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Effect of Genetic Strain and Sex on Water Absorption and Water-To-Protein Ratio in Chicken Meat

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ABSTRACT

The objectives of the present study were to evaluate the water and protein contents and the water-to-protein ratio of chicken parts before and after the pre-chilling process, to compare these results with the values officially recommended by the Brazilian Ministry of Agriculture, and to evaluate the effect of genetic strain and sex on these parameters. Water (%) and protein (%) contents, and water-to-protein ratio (WPR) of boneless and skinless breast (FILLETS) and breast with bone and skin (BREAST) were determined before (BPC) and after (APC) carcass pre-chilling. A total of 585 samples were evaluated: 221 fillets/male, 216 breasts/male, 76 fillets/female, and 72 fillets/female of four different broilers strains were evaluated before (BPC) and after (APC) samples. Water and protein contents and water-to-protein ratio were determined according to the Brazilian legislation. Results showed that there were no significant differences between genetic strains ($p<0.05$) neither in samples collected before or after the chiller. There were no statistical differences in the parameters studied among genetic strains. However, a high percentage of male breast samples presented water level and water-to-protein ratio above the official limits already before pre-chilling.

INTRODUCTION

Chicken processing is much more automated than that of other animal species used for meat production and applies advanced technologies. One of the characteristics of chicken processing is the wide use of water that, among other consequences, leads to the absorption water in the muscle. The Brazilian Ministry of Agriculture (MAPA) has established regulations on the use of water in chickens laughtering and processing, as well as on carcass water absorption, defining upper limits to prevent frauds. The most important regulation is n. 210 (Brazil, 1998), which defines the technical regulations for poultry meat health inspection of poultry meat. It determines that chicken meat water absorption after pre-chilling process should not be higher than 8% of the initial carcass weight. Frozen whole carcasses, with or without giblets, should not contain more than 6% water after thawing (drip test).

In 2000, the MAPA developed the Program for the Prevention and Control of Water Absorption in Poultry Products and Carcasses (PPCAAP) in order to prevent frauds due to water absorption during carcass chilling. In 2002, a fraud control program was established based on MAPA's regulation n. 210, which determined a regular sampling program in fiscal analyses, both in processing plants and retail stores (Brazil, 1998).

In addition of the parameters related to water absorption, MAPA established in 2010 regulation n. 32 (Brazil, 2010), which establishes parameters for the assessment of total water content of chilled and frozen poultry parts, measuring water (%) and protein (%) contents, and water-to-protein ratio in chicken breasts, half breasts, skinless breasts, thighs, drumsticks and legs. The method used to calculate the remaining water is based on the premise that water and protein contents and the water-to-protein ratio (WPR) are constant for a given animal species and/or specific part. The WPR may be influenced by the amount of water absorbed during processing, which may lead to a "dilution" of the protein content. Consequently, total water absorption during poultry processing is influenced by carcass immersion during the pre-chilling process, scalding, defeathering, and other cleaning procedures during poultry evisceration, which may increase meat water content in up to 3%, on average (Brazil, 1998). This change is directly assessed by the variables mentioned above.

However, the Brazilian regulations that determine water absorption limits in skinless and boneless chicken parts do not take into account the influence of other factors, such as genetic strain, weight and sex may, either individually or in combination. Therefore, it is essential that "technically inevitable water" is accurately differentiated from fraud in order to enable the detection of products with excessive water content, to protect consumers, and to ensure that the poultry industry is using the correct parameters.

The objectives of the present study were to evaluate the water and protein contents and the water-to-protein ratio of chicken meat before and after pre-chilling, to compare these results with the officially recommended values defined by the Brazilian Ministry of Agriculture, and to evaluate the effect of broiler strain and sex on these parameters.

MATERIAL AND METHODS

Sample collection location

This study was carried out between August, 2013 and June, 2014 in a poultry and rabbit processing plant located in the western region of the state of Parana, Brazil. The plant is inspected by the Federal Inspection Service, and it is licensed for exports. In total, 340,000 broilers between 44 and 48 days of age are processed daily, and three-stage pre-chilling tanks are used.

Selection of carcasses and sampling

Whole carcasses were removed from the trolley immediately after scalding, and males and females were identified according to the size of their crests. Genetic strains were obtained from the farmer flock record, and were identified as strains A, B, C, and D, which are commonly reared in Brazil. Carcasses were placed again in the trolleys, and after the crop and the trachea were extracted, they were removed from the line and placed on an auxiliary trolley to remove the FILLET (boneless and skinless breast) or the BREAST (breast with bone and skin). Half of the samples were immediately submitted to the laboratory for physical-chemical analyses. The other samples entered the pre-chilling system for cooling by immersion in three-stage tanks, according to the legal pre-chilling parameters defined by the Brazilian legislation (Brazil, 1998), after which they were also submitted to the laboratory for analyses.

Physical-chemical analysis

Water content (W,%) and protein (P,%) content, and water-to-protein ratio (WPR) of the evaluated parts were determined according to the methods defined in Brazil (1999), which determines physical-chemical methods for the control of meat products and their ingredients; and in Brazil (2013), which defines the official methods to determine total water content in chicken chilled carcasses and parts.

Statistical analysis

Data were distributed according to completely randomized experimental design with two treatments (before and after chilling). In total, 585 samples were collected and analyzed for water and protein contents and water-to-protein ratios according to part (fillet or breast), sex (male of female), time of analysis (before and after chilling), and strain (A, B, C, D). The following numbers of samples were evaluated: 221 FILLETS from males, 216 BREAST from males, 76 FILLET from females, and 72 BREAST from females; and half of the collected samples were analyzed before and half after chilling (BPC and APC, respectively). The effect of each genetic strain was evaluated in one fourth of BPC and APC samples. The obtained results were compared with the reference values established by the Brazilian legislation (Brazil, 2010) for poultry processing plants producing meat for human consumption.

Data were analyzed using analysis the general linear model procedure of SAS software (Statistical Analysis System, version 9.0). Mean values above and below the reference values were compared by Fisher's test at a 5% significance level.

RESULTS AND DISCUSSION

Tables 1 to 4 show the results of the analyses of 585 samples (289 BPC and 296 APC), according to strain (A, B, C, and D), sex, and part (FILLET or BREAST). The results shown in the Tables are only related to samples which values outside the acceptable limits for W, P, and WPR.

Genetic strain had no influence ($p<0.05$) on the evaluated parameters neither in samples collected before (BPC) or after (APC) the chiller (Tables 1 to 4).

The 18.5% samples (Table 1) with water content above the official limit before the pre-chilling process stand out, and may be considered a high percentage of altered samples. This suggests that further studies are needed to investigate factors that may affect water absorption in chicken muscles before pre-chilling, such as direct influence of genetic strain or related physiological factors (Xiong *et al.*, 1993).

In the present study, four genetic strain commonly raised in Brazil were evaluated. As a result of differences in their performance on the field, changes in the natural composition of the muscles may be expected, showing the need to review the official limits in the Brazilian legislation, which does not take into account possible genetic influences on chicken muscle composition.

Moreover, as expected, the water content obtained before chilling (18.5%), as an average of the four evaluated strains, increased after chilling (31.0%), as well as WPR, which increased from 20.4% in BPC samples to 24.8% in APC samples. This is explained by the inevitable absorption of water during chilling and is related with water temperature, length of immersion, size of the abdominal cut, etc. (Scaratti *et al.*, 2010). Carcass pre-chilling is a highly complex operation, because chicken carcasses do not have a defined geometry and present differences in weight and dimension, which are specific of male and female carcasses, as well as variable chemical composition, among other characteristics (Carciofi, 2005). However, protein content was not different between BPC and APC samples. Further studies are necessary for better understanding these differences and the dynamics of these changes.

Table 2 shows that the protein content of 22.9% of the BREAST samples of males were higher than the acceptable limit determined by the official regulations. However, water content and WPR complied with the official limits both in BPC and APC samples. Results showed that the parameter WPR may be used for the evaluation of total water content, and may be even more important than the individual evaluation of parameters, and which is currently applied in the European Union, according to EC regulation n. 543/2008 (Commission Regulation, 2008).

Table 1 – Water and protein contents and water-to-protein ratio above the official limits of FILLET samples collected before and after the chiller of male chickens of different genetic strains.

Strain	Water content		Protein content		WPR	
	BPC (n=108)	APC (n=113)	BPC (n=108)	APC (n=113)	BPC (n=108)	APC (n=113)
	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)
A	3 (2.8)	6 (5.3)	ND	ND	3 (2.8)	1 (0.9)
B	11 (10.2)	8 (7.1)	ND	ND	11 (10.2)	11 (9.7)
C	4 (3.7)	18 (15.9)	ND	ND	6 (5.5)	14 (12.4)
D	2 (1.9)	3 (2.7)	ND	ND	2 (1.9)	2 (1.8)
TOTAL	20 (18.5)	35 (31.0)	ND	ND	22 (20.4)	28 (24.8)

BPC= samples collected before the chiller; APC= samples collected after the chiller; WPR= water-protein ratio; ND=absence of non-compliant samples.

Table 2 – Water and protein contents and water-to-protein ratio the official limits of BREAST samples collected before and after the chiller of male chickens of different genetic strains that were above.

Strain	Water content		Protein content		WPR	
	BPC (n=109)	APC (n=107)	BPC (n=109)	APC (n=107)	BPC (n=109)	APC (n=107)
	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)
A	ND	ND	6 (5.5)	1 (0.9)	ND	ND
B	ND	ND	3 (2.7)	ND	ND	ND
C	ND	1 (0.9)	7 (6.4)	ND	ND	3 (2.8)
D	ND	ND	9 (8.3)	ND	ND	ND
TOTAL	ND	1 (0.9)	25 (22.9)	1 (0.9)	ND	3(2.8)

BPC= samples collected before the chiller; APC= samples collected after the chiller; WPR= water-to-protein ratio; ND= absence of non-compliant samples.

Table 3 – Water and protein contents and water-to-protein ratio above the official limits of FILLET samples collected before and after the chiller of female chickens of different genetic strains that were.

Strain	Water content		Protein content		WPR	
	BPC (n=35)	APC (n=41)	BPC (n=35)	APC (n=41)	BPC (n=35)	APC (n=41)
	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)
A	ND	ND	ND	ND	ND	ND
B	ND	ND	ND	ND	1 (2.9)	1 (2.4)
C	1 (2.9)	ND	ND	ND	2 (5.7)	2 (4.9)
D	1 (2.9)	ND	ND	ND	ND	1 (2.4)
TOTAL	2 (5.7)	ND	ND	ND	3 (8.6)	4 (9.8)

BPC= samples collected before the chiller; APC= samples collected after the chiller, WPR= water-to-protein ratio; ND= absence of non-compliant samples.

Table 4 – Water and protein contents and water-to-protein ratio above the official limits of BREAST samples collected before and after the chiller of female chickens of different genetic strains.

Strain	Water content		Protein content		WPR	
	BPC (n=37)	APC (n=35)	BPC (n=37)	APC (n=35)	BPC (n=37)	APC (n=35)
	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)	N. (%)
A	ND	ND	ND	ND	ND	ND
B	ND	ND	2 (5.4)	ND	ND	ND
C	ND	ND	4 (10.8)	ND	ND	ND
D	ND	ND	5 (13.5)	1 (2.9)	ND	1 (2.9)
TOTAL	ND	ND	11 (29.7)	1(2.9)	ND	1 (2.9)

BPC= samples collected before the chiller; APC= samples collected after the chiller; WPR= water-to-protein ratio; ND= absence of non-compliant samples.

Tables 3 and 4 show the results of female FILLET and BREAST samples, respectively. The number and percentage of samples that did not comply with the official regulations was low, but number of samples was lower than that of males. This difference in the sampling universe prevented the statistical analysis for the parameter sex. Vieira (2007), however, analyzed male and female chicken breasts and reported no effect of sex on breast meat water content. In the chicken breasts of males, water content ranged between 72.83% and 74.11%, and between 72.27% to 74.52% in females.

The results of the present study did not detect any meat water absorption differences among the evaluated broiler strains. However, a high percentage of male breast samples presented water level and water-to-protein ratio above the official limits already before pre-chilling.

Due to the lack of conclusive data, further studies are necessary in order to define the parameters that determine the acceptability of chicken meat, aiming at reducing losses to the industry and ensuring the supply good quality chicken products to consumers.

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