INFLUENCE OF NON-MEAT INGREDIENTS AND MARINATION OF RAW MATERIAL ON THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF LOW-FAT GROUND BEEF PATTIES

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Background

A surge of intense competition amongst meat processors to provide consumers with low-fat meat products has dominated product development efforts in this area in recent years. The final goal has been to reduce fat while retaining traditional full-fat flavor and texture (Brewer et al., 1992). To be labeled "low-fat", a product must contain 3g less fat per reference amount, per serving size, and per 100g of product. The desirable sensory characteristics of juiciness and mouth feel of a ground beef patty are associated with higher fat levels. To retain these characteristics when the fat content is reduced, non-meat ingredients are used (Jimenez-Colmenero, 1996). Carrageenan is possibly the most widely used binder for low-fat meat products, since it enhances water retention. Iota-carrageenan has been recommended since ground beef patties are manufactured at low temperatures. The cold solubility and freeze/thaw capacities of some iota-carrageenans enhance machinability during processing (Berry, 1985; Huffman et al., 1991). Isolated soy protein has also been used for its easy use and familiarity as an ingredient. It also has the advantage of providing nutritionally complete protein (McMendes, 1991). Modified food starches can be used as binders to maintain juiciness and tenderness in low-fat meat products. The starches are used to structure and bind water and they are said to decrease cooking losses (Keaton, 1994; Trout et al., 1992). Injection of meat with brine solutions containing polyphosphates and sodium chloride has been commonly used in the production of value added meat and poultry products, because it increases palatability and shelf life.

Objectives

The objective of this study was to determine the influence of different non-meat ingredients on the chemical and physical characteristics of low-fat beef patties formulated with injected and non-injected chuck beef cuts as raw material.

Materials and methods

Chuck beef cuts were analyzed for fat, protein, water and ash content. The beef cuts were separated into two groups, one was injected (I) with a brine containing 84.25% water, 5% isolated soy protein – ISP (SUPRO 516/Protein Technologies International), 2% sodium tripolyphosphate- STT (Clariant), 7% sodium chloride and 1.75% spices (Fuchs Gewurze), representing 20% injection in the final product, and the other group was not injected (NI). Both were vacuum packed, quick frozen in liquid nitrogen and stored at -18°C for 3 months. The meat was thawed at 2°C for 48 hours before being used in ground beef patty formulations. Total moisture, fat and protein content were determined for each raw material. The initial meat pH was measured in the raw material, which was ground to pass through an 8mm plate. Individual patties (90g) were formed using a Hollimatic forming machine. Nine treatments were applied as shown in **Table 1**. The non-meat ingredients used in the patty formulations were modified food starch (S) (Firmitex, National Starch), carrageenan (C) (Viscarin FMC), ISP (SUPRO S16, Protein Technologies International), Sodium Tripolyphosphate and spices. The nine treatments were the following: Injected meat, isolated soy protein (IP), Non-injected meat, isolated soy protein (NIP), Injected meat, isolated soy protein, modified food starch (IPS), Non-injected, isolated soy protein, modified food starch (NIPS), Injected meat, isolated soy protein, carrageenan (IPC), Non-injected meat, isolated soy protein, carrageenan (NIPC), Injected meat, isolated soy protein, modified food starch, carrageenan (IPSC), Non-injected meat, isolated soy protein, modified food starch, carrageenan (NIPSC), Non-injected meat (NI). A preliminary sensory evaluation showed that IPC and NIPC were considered not acceptable, so they were not included in the following physical and chemical analysis. Enough samples of each treatment were prepared to allow for two complete replications.

Total moisture, fat, total protein and ash contents were determined for each raw product formulation, using AOAC methods (1990). The pH of each treatment was also measured. Cooking losses and shrinkage were also determined. Instrumental color determinations were made on the surface of thawed, uncooked samples. Spectral reflectance was determined using a C illuminant and a 2° angle, using a Minolta spectrocolorimeter (model CM508-9). The CIE LAB values were calculated.

Ground beef patties were analyzed using two textural analysis methods, Warner-Bratzler shear (WBS) force and a texture profile analysis using a TAXTII texturometer. Four patties per treatment were cooked to 77 °C , three minutes each side, on a preheated electric griddle (190 °C). The patties were cooled to 30 °C. For Warner-Bratzler shear, two patties were sheared three times with a hamburger probe (HP). It was programmed for the 30.0mm load range of a 5.0g load cell and a crosshead speed of 3.0mm/s. The two other patties were compressed twice at three different points, to 40% of their original height, at a crosshead speed of 3.0mm/s with a 5.0g load cell.

A statistical analysis (ANOVA) and Tukey's test were applied. The statistical data analysis was undertaken using the statistical package STATISTICA version 3.2.

Results and Discussion

Beef patties manufactured with injected and non-injected meat showed slight differences in their pH values. However the differences observed in the raw material were significant, 5.65 and 5.93 for non-injected and injected meat, respectively. Total moisture determinations showed significant differences between injected and non-injected samples ($p<0.05$). For the ash, protein and fat contents, no significant differences were found ($p<0.05$) (**Table 2**). No differences were observed for the CIE LAB values (data not shown).

Cooking loss and shrinkage data revealed that beef patty formulations with the addition of only ISP (NIP and IP) were not significantly different ($p<0.05$). However, these treatments showed greater shrinkage as compared to NI. Patties with ISP and S (NIPS and IPS), regardless of the raw material, showed intermediate cooking losses, as well as IPSC. Lower cooking losses were observed when IPS, S and C were mixed together and NI was the raw material. However, shrinkage values were not different for NIPS, IPS, NIPS and IPSC.

The WBS force values showed significant differences between the treatments. The treatments containing injected meat showed lower shear values than those containing non-injected meat as raw material (**Table 3**). ISP addition did not affect shear force values regardless of the raw material. A great decrease in shear force could be observed when S was added. However, the addition of carrageenan had a smaller effect when NI was used as raw material. The addition of C together with ISP and S to injected meat produced a considerable decrease in the Warner Blatzer shear force.

Hardness and peak force/2nd compression showed increased values for treatments containing S and C added to ISP, regardless of the raw material, except when S was added to NI meat. Springiness (base width of 2nd compression/base width of 1st compression x 100) and cohesiveness (total energy of 2nd compression/ total energy of 1st compression x 100) were very highly correlated to each other and no differences of practical importance were observed between the treatments. Non-protein fat substitutes seem to behave differently in low-fat meat products.

An informal sensory panel analysis was conducted to evaluate the products. Panelists scored IPS as the most acceptable. NI and NIP were rejected due to excessive firmness. Excessive tenderness was the reason for considering IPSC unacceptable.

Conclusions

Low-fat (<3%) ground beef patties can be produced with acceptable physical, chemical and textural characteristics by the addition of isolated soy protein, modified food starch and carrageenan. The use of injected beef cuts seems to be appropriate using isolated soy protein and starch.

References

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Table 1. Composition of different beef patty formulations

Ingredients	Formulations								
	NI	NIP	IP	NIPC	IPC	NIPS	IPS	NIPSC	IPSC
Water*	10	10	8	10	8	10	8	10	8
Sodium tripolyphosphate**	0.25	0.25	-	0.25	-	0.25	-	0.25	-
Sodium chloride**	1.7	1.7	0.8	1.7	0.8	1.7	0.8	1.7	0.8
Spices**	0.44	0.44	0.32	0.44	0.32	0.44	0.32	0.44	0.32
Isolated Soy Protein**		1	0.13	1	0.13	1	0.13	1	0.13
Modified food starch**	-	-	-	-	-	1	1	1	1
Carrageenan**	-	-	-	0.3	0.3	-	-	0.3	0.3

* Amount was calculated as a percentage of the meat ** Amount was calculated as a percentage of the total (meat+water)

Table 2- Total moisture, fat, protein, ash, cooking loss and shrinkage of different ground beef patty formulations*

Treatments	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Cooking loss	Shrinkage (%)	PH
NI	76.0 ± 0.2 ^{b}	17.8 ± 0.5 ^{ab}	2.6 ± 0.2 ^{a}	2.2 ± 0.4 ^{b}	29 ± 3 ^{a}	8.2 ± 0.7 ^{b}	5.72 ± 0.03 ^{bc}
NIP	75.5 ± 0.2 ^{bc}	19.5 ± 0.2 ^{a}	2.3 ± 0.3 ^{a}	2.4 ± 0.1 ^{abc}	29 ± 3 ^{a}	12.5 ± 0.7 ^{a}	5.74 ± 0.03 ^{ac}
IP	77.7 ± 0.5 ^{a}	16.0 ± 0.2 ^{b}	2.4 ± 0.2 ^{a}	2.7 ± 0.2 ^{abc}	31 ± 3 ^{a}	14.7 ± 0.5 ^{a}	5.66 ± 0.03 ^{bc}
NIPS	74.9 ± 0.5 ^{de}	17.9 ± 0.2 ^{ab}	2.8 ± 0.1 ^{a}	2.6 ± 0.1 ^{abc}	16.7 ± 0 ^{b}	4.8 ± 0.1 ^{c}	5.80 ± 0.02 ^{a}
IPS	76.3 ± 0.4 ^{bcd}	16.6 ± 0.2 ^{b}	2.6 ± 0.7 ^{a}	2.4 ± 0.3 ^{abc}	19 ± 1 ^{b}	7.8 ± 0.3 ^{b}	5.80 ± 0.03 ^{a}
NIPSC	75.0 ± 0.3 ^{bceg}	18.7 ± 0.5 ^{ab}	2.3 ± 03 ^{a}	2.8 ± 0.1 ^{ac}	9.1 ± 0 ^{c}	6.9 ± 0.7 ^{bc}	5.78 ± 0.00 ^{ac}
IPSC	77.1 ± 0.3 ^{adf}	18.0 ± 0.2 ^{ab}	2.1 ± 0.1 ^{a}	2.9 ± 0.9 ^{ac}	16.7 ± 0 ^{b}	6.4 ± 0.6 ^{bc}	5.79 ± 0.00 ^{a}

*Means of three replications $^{a-g}$ Means in the same column with different superscripts are different ($p<0.05$)

Table 3- Textural analyses of cooked beef patties*

Textural parameters	Treatments						
	NI	NIP	IP	NIPS	IPS	NIPSC	IPSC
WBS force, Kg	9 ± 1 ^{ab}	7 ± 1 ^{a}	6.4 ± 0.9 ^{a}	5.5 ± 0.4 ^{ac}	4.6 ± 0.5 ^{c}	5.6 ± 0.4 ^{ac}	3.8 ± 0.3 ^{c}
Hardness, Peak force, Kg	1.5 ± 0.8 ^{abc}	2.3 ± 0.9 ^{abc}	2.6 ± 0.9 ^{abc}	3.9 ± 0.9 ^{abc}	1.7 ± 0.2 ^{bc}	3.9 ± 0.5 ^{a}	4.1 ± 0.4 ^{bc}
Peak force, Kg	1.4 ± 0.7 ^{abc}	2.1 ± 0.8 ^{bc}	2.4 ± 0.8 ^{abc}	3.6 ± 0.9 ^{ab}	1.7 ± 0.2 ^{bc}	3.6 ± 0.4 ^{ab}	3.8 ± 0.4 ^{ab}
Springiness	88 ± 4 ^{abc}	88 ± 2 ^{abc}	93 ± 5 ^{a}	88.5 ± 0.6 ^{abc}	86 ± 2 ^{bc}	93 ± 4 ^{a}	86.3 ± 0.2 ^{bc}
Cohesiveness	79 ± 6 ^{ab}	82.7 ± 0.2 ^{a}	79 ± 5 ^{ab}	80 ± 2 ^{ab}	82.1 ± 0.8 ^{a}	77 ± 3 ^{ab}	74 ± 2 ^{b}

*Means of three replications $^{a-c}$ Means in the same row with different superscripts are different ($p<0.05$)