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Cholesterol and total lipid content in raw and heat processed commercially produced meat from two farms

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A b s t r a c t: The present study was conducted to present information about the cholesterol and total lipid content in fresh and roasted chicken meat with skin (breast and drumstick meat), most commonly consumed in Serbia. In addition, to assess the possible effects of carcass weight and nutrition on total lipid and cholesterol content in examined meat cuts. A total number of 48 samples of breast and drumstick muscle of broilers from two farms (Farm I and II), fed ad libitum by commercial diets for growing broilers,were taken in summer, 2012 and autumn, 2013. Total lipid and cholesterol content were determined in raw and heat-processed breast and drumstick muscle with skin. Total lipid content was determined by extraction of fat by petrol ether (Soxhlet) after acid hydrolysis of samples (SRPS ISO 1443/1992).Cholesterol determination was performed after direct saponification (without prior lipid extraction) by using HPLC/PDA system.

Generally, all parameters measured were influenced by interaction of care and management and broiler performance at the 5% level or less. The total lipid content in samples of raw breast muscle of chicken from Farm I were the highest in summer (5.53%), (4.2%, in autumn), compared to samples of chickens from Farm II (3.05% in summer and 2.61% in autumn). The total lipid content in samples of raw drumstick were significantly differ ($p < 0.001$) between Farm I (9.63%) and Farm II (5.19%), only in summer. Cholesterol content (mg/100 g) in the raw breast muscle from Farm I was 53.9 (autumn) and 62.1 (summer), while in samples from Farm II was 46.97 (autumn) and 49.53 (summer). There was significant difference ($p < 0.001$) in cholesterol content in raw breast muscle of chickens in summer from two farms. In raw drumstick from Farm I the average cholesterol content (mg/100 g) was 70.24 (autumn) and 83.95 (summer), while in samples of chickens from Farm II was 65.05 (autumn) and 60.92 (summer). These differences were significant for cholesterol levels in drumstic between farms in summer ($p < 0.001$).

In heat-processed meat belonging to chickens from Farm I, breast and drumstick contained higher quantities of total lipids compared to samples from Farm II. These differences was significant ($p < 0.01$) in drumstick between Farm I and II (autumn) and were 13.37%, and 11.10%, respectively. The average cholesterol content (mg/100 g) in samples of heat-processed meat of chicken from Farm I varied between 70.32 (autumn) and 87.37 (summer) and from 75.23 (autumn) to 78.92 (summer) in drumstick, versus 64.33 (summer) and 66.24 (autumn) in breast muscle and from 81.31(summer) to 91.6 (autumn) in drumstick samples of chickens from Farm II.

We conclude that factors, such as feed composition, genotype (breed) and gender, influence the total lipid and cholesterol content in the meat. There were no obviously effects of slaughter traits on cholesterol and total lipid content. The results presented here, also shows that further investigations have to be conducted on greater number of samples.

***Key words:** chicken meat, cholesterol, total lipid.*

Introduction

Poultry has a leading position among all types of meat in the most developed countries in the world because of many reasons: short breeding time, a greater ammount of live weight of poultry in the poultry house, the great reproductive power of breeding flocks, excellent feed conversion, relatively low selling price and the suitability through so-called "fast food" (*Jahić et al.,* 2012). The consumption of poultry meat has become very popular due to their nutritional, but also sensory and aeshtetic characteristics (*Bogosavljević-Bosković et al.,* 2010). Consumer needs not only lean, but tasty meat, characterized by good culinary, technological and biological properties (*Jukna et al*., 2005). In fact, skinless chicken meat provides high protein (around 20 g/100 g) and low fat intakes (around 5

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g/100 g). Moreover, chicken lipids are characterized by relatively high levels of unsaturated fatty acids, especially polyunsaturated fatty acids (PUFA), which are regarded as a positive healthy aspect by consumers (*Bonoli et al.,* 2007). For most of many societies, meat and animal products represent a source of high quality protein, although high intakes of some animal products can lead to excessive fat intakes. The chemical composition of muscle tissue from major primal cuts is an important element of broiler meat quality (*Holcman et al.,* 2003; *Suchy et al*., 2002) depending on a number of biological factors (genotype, sex and age), (*Hellmeister et al*., 2003) and also numerous non-genetic factors (e.g. broiler rearing system), (*Ristic,* 2003; *Dou et al*., 2009). But despite its nutritional richness, meat has been considered a disease-promoting food.

In Western societies, coronary heart disease and arteriosclerosis are strongly related to the dietary intake of cholesterol and saturated fatty acids and are among the most important causes of human mortality (*Sacks, 2002*). Increases the amount and proportion of animal fat in human diets are associated with the occurrence of cardiovascular diseases (*Lichtenstein*, 1999; *Katan*, 2000). In addition, a strong relationship has been demonstrated between cellular cholesterol concentration and Alzheimer's disease (*Michikawa*, 2003). Relationships appear to exist, also, between a high-fat intake, especially saturated fat and an increased risk of some cancers, such as cancers of the colon, breast and prostate (*Reddy,* 1995). Among these factors, genetics and antioxidant dietary intakes appear to be very important (*Chizzolini et al*., 1999). It is widely acknowledged that there is an urgent need to return to a balanced fatty acid diet by decreasing intake of cholesterol and saturated fats (*Evans et al*., 2002). According to the *American Heart Association* (2004), the daily ingestion of lipids for individuals with normal blood cholesterol levels, should not be more than 30% of the total calorie intake; saturated fat should not exceed 10% of the total calorie intake and cholesterol intake should be below 300 mg/day. Therefore, the knowledge about the cholesterol content in food is important, especially in poultry and fish meat, because the consumption of these foods in nowadays increases in relation to recommendations of healthy nutrition. It is known that the cholesterol content in animal tissues can be influenced by dietary treatment such as feed rations (*Konjufca et al.,* 1997), despite the regulatory mechanisms at the level of synthesis and absorption, which supposedly maintain cholesterol concentration in these tissues (*Harris et al.,* 1993).

Meat composition, as well as its physicochemical properties, undergoes significant changes during heat treatment. It is well known that meat composition, especially its fat content, combined with a specific cooking methodology is among the factors that mostly affect the final quality of meat products (*Serrano et al*., 2007). Several authors pointed out that the cooking process can affect the lipid composition of meat, especially the fatty acid content, by changing the nutritional value of cooked products in relation to raw samples (*Badiani et al*., 2002). Moreover, it was reported that heat treatment can lead to undesirable changes, such as loss of essential fatty acids (FA), reducing the nutritional value of meat, mainly due to lipid oxidation (*Rodriguez-Estrada et al.,* 1997). Some lipid oxidation products (e.g. cholesterol oxidation products) can be involved in lipid metabolism, various chronic and degenerative diseases (such as cancer, aging and human atherosclerosis) and disturbance of cell functionality (*Schroepfer*, 2000; *Osada*, 2002). It is also reported (*Ono et al.,* 1985) that there is an increase in polyunsaturated/saturated ratio, probably because polyunsaturated fatty acids are part of the cell membrane and thus have less contact with heat. *Gerber et al.,* (2009) have shown considerable fat losses in several meat cuts submitted to grilling, broiling or pan-frying without addition of fat. Taking into account controversies around meat consumption and disease risk some studies distinguished the influence of meat cuts from processed meat products in cardiovascular disease pointing out the need to consider processing technique and cooking as important variables which could influence the final result and contribute to the bad image of meat *(Misha et al.,* 2010).

The present study was conducted to present information about the cholesterol content and total lipid content in fresh and roasted chicken meat; white meat (breast meat) and red meat (drumstick meat), most commonly consumed in Serbia. An assessment of possible effects of carcass weight and nutrition on total lipid and cholesterol content in the tissues reached at the slaughter age of the animals, was an integral part of the experiment.

Materials and methods

Bird management and dietary treatments

Two homogeneous groups of male and female (50:50%) Ross 508 and Hubbard broilers were housed under standard conditions of temperature, humidity and ventilation in two farms from different locations of the north province of Serbia – Vojvodina (Farm I and

Farm II). The feeding programme consisted of starter (0–15 d), grower (16–32 d), and finisher (33–38 d) basal diets that were formulated to meet the bird's dietary nutrient requirements (Table 1). Feed and fresh water were offered *ad libitum* throughout the 38-day rearing period. Feed:gain and body weight (BW) were recorded on a cage, based at weekly intervals. Feed conversion ratio, corrected for mortality was calculated.

Slaughter procedure and sampling

The birds (n = 12) aged 39 days selected on the basis of live weight within wider possible range were slaughtered in the approved abattoir. After slaughtering and dressing, hot carcasses were chilled for two hours at 4°C. The carcasses were weighted and refrigerated for 24 h. The breast meat (*Mm. pectoralis major et minor*) with skin and drumstick meat with skin (muscles of *regio tibio-femoralis*) were cut up, separated and weighted. The total of 48 breast and drumstick meat samples were taken from chilled broiler carcasses, collected in the summer, 2012 and the autumn, 2013. Samples of both meats were roasted in an electric oven in the open aluminum pan at 220°C for 30 min.

Determination of total lipid and cholesterol content

Total lipid and cholesterol content were determined in raw and roasted breast and drumstick meat with skin. Total lipid content was determined by extraction of fat by petrol ether (Soxhlet) after acid hydrolysis of samples (*SRPS ISO* 1443/1992). Cholesterol determination was performed after direct saponification (without prior lipid extraction) by using HPLC/PDA system (Waters 2695 Separation module/Waters photodiode array detector, USA), according to the method described by *Maraschiello et al*. (1996). *Empower Pro* software was used to control the HPLC system as well as for data acquisition and data processing.

Statistical Analysis

Statistical analysis was performed by the MINITAB software package, version 16.0. Data obtained from the experiment were analyzed by descriptive statistics (mean, standard deviation, range). The One Way ANOVA and the post-hoc HSD Tukey test were used to examine statistical differences betewen examined parameters within the same and accros the farms. The differences were considered statistically significant when the p value was less than 0.05. The significance of correlations (Pearson′s correlation coefficient – r) were calculated using the correlation procedures.

Results and discussion

Table 1 shows ingredients (%) and nutrition composition (%) of commercial broiler feed mixtures which were used for chicks feeding in Farm I and Farm II, in the summer (a) and the autumn (b).

Growth performances of the broilers

Growth performances and slaughter characteristics of broilers are reported in Table 2. Average live weight, daily gain, carcass, breast and drumstick meat weights (2240g, 57g, 1764.87 ± 227.83g, 647.95 ± 78.70g and 536.40 ± 88.41g, respectively) were the highest and the least mortality rate (3.19%) were determined for chicken at farm I (autumn). The highest mortality rate (28.37%) and the least average live weight (1470g), daily gain (39g), daily feed intake (84.33g) as well as carcass (1223.3 ± 116.38g) and breast weight (427.70 ± 53.44g) were obtained at broilers from farm II (summer).

Cholesterol and total lipid content in broiler meat

Distribution of results for cholesterol and total lipids contents (% and mg/100g, respectively) in the raw and heat-prepared chicken meat (breast and drumstick), from both of the farms during periods of investigation was presented in Figures 1-4.

Total lipid content (%), (Figure 1; Table 3) was lower in samples of raw breast meat of broilers from farm II in summer (3.05 ± 1.11) and in autumn (2.61 ± 0.77) in comparison to those from Farm I (5.53 ± 0.61, in the summer and 4.2 ± 1.15, in the autumn).

The difference between total lipid in raw breast meat samples from the both farms in autumn was significant ($p < 0.001$), (Table 3). Obtained results regarding total lipid content in raw drumstick samples from Farm II were significantly lower ($p < 0.001$) only in summer (5.19 ± 0.45%) in comparison to Farm I (9.63 ± 0.64%). Also, there was statistically significant difference ($p < 0.001$) between total lipid contents in drumstick originated from Farm II, in the summer (5.19 ± 0.45%) and the autumn (8.16 ± 2.26%), (Table 3).

Heat-processed breast and drumstick (Figure 2) of broilers from Farm II contained lower total lipid content in the summer (3.57 ± 0.15% and 10.54 ± 0.22%, respectively) and in the autumn (3.72 ± 0.61% and 11.11 ± 2.04%, respectively) in comparison to meat samples of broilers from Farm I (in the summer: 6.08 ± 0.34% and 14.73 ± 0.55%, respectively); in the autumn: 6.25 ± 0.78% and 13.37 ± 0.95%-autumn, respectively). These differences were not statistically

Table 1. Composition (%) of feed mixtures for broiler nutrition
Tabela 1. Sastav smeša (%) za ishranu brojlera

Ingredient/Sastojak (%)	Starter (0-15 day)/ Starter (od 0-15 dana)				Grower (16-32 day)/ Grover (od 16-32 dana)				Finisher (33-38 day)/ Finišer (od 33-38 dana)			
	Farm/Farma											
	Ia	IIa	Ib	IIb	Ia	IIa	Ib	IIb	Ia	IIa	Ib	IIb
Corn/Kukuruz	55.2	55.12	50.06	49.45	56.03	56.03	39.08	49.6	61.1	55.8	55.8	52.75
Soybean meal (46% CP)/ Sojina sačma (46% SP)	34.8	34.8	18	/	30.9	30.9	/	/	25.4	29.8	/	/
Soybean meal (44% CP)/ Sojina sačma (44% SP)	/	/	15	33.60	/	/	31.60	29.4	/	/	23.5	24.5
Wheat grain/Pšenica	3.0	3.0	6.0	6.0	6.0	6.0	20.0	10.0	6.0	6.0	10	10
Sunflower meal (33% CP)/ Suncokretova sačma (33% SP)	/	/	/	/	/	/	/	/	/	/	/	3.0
Yeasts/Kvasac	/	/	1.5	/	/	/	/	/	/	/	/	/
Gluten/Gluten	/	/	/	2,0	/	/	/	2.0	/	/	2.0	/
Sunflower oil/ Suncokretovo ulje	1.65	1.65	2.5	2.62	2.4	2.4	4.42	3.45	3.05	3.45	3.45	4.45
Mono-calcium phosphate/ Monokalcijum fosfat	1.75	1.75	1.70	1.75	1.52	1.52	1.45	1.52	1.32	1.47	1.30	1.30
Limestone/Kreda	1.65	1.65	1.67	1.72	1.5	1.5	1.55	1.55	1.32	1.37	1.37	1.37
Salt/So	0.13	0.13	0.15	0.13	0.21	0.21	0.21	0.19	0.10	0.16	0.21	0.14
Sodium-bicarbonate/ Natrijum-bikarbonat	0.21	0.21	0,17	0.20	0.13	0.13	0.10	0.23	0.32	0.19	0.10	0.33
L – Lysine/Lizin	0.27	0.27	0.29	0.36	0,02	0.02	0,08	0.11	0.16	0.05	0.24	0.11
DL-Methionine/Metionin	0.28	0.28	0.30	0.28	0.15	0.15	0.17	0.15	0.15	0.11	0.14	0.,15
Treonine/Treonin	0.12	0.12	0.13	0.14	/	/	0.03	0.03	0.05	/	0.07	0.06
Choline 60%/Holin 60%	0.13	0.13	0.13	0.14	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamin + mineral premix/ Vitaminsko-mineralni premiks 0,5%	0.60	0.60	0,60	0,60	0.60	0.60	0.50	0.50	0.50	0.50	0.50	0.50
Betafin/Betafin	0.06											
Cocci-diostat/ Kokcidiostatici	0.02		0.05		0.02		0.05		/			
Analyzed nutrient content (%)/Sadržaj hranljivih materija (%)												
Crude protein/Sirovi protein	22.32	22,82	22,46	22.25	19.24	20.39	20.1	20.62	18.71	18.83	19.12	19.82
Water/Voda	11.07	10.23	11.50	13.19	10,69	10.73	11.40	12.79	10.30	11.46	11.11	11.57
Crude fiber/Sirova vlakna	1.15	1.68	1.57	1.88	1.73	1.50	1.66	1.75	1.34	1.55	1.63	2.68
Fat/Mast	4.75	4.48	4.56	4.60	4.69	4.30	4.92	4.90	6,32	5,95	6.10	6.20
Ash/pepeo	5.48	5.80	5.63	5.61	5.32	6.04	5.52	5.21	4.62	4.88	4.98	5.44
Ca	0.82	0.95	0.86	0.88	0.74	1.03	0.86	0.81	0.81	0.74	0.78	0.81
Available P/Usvojivi P	0.71	0.70	0.68	0.65	1.73	0.69	1.05	0.73	0.58	0.70	0.64	0.63

Table 2. Growth performances and slaughter characteristics of broilers from two farms (I and II) during two periods of investigation, summer (a) and autumn (b), ($\bar{X}$ Sd)

Tabela 2. Proizvodni rezultati i klanične karakteristike brojlera sa dve farme (I i II) tokom dva perioda istraživanja, leto (a) i jesen (b), ($\bar{X}$ Sd)

Parameter (range)/ Parametar (opseg)	Farm/Farma			
	I^a (n=12)	II^a (n=12)	I^b (n=12)	II^b (n=12)
Average live weight (g)*/ Prosečna telesna masa (g)	2190	1470	2240	2220
Average daily gain (g)/ Prosečni dnevni prirast (g)	57	39	57	52
Average daily feed intake (g)/ Prosečni dnevni unos hrane (g)	103.9	84.33	100.51	106.1
Feed : gain (g:g)/ Konverzija hrane	1.82	2.16	1.76	2.04
Mortality rate (%)/ Mortalitet (%)	5.34	28.37	3.19	4.38
Age at slaughter (d)/ Uzrast na klanju (d)	38	38	39	38
Carcass weight (g)/ Masa trupa (g)	1279.45 ±174.02 (1021.7−1681.2)	1223.3±116.38 (1055−1486.4)	1764.87±227.83 (1498.8−2226.7)	1400.70±130.01 (1186−1712.7)
Breast weight (g)/ Masa grudi (g)	452.5±80.17 (339−628)	427.70±53.44 (337.1−547.2)	647.95±78.70 (510−775.1)	470.62±61.15 (393.4−614.1)
Drumstick weight (g)/ Masa bataka (g)	389.89±51.19 (316.8−494)	392.9±39,20 (354−472.7)	536.40±88.41 (443.2−703)	476.78±48.20 (398.6−572.4)

* – weight at farm level/ * – masa na nivou farme; n – number of samples/ n – broj uzoraka

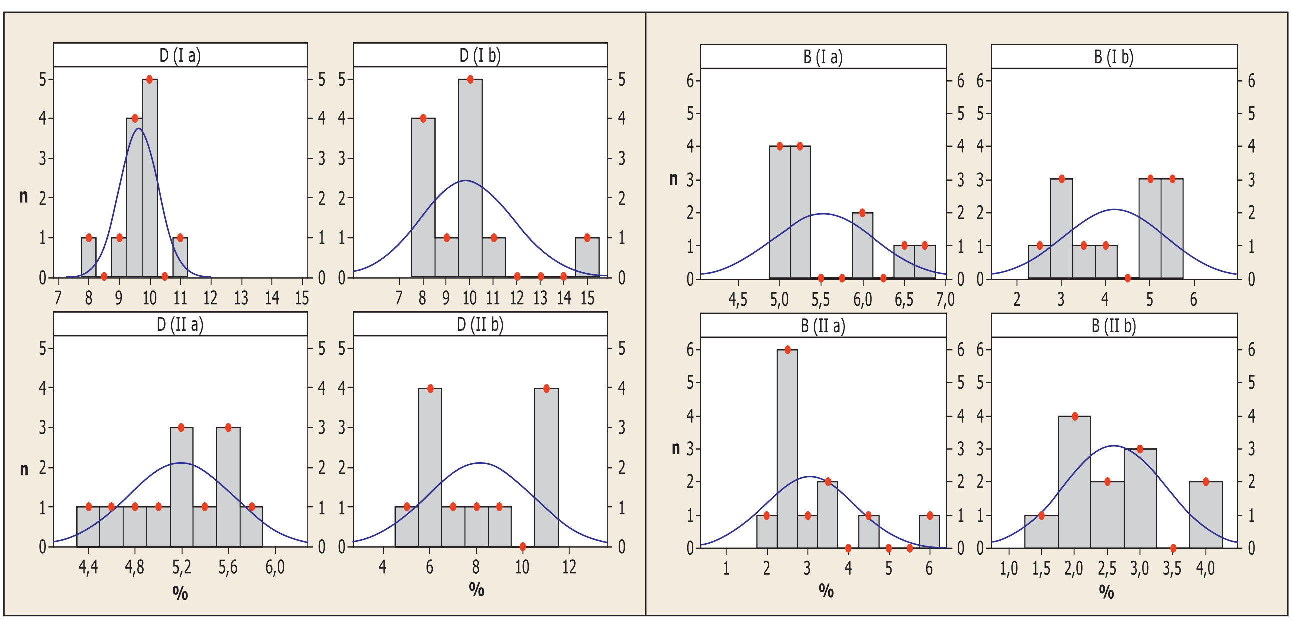

Figure 1. Distribution of total lipid content (%) in raw drumstick (D) and raw breast (B) meat with skin from farm I and II during summer (a) and autumn (b), n – number of samples

Slika 1. Distribucija sadržaja ukupne masti (%) u sirovom bataku (D) i sirovom belom mesu (B) sa kožom sa farme I i farme II tokom leta (a) i jeseni (b), n – broj uzoraka significant ($p < 0.05$) within this raw meat samples, but they did differ significantly ($p < 0.01$) in the relation to roasted drumstick meat (collected in the autumn) of broilers from Farm I and Farm II in which were determined 13.37±0.95% and 11.10±2.04% of total lipid, respectively. Many authors have been determined the fat content either in meat with or without skin. *Holcman et al*. (2003) found the total lipids levels in breast muscle-plus-skin and leg muscle-plus skin as average 7.0% and 13.1%, respectively. *Qiao et al*. (2002) reported significantly lower total fat content in skinless broiler breast meat (1.21–1.25%). *Zlender and Gasperlin* (2005) found 6% and 0.9% of total lipids in breast meat with skin and without skin, respectively. In drumstick meat samples with skin and without skin, average values of total lipids were 12% and 0.9%, respectively. Furthermore, a number of researchers emphasized the effect of sex and its influence upon the protein and fat content in broiler meat. For example a higher fat content in female broilers was reported by *Sanz et al*. (1999) and *Haro* (2005).

Cholesterol content (mg/100g), (Figure 3) in the raw breast meat originated from Farm I and Farm II were: in the autumn (53.9±6.23; 46.97±9.05, respectively) and in the summer (62.1±12.57; 49.53±5.62, respectively). There was significant difference ($p < 0.001$) in cholesterol content in raw breast meat of broilers in the summer between two farms (Table 3). In raw drumstick meat, the average cholesterol content in the samples from Farm I and Farm II, were: 70.24±6.35; 65.05±8.76 in the autumn and 83.95±9.20; 60.92±8.68, in the summer, respectively.

These differences were significant in regard to cholesterol levels in drumstick samples collected from Farm I, in the summer to those collected from Farm II in the autumn and also between samples collected from both of the farms in the summer ($p < 0.001$), (Table 3). In roasted breast meat (Figure 4) originated from Farm I, cholesterol content was 70.32±7.53 mg/100g (the autumn) and 87.37±8.02 mg/100g (summer). The cholesterol levels measured in roasted drumsticks taken from the same farm were: 75.23±8.15 mg/100g (autumn) and 78.92±20.35 mg/100g (summer). On the other hand, roasted breast and drumstick meat taken from Farm II in regard to cholesterol content was 66.24±6.02 mg/100g and 91.6±7.25 mg/100g (autumn), respectively and 64.33±10.06 mg/100g and 81.31±10.19 mg/100g (summer), respectively.

The statistically significant differences ($p < 0.05$) were registered between the cholesterol content in the chicken raw breast meat accros the farms in the autumn and in the summer. Cholesterol content registered in chicken raw breast samples from Farm II were at lower level in comparison to Farm I. In the summer and in the autumn, measured levels of cholesterol in raw and heat processed samples of breast meat collected from Farm II were lower ($p < 0.01$). Concerning the

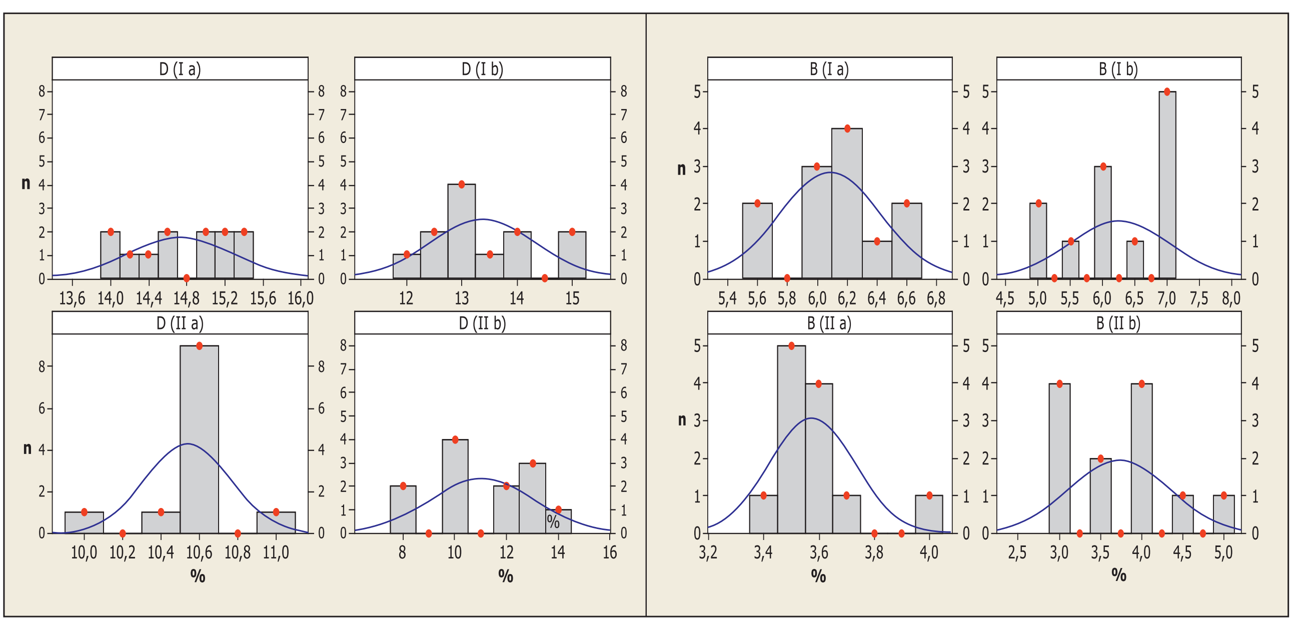

Figure 2. Distribution of total lipid content (%) in heat-processed drumstick (D) and breast (B) meat with skin from farm I and II during summer (a) and autumn (b), n– number of samples

Slika 2. Distribucija sadržaja ukupne masti (%) u termički tretiranom bataku (D) i belom mesu (B) sa kožom sa farme I i farme II tokom leta (a) i jeseni (b), n– broj uzoraka

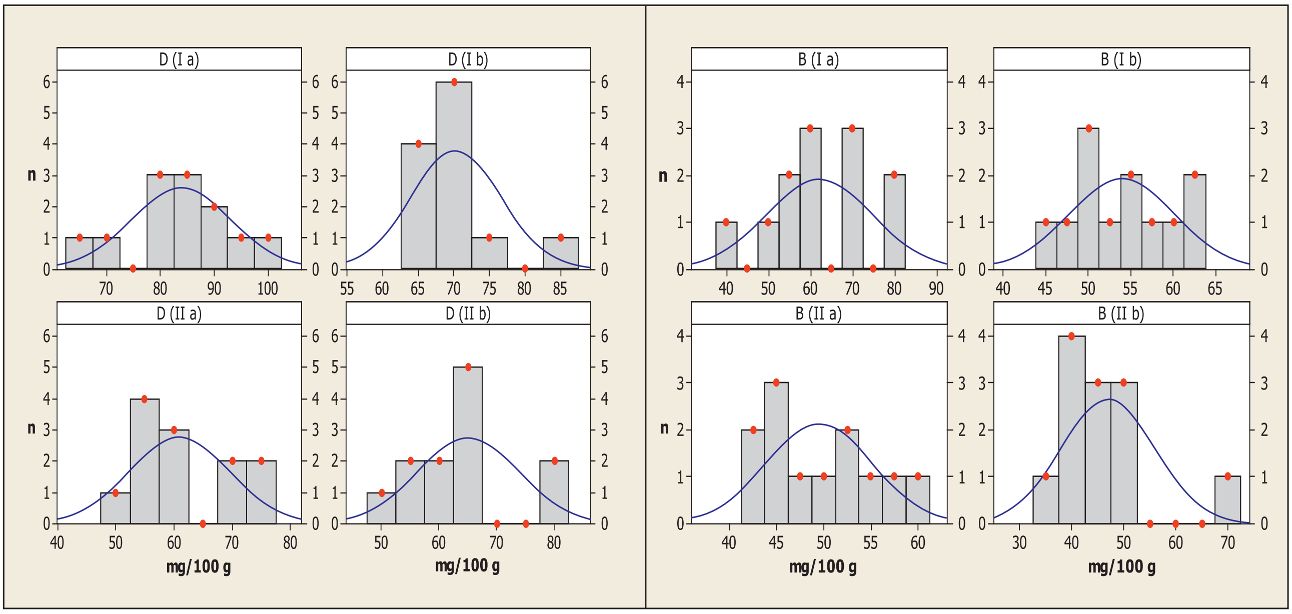

Figure 3. Distribution of cholesterol content (mg/100g) in raw drumstick (D) and raw breast (B) meat with skin from farm I and II during summer (a) and autumn (b), n – number of samples

Slika 3. Distribucija sadržaja holesterola (mg/100g) u sirovom bataku (D) i sirovom belom mesu (B) sa kožom sa farme I i farme II tokom leta (a) i jeseni (b), n – broj uzoraka

cholesterol content in raw and heat processed drumstick meat collected from both farms, siginifcant differences ($p<0.001$) were registered between the raw samples accros the farms in the autumn.

Obtained results are similar to data of cholesterol content (mg/100g) given in study of *Honikel* (1995), that found out 61.45 in raw white meat with skin and 84.65 in raw drumstick with skin. In the mentioned study, it is stated that the chicken meat with skin contains, besides higher cholesterol content also ten times higher fat content (breast meat without skin 0.70%, the breast with skin 6.20%;

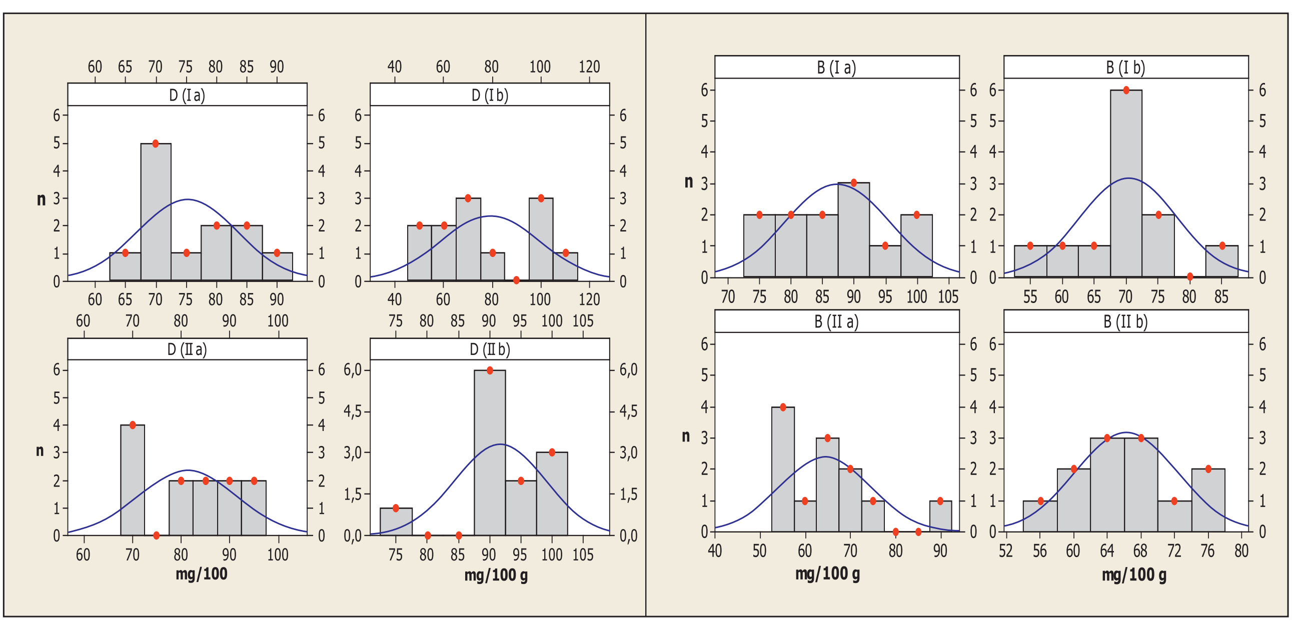

Figure 4. Distribution of cholesterol content (mg/100g) in heat-processed drumstick (D) and breast (B) meat with skin from farm I and II during summer (a) and autumn (b), n – number of samples

Slika 4. Distribucija sadržaja holesterola (mg/100g) u termički tretiranom bataku (D) i belom mesu (B) sa kožom tokom leta (a) i jeseni (b), n – broj uzoraka drumstick meat with skin 15.10% and drumstick meat without skin 6.45% fat). Our results support the fact, generally adopted, that cooked and processed meat products usually have a greater cholesterol content than raw meat because of moisture loss wherein cholesterol being retained in the tissues (*Baggio and Bragagnolo*, 2006), despite the fact that some amount of cholesterol also being lost during the cooking. According to *Swize et al*. (1992), the migration of cholesterol from fat tissues to muscle tissues was used as an explanation for greater cholesterol content in cooked meat.

Our results are in accordance with results of *Piironen et al*. (2002), who reported 56.2 mg/100g cholesterol and 1.5% total lipid content in breast fillet and 84 mg/100g cholesterol and 11.2% total fat content in leg and thigh. In the mentioned study, it is stated that cholesterol content is not in correlation with fat content, and because of that (like in the case of the meat from livestock), consumption of chicken meat with reduced fat content does not imply that cholesterol intake also will be reduced. But, our results showed the total lipid content in drumstick meat that was higher than in breast meat, were accompanied with a higher cholesterol level.

However, it is more difficult to compare the cholesterol content of poultry meat with its content in beef and pork because of, when being analyzed chicken meat with skin, cholesterol content is always higher, approximately from 80 to more than 100 mg/100g (*Bragagnol*o, 2009).

It has been shown that total lipid content in raw skinless chicken breast (1.2%) was less than in raw chicken breast with skin (8.9%), (*Pereira and Vicente*, 2013; *Komprda et al.*, 2003). Additionally, significant differences in cholesterol and lipid content have reported between muscle types due to differences in their fiber types (*Bragagnolo*, 2009). According to literature data (*Chizzolini et al*., 1999; *Bragagnolo*, 2009), raw poultry meat has approximately 27 to 90 mg cholesterol/100g and cooked poultry meat contains around 59 to 154 mg/100g. According to *Archuleta* (2003), observing quantity of 3 ounces, total lipids in roasted skinless breast and thigh were 3g and 9g, respectively, while cholesterol content was 73 mg and 80 mg, respectively. A significant factor that influences the cholesterol content in the poultry meat is a type of retail cut, because of the difference between dark and white chicken meat and the presence of skin. Poultry skin has the greatest cholesterol content compared with poultry meat or poultry fat. Cholesterol content of visible fat and breast meat is similar to or lower than dark meat (*Komprda et al*., 2003). Moreover, the difference in cholesterol content between white and dark poultry meat is more pronounced than that between white muscles (predominantly glycolytic) and red muscles (predominantly oxidative) of beef and pork (*Browning et al*., 1990; *Sinclair et al*., 2010). *Van de Bovenkamp and Katan* (1981) also suggested that the high cholesterol content of chicken skin that had been reported up to that date was erroneous, and they reported an analytical value for chicken skin of 71 mg/100g of raw wet tissue, while *Dinh et al.* (2011) has been reported higher concentration of cholesterol in raw and cooked chicken skin (more than 100 mg/100g).

Cholesterol content of the animal tissues can be influenced by the composition of the feed mixtures such as the ratio of polyunsaturated fatty acids, especially alpha-linolenic acid ratio (*Komprda et al*., 2003). *Crespo and Esteve-Garcia* (2001) suggested that dietary fatty acid profile plays an important role in lipid deposition and metabolism and results of lower abdominal fat in broilers fed on PUFA. They also showed that this fatty acid (coming from altered lipid ingredient in feed mixture through sunflower, tallow, lard) could cause an inhibition of lipogenesis, redistribution of lipids in the body or higher energy expenditure despite their higher digestibility respect to SFA. According to *Wang et al*. (2006), cholesterol content in chicken meat can be altered by varying the composition of diet, age and gender. However, many variables, such as broiler provenience, age, sex, nutrition, rearing size, carcass dressing and type of meat, could affect the nutritional value of meat and also can induce small or large differences in the obtained results (*Bogosavljevic-Boskovic et al*., 2010). Our results support the generally accepted fact that at decreasing rate of moisture the total fat content increases (*Woolsey and Paul*, 1969). In fact, content of lipids and cholesterol were always higher in roasted meat than in raw ones, due to loss of water during the heat treatment. According to *Chizzolini et al*. (1999), calories and cholesterol per gram, therefore, normally increase on a wet tissue basis, but the picture is obviously different when it is expressed on the basis of a dry matter.

With respect to the nutritional aspects and obtained results for cholesterol content in examined meat samples (mean value of results for autumn and summer), a two hundred gram portion of roasted chicken drumstick meat with skin represents 51% (Farm I) and 58% (Farm II) of the upper limit of daily cholesterol intake (300 mg), (*American Heart Association*, 2004). On the other hand, it is 52% (Farm I) and 43% (Farm II) in the case of chicken roasted breast meat with skin.

Large differences in cholesterol and total lipid content can be explained by possible other factors. In fact, in the summer, it was noted that growth performances for broilers from both of the farms were very different: average daily gain 57g (Farm I) and 39g (Farm II); average daily feed intake 103.9 g (Farm I) and 84.33 g (Farm II); feed: gain 1.82 g:g (Farm I) and 2.16 g:g (Farm II); mortality on the farm 5.34% (I) and 28.37% (II). In the autumn, the differences in these growth performances between farms were smaller, but did exist: average daily gain 57g (Farm I) and 52g (Farm II); average daily feed intake 100.5 g (Farm I) and 106.1 g (Farm II); feed: gain 1.76 g:g (Farm I) and 2.04 g:g (Farm II); mortality on the farm 3.19% (I) and 4.38% (II). These data show much worse growth performances for broilers on the Farm II comparing to Farm I, probably due to the problems in lipid metabolism, liver function and *de novo* synthesis of cholesterol, which might have influenced the levels of cholesterol and total lipid content in the meat of broilers from this farm (Figures I and II). Also, the observed differences could be associated with metabolic differences, higher competitiveness among males, different fat deposition, different nutritional requirements and higher hormonal effect in female broilers (*Tumova and Teimouri*, 2010).

Obtained differences in content of total lipid and cholesterol in the examined samples might be related to nutritional stress imposed by lower feed intake or some other reasons. *Komprda et al.* (2003) reported that total lipid content increased linearly and significantly in breast and thigh chicken tissues with the increasing live weight at the given age. Cholesterol content significant decreases in total muscle lipids while total lipid content in the muscle tissue increases, and in fact, there is decreasing trend in cholesterol content by increasing live weight.

Coefficients of correlation (r) in our trial were conducted in order to establish the relationship between total lipids and cholesterol content in breast and drumstick and carcass weight (Table 3). There were no– to moderate significant relationships between examined parameters.

For meat samples of the chickens from Farm I, in the summer, it was established a low significant positive correlation between cholesterol content in drumstick and carcass weight (0.41) and moderate positive correlation between cholesterol content in breast meat and carcass weight (0.51). There was a moderate significant relationship between total lipid content and carcass weight in samples of chicken breast from Farm I in the autumn (0.72). In the chicken meat samples from Farm II, there were registered moderate significant negative correlation between carcass weight and cholesterol content in drumstick and breast (-0.66 and -0.58, respectively), in the summer, while relationships

Table 3. Coefficient of correlation *(r)* between carcass weight (g), total lipid (%) and cholesterol (mg/100g) content

Tabela 3. Koeficijent korelacije *(r)* između mase trupa brojlera (g), sadržaja ukupne masti (%) i sadržaja holesterola (mg/100g)

Farm I, Summer	**Carcass weight** $\bar{X}$ 1279.5 g
	r
Total lipid – drumstick[d]	–0.001
Cholesterol – drumstick[a, e]	0.41
Total lipid – breast [b, f]	0.05
Cholesterol – breast [g]	0.51
Farm I, Autumn	**Carcass weight** $\bar{X}$ 1764.9 g
	r
Total lipid – drumstick	–0.49
Cholesterol – drumstick[a]	0.28
Total lipid – breast [b, h]	0.72
Cholesterol – breast	0.004
Farm II, Summer	**Carcass weight** $\bar{X}$ 1223.3 g
	r
Total lipid – drumstick[c, d]	0.02
Cholesterol – drumstick[e]	–0.66
Total lipid – breast [f]	0.17
Cholesterol – breast [g]	–0.58
Farm II, Autumn	**Carcass weight** $\bar{X}$ 1400.7 g
	r
Total lipid – drumstick[c]	–0.03
Cholesterol – drumstick	0.58
Total lipid – breast [h]	–0.51
Cholesterol – breast	–0.49

Legend/ Legenda: [a:a; b;b: c:c: d:d; e:e; f:f;; h:h] p0,001, [g:g] $p<0,001$
Chemical parametars in the same column followed by the same letters differ significantly/Hemijski parametri u istoj koloni sa istim slovnim oznakama se značajno razlikuju.

between cholesterol content in drumstick and carcass weight and total lipid content in breast meat and carcass weight were classified as significantly moderate positive and negative (0.58 and -0.51, respectively), in autumn.

Conclusion

The present experiment provides data of total fat and cholesterol content in fresh and roasted breast and drumstick chicken meat most commonly consumed in Serbia.

With the aim of getting more reliable results, content of total lipid and cholesterol have to be discussed in the light of other factors, such as genotype (breed), gender, feed composition, slaughtered age. Apart from these parameters, reduce in fat and cholesterol content in meat could be achieved with the use of various growth promoters, as well as with correct preparation of meat (trimming of fat, cooking methods, etc.).

Taken together the results presented here as well as high values for standard deviation, coefficient of variation and its wide range (big disparity for cholesterol contents, particularly) for examined samples of chicken meat shows that further investigations have to include greater number of samples of broilers meat from both of the farms.

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Sadržaj holesterola i ukupne masti u sirovom i termički tretiranom komercijalno proizvedenom pilećem mesu sa dve farme

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R e z i m e: Cilj ovih istraživanja je bio ispitivanje sadržaj holesterola i ukupne masti u sirovom i pečenom pilećem mesu brojlera poreklom sa dve komercijalne farme (Farma I i Farma II) u Vojvodini. Program ishrane brojlera i recepture za smeše za njihovu ishranu uradene su na bazi preporuka proizvodača hibrida ROSS, kako je predstavljeno u tabeli 1. Nakon tova od 39 dana, brojleri (po 12 jedinki sa svake farme), približno iste završne mase, zaklani su i obrađeni na liniji klanja, zatim ohlađeni, uobičajenim tehnološkim postupom. Od svake jedinke su uzeti uzorci belog mesa (Mm. pectoralis major et minor) i bataka (Mm. of regio tibio-femoralis) sa kožom, za određivanje sadržaja masti i holesterola u sirovom i pečenom mesu. Sadržaj ukupne masti je određen ekstrakcijom masti sa petroletrom nakon kisele hidrolize uzorka (SRPS ISO 1443/1992). Sadržaj holesterola je određen nakon direktne saponifikacije uzorka (bez prethodne ekstrakcije masti) tehnikom visokoefikasne tečne hromatografije (HPLC/PDA), prema metodi Maraschiello i dr. (1996).

Sadržaj ukupne masti je bio manji u uzorcima sirovog belog mesa pilića sa Farme II, u letnjem (3,05%) i jesenjem periodu (2,61%), u odnosu na sadržaj masti u uzocima sa Farme I (5,53%, leto i 4,20%, jesen). U uzorcima bataka sa Farme II sadržaj ukupne masti je bio statistički značajno manji (p < 0,001) samo u letnjem periodu (5,19%) u poređenju sa rezultatima sa Farme I (9,63%).

U uzorcima termički treiranog belog mesa i bataka koji su pripadali pilićima sa Farme II utvrđen je manji sadržaj ukupne masti u letnjem (3,57% i 10,54%, respektivno) i jesenjem periodu (3,72% i 11,11%, respektivno) u odnosu na uzorke sa Farme I (6,08% i 14,73%, respektivno, leto i 6,25% i 13,37%, respektivno, jesen). Razlike u sadržaju ukupne masti u uzorcima termički tretiranih bataka uzorkovanim u jesenjem periodu (13,37%, Farma I i 11.10%, Farma II) pokazale su se statistički značajne (p < 0,01). Sadržaj holesterola (mg/100g) u sirovom belom mesu je bio 53,90 (jesen) i 62,10 (leto), Farma I; 46,97 (jesen) i 49.53 (leto), Farma II. Utvrđena je statistički značajna razlika (p < 0,001) u sadržaju holesterola u uzorcima sirovog belog mesa pilića sa obe farme, u letnjem periodu. U sirovom bataku, prosečni sadržaj holesterola (mg/100g) iznosio je 70,24, u jesen i 83,95, u leto (Farma I) i 65,05, u jesen i 60,92, u leto, (Farma II). Dobijene razlike u sadržaju holesterola u uzorcima sirovih bataka su bile statistički značajne u uzorcima sa Farme I, u letnjem i jesenjem periodu i sa obe farme, u letnjem periodu (p < 0,001).

U pečenom mesu prosečan sadržaj holesterola (mg/100g) je bio između 70,32 (jesen) i 87,37 (leto), za belo meso i od 75,23 (jesen) do 78,92 (leto), za batak (Farma I) i između 64,33 (leto) i 66,24 (jesen), za belo meso i od 81,31(leto) do 91,6 (jesen), za batak (Farma II). Dobijeni rezultati ukazuje da je sadržaj ukupne masti i holesterola bio manji u sirovom i pečenom belom mesu sa kožom u odnosu na sirovo i pečeno crveno meso sa kožom. Dalja istraživanja je potrebno sprovesti na većem broju uzoraka mesa, a sadržaj ukupne masti i holesterola se mora sagledati uzimajuči u obzir faktore kao što su rasa (heritabilnost), pol, starost, masa životinja za klanje i adekvatna ishrana. Pored toga, primena određenih dodataka u ishrani brojlera, način obrade i pripremanja mesa može značajno da smanji sadržaj masti i holesterola u mesu.

Ključne reči: *pileće meso, holesterol, ukupne masti.*

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