The Effect of Omega-3 Rich Oils on Functionality, Quality and Consumer Acceptance of Low- and High-Fat Bologna

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***Abstract*— The effects of substituting pork fat with three omega-3 rich oils (canola, flax or fish) on functionality, quality, and consumer acceptance of low- (LF, 10%) and high-fat (HF, 22%) bologna were investigated. Measurements included cook yield, expressible moisture, purge during simulated retail display, colour (CIE *L*a*b** values) and texture profile analysis parameters. Consumer (N=74) acceptance of bologna aroma, appearance, colour, flavour, juiciness, firmness, texture, and overall acceptability was evaluated on 9-point hedonic scales. Generally, LF bolognas were darker, with poorer binding properties, than HF formulations. Loss of functionality due to the substitution of fat with water in LF bologna was partially overcome by the addition of canola oil, which improved hydration properties and resulted in colour values to levels equivalent to HF bologna. Higher fat content improved flavour and juiciness acceptability and masked differences in flavour and juiciness acceptability amongst oil types. In HF bologna, the fatty acid profile could be customized using any of the oils without a detrimental effect on consumer acceptance. Of the three oils tested in LF products, canola was most effective; consumer acceptance was similar to HF bologna. Results indicated that enhancement of low-fat bologna with omega-3 rich oils can maintain product functionality without compromising consumer acceptance.**

Keywords— **Bologna, omega-3, acceptability.**

I. INTRODUCTION

The growing demand by consumers for healthier products is stimulating the development of processed meat products with reduced fat content and/or altered fatty acid profiles. Developing reduced fat products is not, however, as simple as just removing the fat. Fat provides succulence, texture, and flavour, all of which are altered if fat is removed, resulting in meat products with a rubbery, dry texture [6, 9].

Strategies to reduce animal fat usage in meat products have included the use of omega-3 rich oils as a substitute for animal fat, giving rise to products with an improved fatty acid profile and lower cholesterol level compared to traditional ones [8]. It is conceivable that incorporation of relatively small amounts of oils containing omega-3 fatty acids into meat products would result in consumer acceptable reduced fat products with nutritionally significant levels of these bioactive lipids.

The objective of this study was to determine the effects of substituting pork fat with three omega-3 rich oils (canola, flax or fish) on functionality, quality, and consumer acceptance of low- (LF, 10%) and high-fat (HF, 22%) bologna.

II. MATERIALS AND METHODS

The study was set up as a completely randomized design with a 2 x 4 complete factorial arrangement of treatments. The main effects investigated were: fat (F) level (LF, 10% and HF, 22%) and type of oil (source of omega-3) addition (C- control, CO-canola oil, FX – flaxseed oil, FI – fish oil).

Beef trim (84:16) and pork back fat were separately ground through a 3 mm plate (K & G Wetter, Model AW114, Mississauga, ON, Canada). Meat protein was adjusted to a constant level of 11% in all formulations by adding water and shredded ice. The both low- and high-fat bolognas were formulated to contain 5.0% canola oil (Bunge Canada, Oakville, ON), 1.0% flaxseed oil (Shape Foods, Brandon, MB) or 2.0% fish oil (Ocean Nutrition Canada, Dartmouth, NS). The required quantities of ground beef, ground pork fat, spices (Newly Weds Foods, Edmonton, AB), ice/water, and, where required, oil ingredients were combined and mixed at high speed under vacuum (-0.8 bar) in a 30 L bowl silent cutter (Seydelmann, Stuttgart, Germany). The final temperature of the

batter never exceeded 10°C. The total amount of each batch was 10 kg. The mixture was then vacuum stuffed (Handtmann, Model VF80, Waterloo, ON, Canada) into fibrous casings (105 mm diameter) at full vacuum. Casings were tensioned and clipped, and the bologna sausages were thermally processed in a smokehouse (Maurer & Söhne, Insel Reichenau, Germany) to a final internal temperature of 72°C. The product was then cooled in running water until a core temperature of 30°C was reached and stored at 1°C. Following overnight storage, each chilled meat chub was removed from its casing and weighed to determine cook yield. One chub per formulation was prepared as 3 mm slices that were vacuum packed (10 slices per package) in high-barrier, mylar/polyethylene pouches (Ulma TF-Supra packaging machine, CyE.S. Coop Ltd., ONATI, Spain). The remainder was vacuum packaged whole and all samples were stored at 1°C until sampling for sensory and instrumental evaluations. The variables measured on bologna included: pH, cook yield (% of the raw stuffed weight), expressible moisture (EM) and purge during simulated retail display. Instrumental texture profile analysis was performed on bologna samples using an Instron texture analyzer. Five center cores (22 mm in diameter, 15 mm height) of bologna samples were compressed twice to 30% of their original height at a constant cross-head speed of 60 mm/min. Colour of the meat gels was measured using a Konica CM-2500C spectrophotometer and expressed as CIE L^* (lightness), a^* (redness) and b^* (yellowness) values. Consumer (N=74) acceptance of bologna appearance, colour, flavour, juiciness, firmness, texture, and overall acceptability was evaluated on 9-point hedonic scales.

Data were analyzed as a 2x4 factorial design with two fat levels (10 and 22%) and four oil treatments (source of omega-3) (C, CO, FX, FI) as main factors. The Least Significant Difference test at P=0.05 was used to determine differences between treatment means.

III. RESULTS AND DISCUSSION

The pH values of the raw meat batters and cooked products ranged from 6.13 to 6.18 and 6.25 to 6.29, respectively. In general, none of the treatments had any effect on pH of the raw and cooked products. The raw low fat batters had slightly lower pH compared to regular fat bologna batters.

Generally, reduction of fat content resulted in lower cook yield and decreased the hydration properties of bolognas, resulting in significantly higher expressible moisture (EM) and purge losses in LF formulations compared to HF samples (Fig. 1). The present results are consistent with reports of increased weight losses when fat reduction is accompanied by an increase in the proportion of moisture [4, 5, 10, 11].

Cooking yield was not affected (P>0.05) by incorporation of oils. Incorporation of oils had no significant (P>0.05) effect on the water holding capacity of HF bolognas, as determined by EM and purge from packaged slices during storage, however, in LF products, addition of canola oil improved moisture retention compared to control.

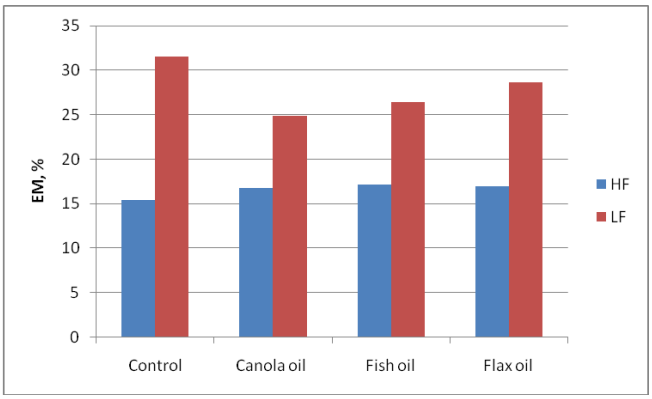

Figure 1. Effect of oil type and fat level on expressible moisture from bologna

Formulation treatment had a significant effect (P<0.05) on the instrumental textural properties of the bologna sausages (Table 1). The canola oil treatment was harder and chewier than the control, but not different from bologna containing flax or fish oils. High fat bologna samples were softer and less springy and chewy compared to their low fat counterparts. Numerous authors have also found low fat comminuted products to be tougher than higher fat formulations [1, 3, 7, 10]. Most researchers report that fat reduction in frankfurters and bologna results in products that are firmer, chewier, and more rubbery; however, when a decrease in fat content is

accompanied by increase in water, products with the opposite characteristics can be obtained [2, 4].

Table 1. Effect of oil type and fat level on textural characteristics of bologna.

	HD[x] (N)	COH	SPR (mm)	CHEW (Nmm)
Oil Type				
C	28.2b	0.26	5.67	42.9b
CO	39.8a	0.27	6.78	78.4a
FI	33.3ab	0.26	6.17	54.6b
FX	34.5ab	0.24	5.68	47.3b
P	*0.01*	*0.20*	*0.13*	*0.02*
Fat level				
HF	30.7	0.25	5.60	44.0
LF	37.2	0.27	6.55	69.1
P	*0.01*	*0.16*	*0.01*	*0.00*

a, b, Means with different letters in the same column (within each main effect) are significantly different ($P<0.05$).
[x]HD=Hardness; COH=Cohesiveness; SPR=Springiness; CHEW=Chewiness

As expected, the colour of the bolognas was directly related to the fat content, with HF samples being significantly ($P<0.05$) lighter, more yellow and less red compared to LF bolognas. This darker appearance was likely due to a reduction in the overall light scattering properties associated with fat.

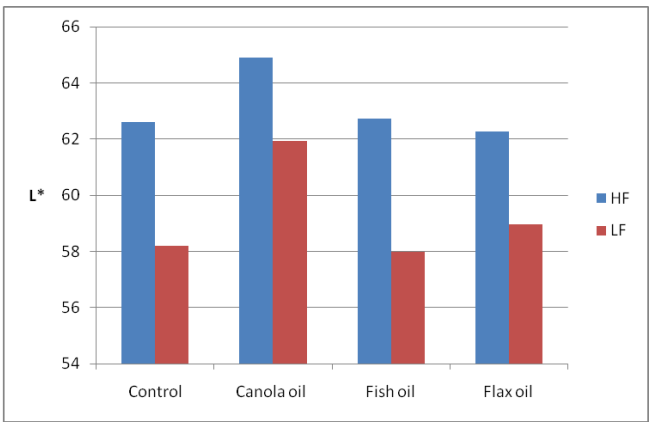

Figure 2. Effect of oil type and fat level on lightness (L^*) of bologna

Regardless of fat level, bologna samples containing canola oil were lighter (larger L^*) and less red (lower a^*) compared to other treatments. Colour of LF canola oil treatment was equivalent to HF control bologna.

Consumer acceptability of bologna appearance and colour were unaffected by fat level and oil type (Table 2). Increasing bologna fat level improved flavour acceptability of the control bologna and resulted in equivalence in flavour and juiciness acceptability across oil types. Therefore, in high fat bologna, the fatty acid profile could be customized using any one of the oils without a detrimental effect on flavour or juiciness. If a low fat product was targeted, the canola oil formulation represents a significant improvement in juiciness over the control product while both canola and flax oil improved low-fat bologna flavour. Firmness, texture, and overall acceptability were influenced by oil type, with the canola oil formulation representing a significant improvement over the control product.

IV. CONCLUSIONS

Except for improving fatty acid profile, the incorporation of omega-3 rich oils did not provide additional benefits compared to control samples in HF bologna formulations. Of the three oils tested in LF products, canola was most effective, bringing consumer acceptance on par with HF bologna. Results indicated that enhancement of low-fat bologna with omega-3 rich oils can maintain product functionality without compromising consumer acceptance.

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Table 2**.** Mean scores for main effects of fat level and oil type for various bologna acceptability characteristics

Treatment		Acceptability scores[1]						
		Appearance	Colour	Flavour	Juiciness	Firmness	Texture	Overall
Fat level								
HF		6.1	6.3	6.4	6.6	6.2	6.2	6.2
LF		6.1	6.3	6.2	6.5	6.2	6.1	6.0
P-value		*0.90*	*0.51*	*0.08*	*0.26*	*0.77*	*0.41*	*0.06*
Oil type								
C		6.1	6.2	6.1	6.3 b	5.9 b	5.7 b	5.8 b
CO		6.1	6.3	6.4	6.7 a	6.5 a	6.5 a	6.4 a
FI		5.9	6.2	6.3	6.5 ab	6.2 ab	6.1 ab	6.0 ab
FX		6.3	6.5	6.3	6.6 ab	6.2 ab	6.0 ab	6.2 ab
P-value		*0.10*	*0.12*	*0.13*	*0.03*	*<0.01*	*<0.01*	*<0.01*
Fat x Oil								
HF	C	6.2	6.2	6.4 a	6.5 ab	6.0	5.9	6.0
	CO	5.9	6.2	6.4 a	6.5 ab	6.5	6.4	6.4
	FI	5.9	6.3	6.4 a	6.6 ab	6.1	6.2	6.2
	FX	6.5	6.6	6.3 ab	6.6 ab	6.1	6.1	6.3
LF	C	6.0	6.2	5.7 b	6.1 b	5.8	5.6	5.5
	CO	6.2	6.4	6.5 a	6.9 a	6.6	6.6	6.4
	FI	6.0	6.2	6.1 ab	6.4 ab	6.3	6.1	5.9
	FX	6.1	6.4	6.4 a	6.5 ab	6.2	5.9	6.2
P-value		*0.15*	*0.78*	*0.01*	*0.05*	*0.48*	*0.37*	*0.38*

[1]Scored on 9-point hedonic scales where 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=like extremely

a, b, Within a column and within a treatment effect, mean values followed by different letters are significantly different ($P \leq 0.05$)

REFERENCES

1. Barbut, S., & Mittal, G. S. (1996). Effects of three cellulose gums on the texture profile and sensory properties of low fat frankfurters. Int J Food Sci Tech, 31, 241-247.
2. Bloukas, J. G., & Paneras, E. D. (1993). Substituting olive oil for pork backfat affects quality of low-fat frankfurters. J Food Sci, 58, 705-709.
3. Bloukas, J. G., Paneras, E. D., & Papadima, S. (1997). Effect of carrageenan on processing and quality characteristics of low-fat frankfurters. J Muscle Foods, 8, 63-83.
4. Carballo, J., Mota, N., Baretto, G., & Colmenero, F. J. (1995). Binding properties and colour of bologna sausage made with varying fat levels, protein levels and cooking temperatures. Meat Sci, 41, 301-313.
5. Claus, J. R., & Hunt, M. C. (1991). Low-fat, high-water added bologna formulated with texture-modifying ingredients. J Food Sci, 56, 643-647, 652.
6. Colmenero, F. J. (1996). Technologies for developing low-fat meat products. Trends Food Sci Tech, 7, 41-48.
7. Hand, L. W., Hollingsworth, C. A., Calkins, C. R., & Mandigo, R. W. (1987). Effects of preblending, reduced fat and salt levels on frankfurter characteristics. J Food Sci, 52, 1149–1151.
8. Jimenez-Colmenero, F., Carballo, J., & Cofrades, S. (2001). Healthier meat and meat products: their role as functional foods. Meat Sci, 59(1), 5−13.
9. Keeton, J.T. (1994). Low-fat meat products - technological problems with processing. Meat Sci, 36, 261-276.
10. Pietrasik, Z. (1999). Effect of content of protein, fat and modified starch on binding and textural characteristics, and colour of comminuted scalded sausages, Meat Sci, 51 (1), 17-25.
11. Youssef, M. K., & Barbut, S. (2011). Fat reduction in comminuted meat products-effects of beef fat, regular and pre-emulsified canola oil. Meat Sci, 87, 356-360.