INTRODUCTION

The US yearly per capita consumption of broiler meat reached 37.6 kg (82.9 pounds) in 2011, with an estimated 46% of this production marketed as further processed poultry products (NCC, 2012). Further processed poultry products include but are not limited to rotisserie chickens (whole birds without giblets) and boneless/skinless breast (BSB) is a challenge for processors. The objective of this study was to determine if using an all-natural nonphosphate blend (SavorPhos-200, SP) in water-based (WB) and oil-based (OB) marinades would perform better than a commercial phosphate blend (PB). The treatments included WB+PB (water, 0.4% phosphate, 0.7% salt), WB+SP (water, 0.5% SavorPhos-200, 0.7% salt), OB+PB (water, 3% oil, 0.4% phosphate, 0.7% salt), and OB+SP (water, 3% oil, 0.5% SavorPhos-200, 0.7% salt). The rotisserie chickens and BSB were injected with a multineedle injector to 20% (wt/wt) pickup at a constant pressure (103–138 kPa). The parameters measured were marinade pickup %, 20-min and 24-h marinade retention %, and cook loss %. Color, tenderness, total moisture, and sensory test were conducted on BSB. Data were analyzed within marinade type (WB and OB). Rotisserie birds picked up and retained the same yield in WB marinades. In OB marinades, SP had higher yields postinjection and lower cook loss % than the PB, while retaining the same yield over 24 h. For BSB, the cook loss was lower in SP than the PB in WB marinades. Higher yields postinjection were achieved with OB, but had the same retention 20 min and 24 h postinjection and cook loss % as the PB. No differences were observed for total moisture or L* (lightness) within marinade type and treatment. Texture was lower, indicating increased tenderness (P < 0.05) on SP samples in both marinades. However, consumers were not able to distinguish between treatments in sensory analyses. Therefore, SavorPhos-200 can be used as a natural nonphosphate blend in WB marinades with no detriment to yield. In addition, SavorPhos-200 can be used as a natural nonphosphate blend in OB marinades with yield improvements.

Key words: natural marinade, nonphosphate blend, rotisserie chicken, oil-based marinade, SavorPhos

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tail. Higher contents of oils increase desirability of meat products to consumers because of their better sensorial attributes, thus providing incentives for the foodservice industry to include oils in their formulations (Yackel and Cox, 1992). Fueled by customer concern over label and nutritional statements, retail markets mostly use water-based marinades. This labeling concern has led the industry to remove high caloric content oils, and develop “cleaner labels” (e.g., enhanced with chicken broth) containing other all-natural ingredients (Saha et al., 2009; Morey et al., 2012).

Phosphates, in particular sodium tri-polyphosphate, have been the functional ingredients of choice in marinades because of their ability to form chemical bonds by dissociating myofibrillar proteins and increasing meat pH and ionic strength, thus allowing the fixation of free water into bound water. Phosphates are extracted from mineral rocks through acid extractions and are not considered an all-natural ingredient, but are generally recognized as safe by the Food and Drug Administration. Phosphates are controlled ingredients by the USDA and can be added to a maximum of 0.5% of the final product (FSIS, 2005). Performance of commercial phosphate blends is affected by the use of hard water, inadequate brine temperature, improper blend of phosphates (diphosphates, triphosphates, sodium tri-polyphosphate, hexametaphosphate, and pyrophosphate), and incorrect formulations of the marinade (Baluyot and Clark, 1996).

Salts are also common functional ingredients in marinades. Salts (KCl and NaCl) are used to solubilize myofibrillar proteins, allowing more water to be bound to the muscle, thus improving sensorial attributes. The water binding ability of salts is similar to that of phosphates because they dissociate proteins due to their ionic strength, exposing more binding sites and increasing the meat’s water-holding capacity (WHC). Salts are not regulated because their use is self-limiting to 2%, but higher percentages are reported to increase WHC in meats (Post and Heath, 1983; Alvarado and McKee, 2007; Saha et al., 2009). Health concerns such as hypertension also arise when higher amounts of salts are used to marinate poultry meats (Saha et al., 2009). Health concerns together with cleaner label demands from consumers have created the development of niche markets for all-natural marinated meat products.

The USDA Food Safety And Inspection Service (FSIS, 2005) defines the “all natural” label as an ingredient or product that has been minimally processed, does not contain artificial flavors or flavorings, color agents, chemical preservatives, or any other synthetic ingredient. The use of natural products in foods is a growing trend. This trend can be problematic for processors looking for commercially available all-natural ingredients that perform equally or better than phosphates. Phosphate replacers must be able to increase WHC, improve palatability, improve texture, and be labeled as an all-natural ingredient. Prior research has focused on products such as seaweed, tubers, barks, resins, cereals, and bacteria exudates, which can act as water binders in ready-to-eat products (Bater et al., 1993; Hachmeister and Herald, 1998; Barbut and Somboonpanyakul, 2007). Gums and fibers and nonmodified starches, provided they are used as recommended, offer the possibility to replace phosphates. New products are being created and tested, and are found to be as functional as phosphate blends.

SavorPhos (Formtech Solutions Inc., College Station, TX) is a proprietary blend labeled as citrus flour, all natural flavorings, and less than 2% of sodium carbonate as a processing aid that is, according to the manufacturer, currently approved for sale as an all-natural ingredient for chicken marinades. Citrus flour is believed to be the functional fraction of the phosphate replacer that serves as a water binder, whereas the other ingredients also help with WHC. Citrus flour originates from various citrus pulps. The high fiber and low protein content are believed to contribute to the WHC of the product. The objectives of this study were to test the hypothesis that SavorPhos can act as an all-natural phosphate replacer and to compare the performance of SavorPhos AF-200 against the commercially available phosphate blend on the quality and acceptability of the rotisserie chicken and boneless/skinless chicken breast using water and oil-water based marinades.

**MATERIALS AND METHODS**

**Experiment 1**

A total of 100 Ross broilers were raised to 42 d of age (~2.89 kg) at the Poultry Science Research, Teaching, and Extension Center (Texas A&M University, College Station). Birds were raised on a litter-lined floor and fed ad libitum a starter, grower, and finisher corn/soybean meal-based diet (NRC, 1994). Eight hours before slaughter, birds were removed from feed and allowed access to water ad libitum. Birds were then cooped and transported to the Poultry Processing Research Center and stunned 13 to 15 mA for 5 to 7 s with an electrified knife (Cervin Electrical Systems, Minneapolis, MN) with an AC/DC converter set to 500 Hz. After the left carotid artery and jugular vein were severed, the birds bled for 90 s. Birds were then scalded for 45 s in 60°C water (model SS-36-SS, Bower Corp., Haughton, IA), and feathers were picked in a rotary drum picker for 25 s (model sp30ss, Bower Corp.). Manual evisceration was performed before chilling (4°C) for 90 min in an ice slush bath. Following chilling, the rotisserie whole birds without giblets were stored in plastic tubs with lids inside a cooler at 4°C. The rotisserie whole birds without giblets were used at 24 h postmortem (PM). Raw weights and pH (model IQ150, piercing probe PH77-SS, IQ Scientific Instruments Inc., Carlsbad, CA) of the individually tagged whole birds were obtained.

Four treatments were used in the study (Table 1) consisting of the 2 types of functional ingredients, the SavorPhos AF-200 and a commercially available...
phosphate blend (di- and triphosphates, and hexameta phosphates), and 2 kinds of marinade blends, water and oil-water, formulated according to industry standards. A total of 50 birds each of 2 trials and 2 replications were individually multineedle injected (Inject-star BI-88 P-VSP, Mountain View, AZ) at 20% wt/wt with each marinade type. The yield uptake (%) and pH were recorded immediately after injection, after 20 min drip time and at 24 h postinjection. Between sample times, the whole birds were stored in a cooler at 4°C. At 24 h postinjection, the marinated whole birds were netted and hung inside a smokehouse (model MP-2, Koch equipment, Kansas City, MO). The whole birds were then cooked at 95°C with no smoke or steam until the internal temperature reached 73°C. Cooked carcasses were cooled at room temperature (90 min) to equilibrate temperatures before cook weights were measured to calculate cook loss. The amount of pickup, retention, and cooking loss percentages were calculated.

**Experiment 2**

One hundred twenty-eight boneless/skinless breast fillets (~36 kg) were obtained from a local distributor 48 h PM and divided into 4 treatments (n = 32/treatment) before being stored for 24 h in plastic tubes with lids in a cooler (4°C). Color measurements were obtained before injection from the bone-side of the fillets by averaging 3 readings using an L*a*b* scale (where L* represents the lightness, a* the redness, and b* the yellowness of meat) of a calibrated colorimeter (Minolta Chroma Meter Model CR-200, Minolta Corp., Ramsey, NJ). Calibration was performed with the provided white tile. In addition, raw weights and pH (model IQ150, piercing probe PH77-SS, IQ Scientific Instruments Inc.) were obtained from the individually tagged boneless/skinless breast before injection (Inject-star BI-88 P-VSP) with a 20% wt/wt solution (Table 1). Uptake (%) was calculated after injection for the whole treatment. Per the industry standard, marinade was added only to complete the 20% uptake target before vacuum tumbling for 20 min with 135 kPa of Hg at 25 rpm (Inject-star MC-25). The same marinade formulations were used from experiment 1. They consisted of 2 types of marinades: water and oil-water base, and within each, SavorPhos and phosphate blend treatments were compared. Yield uptake % and tumbled pH were recorded immediately after tumbling, 20 min after tumble, and again at 24 h posttumbling.

Color values for L*a*b* scale were collected using a 3 reading average of the bone-side of the fillets at 24 h posttumble (Minolta Chroma Meter Model CR-200, Minolta Corp., Ramsey, NJ). Between sample times boneless/skinless breast were stored in cooler at 4°C. After data collection, boneless/skinless breast were baked at 177°C using a convection oven (Blodgett Zephaire G-1 speed, Blodgett Oven Co., Burlington, VT) as described in the method of (Sams, 1990). Individual boneless/skinless breasts were put on metal racks in a 10.16-cm-high aluminum pan lined with foil. When the internal temperature of the boneless/skinless breasts reached 73°C, they were removed from the oven, weighed, individually wrapped with aluminum foil, and stored in the cooler overnight (4°C). Cooked weights were obtained after 24 h chilling to determine cook loss. Half of the cooked boneless/skinless breasts were stored for texture and moisture analysis on the same day, and the other half were stored at 4°C for 3 d before sensory analysis. Formulas used to calculate injected pickup, 20 min retention, 24 h retention, and cook loss/yield were the same as described previously.

Shear values (kg/g) were determined using the Instron Universal Testing Machine (Instron Corp., Canton, MA) using a 10-blade Allo-Kramer shear compression with a 500-kg load cell with a load range of 200 kg and a crosshead speed of 500 mm/min (Sams, 1990). Moisture content was determined following methods 950.46 and 934.01 (AOAC, 1990).

Sensory analysis was performed on half of the cooked boneless/skinless breasts at the Texas A&M Kleberg Center sensory kitchen. A consumer taste panel was conducted with a triangle test designed to determine if consumers could detect differences between the treatments following the Meilgaard et al. (2007) procedure. Randomly selected panelists (n = 50) were presented with 2 sets (water marinade and oil-water marinade) of samples displayed in a random fashion, 2 of SavorPhos and 1 phosphate blend, whereas the other half of the

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**Table 1.** Marinade formulation percentages in whole birds and boneless/skinless breast fillets injected with a phosphate blend or SavorPhos (Formtech Solutions Inc., College Station, TX) in water and oil-water marinades

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Water marinade</th>
<th>Oil marinade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phosphate</td>
<td>SavorPhos</td>
</tr>
<tr>
<td></td>
<td>blend</td>
<td>AF-200</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.40</td>
<td>0.00</td>
</tr>
<tr>
<td>SavorPhos AF-200</td>
<td>0.00</td>
<td>0.50</td>
</tr>
<tr>
<td>Salt</td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td>Oil</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Meat</td>
<td>80.00</td>
<td>80.00</td>
</tr>
<tr>
<td>Water</td>
<td>18.9</td>
<td>18.8</td>
</tr>
<tr>
<td>Total batch</td>
<td>100.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>
Panelists were presented with 2 of the phosphate blend and 1 of SavorPhos. Panelists were instructed to cleanse their palates between samples with distilled deionized water and unsalted saltine crackers. All samples were presented with a randomly generated 3-digit code in individualized booths that had controlled lighting and a hatched door through which the samples were served.

**Statistical Analysis**

Whole bird data were analyzed using the single-way ANOVA method from SigmaStat software (Systat Software 2003, San Jose, CA) and Tukey’s mean separation \((P \leq 0.05)\) to determine difference between treatments. Treatments within each of the marinades were compared but not between marinades or experiments. Boneless/skinless breast data were analyzed using the single-way ANOVA method from SigmaStat software (Systat Software 2003) and Tukey’s mean separation \((P \leq 0.05)\) to determine the difference between treatments. Treatments within each of the marinades were compared but not between marinades or experiments. Sensory results were considered to be different \((\alpha = 0.05)\) if the numbers of responses from the panelists were higher than 22 out of 50 (Meilgaard et al., 2007).

**RESULTS AND DISCUSSION**

**Experiment 1**

Water-holding capacity is a desirable attribute for consumers and processors of rotisserie whole birds and is directly correlated with yield, and indirectly proportional to cook loss (Farr and May, 1970; Carpenter et al., 1979; Young and Lyon, 1997a,b; Alvarado and Sams, 2004; Bowker et al., 2010a). Retention of the injected brine affects yield and quality traits of rotisserie birds; thus, an increase in retained yield is favorable to the manufacturer and the consumer. Marination with multineedle injectors is known to produce higher drip loss after the injection process (Owens et al., 2009), possibly due to the openings created by the needles when the meat is penetrated. These openings may act as channels from which brine escapes.

Table 2 shows pickup % yields collected immediately after injection, 20 min of retention, 24 h of retention, and cooked loss % in whole birds marinated with water and oil-water marinades. There was no significant difference \((P > 0.05)\) among treatments in the pickup %, at 20 min and 24 h retention %, and cook loss % in the water marinade-treated whole birds. Therefore, SavorPhos AF200 resulted in an equal performance as that of phosphate blend when injected with water-based marinades in whole birds.

In the oil-water marinade, SavorPhos had higher \((P < 0.05)\) pickup % and lower \((P < 0.05)\) cook loss % than the traditional phosphate blend. Retention times of 20 min and 24 h postinjection were not different \((P > 0.05)\) between the treatments. These results indicate

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**Table 2.** Pickup percentage, 20-min and 24-h marinade retention yields, cook loss percentage, and pH values of rotisserie whole birds treated with a phosphate blend or SavorPhos (Formtech Solutions Inc., College Station, TX) in water or oil-water marinades

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marinate</th>
<th>Postinjection Yield</th>
<th>20-min Retention</th>
<th>24-h Retention</th>
<th>Cook Loss</th>
<th>pH</th>
<th>Postinjection pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Marinade</td>
<td>Phosphate blend</td>
<td>23.24 ± 5.01</td>
<td>97.68 ± 1.09</td>
<td>90.04 ± 2.84</td>
<td>18.77 ± 4.98</td>
<td>5.78 ± 0.33</td>
<td>6.18 ± 0.29</td>
</tr>
<tr>
<td>Oil Marinade</td>
<td>SavorPhos AF200</td>
<td>25.08 ± 2.85</td>
<td>98.05 ± 0.61</td>
<td>91.36 ± 3.75</td>
<td>18.76 ± 4.68</td>
<td>5.84 ± 0.16</td>
<td>6.04 ± 0.19</td>
</tr>
</tbody>
</table>

For each marinade, different superscripts within a column differ statistically \((P \leq 0.05)\). Data presented as means and SD (n = 100) of samples.
that SavorPhos can replace the phosphate blend with improved pickup % and reduced cook loss %. This gain in pickup and reduced cook loss can be attributed to the citrus flour, a main functional component of SavorPhos. The citrus flour is a source of fiber, and when used according to the manufacturer’s recommendations, fiber can hold and retain water during the cooking process (Keeton, 1994). The cook loss % was significantly lower and presented less variation than the oil-water phosphate blend marinated whole birds. Natural fibers, such as the ones extracted from citrus albedo, have been used to increase the cooked yields. This increase is attributed to the ability of citrus albedo to bind oil and water in restructured and emulsion meat products (Iyengar et al., 1991; Jiménez-Colmenero, 1996; Casas et al., 1998a,b; Fernández-Gínés et al., 2004). Lemon albedo used in conjunction with sodium tri-polyphosphate and potato starch had better retention of moisture compared with a control with no albedo in beef bologna (Fernández-Gínés et al., 2004). The similar performance attained by SavorPhos to the phosphate blend in water marinades, and the higher pickup % with lower cook loss % of SavorPhos in oil-water marinades can be due to the citrus fiber as a functional ingredient. An effect of the other components of the SavorPhos must also be taken into account as a source of functionality or even a possible synergistic effect among the ingredients.

The pH of the meat was measured as another WHC attribute of proteins (Table 2). Research has indicated that chicken pH PM ranges between 5.7 and 6.0 (Owens et al., 2009; Gorsuch and Alvarado, 2010; Perlo et al., 2010; Petracci et al., 2012). The pH decreases closer to the isoelectric point (~5.3) of actin and myosin water binding ability is reduced (Alvarado and McKee, 2007), thus hindering the ability of meat to retain marinades postinjection. For this experiment, there was no difference ($P > 0.05$) in the pH of the injected birds when raw, postinjection, and 20 min and 24 h postinjection in both treatments using water marinade. However, in the oil-water marinade, the phosphate blends gave a higher ($P < 0.05$) pH at postinjection compared with SavorPhos AF-200. However, by 24 h PM, there were no significant differences ($P > 0.05$) between the treatments. Therefore, meat quality was not negatively affected as indicated by similar ($P > 0.05$) retention at 24 h PM between the treatments. Prior research on salt and phosphate marinated breast fillets shows an increase in pH after marination (Gorsuch and Alvarado, 2010; Perlo et al., 2010). The use of high pH (>9.0) phosphate marinades demonstrated an increase in broiler pectoralis pH (Alvarado and Sams, 2004). Sheard and Tali (2004) reported an increase of 0.5 in pH on injected pork loins compared with loins injected just with salt. Sarıçoban et al. (2008) reported no change in pH in mechanically deboned chicken meat batters containing lemon albedo (2.5%), salt (2.5%), and phosphate (0.25%) compared with a control containing no albedo.

Overall SavorPhos performed equally or better than a phosphate blend on yield results, when used in a water or oil-water marinade for injection rotisserie whole birds. Therefore, SavorPhos can be used as a replacement for phosphates when consumers are concerned about clean labels.

**Experiment 2**

Uptake and retention yield positively affect consumers’ quality perception as well as manufacturers’ margins (Owens et al., 2009; Gorsuch and Alvarado, 2010; Perlo et al., 2010; Petracci et al., 2012). Boneless/skinless breast fillet yield parameters (Table 3) were measured at postmarination, 20 min and 24 h postmarination, and after cooking. In water-based marinades, the boneless/skinless breast treatments were similar ($P > 0.05$) in pickup %, and 20 min and 24 h retention %. However, cook loss % was decreased ($P < 0.05$) for SavorPhos compared with the phosphate blend. This observed difference on cook loss % may be explained due to the high variability obtained on this measurement. Moreover, in the oil-water marinades, pickup % was significantly higher ($P < 0.05$) for SavorPhos compared with the phosphate blend, but showed no difference ($P > 0.05$) in 20 min, 24 h retention %, and cook loss %. These results indicate that in oil-water marinade, SavorPhos performs similarly to the phosphate blend in retention % and cook loss %. This observation agrees with the finding described by Post and Heath (1983), Ang and Young (1987), Bowker et al. (2010b), who reported yield loss from tumble marinated breast fillets stored between 1 and 3 d. The use of citrus fiber (citrus albedo) is well documented in other types of meat products, and shows similar results as the ones observed in this study. Aleson-Carbonell et al. (2005) found that beef patties formulated with dry cooked lemon albedo and salt had higher cook yields (73.27%) than patties without the lemon albedo (62.31%). Results described by Aleson-Carbonell et al. (2005) suggested that lemon albedo fiber added to breakfast fresh sausage achieved a higher moisture retention, reduced cooking loss, and retained more fat compared with a sausage that contained no albedo. Marin et al. (2007) results showed that the insoluble fiber of citrus albedo is responsible for the lipid-holding capacity, whereas the soluble portion is responsible for the WHC of the product.

The premarination and postmarination pH of the meat can affect the WHC (Alvarado and McKee, 2007). The lower the meat pH premarination, the more predisposed the meat is to retain less water due to low isoelectric charges within the myofibrillar protein. The pH of the boneless/skinless breast fillets marinated (water) with a phosphate blend were not different ($P > 0.05$) compared with the SavorPhos for the raw meat. The water marinade pH postinjection, 20 min, and 24 h retention were higher ($P < 0.05$) on all sample times for the phosphate blend compared with Savo-
Phos. In the oil-water marinades, the same differences were observed. Even though the pH results are lower ($P < 0.05$) than the phosphates in both treatments, the pH values are still within normal meat range for good meat quality (Alvarado and Sams, 2004; Gorsuch and Alvarado, 2010). These results are in agreement with prior research where the phosphate blend increased the pH of the meat after marination and lemon albedo maintained the meat batter pH on dry sausage (Sheard and Tali, 2004; Alvarado and McKee, 2007; Sarıçoban et al., 2008; Perlo et al., 2010). Phosphates increase meat pH (Alvarado and McKee, 2007), even though SavorPhos decreased meat pH postinjection, this decrease in pH did not negatively affect meat quality.

Meat pH values have been correlated to color measurements ($L^*$) of boneless/skinless breast, where the lighter the color the lower the pH (Alvarado and McKee, 2007; Barbut, 2009; Owens et al., 2009). Color variation of meat is of great importance to the consumer acceptability and meat functionality (Alvarado and McKee, 2007; Owens et al., 2009; Gorsuch and Alvarado, 2010). Barbut (2009) reported that consumers become concerned when boneless/skinless breast meat is too pale or too dark. Wilkins et al. (2000) stated that color extremes are likely to be discriminated at the point of purchase. Color is measured with the $L^*$, $a^*$, and $b^*$ scale. As expected, raw meat color did not differ ($P > 0.05$) in $L^*$, $a^*$, and $b^*$ values in the water and oil-water marinades between the 2 treatments (Table 4).

At 24 h postinjection, the oil-water marinade treatments were also similar ($P > 0.05$) in $L^*$, $a^*$, and $b^*$. However, at 24 h postinjection in the water marinade, the phosphate blend $a^*$ values were higher ($P < 0.05$) compared with the SavorPhos, indicating a more reddish color. Also, the $b^*$ value were significantly higher ($P < 0.05$) in the SavorPhos treatment compared with the phosphate treatment, indicating a more yellow appearance. However, these objective differences were not observed in the consumer panel, which suggested that these differences were not discernible by consumers. Prior research has shown an increase in $L^*$ values 3 h after marination with a phosphate blend possibly due to the increase in extracellular water (Gorsuch and Alvarado, 2010). The $L^*$ value increase was not observed in the current experiment. Fernández-Ginés et al. (2004) reported an increase of all color values in bologna made with citrus albedo. The yellowness in the citrus fiber may explain the increase of the $b^*$ value of 24-h water-marinated fillets. Aleson-Carbonell et al. (2005) reported similar findings in the internal color of cooked beef patties. Though differences ($P < 0.05$) were found for water-marinated breast fillets on the $a^*$ and $b^*$ values 24 h postinjection of boneless/skinless breast fillets, real-life application would not be affected because one of the main drivers of customer acceptance of raw breast meat is the lightness (Wilkins et al., 2000; Alvarado and McKee, 2007; Barbut, 2009; Owens et al., 2009; Gorsuch and Alvarado, 2010).

### Table 3. Pickup percentage, 20-min and 24-h marinade retention yields, cook loss percentage, and pH values of boneless/skinless breast fillets treated with a phosphate blend or SavorPhos

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield</th>
<th>pH Postinjection 20 min</th>
<th>pH 24 h</th>
<th>pH Cook loss 20 h</th>
<th>pH Cook loss 24 h</th>
<th>pH Postinjection 24 h</th>
<th>pH Postinjection 24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water marinade</td>
<td>Raw meat</td>
<td>8.80</td>
<td>5.62 ± 0.10</td>
<td>5.58 ± 0.04</td>
<td>5.54 ± 0.08</td>
<td>5.56 ± 0.08</td>
<td></td>
</tr>
<tr>
<td>Oil-water marinade</td>
<td>Raw meat</td>
<td>8.80</td>
<td>5.62 ± 0.10</td>
<td>5.58 ± 0.04</td>
<td>5.54 ± 0.08</td>
<td>5.56 ± 0.08</td>
<td>5.54 ± 0.08</td>
</tr>
</tbody>
</table>

For each marinade, different superscripts within a column differ statistically ($P \leq 0.05$). Data presented as means and SD (n = 128) of samples.

Phos.
Moisture content on cooked boneless/skinless breast was measured as a WHC parameter (Table 4). No difference ($P > 0.05$) was found between SavorPhos and the phosphate blend for both types of marinades (water and oil-water). These results are interesting because SavorPhos had a decreased cook loss % in the water marinade. Lee et al. (2008) reported similar results where 2 natural marinated chicken breasts, one with carrageenan the other without, showed the same moisture content (71.9 vs. 70.8, respectively) between each other but cook loss (19.0 vs. 24.1%) was lower for the marinade containing carrageenan. Therefore, these results indicate that SavorPhos can replace phosphate without negatively affecting total moisture.

Texture was analyzed to determine tenderness of the marinated boneless/skinless breast fillet. Prior research has correlated texture values with consumer perception of tenderness (Saha et al., 2009). SavorPhos had significantly lower ($P < 0.05$) texture values indicating more tender meat compared with the phosphate blend in both the water marinade and the oil-water marinade. This increased tenderness can be explained by the lower cook loss % of the water marinade. Another explanation could be related to the swelling of the citrus fiber within the meat marinated with SavorPhos, which might cause an increase in tenderness (Hughes et al., 1997).

A consumer triangle test was performed to establish if consumers could distinguish between the SavorPhos and the phosphate blend in water and oil-water marinades of cooked boneless/skinless breast fillets. There were no significant differences ($P > 0.05$) in the consumer panel. Therefore, the consumer panel was not able to distinguish between the 2 products for each of the 2 marinades, indicating SavorPhos can be used as a natural replacement for phosphates without negatively affecting consumer preferences.

In conclusion, the use of SavorPhos in water and oil-water base marinades will allow an equally or enhanced performance of pickup and retention yields, as well as cook loss % compared with a phosphate blend in rotisserie chickens and boneless/skinless breast meat. Texture values of boneless/skinless breast meat are improved with the use of SavorPhos and without negatively affecting color or consumer preferences. This makes SavorPhos a potential all-natural replacer of phosphate blends for use in boneless/skinless breast meat, as well as rotisserie whole birds.

### REFERENCES


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**Table 4.** Boneless/skinless breast fillets percentage moisture, objective texture, and color of raw and 24-h postmarination meat treated with a water and water-oil marinade$^1$

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Color (raw)</th>
<th></th>
<th></th>
<th>Color (24 h)</th>
<th></th>
<th></th>
<th>Moisture (%)</th>
<th>Texture (kg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L$^*$</td>
<td>a$^*$</td>
<td>b$^*$</td>
<td>L$^*$</td>
<td>a$^*$</td>
<td>b$^*$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water marinade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphate blend</td>
<td>55.10</td>
<td>1.67</td>
<td>5.86</td>
<td>52.00</td>
<td>2.33$^a$</td>
<td>4.16$^b$</td>
<td>71.49 ± 1.91</td>
<td>6.75$^a$</td>
</tr>
<tr>
<td>SavorPhos AF-200</td>
<td>57.54</td>
<td>1.36</td>
<td>7.96</td>
<td>54.68</td>
<td>1.25$^b$</td>
<td>6.82$^a$</td>
<td>72.23 ± 2.25</td>
<td>5.92$^b$</td>
</tr>
<tr>
<td>Oil-water marinade</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Phosphate blend</td>
<td>58.62</td>
<td>2.09</td>
<td>6.99</td>
<td>55.32</td>
<td>1.12</td>
<td>3.95</td>
<td>70.20 ± 1.67</td>
<td>6.14$^a$</td>
</tr>
<tr>
<td>SavorPhos AF-200</td>
<td>57.21</td>
<td>2.40</td>
<td>5.80</td>
<td>54.68</td>
<td>1.41</td>
<td>4.96</td>
<td>69.74 ± 1.61</td>
<td>4.94$^b$</td>
</tr>
</tbody>
</table>

$^a$For each marinade, different superscripts within a column differ statistically ($P \leq 0.05$).

$^b$Data presented as means and SD (n = 128) of samples. L$^*$ = lightness; a$^*$ = redness; b$^*$ = yellowness. SavorPhos (Formtech Solutions Inc., College Station, TX).


