Use of porcine blood plasma in “phosphate-free frankfurters”


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Abstract

Porcine plasma was used as ingredient in the production of frankfurters without added phosphates, at laboratory scale. Composition, water holding capacity, texture, and microstructure of these frankfurters were compared to a standard product in which polyphosphate and caseinate were used as functional ingredients. No differences were found in moisture and WHC; and proximate analysis did not show significant differences, except in protein content, slightly higher in plasma sausages. TPA indicated that the tested product was significantly (P<0.05) harder and chewier than control. In spite of that the proposed formula was considered acceptable.

Keywords: porcine plasma, phosphate-free-frankfurters, technofunctional ingredients

1. Introduction

Porcine blood from slaughterhouses is a by-product obtained in large volumes and often considered and treated as a waste. However, blood has a high reutilization potential in the food industry, thus minimizing environmental risks or reducing its management costs. Economic and ecologic advantages are the incentives for the use of porcine blood and its derivatives as food ingredients. Hygienically collected porcine blood can be processed in order to obtain different hemo-derivatives, which can be used in food products for different purposes, e.g., to improve water holding capacity or emulsion stability [1-3]; as food colourings [4,5]; to increase nutritional value [6,7]; to stabilize gels or foams [8,9]; to improve bakery and meat batters [10,11]; to reduce fat content in different products [12], etc.

Frankfurters are one of the most popular meat products targeted in children in Spain. As they are treated as cheap and fast food, the quality of raw materials is often poor. Thus, different proteins and additives such as polyphosphate and sodium caseinate are used in frankfurters in order to improve...
texture, as well as water and fat binding properties. Polyphosphate mainly enhances water holding capacity (WHC) and reduces cooking losses, leading to increased yields of juicier products showing better texture.

There is evidence that an excessive dietary intake of phosphate might affect the optimum calcium/phosphorous ratio in the human body, and can consequently be responsible of health imbalances e.g. in renal phosphorous homeostasis or in bones’ calcification system [13, 14]. In recent years, there is an increasing demand of products perceived as healthier, safer and respectful towards environment. Therefore, new formulas avoiding the use of polyphosphate are being developed.

Plasma could be seen as a cheap, healthy and ecologic source of functional proteins without allergenic potential, which allows getting better texture and sensory characteristics and at the same time increases the nutritional value of the product.

In light of these considerations, the aim of this study was to produce phosphate-free frankfurters by using porcine plasma as functional ingredient to replace sodium caseinate and polyphosphate. At the same time, the effect of this replacement in both physicochemical and textural properties was determined by comparing the composition, microstructure, texture (TPA) and water holding capacity (WHC) of plasma containing sausages with sausages produced using a standard commercial formula, which included added phosphates and caseinate.

2. Materials & Methods

Plasma was obtained in our laboratory from hygienically collected porcine blood from a local slaughterhouse (Frigorifics del Ter, Salt, Girona, Spain). 1% of sodium citrate was used as anticoagulant. The mean composition of plasma was: 90.76% moisture, 1.29% ash, and 6.61% protein.

Frankfurt type sausages were prepared using a Thermomix TM-31 (Vorwerk, Wuppertal, Germany) food processor to mince and emulsify ingredients; the used formulas are shown in Table 1. Air was removed from batter under vacuum, and then it was stuffed into 24 mm diameter cellulose casings (Wienie-paks 2350/84, Teepak LLC, Lommel, Belgium). Frankfurters were cooked in a three-step process (1) heating the sausages in a lab oven (JP Selecta Conterm, Spain) at 55ºC during 15 min, (2) poaching in a water bath at 80-85ºC until the core temperature reached 70ºC (approx. 24 min) and (3) drying in the oven at 80ºC for 5 min [15,16]. The cooked sausages were water cooled, peeled and stored at 4 ± 2ºC.

Proximate analysis: moisture, ashes, protein (Kjedahl), collagen, and fat, were performed using standard AOAC methods.

Water Holding Capacity (WHC) was determined as described by Hughes et al. [17]. Two cores representative of each treatment were cut (8 ± 1g) and placed in glass jars, closed and heated for 10 min in a water bath at 90ºC. After heating, samples were cooled to room temperature, wrapped in cotton cheesecloth and centrifuged in 10 mL polycarbonate tubes (containing absorbent cotton wool) for 10 min.

Table 1. Formulation (g) of frankfurters (C: control and P: formulation with frozen plasma)

<table>
<thead>
<tr>
<th>Lean pork</th>
<th>Fat</th>
<th>Frozen water</th>
<th>Frozen plasma</th>
<th>NaCl1</th>
<th>Sugar</th>
<th>Sodium caseinate2</th>
<th>Maize Starch</th>
<th>Poly Phosphate1</th>
<th>Black pepper</th>
<th>Sodium ascorbate3</th>
<th>Smoke extract2</th>
<th>Sodium nitrite1</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>400</td>
<td>220</td>
<td>318</td>
<td>-</td>
<td>17</td>
<td>15</td>
<td>10</td>
<td>1.5</td>
<td>5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>P</td>
<td>400</td>
<td>220</td>
<td>-</td>
<td>333</td>
<td>-</td>
<td>17</td>
<td>15</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

1Sodium chloride and nitrite, and pentasodium tripolyphosphate (Panreac Quimica, SA, Barcelona, Spain). 2Dehydrated sodium caseinate and dehydrated smoke extract (BDF Natural Ingredients SL, Barcelona). 3Sodium ascorbate (Induxtra de Suministros, Girona, Spain).
at 9,000g (Sorvall RC-SC plus, Dupont Co, Newton, Connecticut, EUA) at 4°C. The cheesecloth was removed and sample weights were recorded.

Texture profile analyses (TPA) were carried out in a Texture Expert TA.XT2 (Texture Technologies Corp., Scarsdale, NY, USA). Three cores (diameter = 2 cm; height = 1.5 cm) were cut from each sample and were axially compressed by a two-cycle compression test to 50% of their original height using an aluminium 50 mm cylindrical probe. Determinations were performed at room temperature (22-23°C). Force-time deformation curves were recorded with a 25 kg load cell at a crosshead speed of 2 mm/s.

Microstructure pictures were obtained by using a Zeiss DSM 960 scanning electron microscope (SEM) (Carl Zeiss; Electron Optics Division, Oberkochem, Germany). Samples were processed as follows: small squared pieces of frankfurter were fixed with a mixture (1:1 v/v) of paraformaldehyde (2%) and glutaraldehyde (0.25%) in cacodylate buffer (0.1%) pH 7.2. Samples were refrigerated overnight and post-fixed with 1% osmium tetraoxide. After washing samples where dehydrated in a graded series of acetone, critical-point-dried and sputter-coated with a layer of gold/palladium in an Emitech K550 (EM Integrated Technology, Kent, UK) diode sputtering instrument. Micrographs were taken at a voltage of 20kV.

Three complete experiments were carried out and T-Test was used to perform the statistical treatment of the data by means of the SPSS (SPSS v13.0, SPSS Inc., Chicago IL, 2006).

3. Results & Discussion

Proximate analyses and water holding capacity of control and phosphate-free frankfurters are shown in Table 2. No significant differences were found in moisture contents neither in water holding capacity, therefore the substitution of sodium caseinate and polyphosphate by plasma did not affect the capacity of products to link water, that is due to high hydrophilic character of plasma proteins if compared with dairy or meat proteins [18,19,20]. An increase in WHC was previously observed by Cofrades et al. [1] in meat products containing bovine plasma. Significant differences were found in protein and fat contents. These could be explained by the different composition of ingredients, plasma being richer in protein than sodium caseinate plus polyphosphate, as well as some possible heterogeneity in raw materials composition. The difference in fat contents could indicate that plasma proteins were not as good emulsifiers as caseinates, thus leading to increased fat losses during cooking. However, this observation was not confirmed in other experiments carried out in our laboratory, in which differences in emulsifier capacity of both plasma and caseinate were not significant, and can not explain the occurred differences in this experiment. Even though, the mean composition of both products is included in the range of characteristic values of commercial frankfurters [21].

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>Collagen</th>
<th>WHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>60.99 ± 0.58</td>
<td>1.85 ± 0.02</td>
<td>10.11* ± 0.19</td>
<td>27.21* ± 2.73</td>
<td>1.25 ± 0.07</td>
<td>73.47 ± 1.69</td>
</tr>
<tr>
<td>P</td>
<td>59.30 ± 1.54</td>
<td>1.72 ± 0.05</td>
<td>11.32* ± 0.29</td>
<td>22.91* ± 2.53</td>
<td>1.30 ± 0.10</td>
<td>77.09 ± 0.58</td>
</tr>
</tbody>
</table>

*Significant (p<0.05, significance using a T-test)

Parameters from Texture Profile Analysis of frankfurters are summarized in Table 3. Plasma frankfurters were significantly harder (p<0.05) than the respective controls, and consequently chewiness of plasma containing samples was also significantly higher than control sausages; contrary to adhesiveness in which the control was found to be significantly more adhesive than its respective phosphate-free sample. However, springiness and cohesiveness were not affected when caseinate and
polyphosphate were replaced by plasma. These results agreed with previous studies, in which increased hardness and chewiness, without effect on cohesiveness, have been reported related to protein content in frankfurters \cite{17, 22, 23}. On the other hand, it has been previously described that less fat content produced hardest frankfurters \cite{23}, so, the observed differences in fat contents among control and plasma samples could influence this textural parameter. In our case the hardness differences could be also due to the thermogelling ability of plasma that contributes to form an internal network-like structure in which fat and water can be retained, with plasma proteins showing better capacity than caseinate to bind the other ingredients, thus rendering more structured meat gels. The higher adhesiveness of control samples must be due to adhesive properties of caseinate as well as to the higher fat contents.

We expected that SEM images of the microstructure help to confirm these results.

**Table 3. Texture Profile Analysis of frankfurters (C: control; P: plasma frankfurter) (mean ± S.D. for n = 3)**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Hardness (N)</th>
<th>Springiness (mm)</th>
<th>Cohesiveness</th>
<th>Adhesiveness</th>
<th>Chewiness (N x mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>25.23* ± 1.85</td>
<td>0.85 ± 0.04</td>
<td>0.48 ± 0.02</td>
<td>-0.99* ± 0.13</td>
<td>10.40* ± 1.14</td>
</tr>
<tr>
<td>P</td>
<td>29.84* ± 2.69</td>
<td>0.84 ± 0.04</td>
<td>0.49 ± 0.03</td>
<td>-0.65* ± 0.12</td>
<td>12.20* ± 0.86</td>
</tr>
</tbody>
</table>

*Significant (p<0.05, significance using a T-test)

Figure 1 shows the scanning electron microscopic images of both control and plasma samples. A spongy appearance due to dense protein aggregates with irregular cavities among them and fat globules suspended in the protein matrix can be seen in the microscopic structure of both formulations; thus, being similar to the structure described by other authors for this kind of meat products \cite{23, 24}. Protein aggregates looked quite similar in both samples, however, the conventional sausages showed fewer but deeper cavities than those containing plasma. These differences might explain the results of the TPA, which in turn agree with those reported by Jiménez-Colmenero et al. \cite{25}, who associated the presence of larger cavities with reduced hardness in frankfurters. The aspect of protein aggregates of test samples seemed to be slightly denser than control that could also be related to more firmness we observed in TPA, but according our results, these microstructure differences did not affect significantly water holding capacity.
Plasma yields harder frankfurters, thus increasing chewiness, but this change may not be perceived as negative by the consumer, since frankfurters are expected to be chewy [21]. In fact, these results could be even considered positive; however, further studies, including sensory and consumer acceptance analyses, are necessary in order to support the use of plasma as functional ingredient in frankfurters.

4. Conclusion

The replacement of polyphosphate and caseinate by porcine plasma did not affect moisture content neither WHC in comparison with control but an increase in hardness and chewiness, related to microstructure, was observed in plasma containing sausages. In spite of that, porcine plasma can be considered as a possible ingredient in free-polyphosphate-frankfurters formulation.

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References


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