USING THE RESPONSE SURFACE METHODOLOGY TO FACILITATE THE OPTIMIZATION OF TEXTURE-MODIFIED INJECTED MEAT PRODUCTS TARGETED AT ELDERLY CONSUMERS

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Abstract - There is a need to develop softer-textured beef products for older consumers with masticatory issues, which might contribute to offsetting the decline in meat intake. In this study a response surface methodology (RSM) approach was considered in order to analyse the interactions between citric acid, apple fibre and rice starch on texture, to facilitate the optimization of texture modified beef products targeted at elderly consumers. The studied ingredients could represent a feasible alternative to traditional ingredients used for beef injection and the final products could be suitable for consumption by elderly population.

Key Words – beef, elderly, response surface methodology, tenderness

I. INTRODUCTION

Among diverse and numerous food energy sources, beef is a valuable dietary source of high quality bioavailable protein and is very suitable to the diet of elderly population [1]. There is a need to develop softer-textured beef products for older consumers with masticatory issues, which might contribute to offsetting the decline in meat intake [2]. The effect of citric acid on meat tenderness has been studied by several authors, and was reported to have a beneficial effect on meat tenderness, contributing to the partially denaturation of proteins which might make it accessible for the absorption of different added ingredients [3, 4]. On the other hand it has been reported that dietary fibres – which includes fruit fibres and rice starch could be used as functional ingredients in meat products [5]. It has been suggested that apple pulp represents a typical source of dietary fibre and due to its high concentration of flavonoids and carotenes with superior quality compared with other fibres [6, 7].

II. MATERIALS AND METHODS

II.1. Beef processing

Beef [*M. semitendinosus* (*ST*)] from Holstein-Friesian steers, were purchased on day 1 *post mortem* and aged for 7 days at 3°C. Muscles were pumped to 115% of their green weight, with Inject-O-MAT type PSM-21 (Dorit Maschinen, Switzerland). Muscles were tumbled for 2h continuous at 7 rpm (2-4°C). Tumbled muscles were vacuum packed in pouches and steam cooked (Fessmann cooker, T1800, Germany) to a core temperature of 72°C (≈4h). Cooked muscles were chilled (2-4°C, overnight) before being sub-sampled and vacuum packed for texture and colour analyses.

II.2. Warner-Bratzler shear force (WBSF) and Texture Profile Analysis (TPA)

The analyses were carried out on cooked samples according to AMSA guidelines [8] and Wheeler *et al.* [9]. Samples were sheared perpendicular to the fibre direction using the Instron Universal testing machine, model 4464 (Instron Ltd., UK), load cell of 500 N, cross head speed 250 mm/min and analysed in Bluehill®2 Software. For TPA, cooked samples were analysed according to the method used by Botinestean *et al.* [2]. Force time deformation curves were obtained at a cross speed of 500 mm/min.

II.3. Colour analysis

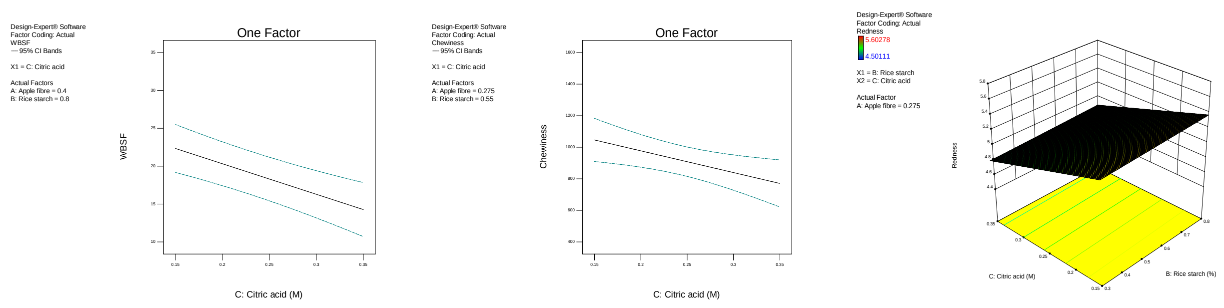
Measurements were taken using the CIE L*a*b* system with a dual beam xenon flash spectrophotometer (Hunter Lab Ultra Scan Pro, Inc., Reston, VA). CIE L* (lightness), a* (redness), b* (yellowness) values were recorded. Means of readings at three locations on each side of the thermal treated sample were determined.

II.4. Experimental design and statistical analysis of data

A D-optimal RSM experiment was designed using Design Expert software (v. 10.0.3, Stat-Ease Inc., USA). Three numerical factors were used: citric acid (0.15-0.35M), apple fibre (0.15-0.4%) and rice starch (0.3-0.8%). The experimental design had 19 runs, divided in 2 blocks with each run representing a different combination of the three numerical factors, including 11 model points, 4 replicate points and 4 points lack of fit points. Each combination was applied to *ST* muscles. Models were considered significant when $P<0.05$.

III. RESULTS AND DISCUSSION

For the WBSF values a linear model was significant (*P*=0.002), with WBSF values negatively correlated with citric acid concentration (Figure 1a). No main or interaction effects were observed for rice starch and apple fibre. Ke et al. (2009) studied the impact of citric acid on the tenderness of beef muscle, and reported similar results.



a. **b.** **c.**

Figure 1. Representation of the response surface models for **a.** WBSF (N), **b.** TPA chewiness (N) and **c.** redness (a*) of injected beef products

TPA parameters chewiness, hardness, and gumminess were each fitted with linear models. All three showed similar response surfaces and again, only citric acid was a significant factor. These parameters were minimised with maximal citric acid concentration as can be observed in Figure 1b, chewiness (*P* =0.001). The same softening effect caused by organic acids was reported by Chang et al. (2010), who explained that the increase in meat tenderness was caused by the physical weakening of muscle structure, acid inclusion caused dramatic heterogeneous changes in the myofibrillar ultrastructure. No significant effect was observed for cohesion force, springiness, L* and b* values. However, the inclusion of citric acid had a minor effect on a* values (Figure 1c).

IV. CONCLUSIONS

D-optimal RSM was found to be an effective technique to investigate the synergistic effect of the proposed ingredients for beef injection on tenderness. The presented results suggest that the model was reliable and fitted well to the experimental data. Apple fibre and rice starch don't have a negative effect on meat tenderness, but they might improve the health profile of a meat product with benefits for consumers, particularly the elderly. Citric acid had a positive effect on texture parameters, and a combination with the other two ingredients may result in a product that might be suitable for consumption by elderly population. Future work could focus on sensory evaluation to determine the acceptance of technologically optimised products among elderly consumers.

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