Abstract: The use of phosphate in meat processing industry has been studied for long time, but few studies focused on the deboned poultry meat (DPM). The effect of selected phosphate salts [monosodium phosphate (MSP), disodium phosphate (DSP), trisodium phosphate (TSP), tetrasodium diphosphate (TSPP), disodium diphosphate (SAPP), sodium hexametaphosphate (SHMP), tripotassium phosphate (TKP), tetrapotassium diphosphate (TKPP) and potassium triphosphate (KTPP); in concentration of 0.25% w/w] on the texture properties of DPM and pH-values was observed. Control samples without addition of phosphate were also manufactured. The added phosphates influenced the pH-values of the batters tested. Values of pH of the batters with selected phosphates increased as follows: TSP, DSP, TSPP, STPP, TKP, TKPP and KTPP. In addition, TSP, TSPP, SHMP, STPP, TKP and TKPP changed hardness value of batters while DSP, STPP and TKP changed cohesiveness value of batters, compared with control sample (p<0.05). Overall, the study demonstrated the beneficial effect of using phosphate in influencing the texture of DPM batters.

Key-Words: phosphate, texture, hardness, cohesiveness, pH, deboned poultry meat

1 Introduction

Deboned poultry meat (DPM) is mechanically separated meat in the poultry processing industry which is produced from the deboning and cutting of parts with lower commercial value, such as back, neck, feet, and head skins and bones [6,25]. The use of protein sources replacing raw meat in processing meat products has been used by economic factors, that is, will raise the profit of the manufacturer. In fact, DPM has good nutritional and functional properties and is suitable for using as an ingredient for different meat products [18,25]. DPM is currently used in the manufacture of meat products such as sausages, bolognas, or salamis [14,19,25].

In manufacturing meat products, the sensory quality is an important factor which is directly related to the textural parameters of meat products. Thermal processing is applied to DPM-products. After thermal processing, sensory value, textural properties and/or water holding capacity (WHC) could be negative changed which could lead to losses. To improve the texture of meat products, salt, phosphates and/or alkaline (NaOH or NH₄OH) have been used [21,28,31]. Salt enhances water binding but can not be used in high amounts because of the effects it has on taste and risk of diseases [1,5,27]. Phosphates used in meat and meat products have several functions, especially functions such as the adjustment of pH, buffer properties, sequestration of selected cations (especially calcium and magnesium), changing the ionic charges distributions, changing the ionic strength of environment and /or bacteriostatic effects [9,10,12,13,14,17,21,30]. Although alkaline has also been used to adjust pH leading to increased WHC, its contribution is not so significant compared with phosphates [2,15]. Therefore, many types of phosphates and their mixtures at different concentrations and in combinations with other substances were examined in meat and meat products. The results of these studies showed that the use of phosphates increased WHC [2,4,16,20,23], and improved textural properties [3,7,11,24,26,29]. In general, the researches have tended to focus only on pork and beef rather than on poultry meat, especially DPM. Practically, no systematic information about the effect of phosphates addition on texture of DPM is available.

This present study is a part of the project aiming at the improvement of textural parameters of meat products made from DPM. The main purpose of the experiment reported here is to investigate the effects of selected phosphates on hardness, cohesiveness and pH-values in meat batters. Overall, the better understanding of the interactions between...
phosphates and DPM is important in any new product development.

2. Materials and methods

In order to obtain samples, DPM (525 grams), ice water (161 grams), salt (mixture of NaCl and NaNO$_2$ in ratio of 500:1; 14 grams) and selected phosphates were used. For the purpose of this study, we added the following phosphates: monosodium phosphate (MSP), disodium phosphate (DSP), trisodium phosphate (TSP), tetrasodium diphosphate (TSPP), disodium diphosphate (SAPP), sodium triphosphate (STPP), sodium hexametaphosphate (SHMP), tripotassium phosphate (TKP), tetrapotassium diphosphate (TKPP) and potassium triphosphate (KTPP) with the level of 0.25% (w/w), respectively. Control samples without phosphates were also manufactured.

All the above raw materials were mixed by the mixer Vorwek Thermomix TM31-1 instrument (Vorwerk & Co., GmbH, Wuppertal, Germany) at a low speed (approx. 100 - 480 rpm) for 3 minutes at temperature lower than 12°C to form homogeneously emulsified mixtures. These mixtures were stuffed into glass cans (diameter 8.0 cm, height 7.0 cm), closed with screw lids and heated in the hot water bath to 70°C, remained heating for 20 minutes, then cooled in an ice water tub for 30 minutes to achieve the endpoint product temperature of 25°C; after that, these samples were stored at 5±1°C in the fridge for 7 days. The samples were removed after seven days of storage to analyze their textural parameters and pH measurement. Each type of samples (10 phosphates and a control sample; 11 types in total) were manufactured three times for statistical purpose.

The pH values of meat batters were measured directly by the pH instrument (pH Spear–Eutech Instrument) with a glass-electrode. The pH value of raw DPM was 6.35 ± 0.02.

The hardness and cohesiveness values were expressed in relation to control samples (relative values obtained by dividing using values for control samples).

Data were analyzed by one-way analysis of variance with Unistat 5.5 software (Unistat, London, UK). Means comparisons of different treatments were performed by Median and Mann-Whitney tests to determine significant differences between mean values of the different results. The significance level used in tests was 0.05.

3. Results

3.1. pH values

The pH values of DPM batters prepared with different levels of selected phosphates are shown in Figure 1. Samples with TSP and TKP significantly increased pH, whereas samples with MSP, SAPP and SHMP had lower pH values than the control samples and the other products tested.

![Figure 1. pH values of DPM batters prepared with and without selected phosphates.](image)

The pH of samples had the highest value (6.74 ± 0.01) when adding 0.25% TSP, and the lowest value (6.02 ± 0.01) when adding 0.25% MSP. In all cases, the pH values of samples with TSP, DSP, TSPP, STPP, TKP, and KTPP increased, compared to the sample with MSP, SAPP, SHMP and controls (p<0.05).

3.2. Textural parameters of batters

The effect of selected phosphates’ level on hardness and cohesiveness of a DPM batter was shown in Table 1. As can be seen, the adding selected phosphates as TSP, TSPP, SHMP, STPP, TKP and KTPP in the level of 0.25% (w/w) in
batters resulted in changed hardness of batter compared to the batter without any phosphates (p<0.05). The batters’ cohesiveness was only significantly decreased in the samples with TSP, STPP, TKP and KTPP compared to the control sample (p<0.05). These showed that samples with phosphates with one, two and three phosphorus atoms in the molecule have lower relative hardness and relative cohesiveness in comparison with control samples. Products with SAPP were only exception which could be the cause of low pH-values (nearer to isoelectric point of proteins). Similar trend was obtained which MSP and SHMP.

Table 1. Effects of selected phosphates on textural properties of the DPM batters *

<table>
<thead>
<tr>
<th>Phosphate</th>
<th>Relative hardness**</th>
<th>Relative cohesiveness**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>MSP</td>
<td>97.47 ± 8.83</td>
<td>98.61 ± 3.53</td>
</tr>
<tr>
<td>TSP</td>
<td>75.07 ± 7.18</td>
<td>81.24 ± 14.75</td>
</tr>
<tr>
<td>DSP</td>
<td>96.90 ± 4.83</td>
<td>92.25 ± 4.41</td>
</tr>
<tr>
<td>SAPP</td>
<td>102.92 ± 9.12</td>
<td>96.10 ± 4.45</td>
</tr>
<tr>
<td>TSPP</td>
<td>80.80 ± 14.24</td>
<td>93.67 ± 10.38</td>
</tr>
<tr>
<td>SHMP</td>
<td>93.69 ± 4.16</td>
<td>95.75 ± 7.61</td>
</tr>
<tr>
<td>STPP</td>
<td>85.48 ± 7.54</td>
<td>90.36 ± 3.42</td>
</tr>
<tr>
<td>TKP</td>
<td>79.06 ± 5.83</td>
<td>91.63 ± 3.15</td>
</tr>
<tr>
<td>TKPP</td>
<td>84.07 ± 12.17</td>
<td>97.44 ± 5.64</td>
</tr>
<tr>
<td>KTPP</td>
<td>87.95 ± 7.38</td>
<td>90.80 ± 3.84</td>
</tr>
</tbody>
</table>

* Values are means ± SD of triplicate analyses, calculated as percentage when compared to control sample.

ab Within the same column, means having different superscripts are significantly different by Median and Mann-Whitney tests.

4. Discussion

The main purpose of this paper was to study the effects of phosphates on the textural properties through the hardness and cohesiveness values of the DPM batters. It is clear that phosphates have adjusting abilities of pH in meat products, and that hardness and cohesiveness of DPM also change, compared with the control sample, and thirdly those they have different values for different phosphates. The pH values in the DPM batters is significantly different (p<0.05) and can be explained by chemical properties of the added phosphates. The pH values of TSPP, TKP, TSP, KTTP and STPP, respectively, in 1% solution are higher than 7, while the pH of MSP, SHMP and SAPP are lower than 7 [17]. This fact can explain why the adding level of 0.25% of TSP, DSP, TSPP, STPP, TKP, KTTP and KTPP increased the pH of DPM batter, but MSP, SHMP and SAPP decreased the pH.

In previous studies, Fernandez-Lopez et al. noted that the increasing level of STPP increased the pH value [8]. Puolanne et al. also showed that the increase in WHC is related to the increase of pH value [20]. In addition, the reports of Anjaneyulu et al. and Moiseev and Cornforth showed that phosphates are more effective than NaOH comparing their functional properties [2,16]. These studies published in 1990s can confirm that the phosphates affect more than the pH only.

The texture of meat products could be influenced by many factors. Firstly, phosphates form a complex with Ca$^{2+}$, Mg$^{2+}$ to separate actin and myosin in meat protein. Combining with salt, phosphates increase the extractability of muscle protein leading to the formation of the gel matrix [1]. Thus, the gel matrix with these ingredients is more and stronger in DPM batter. In addition, because of the different chemical and functional properties of phosphates, the hardness and cohesiveness of DPM batters was different in this study. According to Molins, the most functional phosphates are diposphates, especially TSPP, because they act on the actomyosin complex of the meat protein right away and have a high pH value [17]. On the other hand, when using phosphate, the pH of meat product increased leading to their WHC increased, but with a limitation. Puolanne et al. reported that the pH value of raw meat materials for the maximum water holding was 6.3 [20]. Hence, the binding water and the gel matrix, formed in meat products, are different and depend on the concentration and type of phosphates. And the textural properties of meat batter such as hardness, cohesiveness, tenderness, juiciness, chewiness, and springiness must be changed when adding phosphates. Baublits et al. showed that STPP, TSPP in 0.4% improve sensory tenderness perceptions of beef without decreasing product yields [3]. Barbut and Somboonpanyakul also reported that the hardness value of the using 0.5% STPP in DPM batter was lower than that without phosphate batter but the chewiness, springiness and cohesiveness values were higher [29]. However, the results also indicated that the texture parameters in the different levels should be examined in further studies which will give the full evaluations of the effect of phosphates in DPM batter.
5. Conclusions
In this paper, the textural properties and pH-values of MDP batters were studied with selected phosphates as MSP, TSP, DSP, SAPP, TSPP, SHMP, STPP, TPK, TKP, and KTTP. The results indicated that adding phosphates changed of pH and textural properties in DPM batter with the level of 0.25%, compared to without phosphate batter. The pH-values of the samples with TSP, DSP, TSPP, STPP, TPK, and KTPP increased whereas that with MSP, SAPP and SHMP decreased. Hardness of the samples with TSP, TSPP, SHMP, STPP, TPK and TKPP decreased, while only cohesiveness of the samples with TSP, STPP, TPK and TKPP decreased. Overall, the results point to a potential use of phosphates by the poultry meat processing industry.

ACKNOWLEDGMENTS
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