DYNAMICS OF BROILERS THIGHS CHEMICAL COMPOSITION AND ENERGY CONTENT, UNDER THE INFLUENCE OF DIFFERENT TECHNOLOGICAL TEMPERATURES DURING SLAUGHTER

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Abstract

Are the variations of temperature applied on certain key points quite significant in affecting the ultimate compositional and nutritional features of the chicken broiler meat? This was the question leading the research to further investigate three groups of carcasses (one control - CG, and two treatments - T1 and T2) in relation with the single experimental factor – temperature - variations on certain technological flow moments in the slaughterhouse: scalding station (CG:51-53 ℃,T1:53-54 ℃,T2:55-56 ℃); chilling process (CG:1-4 ℃, T1:2-3 ℃; T2:1-2 ℃); sorting- packaging moment (CG<2 ℃; T1:8-10 ℃; T2:6-8 ℃); storage before delivery (CG:0-2 ℃; T1 and T2:0-1 ℃). The biological material comprised 150 ROSS-308 carcasses (50 per group), stored by refrigeration 1 day in slaughterhouse before shipping. Meat pieces weighing 50-100 grams, without skin, were cut around femoral bone from the thighs musculature of each carcass, in order to form homogenous samples per group; they were submitted to analytical laboratory assessment to quantify the main nutritional compounds (water, dry matter, crude ash, total lipids and protein content, nitrogen free extract) as well as gross energy value, using conventional A.O.A.C.-I.S.O. methods in 15 replications per compound. Thus, total dry matter varied between 28.34 g/100 g in CG and 28.81 g/100 g in T2 ($P<0.05$), while crude ash was found at 1.00g/100 g in CG, at 0.93g/100 g in T1, at 0.95 g/100 g in T2 ($P<0.01$ for T1, T2 vs. CG). Total lipids content was the most variable feature of thigh meat, thus in CG reached 8.00 g/100g, while in T1 was 3.25% higher (8.26 g/100 g, $P<0.001$ vs. CG) and in T2 was 4.88% higher (8.39 g/100 g, $P<0.001$ vs. CG and $P<0.05$ vs. T1). Total nitrogen matter slightly decreased from 18.78 g/100 g in CG till 18.59 g in T2, but the differences were not big enough to generate reaching of 95% significance threshold. The gross energy content was influenced by experimentally induced variable temperature, via lipids and nitrogen free extract differences and was calculated at 154.04 kcal/100 g meat in CG, at 156.71 kcal/100 g meat in T1 and at 157.93 kcal/100 g sample in T2, that resulted in highly significant differences between control and experimental treatments samples.

Key words: broilers, thigh meat, slaughtering temperature, nutrients

INTRODUCTION

Temperature is a key technological element affecting the safety of meat products [12]. The variation of this factor could be an ally for the food processors in applying it as a sterilizing like agent [19]when conveyed flow passes from dirty areas to cleaner areas in slaughterhouses (such as the high temperatures in scalding poultry carcasses after deplumation) or using it as preservation agent to inhibit the development of potentially dangerous microorganisms [18] in other stages of the flow (such as chilling, sorting-packaging and storing prior to delivery). Among the most occurring contamination microorganism, *Campylobacter sp.* could be found on chicken carcasses if not adequate thermal treatments are used in slaughtering flows [9]. Also, *Pseudomonas spp.*, *Salmonella enteridis* and *Lysteria monocytogenes* are known as another

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contaminants [4, 13, 21] that could be inactivated through thermal treatment alone or in common with other methods. As the temperature at refrigerating storage is kept as closer to 0ºC, as the development of pathogen microorganisms is in stasis [6]. New technologies [24], the so called low chilling, are applied to increase safety and to extend shelf life (up to 5 weeks) of poultry carcasses, using around 0 Celsius degrees temperatures, preferable -1…-2 ºC. Apart from using temperatures as safety warrant of the meat, other methods were tried to be applied to chilled meat, such as irradiation [20, 23] (still questioned, due to mutagenic and sensorial depreciating effects), high pressure treatments [2, 7] (not totally approved due to alterations in commercial and nutritional quality) and packaging under modified atmosphere conditions [1, 5], that could provide the optimal anaerobic environments, with high rates of bacteriostatic or bactericidal effects.

There are preoccupations to investigate the way of action of temperatures used in scalding carcasses (especially of those ones closed to pasteurization) on the nutritional quality of the poultry and of any denaturation that could occur in complementarity with microbial payload reduction [3, 8]. The present paper subscribes to the same research idea, that to identify to what extent high thermal treatments during scalding and lower thermal treatments during chilling, packaging and storage could affect the chemical composition and eventually nutrient loss in refrigerated broilers thigh meat.

MATERIAL AND METHOD

The study was started from the hypothesis that variations in temperature during certain key points of the broilers slaughtering flow would not influence the chemical composition of the meat, therefore the ultimate commercial quality.

Biological material: carcasses of 150 ROSS 308 chicken broilers aged 42 days and issued from the same culling group and transport, randomly assigned to three groups: control (CG), treatment 1 (T1) and treatment 2 (T2).

Experimental factor: temperature applied on several key points of the technological flow (table 1).

Table 1 - Graduation of experimental factor per key points and groups (ºC)

Key point on the flow	CG group	T1 group	T2 group
Scalding	51-53	53-54	55-56
Chilling	1-4	2-3	1-2
Sorting-packaging	<12	8-10	6-8
Storage before delivery	0-2	0-1	0-1

The effect of the experimental factors was measured via certain reasoning criterion belonging to meat proximate composition and energetic value elements (measured/calculated on 15 repetitions per trait and group):

**meat chemical composition* (water, dry matter, crude ash, total nitrogen matter, total lipids, nitrogen free extract – g/100g) (analytical standards: water and DM-ISO 1442:1997 [14], crude ash-ISO 936:1998 [15], total nitrogen-ISO 937:2007[16], total lipids-ISO 1443:2008[17], nitrogen free extract by difference between dry matter and ash, lipids, proteins) [11].

**meat gross energy content* (Kcal/100 g edible portion) (calculation using the F.A.O. proximate composition transforming relation into gross energy: 8.96 kcal per g of lipids; 4.27 kcal per g of proteins and 3.85 kcal per g of nitrogen free extract) [10]

Data were statistically processing to obtain descriptive parameters and to analyze the variance, in accordance with Petrie and Watson [22].

RESULTS AND DISCUSSIONS

The results on the proximate composition and energetic value of refrigerated thighs meat submitted to various different temperatures of scalding, chilling, sorting-packaging and pre-delivery storage are presented in table 2.

Thus, in control group, where the regular slaughtering technology has been applied, using 51-53ºC in scalding, followed by a range of 1-4 ºC in chilling and by an arbitrary upper level of 12 ºC in sorting packaging and finished by 0-2 ºC storage temperature pre-delivery, the analytical procedure revealed a water content of 71.66±0.38 g/100 g product, hence the dry matter content of 28.34±0.38 g/100 g edible portion.

Table 2 – Proximate composition and gross energy content of broiler thigh samples, as influenced by the variation of temperature in slaughtering key points (n = 15 / trait / group)

Chemical composition (g/100 g)	**Control (CG)** (Mean±StDev │ V%)		**Treatment 1 (T1)** (Mean±StDev │ V%)		**Treatment 2 (T2)** (Mean±StDev │ V%)	
Water	71.66±0.38	0.53	71.36±0.59 - 0.42% vs. CG *(P=0.11>0.05)***n.s.**	0.83	71.19±0.61 - 0.66% vs. CG *(P=0.02<0.05)**** - 0.24 % vs. T1 *(P=0.45>0.05)* **n.s.**	0.86
Dry matter	28.34±0.38	1.33	28.64±0.59 + 1.06 % vs. CG *(P=0.11>0.05)* **n.s.**	2.06	28.81±0.61 + 1.66% vs. CG *(P=0.02<0.05)* ***** + 0.59 % vs. T1 *(P=0.45>0.05)* **n.s.**	2.12
Total minerals	1.00±0.05	5.19	0.93±0.07 - 7% vs. CG *(P=0.006<0.01)******	7.98	0.95±0.02 - 5% vs. CG *(P=0.002<0.01)* ****** - 2.15 % vs. T1 *(P=0.30>0.05)* **n.s.**	1.93
Total lipids	8.10±0.14	1.81	8.26±0.04 +1.98 % vs. CG *(P=0.03<0.05)****	2.00	8.39±0.15 +4.81% vs. CG *(P=0.5x10^-8^<0.001)* ******* +1.57 % vs. T1 *(P=0.03<0.05)* *****	1.76
Total nitrogen matters (protein)	18.78±0.39	2.09	18.63±0.59 - 0.80 % vs. CG *(P=0.43<0.05)***n.s.**	3.16	18.59±0.63 - 1.01% vs. CG *(P=0.33<0.05)* **n.s.** - 0.21 % vs. T1 *(P=0.85<0.05)* **n.s.**	3.38
Nitrogen free extract	0.58±0.12	21.58	0.82±0.10 + 41.37% vs. CG *(P=0.2x10^-6^<0.001)* *******	12.25	0.88±0.11 +51.72% vs. CG *(P=0.2x10^-7^<0.001)* ******* +7.31 % vs. T1 *(P=0.16>0.05)* **n.s.**	12.86
Gross energy (Kcal/100g)	154.04±1.80	1.17	156.71±2.82 +1.73% vs. CG *(P=0.005<0.01)******	1.80	157.93±2.71 + 2.52% vs. CG *(P=0.7x10^-5^<0.001)* ******* + 0.78 % vs. T1 *(P=0.23>0.05)* **n.s.**	1.71

n.s. = not significant; * - significant for 95%;
** - distinguished significant for 99%; *** - highly significant for 99.9% probability thresholds

Subsequently, the components of dry matter were quantified at 1.00±0.05 g total minerals/100 g meat, at 8.10±0.14 g total fat/100 g product and total protein like substances of 18.78±0.39 g/100 g edible portion, while the nitrogen free extract was calculated at 0.58±0.12 g/100 g. the homogeneity of assessed proximate compounds was very good, except for the nitrogen free extract which was found highly heterogenic, suggesting a certain amount of individual variation between the 15 repetitions. It would be better to use an analytical procedure for a targeted NFE compound which is usually found in higher proportion in meat, in order to avoid such non homogenous calculation results.

These organic compounds resulted in a gross energy content of 154.04±1.80 Kcal/100 g thighs meat.

Increasing of scalding temperature by 2 degrees and forcing of chilling between 2-3ºC, as well as packaging running between 8-10ºC in Treatment 2 group induced slight modifications in water content (-0.42% compared to control;71.36±0.59 g/100 g) and in dry matter content, as well (+1.06% vs. CG, 28.64±0.59 g/100 g), with no significant differences. However, within the dry matter structure, the changes were more significant, for instance in total minerals content (-7% compared to CG, $P<0.01$). Total fat was also significantly different ($P<0.05$), in T1 group the temperature modification inducing an increase by 1.98% of lipids, as reported to water and dry matter content (8.26 g/100 g vs. 8.10 g/100 g in control), suggesting that some of the alterations in thermal treatment parameters induced water loss and concentration of hydrophobic nutrients (lipids). Concerning the total nitrogen matters, despite the fact they were 0.8% lower than in control samples, the differences were not significant. Nitrogen free extract was calculated 41.3% more in T1 thighs meat than in control ($P<0.001$) and was, as in the first case, the most heterogenic compound. The gross energy content reached 156.71 kcal/100 g meat (+1.73% vs. CG, $P<0.01$).

In T2 group, that reached 55-56 ºC in scalding and even lower temperatures in chilling and sorting/packaging, the water losses were more intense (-0.66% compared to control, $p<0.05$), leading to chain alteration of the proximate composition, such as distinguished different minerals level (-5% compared to control) or highly significant changes of total lipids level (+4.81% vs. control group, $P<0.01$ and +1.57% vs. T1 group, $P<0.05$). Differences in proteins content were lower (-1.01% vs. CG and -0.21% vs. T1), hence the non-occurrence of any statistical significance. In comparison with control, the nitrogen free extract was 51.7% higher in T2 samples. These findings lead to a n energetic value of the thighs meat of 157.93 kcal/100 g meat (+2.5% compared to control, $P<0.001$ and +0.78% compared to T1 samples, not significant).

CONCLUSIONS

The findings are quite interesting through the lenses of a nutritionist, because the higher was the scalding temperature and the lower the chilling, sorting, storage temperature, the more intense were the water drips and the concentration of dry matter compounds, especially of those non-miscible with water (lipids), leading to a higher gross-energy content.

As follow-up, it would be interested to investigate to what extent the raising of temperatures during scalding become less effective on the overall quality picture of the meat, through depreciations of sensory characteristics, such as color, texture, juiciness, that could be damaged due to heat abuse and that could induce decreased acceptability of the meat in consumers.

Also, it would be interesting to comparatively investigate the quality response to controlled temperature variations across slaughtering flow of limbs meat (thighs, drumsticks and wings) in comparison with the breast meat, knowing the subsequent muscles in those regions are quite different in terms of metabolism and proportions of connective and pure muscular tissue.

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