Study on the Profile of Fatty Acids of Broiler Chicken Raised and Slaughtered in Industrial System

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Fatty acid profile and the related nutritional indices of the breast, thigh and drumstick muscles were studied at three farms, suppliers of ROSS 308 line of broilers, slaughtered at the age of 42 days. The proximate chemical composition of the commercial slaughter cuts revealed contents between 16.26–22.78% for proteins and 1.80–7.45% for total lipids, the breast having the highest protein and ash content and lowest values for fat and moisture. The obtained values were mainly affected by region (P<0.001). Meat fatty acid profile was affected (P<0.001) by commercial slaughter regions (CSR) and by the interactions between CSR and supplier farms (Farm A, B, and C) at different levels. The obvious findings highlighted that Farm B supplied broilers with a delivered higher content of beneficial fatty acids (LA, LNA, AA, EPA, and DHA) in breasts and drumstick, while for thigh, Farm C had the best results. The content of total saturated fatty acids (SFAs), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFAs) had the highest level in the thigh (P<0.001).

Keywords: broiler meat, fatty acids, lipids quality

Materials and methods

Animals, slaughtering and meat samples

The Bioethical Committee of the Ion Ionescu de la Brad University of Applied Life Sciences and Environment, Iasi, Romania endorsed the current experiment in cooperation with Room Trading Company Ltd. The assumption of this research has passed from the ongoing need to deliver broiler chicken meat of steady quality in all aspects, including dietary. 150 chicken broilers (ROSS 308) were considered for meat quality evaluation from 3 supplier farms within the company group (50 birds/every experimental group (L1 = Farm A, L2 = Farm B, L3 = Farm C) stochastically divided in a completely randomized design at the time of slaughter, 42 days old, Table 1 describing both, the entire population of birds and the selected biological material. Pre-harvest handling, transportation (between 0.25-2.75 hours), and slaughtering procedures (stunning, decapitation and bleeding) were in accordance with the implemented good animal welfare practices approved by the E.U. rules [9] after a fasting period of 12 hours (overnight) and a resting time before slaughter of 30-90 minutes. All the chickens were weighed before being slaughtered and eviscerated, the resulted carcasses were cooled and maintained at 4°C for 24 h postmortem and after, the breasts, thighs and drumsticks were separated, and frosted at -18°C for use in chemical analysis (brute chemical composition and fatty acid profile).

All the farms from the experimental design applied the same industrial technology of raising; population with 1 day chicken broilers on the same day, biological material purchased from the same commercial hatchery; accommodation in a deep litter (chopped straw with wood shavings in a ratio of 60:40) in climate controlled facilities with a photoperiod of 23 hours of light/day ‘till 7 days old and 18 hours light/day starting on the 8th day of life, the environment temperature ranged between 20–25°C and a relative humidity of 55–75%. All birds were fed a starter, grower and finisher diet, with ad libitum access to water (using a nipple water system) and corn-wheat-soy diet (Table 2), formulated to meet the nutrient requirements for finishing. To improve feed

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conversion, carcass yield and breast meat yield was added a supplement of Lysine. The feed supplier performed values of descriptive parameters for diet proximate chemical composition.

Prior to the beginning of the assessment, samples maintained for 2 months in freezing conditions were thawed overnight, deboned, minced and homogenized. Meat nutrient content was determined according to AOAC (2000), by measuring dry matter, ash, fat (using ether extraction Soxhlet method) and protein (using Kjeldahl method) [23].

The concentration of individual fatty acids was determined in two extracts from all samples by gas-liquid chromatography (GLC). Nonadecanoic acid (C19:0; 3–5 mg) was added to the sample (1.5–2.5 g) as internal standard (IS). The extraction of lipids from meat samples was performed with a mixture of chloroform and methanol (2:1 v/v), as described by Folch [24]. Next, lipid extracts were converted to fatty acid methyl esters (FAME) through a consecutive trans-esterification with methylene chloride [25-27]. Separation and quantification of the fatty acid methyl esters (FAME) was performed using CarloErba 5300 mega series gas chromatograph (GS) equipped with a flame ionization detector (FID) suited for a fused-silica Omegawax 320 capillary column type SP-2380 (60 x 0.25 mm internal diameter x 0.20 µm film thickness, Supelco Inc., Bellafonte, PA). The chromatographic operating conditions were as follows: initial column oven temperature 160°C (programmed to increase at a rate speed of 1°C/min. and from 180°C to 260°C at a rate speed of 5°C/min.) and then maintaining it at 260°C for 5 minutes, the total running time being 45 min. The carrier gas was helium at a flow rate of 1.2 mL/min. and the splitting ratio, 1:20. The peaks were identified by comparison with the retention times of the standard fatty acids methyl esters -C19:0 (Supelco, 37 components FAME mix).

### Table 1: DESCRIPTION OF THE BIOLOGICAL MATERIAL

| Items | L1 (Farm A) | L1 (Farm B) | L1 (Farm C) |
|-------|-------------|-------------|-------------|
| Broilers population, (N) | 98560 | 105600 | 112540 |
| Broilers at slaughterhouse reception, (N) | 98353 | 105435 | 112352 |
| Mortality during transport, (%) | 0.2±0,01 | 0.16±0,01 | 0.08±0,01 |

| Proximate and fatty acid analysis | | | |
|-----|-----|-----|
| The following Eqs. were used to calculate saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs): | | |
| SFA = C8:0 + C10:0 + C12:0 + C14:0 + C15:0 + C16:0 + C17:0 + C18:0 + C20:0; | | |
| MUFA = C14:1 + C16:1 + C17:1 + C18:1 n-9 + C18:1 n-7 + C20:1 n-9; | | |
| PUFAs = C18:2n-6cis + C18:3n-6 + C18:2n-6cis + C18:3n-3 + C20:2 + C20:3 n-3 + C20:4 n-6 + C20:5 n-3 + C22:5 n-6 + C22:5 n-3 + C22:6 n-3; | | |
| The algorithm of the lipids indices was based on the fatty acid composition of the intramuscular lipids extracted here, being calculated Index of Atherogenicity (IA), Index of Thrombogenicity (IT) [28, 29] and Hypocholesterolemic/ Hypercholesterolemic ratio [30] It by using the next Eqs.: | | |
| IA = (4 x C14:0 + C16:0)/(MUFA + Σ(n-6) + Σ(n-3)); | | |
| IT = (C14:0 + C16:0 + C18:0)/(0.5 x MUFA + 0.5 n (n-6) + 3 x (n-3) + (n-3)/(n-6)); | | |
| h/H = (ΣMUFA + ΣPUFAs)/(C14:0 + C16:0); | | |
| Statistical analysis | | |
| Data are presented as mean ± SEM. All statistical analysis was performed using the software package SPSS v.20 (SPSS Inc., Chicago, IL). Fatty acid profile and meat chemical composition data were analyzed using a general linear model (GLM) with CSR (commercial slaughter region: breast, thigh, drumstick), supplier (L1 = Farm A, L2 = Farm B, L3 = Farm C) and their interaction as fixed effects. Carcass weight and muscle fat content was included as corrected covariates because of variations in fatness rate. Principal component analysis (PCA) was used to explore and understand the variability of bird’s meat composition by studying the correlation among the various fatty acids indices and summarizing them in meaningful components (PCs). | | |
| Results and discussions | | |
| Processing and its impacts on poultry’s dietary meat have become more worrying in recent years. Overall, literature describes the low impact of primary and further processing on the dietary significance of chicken meat, with the exception of wet chilling, where exposure can immediately influence water-soluble nutrients, but without significant impact on proteins or fats [20]. | | |
Results from the analyzed meat samples on the proximate chemical composition of broilers commercial slaughter cuts, shown in Table 3, revealed contents between 16.26-22.78% for proteins and 1.80-7.45% for total lipids. The commercial slaughter region had a major impact (P<0.001) on the overall chemical composition, with the breast having the highest protein and ash content and lowest values for fat and moisture. The management of the suppliers influenced the muscle protein content (P<0.05), and the interactions between suppliers and carcass commercial slaughter regions had both an extensive and deeper effect on fat (P<0.01) and moisture (P<0.05). Our results are comparable to other studies that indicated wide range of values for proteins, lipids, and minerals, between 18.4-23.4%, 1.3-6.0%, and 0.8-1.2%, respectively.

The fatty acid composition and their health-related lipid indicators of breast, thigh, and drumstick meat of birds fed on a cereal-based diet centered on corn, wheat, soy meal, sunflower meal, sunflower oil, and supplemented with lysine, methionine, and mineral complexes is provided in Tables 4 and 5.
C16:0, C18:0, C18:3n-3 (LNA), C16:1, C20:4n-6 (AA) and C20:5n-3 (EPA). The literature reports the same decreasing order of concentration for the main fatty acids of broiler meat, important for human nutrition (LA, LNA, AA, EPA) as a result of the dietary inclusion of oil sources rich in n-3 polyunsaturated fatty acids. More than that, because these FA are recommended for human nutrition due to their ability to minimize the probability of lifestyle-related diseases occurrence [33, 34], the recent researches centered on n-3 PUFA targeted broiler meat enrichment through new ultrasound-assisted nano-emulsion preparation [36] and consecrated strategies, like direct feed supplementation [37-46]. These approaches are used to minimize ù-6: ù-3 ratio in human diets [47, 48].

As we mentioned, in agreement with the values of total fat content, the predominant lipid fractions in broiler meat is displayed in Figure 1, monounsaturated fatty acids (MUFA) ranging between 28.97–38.04% of the total IMF. C18:1 n-9 is the most important in the MUFA group, with an average overall value of 31.38%, being the dominant one in total PUFA. The overall average values for this fraction were between 31.85–32.91% of total FA. C18:2n-6c and C18:3n-3 were found to be the dominant ones, responsible for 83.77% and 5.72% of total PUFA. The total SFA content of breast, thigh and drumstick meat did not differ between suppliers (P>0.05), although thigh and drumstick had the higher content (P<0.05) being unfavorable to human health [49].

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28.60–33.85% of total FA. Here, C16:0 was the most abundant in terms of quantity (70.17% of total SFA), followed by C18:0, (26.22% of total SFA).

In our study there is an evident statistically significant effect (P<0.001) of CSR on each fatty acid content, with less extensive rate for C18:3n-6 (P<0.05). The obvious findings highlighted that Farm B supplied broilers with a delivered higher content of beneficial fatty acids (LA, LNA, AA, EPA, DHA) in breasts and drumstick, while for thigh Farm C had the best results. For C20:5n-3 (EPA), it was noted that the quantity of the drumstick lipids was comparatively nearly two times greater than that of the IMF breast muscles (P<0.001).

Dietary incorporation of sunflower meal and oil lowered the C18:2n-6c (LA) content in breast, but not in thigh and drumstick meat. The same pattern is retained for some undesirable saturated fatty acids (USFA), such as C10:0, C12:0, C14:0, C16:0, C17:0 and C20:0.

C18:1 was the major MUFA, while PUFA was mainly defined by C18:2n-6. No statistical differences (P>0.05) were found in the whole monounsaturated fatty acids (MUFA) and total polyunsaturated fatty acids (PUFA) contents of breast, thigh and drumstick meat between suppliers, only CSR and interaction CSR x S had a significant, but specific effect on almost all FA.

Meat fatty acids profiles of chicken meat (SFA, MUFA, PUFA, n-3, n-6), and the ratios among breast, but not in thigh and drumstick meat. The same pattern is retained for some undesirable saturated fatty acids (USFA), such as C10:0, C12:0, C14:0, C16:0, C17:0 and C20:0.

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Lipid nutritional quality indices for adipose tissue ranged from 0.31 to 0.39 for IA, respectively 0.57 and 0.77 for IT. According to the relative contents of the particular groups of fatty acids, the thigh lipids showed the lowest atherogenic (IA; P<0.001) and thrombogenic (IT; P<0.001) indexes in comparison with the analyzed fats of drumstick and breast muscles (Table 4). This image is clearly represented throughout the principal component analysis (PCA), where CSR samples were displayed in the multi-dimensional space of the newly calculated variables. The first two PCs calculated from these descriptors account for 93.71% of the total data variability, as shown in Figure 2.

IT and IA indices are strongly correlated with breast muscle lipids composition, being adjacent and related with F1 plane in a negative way. The lipids of drumstick have loading values affiliated stronger to F2 plane. The thigh meat samples are positively correlate with F1 plane, having lipids strongly related and positively described by all health-related indices. As anticipated, studied CSR and their FA profiles reflected the FA composition of bird’s diet fat (especially sunflower oil), this type of supplementation being company nutritional strategy, based on literature studies [50, 51].

Conclusions
The proximate chemical composition of the commercial slaughter cuts revealed breast superiority, the obtained values, especially for proteins (16.26-22.78%) and lipids (1.80-7.45%) being mainly affected by region (P<0.001). Meat fatty acid profile (P<0.001) was affected by commercial slaughter regions (CSR) and interactions between CSR and supplier farms (Farm A, B, and C) at different levels, with quantitative values comparable to
those mentioned in the literature, with emphasis on dietary manipulation. Total content of SFAs, MUFAs and MUFAs had the highest level in the thigh (P < 0.001). Farm B supplied broilers with a delivered higher content of beneficial fatty acids (LA, LNA, AA, EPA, and DHA) in breasts and drumstick, while for thigh Farm C had the best results.

Although the results of the current study demonstrate that the fatty acid profile in edible tissues (breast, thigh and drumstick) depends on the feed composition, it definitely can be influenced by the performance management of the supplier farms in all aspects, such as: nutritional management, training of the people or degree of the good raising practices (GRP) implementation. This assessment played an active role in the future execution of the company brand growth plan.

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