PE9.23 Characteristics of nutritionally enhanced frankfurters 162.00

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***Abstract*—An increase in consumer concern over dietary fat intake in recent years has prompted the development of novel technologies to the alter fatty acid composition of some popular muscle foods. We hypothesized that replacement of beef fat by a lipid blend comprised of beef tallow, edible oil and a rosemary extract would enhance the fatty acid composition of frankfurters while maintaining processing characteristics, shelf life and sensory attributes. Treatment and control frankfurters were formulated to contain 20% fat by combining lean beef trimmings (3% fat) and fat beef trimmings (44%,CT) or a mixture (17% addition) of 57% beef tallow, 43% high oleic safflower oil (SO), olive oil (OO) or corn oil (CO) and 0.3% of a rosemary extract antioxidant. SO, OO and CO all displayed higher values than CT for instrumental tenderness determinations, although no differences were seen for trained sensory texture analysis. TBA values were not different between the control and treatment frankfurters. Both internal and external color space determinations showed SO, OO and CO to have higher L* and b* values than CT. Control frankfurters had more myristic (14:0) and palmitic (16:0) acid than SO, OO and CO. SO and OO had the highest MUFA:SFA ratios. Incorporation of a lipid blend containing beef tallow, edible oil, and a rosemary extract antioxidant could be beneficial in the manufacture of nutritionally enhanced frankfurters.**

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***Index Terms*— frankfurters, fat replacement, fatty acids**

I. INTRODUCTION

THE importance of dietary fat intake to the health of consumers has increased in recent years. Although red meat products play an important role in human health, they are often viewed by consumers as promoting cancer, diabetes and cardiovascular diseases [1]. The high amount of saturated fatty acids and lack of long chain n-3 PUFA in red meat, which are known to contribute to the pathogenesis of some cancers and cardiovascular diseases [2,3], has helped to promote this image. It, however, is an image can be changed through the development of technologies to alter the fatty acid profile of red meat products.

Frankfurters are an emulsified sausage product containing up to 30% fat that accounted for approximately 1.6 billion dollars in sales in 2007 [4]. The enormous popularity of this product combined with its ability to emulsify fat make it an ideal platform for attempts to produce a healthier red meat product by altering fatty acid composition. This is evidenced by the large body of previous work [5,6,7,8] investigating the effects of adding more unsaturated fatty acids, through the use of vegetable or marine oils, to frankfurters. Although a general shift from saturated to unsaturated fatty acids is desirable from a nutritional standpoint, it has often presented problems including reduced shelf life, altered appearance or texture and undesirable sensory attributes [9].

A lipid blend formulated by Rhoades et al. [10] consisting of beef tallow and high oleic safflower oil displayed a texture and appearance similar to beef intramuscular fat while also possessing a high amount of monounsaturated fatty acids. A mixture such as this could be useful in an effort to produce a product texturally similar to a traditional frankfurter, but containing more unsaturated fatty acids.

The objective of this study was to evaluate the textural, shelf life and sensory characteristics of a beef frankfurter formulated with a blend of beef tallow and vegetable oils when compared to control frankfurters.

II. MATERIALS AND METHODS

Lipid blends were manufactured by combining portions of beef tallow (BT) with either high oleic safflower oil (SO), olive oil (OO), or corn oil (CO) in a bowl chopper to achieve a 57% BT/43% oil blend. A rosemary antioxidant was added at 0.3%. Blends were chopped for 45 seconds at 2000 rpm before being evacuated and frozen (-10˚C) in a plastic container. Once the blend was frozen it was removed from the container and vacuum packaged for frozen storage. Before being added to the ground beef, the lipid blends were cut into fist-sized pieces and chopped in the bowl chopper at 2000 rpm for 15 seconds.

Beef lean trim (2% fat) and beef plates (44% fat) were ground separately through a 0.95 cm plate, vacuum packaged, and stored (0˚C) until further use. Treatment and control (CT) batches of 13.6 kg were formulated to 20% total fat. For the treatment and control batches, lean beef was chopped for 2 min at 2000 rpm with salt, Prague powder (6.25% sodium nitrite), and sodium phosphate. The ground beef plate (CT) or chopped lipid blend (SO, OO, CO) were added and the batter was chopped for an additional 2 min at 4000 rpm.

The emulsion was stuffed by a Handtmann vacuum stuffer into 30 mm cellulose casings. An automatic linking mechanism was used to create 86 g individual links. Frankfurters were weighed, and then cooked in an Alkar single truck smokehouse to 71˚C internal temperature. No smoke was applied so that differences in external color could be detected. Cooked frankfurters were showered to 38˚C before being stored overnight at 4˚C. Chilled frankfurters were reweighed to determine cook yield and removed from their casings by hand before being vacuum packaged until further analyses were performed.

Proximate composition, including fat, moisture and protein, was determined using modified methods of AOAC [11]. Fat and moisture were determined using the air-dry oven and soxhlet ether extraction method, while protein was determined using a Leco nitrogen analyzer.

Torsion analysis was performed as described by Kim et al. [12]. Shear stress and strain at gel failure was determined. Texture Profile Analysis (TPA) was performed using the procedure of Bourne [13] by compressing 14 mm frankfurter discs to 50% of their original height. Hardness-1 (first bite), hardness-2 (second bite), cohesiveness and gumminess were determined.

The thiobarbituric acid test of Tarladis et al. [14] as modified by Rhee [15] was used to determine lipid oxidation on days 0, 7, 14, 28 and 56 of the study. CIE L^*, a^* and b^* values were determined on the external and internal cut surface of frankfurters using a Hunter Miniscan XE colorimeter using illuminant *A* with a 10˚ observer. Color measurements were taken on days 0, 7, 14, 28 and 56.

Lipids were extracted by the method of Folch et al. [16] and methylated by the method of Slover and Lanza [17]. Methylated lipids were extracted on a gas chromatograph and quantified as g fatty acid/100 g total fatty acids identified.

A five member trained sensory panel was selected and trained according to AMSA [18] and Meilgaard et al. [19]. Frankfurters were steeped in boiling water for 5 min before being removed, cut into 1.27 cm slices and served immediately to panelists.

Data analysis was conducted using the MIXED model of SAS (Version 9.2, SAS Institute, Cary, NC). The experiment was designed as a randomized complete block design using processing day (replication) as the block. Lipid blend treatment (CT, SO, OO, CO) was used as a fixed effect. Shelf life analyses (lipid oxidation and color) included storage day as a fixed effect. Tukey's studentized range test was used to separate means at $P < 0.05$.

III. RESULTS AND DISCUSSION

Final cook yield (Table 1) ranged from 89.1% (OO) to 91.1% (SO) and was not significantly affected ($P > 0.05$) by treatment.

Fat percentage (data not shown) of cooked frankfurters was not affected ($P > 0.05$) by treatment, but all were lower than the 20% formulated target (15.88-16.35%). CT was higher ($P < 0.05$) than all lipid blend treatments for cooked protein percentage (data not shown). Cooked moisture percentage (data not shown) did not differ between treatments.

Torsion analysis data is presented in Table 1. Stress (kPa) values at failure ranged from 30.72 (CT) to 33.78 (CO) but no significant ($P > 0.05$) differences were seen. Similarly, differences in strain at gel failure displayed no significance ($P > 0.05$) with CO possessing the highest value (2.03). Overall, torsion analysis showed no impact on texture due to the addition of blended lipid solutions.

Texture profile analysis values of cooked frankfurters are presented in Table 1. Control frankfurters were lower than all lipid blend treatments ($P < 0.01$) for hardness-1, hardness-2, cohesiveness and gumminess. CO was lower ($P < 0.01$) than SO and OO for hardness-1, hardness-2 and gumminess, but not significantly lower for cohesiveness. Overall, frankfurters formulated with lipid blends showed increased hardness for instrumental tenderness.

TBA values (Table 1) ranged from 0.15 to 0.18 mg malonaldehyde/kg meat, but no significant differences were seen ($P > 0.05$) for the fixed effects of day or lipid blend treatment. All values were below the threshold TBA value of 1, the point at which a product is considered rancid [20].

Means for color space values are presented in Table 1. L^* (lightness) values for the external and internal cut surface were higher ($P < 0.05$) for the lipid blend treatments SO, OO, and CO than for CT external and internal values (58.35 and 62.43, respectively). Redness, indicated by a^* values, was not affected by treatment for the external or internal cut surface. Yellowness values (b^*) displayed a similar pattern to the lightness values, with CT possessing significantly lower ($P < 0.05$) internal and external b^* values (12.83 and 21.04, respectively) than the lipid blend treatments. Objective color data would seem to indicate that use of the lipid blends imparted a slightly lighter and more yellow color to the frankfurters.

Trained sensory analysis (data not shown) for the basic tastes salt and sweet revealed no significant differences. Cooked beef lean and cooked beef fat were also not significantly different between treatments. Springiness, fracturability, hardness, and cohesiveness, as determined by trained sensory panel, were also not affected by lipid blend treatment.

Means for fatty acid composition are presented in Table 2. Differences due to lipid blend treatment were seen in six different fatty acids (14:0, 16:0, 18:0, 18:1, 18:2 and 18:3). Use of the lipid blend treatments resulted in much lower ($P < 0.01$) values for both 14:0 and 16:0. SO frankfurters contained more ($P < 0.05$) 18:1 (54.43%) than all other treatments. As expected, the CO frankfurters contained the most 18:2 (22.95%), with significant differences ($P < 0.01$) from SO (7.59%) and CT (2.91%). Control frankfurters contained more ($P < 0.05$) 18:3 (0.68%) than SO, OO or CO (0.57, 0.57 and 0.60% respectively). The highest ($P < 0.05$) MUFA:SFA ratio was in SO frankfurters (1.93).

IV. CONCLUSION

The use of a lipid blend containing beef tallow and various mono- or polyunsaturated oils, was effective in enhancing the fatty acid profile of frankfurters. A blend containing high oleic safflower oil was the most effective in increasing the amount of monounsaturated fatty acids. Shelf life as determined by color and lipid oxidation was not affected by using the lipid blend, nor was cook yield. The instrumental texture differences revealed by TPA analysis were not replicated by trained sensory panelists. Inclusion of a blended lipid solution, especially one containing high oleic safflower oil, would be effective in manufacturing nutritionally enhanced frankfurters.

REFERENCES

[1] Valsta, L. M., Tapanainen, H., & Mannisto, S. (2005). Meat fats in nutrition. Meat Science, 70, 525-530.

[2] Leaf, A., Xiao, Y. F., Kang, J. X., & Billamn, G. E. (2003). Prevention of sudden cardiac death by n – 3 polyunsaturated fatty acids. Circulation, 98, 355–377.

[3] Calder, P. C. (2004). N - 3 Fatty acids and cardiovascular disease evidence explained and mechanisms explored. Clinical Science, 107, 1–11.

[4] American Meat Institute. (2008). The size and scope of the U.S. hot dog market - 2007. http://www.hot-dog.org/ht/d/sp/i/38580/pid/38580

[5] Park, J., Rhee, K. S., Keeton, J. T., & Rhee, K. C. (1989). Properties of low-fat frankfurters containing monounsaturated and omega-3 polyunsaturated oils. Journal of Food Science, 54(3),500-504.

[6] Bloukas, J. G., Paneras, E. D., & Fournitzis, G. C. (1997). Effect of replacing pork backfat with olive oil on processing and quality characteristics of fermented sausages. Meat Science, 45(2),133-144.

[7] Paneras, E. D., Bloukas, J. G., & Filis, D. G. (1994) Production of low-fat frankfurters with vegetable oils following the dietary guidelines for fatty acids. Journal of Muscle Foods, 9(2), 111-126.

[8] Vural, H., Javidipour, I., & Özbas, Ö. Ö. (2004). Effects of interesterified vegetable oils and sugarbeet fiber on the quality of frankfurters. Meat Science, 67(1), 65-72.

[9] Jimenez-Colmenero, F. (2007). Healthier lipid formulation approaches in meat based functional foods. Technological options for replacement of meat fats by non-meat fats. Trends in Food Science and Technology, 18, 567-578.

[10] Rhoades, R. D., Osburn, W. N., & Smith, S. B. (2005). Blended lipid solutions as a functional ingredient to enhance lower quality beef. In Proceedings 51st international congress of meat science and technology (529-535), 7-12 August 2005, Baltimore, MD, USA.

[11] AOAC. (2005). Meat and meat products. In: Cunniff, P, editor. Official methods of analysis of AOAC International. (pp. 1-23). AOAC International:Washington, D.C.

[12] Kim, B. Y., Hamann, D. D., Lanier, T. C., & Wu, M. C. (1986). Effects of freeze-thaw abuse on the viscosity and gel-forming properties of surimi from two species. Journal of Food Science, **51,** 951–956

[13] Bourne, M. C. (1978). Texture profile analysis. Food Technology, 32, 62-66.

[14] Tarladgis,B. G., Watts, B. M., Younathan, M. T., & Dugan, L. R. (1960). A distillation method for the quantitative determination of malonaldehyde in rancid foods. Journal of the American Oil Chemists Society, 37(1), 44–48.

[15] Rhee, K. S. (1978). Minimization of further lipid peroxidation in the distillation 2-thiobarbituric acid test of fish and meat. Journal of Food Science, 43(6), 1776-1778.

[16] Folch, J., Lees, M., & Stanley, G. H. S. (1957). A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry, 226, 497-509.

[17] Slover, H. T., & Lanza, E. (1979). Quantitative analysis of food fatty acids by capillary gas chromatography. Journal of the American Oil Chemists Society, 56, 933–943.

[18] AMSA. (1995). Research Guidelines for Cookery, Sensory Evaluation and Instrumental Measurements of Fresh Meat. American Meat Science Association and National Livestock and Meat Board, Chicago, IL.

[19] Meilgaard M, Civille GV, & Carr BT. (1991). Sensory Evaluation Techniques. CRC Press, Boca Raton, FL.

[20] Younathan, M. T., & Watts, B. M. (1959). Relationship of meat pigments to lipid oxidation. Journal of Food Science, 24(6), 728-34.

Table 1. Least squares means of cook yield, stress (kPa), strain, hardness-1, hardness-2, cohesiveness, gumminess, TBA, internal and external CIE L*, a* and b* color space values for cooked frankfurters formulated to contain 17% of a blended lipid solution composed beef tallow (57%) and various edible oils (43%)

	CT	SO	OO	CO	SEM[d]
Processing data					
Cook Yield (%)	90.76	91.10	89.10	91.06	0.81
Torsion					
Stress (kPa)	30.72	31.21	32.90	33.78	3.12
Strain	1.70	2.03	1.74	1.86	0.12
TPA[e]					
Hardness-1	57.17[c]	90.17[a]	90.87[a]	82.73[b]	1.16
Hardness-2	34.67[c]	64.73[a]	64.73[a]	59.07[b]	1.28
Cohesiveness	0.31[b]	0.43[a]	0.43[a]	0.41[a]	0.01
Gumminess	16.55[c]	39.26[a]	38.73[a]	34.30[b]	1.06
Lipid Oxidation					
TBA[f]	0.18	0.15	0.17	0.18	0.01
Internal Color[g]					
L*	58.35[b]	61.13[a]	61.17[a]	61.32[a]	0.26
a*	23.70	23.70	23.47	23.55	0.35
b*	12.83[b]	14.98[a]	15.09[a]	14.92[a]	0.11
External Color[g]					
L*	62.43[b]	65.26[a]	64.96[a]	64.86[a]	0.50
a*	24.16	24.11	23.88	24.40	0.52
b*	21.04[b]	22.83[a]	23.06[a]	23.34[a]	0.26

[a-c]Means with differing superscripts within a row are significantly different ($P < 0.05$)
[d]Standard error of the mean
[e]Texture profile analysis
[f]Thiobarbituric acid reactive substances; mg malonaldehyde/kg of meat
[g]L* = lightness; a* = redness; b* = yellowness

Table 2. Least squares means of fatty acid composition (% of total fatty acids) for cooked frankfurters formulated to contain 17% of a blended lipid solution composed beef tallow (57%) and various edible oils (43%)

Fatty Acid		CT	SO	OO	CO	SEM[d]
Myristic	14:0	3.07[a]	1.52[b]	1.40[bc]	1.37[c]	0.03
Palmitic	16:0	24.33[a]	16.21[b]	17.04[b]	17.87[b]	0.43
Stearic	18:0	12.33[a]	10.90[b]	11.50[b]	10.92[b]	0.13
Oleic	18:1	41.04[bc]	54.43[a]	43.49[b]	35.41[c]	1.55
Linoleic	18:2	2.91[c]	7.59[bc]	14.99[ab]	22.95[a]	2.33
Linolenic	18:3	0.68[a]	0.57[b]	0.57[b]	0.60[b]	0.01
n6:n3 Ratio[e]		4.29[b]	13.42[b]	25.90[ab]	38.68[a]	4.75
MUFA:SFA Ratio[f]		1.20[c]	1.93[a]	1.52[b]	1.24[c]	0.03
PUFA:SFA Ratio[f]		0.10[c]	0.29[c]	0.53[ab]	0.77[a]	0.08

[a-c]Means with differing superscripts within a row are significantly different
[d]Standard error of the mean
[e]Ratio of n-6 to n-3 fatty acids
[f]Ratio of monounsaturated fatty acids to saturated fatty acids
[g]Ratio of polyunsaturated fatty acids to saturated fatty acids