EFFECT OF THE WOODEN BREAST CONDITION ON SHEAR FORCE AND TEXTURE PROFILE ANALYSIS OF RAW AND COOKED BROILER PECTORALIS MAJOR

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Abstract – The objective was to characterize texture properties of raw and cooked broiler fillets (Pectoralis major) with the wooden breast condition (WBC) using the instrumental texture techniques of Meullenet-Owens Razor Shear (MORS) and Texture Profile Analysis (TPA). Broiler fillets were collected from a commercial plant and categorized as normal, moderate, or severe WBC. The fillets were then either stored at 4°C overnight (chilled treatment) or in a -20°C freezer (freezing treatment). The MORS and TPA of the fillets were determined for both raw and cooked samples. Regardless of storage (chilled vs. freezing), cooking (raw vs. cooked), and degree of WBC, the MORS force and TBA hardness of the WBC fillets were higher than that of the normal fillets ($P<0.05$). Regardless of texture measurement, there were no interactions between storage method and the WBC and no differences between moderate and severe WBC fillets ($P > 0.05$). These results demonstrate that WBC significantly affects instrumental texture properties of both raw and cooked chicken fillets regardless of storage method. Cooked WBC meat would likely be tougher than cooked normal meat.

Key Words – chicken, MORS, storage

I. INTRODUCTION

The wooden breast condition (WBC) is a novel chicken muscle abnormality [1]. The meat with the WBC is hardened to the touch and exhibits hardened “ridges” along the ventral portion of the breast. Limited published data have shown that WBC significantly affects the meat quality attributes of finished products. Mudalal et al. [2] found that raw WBC fillets showed lower marinade uptake, higher cooking losses, and higher compression force.

Meullenet-Owens Razor Shear (MORS) [3] and Texture Profile Analysis (TPA) [4] are common methods to measure meat texture. Early studies [5] demonstrated that both MORS force and energy measurements are highly correlated with Allo-Kramer (AK) shear and Warner-Bratzler (WB) shear ($r > 0.80$) and can predict well both descriptive and consumer sensory texture attributes. Lyon and Lyon [6] showed that there were significant differences between hot-boned and cold-deboned chicken breast fillets for TPA parameters of hardness, cohesiveness, springiness, and chewiness.

Palpable hardness is a typical characteristic of raw WBC meat [1]; however, there is a lack of specific descriptions of the texture properties for both raw and cooked WBC chicken breast with MORS and TPA methods. Thus, the objective of the present study was to investigate the texture characteristics of both raw and cooked broiler breast fillets with different degrees of the WBC using MORS and TPA measurements. In addition, we also evaluated the effects of freezing storage on these measurements.

II. MATERIALS AND METHODS

Individual broiler breast fillets were collected from the deboning line of a commercial processing plant (approximately 3 h PM) and scored into normal, moderate, and severe WBC categories based on the incidence of diffuse hardened areas throughout the fillets and the severity of palpable hardness. Breast fillets were then either stored at 4°C (chilled storage) overnight or stored at -20°C (freezing storage) for more than 2 days and thawed at 4°C for 24 h before the texture analysis was conducted on the raw samples. For cooked samples, fillets were cooked in a combi steam oven to the endpoint temperature of 78°C.

MORS force and energy of raw (refrigerated temperature) and cooked broiler breast (room temperature) were measured using a Texture Analyzer (Model TA-XT-plus, Texture Technologies Corp, Hamilton, MA) with a 50-kg load cell, a crosshead speed of 10 mm/s and a blade (24-mm high and 8.9-mm wide sharp razor blade) penetration depth of 20 mm [5]. For TPA, two 2.5-cm diameter cores were removed perpendicular to the fillet surface and compressed twice to 50% of the original height on a TA-XT-plus Texture Analyzer at crosshead speed 50 mm/min using a 7.5-cm-diameter compression plate [7].

Data were analyzed using PROC MIXED procedure of SAS (Version 9.2, SAS Institute Inc., Cary, NC). The model included storage, cooking, and WBC factors as well their two-way and three-way interactions as fixed effects, and replication, fillet and sub-sampling as random effects. The LSMEANS and adjust Tukey were used to identify significant differences between means ($P<0.05$).

III. RESULTS AND DISCUSSION

MORS of Wooden Breast Fillets

There were no three-way interactions among storage, cooking, and WBC and two-way interactions between storage and WBC for either MORS force or energy ($P>0.05$). For MORS force, there was no interaction ($P>0.05$) between WBC and cooking; however, for MORS energy, the interactions were significant (data not shown).

The average MORS force and energy values of the cooked normal fillets were lower ($P<0.05$) than those of the cooked fillets categorized as moderate and severe WBC, which did not differ ($P>0.05$) from each other (Table 1). The relationships between the three WBC categories were not affected by fillet storage methods and cooking status ($P>0.05$). Moderate and severe WBC consistently resulted in higher ($P<0.05$) shear force and energy than the normal breast condition. These results suggest that the extent of palpable hardness of broiler breast meat between the moderate and severe categories cannot be differentiated based on either MORS force or MORS energy measurements regardless of fillet cooking status. However, MORS measurements can be used to separate fillets with the WBC from normal fillets.

Our MORS measurements also indicated that it takes more force to cut through breast muscle with the WBC in both raw and cooked fillets and that the effects of the WBC on the muscle shear do not change due to freezing/thawing or cooking. This is consistent with the results reported by Trocino et al. [8] in which the WBC resulted in increased shear force compared to the normal condition. The increased shear force in the cooked WBC fillets has been attributed to increased liquid losses during cooking (or higher cook loss) [2] and/or may be due to the accumulation of interstitial connective tissue [9]. It has previously been demonstrated [5] that a MORS energy value of 154-170 N•mm for cooked chicken fillets corresponds to ‘neither dislike nor like’ on a 9-point hedonic scale for meat tenderness acceptance; and a value greater than 204 N•mm indicates that the tenderness is in a category of ‘dislike very much or dislike extremely’. According to this classification, the texture of the cooked normal fillets in our experiment would be neither disliked nor liked by consumers. The texture of the cooked fillets with moderate WBC would be rated as ‘dislike very much’, and the severe WBC fillets as ‘disliked extremely’.

TPA of Wooden Breast Fillets

The effects of experimental factors on the TPA measurements differed from its parameters. None of the TPA attributes exhibited a 3-way interaction among storage, cooking, and the WBC or a 2-way interaction between storage and the WBC ($P>0.05$). For TPA hardness, adhesiveness, springiness, and chewiness, there were no two-way interactions between the experimental factors of WBC, storage, and cooking ($P>0.05$). In regards to main effects for hardness and chewiness there were no differences between fresh and frozen samples ($P>0.05$), but there were differences between raw and cooked samples and among the three WBC groups ($P<0.05$). For TPA adhesiveness, there were no differences between fresh and frozen samples or among the three WBC groups (P>0.05); however, it was significantly affected by cooking (P<0.05). For TPA springiness, any of three main variables affected the measurement results (P<0.05). For the parameters of cohesiveness and resilience, there were two-way interactions (P<0.05) observed between storage and cooking and between WBC and cooking (data not shown).

There were differences (P<0.05) among the three WBC groups for TPA hardness regardless of cooking (Table 2). The average hardness values of the normal fillets were lower than those of the moderate and severe WBC fillets (P<0.05), which did not differ from each other (P>0.05). Although there were no differences in chewiness between three WBC groups for raw meat (P > 0.05), for cooked samples the average chewiness value of the normal fillet was lower (P<0.05) than those of the moderate and severe WBC fillets, which did not differ from each other (P>0.05). Regardless of cooking, there were no differences between three WBC groups for TPA resilience (P>0.05). For cohesiveness, there were no differences between the three WBC groups for cooked fillets (P>0.05); however, for raw fillets the mean value of normal samples was higher than those of the WBC fillets (P<0.05). Using a similar texture technique, Mudalal et al. [2] also observed greater hardness in raw WBC fillets versus normal fillets. It is not surprising to see that the texture of chicken breast fillets and further processing treatments have different effects on TPA parameters. In an investigation of the texture profiles of broiler fillets deboned at either early postmortem (5 min and 2 h, resulting in tough meat with similar sensory texture properties and shear force) or later postmortem (6 h and 24 h, resulting in tender meat with similar texture characteristics) times, Lyon and Lyon [6] found that there were significant differences between the 4 deboning times for TPA chewiness. However, there were no difference observed between 2-h and 24-h samples for TPA hardness and there was a significant difference between 6-h and 24-h samples for TPA cohesiveness. Our results suggest that in whole fillets, WBC has no effect on meat texture adhesiveness, or resilience; however, it makes cooked fillets harder, springier, and chewier and could also affects hardness and cohesiveness in raw broiler breast meat.

IV. CONCLUSION

Under our experimental conditions, data showed that the WBC can significantly affect instrumental texture properties of both raw and cooked chicken breast meat. Both raw and cooked WBC fillets require more force and energy to shear than normal fillets. The WBC does not affect meat texture adhesiveness or resilience regardless of cooking. However, there were significant differences in hardness and chewiness between cooked WBC and normal fillets. The cooked WBC fillets were significantly harder and chewier than the normal fillets. For meat cohesiveness, no differences were found between the WBC and normal samples for cooked meat; however, in raw meat the WBC fillets were less cohesive than the normal fillets. Neither MORS nor TPA measurements showed differences in the texture attributes between the moderate and severe WBC fillets. Freezing did not change the effects of the WBC on fillet texture properties. Either MORS or TPA hardness measurements may be used to objectively determine the presence of the WBC in fresh broiler fillets; however, neither method can separate moderate and severe WBC fillets. These data also suggest that the WBC can result in tougher texture of cooked fillets.

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Table 1. Effect of the wooden breast condition (WBC) on Meullenet-Owens Razor Shear (MORS) measurements of raw and cooked broiler fillets (mean±SD; n≥18).

WBC	MORS	
	Force (N)	Energy (N x mm)
Raw		
Normal	7.2±1.4^{d}	65.5±16.0^{d}
Moderate	9.6±2.1^{c}	90.4±21.7^{c}
Severe	10.0±2.2^{c}	94.8±23.1^{c}
Cooked		
Normal	12.9±2.9^{b}	169.9±31.6^{b}
Moderate	15.2±2.6^{a}	210.6±38.8^{a}
Severe	16.6±2.9^{a}	225.9±39.0^{a}

$^{a\text{-}d}$ Mean values with no common superscript in the same column are different from each other (P<0.05).

Table 2. Effect of the wooden breast condition (WBC) on Texture Profile Analysis (TPA) measurements of raw and cooked broiler fillets (mean±SD; n≥18).

WBC	TPA					
	Hardness	Adhesiveness	Springiness	Cohesiveness	Chewiness	Resilience
Raw						
Normal	4.99±1.96^{c}	-80.01±28.67^{b}	0.85±0.10^{a}	0.55±0.05^{a}	2.39±1.11^{b}	0.40±0.07^{a}
Moderate	8.19±2.34^{b}	-67.49±22.73^{b}	0.82±0.10^{a}	0.47±0.11^{b}	3.05±0.93^{b}	0.35±0.11^{a}
Severe	9.32±4.56^{b}	-82.46±26.85^{b}	0.86±0.11^{a}	0.47±0.12^{b}	3.85±3.06^{b}	0.36±0.12^{a}
Cooked						
Normal	9.97±2.27^{b}	-8.65±12.95^{a}	0.63±0.07^{c}	0.55±0.05^{a}	3.44±1.20^{b}	0.24±0.03^{b}
Moderate	13.49±3.56^{a}	-5.34±8.50^{a}	0.67±0.07^{bc}	0.59±0.07^{a}	5.49±2.58^{a}	0.27±0.05^{b}
Severe	12.76±3.78^{a}	-2.25±3.68^{a}	0.69±0.09^{b}	0.58±0.10^{a}	5.43±3.36^{a}	0.27±0.07^{b}

$^{a\text{-}c}$ Mean values with no common subscript in the same column are different from each other (P<0.05).