OPTIMIZING PHYSICAL AND CHEMICAL CHARACTERISTICS OF LOW-FAT GROUND BEEF PATTIES

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Background

The nutritional quality of food has emerged as a major concern of today's consumer. Many of them are currently limiting the amount of fat and calories in their diets (Desmond et al., 1998). Developing an extra lean ground beef product, while assuring the necessary palatability demanded by consumers, is not as simple as just removing fat (Trout et al, 1992). Fat has a profound effect on rheological and structural properties of meat products. The active approach to fat replacement is to add fat-mimetic ingredients, which either replace fat or modify the interactions of the remaining components (El-Magoli et al., 1996). These fall under three categories: non meat proteins (i.e. soy and milk), carbohydrate based (i.e. caragenan, starches) and blends of ingredients. Low-fat beef burgers with isolated soy proteins were reported by McMindes (1991) to have scored significantly higher in flavour and overall quality. Among milk proteins, whey protein concentrate (WPC) has been reported in many studies to exhibit functional properties proven to be useful in fat replacement (Lucca & Tepper, 1994). Possibly the most widely used binder in the series of low-fat meat products is carragenan (Giese, 1992). Among the various properties of iota-carrageenan is its ability to retain moisture (Egbert et al., 1991). Starch has long been used by the meat industry as a functional additive for its binding and gel-forming capacities. Low fat meat products require innovative moisture and fat binding systems (blends of different non meat ingredients) to producing market-competitive, consumer-accepted meat products. Therefore, Response Surface Methodology (RSM) is a useful approach to optimize the physical, chemical and sensory quality of a product through simultaneous variation of considered factors, previously selected for their influence in a given parameter. Following appropriate statistical designs the experimental data relate variations in responses with variations in factors studied. When based on sensory data the selected formulation must be compared with a standard or control formulations (Pastor et al. 1983).

Objectives

The objectives of our study were to optimize the cooking loss, the shrinkage and the objective texture of a low fat (<3% fat) ground beef patty formulation using different levels of isolate soy protein (ISP), texturized soy protein (TSP), carrageenan (C) and whey protein concentrate (WPC).

Materials and methods

Twenty seven different ground beef patties formulations (Table 1) were prepared using the following functional ingredients: TSP (Proteimax Tri 120, Ceval), ISP (Supro 516 - PTI), C (Viscarin ME 3820, FMC) and WPC (Alacen 162, NZMP), sodium tripoliphosphate (STT) (Clariant), commercial sodium chloride and spices (Fuchs Gewürze).

Samples were selected according to a four-factor central composite rotable design comprising 27 points:16 factorial, 8 axial and 3 central points, with a design radius α=2. Concentration ranges for ingredients were selected on the basis of previous results: 0 to 6% TSP, 0 to 2% ISP, 0 to 0,3% (Lemos et al, 2000) and 0 to 4% WPC (El-Magoli et al., 1996). The amount of the ingredients added was calculated based on the total meat plus water. Total moisture and fat contents were determined for the raw material (chunk). The meat was first ground through plates with 20mm holes, then the other ingredients were added and the mixture was ground through 8 mm plates, using a Hermann meat grinder (Model 106). Individual patties were formed using a Hollymatic forming machine (Model 54), frozen quickly in liquid nitrogen and stored at $-16^{\circ}C$. A control sample was formulated to have 13% fat by mincing extra lean ground beef , pork tallow and additives to be adopted as a reference for the identification of the WBS region similar to that of the control.

Cooking loss and shrinkage were determined for each treatment which was next submitted to textural analysis. Warner Blatzler shear force was measured using a TA-XT2 texture analyser. Statistical analysis was undertaken using the statistical package STATISTICA v. 5.0

Results and Discussion

Beef patties formulations showed non significant differences no pH values (5,64) and fat content (2%); slight differences on protein content due to addition of different amounts of non meat adjuncts.

The effects of WPC and ISP addition on the shrinkage of beef patties, fixing carrageenan concentration in 0.3%, are showed in Figure 1, where the fitted surface response is presented. ISP concentration had a linear effect on shrinkage (p=0.04), ISPxC and ISPxWPC interactions were significant (p=0.03 , p=0.02 , respectively). The regression model for shrinkage variation (R^2=0.6228) does not fully explain the experimental data. Higher concentrations of WPC and ISP are required when carrageenan is added at its maximum level to achieve the lowest shrinkage, however at its minimum level, WPC and ISP addition should be minimised (Figs. 1 and 2).

WPC had a linear effect on cooking loss (p=0.04), although none of the other factors analysed were significant. Figure 3 presents the fitted surface response. The cooking losses predicted by the fitted surface response were very close to the experimental data obtained (R^2=0.7244). As long as WPC is added at its maximum level the lowest cooking loss is achieved.

Only 56% (R^2=0.5628) of the WBS variation was explained by the regression model. Carrageenan and WPC concentration had a linear effect on WBS. Adopting the WBS value obtained for the control, an optimum region was identified in the response surface (Fig. 4) where carrageenan addition is between 0.1 and 0.25%, and WPC is between 1.5 and 3.5.

The highest cooking yields and the lowest shrinkage values were obtained by addition of ISP and/or WPC, indicating the effectiveness of the adjuncts in the binding water and retaining moisture during cooking without changing patty's shape.

However, to achieve WBS values similar to the control the protein amounts has to be reduced and carrageenan added, probably due to its ability to retain water giving a gel strength with similar WBS values to regular fat beef patties.

Conclusions

This study indicates that there are several alternatives for fat substitution in order to optimize physical characteristics of low-fat ground beef patties. Non meat protein substitutes, ISP and WPC, increased yields since they lowered shrinkage and cooking losses, although WBS optimization seems to require the addition of carrageenan along with WPC. Therefore, to optimize the low-fat formulation, an acceptability sensory test will be run.

References

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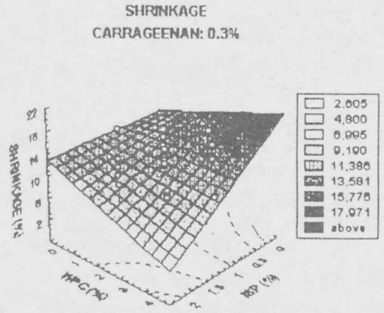

Figure1. Fitted surface response of the effects of WPC and ISP on the shrinkage (carrageenan fixed at 0.3%).

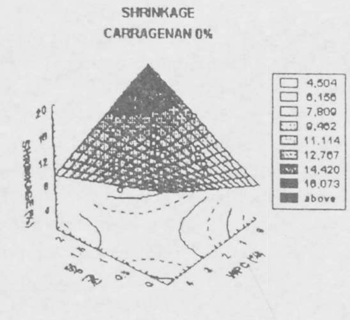

Figure2. Fitted surface response of the effects of WPC and ISP on the shrinkage (carrageenan fixed at 0%).

Table 1. Experimental design, uncoded values of levels and shrinkage, cooking loss and WBS data.

Treatments	TSP (%)	ISP (%)	C (%)	WPC (%)	S(%)	CL(%)	WBS(Kgf/cm^2)
1	1.5	0.5	0.075	1	18,01	8,86	2,1
2	4.5	0.5	0.075	1	17,16	8,91	2,2
3	1.5	1.5	0.075	1	14,74	10,87	2,1
4	4.5	1.5	0.075	1	12,77	11,49	2,2
5	1.5	0.5	0.225	1	14,74	8,98	1,8
6	4.5	0.5	0.225	1	13,44	10,76	1,8
7	1.5	1.5	0.225	1	10,89	7,85	1,8
8	4.5	1.5	0.225	1	11,10	9,46	1,9
9	1.5	0.5	0.075	3	14,46	11,40	1,8
10	4.5	0.5	0.075	3	12,91	10,31	1,7
11	1.5	1.5	0.075	3	11,60	8,85	1,7
12	4.5	1.5	0.075	3	10,01	8,69	1,4
13	1.5	0.5	0.225	3	12,46	13,99	1,5
14	4.5	0.5	0.225	3	11,04	10,78	1,5
15	1.5	1.5	0.225	3	7,00	7,83	1,3
16	4.5	1.5	0.225	3	7,23	9,41	1,4
17	0	1	0.15	2	14,21	11,66	1,9
18	6	1	0.15	2	16,75	13,21	2,3
19	3	0	0.15	2	15,81	12,07	2,0
20	3	2	0.15	2	15,63	10,98	2,7
21	3	1	0	2	13,64	10,06	2,3
22	3	1	0.3	2	14,47	9,65	2,0
23	3	1	0.15	0	13,86	12,89	2,3
24	3	1	0.15	4	7,45	7,94	1,7
25	3	1	0.15	2	11,44	10,84	1,9
26	3	1	0.15	2	13,44	9,92	2,0
27	3	1	0.15	2	9,95	10,12	2,1
Control					15,70	13,25	1,9

S=Shrinkage; CL=Cooking loss; C=Carrageenan
S and CL:Means of three replications WBS:Means of six replications

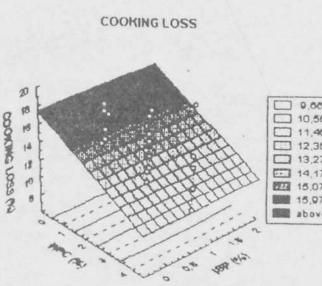

Figure 3. Fitted surface response of the effects of WPC and ISP on the cooking loss.

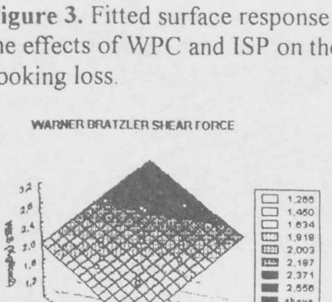

Figure 4. Fitted surface response of the effects of WPC and carrageenan on the WBS.