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Cholesterol Oxides, Cholesterol, Total Lipid, and Fatty Acid Composition in Turkey Meat

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The contents of cholesterol oxides, cholesterol, and total lipid, and the fatty acid composition were determined in frozen turkey meat. The 7-ketocholesterol content varied from 33 μg/100 g in the breast to 765 μg/100 g in the skin, and the levels of 7β-hydroxycholesterol varied from not detected in the leg, breast, and skin to 370 μg/100 g in the skin. The values for total lipid (g/100 g) in the wings, legs, breast, and skin were 0.9 $\pm$ 0.4, 1.1 $\pm$ 0.2, 0.5 $\pm$ 0.1, and 12 $\pm$ 3, respectively. The contents for cholesterol (mg/100 g) were 46 $\pm$ 5, 35 $\pm$ 2, 27 $\pm$ 3, and 81 $\pm$ 6 in the wing, legs, breast, and skin, respectively. The main fatty acids identified in all cuts were C18:2*n*6, C18:1*n*9, C16:0, C18:0, and C20:4*n*6.

KEYWORDS: Turkey meat; cholesterol oxides; cholesterol; total lipid; fatty acids

INTRODUCTION

Foods containing high levels of cholesterol, such as eggs, milk, meat, and their processed products, when exposed to air, high temperatures, light, radiation, or any combination of these factors during processing or storage, can represent important sources of cholesterol oxides in the diet (*1*). These compounds may be associated with the development of a series of undesirable biological effects, such as arteriogenic, mutagenic, carcinogenic, and cytotoxic effects and inhibition of sterol biosynthesis, possibly contributing to the initiation of formation of arteriosclerotic deposits (*2*). Eight common cholesterol oxides have been identified: 25-hydroxycholesterol, cholestane-triol, α- and β-epoxide, 7α- and 7β-hydroxycholesterol, 7-ketocholesterol, and cholesta-3,5-dien-7-one (*3*).

Cardiovascular diseases are the main cause of death in many countries. To minimize this situation, cardiologists and nutritionists recommend a balanced diet, that is, one containing low contents of cholesterol, total lipids, and saturated fatty acids, and a higher content of monounsaturated and polyunsaturated fatty acids. Saturated fatty acids are considered to be hypercholesterolemic, and, in this respect, the most worrying are myristic, lauric, and palmitic acids. Stearic acid has a neutral function because it is immediately transformed into oleic acid in the organism (*4*). Of the unsaturated fatty acids, the trans fatty acids produced mainly during the processing and hydrogenation of fats and oils deserve special attention, as they are considered to be more arteriogenic than the saturated fatty acids (*5*). Naturally occurring cis polyunsaturated fatty acids, mainly the *n*-3, are considered to be hypocholesterolemic because they reduce plaque aggregation, reduce triacylglycerides, and consequently reduce the risk of cardiovascular diseases (*6*). The *n*-6 and *n*-3 fatty acids are the parent fatty acids for the production of eicosanoids, e.g., protaglandins, thromboxanes, and leukotrienes. Eicosanoids devived from *n*-6 fatty acids have metabolic properties opposite to those derived from *n*-3 fatty acids (*7*). A balanced intake of both *n*-6 and *n*-3 fatty acids is essential for health. According to Simopoulos (*7*) the recommended ratio of *n*6/*n*3 fatty acids is about 1−2:1.

The availability of turkey meat on the market has greatly increased in recent years due to its alleged characteristic of presenting low levels of cholesterol and total lipids and high levels of polyunsaturated fatty acids. Apart from this, the good acceptability due to its neutral taste and smooth texture is the other important factor for its growing place on the market. The world production of turkey meat increased by 18% from 1996 to 2001, with the United States, France, Italy, Germany, and Hungary being the greatest consumers (*8*).

Thus, the objective of this study was to determine the contents of cholesterol oxides, cholesterol, and total lipids, and the fatty acid composition in frozen turkey meat samples.

MATERIALS AND METHODS

Materials. Cholesterol and the cholesterol oxides cholesta-4,6-dien-3-one, 20α-hydroxycholesterol, 25-hydroxycholesterol, 7-ketocholesterol, and 7β-hydroxycholesterol were purchased from Sigma Chemical Company (St. Louis, MO). 7α-Hydroxycholesterol was obtained from

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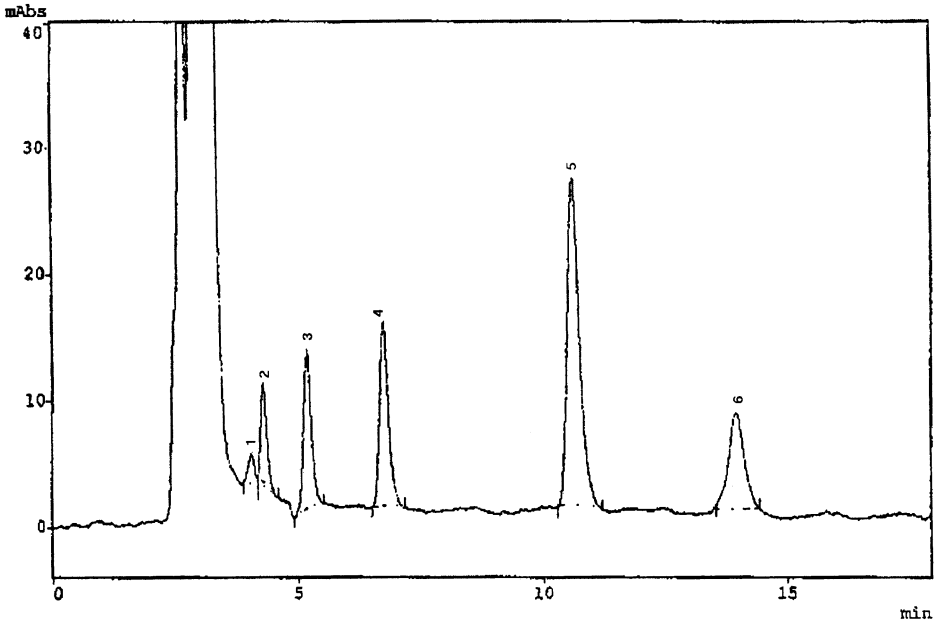

Figure 1. Typical HPLC chromatogram of the cholesterol (peak 1) and cholesterol oxide standards (peaks: 2, cholest-4,6-dien-3-one; 3, 20α-hydroxycholesterol; 4, 25-hydroxycholesterol; 5, 7-ketocholesterol; 6, 7β-hydroxycholesterol). Nova Pak CN HP column (4 μm, 300 × 3.9 mm) with hexane/2-propanol (96 + 4) as mobile phase at 1 mL/min. Chromatogram processed at 210 nm.

Steraloids Inc. (Newport, RI). A total of 36 saturated, monounsaturated, and polyunsaturated fatty acid standards (Sigma) were used. Five different batches of frozen turkey meat (*Meleagris gallopavo*) were purchased from supermarkets in Campinas, State of São Paulo, Brazil. Each batch, consisting of three units of turkey meat, was taken at random. In Brazil, turkey meat is available for purchase only in the frozen form, and the shelf life of these products is 16 months.

Lipid Extraction. The samples were thawed at room temperature immediately after purchasing. After the samples were deboned, and visible fat and skin were removed, the wing, legs, and breast muscles were ground until a minced paste was obtained. Samples were taken for duplicate analyses. The lipids were extracted according to Folch et al. (*9*). Briefly, each sample (10 g of wing and skin and 50 g of leg and breast) and 200 mL of chloroform/methanol (2:1) were added to a blender (Eberback, New Hartford, CT) and homogenized for 3 min (minimum speed). The homogenate was filtered through a Whatman No. 1 filter paper into a 500-mL separating funnel. The filtrate was re-extracted with 50 mL of chloroform/methanol (2:1) and again filtered through the same filter paper. The blender and filter paper were rinsed twice with 20 mL of chloroform/methanol (2:1). A 60-mL portion of 0.72% KCl was added to the solution in the separating funnel and the contents were mixed. After phase separation, the lipid layer was separated and another 20 mL of 0.72% of KCl was added. The lipid phase, after phase separation, was filtered through a Whatman No. 1 filter with anhydrous $NaSO_4$, into the 200-mL volumetric flask. From this extract, an aliquot of 10 mL was taken and the total lipid content was determined gravimetrically. Another aliquot (50 mL) was taken for the determination of cholesterol and its cholesterol oxides by high-performance liquid chromatography (HPLC). Another aliquot, with approximately 100 mg of lipid, was taken and the fatty acid composition was determined by gas chromatography (GC).

Simultaneous Determination of Cholesterol and Cholesterol Oxides by High-Performance Liquid Chromatography. The pre-chromatographic stages were carried out according to Sander et al. (*10*). Briefly, 50 mL of lipid extract was evaporated with a vacuum rotatory evaporator (Buchi Rotavapor, Switzerland), and 10 mL of 1 N KOH in methanol was added to the sample and shaken until the mixture became free of dispersed fat particles. Before closing the flask, the air was removed by a current of nitrogen. The flask was wrapped in aluminum foil and the mixture was shaken for 18 h at 20 °C. Distilled water (10 mL) was added to the saponified mixture, which was transferred to a 125-mL separating flask. Nonsaponifiables were extracted three times with 10 mL of diethyl ether, and the pooled diethyl ether extracts were washed once with 5 mL of 0.5 N KOH and twice with 5 mL of distilled water. After the extracts were dried by shaking with anhydrous $NaSO_4$, they were filtered using Whatman No. 1 filter paper, which was re-extracted with another 10 mL of diethyl ether. The combined filtrates were dried in a vacuum evaporator and freed of solvent by using a nitrogen flush, before dissolving in 2 mL of mobile phase and injection into the HPLC.

For HPLC, a Shimadzu chromatograph equipped with a quaternary solvent delivery system (LC-10ATVP), rheodyne injector with a 10-μL loop, photodiode array (SPD-M10AVP), oven column (CTO-10ASVP), and software (CLASS-LC 10) was used. The analytical column was a Nova Pak CN HP, 300 × 3.9 mm column, 4 μm (Waters, Milford, MA); preceded by a guard column Hypersil BDS CN 7.5 × 4.6 mm, 5 μm; and the column temperature was 32 °C. The mobile phase consisted of hexane/2-propanol (96 + 4) at a flow rate of 1.0 mL/min. Absorption spectra were taken at 200−400 nm and the chromatograms were taken at 210 nm. Characteristic chromatograms of the standards of cholesterol and cholesterol oxides and of the turkey meat samples, can be seen in **Figures 1** and **2**.

The cholesterol and cholesterol oxides were identified by (1) comparison of retention times of unknown peaks with those of reference standards, (2) addition of standards to the sample for co-chromatography, and (3) spectra obtained with the photodiode array detector, taken at the maximum, and ascending and descending slopes of the peak. Quantification was done by using an external calibration method. Five concentrations, ranging from 0.5 to 2.22 mg/mL for cholesterol and from 0.5 to 64.0 μg/mL for the cholesterol oxides, were injected onto the HPLC, and the calibration curve was obtained by plotting concentration against area.

To confirm the structures of cholesterol and cholesterol oxides a gas chromatograph−mass spectrometer (GC−MS) consisting of a Hewlett-Packard 6890 GC and 5973 MS was employed. The GC−MS conditions were as follows: HP-5MS (Palo Alto, CA) fused-silica capillary column (30 m × 0.25 mm i.d., film thickness 0.25 mm); carrier gas, helium at 0.7 mL/min; splitless injection at 290 °C. The oven temperature program was as follows: 110 °C (2 min), increasing at 40 °C/min to 235 °C (5 min) and then at 1 °C/min to 310 °C (5 min); interface temperature, 320 °C. The mass spectrometers were operated under electron ionization conditions with an electron energy of 70 eV. The samples and standards of cholesterol and its oxides were derivatized according to Schmarr et al. (*11*).

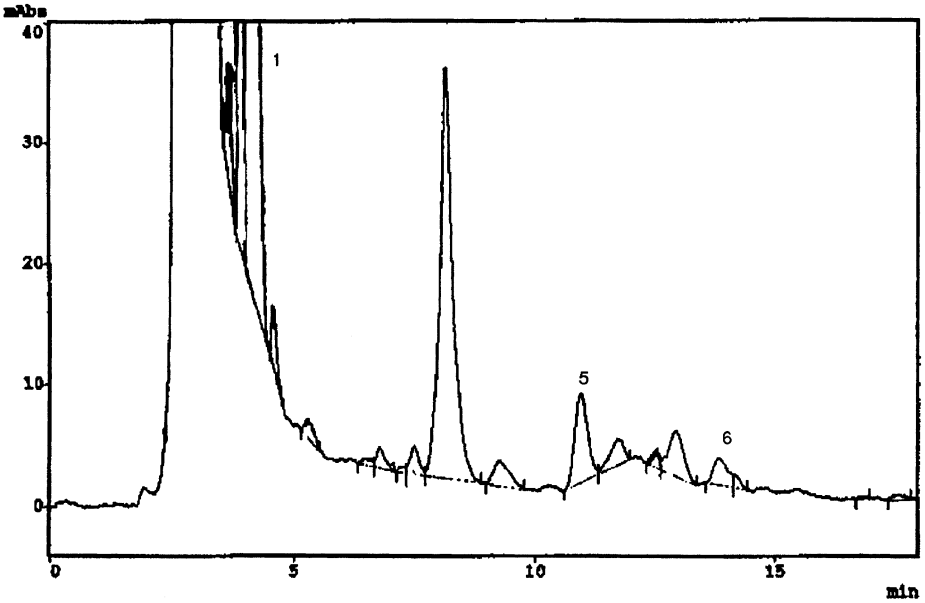

Figure 2. Typical HPLC chromatogram of the cholesterol (peak 1) and cholesterol oxides (peaks: 5, 7-ketocholesterol; and 6, 7β-hydroxycholesterol) in turkey meat. Nova Pak CN HP column (4 μm, 300 × 3.9 mm) with hexane/2-propanol (96 + 4) as mobile phase at 1 mL/min. Chromatogram processed at 210 nm.

The recovery percentages for cholesterol, 7-ketocholesterol, and β-hydroxycholesterol were 88.8 ± 0.2, 91.2 ± 0.0, and 96.8 ± 0.1%, respectively, adding 10 mg of the cholesterol and 80 μg of the 7-ketocholesterol and 7β-hydroxycholesterol to the 50 g of breast meat. The detection and quantification limits for cholesterol, 7-ketocholesterol, and 7β-hydroxycholesterol were 0.48 mg/100 g and 1.6 mg/100 g, 0.09 μg/g and 0.3 μg/g, and 0.18 μg/g and 0.6 μg/g, respectively, calculated according to Chairman et al. (*12*).

Determination of the Fatty Acid Composition. The dried lipid extract was methylated according to Hartman and Lago (*13*). Fatty acid methyl esters were separated on a gas chromatograph (Philips, PU 4550) equipped with a split injector (100:1), fused silica capillary column (50 m × 0.25 mm i.d., 0.20 μm film thickness of poly(ethylene glycol)) (CP-SIL 88, Crompak, Netherlands), flame ionization detector, and work station (Borwin, France). The column temperature was 180 °C (isothermal), the injector temperature was set at 270 °C, and the detector temperature was set at 300 °C. The carrier gas was hydrogen at a flow rate of 2.25 mL/min, and nitrogen was used as the makeup gas at 30 mL/min. The fatty acids were identified by comparison of the retention times of the sample with those of the standards, and by co-chromatography. Quantification was done by normalization and transformation of the area percentage into mg/100 g of edible portion, using the lipid conversion factor (*F*). An *F* value of 0.945 was used for the turkey meat cuts, based on McCance and Widdowson's (*14*), and the value of $F = 0.954$ for skin was calculated according to Weihrauch et al. (*15*) with the data for phospholipids and triacylglycerols obtained by Marion et al. (*16*).

Statistical Analysis. To verify the differences between the turkey cuts (wing, leg, breast, and skin), the results for cholesterol, total lipid, and fatty acids were submitted to an analysis of variance (ANOVA) at the 5% level of confidence.

RESULTS AND DISCUSSION

Cholesterol Oxides and Cholesterol in Turkey Meat. Highly significant differences existed in the cholesterol levels among the different cuts of turkey meat analyzed. The skin showed the highest amount, whereas the breast meat presented the lowest values (**Table 1**).

The value found in the leg muscle (35 ± 2 mg/100 g) was similar to that found by Paleari et al. (*17*), which was 36.6 ± 4.3 mg/100 g. However, higher values than those found in the present study were reported by Wong and Sampugna (*18*) for all cuts. McCance and Widdowson's (*19*) also described higher levels for the white and dark meats, and USDA reported higher levels (*20*) for dark turkey meat, as compared to our results.

Table 1. Cholesterol (mg/100 g) and Total Lipid (g/100 g) Levels in Turkey Meat

turkey meat	cholesterol M ± DP[a]	total lipids M ± DP[a]
wing	46 ± 5 b	0.9 ± 0.4 bc
leg	35 ± 2 c	1.1 ± 0.2 b
breast	27 ± 3 d	0.5 ± 0.1 c
skin	81 ± 6 a	12 ± 3 a

[a] Mean and standard deviation of 5 samples in duplicate. Values in the same column with the same letters do not present significant differences at the 5% level.

Two cholesterol oxides were found in the samples analyzed: 7-ketocholesterol and 7β-hydroxycholesterol; the results are shown in **Table 2**. Differently from the cholesterol levels, the contents of cholesterol oxides varied considerably among the samples. The 7-ketocholesterol contents varied from 330 μg/100 g in the breast to 765 μg/100 g in the skin, and the levels of 7β-hydroxycholesterol varied from not detected in the leg, breast, and skin to 370 μg/100 g in the skin. No correlation was found between the storage time and the level of cholesterol oxides of the samples analyzed. It is possible that the variations found between the samples could be related to alterations in the storage conditions of the samples before being purchased and analyzed, of which we have no knowledge.

In the present study, the highest level for 7-ketocholesterol (765 μg/100 g) found was similar to the lowest value (800 μg/100 g) encountered by Sander et al. (*10*) in freeze-dried turkey meat products. The higher levels detected by Sander et al. (*10*) could be attributed to the severe conditions used during freeze-drying. Ahn et al. (*21*) found, in turkey leg cooked meat, levels of 7β-hydroxycholesterol higher than those found in this present work, but for 7-ketocholesterol some results were the same and others were lower or higher. Five cholesterol oxides (7-ketocholesterol, 7β-hydroxycholesterol, 7α-hydroxycholesterol, 5,6β-epoxycholesterol, and 5,6α-epoxycholesterol) were found

Table 2. Cholesterol Oxide Levels (μg/100 g) in Turkey Meat

cholesterol oxide	cut	sample 1 M ± SD[a]	sample 2 M ± SD[a]	sample 3 M ± SD[a]	sample 4 M ± SD[a]	sample 5 M ± SD[a]
7-ketocholesterol	wing	327 ± 27	210 ± 17	190 ± 8	365 ± 44	263 ± 5
	leg	87 ± 5	69 ± 8	492 ± 20	146 ± 0	161 ± 11
	breast	33 ± 3	206 ± 12	252 ± 14	65 ± 0	97 ± 9
	skin	176 ± 4	593 ± 48	765 ± 87	267 ± 5	145 ± 10
7β-hydroxycholesterol	wing	110 ± 10	180 ± 60	190 ± 70	200 ± 20	150 ± 90
	leg	ND	100 ± 40	60 ± 10	60 ± 13	ND
	breast	130 ± 26	70 ± 10	ND	47 ± 6	ND
	skin	310 ± 160	ND	370 ± 150	270 ± 17	240 ± 90

[a] Mean and standard deviation of duplicate determination. ND = not detected (detection limit ≤ 18 μg/100 g)

Table 3. Fatty Acids Composition (mg/100 g) in Turkey Meat

fatty acid	wing (M ± SD)[a]	leg (M ± SD)[a]	breast (M ± SD)[a]	skin (M ± SD)[a]
C10:0	1.5 ± 0.2 b	tr	0.5 ± 0.1 c	6.9 ± 0.8 a
C12:0	2.6 ± 0.5 b	2.6 ± 0.1 b	tr	11.5 ± 0.2 a
C14:0	6.5 ± 0.6 b	7.1 ± 0.8 b	2.6 ± 0.3 c	93.9 ± 23.6 a
C15:0	40.7 ± 10.2 a	44.7 ± 9.4 a	28.8 ± 5.9 b	51.5 ± 9.2 a
C16:0	176.7 ± 12.1 bc	201.7 ± 47.2 b	91.4 ± 16.8 c	2619.3 ± 616.5 a
C17:0	4.9 ± 0.8 b	10.4 ± 2.6 a	7.0 ± 1.1 b	tr
C18:0	107.4 ± 25.7 bc	133.2 ± 25.1 b	62.1 ± 9.6 c	892.9 ± 222.0 a
C21:0	tr	0.5 ± 0.1 c	0.9 ± 0.2 b	9.2 ± 0.9 a
C22:0	1.3 ± 0.3 a	1.5 ± 0.2 a	1.1 ± 0.1 a	tr
C14:1*n*9	tr	1.0 ± 0.1 b	0.5 ± 0.2 c	14.9 ± 2.6 a
C16:1*n*7	20.0 ± 1.6 bc	26.3 ± 6.8 b	7.0 ± 0.8 c	515.2 ± 146.1 a
C18:1*n*9t	tr	2.8 ± 0.8 a	0.4 ± 0.0 b	tr
C18:1*n*9	189.2 ± 18.5 bc	228.1 ± 48.8 b	89.6 ± 8.9 c	3795.0 ± 890.1 a
C18:2*n*6	223.0 ± 90.4 bc	279.7 ± 46.6 b	127.4 ± 24.3 c	3194.0 ± 500.3 a
C18:2*n*6t	tr	1.7 ± 0.2 b	tr	2.3 ± 0.0 a
C18:3*n*3	5.8 ± 1.8 bc	8.8 ± 2.9 b	2.6 ± 0.6 c	143.1 ± 44.4 a
C20:2*n*6	3.1 ± 1.2 b	3.1 ± 0.5 b	1.9 ± 0.5 c	17.2 ± 3.1 a
C20:4*n*6	55.5 ± 3.1 b	73.9 ± 8.6 a	40.2 ± 8.3 c	67.5 ± 12.6 a
C22:5*n*3	3.8 ± 1.4 b	4.4 ± 0.9 a	3.0 ± 0.8 b	4.6 ± 1.6 a
C22:5*n*6	3.5 ± 0.4 a	4.8 ± 0.9 a	3.1 ± 0.7 a	3.4 ± 1.3 a
C22:6*n*3	3.1 ± 0.8 b	3.2 ± 0.3 b	2.5 ± 0.7 c	4.6 ± 1.8 a
saturated (%)	40	39	41	32
monounsaturated (%)	25	25	21	38
polyunsaturated (%)	35	36	38	30
saturated/polyunsaturated	1.15	1.07	1.08	1.07
total *n*3 (%)	1.5	1.6	1.7	1.3
total *n*6 (%)	34	35	37	29
*n*6/*n*3	0.04	0.04	0.04	0.04

[a] Mean and standard deviation of 5 samples in duplicate; tr = traces (< 1 mg/100 g); values in the same line with the same letters do not present significant differences at the 5% level.

in turkey leg cooked meat (*21*) and four (5,6β-epoxycholesterol, 5,6α-epoxycholesterol, 7β-hydroxycholesterol, and 7-ketocholesterol) were found in freeze-dried turkey meat products (*10*). According to Korahani et al. (*22*), of all the oxides formed in foods, 7-ketocholesterol is always present and also predominates, as was seen in this research. The content of cholesterol oxides in meat varies widely depending upon packaging, heating, irradiation, and storage time and conditions (*21*). The results obtained by Muench and Arneth (*23*) in heated meat products suggested that nitrite curing salt, modified-atmosphere packaging, and vacuum protected against the formation of cholesterol oxides. Apart from this, some quantitative data may not be consistent due to difficulties associated with the separation and analysis of the cholesterol oxides (*24*).

Total Lipids and Fatty Acids Composition. There was no significant difference in the total lipid levels of the wings, legs, and breast. The levels of total lipid ranged from 0.5 ± 0.1 in the breast to 12 ± 3 g/100 g in the skin (**Table 1**). Levels varying from 0.8 to 2.0 g/100 g in the white meat (*18*−*20*, *25*) and from 1.0 to 5.1 g/100 g in the dark meat (*18*−*20*, *25*−*27*) have been reported in the literature. Wong and Sampugna (*18*) and Marion et al. (*16*) found values in the skin higher than those in the present study, but in the USDA Nutrient Database (*20*), there were similar results.

The main fatty acids found in the wing, leg, breast muscles, and skin were C18:2*n*6, C18:1*n*9, C16:0, C18:0, and C20:4*n*6 (**Table 3**). The skin presented the highest contents for most fatty acids, followed by those of the leg. Among the meats, the main difference found was with respect to the breast, which presented lower levels, although not always significantly different, for the following fatty acids: C14:0, C16:0, C18:0, C16:1*n*7, and C18:2*n*6, and significantly higher values for C21:0. The fatty acids C15:0, C17:0, C22:0, C20:2*n*6, and C22:5*n*3 showed no significant differences among the meats, and C17:0 and C22:0 were not detected in the skin.

The percent of total saturated fatty acids varied from 32% in the skin to 44% in the wing, with the fatty acid C16:0 being that found in greater concentration, followed by C18:0, in all cuts. The percentage of total monounsaturated fatty acids was lowest in the wing and highest in the skin, with the fatty acid C18:1*n*9 predominating, followed by C16:1*n*7. The percentage of total polyunsaturated fatty acids was similar in the meats,

while lower in the skin. The fatty acid found in the highest amounts was C18:2*n*6, followed by C20:4*n*6. The content of the fatty acid C20:4*n*6 in the leg was similar to that found by Li et al. (*27*). The contents of the *n*3 fatty acids varied from 2.8 in the breast to 144.8 mg/100 g in the skin for C18:3*n*3, from 2.7 in the leg to 4.6 mg/100 g in the skin for C22:5*n*3, and from 1.9 in the leg to 3.8 mg/100 g in the skin for C22:6*n*3.

The percent of total saturated fatty acids found in the present study for leg was higher than the values obtained by Wong and Sampugna (*18*) and lower than those found by Paleari et al. (*17*), but agrees with those found in the USDA Nutrient Database (*20*), McCance and Widdowson's (*19*), and Li et al. (*27*). Similar results were also found in skin by McCance and Widdowson's (*19*). The percent of total monounsaturated fatty acids in the leg was similar to that found by Li et al. (*27*) and less than that reported in McCance and Widdowson's (*19*), USDA Nutrient Database (*20*), and Pinto and Silva (*26*). The total percentage of polyunsaturated fatty acids were slightly lower than that obtained by Wong and Sampugna (*18*), but higher than that in the USDA Nutrient Database (*20*), and agrees with that of Li et al. (*27*). According to Meynier et al. (*28*) the fatty acid composition of the turkey meat can be altered by the diet.

The ratio of the saturated to the polyunsaturated fatty acids found in this study showed no significant differences between the samples analyzed, showing a mean of 1.1. This value is similar to that found by Wong and Sampugna (*8*) and Li et al. (*27*) for light and dark turkey meat. The ratio of *n*6/*n*3 was higher than the results obtained by Li et al. (*27*). This ratio is much higher than that recommended by Simopoulos (*7*) for the total diet. This lack of balance must be compensated by other components of the diet.

The presence of trans fatty acids was insignificant in the turkey samples analyzed. The leg presented the trans fatty acids C18:1*n*9 and C18:2*n*6, and the breast presented only C18:1*n*9. Wong and Sampugna (*18*) found elevated amounts of trans fatty acids in all the samples analyzed, which they attributed to coming from the feed given to the turkeys.

Comparing the values for lipids, cholesterol, and saturated fatty acids found in this study with those of the USDA Nutrient database (*20*) for the light meat of chicken, it can be seen that the turkey meat showed lower values; with the values found by the above-mentioned authors being as follows: 1.65 g/100 g lipids, 58 mg/100 g cholesterol and 440 mg/100 g of saturated fatty acids.

In conclusion, the turkey meat showed low values of total lipid, cholesterol, and higher polyunsaturated fatty acids, being a good alternative for diets aimed at controlling blood cholesterol levels. Of all the cuts analyzed, the breast meat showed the lowest values for total lipids and cholesterol and the highest values for total polyunsaturated fatty acids. Two cholesterol oxides, 7-ketocholesterol and 7β-hydroxycholesterol, were found, with levels showing great variation among batches indicating the possibility of variations in the storage condition.

LITERATURE CITED

(1) Smith, L. L. Cholesterol autoxidation. *Chem. Phys. Lipids* **1987**, *44*, 87−125.

(2) Hubbard, R. W.; Ono, Y.; Sanchez, A. Atherogenic effect oxidized products of cholesterol. *Prog. Food Nutr. Sci.* **1989**, *13*, 17−44.

(3) Finocchiaro, E. T.; Lee, K.; Richardson, T. Identification and quantification of cholesterol oxides in grated cheese and bleached butter oil. *J. Am. Oil Chem. Soc.* **1984**, *61*, 877−882.

(4) Sinclair, A. J. Dietary fat and cardiovascular disease: the significance of recent developments for the food industry. *Food Aust.* **1993**, *45*, 226−239.

(5) Lambertson, G. Trans fatty acids topic for lipidforum. *Am. Oil Chem. Soc.* **1992**, *3*, 196−201.

(6) Kinsella, J. E.; Lokesh, B.; Stone, R. A. Dietary n-3 polyunsaturated fatty acids and amelioration of cardiovascular disease: possible mechanisms. *Am. J. Clin. Nutr.* **1990**, *52*, 1−17.

(7) Simopoulos, A. P. Human requirement for n-3 polyunsaturated fatty acids. *Poultry Sci.* **2000**, 79, 961−970.

(8) USDA. *FASonline*. United States Department of Agriculture, 2001. http://www.fas.usda.gov/commodities.

(9) Folch, J.; Less, M.; Stanley, S. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.* **1957**, *226*, 497−509.

(10) Sander, B. D.; Addis, P. B.; Park, S. W.; Smith, D. E. Quantification of cholesterol oxidation products in a variety of foods. *J. Food Prot.* **1989**, *52*, 109−114.

(11) Schmarr, H. G.; Gross, H. B.; Shibamoto, T. Analysis of polar cholesterol oxidation products: evaluation of a new method involving transesterification, solid-phase extraction, and gas chromatography. *J. Agric. Food Chem.* **1996**, *44*, 512−517.

(12) Chairman, L. H. K.; Crummett, W.; Deegan, J. J.; Libby, R. O.; Taylor, J. K.; Wentler, G. Principles of Environmental Analysis. *J. Am. Chem. Soc.* **1983**, *55*, 2210−2217.

(13) Hartman, L.; Lago, R. C. A. Rapid preparation of fatty acid methyl esters from lipids. *Lab. Pract.* **1973**, *22*, 475−481.

(14) Holland, B.; Welch A. A.; Unwin, I. D.; Buss, D. H.; Paul, A. A.; Southgate, D. A. T. Miscellaneous Foods. In *McCance and Widdowson's The Composition of Foods*; Chan, W., Brown, J., Buss, D. H., Eds.; Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food: Cambridge, UK, 1994; pp 8−9.

(15) Weihrauch, J. L.; Posati, L. P.; Anderson, B. A.; Exler, J. Lipid conversion factors for calculating fatty acid contents of foods. *J. Am. Oil Chem. Soc.* **1977**, *54*, 36−40.

(16) Marion, W. W.; Maxon, S. T.; Wangen, R. M. Lipid and fatty acid composition of turkey liver, skin and depot tissue. *J. Am. Oil Chem. Soc.* **1970**, 47, 391−392.

(17) Paleari, M. A.; Camisasca, S.; Beretta, G.; Renon, P.; Corsico, P.; Bertolo, G.; Crivelli, G. Ostrich meat: physicochemical characteristics and comparison with turkey and bovine meat. *Meat Sci.* **1998**, *48*, 205−210.

(18) Wong, M. K.; Sampugna, J. Moisture, total lipids, fatty acids and cholesterol in raw ground turkey. *J. Agric. Food Chem.* **1993**, *41*, 1, 1229−1231.

(19) Meat, Poultry and Game. In *McCance and Widdowson's The Composition of Foods*; Chan, W., Brown, J., Lee, S. M., Buss, D. H., Eds.; Bath Press: Bath, UK, 1995; p 161.

(20) USDA. *Nutrient Database for Standard Reference*, Release 13, Poulty Products. Nutrient Data Laboratory, Agricultural Research Service: Beltsville, MD, **2000**; 661 (http://www.nal.usda.gov/fnic/foodcomp/Data/SR13/sr13doc.htm.

(21) Ahn, D. U.; Lee, J. I.; Jo, C.; Sell, J. L. Analysis of cholesterol oxides in egg yolk and turkey meat. *Poult. Sci.* **1999**, *78*, 1060−1064.

(22) Korahani, V. B. J.; Crastes de Paulet, A. Autoxidation of cholesterol fatty acid esters in solid state and aqueous dispersion. *Lipids* **1982**, *17*, 703−707.

(23) Muench, S.; Arneth, W. Studies on the content of cholesterol oxides in heated meat products. *Mitteilungsblatt* **2001**, *40*, 177−186.

(24) Paniangvait, P.; King, A. J.; Jones, A. D.; German, B. G. Cholesterol oxides in foods of animal origin. *J. Food Sci*. **1995**, *60*, 1159−1173.
(25) Wilson, B. R.; Pearson, A. M.; Shorland, F. B. Effect of total lipids and phospholipids on warmed-over flavor in red and white muscle from several species as measured by thiobarbituric acid analysis. *J. Agric. Food Chem.* **1976**, *24*, 7−11.
(26) Pinto e Silva, M. E. M., Mazzilli, R. N., Cusin, F. Composition of hydrolysates from meat. *J. Food Compos. Anal*. **1999**, *12*, 219−225.
(27) Li, D., Ng, A., Mann, N. J., Sinclair, A. J. Contribution of meat fat to dietary arachidonic acid. *Lipids* **1998**, *33*, 437−440.
(28) Meynier, A.; Genot, C.; Gandemer, G. Oxidation of muscle phospholipds in relation to their fatty acid composition with enphasis on volatile compounds. *J. Sci. Food Agric*. **1999**, 79, 797−804.

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