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EVALUATION OF CARRAGEENAN, ISOLATED SOY PROTEIN AND A MODIFIED STARCH IN LOW-FAT FRANKFURTERS

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INTRODUCTION

Most market-driven research to develop and merchandise low-fat meat products has so far been conducted in the US. The revised USDA regulations for cooked sausages permit fat and water to substitute one for the other, provided their total does not exceed 40% and the fat content is no greater than 30%. The food regulations in Australia, however, require a minimum meat content of 66% in manufactured meat products and the meat is defined as both lean meat and fat. Consequently, in order to comply with the regulation, fat can be replaced by lean meat only and this results in a commensurate increase in the cost of low-fat products. Besides this regulatory difference between the US and Australia, difference also exists in the types of commonly consumed meat products as well as in the quality and taste of these products. For example, beef patties account for about 44% of the beef consumed in the US whereas in Australia, there does not seem to be such a single, high-volume meat product. It is important, therefore, to specifically investigate and develop low-fat meat products that will suit the Australian market. We conducted a series of experiments to evaluate a number of fat substitutes in low-fat frankfurters of medium quality and compare the frankfurters containing these fat substitutes to control frankfurters with both high and low fat contents. We report here the experiment with carrageenan, isolated soy protein and modified starch.

MATERIALS & METHODS

The frankfurters were formulated to have either a normal (22%) or a low (10%) fat content with all of part of the fat in the low-fat products being replaced by water. There were 4 controls and 9 low-fat treatments in the experiment which was repeated three times. Controls 1 and 2 were formulated to contain 22% fat with Control 1 containing 1% isolated soy protein plus 4% potato starch as binders and Control 2 containing 1% isolated soy protein and 6% Bindo (a heated cereal commonly used by the Australian smallgoods industry as a binder). Controls 3 and 4 were formulated to contain 10% fat with Control 3 without binders and Control 4 containing the same binders as Control 1. The low-fat treatments contained one of the three fat substitutes at one of the following concentrations: 0.5, 1.0, 1.5% carrageenan, 1.0, 2.5, 4.0% isolated soy protein, or 2.0, 3.5, 5.0% modified starch. The batter was made by initially chopping the meat ingredients (95CL beef trimmings, 90CL pork shoulder, pork fat, 75CL mutton trunk and mechanically deboned pork), one-half ice, salt, sodium tripolyphosphate, nitrite, dextrose and seasonings in a vacuum cutter before the remaining ingredients were added and chopped under vacuum. The finished batter was stuffed into 24 mm diameter casings and weights were recorded before cooking. Frankfurters were heat-processed and smoked in a smokehouse to an internal temperature of 72°C and showered with cold water. After chilling overnight, the cooked products were weighed again to determine cooking yields and then vacuum packaged and stored at 0°C until analysis. The moisture and fat contents were determined on both raw and cooked products and the pH was measured on the cooked product. Purge loss was obtained by measuring the amount of juice released in the bag after the vacuum-packaged frankfurters were stored for 4 weeks at 0°C.

Texture profile analysis (TPA) was performed with an Instron Materials Testing Machine Model 1122 on 12 frankfurter sections which were equilibrated to 50°C in a waterbath before testing. The 13-mm long sample was compressed to 25% of its original height through a two-cycle compression to obtain the following textural variables: Fracturability (F_F) = force (N) required to fracture, First bite hardness (F1) = maximum force (N) required for the first compression, First bite area (A1) = total energy (J) required for the first compression, Second bite area (A2) = total energy (J) required for the second compression (J); springiness (S) = height (mm) that the sample recovered between the end of the first and start of the second compression, cohesiveness = A2/A1, gumminess = F1 x A2/A1 and chewiness = S x gumminess.

Sensory evaluations were conducted within a week after the products were manufactured by an 8-member trained descriptive sensory panel on an 8-point scale for internal colour, firmness, springiness, cohesiveness, juiciness, spice flavour, foreign flavour, greasiness and overall palatability (1 = extremely grey, extremely soft, not springy, extremely mushy, extremely dry, extremely bland, no foreign flavour, not greasy and extremely unpalatable, 8 = extremely pink/red, extremely firm, extremely springy, extremely cohesive, extremely juicy, extremely spicy, extremely intense foreign flavour, extremely greasy and extremely palatable). Frankfurters were steeped in an 80°C waterbath for 20 minutes and sliced into approximately 5 cm-long pieces. The reproducibility and ability of each panellist to determine differences within sensory parameters for each attribute was determined before the data was included in the analysis of variance using the general linear model of the Statistical Analysis System.

RESULTS AND DISCUSSION

The low-fat frankfurters had significantly higher moisture and lower fat contents than the normal-fat controls in both raw and cooked products (Table 1, data for raw products not shown and similar to cooked). There was no difference in the pH (~6.4) and cooking yield (96-98%) of the products. Purge loss was reduced by all the fat substitutes evaluated, with modified starch being particularly effective. With increasing level of fat substitute, there was a significant decease in purge loss although this decrease seemed to plateau at the medium addition level of all the three fat substitutes.

No difference was observed in internal colour, foreign flavour (data not shown) and overall palatability between treatments (P>0.05, Table 1). With the increased concentration of fat substitutes, there was a decrease in juiciness and an improvement in the textural attributes in both sensory evaluation and texture profile analysis. For the major attributes in the instrumental texture profile analysis (fracturability, first bite hardness, first bite energy, second bite energy), the improvement by carrageenan was significant only from 0.5% to 1.0% and not from 1.0% to 1.5%, that by the modified starch was significant only from 3.5% to 5.0% and not from 2.0% to 3.5% while the improvement by isolated soy protein was significant at all the three addition levels. Similar changes were observed in the textural attributes (firmness, springiness and cohesiveness) and juiciness in sensory evaluation. This improvement in the texture of low-fat frankfurters is important in that, when fat is replaced with water in low-fat processed meats, the products tend to be softer than traditional products.

All the textural parameters (except for cohesiveness) obtained from the texture profile analysis were highly and positively correlated with firmness, springiness and cohesiveness, the textural attributes in sensory evaluation, while negatively correlated with juiciness and greasiness. Of the sensory attributes evaluated, the three textural parameters, firmness, springiness and cohesiveness, were very highly correlated with each other (r~0.9) and with overall palatability. Juiciness and greasiness were highly and positively correlated (r=0.74) while both attributes were negatively correlated with firmness, springiness and cohesiveness. Overall palatability was negatively correlated with foreign flavour and also correlated negatively with juiciness and greasiness. The fracturability, first bite hardness, first bite energy, springiness, gumminess and chewiness from the texture profile analysis were highly significantly correlated with each other. There was a significant correlation between cooked and raw moisture contents and between cooked and raw fat contents (r>0.99). Purge loss was positively correlated with moisture content, sensory juiciness and greasiness.

CONCLUSION

Low-fat (<10%) frankfurters with quality and taste comparable to, or better than, those with normal fat content can be produced with carrageenan, isolated soy protein or modified starch. Modified starch seemed to be most beneficial in controlling purge loss and improving the texture of low-fat products.

Table 1: Proximate analysis, purge loss and sensory and instrumental evaluation of low-fat frankfurters containing fat substitutes

	Control				Carrageenan			Isolated soy protein			Modified starch		
	1	2	3	4	0.5%	1.0%	1.5%	1.0%	2.5%	4.0%	2.0%	3.5%	5.0%
Fat (%)	21.7a	22.3a	9.1b	9.4b	9.2^{34}	8.9^{34}	8.6^{3}	9.2^{34}	9.1^{34}	9.0^{34}	9.0^{34}	8.5^{3}	7.7
Moisture (%)	62.1c	59.9d	78.2a	73.7b	77.8^{3}	77.5^{3}	76.9	77.4^{3}	76.2	74.6	76.4	75.3	73.9^{4}
Purge loss (%)	2.7c	2.1c	7.9a	5.6b	6.5^{4}	5.2^{4}	4.5	6.5^{4}	5.2^{4}	4.8^{4}	5.2^{4}	3.1^{1}	2.3^{12}
Sensory evaluation													
Firmness	5.5a*	5.1a	3.1b	5.2a	$3.4^{3\#}$	4.2	4.6^{2}	3.3^{3}	4.0	5.3^{124}	3.5^{3}	4.4	4.7^{24}
Springiness	4.6a	4.4a	3.1b	4.8a	3.4^{3}	3.7^{3}	4.0^{12}	3.4^{3}	3.8^{23}	4.8^{124}	3.2^{3}	3.8^{23}	4.4^{124}
Cohesiveness	5.7a	5.6a	3.8b	5.6a	3.9^{3}	4.6	4.8	3.8^{3}	4.6	5.8^{124}	3.9^{3}	4.8	5.3^{124}
Juiciness	4.0bc	3.6c	5.9a	4.1b	5.8^{3}	5.3	5.1	5.7^{3}	5.4	4.6	5.0	4.5^{4}	4.0^{124}
Spice flavour	4.4ab	3.9b	4.7a	4.9a	4.8^{134}	5.1^{34}	5.1^{34}	5.0^{34}	4.9^{134}	4.9^{134}	4.7^{134}	4.7^{134}	4.8^{134}
Overall palatability	5.6	5.1	5.1	5.5	4.8	5.9	5.3	5.1	5.8	5.7	5.0	5.5	5.1
Texture profile analysis													
Fracturability (N)	60.2a	63.7a	37.9b	62.8a	$36.8^{3\#}$	49.7	53.3	39.6^{3}	47.0	57.4^{1}	49.9	53.4	60.7^{124}
First bite hardness (N)	69.0a	67.7a	38.3b	64.2a	40.0^{3}	45.5	48.5	46.7	52.7	67.2^{124}	46.3	45.2	52.4
Cohesiveness	0.85	0.84	0.86	0.83	0.88^{13}	0.88^{13}	0.90	0.86^{1234}	0.85^{1234}	0.87^{123}	0.80^{4}	0.82^{124}	0.80^{4}
Springiness	11.3a	10.5b	8.8c	11.2a	8.5^{3}	9.0^{3}	8.9^{3}	9.1^{3}	9.8	11.0^{124}	10.0^{2}	10.1^{2}	10.9^{124}
Gumminess	11.8a	10.2b	6.7c	10.8ab	5.8^{3}	6.3^{3}	6.4^{3}	8.3	9.2^{2}	11.9^{14}	7.1^{3}	6.5^{3}	7.5^{3}
Chewiness	0.13a	0.11b	0.06c	0.12ab	0.05^{3}	0.06^{3}	0.06^{3}	0.08	0.09	0.13^{14}	0.07^{3}	0.07^{3}	0.08

* Means of the controls within the same row with the same letter are not significantly different (P > 0.05). # Means of the low-fat treatments containing a fat substitute within the same row with Number 1, 2, 3, or 4 are not significantly different from Control 1, 2, 3, or 4 (P > 0.05).