PROCESSING AND PRODUCTS

Texture and quality of chicken sausage formulated with woody breast meat

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ABSTRACT Woody breast (**WB**) myopathy is a quality defect, afflicting a large portion of commercial broilers to some degree. The WB myopathy is commonly attributed to rapid bird growth and characterized by excessive fibrosis within the pectoralis major, which is thought to cause the palpably hardened texture observed in the afflicted breast meat. These phenotypically tough breast fillets are not marketed for traditional intact muscle products owing to poor quality and eating experience. Potential avenues for these afflicted breast fillets include their use in formulation of fresh and cooked sausages. Two degrees of WB fillets (moderate and severe) were used as a replacement for normal (unafflicted) breast fillet meat at levels of 25, 50, and 100%, in a sausage formulation with 1.5% salt and 15% chicken fat. All 6 treatments were compared with a control formulation (100% normal breast meat) and analyzed for texture profile, cook loss, color, and proximate composition. Moisture and fat content for all formulations were similar ($P = 0.95$ and $P = 0.33$, respectively), but with increase in the inclusion rate of WB meat, lower protein content ($P < 0.01$) was observed. Raw sausage color indicated a lighter ($P < 0.05$) color for the control sausage (100% normal) than with both 100% moderate and 100% severe formulations. Similarly, sausages containing 100% severe WB meat were the darkest (L*; $P < 0.05$), but they were similar to sausages containing 100% moderate ($P > 0.05$) WB meat. Texture profile analysis indicated a decrease in hardness, cohesiveness, and springiness with use of 100% severe WB meat, while inclusion of lower proportions of severe WB meat resulted in similar textural characteristics. These results indicate the possibility of using WB fillet meat in a sausage formulation with minimal impact on sausage texture profiles.

Key words: chicken, sausage, wooden breast, myopathy, texture

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INTRODUCTION

The United States Department of Agriculture, Agricultural Marketing Service (USDA AMS, 2019) reported that 174 million broilers were processed in the United States in the week ending December 6, 2019. Although the United States Department of Agriculture, Agricultural Marketing Service does not report quality defects in their weekly reports, examination of the peer-reviewed literature indicates that the prevalence of the woody breast (**WB**) myopathy is relatively high. Huang and Ahn (2018) reported that industry-wide prevalence rates of WB meat are difficult to assess, although various reports indicate that prevalence rates are typically in the range of 5 to 50% (Gratta et al., 2017) and as high as 100% in controlled feeding studies in 42-day-old broilers (Cruz et al., 2017).

The economic impact of broiler carcasses afflicted with WB surpasses $200 million and potentially as much as $1 billion annually, with some plants discarding wooden breast meat owing to customer complaints or condemnations, leading to a lack of marketing avenues (Kuttappan et al., 2016). Although WB meat may not be marketed as a fillet, it is possible to use it in other meat products that use comminution and particle size reduction via

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grinding of meat to minimize the impact of WB on product texture (Sanchez-Brambila et al., 2017). Use of mechanical tenderization to improve the texture of WB fillets and utilization in other products such as meatballs and other meat batters has been evaluated (Chen et al., 2018; Tasoniero et al., 2019). Chen et al. (2018) reported that WB meat could not be used to produce batter-type comminuted meat products owing to its low functionality. However, these meat batters were formulated as complete replacement of normal breast fillets and not as partial inclusion at various levels.

The characterization of wooden breast myopathy is well documented and commonly described as myodegeneration and fibrosis of atrophied myofibers in conjunction with vacuolar degeneration (Sihvo et al., 2014; Velleman, 2019). In breast fillets classified as WB, the textural properties (especially the hardness) are not uniform throughout the muscle. Soglia et al. (2016) reported development of a greater proportion of nonfunctional proteins from the cranial to caudal end, with associated loss in water-holding capacity and other textural traits. These findings indicate that although WB fillets have decreased functionality, there are still portions of the breast fillet that have functional proteins that could be useful in comminuted chicken products. The objective of this research was to examine and benchmark the textural and quality characteristics of ground breast meat with the inclusion of wooden breast fillets at varying levels in a sausage-like product.

MATERIALS AND METHODS

Chicken Fillet Procurement and Batter Processing

On 3 separate trial days (replications), butterfly breast fillets (pectoralis major) were selected 3 h postmortem from the deboning line of a commercial processing plant, placed in Ziploc bags, and transported on ice to the University of Georgia Meat Science Technology Center. The broilers were male Ross broilers, with an average live weight of ca. 4.1 kg when received at the commercial processing plant. Breast fillets were trimmed to remove excess fat and connective tissue and assigned WB scores of normal (N), moderate WB (M-WB), or severe WB (S-WB) based on palpable hardness and muscle rigidity (Tijare et al., 2016). Each category of the breast fillets was ground to 25.4 mm (Biro Model G58483; Biro, St. Louis, MO) separately and mixed with normal breast meat into 10-kg treatment blends: 25% moderate, 50% moderate, 100% moderate, 25% severe, 50% severe, 100% severe, and one formulation with 100% normal breast meat as a control. Chicken fat was added to each treatment, targeting 15% fat in the meat block, and then ground to 4.76 mm. Final meat blocks were transferred to a reverse action mixer (model A-80; Koch, Kansas City, MO) and mixed for a total of 1 min with 1.5% noniodized salt (Mortons, Chicago, IL). Sausage formulations were then stuffed into links weighing approximately 150 g, using 35-mm natural hog casings (29 ± 2°C; Globe Packaging Co., Inc., Carlstadt, NJ), frozen (−20°C), vacuum packaged (B-620 series; 30–50 cm^3 $O_2/m^2/24$ h/101,325 Pa/23°C; Cryovac Sealed Air Corporation, Duncan, SC), and stored (−20°C) until further analysis.

Proximate Analysis

Proximate analyses of the raw breast fillets (ground) and sausage formulations (after stuffing, casing excluded) were carried out for a full complement of data and characterization of the meat. For each individual replication as represented by different breast fillet meat collection (different days of deboning at the poultry processing plant), 3 (triplicate) raw material samples were collected from each treatment for the determination of moisture, fat, and protein in addition to formulation samples collected for determination of moisture, fat, protein, and collagen (soluble, insoluble, and total collagen).

Moisture content was measured (in triplicate) in the ground raw meat and formulated product using a rapid microwave moisture analyzer (SMART 6 ProFat; CEM Corporation, Matthews, NC). Fat content was measured in triplicate samples using a rapid NMR fat analyzer (ORACLE; CEM Corporation, Matthews, NC). Protein content was determined using a nitrogen autoanalyzer (Leco FP-528 Nitrogen analyzer; Leco Company, St Joseph, MI) in duplicate samples for the determination of N content (0.1 ± 0.05 g) and was expressed as percentage of CP (N content × 6.25; Merrill and Watt, 1955).

Collagen was analyzed in duplicate using methods outlined by Hill (1966), wherein samples were pulverized in liquid nitrogen and heated for separation of soluble and insoluble collagen fractions. The duplicate samples of both soluble and insoluble collagen were then autoclaved for 18 h at 121°C and 0.131 MPa, and spectrophotometric analysis of hydroxyproline content, as outlined by Bergman and Loxley (1963) and modified by Cross et al. (1973), was carried out. A factor of 7.25 was used for the determination of the insoluble collagen fractions, and a factor of 7.52 was used for the determination of the soluble collagen fraction (Cross et al., 1973). Collagen values are reported as milligram of collagen per gram of meat.

Texture Profile Analysis

Texture analysis was performed on 3 cooked sausage links for each treatment per replication subsequent to sous vide cooking. As the main objective of the research was to evaluate the functionality of the breast meat afflicted with WB myopathy, we chose the sous vide cooking method as it provides a uniform cooking method, and all the products (sausage links) are exposed to the same temperature for a fixed time in the heating medium (water), separated by the bag material. Each sausage link was placed in an open topped bag, and the bag was submerged in a water bath heated to 70°C (PolyScience immersion circulator; Professional Classic, Warrington, PA) for 46.5 min to attain a target temperature of 70°C. Raw and cooked sausages were weighed, and cook loss was determined. After cooling (32 ± 4°C), sausage links were sliced to 2.54 cm and compressed to 50% of their height using a double compression method for the determination of instrumental texture (TA-XT; Texture Technologies Corp., Hamilton, MA). Sliced sausage samples were placed in the center of the platform (with the cut surface up) and compressed using a 65-mm compression probe at 5 mm/s, with a 10-g trigger force and a 5-s recovery time between compressions to allow for sample recovery. Force–time curve readings were analyzed by Exponent Connect (Texture Technologies Corp., Hamilton, MA) for the determination of texture profile analysis values including hardness, cohesiveness, springiness, gumminess, and chewiness (Bourne, 1978). Gumminess was calculated by multiplying the values of hardness with cohesiveness, and chewiness was calculated by multiplying the values of hardness with cohesiveness and springiness.

Objective Color

Color (CIE-L*a*b*) of sausage links was analyzed in triplicate for each treatment per replication on the external surface (on the casing) of the sausage link (4 ± 2°C) using a Minolta Spectrophotometer (CM-700d; Konica Minolta, Ramsey, NJ) using illuminate C and a 10° viewing angle through an 8-mm aperture for both raw and cooked links. Color measurements were expressed as the average of the 3 measurements taken at 3 locations on the surface of the raw and cooked sausage links.

Statistical Analysis

Data were analyzed using standard least squares as a mixed model using JMP (version 14.3; SAS Inst., Cary, NC). Either raw product category (normal, moderate, or severe) or formulated sausage treatment was considered the fixed effect. Replication was included as a blocking factor, and raw source sample or sausage link was considered the experimental units and observational unit. Depending on the point of analysis, either replication (meat block) or sausage within treatment (normal, moderate, severe; 100% normal [N], 25% moderate [25M-WB], 50% moderate [50M-WB], 100% moderate [100M-WB], 25% severe [25S-WB], 50% severe [50S-WB], 100% severe [100S-WB]) was considered the random term. Least squares means were generated, and means were separated by the Student t test option. Means were considered different at $\alpha < 0.05$.

RESULTS AND DISCUSSION

Proximate Analysis

The moisture and protein values of the raw, ground breast fillets (normal, moderate, and severe WB) were different across the varying degrees of WB fillets ($P < 0.01$; Table 1). Normal, unafflicted meat contained less water ($P < 0.01$) than both moderate and severe WB fillets, which were similar ($P = 0.10$). Normal breast meat had higher protein content ($P < 0.01$), followed by moderate WB meat, which had more protein ($P < 0.01$) content than severe WB meat. Fat content of breast fillets was similar across all degrees of WB fillets ($P = 0.21$). Considering the raw meat source, all treatments had similar ($P = 0.59$) soluble collagen content. Normal breast meat had lower ($P = 0.02$) insoluble collagen content than moderate or severe WB meat, and total collagen content increased ($P = 0.05$) as severity of WB increased, with normal breast meat having less total collagen content than severe breast meat.

The moisture and fat concentrations across all treatments of the formulated chicken sausage were similar ($P = 0.95$ and $P = 0.33$, respectively; Table 2); however, there was a treatment effect on protein content ($P < 0.01$). Sausage formulations containing 100% normal breast meat contained more protein ($P \leq 0.01$) than all treatments except 25% moderate WB formulations ($P = 0.16$). Protein content of sausage formulations containing 25 and 50% moderate WB meat was similar to formulations containing 25% severe WB meat ($P \geq 0.27$). All sausage formulations contained more protein ($P < 0.01$) than both formulations made with 100% WB meat, regardless of the severity. The protein content of 100% severe WB meat was the lowest for all treatments ($P < 0.01$).

Similar to the raw meat block, the sausages formulated with varying degrees of WB meat contained similar ($P = 0.45$) amounts of soluble collagen. Insoluble collagen content increased ($P = 0.02$) with increasing proportions of wooden breast material; however, all sausages containing severe WB meat were similar to each other and those containing 100% moderate WB material. Total collagen content in sausages followed a trend similar to that of insoluble collagen content, with the total amount of collagen present in the sausages increasing with increase in wooden breast material and severity. Only those sausages formulated with 50 and 100% severe WB material were different ($P = 0.03$) from sausages formulated with 100% normal breast material.

Soglia et al. (2016) reported higher moisture content in WB fillets than in normal (control) breast fillets, which is similar to the observation for the raw formulation in the present study. Although Soglia et al. (2016) reported a slight difference in fat concentration, the elevated water concentration in WB fillets is likely a consequence of lower protein content in WB fillets that was reported. Malila and Juthawut (2018) reported similar fat content in normal and WB meat, along with a decrease in percentage of protein and an increase in percentage of moisture. The percentage of moisture and percentage of protein in the present study were inversely related, regardless of the change in fat. However, after blending the raw materials, it was noted in the present study that percentage of moisture is normalized and that the only remaining trend is the decrease in

Table 1. Least squares means for proximate analysis of ground raw breast fillets.

Parameter	N[1]	M-WB[2]	S-WB[3]	SEM	*P*-value
Moisture, %	75.9[b]	77.0[a]	77.8[a]	0.31	<0.01
Protein, %	21.9[a]	20.6[b]	19.3[c]	0.22	<0.01
Fat, %	2.3	2.3	3.0	0.31	0.21
Collagen, milligram per gram of meat					
Soluble	1.0	1.2	1.1	0.14	0.59
Insoluble	3.3[b]	4.8[a]	5.6[a]	0.43	0.02
Total	4.3[b]	6.1[a,b]	6.7[a]	0.55	0.05

[a-c]Means within an attribute with differing superscripts differ; $P < 0.05$.
[1]N: normal broiler meat (100%).
[2]M-WB: moderate woody breast.
[3]S-WB: severe woody breast.

percentage of protein with increased inclusion of WB meat. This indicates that the major difference between raw breast fillets and chicken sausage blends is the protein content and that the difference in water is potentially changed solely by the difference in protein content in the raw material.

Velleman (2019) reported varying degrees of fibrosis with the deposition of extensive fibrillar collagen in WB fillets. In agreement with the present study for S-WB, Soglia et al. (2016) reported that WB fillets had a greater percentage of collagen than normal breast fillets, which appears to be from the increase in the insoluble collagen fraction. The increase in both the total collagen content and the insoluble collagen fractions could negatively impact the ultimate functionality and bind of sausages formulated with wooden breast meat.

Objective Color Analysis

Raw (uncooked) sausages formulated with normal breast meat were lighter (L*; $P < 0.05$) than sausage formulations containing 50 or 100% moderate WB meat and 25 or 100% severe WB meat (Table 3). Sausage prepared with 100% normal breast meat had similar L* values to sausages containing 25% moderate and 50% severe formulations ($P \geq 0.09$). The b* values of the raw sausage formulated with 100% normal breast meat were similar ($P > 0.05$) to those of the sausages formulated with 25 and 100% moderate WB meat and 25 and 50% severe WB meat. Objective measurements of a* did not differ ($P = 0.49$) among raw sausage formulations.

After sous vide cooking, sausage L* was also different among the varying formulations ($P < 0.01$). Sausage formulations made of 100% severe WB fillets were darker than all treatments containing 50% WB meat or less regardless of severity ($P < 0.05$). L* values of 100% normal, 100% moderate, 50% moderate, 50% severe, and 25% severe WB meat were all similar ($P \geq 0.09$) to each other. Twenty-five percent of moderate WB formulations were lighter in color ($P < 0.05$) than all 100% WB meat formulations, regardless of severity. Twenty-five percent of moderate formulations were similar to 100% normal, 50% moderate and severe, as well as 25% severe ($P \geq 0.14$) meat. The b* values of sausages formulated with 25 and 50% severe WB meat were lower than those formulated with 100% moderate WB meat, with the others being similar ($P > 0.05$). Objective cooked color measurements of a* were not different between treatments ($P = 0.33$ and $P = 0.10$, respectively).

The overall trend of the data indicates that increasing the inclusion of WB fillets will darken the raw sausage color, with no change to redness or yellowness of the sausage formulation. The results of the present study follow closely to those described by Zhuang and Bowker (2018), who measured the surface color of normal and WB fillets, showing that normal breast fillets are lighter in cooked color (increased L* values) than WB fillets. Although instrumental values (L*) were different, visual difference in cooked color between treatments was minimal or undetectable. Fletcher (1999) reported L* values of normal breast fillets (compared with pale or dark fillets) collected from 5 poultry processing plants to be between 43.9 and 47.5. The variability in the color of the fresh sausage resulting from

Table 2. Least squares means of proximate analysis of raw formulated chicken sausage.

Parameter	N[1]	25M-WB[2]	50M-WB	100M-WB	25S-WB[3]	50S-WB	100S-WB	SEM	*P*-value
Moisture, %	68.44	68.79	68.18	68.13	68.78	68.84	68.65	0.73	0.95
Protein, %	17.67[a]	17.21[a,b]	16.56[b,c]	15.36[d]	16.84[b,c]	16.26[c]	14.46[e]	0.29	<0.01
Fat, %	11.64	11.48	12.99	14.00	13.22	12.20	13.90	0.93	0.33
Collagen, milligram per gram of meat									
Soluble	1.15	1.25	1.47	1.37	1.34	1.50	1.25	0.13	0.45
Insoluble	4.36[b,c]	3.74[c]	4.89[b,c]	5.12[a,b]	5.12[a,b]	5.53[a,b]	6.23[a]	0.42	0.02
Total	5.51[b,c]	4.99[c]	6.37[a,b,c]	6.49[a,b]	6.46[a,b]	6.98[a]	7.47[a]	0.46	0.03

[a-c]Means within an attribute with different superscripts differ; $P < 0.05$.
[1]N: normal broiler meat (100%).
[2]M-WB: moderate woody breast (the number represents the percentage of the formulation, with the remaining normal broiler meat).
[3]S-WB: severe woody breast (the number represents the percentage of the formulation, with the remaining normal broiler meat).

Table 3. Least squares means of formulated sausage link color.

Parameter	N[1]	25M-WB[2]	50M-WB	100M-WB	25S-WB[3]	50S-WB	100S-WB	SEM	*P*-value
Raw									
L*	69.3[a]	67.4[b,c]	67.0[b,c]	66.0[c]	66. 0[b]	67.9[b]	66.1[c]	1.57	<0.01
a*	1.0	0.8	1.0	0.8	0.90	0.91	1.0	0.18	0.49
b*	13.6[a]	13.3[a,b]	12.1[c]	13.0[a,b]	12.8[a,b,c]	13.0[a,b,c]	12.5[b,c]	0.38	0.04
Cooked									
L*	79.8[a]	80.8[a]	79.9[a]	78.7[b]	79.81[a]	79.0[a]	78.2[b]	0.82	<0.01
a*	1.0	0.7	0.8	0.8	0.7	0.74	0.86	0.13	0.15
b*	16.9[a,b]	15.9[b,c]	16.1[b,c]	17.5[a]	15.7[c]	15. 5[c]	16. 6[a,b,c]	0.53	<0.01

[a-c]Means within an attribute with different superscripts differ; $P < 0.05$.
[1]N: normal broiler meat (100%).
[2]M-WB: moderate woody breast (the number represents the percentage of the formulation, with the remaining normal broiler meat).
[3]S-WB: severe woody breast (the number represents the percentage of the formulation, with the remaining normal broiler meat).

incorporation of the WB meat may not affect consumer acceptance.

Texture Profile Analysis

There was no treatment effect on cook loss ($P = 0.15$; Table 4) after thermal treatment when the sausages were heated to 70°C internal temperature. Differences in springiness between the treatments were not observed ($P = 0.92$). In the present study, we used the sous vide cooking method, wherein the sausages were placed inside a plastic bag and immersed in a hot water bath to attain consistent temperature in all the sausages. It is possible that the cook loss resulting from this method of cooking might be lower than what would be expected from traditional cooking on a skillet or a grill as losses due to evaporation in addition to drip loss during cooking would result in higher cook loss. Sausages formulated with 100% normal breast meat and 25, 50, and 100% moderate WB and 25% severe WB meat were similar in hardness and were harder than those formulated with 50 and 100% severe WB meat. This probably was due to greater binding of the moisture by the sausages and better extraction of salt-soluble myofibrillar proteins during mixing as the moisture content of raw, formulated sausages and the cook loss during cooking of the sausages were similar, indicating that the moisture content of the cooked sausages could have been similar, but differing in hardness. The cooked sausages formulated with 100% severe WB meat had lower hardness values than the sausages formulated with 100% normal, 25 and 50% moderate WB, and 25% severe WB meat.

Chatterjee et al. (2016) reported that cooked, WB fillets showed higher hardness values than the normal breast fillets, although the cohesiveness values were similar. In marinated breast fillets, cooked breast fillets with severe WB condition were significantly harder (8.13 vs. 13.95 kg) and more cohesive (0.46 vs. 0.56; Aguirre et al., 2018).

Sausage formulations containing 100% normal breast meat had greater cohesiveness values ($P < 0.05$) and were similar to the sausages containing 25% moderate WB meat. The cohesiveness value for sausage formulation containing 100% severe WB meat was the lowest, but was similar to sausage formulations containing 50% or higher moderate WB meat and all of the formulations containing severe WB meat. Using sensory analysis, Sanchez-Brambila et al. (2017) reported slightly lower cohesiveness values (4.8 vs. 4.5) of breast meat patties formulated with WB meat. Similarly, Caldas-Cueva et al. (2020) reported lower instrumental cohesiveness values in chicken patties containing 100% severe WB meat than in those formulated with 100% normal and 33% mild WB meat (lower woodiness scores than moderate WB fillet scores by palpation).

Chewiness, a product of the hardness, cohesiveness, and springiness, also showed a significant treatment effect ($P < 0.01$). Sausage formulations made with normal breast fillets and with 25 and 50% moderate WB meat had higher chewiness values ($P < 0.05$), wherein all sausages made with 100% WB meat inclusions regardless of

Table 4. Least squares means of texture profile analysis attributes of cooked chicken sausage.

Parameter	N[1]	25M-WB[2]	50M-WB	100M-WB	25S-WB[3]	50S-WB	100S-WB	SEM	*P*-value
Hardness, g	7,389[a]	7,294[a]	7,394[a]	6,568[a,b,c]	6,947[a,b]	6,348[b,c]	6,013[c]	539	<0.01
Cohesiveness	0.46[a,b]	0.49[a]	0.41[b,c]	0.42[b,c]	0.41[bc]	0.43[b,c]	0.38[c]	0.07	0.01
Springiness, %	79.9	80.0	79.1	78.4	79.4	79.3	80.2	1.52	0.92
Chewiness[4]	2,690[a]	2,755[a]	2,402[a,b]	2,105[b,c]	2,156[b,c]	2,128[b,c]	1,798[c]	236	<0.01
Cook loss, %	11.9	10.3	11.8	13.8	13.5	13.4	12.3	0.96	0.08

[a-c]Means within an attribute with different superscripts differ; $P < 0.05$.
[1]N: normal broiler meat.
[2]M-WB: moderate woody breast (the number represents the percentage of the formulation, with the remaining normal broiler meat).
[3]S-WB: severe woody breast (the number represents the percentage of the formulation, with the remaining normal broiler meat).
[4]Values for chewiness were calculated by multiplying the hardness by the cohesiveness and springiness.

the severity are similar to both 25 and 50% severe sausage blends ($P > 0.11$). Chatterjee et al. (2016) reported a gradual increase in chewiness of breast fillets with moderate and severe WB condition compared with normal breast fillets. Similarly, Aguirre et al. (2018) reported increased instrumental chewiness in severe WB fillets (marinated) compared with normal breast fillets (2.50 vs. 5.85). Caldas-Cueva et al. (2020) reported that chicken patties prepared with 100% severe WB meat had low instrumental chewiness scores compared with other treatments containing ≤67% severe WB meat in combination with normal breast meat.

It is often reported that the hardness of WB fillets is dramatically increased for intact muscle (Soglia et al., 2016; Malila and Juthawut, 2018; Maxwell et al., 2018). However, the present study showed that comminution of the WB fillet meat and subsequent sausage production, through inclusion of WB fillet meat into normal breast fillet meat, had a tendency for decreased sausage hardness and decreased chewiness. The reduction in hardness values may be an advantage in this case as chicken sausages often have undesirable high hardness values and are springy. Incorporation of WB meat into sausage formulations resulted in lower hardness values and lower springiness. The increase in muscle atrophy (Abasht et al., 2016; Huang and Ahn, 2018; Velleman, 2019) may explain the decrease in sausage hardness. Soglia et al. (2016) also showed a decrease in myofibrillar content and increased presence of connective tissue deposition as wooden breast severity increased. The decreased myofibrillar and increased collagen content (especially in the insoluble fraction) would decrease the functionality and bind values of wooden breast meat sources and thereby could cause a decrease in the hardness, gumminess, and chewiness in ground, nonemulsified sausages. This is further substantiated by a 16.5% decrease in cohesiveness between sausage formulations with normal breast meat and 100% severe WB meat. Although these 2 texture parameters were not statistically significant, their use in the calculation of gumminess and chewiness is statistically significant. The use of WB fillet meat could be included at low levels into sausage formulations, such as 25%, with little or no impact on sausage texture; however, the preferred texture of sausages formulated with wooden breast meat warrants further investigation.

CONCLUSIONS

Although WB meat has been shown to have decreased protein functionality, this research highlights the potential for WB meat inclusion with minimal alterations to chicken sausage quality. The difference in color between normal chicken meat sausage and low-level WB meat inclusion is minimal. Although there was a high degree of variability among cook losses recorded, cook loss was not different among the various treatment combinations. Furthermore, the lack of differences in various textural properties indicates that although the differences in texture of intact WB muscle are significant, comminution and subsequent inclusion of WB fillet meat in a ground product such as a sausage may not be detectible to a consumer. Incorporation of discounted WB meat into sausage products may be a viable option for poultry processors to recapture utility and value while decreasing waste.

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DISCLOSURES

There are no conflicts of interests for any of the authors in the manuscript.

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