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INFLUENCE OF TEMPERATURE DURING SLAUGHTER ON THE CHEMICAL COMPOSITION AND GROSS ENERGY OF REFRIGERATED BROILER BREAST MEAT

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Abstract

The aim of the study was to assess whether different temperatures applied in certain points of the broilers slaughtering technological flow affects or not the chemical composition and the gross energy value of the meat. Three groups of carcasses were studied (LC, L1E and L2E), in relation with the slaughtering key points with altered temperature: scalding stage (LC = 51-53°C; L1E = 53-54°C; L2E = 55-56°C); chilling (LC = 1-4°C; L1E = 2-3°C; L2E = 1-2°C); sorting and packaging (LC < 12°C; L1E = 8-10°C; L2E = 6-8°C); final storage (LC = 0-2°C; L1E = 0-1°C; L2E = 0-1°C). Fifty carcasses of ROSS-308 chicken broilers per group, kept throughout 1 day in chill store room prior to shipping, were investigated for the proximate composition (water, dry matter, minerals, total lipids and protein content, nitrogen free extract) and gross energy value, using samples of 50 g taken from breast (Pectoralis major and Pectoralis minor muscles). Standard A.O.A.C. methods were applied for the analytical chemistry protocols in 15 replications per parameter, while the gross energy content was computed using the nutrient caloric conversion factors proposed by F.A.O. Water content reached 73.23 g/100 g in LC, 73.02 g/100 g in LE1 and 72.90 g/100 g in LE2. Dry matter content varied accordingly (26.77 g/100 g in LC to 27.10 g/100 g in LE2). Total minerals were found within the 1.08-1.10 g/100 g range. Major differences were observed between the total lipids of the control group (2.14 g/100 g) and the experimental groups, i.e. 2.65 g/100 g in LE1 group (P<0.05) and 2.90 g/100 g in LE2 group (P<0.01). Although the total proteins content decreased (LC = 23.01 g/100 g; LE1 = 22.76 g/100 g; LE2 = 22.60 g/100 g) as the experimental factor was gradually altered, there were not significant differences found. Nitrogen free extract calculations resulted in close values between groups, while the energetic value was affected due to lipid content variations (P<0.05 for the LC vs. LE2 comparison, i.e. 119.77 vs. 124.71 kcal/100 g). Therefore, the increase of temperature during scalding and its decrease during sorting, packaging and storage induced exudation and significant variations of lipids and energetic content.

Key words: *chicken, slaughtering, temperature, proximate composition, gross energy.*

INTRODUCTION

Poultry meat ultimate quality is affected by several pre-slaughter factors, such as fowl age (Wideman et al., 2016) farming technology and culling (Baracho et al., 2006), transportation, crating, hanging to slaughterhouse conveyor (Petracci et al., 2010) and stress leading to intense muscular efforts and spasms (Huang et al., 2018), pre-slaughter fastening (Jiang et al., 2011), type of stunning (electrical, low-pressure atmosphere, gaseous) (Kissel et al., 2015; Sirri et al., 2015; Fuseini et al., 2016; Mackie and McKeegan, 2016; Silva-Buzanello et al., 2018).

Also, the technological flow in the slaughterhouse, through its microclimate factors affects the ultimate quality of poultry meat (Wang et al., 2016).

It is known that several pathogenic bacterial species (*Salmonella* ssp., *Campylobacter* ssp.) (Giombelli and Gloria, 2014) colonise the poultry carcasses and most of them occur after slaughtering, de-feathering and evisceration (Zweifel et al., 2015). Particularly, the temperature, as one of the slaughterhouse microclimate component, is used as a decreasing factor of microbial contamination of carcasses (Lehner et al., 2014) is suspected to influence the meat quality in general (Anghinoni et al., 2019), the meat yield and its quality (Buhr et al., 2014) or the chemical composition of the poultry meat in particular, subsequently the nutritional value (Bowker et al., 2014), due to slightly induced changes in meat tissues and, therefore in their capacity to retain or exudate fluids, such as water,

cytoplasm colloids, interstitial fluids and so on (Silva-Buzanello et al., 2019).
Within this context, the original research protocol aimed to find out whether higher scalding temperatures and lower chilling and storage temperatures, used both in reducing the microbial contamination of broilers carcasses and of cut parts influence or not the chemical composition and caloricity of the meat.

MATERIALS AND METHODS

Hypothesis: increased temperature in scalding stage of broilers carcasses and decreased temperatures in chilling, sorting, storing stages does not affect the chemical composition and gross energy content in breast muscles.
Graduation of experimental factor, temperature across some key stages of the slaughter technological flow. Three groups of 50 carcasses each (LC, L1Exp and L2Exp) were randomly formed, in order to investigate the altered temperature influence on meat quality, in certain key stages of the technological flow:

- scalding: LC = 51-53°C; L1E = 53-54°C; L2E = 55-56°C;
- chilling: LC = 1-4°C; L1E = 2-3°C; L2E = 1-2°C;
- sorting and packaging: LC < 12°C; L1E = 8-10°C; L2E = 6-8°C;
- final storage: LC = 0-2°C; L1E = 0-1°C; L2E = 0-1°C.

Sampling. By the end of the flow, the carcasses were kept throughout 1 day in chill store room. Then, samples of 50 g samples of skinless breast meat (both *Pectoralis major* and *Pectoralis minor*) were harvested from each carcass in order to investigate the meat proximate composition (water, dry matter, minerals, total lipids and protein content, nitrogen free extract and to calculate the gross energy content within.
Analytical protocols. Official AOAC 983.18 method was used to prepare homogenously the meat samples before submitting them to other analytical procedures. Then, the samples were tested to assess water and dry matter content, via microwave evaporation using the AOAC official method no. 985.14. Subsequently, the dry matter compounds were assessed: crude ash (Kolar, 1992), protein (total nitrogen AOAC 928.08) and total lipids - crude fat (AOAC 991.36). Nitrogen free extract was calculated by difference, between the total dry matter and the sum of ash, fat and total nitrogen (Apata et al., 2015). Then, using the Atwater coefficients proposed by FAO, the organic content of each sample was converted into gross energy (FAO, 2003).
For every proximate composition trait and for the energy content calculation, there were run 15 analytical replications.
Statistical processing. Acquired data via analytical methods or computations were statistically analysed using the GraphPad Prism 8 Software, running ANOVA single factor analysis, followed by post-hoc Tukey computations, in accordance with the data treatment methodology proposed by Mendenhall and Sincich, 2016.

RESULTS AND DISCUSSIONS

Water content gradually decreased (by 0.3% to 0.45%) in the analysed samples as scalding temperature increased and chilling temperature was lower in experimental groups, compared to control group (Table 1). The difference between the L2Exp group and LC group was significant (P<0.05) suggesting a likelihood of at least 95% that water content would decrease in broilers breast meat as the temperature in scalding would increase by 3-4°C. The content of dry matter varied accordingly and reversed proportionally with the water content of samples.

Table 1. Moisture, dry matter and total mineral vs. organic compounds in the broiler breast meat, as influenced by temperature during slaughter (n = 15)

Trait	LC group (mean ± SD) (g/100 g wet weight)	L1Exp group (mean ± SD) (g/100 g wet weight)	L2Exp group (mean ± SD) (g/100 g wet weight)
Water	73.23±0.35	73.02±0.29	72.90±0.43
± % and ANOVAs	100%	-0.29% *P*=0.09 vs. LC	-0.45% *P*=0.03 vs. LC * *P*=0.09 vs. L1Exp
Dry matter	26.77±0.35	26.98±0.29	27.10±0.43
± % and ANOVAs	100%	+0.78% *P*=0.09 vs. LC	+1.23% *P*=0.03 vs. LC * *P*=0.09 vs. L1Exp
Total minerals	1.08±0.03	1.10±0.06	1.10±0.04
± % and ANOVAs	100%	+1.85% *P*=0.28 vs. LC	+1.85% *P*=0.06 vs. LC *P*=0.69 vs. L1Exp
Total organic matters	25.69±0.34	25.88±0.28	26.00±0.42
± % and ANOVAs	100%	+0.74% *P*=0.11 vs. LC	+1.20% *P*=0.04 vs. LC * *P*=0.38 vs. L1Exp

** significant differences (0.01<P<0.05)*

Total inorganic matters (minerals) content varied between 1.08 g/100 g (LC) and 1.10 g/100 g (both experimental groups), the small differences did not reach any significance threshold. In terms of total organic matters, the control group samples reached 25.69 g/100 g meat, while those in L1Exp group were 0.74% richer and those in L2Exp group contained 1.2% more organic substances (P<0.05), suggesting that the draining of water due to higher scalding temperature also induced a concentration of dry matter and, subsequently, of organic matters.

The compounds with more nutritional significance and with caloric power within (lipids, total nitrogen matters and nitrogen free extract) varied accordingly, as they are directly correlated to the total organic matters content (Table 2).

Crude fat content in L1Exp group was 23.8% higher compared to control samples (P<0.001) and 35.5% higher in L2Exp samples (P<0.001).

Table 2. Organic nutrients and the gross energy contained within, as influenced by temperature during slaughter (n = 15)

Nutrient	LC group (mean ± SD)	L1Exp group (mean ± SD)	L2Exp group (mean ± SD)
Crude fat (g/100 g wet weight)	2.14±0.18	2.65±0.15	2.90±0.17
± % and ANOVAs	100%	+23.8% *P*=2 x 10^{-9} vs. LC***	+35.5% *P*=2 x 10^{-12} vs. LC*** *P*=0.0003 vs. L1Exp***
Total nitrogen matters (g/100 g wet weight)	23.01±0.36	22.76±0.08	22.65±0.24
± % and ANOVAs	100%	-1.1% *P*=0.04 vs. LC *	-1.6% *P*=0.003 vs. LC ** *P*=0.26 vs. L1Exp
Nitrogen free extract (g/100 g wet weight)	0.55±0.09	0.47±0.24	0.45±0.40
± % and ANOVAs	100%	-17.0% *P*=0.24 vs. LC	-22.2% *P*=0.39 vs. LC *P*=0.90 vs. L1Exp
Gross energy (kcal/100 g meat)	119.77±1.92	123.05±1.10	124.71±1.45
± % and ANOVAs	100%	+2.73% *P*=4 x 10^{-6} vs. LC***	+4.12% *P*=1 x 10^{-8} vs. LC*** *P*=0.002 vs. L1Exp**

** significant differences (0.01<P<0.05)*
*** distinguished significant differences (0.001<P<0.01)*
**** very significant differences (P<0.001)*

Total nitrogen matters varied in accordance with the water content, decreasing thus with 1.1%, compared to control (P<0.05), while in L2Exp group it decreased by 1.6% vs. control group samples (P<0.001). Therefore, the hydro soluble nutrients, such as the proteins, decreased as temperature increased during scalding and was lower during chilling, sorting, packaging and storage and induced more accentuated water drips. On the contrary, the lipids trended to concentrate because they were not water soluble and did not left the tissues.

The other organic compounds soluble in water (nitrogen free extract) were lower in experimental groups compared to control one, but the differences were not found bearing statistical significance.

Gross energy content was significantly influence by the dynamics of total lipids and reached 119.77 kcal/100 g meat in LC samples, 123.05 kcal/100 g meat in L1exp samples (+2.73%; P<0.001) and 124.71 kcal/100 g meat in L2Exp group (+4.12%; P<0.001).

The proximate compounds were found within the normal variation limits for the chicken breast meat, comparable with other findings in the scientific literature, suggesting the influence of higher temperature in scalding and of lower in chilling, sorting and packaging on the decrease of water content and on the concentration of fats (Ang and Hamm, 1983; Mir et al., 2017).

However, in order to have a wider image on the temperature effect on the chemical and physical properties of the breast meat investigations should be completed with instrumental textural profile analysis, knowing the fact that higher scalding temperatures could decrease meat moisture (Bai and Wang, 2013), increase pH value and negatively affect meat tenderness (Zhuang et al., 2013).

CONCLUSIONS

Increasing the experimental factor temperature with 4-5°C in scalding stage and decreasing it by 1-4°C in chilling, packaging and storing stages led to changes in water and dry mater content of the breast meat (P<0.05).

Water loss induced concentration of lipids by 24-35% in experimental groups (P<0.001) and decrease of hydro soluble compounds, such as proteins by 1.1-1.6% (P<0.05; P<0.01) and nitrogen free extract.

The changes of proximate composition due to increased scalding temperatures and lowering the cold treatments stages values led to gross energy increase of breast meat by 2.7-4.1% in experimental groups vs. control (P<0.001).

Hence the variations of the experimental factor induced changes in the chemical and nutritional value of the breast meat, it would be challenging to assess, as follow-up of the research, the sensory and textural dynamics of the samples and to run correlational and regression computations, in order to determine whether such quality descriptors are influenced and in which manner, by the processing temperature during slaughtering flow.

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