EFFECT OF WHEY PROTEIN CONCENTRATE, SODIUM CHLORIDE AND COOKING TEMPERATURE ON PHYSICOCHEMICAL AND TECHNOLOGICAL PARAMETERS OF *SOUS VIDE* COOKED BEEF MUSCLES

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Introduction

Application of *sous vide* system to beef appears to be an interesting alternative to diversify the consumption of ready-to eat beef products. The main drawback of this approach is the retention of liquid released during cooking inside the package, which affects product appearance. In order to increase water-holding capacity (WHC), and hence reduce cooking weight loss, the addition of whey protein concentrate (WPC) seems to be a novel alternative to replace or reduce conventional ingredients [sodium chloride (SC) and alkaline phosphates]. Thus, the aim of this work was to evaluate the effect of WPC and SC concentrations and cooking temperature on physicochemical and technological parameters of *sous vide* cooked beef muscles using a response surface methodology.

Materials and Methods

Response surface methodology (Doehlert design; Araujo and Brereton, 1996) was used to study the simultaneous effect of WPC concentrations (0, 0.9, 1.7, 2.6, 3.5% on raw injected muscle basis), SC concentrations (0, 0.6, 1.2, 1.9, 2.5% on raw injected muscle basis) and cooking-pasteurisation temperatures at the slowest heating point (SHP) of the muscles (65°C, 70°C, 75°C). The cooking-pasteurisation time applied at the muscle SHP for each temperature was the thermal death time suggested by FAIR (1999) to achieve 6D Log reduction of *Listeria monocytogenes* (9 min-65°C, 2 min-70°C, 26s-75°C).

Forty-five *Semitendinosus* beef muscles (48h post-slaughter, average weight: 1708.73±165.62g and average pH: 5.57±0.07) were used. The muscles were vacuum packaged and continually tumbled at 8.5rpm for 0.5h (1.5±0.5°C). Then, they were injected at 130% (over green weight) using an automatic multi-needle injector. Brines, prepared with WPC (Lacprodan80, Arla Food Ingredients S.A) and SC, were formulated to give the concentrations of ingredients defined by the experimental design. After the injection, muscles were continually tumbled at 8.5rpm for 5h (1.5±0.5°C), and then submitted to *sous vide* cooking in a water cascading retort (Microflow Barriquand). After cooking, samples were stored at 1.5±0.5°C for 18h until further testing.

The pH of raw and cooked muscles was measured on the slurries. Post-injection tumbling (PostIT, P_1) and cooking (P_2) weight loss percentages were determined using the following relationship: $P_i = (m_i - m_f)*100/$ trimmed raw muscle weight, where for P_1: m_i is the weight of the injected muscle and m_f is the weight of the muscle after PostIT treatment, for P_2: m_i is the weight of the muscle after PostIT treatment and m_f the one after thermal process. Total yield was calculated as TY= cooked muscle weight*100/raw non-injected muscle weight. Expressible moisture (EM) was calculated as the percentage of liquid lost after centrifugation (20min, 4°C, 4800x*g*) related to the initial sample weight. Statistical analysis was performed using SAS 8e for Windows (1991-2001).

Results and Discussion

The pH of cooked beef muscles was significantly ($P<0.05$) affected by WPC concentration and cooking temperature applied (Table 1). The pH increased proportionally to the increment of WPC concentration, probably induced by the pH of the injected brines (range 6.64-7.08). Cooking temperature had linear and quadratic effect. However, their estimated coefficients were lower than the one obtained for WPC, suggesting a minor influence on the pH parameter.

In the case of P_1 parameter, it was significantly affected ($P<0.05$) by SC concentration (linear and quadratic effects). The lowest P_1 value was obtained with the highest SC level (Table 1). Instead, WPC addition did not affect significantly this parameter (Table 1). The increment of SC content inside the tissue would induce fibre swelling, protein hydration properties modification, promoting an increase in WHC as a result. This increase can be evidenced by the observed reduction of PostIT weight loss.

Regarding P_2 parameter, at a fixed cooking temperature P_2 diminished linearly following the increment of SC and WPC concentrations (Table 1, Figure 1). This result could be a consequence of the augmented concentration of tissue proteins because of the addition of whey proteins, and/or a higher myofibrillar protein extraction exerted by the presence of the salt. The mechanisms involved in the water retention are difficult to describe, probably solubilised proteins are able to form a gel that entrap and retain water inside, and/or due to the interaction between water and added proteins. The P_2 parameter increased linearly and quadratically with cooking temperature. This result could be associated with the effect of heating upon tissue structure, such as the damage of cell membranes, transversal and longitudinal shrinkage of muscle fibres, and connective tissue contraction, which reduce in turn meat WHC (Tornberg, 2005).

The effect of ingredient concentrations and cooking temperature on TY were almost the same as those observed for P_2 (Table 1). In the regression model for TY, the interactions SC^2 and WPCxSC were significant ($p<0.05$). The WPCxSC interaction implies that WPC concentration effect was highly dependent on the SC concentration. Up to a SC concentration of 1.6%, the incorporation of WPC had a positive influence on TY (Figure 2). Beyond this concentration no effect was observed. This result let us assume that a similar TY can be obtained replacing part of the SC added by WPC.

Expressible moisture is a measured of the content of free water in the cooked product. This parameter may be used as an indicator of the purge expected in the packaged product (Boles and Shand, 2001). The highest EM value was observed in muscles processed at the lowest cooking temperature and the highest SC concentration (Figure 3). As expected, the EM parameter had a significant ($P<0.05$) positive correlation ($R^2=0.789$) with TY.

Conclusions

There is a positive effect of SC concentration on tissue WHC. Thus, the increased SC concentration was capable of reducing weight losses in the different stages of the process. In addition, the WPC increment produces an enhancement of total yield at low SC concentrations. Similar results were observed at the different cooking temperature studied, however the maximum yield was obtained at 65°C.

Table 1: Regression coefficients and analysis of variance of the regression model for cooked beef pH, post-injection tumbling (P_1) and cooking (P_2) weight loss percentages, total yield (TY), and expressible moisture (EM).

		pH	P_1	P_2	TY	EM
Constant		6.04*	7.4*	25.8*	96.2*	32.78*
Lineal	WPC	0.11*	-0.3	-5.6*	4.7*	-0.07
	SC	0.02	-8.6*	-8.4*	18.6*	3.26*
	T	-0.07*	-	8.7*	-9.0*	-2.46*
Quadratic	WPC^2	0.03	1.2	-0.1	-0.3	-0.67
	SC^2	0.08	1.9*	0.8	-4.6*	-1.90*
	T^2	0.01*	-	5.9*	-3.6*	-2.58*
Interactions	WPCxSC	0.03	2.5	1.9	-5.0*	-3.50*
	SCxT	-0.03	-	-0.5	2.7	-0.25
	WPCxT	0.00	-	-1.1	2.1	-3.10*
R^2		0.57	0.91	0.95	0.96	0.79
p-value		*<0.05*	*<0.05*	*<0.05*	*<0.05*	*<0.05*

*significant $p<0.05$. Regression coefficients calculated for coded values.

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Figure 1: Effect of whey protein concentrate (WPC) and sodium chloride (SC) on cooking weight loss (cooking temperature fixed at 70°C).

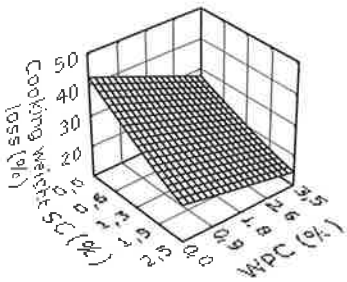
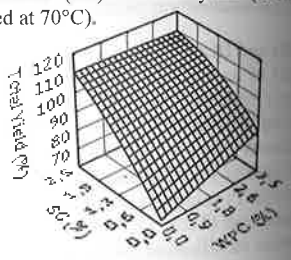


Figure 2: Effect of whey protein concentrate (WPC) and sodium chloride (SC) on total yield (cooking temperature fixed at 70°C).



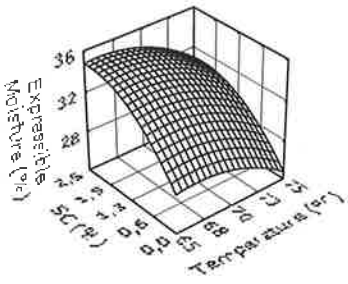


Figure 3: Effect of sodium chloride (SC) and cooking temperature on expressible moisture (whey protein concentrate concentration fixed at 1.25%).