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Using fluid whey in comminuted meat products: effects on technological, chemical and sensory properties of frankfurter-type sausages

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Abstract

The possibility of using fluid whey to replace ice in frankfurter formulation was studied and some technological, chemical and sensory quality properties of these sausages were determined. Results showed no statistically significant differences in most technological, chemical and sensory parameters determined. However, emulsion stability rate was significantly increased by liquid whey addition to the formulation. A slight increase in ash content and pH value was also observed with liquid whey addition. Even 100% whey replacement did not produce any adverse effects in cooked sausage sensory properties. Present results suggest natural fresh liquid whey can be added to frankfurter-type sausage formulations to improve the environment by utilizing a valuable animal product, often wasted, to create a valuable food product at minimal cost.

Keywords: Liquid whey; Comminuted meat processing

1. Introduction

High protein, non-meat additives have been evaluated for use in emulsion-type meat products to produce less expensive, more stable, more acceptable textural and nutritional properties in food products (Comer & Allan-Wojtas, 1988; Müller, 1998; Yetim, Gokalp, Kaya, Yanar, & Ockerman, 1992; Zorba, Naes, & Baardseth, 1995). Increasing the utilization of dairy products as ingredients in formulated food applications has been investigated (Demott, Helms, & Sanders, 1977; Ellekjaer, Naes, & Baardseth, 1996; Hoven, 1987; Mann, 1985). Milk proteins are good moisture binders when used in meat processing, although they have a lower emulsifying capacity on a soluble protein basis (Mittal & Usborne, 1985; Zorba et al., 1995).

Whey has a promising potential for use in food formulations and is usually opaque or greenish yellow in color, with total solid of 6.5–7.0%, and a biological oxygen demand (BOD) of 32 000 or higher. Fresh whey contains approximately 93% water and 7% solids: 5% lactose, 1% protein and 1% minerals (Kosikowski, 1982; Uraz, Yetismeyen, & Atamer, 1990). There has been little use made of liquid or concentrate whey. For example, currently, about 118 million tones of fluid whey are generated annually, but only about 62% of this liquid is currently being utilized as food or feed production (de Wit, 1998; Marriott, Wang, Claus, & Graham, 1998). Whey constitutes a massive potential food source, and as long as whey is not fully utilized by man or animals, this is a tragedy in a world concerned with a shortage of food.

Liquid whey is nutritionally rich, containing 50% of the nutrients of the whole milk, but it is considered an expensive and frustrating disposal problem (Kosikowski, 1982; Uraz et al., 1990). Whey is often dumped because of lack of technology to process it, due primarily to the cost of concentrating or drying. Liquid whey could be used directly in many food formulation, and could also be converted into a variety of protein concentrates, through electrodialysis, ion-exchange, gel filtration, metaphosphate complexing, reverse osmosis or ultrafiltration techniques (Ensor, Mandigo, Calkins, & Quint, 1987; Marriot et al., 1998).

Concern exists with lactose, which may produce discoloration in meat products, due to the Maillard

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reaction (Mortensen, 1986), whey products have nutritional and functional proteins which are available at relatively low prices. Whey proteins are an excellent source of essential amino acids, particularly lysine, which may be beneficial in frankfurter manufacture, resulting in a more balanced amino acid composition than with full meat controls (Holsinger, Posati, & Pallansch, 1971; Lee, Cannon, & Huffman, 1980). Research has been conducted to utilize this economic protein source in different meat products, and to study the effects of different milk or whey proteins on the quality of comminuted meat products (El-Magoli, Laroia, & Hansen, 1996; Hoogenkamp, 1986; Lauck, 1975; Zorba et al., 1995), but most research has utilized either dry milk products or model systems, instead of practical meat emulsion systems.

Information on the feasibility of incorporating unconventional fluid whey into comminuted meat products is not widely available (Baardseth, Naes, Mielnik, Skrede, Holland, & Eide, 1992; Marriot et al., 1998; Mortensen, 1986; Zorba et al., 1995). As previously mentioned, a tremendous need exists to utilize whey proteins or products in food processing to prevent wasting this valuable protein and mineral source. Marriot et al. replaced water with liquid whey in restructured boneless ham cure formulations, and reported up to 30% liquid whey may successfully be incorporated into cured ham formulations, and resulted in similar appearance, flavor and stability as non-whey controls. It is also important to obtain reliable, practical, technical and scientific information concerning fluid whey incorporation into comminuted meat systems, to produce higher quality emulsion-type cooked meat products. The meat industry currently uses more expensive whey protein concentrates (WPC) or dried whey powders, but not fluid whey in comminuted meat products. Therefore, the objectives of this experiment were to explore the possibility of incorporating liquid whey into a frankfurter-type meat product, and to assess the influence on some technological, chemical and sensory quality characteristics of the product.

2. Materials and methods

2.1. Sausage processing

Fat and lean from a 3 year old steer provided by a meat packer in Kulmbach Germany, and whey donated by a cheese plant in Bayreuth, Germany were used for frankfurter production. The basic formulations of the trial sausage batters are tabulated in Table 1 with a total mix of 10 kg, which was cutter capacity. All ingredients including spice and curing ingredients were identical for all batches, except for ordinary ice or liquid whey. The fluid whey contained 5.8% dry matter, of which 0.25% was fat, 0.75% was protein, 0.55% was ash and 4.25%, was lactose. Liquid whey was used to substitute for 0, 25, 50, 75 and 100% of the ice (Table 1), after being cooled to 0–1°C before adding to the batter formulation. Emulsifying, stuffing, smoking, cooking and other technological aspects of sausage production were as described by Yetim et al. (1992) and Müller (1998). During emulsion formation the temperature was kept at 11–12°C using liquid nitrogen. Each batch was stuffed into two different casing materials (natural sheep and artificial fibrous casing).

Table 1
Formulation of fluid whey frankfurters

	Percent fluid whey substituted for ice				
Ingredients (kg)	0	25	50	75	100
Lean beef	5.00	5.00	5.00	5.00	5.00
Fatty tissue	2.00	2.00	2.00	2.00	2.00
ICE	2.700	2.025	1.350	0.675	0
Cold whey	0	0.675	1.350	2.025	2.700
Cure mix[a]	+	+	+	+	+
Spice mix[b]	+	+	+	+	+
Starch[c]	+	+	+	+	+
Total batch (kg)	10	10	10	10	10

[a] 175 g salt containing 200 ppm $NaNO_2$, 30 g K_2HPO_4, 12 g table sugar, 3 g ascorbic acid.
[b] 12 g black pepper, 6 g red pepper, 6 g coriander, 3 g coconut, 3 g ginger (all powder).
[c] 50 g potato starch.

2.2. Emulsion evaluation and stability determination

Visual characteristics (uniformity and consistency of phases) of the batters or prepared emulsions were evaluated visually by three panelists (average 10 years experience) from the research team with respect to texture and smoothness (1 = fine, 9 = coarse) and viscosity (1 = liquid, 9 = firm). The centrifugation method was utilized for emulsion stability determination, as described by Ockerman (1985). The pH of the batter was determined using the AOAC (1990) standard method.

2.3. Physical, chemical and sensory evaluation of the sausages

These analyses were performed the day after production, except for cooking yield which was determined by weighing the sausages before and immediately after cooking (Yetim et al., 1992). Proximate composition (% moisture, fat, protein and ash) and pH were determined by the standard methods of AOAC (1990).

2.4. Sensory evaluations

Organoleptic characteristics of the boiled and/or broiled products were evaluated using nine-point hedonic scale for: texture (9 = very fine, 1 = very coarse),

color [9 = bright pink, 1 = faded (not pinkish)], flavor and aroma (9 = typical frankfurter flavor and aroma, 1 = atypical frankfurter flavor and aroma), off-flavor and aroma (9 = no off-flavor, 1 = very intensive off-flavor) and juiciness (9 = Optimum juiciness, 1 = Very dry or very juicy). Panel tests were conducted in an appropriately designed sensory panel room. Six to eight panelists (average 5 years meat product assessment experience) were used to evaluate the boiled (5 min in tap water) and/or broiled (3 min in a 250°C oven) sausages, and the panelists were informed how to evaluate or identify sensory attributes and what the methods used as described by AMSA (1978). In addition, the sausages were offered to members of the institute (BAFF), and their responses were considered to constitute a small-scale consumer panel evaluation.

2.5. Statistical analysis

Collected data was subjected to one-way ANOVA. Significant treatment and interaction means were separated using the Duncan's multiple range test (Duzgunes, 1982).

3. Results and discussion

3.1. Batter emulsion stability

The panel indicated the control group (0% whey) and treatment groups (25, 50, 75 and 100% whey replacing ice) had similar consistency, fine texture and smoothness. No indication of emulsion breakage was noted. However, the amount of separated water and fat and the emulsion stability ratio of the treatment batches was sometimes significantly different. However, no difference was observed in pH of the sausage batters (Table 2). Based on the data presented in Table 2, all batters had acceptable stability, and treatment batters generally had more acceptable emulsion properties in terms of separated fat, water and stability. For example, as the liquid whey increased in the formulation, the separated water and fat generally decreased causing the stability to increase (Table 2). Whey replacement of 100% of the ice in this sausage formulation gave the most satisfactory results, with respect to the emulsion stability, and was significantly ($P < 0.05$) greater than that of the control group and the 25% replacement group. Similar results have been reported in model systems, Zorba et al. (1995) and Zorba, Ozdemir, and Gokalp (1998) noted liquid whey had positive effects on emulsion characteristics of model meat emulsion systems, and indicated emulsions with total muscle proteins and fluid whey had the highest emulsion stability. A number of significant improvements in functional properties were also reported with WPC addition to the comminuted meat formulations (Correia & Mittal, 1991; de Wit, 1984; Hoogenkamp, 1986; Lauck, 1975; Lyons, Mornsey, & Buckley, 1999; Mortensen, 1987).

Table 2
Emulsion stability properties of whey substituted sausage batters[a]

% Whey in ice	Emulsion stability of the batters			
	pH of batter	Separated water[b]	Separated fat[c]	Stability rate (%)[d]
0	5.70a	2.50a	0.20a	86.50b
25	5.71a	2.35a	0.18a	87.35b
50	5.70a	2.00b	0.15b	89.25a
75	5.72a	1.90b	0.17a	89.65a
100	5.72a	1.85b	0.15b	90.00a

[a] Means in a column with identical letters are not significantly ($P < 0.05$) different.
[b] ml of water/20 g batter.
[c] ml of fat/20 g batter.
[d] 100−5 [20−(ml water + ml fat)].

3.2. Physical and chemical analysis of the sausages

A slight variation was detected in proximate composition between the treatments (Table 3). No significant ($P > 0.05$) differences were noted in% protein,% ash and pH, but significantly ($P < 0.05$) higher fat and lower moisture content were observed for the 75 and 100% whey replaced treatments (Table 3). Despite this slight increase, no statistically significant ($P < 0.05$) differences were noted for% protein,% ash or pH. The slight but statistically significant increase in fat content of the higher whey replaced treatments may be due to the lower moisture content in combination with a slight contribution from the liquid whey which contained 0.25% milk fat.

Milk products added to meat systems usually decrease the cooking loss and increase the moisture content of the product (Ellekjaer et al., 1996; Hoogenkamp, 1986). However, differences in cooking losses observed in this study were not significant, even though a slight increase was noted in cooking loss with 75 and 100 whey replaced treatments.

3.3. Sensory evaluations

The frankfurters in the control and liquid whey added treatments generally had a desirable pinkish red color with no fading or stickiness on the surface. The texture of the sausages was normal and elastic when sliced, and all treatment franks sliced well and did not stick to the knife or crumble and the surface cuts were smooth (data not presented). No statistically significant ($P > 0.05$) differences in texture, color, flavor and aroma, off-flavor or juiciness were observed (Table 4). Hypothetically a potential existed for off-flavor development in the products containing higher liquid whey but the panelists

Table 3
Proximate compositions, pH and cooking yield of cold whey substituted sausages[a]

% Whey in ice	% Moisture	% Fat	% Protein	% Ash	pH	Cooking loss
0	62.50a	18.74b	13.89a	2.89a	5.82a	10.80a
25	62.70a	18.90b	13.96a	2.85a	5.79a	10.40a
50	62.04a	19.36ab	13.99a	3.03a	5.84a	10.50a
75	61.12b	19.98a	14.02a	3.03a	5.88a	11.20a
100	61.26b	19.83a	13.97a	3.07a	5.91a	11.10a

[a] Means in a column with identical letters are not significantly ($P < 0.05$) different.

Table 4
Sensory quality of control and fluid whey substituted sausages[a]

% Whey in ice	Texture[b]	Color[c]	Taste and aroma[d]	Off-flavor[e]	Juiciness[f]
0	7.84	8.63	6.90	6.90	7.86
25	7.85	8.70	7.10	7.07	7.97
50	7.60	8.66	7.15	7.18	7.86
75	7.78	8.54	6.95	6.80	7.86
100	7.77	8.56	6.77	7.15	7.86

[a] No significant difference at the 5% level for any sensory factors.
[b] 1 = very coarse, 9 = very fine texture.
[c] 1 = faded not pinkish, 9 = pinkish bright color.
[d] 1 = atypical frankfurter taste and aroma, 9 = typical frankfurter taste and aroma.
[e] 1 = very intensive off-flavor, 9 = no off-flavor.
[f] 1 = very dry or very juicy, 9 = optimum juiciness.

did not detect a difference in off-flavor (Table 4). In addition, Ellekjaer et al. (1996) reported lowest off-flavor development and stickiness in whey protein containing cooked sausages, and Marriot et al. (1998) reported liquid whey containing boneless hams did not have any whey flavor. Sausages offered to members of the institute (as a small scale consumer panel) received favorable ratings, and most people had no criticism of the products.

4. Conclusion

Fluid whey could replace up to 100% of the ice successfully in frankfurter-type sausage formulation. Similar or more desirable emulsion stability, chemical and sensory properties were obtained in comparison to controls with no whey added. Therefore, utilization of liquid whey in comminuted meat products offers an enormous potential to fortify and improve functionality of processed meat products. Not only is the drying or condensing expenses excluded, but environmental concerns over surplus whey being dumped is eliminated.

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