Meat and Muscle Biology™

Quality Differences in Traditional and Clean Label Chicken Patties Formulated with Woody Breast Meat

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Abstract: Wooden breast (WB) is a myopathy that affects the *pectoralis major* of broilers and negatively affects broiler breast meat quality, yields, and profits. Therefore, the objective of this research was to evaluate quality differences between chicken patties that differed in the percentage of normal (% NOR) and severe (SEV) breast meat: 0% NOR, 33% NOR, 67% NOR, and 100% NOR. Patties were formulated with a control (salt), traditional (salt, sodium phosphate), or clean label (salt, potassium carbonate) marinade. A 3 × 4 factorial structure within a randomized complete block design with 3 replications was used to evaluate the effects of marinade (control, traditional, and clean label) and % NOR (0% NOR, 33% NOR, 67% NOR, and 100% NOR) on product quality. The 100% NOR patties had greater cook yields than 33% NOR and 0% NOR patties ($P < 0.05$) and better protein bind than other % NOR treatments ($P < 0.05$). Traditional patties had greater cook yields and better protein bind than clean label and control patties ($P < 0.05$). For texture profile analysis, 100% NOR patties were harder, gummier, chewier, and springier than 33% NOR and 0% NOR patties ($P < 0.05$). For descriptive analysis, 100% NOR patties were chewier and more cohesive than 0% NOR patties ($P < 0.05$), and traditional patties were springier, gummier, chewier, juicier, more cohesive, more uniform, and more fracturable than clean label patties ($P < 0.05$). Consumers rated all patties acceptable for appearance, aroma, texture, flavor, and overall acceptability (>6). Use of sodium phosphate increased protein bind and cook yields at all % NOR. Quality differences were still detectable in patties formulated with 67% or more WB, which will continue to cause yield losses and decreased quality in processed poultry products. However, if these yields and protein functionality deficiencies are acceptable to processors, it would be feasible to use either 33% or 67% SEV WB in the formulation of ground patties.

Key words: chicken breast, myopathy, water-holding capacity, marination
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Introduction

Wooden breast (WB) myopathy contributed to more than $200 million in annual losses in 2015 and 2016, which is expected to be a much greater amount by 2020 (Mudalal et al., 2015; Owens, 2016). Most WB exhibits poor eating quality and is visually unpleasant, even after the meat is ground (Figure 1). Most severe (SEV) WB meat is graded out of breast meat production and trimmed, and the trimmed portion is condemned (USDA FSIS, 2017). Not all WB meat is SEV. In most instances, a large portion of each broiler breast exhibits slight to moderate WB characteristics and is therefore utilized as normal (NOR) breast meat. There is no estimation of the total amount of WB (slight to SEV) in the poultry industry since only moderate WB and SEV WB affect the eating quality of marinated breasts (Jarvis et al., 2020).

Chopped and formed chicken products make up a fair portion of the marketplace and provide poultry companies the opportunity to produce value-added products, with meat that may not otherwise be utilized

Figure 1. Visual difference in ground normal (NOR; left) and severe (SEV; right) wooden breast (WB) meat after 1/4 in grind (top) and 3/16 in grind (bottom).

from the carcass. Utilization in a chopped and formed product may be a viable option for SEV WB. Some processors sort out WB fillets to go into comminuted products, such as nuggets or patties (Crews, 2016). Therefore, it is important to research the impact that using WB has on product quality.

Chicken patty marinades include traditional phosphate and clean label formulations. The difference in traditional and clean label marinades is the replacement of sodium phosphate in traditional marinades with potassium carbonate in clean label marinades. Sodium phosphates are regulated to levels at 0.5% or less of the final product and must be listed on an ingredient label (9 CFR 318.7; Code of Federal Regulations, 2015). Sodium phosphates are negatively charged molecules. Diphosphates from sodium phosphate break actomyosin bonds, which creates more space for water within the sarcomere structure of muscle (Trout and Schmidt, 1983; Huynh Bach et al., 1987). This improves water-holding capacity, which also enhances tenderness and juiciness of processed meats, including comminuted products (Lopez et al., 2012).

Potassium carbonate is commonly used in clean label marinades as a partial phosphate replacer. Potassium carbonate is currently an ingredient that is generally recognized as safe. It is to be used according to good manufacturing practices (21 CFR 184.1619; Code of Federal Regulations, 2015). Potassium carbonate is also favored by meat producers because, according to 21 CFR 184.1619 and 21 CFR 184.16.13 (Code of Federal Regulations, 2015), it is not required to be on a food label since it is recognized as a "pH control agent and processing aid" (21 CFR 184.170.3; Code of Federal Regulations, 2015). Potassium carbonate disassociates in water and meat and raises the pH of the water from slightly acidic to slightly basic. The negative charge from the carbonate increases the pH of the water in a marinade and ties up positive ions, which increases the pH of the meat (LeMaster et al., 2019). Increasing the water-holding capacity in comminuted products is important to improve quality, increase product yields, and lower production costs. Therefore, this research was conducted to evaluate the instrumental quality, sensory attributes, and consumer acceptability of chicken patties formulated with differing percentages of NOR breast meat (100% NOR, 67% NOR, 33% NOR, 0% NOR) using marinades differing in functional ingredients (control [salt], traditional [salt, sodium phosphate], and clean label [salt, potassium carbonate]) to understand the potential of using WB in comminuted products.

Materials and Methods

Sample collection

On each collection date ($n = 3$), 227 kg of NOR breast meat and SEV WB were collected from broilers with an average live weight of 4.2–4.3 kg at a commercial poultry plant. These chicken breasts were collected after the birds were auto-deboned at 2 h postmortem. As collected, the breasts were graded by hand palpitation based on degree of woodiness: NOR, which was flexible throughout the breast, or SEV WB, which was extremely hard and rigid throughout the breast (Tijare et al., 2016). NOR breasts were selected very carefully so they did not contain any WB lesions. All breasts were stored at 2°C–3°C for 6 d prior to processing.

Sample processing

Two hundred twenty-seven kg of NOR and 227 kg of SEV WB were first ground through a 1.27-cm plate (Triumph, Model #103306, Speco, Inc., Schiller Park, IL) followed by a second grind through a 0.48-cm bone-extracting plate (Triumph, Model #103060, Speco, Inc.), using a Biro auto-feed-mixer grinder (Model AFMG; Biro, Marblehead, OH). The correct amounts of NOR and SEV ground breast meat were combined into 18.1-kg batches (Table 1) of percentage of normal (% NOR) formulations with the following % NORs: 100% NOR (100% NOR breast meat/0% SEV WB meat), 67% NOR (67% NOR breast meat/33% SEV WB meat), 33% NOR (33% NOR breast meat/67% SEV WB meat), and 0% NOR (0% NOR breast meat/100% SEV WB meat).

Each % NOR breast meat was blended with control, traditional, or clean label formulations, all of which contained salt (1.0%,), garlic powder (0.35%, Olam Spices and Vegetables Ing, Product #200026), onion powder (0.35%, Olam Spices and Vegetables Ing, Product #100260), and black pepper (0.20%, Elite Spice Inc., Product Code PB9407). The marinade treatments consisted of the following: control: reverse osmosis water (14.77%); traditional: reverse osmosis water (14.37%) and sodium phosphates (a blend of poly- and pyrophosphates, Brifisol 960; 0.40%); and clean label: reverse osmosis water (14.52%) and potassium carbonate (Aquahawk GFS, Hawkins Inc., Roseville, MN; 0.25%). Each meat batch and its designated brine were added to a vacuum blender (Food Processing Equipment Co., Model #814) that was set to 25 mmHg. Each combination was blended for 5 min forward at 12 revolutions per minute (RPM) and then 5 min in reverse at 12 RPM. Each blend was then chilled with CO_2 to −2.7°C. After chilling, each treatment was blended for an additional 3 min forward at 12 RPM. After blending, each batch was emptied into a 136-kg hopper capacity Formax (Model #F-6, Formax, Mokena, IL) to make patties with a $11\frac{3}{4} \times 10\frac{4}{5} \times 25$ cm^3 plate (166 g). Ten patties were frozen in their raw form to −62.2°C in a CO_2 cabinet (Model CES-BF-CO2-15x15x21-E; CES Group, Cincinnati, OH). The remaining patties were belt grilled at 257.2°C for 75 s (Model #409E FMC Food Tech). After being belt grilled, the patties were fully cooked in a Unitherm spiral oven (Model #XSS0-12-1.1-5T; Unitherm Food Systems, Inc., Bristow, OK) for 12 min at 162.8°C, 82.2°C dew point, and an 800 RPM fan speed. Fully cooked patties were individually frozen in a BOC freezer (Model #KFT36.10CU; BOC Gases, Murray Hill, NJ) for 25 min at −62.2°C. Samples were stored at −23°C. All samples were evaluated within 3 mo of processing.

Table 1. Experimental design of marinades and % NOR breast meat in ground chicken breast patties

Marinade	Ingredients	% NOR
Control	Salt, garlic powder, onion powder, black pepper	0
		33
		67
		100
Traditional	Sodium phosphates, salt, garlic powder, onion powder, black pepper	0
		33
		67
		100
Clean Label	Potassium carbonate, salt, garlic powder, onion powder, black pepper	0
		33
		67
		100

% NOR = percentage of normal.

pH

Four pH readings were collected from each meat block after blending using an Accumet pH meter

(Model Accumet 61; Fisher Scientific, Hampton, NH) with a meat-penetrating probe (Model FlexipHet SS Penetration tip; Cole Palmer, Vernon Hills, IL). These samples were discarded after data collection. Prior to measuring the pH of each batch, the pH probe was standardized using calibration buffers with pHs of 4.01 and 7.00. The pH meter was recalibrated between meat batches to ensure measurement accuracy. pH was also measured in triplicate for each marinade and % NOR prior to blending using the same method.

Proximate analysis: Near-infrared reflectance

This near-infrared reflectance (NIR) method followed a method described by Byron et al. (2020). Three frozen raw chicken patty samples from each batch were thawed for 2 h and then analyzed for fat, protein, moisture, and collagen content, with duplicate measurements per chicken patty. Each sample was packed tightly in a 140-mm-diameter sample cup for analysis. Proximate composition (protein, fat, collagen, and moisture) was measured using an AOAC-approved method with a near-infrared spectrometer (Food Scan Lab Analyzer, Model 7880; Foss Analytical, Eden Prairie, MN).

Cook yields

Cook yield was measured during initial cooking and reconstituted (recon) cooking. During initial cooking, raw chicken patties ($n = 10$) were weighed prior to belt grilling and cooking. After cooking, the same chicken patties ($n = 10$) were weighed prior to freezing. Initial cook yield was calculated from these weights. During recon cooking, individually frozen chicken patties were weighed immediately out of the freezer and randomly assigned to one of 9 positions on an aluminum-foil–covered tray. Patties were cooked in a convection oven (Model SCVX20E; Hobart, Chattanooga, TN) for 22 min at 177°C to an internal temperature of 76°C. After cooking, patties were cooled to room temperature and weighed. Recon cook yield was calculated from these weights. The estimation of overall cook yield was calculated from the combination of initial cooking and recon cooking.

$$\text{Initial Cook Yield}(\%) = \left(\frac{\text{wt of raw patty-wt of cooked patty}}{\text{wt of raw patty}}\right) * 100$$

$$\text{Recon Cook Yield}(\%) = \left(\frac{\text{wt of frozen patty-wt of reconned patty}}{\text{wt of frozen patty}}\right) * 100$$

Protein bind

Chicken patty samples ($n = 10$) were recon cooked the same way as described for cook yield collection, cooled for 30 min to room temperature, and then placed on a plexiglass stand to hold the sample in place. A steel ball (25.0-mm diameter) was attached to a rod that was secured in a 50-kg load cell with a chuck and used at a crosshead speed of 100 mm/min using an Instron Universal Testing Center (Model 3345; Instron, Norwood, MA) to penetrate through the center of each of the 10 chicken patties from each treatment within each replication (Field et al., 1984; Schilling et al., 2004). Protein–protein bind was reported as the peak force (Newtons) required for the steel ball to penetrate through the chicken patties for each treatment.

Texture profile analysis

For texture profile analysis (TPA), chicken patty samples ($n = 10$) were recon cooked as described for cook yield and then cooled for 30 min to 20°C. One 2.5-cm core was cut from each patty and trimmed to 20 mm in height. TPA samples were compressed twice to 50% of the original sample height at 100 mm/min using a metal weighted cylinder that was mounted onto an Instron Universal Testing Center (Model 3345; Instron, Norwood, MA). Texture profile attributes were expressed and calculated according to Bourne (1978).

Descriptive sensory analysis

Chicken patty samples were placed on an aluminum-foil–covered tray, covered with aluminum foil, and cooked in a convection oven (Model SCVX20E; Hobart, Chattanooga, TN) at 177°C for 22 min to an internal temperature of 76°C. The edges of the chicken patty samples were trimmed, and the remaining sample was cut into twelve 2.54 cm × 2.54 cm in cube samples. The panelists ($n = 10$) were trained for 12 h on the evaluation of texture and flavor attributes of chicken patties on a 0- to 15-cm line scale, such that 0 and 15 are relevant to chicken standards only. Chicken patty texture attributes were based on Civille and Carr (2015), with some slight changes to accommodate chicken patties. Texture attributes and reference standards are listed in Table 2 (Civille and Carr, 2015). The texture and flavor attributes that were evaluated included moistness, springiness, uniformity, fracturability, tenderness, cohesiveness, chewiness, initial juiciness, overall juiciness, gumminess, mushiness, sourness, saltiness, bitterness, umami, brothy/chicken, seasonings, off-flavors, and mouth coating (Civille and

Table 2. Texture attributes with comparable food standards and typical chicken patty ranges (Civille and Carr, 2015)

Descriptive Attribute	Definition	Comparable Standards	Typical Chicken Patty Range
Moistness	The amount of wetness or oiliness on surface (dry → wet/oily/moist)	Carrot—3 Pound cake—4.4 Apple—7.5	4–8
Springiness(Rubberiness)	Degree to which the sample returns to its original shape after a partial compression (no recovery → springy)	Hot dog—5 Marshmallow—9.5	4–8
Uniformity of Bite	Evenness of force throughout the bite (uneven/choppy → very even)	Pound cake—14	6–10
Fracturability	The force with which the sample breaks (crumbles → fractures)	Graham crackers—4.2 Ginger snaps—8 Life Savers—14.5	6–10
Tenderness	The quality of being easy to cut or chew (tender → tough)	Tough chicken < 7.5 Slim Chickens 12	8–12
Cohesiveness of Mass	Degree to which a chewed sample (10–15 chews) holds together in a mass (loose mass → compact mass)	Hot dog—7.5 Cube cheese—9 Pound cake—9.5	5–9
Chewiness	Amount of work to chew the sample to the point of swallow (mushy → chewy/rubbery)	Normal chicken 0–2 WB/rubbery—up to 6 (usually)	<5
Juiciness	Amount of moisture during the first 5 chews (initial) or after the first 5 chews (overall) (dry → wet)	Dry chicken < 7.5 Apple—10	8–12

WB = wooden breast.

Carr, 2015; Sanchez Brambila et al., 2017; Aguirre et al., 2018) (Table 2).

Consumer sensory analysis

Four consumer panels with approximately 50 different panelists in each panel ($n = 218$ total panelists) were conducted at Mississippi State University's James E. Garrison Sensory Evaluation Laboratory (Institutional Review Board-19-015). Of the 4 consumer panels, the first 2 panels evaluated clean label patties, and the second 2 panels evaluated traditional patties. Three-digit numbers were randomly assigned to identify samples, and sample order was randomized by Compusense Cloud software (Compusense Cloud, Guelph, Ontario, Canada). Panelists were provided with water, apple juice, and unsalted crackers to cleanse their palates. Each panelist was asked to evaluate 4 coded chicken patty samples using a 9-point hedonic scale in which 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely (Civille and Carr, 2015). Both descriptive and consumer panel results were obtained using the Compusense Cloud.

Statistical analysis

A 3 × 4 factorial structure (Table 1) within a randomized complete block design with 3 replications was used to evaluate the impact of marinade (control, traditional, clean label) and % NOR (0% NOR, 33% NOR, 67% NOR, 100% NOR) on pH, cook yields, TPA attributes, and protein bind.

A 2 × 4 factorial structure within a randomized complete block design with 2 replications was used to determine the impact % NOR (0% NOR, 33% NOR, 67% NOR, 100% NOR) on descriptive sensory attributes and consumer acceptability within marinade treatments (traditional and clean label).

All statistical analysis was evaluated using SAS version 9.4 (SAS Institute Inc., Cary, NC). Means were separated using the Fisher's Protected least significant difference test. Orthogonal contrasts were also conducted to determine whether there were linear or quadratic effects ($P < 0.05$) between NOR breast percentage and pH, cook yields, TPA attributes, and protein bind. For consumer sensory analysis, agglomerative hierarchical clustering using XLSTAT (version 2016, Addinsoft USA, New York, NY) was performed to group consumer panelists in clusters based on their liking of chicken patty samples. The number of clusters used to group panelists was determined based on a dendrogram and a dissimilarity plot. Within each cluster, the Fisher's Protected least significant difference test was used to separate treatment means ($P < 0.05$). Differences within clusters were only reported for clusters with $n \geq 10$ panelists.

Results and Discussion

pH

The clean label marinade had a greater pH at 9.5 ($P < 0.05$) than the traditional (7.6) and control (5.4) marinades. In addition, the traditional marinade pH

($P < 0.05$) was greater than that of the control marinade. These values are consistent with previous literature that reported higher pH for marinades that included alkaline sodium phosphate (Trout and Schmidt, 1983; Huynh Bach et al., 1987) or potassium carbonate (LeMaster et al., 2019) than those that did not include either ingredient. For meat pH, no interaction existed ($P > 0.05$) between % NOR and marinade. When averaged over marinades, there was no difference in pH among % NORs ($P > 0.05$) (Table 3). Clean label meat block had a greater ($P < 0.05$) pH (6.17) than traditional (6.00) and control treatments, and the traditional meat block had a greater pH ($P < 0.05$) than the control (5.84). These results are consistent with differences in brine pH. This also agrees with previous research, which indicated that non-marinated whole-muscle SEV WB had a higher pH than NOR breast meat (Kuttappan et al., 2017; Xing et al., 2017; Cai et al., 2018; Dalgaard et al., 2018). Within the traditional marinade, 0% NOR patties had a higher pH than the 100% NOR patties ($P < 0.05$), but both traditional- and clean-label–marinated 0% patties had a higher pH than all the control samples (Table 3). As expected, both marinades increased the pH of the meat. In

Table 3. Meat pH, initial and recon cook yield, and protein bind of chicken patties that were formulated with different marinades and normal chicken breast percentages

			Cook Yields (%)[1]		
Analysis	Treatment	Meat pH	Initial	Recon[6]	Protein Bind (N)
% NOR[2]	**100**	5.97	89.1[a]	90.4[a]	30.0[a]
	67	6.00	87.4[ab]	89.4[ab]	24.6[b]
	33	6.02	86.2[b]	88.0[bc]	21.5[b]
	0	6.04	84.0[c]	86.7[c]	20.5[b]
	SEM	0.023	0.675	0.570	1.321
	***P* value**	0.224	0.001	0.001	0.001
	Linear	0.524	<0.0001	<0.0001	<0.0001
	Quadratic	NA	NA	NA	<0.0001
	Cubic	NA	NA	NA	NA
Marinade	**Control**[3]	5.84[c]	82.8[c]	87.9	22.6[b]
	Trad[4]	6.01[b]	90.5[a]	89.4	27.0[a]
	Clean[5]	6.17[a]	86.7[b]	88.5	22.8[b]
	SEM	0.020	0.585	0.494	1.144
	***P* value**	<0.0001	<0.0001	<0.0001	0.034
Marinade×% NOR	**Control - 100**	5.83d[e]	85.3[def]	89.6[abc]	27.9[b]
	Control - 67	5.85[de]	83.7[efg]	88.6[abcd]	23.3[bcd]
	Control - 33	5.82[e]	82.1[fg]	87.3[bcd]	20.2[cd]
	Control - 0	5.85[de]	80.1[g]	86.1[d]	19.2[d]
	Trad - 100	5.95[cd]	92.3[a]	91.6[a]	36.1[a]
	Trad - 67	5.94[cde]	91.5[ab]	89.9[ab]	27.2[bc]
	Trad - 33	6.03[bc]	89.9[abc]	89.9[ab]	23.7[bcd]
	Trad - 0	6.12[ab]	88.3[bcd]	86.3[d]	20.9[cd]
	Clean - 100	6.14[ab]	89.7[abc]	90.0[ab]	26.0[bcd]
	Clean - 67	6.20[a]	86.9[cde]	89.6[abc]	23.2[bcd]
	Clean - 33	6.20[a]	86.6[cde]	86.6[cd]	20.5[cd]
	Clean - 0	6.16[a]	89.7[efg]	87.7[bcd]	21.5[bcd]
	SEM	0.040	1.169	0.987	2.288
	***P* value**	0.170	0.960	0.483	0.484

[1]Cook yields defined as (weight of cooked or reconned patty) ÷ (weight of raw or frozen cooked patty) × 100%.

[2]Percentage of normal (% NOR) breast meat.

[3]"Control" represents control marinade (salt, seasonings).

[4]"Trad" represents traditional marinade (sodium phosphate, salt, seasonings).

[5]"Clean" represents clean label marinade (potassium carbonate, salt, seasonings).

[6]Recon = Reconstituted.

[a–g]Means within a column lacking a common superscript differ ($P < 0.05$) by analysis. There was no marinade × % NOR interaction effect ($P > 0.05$) for these attributes.

contrast with the traditional marinade results, the 0% NOR patties did not differ in pH from 100% NOR patties for the control and clean label marinades. Although some research has shown improvements in pH for potassium carbonate in meat systems, the impact of potassium carbonate on the actomyosin bonds has not been determined (LeMaster et al., 2019).

Cook yields

When averaged over marinade, cook yield increased linearly ($P < 0.05$) as % NOR breast meat increased (Table 3). In addition, patties formulated with 100% NOR breast meat had a greater cook yield than patties with 33% NOR breast meat ($P < 0.05$), which had a greater cook yield than those made with 0% NOR breast meat ($P < 0.05$) (Table 3). Patties made with 67% NOR breast meat had greater cook yield than 0% NOR patties ($P < 0.05$), but there were no differences ($P > 0.05$) in cook yield between 67% NOR patties and 100% NOR or 33% NOR breast meat patties. When averaged over % NOR, traditional patties had a greater cook yield than clean label patties ($P < 0.05$), which had a greater cook yield than control patties ($P < 0.05$).

When reconned from frozen, 100% NOR patties had a greater cook yield than 33% and 0% NOR patties ($P < 0.05$) (Table 3), and cook yield increased linearly ($P < 0.05$) as % NOR breast meat increased. There were no differences in cook yield between 100% NOR and 67% NOR patties ($P > 0.05$) or between 33% NOR and 0% NOR patties ($P > 0.05$). When averaged over % NOR, traditional patties had a greater cook yield than the control patties ($P < 0.05$). But there were no differences between clean label and traditional patties ($P > 0.05$). There was also no interaction between % NOR and marinade with respect to recon cook yield.

Similar to our research that found no differences between 100% NOR and 67% NOR patties, Qin (2013) also found no differences in cook loss for sausages with the addition of 15% and 30% WB, but their sausage formulations controlled for fat content (13.54%) so pork fat was added to WB sausages to keep the fat ratio the same in sausages with 0% WB or 30% WB. Their sausages were also prepared and cooked with casings that needed to be peeled after cooking, which may have helped the sausage retain water while cooling (Qin, 2013). Chen et al. (2018) reported similar results with meatballs formulated with salt and sodium phosphate; NOR breast meat meatballs had a better cook yield than WB meatballs. These cook yield results also differ from some previous research on patties formulated with WB meat.

The cook yield results on patties are consistent with current results on cook yield of marinated whole chicken breasts, in which SEV WB had lower cook yields than NOR breast meat (Mudalal et al., 2015; Soglia et al., 2016b; Xing et al., 2017; Dalgaard et al., 2018). As expected, the cook yields of patties that were formulated with a combination of NOR meat and SEV WB meat were between that of 100% NOR and 0% NOR patties and decreased linearly ($P < 0.05$) as the percentage of WB increased.

Protein bind

When averaged over marinade, patties made with 100% NOR breast meat had greater protein bind than other % NORs ($P < 0.05$) (Table 3). Data exhibited both linear and quadratic trends ($P < 0.05$), in which there was a linear increase as % NOR increased from 0% to 67% and a quadratic increase as % NOR increased from 33% to 100%. Besides patties with 100% NOR, there was no difference in protein bind in patties made with the addition of SEV WB ($P > 0.05$). When averaged over % NOR, patties made with the traditional marinade had better protein bind than the control and clean label marinade patties ($P < 0.05$). This is likely due to the use of diphosphate to increase ionic strength, which increases protein binding strength, substantiating the importance of using phosphates—specifically diphosphates—in comminuted meat products. This is in addition to diphosphates increasing pH, increasing ionic strength, sequestering bivalent cations, and disassociating actomyosin bonds (Trout and Schmidt, 1983). Use of WB meat had the greatest impact on the traditional marinade, with a decrease ($P < 0.05$) of 36.1 N to 27.2 N when 33% WB was added to the treatment. This indicates that phosphate was not able to increase protein functionality as well when WB was used at 33%, 67%, or 100%. This indicates that even though cook yields were similar between 100% NOR and 67% NOR treatments, inclusion of 33% WB did negatively impact protein–protein interactions. There was no difference in protein bind between patties made with the control and clean label marinades ($P > 0.05$).

Differences in protein bind among % NOR may be due to the fiber degradation and a reduction in myofibrillar proteins in SEV WB meat (Mudalal et al., 2015; Bowker and Zhuang, 2016). Due to protein degradation, proteins may not function well. Therefore, patties with any addition of WB will not bind as well as patties made with 100% NOR meat (Soglia et al., 2016a; Petracci et al., 2019). Chen et al. (2018) reported that meatballs made from WB featured larger separations in muscle fibers which may also hinder the bind, textural properties, and water-holding capacity of the meat.

Proximate analysis: NIR

There was no interaction effect between % NOR and marinade for fat, protein, collagen, and moisture content ($P > 0.05$) (Table 4). Orthogonal contrasts revealed that there were linear, quadratic, and cubic relationships ($P < 0.05$) between % NOR and fat, protein, and moisture percentage (Table 4). When averaged over marinade, there was more fat in 0% NOR patties than 67% NOR and 100% NOR patties ($P < 0.05$). There was no difference in fat between 67% NOR patties and 100% or 33% NOR patties ($P > 0.05$), and there was no difference in fat between 33% NOR patties and 67% or 0% NOR patties ($P > 0.05$). There was no difference in fat content among marinades ($P > 0.05$). When averaged over marinade, 100% NOR patties consisted of more protein than all other % NORs ($P < 0.05$). Also, 67% NOR patties had more protein than both 0% NOR and 33% NOR patties ($P < 0.05$), which were not different from each other ($P > 0.05$). There was no difference in protein content among marinades ($P > 0.05$).

When averaged over marinade, patties with 100% NOR and 67% NOR had more collagen than patties

Table 4. Proximate analysis of fat, protein, collagen, and moisture contents of chicken patties that were different between marinades and normal breast percentages

Analysis	Treatment	Fat (%)	Protein (%)	Collagen (%)	Moisture (%)
% NOR[1]	100	0.78[c]	17.4[a]	1.88[a]	75.9[c]
	67	0.92[bc]	16.7[b]	1.81[ab]	76.6[b]
	33	0.99[ab]	16.1[c]	1.72[bc]	77.3[a]
	0	1.18[a]	16.0[c]	1.67[c]	77.5[a]
	SEM	0.065	0.179	0.398	0.171
	P value	0.002	<0.0001	0.005	<0.0001
	Linear	0.011	0.0262	0.230	0.001
	Quadratic	0.0025	0.0063	NA	<0.0001
	Cubic	<0.0001	<0.0001	NA	<0.0001
Marinade	Control[2]	0.98	16.5	1.75[ab]	76.8
	Trad[3]	1.02	16.6	1.71[b]	76.9
	Clean[4]	0.91	16.5	1.85[a]	76.7
	SEM	0.559	0.155	0.035	0.148
	P value	0.395	0.778	0.027	0.844
Marinade × % NOR	Control - 100	0.83[bc]	17.4[a]	1.87[abc]	76.0[d]
	Control - 67	0.92[bc]	16.7[ab]	1.67[cde]	76.6[bcd]
	Control - 33	1.07[b]	16.0[b]	1.73[bcde]	77.4[ab]
	Control - 0	1.09[b]	16.1[b]	1.74[bcde]	77.3[abc]
	Trad - 100	0.87[bc]	17.6[a]	1.91[ab]	75.8[d]
	Trad - 67	0.90[bc]	16.8[ab]	1.76[bcd]	76.5[cd]
	Trad - 33	0.86[bc]	16.0[b]	1.61[de]	77.1[abc]
	Trad - 0	1.44[a]	16.1[b]	1.55[e]	78.1[a]
	Clean - 100	0.64[c]	17.3[a]	1.88[ab]	75.9[d]
	Clean - 67	0.93[bc]	16.7[ab]	2.00[a]	76.6[bcd]
	Clean - 33	1.04[b]	16.0[b]	1.82[abcd]	77.3[abc]
	Clean - 0	1.01[b]	16.0[b]	1.71[bcde]	77.2[abc]
	SEM	0.112	0.311	0.069	0.295
	P value	0.208	1.000	0.109	0.503

[1]Percentage of normal (% NOR) breast meat.

[2]"Control" represents control marinade (salt, seasonings).

[3]"Trad" represents traditional marinade (sodium phosphate, salt, seasonings).

[4]"Clean" represents clean label marinade (potassium carbonate, salt, seasonings).

[a–e]Means within a column lacking a common superscript differ ($P < 0.05$) by analysis. There was no marinade × % NOR interaction effect ($P > 0.05$) for these attributes.

NA = not applicable.

with 0% NOR meat ($P < 0.05$) (Table 4). There was no difference in collagen between 67% NOR patties and 100% or 33% NOR patties ($P > 0.05$), and there was no difference in collagen between 33% NOR patties and 67% or 0% NOR patties ($P > 0.05$). Surprisingly, when averaged over % NOR, clean label patties had more collagen than the traditional formula ($P < 0.05$), but there was minimal practical significance because the values were 1.71% and 1.85%.

When averaged over marinade, 0% NOR and 33% NOR patties had more moisture than 67% NOR patties ($P < 0.05$), which had more moisture than patties with 100% NOR breast meat ($P < 0.05$). When averaged over % NOR, there was no difference in moisture content among marinated samples ($P > 0.05$) (Table 4).

When averaged over marinade, there were differences in fat, protein, collagen, and moisture for patties that were formulated with different percentages of WB meat. When Wold et al. (2017) tested NIR for online detection of WB meat, it was reported that SEV WB meat contained more fat, less protein, and more moisture than NOR breast meat, which is consistent with the results of the current study. Other researchers have also reported similar differences in fat, protein, and moisture between NOR and SEV WB for whole chicken breasts (Soglia et al., 2016b; Cai et al., 2018; Byron et al., 2020). WB meat generally contains about 2% more water, 0.2%–0.3% more fat, and 2% less protein compared with NOR breast meat; NOR breast meat is 73.8%–75.3% moisture, 0.87%–1.25% fat, and 22.8%–23.5% protein, and SEV breast meat is 74.4%–79.6% moisture, 1.25%–2.0% fat, and 18.4%–21.7% protein (Soglia et al., 2016b; Wold et al., 2017; Cai et al., 2018).

Inconsistent results have been reported with respect to differences in collagen content between NOR and WB. Soglia et al. (2016a, 2016b) reported that there was more collagen in SEV WB (1.18%) than NOR breast meat (1.09%). In contrast, Cai et al. (2018) reported no significant difference in collagen between SEV WB (1.9%) and NOR (2.0%) breast meat. WB also has more crosslinked collagen than NOR, which indicates that differences between WB and NOR is due more to the type of collagen than the total amount of collagen (Mutryn et al., 2015; Velleman and Clark, 2015).

In addition, the protein content results were related to protein bind data to some extent. Chicken patties with 100% NOR breast meat had the highest protein content and greatest protein bind, whereas patties formulated with less NOR breast meat did not bind as well (Tables 3–4). Even though 67% NOR breast meat patties had less protein than 100% NOR patties, and more protein than 0% NOR and 33% NOR breast meat patties, there is still no difference in protein bind between these three percentages. Thus, once adding even just 33% WB to the meat block, the protein content and functionality of the product is negatively impacted.

TPA

There were no marinade × % NOR interaction effects for all descriptive attributes ($P > 0.05$) with the exception of chewiness ($P < 0.05$) (Table 5). Patties with 0% NOR and 33% NOR were moister than the 100% NOR patties ($P < 0.05$). The moistness of 67% NOR patties was not different from any other formulation ($P > 0.05$). In addition, there were no differences in moistness of patties that were formulated with different marinades ($P > 0.05$). Orthogonal contrasts indicated a linear and cubic relationship between % NOR and hardness, gumminess, chewiness, and springiness and a quadratic relationship with all TPA attributes.

Descriptive sensory analysis

The 100% NOR patties were tougher, chewier, and less juicy than patties with all other % NORs ($P < 0.05$) (Table 6). In addition, 100% NOR patties were more cohesive than 0% NOR ($P < 0.05$) but did not differ from 67% NOR and 33% NOR patties ($P > 0.05$). Patties with 33% NOR were mushier than 100% NOR patties ($P < 0.05$), and no other differences existed in texture attributes ($P > 0.05$). A linear relationship existed ($P < 0.05$) between moistness, tenderness, chewiness, and mushy and % NOR, and a quadratic relationship existed for mushy, chewiness, tenderness, and moistness. When averaged over % NOR, traditional patties were springier, gummier, chewier, juicier, more cohesive, more uniform, and more fracturable than clean label patties ($P < 0.05$) (Table 6). This is consistent with protein bind data since patties formulated with the traditional brine had a greater protein bind than the clean label ($P < 0.0001$), since sodium phosphate led to greater protein–protein interaction than the potassium carbonate, thus creating a springier, gummier, and more uniform product. Sanchez Brambila et al. (2017) reported that 100% NOR patties were springier and chewier than 100% WB patties, which agrees with chewiness results from the current study, but springiness was different, and no differences existed in hardness, juiciness, or cohesiveness. Descriptive results from the current paper are similar to

Table 5. TPA attributes of chicken patties that were formulated with different marinades and normal chicken breast percentages

Analysis	Treatment	Hardness[1]	Cohesiveness[2]	Gumminess[3]	Chewiness[4]	Springiness[5]
% NOR[6]	100	13.4[a]	0.4	4.7[a]	26.5[a]	5.6[a]
	67	12.1[b]	0.4	4.4[a]	24.7[a]	5.6[ab]
	33	10.8[c]	0.4	3.8[b]	20.6[b]	5.5[bc]
	0	10.1[c]	0.4	3.6[b]	19.3[b]	5.3[c]
	SEM	0.371	0.007	0.127	0.912	0.061
	P value	<0.0001	0.4588	<0.0001	<0.0001	0.0026
	Linear	0.001	0.590	0.003	0.0002	0.001
	Quadratic	<0.0001	NA	0.029	0.017	0.073
	Cubic	<0.0001	NA	<0.0001	<0.0001	NA
Marinade	Control[7]	12.8[a]	0.4[a]	4.8[a]	26.9[a]	5.6[a]
	Trad[8]	11.0[b]	0.3[c]	3.6[b]	19.5[c]	5.4[b]
	Clean[9]	11.0[b]	0.4[b]	3.9[b]	21.9[b]	5.6[a]
	SEM	0.322	0.006	0.110	0.789	0.053
	P value	0.0007	<0.0001	<0.0001	<0.0001	0.009
Marinade × % NOR	Control - 100	14.3[a]	0.4[ab]	5.3[a]	30.2[a]	5.6[ab]
	Control - 67	13.1[abc]	0.4[a]	4.9[ab]	28.8[ab]	5.7[a]
	Control - 33	12.3[bc]	0.4[ab]	4.6[bcd]	25.4[bcd]	5.5[abc]
	Control - 0	11.5[cde]	0.4[a]	4.3[bcde]	23.3[cdef]	5.4[bcd]
	Trad - 100	13.9[ab]	0.3[de]	4.6[bc]	26.0[abc]	5.6[ab]
	Trad - 67	11.7[cde]	0.3[cde]	4.0[def]	21.1[defg]	5.3[cd]
	Trad - 33	10.0[ef]	0.3[e]	3.2[gh]	16.7[gh]	5.3[cd]
	Trad - 0	8.5[f]	0.3[de]	2.8[h]	14.3[h]	5.2[d]
	Clean - 100	12.1[bcd]	0.3[bcde]	4.1[cdef]	23.2[cdef]	5.6[ab]
	Clean - 67	11.6[cde]	0.4[abc]	4.3[cde]	24.4[bcde]	5.7[a]
	Clean - 33	10.0[ef]	0.4[abcd]	3.6[fg]	19.7[bcd]	5.5[abc]
	Clean - 0	10.2[def]	0.4[abc]	3.8[ef]	20.4[cdef]	5.3[bcd]
	SEM	0.643	0.012	0.219	1.579	0.105
	P value	0.218	0.731	0.065	0.232	0.368

[1]Kg of initial force.

[2]Kg of initial force * distance of force (kg * mm).

[3]Hardnesss * cohesiveness (kg^2 * mm).

[4]Gumminess * springiness (kg^2 * mm^2).

[5]Recovery between first and second bites (compressions) (mm).

[6]Percentage of normal (% NOR) breast meat.

[7]"Control" represents control marinade (salt, seasonings).

[8]"Trad" represents traditional marinade (sodium phosphate, salt, seasonings).

[9]"Clean" represents clean label marinade (potassium carbonate, salt, seasonings).

[a–h]Means within a column lacking a common superscript differ ($P < 0.05$) for each analysis. There was no marinade × % NOR interaction for TPA attributes ($P > 0.05$).

NA = not applicable; TPA = texture profile analysis.

previous research, in which the initial juiciness of SEV WB meat was greater than that of NOR breast meat (Jarvis et al., 2020).

A few flavor attributes were affected by % NOR and marinade (Table 7). There was no % NOR × marinade interaction for each flavor attribute, and linear and quadratic effects were not significant ($P > 0.05$). Patties with 100% NOR breast meat had less umami and brothy/chickeny flavor than patties formulated with any other % NOR ($P < 0.05$). In both cases, traditional patties had more umami and brothy/chickeny ($P < 0.05$) flavor than clean label patties. Traditional patties were saltier than clean label patties ($P < 0.05$). And although there were no differences in off-flavors by % NOR, panelists detected more off-flavors in clean label patties than traditional patties ($P < 0.05$).

Differences in tenderness may be due to less protein binding, which leads to a more tender but mushier

Table 6. Chicken descriptive analysis ($n = 10$ trained panelists): Textural descriptive attributes[1] of cooked chicken patties that were formulated with different marinades and normal breast percentages

Analysis	Treatment	Moist	Springy	Uniform	Fracture	Tender	Cohesive	Chewy	Juicy	Gummy	Mushy
% NOR[2]	100	6.5^{b}	7.3	7.6	7.7	8.1^{b}	6.8^{a}	5.1^{a}	9.5^{b}	4.3	2.9^{b}
	67	7.1^{ab}	7.2	7.7	7.8	8.6^{a}	6.5^{ab}	4.8^{b}	10.2^{a}	4.1	3.1^{ab}
	33	7.7^{a}	7.1	7.8	7.7	8.8^{a}	6.4^{ab}	4.5^{b}	10.3^{a}	4.2	3.4^{a}
	0	7.5^{a}	7	7.5	7.6	8.9^{a}	6.2^{b}	4.5^{b}	10.0^{a}	4.2	3.2^{ab}
	SEM	0.227	0.137	0.150	0.180	0.124	0.161	0.084	0.138	0.108	0.141
	P value	0.013	0.642	0.612	0.892	0.006	0.124	0.001	0.009	0.464	0.117
	Linear	0.003	0.621	0.695	0.658	0.002	0.174	0.008	0.127	0.878	0.438
	Quadratic	0.097	NA	NA	NA	0.229	NA	0.316	NA	NA	NA
	Cubic	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Marinade	Trad[3]	7.2	7.8^{a}	8.1^{a}	8.2^{a}	8.6	7.0^{a}	4.9^{a}	10.2^{a}	4.6^{a}	2.5^{b}
	Clean[4]	7.1	6.5^{b}	7.3^{b}	7.1^{b}	8.6	5.9^{b}	4.5^{b}	9.8^{b}	3.8^{b}	3.7^{a}
	SEM	0.160	0.097	0.106	0.127	0.087	0.114	0.059	0.098	0.077	0.100
	P value	0.676	<0.0001	<0.0001	<0.0001	0.839	<0.0001	0.0004	0.021	<0.0001	<0.0001
Marinade × % NOR	Trad - 100	6.7^{bc}	7.9^{a}	7.9^{abc}	8.2^{a}	8.1^{d}	7.3^{a}	5.4^{a}	9.9^{ab}	4.7^{a}	2.3^{c}
	Trad - 67	7.1^{abc}	7.8^{a}	8.2^{a}	8.3^{a}	8.6^{bcd}	7.1^{a}	5.1^{a}	10.2^{ab}	4.5^{a}	2.5^{c}
	Trad - 33	7.5^{ab}	7.8^{a}	8.3^{a}	8.3^{a}	8.7^{abc}	6.9^{ab}	4.6^{b}	10.3^{ab}	4.6^{a}	2.7^{c}
	Trad - 0	7.6^{ab}	7.8^{a}	7.9^{ab}	8.1^{a}	9.1^{a}	6.7^{ab}	4.5^{b}	10.3^{a}	4.7^{a}	2.5^{c}
	Clean - 100	6.3^{c}	6.6^{b}	7.4^{bcd}	7.3^{b}	8.2^{cd}	6.3^{bc}	4.7^{b}	9.2^{c}	3.9^{b}	3.5^{b}
	Clean - 67	7.3^{abc}	6.8^{b}	7.24^{cd}	7.2^{b}	8.6^{abc}	5.8^{c}	4.4^{b}	10.1^{ab}	3.7^{b}	3.6^{ab}
	Clean - 33	7.8^{a}	6.4^{b}	7.2^{cd}	7.0^{b}	8.9^{ab}	6.0^{c}	4.4^{b}	10.3^{ab}	3.8^{b}	4.1^{a}
	Clean - 0	7.3^{ab}	6.3^{b}	7.1^{d}	7.1^{b}	8.6^{bcd}	5.7^{c}	4.5^{b}	9.7^{bc}	3.8^{b}	3.8^{ab}
	SEM	0.320	0.194	0.212	0.255	0.175	0.228	0.118	0.196	0.153	0.200
	P value	0.658	0.667	0.522	0.847	0.168	0.844	0.028	0.236	0.985	0.891

[1]Descriptive attributor was evaluated based on a 15-point modified quantitative spectrum scale in which 0 = none and 15 = the most that can possibly be expressed within the product.

[2]Percentage of normal (% NOR) breast meat.

[3]"Trad" represents traditional marinade (sodium phosphate, salt, seasonings).

[4]"Clean" represents clean label marinade (potassium carbonate, salt, seasonings).

[a–d]Means within a column lacking a common superscript differ ($P < 0.05$) for each analysis.

NA = not applicable.

product for patties formulated with the mixture of NOR and WB meat. Since patties with 100% NOR breast meat or the traditional marinade were more cohesive and chewier, it can be concluded that the sodium phosphate treatment was more effective than the potassium carbonate treatment at creating the target bite in patties with 100% NOR breast meat. This explains the interaction between % NOR and marinade for the chewiness attribute. Although the overall juiciness of all patties was juicier than average (score > 7.5), the overall juiciness of the traditional patties proves that the sodium phosphate continues to be functional across differing ratios of SEV to NOR breast meat in patties.

Although there is no published research on potassium carbonate's impact on sensory attributes, trained descriptive panelists described the off-flavors associated with the clean label patties as metallic or soapy. This could potentially become a concern if concentrations greater than 0.25% were used in formulations.

Consumer sensory analysis

For traditional patties, consumers detected differences in appearance and texture ($P < 0.05$), but none was rated less than a 6.0, indicating that on average, all treatments were liked slightly (score > 6.0) (Table 8). Consumers preferred appearances of patties formulated with 100%, 67%, and 33% NOR over 0% NOR patties ($P < 0.05$). Consumers also preferred the texture of 67% and 33% NOR patties over 0% NOR patties ($P < 0.05$), but no difference was detected between 100% NOR patties and any other treatments ($P > 0.05$). Though some differences exist, results indicate that 33%, 67%, and 100% NOR treatments were equally acceptable to consumers.

Table 7. Chicken descriptive analysis ($n = 10$ trained panelists): Descriptive taste and flavor attributes[1] of cooked chicken patties that were formulated with different marinades and normal breast percentages

Analysis	Treatment	Sour	Salty	Bitter	Umami	Brothy/Chickeny	Seasoning	Off-Flavor	Mouth Coating
% NOR[2]	100	2.2	3.5	1.2	4.6^{b}	4.8^{b}	5.0	1.3	3.8
	67	2.4	3.4	1.4	4.9^{a}	5.1^{a}	5.1	1.4	3.8
	33	2.1	3.6	1.2	4.9^{a}	5.0^{a}	5.3	1.4	3.9
	0	2.1	3.5	1.1	4.9^{a}	5.1^{a}	5.6	1.4	4.0
	SEM	0.092	0.070	0.059	0.059	0.046	0.211	0.056	0.066
	P value	0.206	0.333	0.737	0.012	0.011	0.234	0.773	0.425
	Linear	0.126	0.378	0.447	0.159	0.100	0.060	0.950	0.224
	Quadratic	NA	NA	NA	NA	NA	NA	NA	NA
	Cubic	NA	NA	NA	NA	NA	NA	NA	NA
Marinade	Trad[3]	2.2	3.6^{a}	1.1	5.0^{a}	5.1^{a}	5.4	1.2^{b}	3.9
	Clean[4]	2.2	3.4^{b}	1.3	4.7^{b}	4.9^{b}	5.1	1.5^{a}	3.8
	SEM	0.065	0.050	0.419	0.042	0.033	0.149	0.040	0.047
	P value	0.366	0.006	0.105	0.002	0.0004	0.131	0.001	0.085
Marinade × % NOR	Trad – 100	2.3^{ab}	3.7^{ab}	1.2^{ab}	4.8^{bcd}	5.0^{bc}	5.2^{abc}	1.4^{abc}	4.0^{ab}
	Trad – 67	2.3^{ab}	3.4^{bc}	1.0^{ab}	5.1^{a}	5.1^{ab}	5.1^{abc}	1.3^{bc}	3.9^{ab}
	Trad – 33	2.3^{b}	3.8^{a}	1.2^{ab}	5.0^{ab}	5.1^{ab}	5.9^{a}	1.1^{c}	3.9^{ab}
	Trad – 0	2.1^{ab}	3.6^{ab}	1.0^{b}	5.0^{abc}	5.2^{a}	5.6^{abc}	1.2^{bc}	4.0^{a}
	Clean – 100	2.2^{ab}	3.3^{c}	1.1^{ab}	4.5^{d}	4.7^{d}	4.9^{bc}	1.3^{bc}	3.7^{b}
	Clean – 67	2.5^{a}	3.5^{bc}	1.3^{a}	4.8^{bc}	5.0^{abc}	5.1^{abc}	1.6^{a}	3.8^{ab}
	Clean – 33	2.2^{ab}	3.4^{bc}	1.2^{ab}	4.9^{abc}	5.0^{bc}	4.8^{c}	1.6^{a}	3.9^{ab}
	Clean – 0	2.1^{ab}	3.5^{bc}	1.2^{ab}	4.7^{cd}	4.9^{cd}	5.7^{ab}	1.5^{ab}	3.9^{ab}
	SEM	0.129	0.100	0.084	0.084	0.066	0.298	0.079	0.094
	P value	0.564	0.147	0.193	0.849	0.406	0.214	0.052	0.464

[1]Descriptive attributor was evaluated based on a 15-point modified quantitative spectrum scale in which 0 = none and 15 = the most that can possibly be expressed within the product.

[2]Percentage of normal (% NOR) breast meat.

[3]"Trad" represents traditional marinade (sodium phosphate, salt, seasonings).

[4]"Clean" represents clean label marinade (potassium carbonate, salt, seasonings).

[a–d]Means within a column lacking a common superscript differ ($P < 0.05$) for each analysis.

NA = not applicable.

When overall acceptability scores were clustered for traditional patties, there were significant preference differences in 2 consumer clusters. In the second group ($n = 14$), 100% and 67% NOR patties were strongly preferred over 33% NOR patties ($P < 0.05$), which were preferred over 0% NOR patties ($P < 0.05$) (Table 8). This group found 33% NOR patties to be unacceptable (acceptability scores less than 6) and strongly disliked, and they found the 0% NOR patty unacceptable (acceptability score of 4.1). In the third group ($n = 35$), the 67% and 0% NOR patties were preferred over 100% NOR patties ($P < 0.05$), but there was no difference in 33% NOR patties and patties of any other % NOR ($P > 0.05$).

For clean label patties, consumers ($P < 0.05$) preferred 100% and 67% NOR breast meat over 33% NOR ($P < 0.05$), and there was no difference between 0% NOR patties and patties of any other % NOR ($P > 0.05$) (Table 8). When consumer overall acceptability scores were clustered for clean label patties, 3 clusters differed ($P < 0.05$) in their acceptability ratings. Group 3 ($n = 17$) consumers preferred 100% and 67% NOR over 33% and 0% NOR patties ($P < 0.05$), and the latter two patties were rated neither liked nor disliked (Table 9). Group 4 ($n = 15$) consumers preferred 100%, 33%, and 0% NOR over 67% NOR patties ($P < 0.05$), which were rated 5.4, a value between "neither like nor dislike" and "like slightly" (Table 9). Group 5 ($n = 19$) panelists did not like any chicken patty samples even though 0% NOR patties were preferred over 67% and 33% NOR patties ($P < 0.05$). Although a few clusters of consumers expressed preferences in overall acceptability of patties, all patties were rated at least "like slightly" by most consumers.

Table 8. Effects of normal chicken breast percentages[1] on the appearance, aroma, texture, flavor, and overall consumer acceptability[2] for chicken patties that were formulated with traditional ($n = 105$) and clean label ($n = 113$) marinades

	Traditional[3]—% NOR					
Attribute	100	67	33	0	*P* value	SEM
Appearance	6.6[a]	6.6[a]	6.7[a]	6.2[b]	0.027	0.131
Aroma	6.8	6.8	6.8	6.4	0.093	0.126
Texture	6.4[ab]	6.8[a]	6.7[a]	6.1[b]	0.008	0.157
Flavor	6.8	6.9	6.8	6.6	0.467	0.149
Overall acceptability	6.7	6.9	6.9	6.4	0.052	0.139
	Clean Label[4]—% NOR					
Attribute	100	67	33	0	*P* value	SEM
Appearance	6.9[a]	6.9[a]	6.5[b]	6.6[ab]	0.029	0.118
Aroma	6.8	6.8	6.7	6.9	0.636	0.106
Texture	6.7	6.8	6.7	6.7	0.949	0.136
Flavor	7.0	6.9	6.7	6.9	0.219	0.125
Overall acceptability	6.9	6.8	6.7	6.9	0.430	0.118

[1]Percentage of normal (% NOR) breast meat.

[2]Consumer acceptability was based on a 9-point scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely).

[3]Traditional marinade (sodium phosphate, salt, seasonings).

[4]Clean label marinade (potassium carbonate, salt, seasonings).

[a–c]Means within a row lacking a common superscript differ ($P < 0.05$).

Table 9. Effects of normal chicken breast percentages[1] on overall consumer acceptability[2] for chicken patties that were formulated with traditional ($n = 105$) and clean label ($n = 113$) marinades according to different clusters of consumer segments

		Traditional[3]—% NOR					
Group	Consumer (n)	100	67	33	0	*P* value	SEM
1	48	7.6	7.7	7.9	7.6	0.554	0.124
2	14	7.4[a]	6.7[a]	5.4[b]	4.1[c]	<0.0001	0.27
3	35	5.8[b]	6.3[a]	6.3[ab]	6.6[a]	0.015	0.18
4	8	5.5	5.3	7.5	2.5	<0.0001	0.441
		Clean Label[4]—% NOR					
Group	Consumer (*n*)	100	67	33	0	*P* value	SEM
1	39	7	7.5	7	7.2	0.055	0.123
2	23	8	8.2	8	8.1	0.841	0.141
3	17	6.8[a]	7.1[a]	5.6[b]	5.4[b]	<0.0001	0.238
4	15	7.0[a]	5.4[b]	7.1[a]	7.3[a]	<0.0001	0.222
5	19	4.9[ab]	4.5[b]	4.7[b]	5.6[a]	0.041	0.296

[1]Percentage of normal (% NOR) breast meat.

[2]Consumer acceptability was based on a 9-point scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely).

[3]Traditional marinade (sodium phosphate, salt, seasonings).

[4]Clean label marinade (potassium carbonate, salt, seasonings).

[a–c]Means within a row lacking a common superscript differ ($P < 0.05$).

Conclusions

Protein functionality was less when WB meat was included in comminuted chicken patties, which contributed to decreased cook yields since the proteins in WB meat were unable to hold the water as well as proteins in NOR breast meat. In addition, use of sodium phosphate in the traditional marinade produced the greatest yields and protein bind in the 100% NOR treatment and was superior to the clean label and control samples, but it was less effective in formulations with WB meat. It is important to note that the ratios of WB in these patties were carefully measured and homogenized. In a plant setting, all breasts graded may not be 100% NOR, which could affect the total percentage of WB in a patty. Based on sensory attributes and consumer data, it appears that all WB formulations could be used without a major impact on acceptability, but yields and protein bind decreased as WB amount increased in the formulation and when potassium carbonate was used in place of sodium phosphate.

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