# Replacement of pork meat with proteins recovered from meat co-products in an emulsion-type breakfast sausage.

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**Abstract – Co-products generated by meat industry can provide a source of high quality proteins, which can impart techno-functional properties and provide an excellent amino acid profile. In this trial, proteins recovered from four different sources (blood plasma, exudates, brine solution and stick water) were incorporated into an Irish breakfast sausage. Either 10 or 20% of the protein from meat was replaced and the results compared against control recipes. The impact of the protein replacement was then analyzed for key sausage characteristics. The batter obtained showed the same proximate composition, the impact on textural and water holding features, and the outcome of amino acid profiling is presented. Evidence shows that some of these protein products hold strong potential for inclusion in meat based products both from a technological and nutritive perspective.**

**Key Words – protein recovery, sausage, proximate, texture**

## I. INTRODUCTION

It is expected that meat production will increase in the coming years, which will lead to the concomitant increase in production of co-products such as offal, blood, trim, exudate, etc. Many of these materials are rich sources of valuable components such as protein, lipids, biomolecules etc. While some co-products command some value, and can provide a nutritious food when consumed directly [1], for others it may be more valuable to extract compounds of interest for use as a protein ingredient. Specifically, proteins can be recovered by several techniques: ultrafiltration, centrifugation, drying, precipitation, dialysis, and so on [2]. Once extracted and characterized, the feasibility of incorporation into a real food matrix, and assessing the impact on techno-functional properties, needs to be assessed. In this research, proteins from four different sources (blood plasma, exudates, brine solutions and stick water) have been extracted, characterized, and then employed as protein substitute in traditional Irish breakfast sausages. The aim of this study was to investigate the impact that the protein replacement on texture, color, proximate composition, amino acid profile, emulsion stability, and cooking loss.

## II. MATERIALS AND METHODS

Plasma (PL) proteins were obtained after blood centrifugation and spray drying (65% protein content). Exudates (EX), from pork hams prior to pumping, were directly freeze-dried (85% protein content). Proteins from brine (BR), recovered during the brining process, were precipitated at pH 4 and then recovered by centrifugation as wet paste (18% protein content). Proteins from stick water (SW), which is a processing stream from fat rendering, were freeze-dried (45% protein content). Breakfast sausage formulations were devised by substituting meat protein to 0% (control), 10 or 20% levels resulting in 9 different formulations: 10PL, 10SW, 10EX, 10BR, 20PL, 20SW, 20EX, 20BR and control. The batter composition of the control sausages was 65% pork loin (18% protein content), 20% pork fat, 15% water (added as ice) and 1.8% of salt. After mincing, the batters were stuffed in collagen casings and then stored at 4 ºC until analysis within the next 48 hours. Analyses performed on cooked and, where relevant, on raw, samples included: texture profile analysis, color, proximate analysis (protein, fat, moisture and ash), amino acid profile, emulsion stability, cooking loss and water holding capacity (WHC) [3]. Results obtained were statistically analyzed by means of ANOVA, followed by a Duncan test.

## III. RESULTS AND DISCUSSION

Results for 20% replacement levels are shown in Table 1 while relevant 10% data is presented in the text. No significant differences ($p>0.05$) were found in raw protein content (average value of 13.5%), except for 20PL where this value was 14.76±0.16 ($p<0.05$). Differences in raw fat content were reflective of the amount of meat (which also contained fat) replaced by protein powders which were fat free, with values ranged from 19.30% (20PL) to 21.78% (controls): no difference was observed between 10% and control formulations. Moisture content of raw sausages (62.84% to 64.33%) was higher in all altered formulations (both 10 and 20%), possibly due to the high hygroscopic capacity of the protein powders. Finally, as consequence of the salt content of some of the protein powders, the ash content of sausages were higher with 20SW and 20PL showing highest level (4.2 and 2.5% respectively) compared to control (2.1%). All other formulations showed identical ash content than control. In order to assess the impact on the color, the factor $\Delta E$ was calculated to look at differences between control and treatments. Highest $\Delta E$ were observed

(8.78 to 4.72) in the raw 20% replacement levels with a smaller effect evident in 10% inclusion (7.79 to 2.53). After cooking the 10% treatments were no different to controls ($\Delta E<3$) with the exception of the 10BR (4.72). For the 20% inclusion levels SW, PL and BR were higher, while EX was no different, to control (Table 1).

Reduction in cooking loss was most significant for 20PL treatments and 20SW compared to control (Table 1). On the other hand 20BR, 20EX and 10 BR (24.70%±2.54) showed a significant increase in this parameter. Emulsion stability showed no significant differences for control and 20EX sausages; while emulsion stability was inferior for 20PL, 20SW and 20BR. For the 10% replacement levels, significant differences were also observed, although the negative effects on emulsion stability were lower for 10SW (8.94%±0.28), 10BR (10.22%±0.38) and not significant for 10PL (7.73±0.62). Formulations containing either 10% or 20% PL and SW showed the best WHC, while EX and BR values performed very poorly. Changes in these techno-functional properties were reflected in the proximate composition of the cooked sausages. Fat content increased in all groups due to a loss of water during cooking process. However, while EX resulted in highest (25%) increase in fat, PL (8%) and SW (5%) gave lower increase than control (12%), likely due to increased water retention (12%). A similar trend was observed for the increase in protein content following cooking (values ranging from 34%in 20BR, to 8.7% in SW20).

Texture profile analysis revealed that hardness was significantly reduced mainly for 20SW and 20EX sausages; when compared to the control (Table 1). Similar results were observed when chewiness and gumminess were studied. In general SW resulted in a dramatic reduction in texture profile analysis (TPA) parameters; however, in 10% formulations only significant differences in hardness were found when SW (20.31±0.74) is employed.

Table 1: Main sausage properties compared to a control when 20% of meat protein is replaced by proteins from stick water (SW), blood plasma (BL), exudates (EX) and brine solutions (BR). Different letter denotes significant differences ($p<0.05$)

| | **Color ΔE§** | **Cook loss (%** | **WHC (%)** | **Emulsion stab (%)†** | **Hardness (N** | **Chewiness (N** | **Gumminess (N** |
|---|---|---|---|---|---|---|---|
| **Contro** | 0 | 14.59±0.50$^{a}$ | 16.56±1.64 | 7.44±0.83$^{a}$ | 27.30±0.43$^{a}$ | 73.14±11.07$^{a}$ | 15.64±1.49$^{a}$ |
| **SW** | 7.26 | 12.69±0.55$^{b}$ | 20.49±0.90 | 12.42±0.73$^{b}$ | 5.09±0.46$^{b}$ | 7.94±1.42$^{b}$ | 2.11±0.39$^{b}$ |
| **PL** | 3.69 | 4.64±0.34$^{c}$ | 18.65±1.01 | 10.60±0.59$^{c}$ | 25.12±2.04$^{c}$ | 72.90±2.57$^{a}$ | 15.27±0.29$^{a}$ |
| **EX** | 1.61 | 20.62±0.82$^{d}$ | 0.09±0.24$^{d}$ | 7.12±0.25$^{a}$ | 16.36±1.39$^{d}$ | 46.91±0.60$^{c}$ | 10.04±0.31$^{c}$ |
| **BR** | 7.09 | 29.92±2.41$^{e}$ | nd | 12.03±0.48$^{b}$ | 26.69±0.66$^{a,c}$ | 67.04±2.74$^{a}$ | 16.38±0.72$^{a}$ |

†: Higher values denote lower emulsion stability. §: cooked sample

Finally, the amino acid profile was studied for 20% levels. It was found that the essential amino acid (EEA) profile did not vary after cooking process. When EX and PL were used as protein source, higher levels of EEA was detected (48.01% and 47.02% respectively), when compared to control (46.01%). On the other hand, SW is mainly composed of collagen proteins and as expected, the percentage of EAA falls to 40.30% for these products. Analysis of amino acid profile in 10% levels is ongoing.

## IV. CONCLUSION

It has been shown that proteins recovered from meat processing co-products and processing streams can be incorporated into a meat emulsion type product and can impart positive benefits on techno-functional properties of the final product. For some protein sources, optimizing the ratio of protein replaced needs to be optimized to avoid the negative effects on texture and cooking loss. In some cases the amino acids profile of the product can even be improved. Tailored blends of these ingredients can be optimized to balance the effect from a technological and nutritional perspective for the final product.

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