
Production system p-value		0.529	0.907	0.537	0.529	0.674	0.462	0.575
intensive		40.98	37.80	21.21	59.01	1.21	19.58	33.41
free range		41.69	37.99	20.31	58.30	1.11	18.66	32.66
Age p-value		0.252	0.289	0.507	0.252	0.630	0.465	0.240
14		41.55	38.82	19.62	58.45	1.13	18.03	32.76
16		42.43	35.88	21.68	57.56	1.32	19.73	31.71
18		40.04	38.98	20.98	59.96	1.03	19.59	34.64
Production system by age p-value		0.233	0.284	0.349	0.233	0.274	0.406	0.126

P – production system, A – age, I – intensive, FR – free range, SEM – standard error of mean.

Table 6. Pheasant breast meat fatty acid index values (%)

Production system	Age	Fatty acid indices						
		MUFA/SFA	PUFA/SFA	NV	AI	TI	h/H	DFA
Intensive	14	0.62	0.27	2.03	0.62	2.10	1.43	71.88
	16	0.62	0.30	1.54	0.69	1.98	1.31	68.51
	18	0.76	0.38	1.72	0.66	1.83	1.64	69.61
Free range	14	0.93	0.32	2.05	0.62	1.70	1.85	70.56
	16	0.49	0.29	1.52	0.80	2.41	1.17	67.39
	18	1.02	0.45	1.74	0.52	1.29	1.89	71.40
SEM		0.086	0.028	0.136	0.049	0.171	0.149	1.183
Production system p-value		0.450	0.564	0.989	0.922	0.662	0.619	0.944
intensive		0.67	0.32	1.77	0.66	1.97	1.46	70.00
free range		0.81	0.36	1.77	0.64	1.80	1.64	69.78
Age p-value		0.369	0.230	0.485	0.525	0.412	0.460	0.653
14		0.78	0.30	2.04	0.62	1.90	1.64	71.22
16		0.56	0.30	1.53	0.74	2.20	1.24	67.95
18		0.89	0.42	1.73	0.59	1.56	1.77	70.50
Production system by age p-value		0.580	0.824	0.998	0.677	0.539	0.788	0.891

P – production system, A – age, I – intensive, FR – free range, SEM – standard error of mean.

1998]. When fatty acids contain large amounts of long-chain PUFAs, oxidative stability decreases and as a result meat flavor is negatively affected [Lu *et al.* 2008]. However, PUFAs are important for human and animal nutrition. In the present study, the ratio of breast and thigh SFAs was higher than those of MUFA and PUFA. Compared to breast meat, the SFA value was lower in thigh meat, whereas PUFA and MUFA

Table 7. Pheasant thigh meat fatty acid index values (%)

Production system	Age	Fatty acid indices						
		MUFA/SFA	PUFA/SFA	NV	AI	TI	h/H	DFA
Intensive	14	0.89	0.52	1.60	0.50	1.24	1.78	72.20
	16	0.84	0.49	1.85	0.49	1.33	1.94	73.74
	18	1.06	0.55	1.94	0.44	1.14	2.21	74.43
Free range	14	0.98	0.43	1.68	0.52	1.30	1.79	71.05
	16	0.85	0.54	1.80	0.47	1.27	1.96	74.09
	18	0.90	0.49	1.62	0.52	1.28	1.81	71.51
SEM		0.031	0.018	0.053	0.013	0.026	0.062	0.580
Production system p-value		0.752	0.403	0.365	0.393	0.411	0.332	0.323
intensive		0.93	0.52	1.80	0.47	1.24	1.98	73.46
free range		0.91	0.49	1.70	0.50	1.28	1.85	72.22
Age p-value		0.231	0.515	0.336	0.561	0.378	0.343	0.333
14		0.94	0.47	1.64	0.51	1.27	1.79	71.63
16		0.85	0.51	1.83	0.48	1.30	1.95	73.92
18		0.98	0.52	1.78	0.48	1.21	2.01	72.97
Production system by age p-value		0.232	0.349	0.321	0.367	0.301	0.313	0.544

P – production system, A – age, I – intensive, FR – free range, SEM – standard error of mean.

values were higher. A balanced fatty acid content was determined in terms of total unsaturated fatty acids (TUFA). Kuzniacka *et al.* [2007] reported that pheasant meat is easily digested and contains an appropriate proportion of unsaturated and saturated fatty acids, thus reducing the risk of obesity, cardiovascular and other diseases. The saturated and unsaturated fatty acid levels obtained in our study are similar to those reported by Kuzniacka et al. [2007].

A low PUFA/SFA ratio (<0.4) is considered to be undesirable, as it leads to an increase in cholesterol levels [Santos-Silva et al. 2002]. In the present study this value was close to 0.4 (0.27-0.45) in breast meat and greater than 0.4 (0.43-0.55) in thigh meat. The AI and TI values below 1 are desirable [Yakan *et al.* 2012], whereas a high AI value is considered harmful for human health [Ulbricht and Southgate 1991]. The opposite is important to provide because of the protective effect of unsaturated fatty acids against cardiovascular diseases [Manso et al. 2009]. In the present study the AI was lower than 1 (0.47-0.74), whereas the TI value was higher than 1 (1.30-2.20). The nutritive value of meat [(C18: 0 + C18: 1) / (C16: 0)] represents the healthy fat content and a significant portion of it consists of fatty acids. Palmitic acid (C16:0) tends to increase blood cholesterol level, whereas stearic acid (C18:0) does not affect blood cholesterol level and oleic acid (C18:1) helps to decrease blood cholesterol levels [Caneque *et al.* 2005]. The h/H value is considered a good nutritional assessment index due to the functional effects of fatty acids [Ahmet *et al*. 2015]. In the present study the high C16:0 value provided a positive result for nutritive and h/H values. Omega fatty acids containing n-3, n-6, and n-9 fatty acids are involved in brain development, they strengthen the immune system and prevent coronary heart disease. If they are deficient, various skin diseases, asthma, growth retardation, diabetes and various types of cancer (such as breast and prostate) may occur [Lewis *et al.* 2000]. In the present study these values were higher in thigh meat.

Lukasiewicz *et al*. [2011] reported lower SFA (30.72-33.51%) values, higher PUFA (22.98-26.26%), n-3 (2.54-6.18%), and n-6 (22.81-26.05%) values and similar MUFA (29.27-40.72%) values in breast and thigh meat when compared to the present study. Unlike the values obtained in the present study, Nuernberg *et al*. [2011] found that PUFA values were higher than SFA values in breast and thigh meat of pheasants. In their research on the extensive production system Franco and Lorenzo [2013] obtained lower SFA, but higher MUFA, PUFA, n-3, n-6 and PUFA/SFA levels. The SFA, MUFA, PUFA, TUFA, and PUFA/SFA values reported by Kokoszynski *et al*. [2014] were similar to those obtained in the present study. Compared to our study, the PUFA and PUFA/SFA values reported by Kokoszynski et al. [2018] were higher, MUFA values were lower, and SFA and TUFA values were similar. Also, in the same study, SFA and PUFA levels in thigh meat were higher, MUFA and TUFA values were lower and PUFA/SFA values were similar when compared to the results of the present study.

The composition and content of fatty acids are related to the fat content of meat and is primarily affected by the feed (ratio, content) and the meat fat ratio. Therefore, they vary between different species, hybrids and lines. As carcass fattening increases, SFA and MUFA values increase more rapidly than PUFA levels [Kokoszynski et al. 2014]. In the present study, the fat content did not vary depending on the production system and slaughter age. However, while the effect of the production system on the fatty acid total and index values of breast and thigh meat was non-significant, slaughter age affected PUFA, n-3, and n-6 values in breast meat. Carcass composition and meat quality can vary significantly in pheasants depending on their slaughter age [Vecerek *et al.* 2005, Kuzniacka *et al.* 2007]. In our study, although the crude fat ratio did not change depending on age, the PUFA, n-3, and n-6 values in breast meat increased with age. However, there was no significant change in thigh meat. This difference may be due to the individual nutrient requirements and consumption habits of pheasants. Kokoszynski *et al*. [2014] reported that the nutrient requirements of pheasants vary depending on their age and the production system used to breed them.

The meat quality characteristics in poultry can change depending on many factors such as production method, age, sex and feed [Franco and Lorenzo 2013, Boz *et al.* 2017]. Both similar and different results were obtained in our study when compared to other publications. These differences are thought to be due to genotype, environment, production conditions, age and feeding.

Production systems and slaughter age can affect the chemical composition, properties and components that contribute to meat quality. In this study the nutrient composition of pheasant meat did not change depending on the production system, while dry matter and crude ash levels were higher only at the 18th week. While the C20:2 value of breast meat was higher in the intensive animal management system, the C15:0, C17:0, and C20:1 values in thigh meat were higher in the free-range system. The fatty acid total and index values did not differ in breast and thigh meat depending on the production system. Depending on the slaughter age of animals the C18:2n6, C20:2, C22:1n9, C22:6n3, PUFA, n-3 and n-6 levels differed in breast meat similarly as it was with C16:1 and C18:0 contents in thigh meat. Considering these results, pheasants can be reared in the free-range production system (in line with animal welfare and consumer preferences) to ensure desirable meat quality traits.

Free-range production systems for pheasants, an alternative poultry species, are thought to be important in promoting meat quality traits, biodiversity and sustainable production. In addition, based on the general meat quality characteristics an intensive production system is also acceptable. Depending on feeding and genotype, pheasants reach slaughter age at 11-24 weeks and are generally offered for consumption at 16-18 weeks [Kokoszynski *et al.* 2012]. The meat quality results obtained in the present study also supported the slaughter age reported in similar studies and week 18 is recommended as the appropriate slaughter age in terms of the nutritional value and fatty acid total and index levels in meat.

REFERENCES

1. ABERLE E.D., FORREST J.C., GERRARD D.E., MILLS E.W. 2001 – Principles of meat science. 4th edn. (Dubuque, IA, Kendall/Hunt Publishing Co.).
2. ADAMSKI M., KUZNIACKA J., 2006 – The effect of age and sex on slaughter traits of pheasants (Phasianus colchicus L). ***Animal Science Papers and Reports*** 24, 11-8.
3. AHMET S.T., ISLAM M.M., BOSTAMI A.B.M.R., MUN H.S., KIM Y.J., YANG C.J., 2015 – Meat composition, fatty acid profile and oxidative stability of meat from broilers supplemented with pomegranate (*Punica granatum L.*) by-products. ***Food Chemistry*** 188, 481-488.
4. BOZ M.A., SARICA M., YAMAK U.S., 2017 – Production traits of artificially and naturally hatched geese in intensive and free-range systems – II: slaughter, carcass and meat quality traits. ***British Poultry Science*** 58, 166-176.
5. BOZ M.A., ÖZ F., YAMAK U.S. SARICA M., CİLAVDAROĞLU E., 2017 – The carcass traits, carcass nutrient composition, amino acid, fatty acid, and cholesterol contents of local Turkish goose varieties reared in an extensive production system. ***Poultry Science*** 98, 3067-3080.
6. CAN E., CÖMERT S., USLU S., BÜLBÜL A., BOLAT F., NUHOGLU A., 2009 – Uzun zincirli **çoklu** doymamış yağ asitlerinin yenidoğan beslenmesindeki rolü. (The role of long chain polyunsaturated fatty acids in neonatal nutrition) ***Journal of Kartal Training and Research Hospital*** 20, 108-112. In Turkish.
7. CANEQUE V., DIAZ M.T., ALVAREZ I., LAUZURICA S., PEREZ C., DE LA FUENTE J., 2005 – The influences of carcass weight and depot on the fatty acid composition of fats of suckling Manchego lambs. ***Meat Science*** 70, 373-379.
8. ÇETIN O., KIRIKÇI K., 2000 – Alternatif Kanatlı Yetiştiriciliği Sülün-Keklik (Alternative Poultry Breeding Pheasant-Partridge) ***Sel-Ün Yayınları,*** Konya. In Turkish.
9. CHERNUKHA I., 2011 – Comparative study of meat composition from various animal species. ***Tehnologija Mesa*** 52, 167-171.
10. COOPER R.G., NARANOWICZ H., MALISZEWSKA E., TENNETT A., HORBANCZUK J.O., 2008 – Sex-based comparison of limb segmentation in ostriches aged 14 months with and without tibiotarsal rotation. ***Journal of the South African Veterinary Assosiation*** 79, 3, 142-144.
11. DORDEVIC M., PEKEC S., POPOVIC Z., DORDEVIC N., 2010 - Influence of dietary protein levels on production results and mortality in pheasants reared under controlled conditions. ***Acta Veterinaria (Beograd)*** 60, 79-88.

12. FAO/WHO. 2009 – Fats and fatty acids in human nutrition. Proceedings of the joint FAO/WHO expert consultation. November 10-14, 2008. Geneva, Switzerland. ***Annals of Nutrition & Metabolism*** 55, 5-300.
13. FRANCO, D., LORENZO, J.M., 2013 – Meat quality and nutritional composition of pheasants (*Phasianus colchicus*) reared in an extensive system. ***British Poultry Science*** 54, 594-602.
14. GÖKALP H. Y., KAYA M., TÜLEK Y., ZORBA Ö., 2010 – Et ve ürünlerinde kalite kontrolü ve laboratuvar uygulama kılavuzu. (V. Baskı), Atatürk Üniv. Yayınları, Yayın No: 751, Ziraat Fak. Yayın No: 318, Ders Kitapları Seri No:69, Atatürk Üniversitesi, Ofset Tesisi, Erzurum (Quality control and laboratory practice guide in meat and meat products). In Turkish.
15. GÓRSKA-HORCZYCZAK E., WOJTASIK-KALINOWSKA I., GUZEK D., SUN D., WIEWRZBICKA A., 2017 – Differentation of chill-stored and frozen pork necks using electronic nose with ultra-fast gas chromatography. ***Journal of Food Process Engineering*** 40, 5, e12540.
16. HOFBAUER P., SMULDERS F.J.M., VODNASKY M., PAULSEN P., EL-GHAREEB W. R., 2010 – A note on meat quality traits of pheasants (*Phasianus colchicus*). ***European Journal of Wildlife Research*** 56, 809-813.
17. HORBAŃCZUK J.O., KAWKA M., SACHARCZUK M, COOPER R.G., BORUSZEWSKA K., PARADA P., JASZCZAK K., 2007 – A search for sequence similarity between chicken (Gallus domesticus) and ostrich (Struthio camelus) microsatellite markers. ***Animal Science Papers and Reports*** 25, 283-288.
18. HORBAŃCZUK J.O., SALES J., CELEDA T., KONECKA A., ZIĘBA G., KAWKA P., 1998 – Cholesterol content and fatty acid composition of ostrich meat as influenced by subspecies. ***Meat Science*** 50, 3, 385-388.
19. HORBAŃCZUK O. K., WIERZBICKA A., 2016 – Technological and nutritional properties of ostrich, emu and rhea meat quality. ***Journal of Veterinary of Research*** 60, 279-286
20. KOKOSZYNSKI D., BERNACKI Z., DUSZYNSKI L., 2012 – Body conformation, carcass composition and physicochemical and sensory properties of meat from pheasants of different origin. ***Czech Journal of Animal Science*** 57, 115-124.
21. KOKOSZYNSKI D., BERNACKI Z., KORYTKOWSKA H., WILKANOWSKA A., 2014 – Effect of different feeding regimens for game pheasants on carcass composition, fatty acid profile and mineral content of meat. ***European Poultry Science*** 78, 1-12. DOI: 10.1399/eps.2014.10.
22. KOKOSZYŃSKI D., KOTOWICZ M., PIWCZYŃSKI D., BERNACKI Z., PODKÓWKA Z., DORSZEWSKI P., GRABOWICZ M., SALEH M., 2018 – Effects of feeding whole-grain triticale and sex on carcass and meat characteristics of common pheasants. ***Italian Journal of Animal Science*** 17, 1083-1093. D.
23. KUZNIACKA J., ADAMSKI M., BERNACKI Z., 2007 – Effect of age and sex of pheasants (Phasianus colchicus L.) on selected physical properties and chemical composition of meat. ***Annals of Animal Science*** 7, 45–53.
24. LEWIS N.M., SEBURG S., FLANAGAN N.L., 2000 – “Enriched Eggs as a Source of N-3 Polyunsaturated Fatty Acids for Humans”, Partially Funded By The University of Nebraska Agricultural Research Division (J. Series No. 12898).
25. LU P., ZHANG L.Y., YIN J.D.,. EVERTS A.K.R, LI D.F., 2008 – Effects of soybean oil and linseed oil on fatty acid compositions of muscle lipids and cooked pork flavour. ***Meat Science*** 80, 910-918.
26. LUKASIEWICZ M., MICHALCZUK M., GLOGOVSKI R., BALCERAK M., POPCZYK B., 2011 – Carcass efficiency and fatty acid content of farmed pheasants (Phasianus colchicus) meat. ***Annals of Warsaw University of Life Sciences – SGGW, Animal Science*** 49, 199-203.
27. MANSO T., BODAS R., CASTRO T., JIMENO V., MANTECON A.R., 2009 – Animal performance and fatty acid composition of lambs fed with different vegetable oils. ***Meat Science*** 83, 511-516.
28. MCGOWAN P.J.K, GARSON P.J., 1995 – Pheasants. IUCN, Gland, Switzerland.

29. MOTTRAM D.S., 1998 – Flavour formation in meat and meat products: A review. ***Food Chemistry*** 62, 415-424.
30. NUERNBERG K., SLAMECKA J., MOJTO J., GASPARIK J., NUERNBERG G., 2011 – Muscle fat composition of pheasants (*Phasianus colchicus*), wild ducks (Anas platyrhynchos) and black coots (Fulica atra). ***European Journal of Wildlife Research*** 57, 795-803.
31. ÖZ F., CELIK T., 2015 – Proximate composition, color and nutritional profile of raw and cooked goose meat with different methods. ***Journal of Food Processing and Preservation*** 39, 2442-2454.
32. ÖZDAMAR K. 2002 – Paket programlar ile istatistiksel veri analizi I., 4. baskı, Kaan Kitabevi, Eskişehir (Statistical data analysis with package programs). In Turkish.
33. PEIRETTI P.G., MEINERI G., 2008 – Effect on growth performance, carcass characteristics, and the fat and meat fatty acid profile of rabbits fed diets with chia (*Salvia hispanica L.*) seed supplements. ***Meat Science*** 80, 1116-1121.
34. SANTOS-SILVA J., BESSA R.J.B., SANTOS-SILVA F., 2002 – Effect of genotype, feeding system and slaughter weight on the quality of light lambs, II. Fatty acid composition of meat. ***Livestock Production Science*** 77, 187-194.
35. SARICA M, KARAÇAY N., CAMCI Ö., 1999 – Slaughter age and carcass traits of pheasants. ***Archiv für Geflügelkunde*** 63, 182-184.
36. SATCHITHANANDAM S., FRITSCHE J., RADER J. I., 2001 – Extension of AOAC Official Method 996.01 to the Analysis of Standard Reference Material (SRM) 1846 and Infant Formulas. ***Journal of AOAC International***, 84, 805-813.
37. SEVERIN K., MASEK T., JANICKI Z., KONJEVIC D., SLAVICA A., HRUPACKI T., 2006 – Copunisation of pheasant at different age. ***Veterinarski Arhiv*** 76 (suppl.), 211-219.
38. SEVERIN K., MASEK T., HORVATEK D, KONJEVIC D., JANICKI Z., CVRTILA Z., KOZACINSKI L., HADZIOSMANOVIC M., BARIC-RAFAJ R., 2007 – The effects of castration on the growth parameters, carcass yield and meat chemical composition of intensively reared Common Pheasant (Phasianus colchicus colchicus L.). ***Italian Journal of Animal Science*** 6, 213-219.
39. SOKOLOWICZ Z., KRAWCZYK J., SWIATKIEWICZ S., 2016 – Quality of poultry meat from native chicken breeds – a review. ***Annals of Animal Science*** 16, 347-368.
40. SPSS, 2011- SPSS IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20. 0 IBM Corp, Armonk, NY.
41. STRAKOVA E., SUCHY P., VITULA F., VECEREK V., 2006 – Differences in the amino acid composition of muscles from pheasant and broiler chickens. ***Archive of Animal Breeding*** 49, 508-514.
42. TUCAK Z., SKRIVANKO M., KRZNARIC M., POSAVCEVIC S., BOSKOVIC I, 2004 – Indicators of biological value of the pheasant meat originated from natural and controlled breeding. ***Acta Agriculture Slovenica*** 1, 87-91.
43. ULBRICHT T.L., SOUTHGATE D.A., 1991 – Coronary heart disease: Seven dietary factors. **The *Lancet*** 338 (8773), 985-992.
44. VECEREK V., SUCHY P., STRAKOVA E., VITULA F., MIKUNDOVA M., 2005 – Variation in the chemical composition of muscles in young pheasants during their growth. ***Archiv für Tierzucht*** 48, 290-298.
45. WHO, 2003 – Diet, nutrition and the prevention of chronic diseases. Report of a joint WHO/FAO Expert Consultation. ***WHO Technical Report Series*** 916, Geneva
46. YAMAK U.S., 2015 – Artificial breeding of wild birds in Turkey: Partridge breeding case. ***Indian Journal of Animal Research*** 49, 258-261.
47. YAMAK U.S., SARICA M., BOZ M.A., UÇAR A., 2016 – The effect of production system (barn and free-range), slaughtering age and gender on carcass traits and meat quality of partridges (*Alectoris chukar*). ***British Poultry Science*** 57, 185-192.