Quality Characteristics of Low-fat Ground Pork Patties Containing Milk Co-precipitate

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ABSTRACT : The optimum level of fresh granulated low-calcium (0.2%) skim milk co-precipitate, as fat substitute in low-fat ground pork patties was determined on the basis of physico-chemical, cooking and sensory properties. Low-fat ground pork patties (<10% total fat), formulated with 15 per cent water, 4 per cent added fat, 1.5 per cent salt and 4-10 per cent milk co-precipitate, were evaluated for proximate composition, cooking characteristics and compared with control patties with 15 % added fat. The moisture and protein content of raw and cooked low-fat patties were significantly ($p<0.05$) higher than control. The incorporation of milk co-precipitate in low-fat patties improved cooking yield, fat and moisture retention and reduced shrinkage. The sensory properties of low-fat patties were comparable with control patties. The overall acceptability of low-fat patties formulated with 7% milk co-precipitate was significantly ($p<0.05$) higher than patties with 10% level and non-significantly ($p<0.05$) higher than low-fat patties containing 4% milk co-precipitate and control. Instrumental Texture Profiles of developed low-fat patties and control patties were comparable with slight increases in hardness and gumminess of the low-fat product. The developed low-fat ground pork patties (7% milk co-precipitate) had lower TBA values, better microbiological and sensory refrigerated storage stability than high-fat control patties packaged in air permeable films for 21 days. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 4 : 588-595)***

Key Words : Low-fat Ground Pork Patties, Milk Co-precipitates, Pork Patties, Fat Replacer

INTRODUCTION

Comminuted meat products are complex food systems in which water absorption, gelation and binding of fat influence the stability and texture of the cooked product. Fat contributes significantly to eating quality of comminuted meat products because fat imparts flavor, texture and juiciness to such products. Fat reduction can, therefore, significantly affect the acceptability of a product (Giese, 1992) and can cause products become dry and bland with hard, rubbery texture (Mendoza et al., 2001). Several approaches have been employed for developing lean or extra lean meat products while assuring the necessary palatability demanded by consumers. The active approach is replacement of fat with fat substitutes or fat mimetics systems such as water (Ahmed et al., 1990), proteins (wheat, maize, soy, milk, egg), carbohydrates (starch, pectin, cellulose, gums, maltodextrins) and fat based fat substitutes (Akoh, 1998; Keeton, 1994).

Various forms of milk proteins such as caseinates, skim milk powder, whey proteins, total milk proteins, milk protein concentrates and milk protein hydrolysates have been traditionally used as fillers, binders and extenders to improve flavor, texture, appearance and the nutritional value of comminuted meat products (Hung and Zayas, 1992). These milk proteins offer excellent functional properties such as solubility and dispersability, color improvement, water holding, fat binding, viscosity, gelation, heat and emulsion stability besides nutritional advantages (Lawson, 1994). In nearly all countries milk proteins are legally allowed in meat products. Amongst milk proteins, whey protein concentrates (WPC) and Non Fat Dry Milk (NFDM) have been reported in many studies to exhibit functional properties to be useful in fat replacement (Lucca and Tepper, 1994). El-Magoli et al. (1996) effectively used a 4% level of WPC in production of low-fat beef patties with better cooking yield and less shrinkage. With technological innovations, various functionally designed milk protein preparations have been standardized to be used in food formulations. Milk co-precipitate is a precipitate of caseins and whey proteins manufactured by heating of skim milk with calcium chloride (Muller, 1982). By varying the calcium content it is possible to produce several types of co-precipitates with various functional properties. Whey proteins and casein complexes of the co-precipitate provides a matrix which helps in stabilizing the texture of a product (Sanderson, 1988). Rao et al. (1997) reported that wet co-precipitate had total solids and protein contents similar to beef and mutton respectively. Bartekova et al. (1985) substituted beef rump meat with different co-precipitates for preparation of luncheon meat. Kesava Rao et al. (1998) incorporated 10 per cent level of low-calcium milk co-precipitate in low-fat (5%) mutton balls with significant improvement in cooking yield and organoleptic properties.

The present study was carried out to select the optimum

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level of low- calcium milk co-precipitate in the formulation of low-fat ground pork patties on the basis of compositional, processing and sensory qualities. The selected formulation was compared to a high-fat control for textural and storage stability.

MATERIALS AND METHODS

Formulation and processing:

Market age crossbred (Landrace×local) hogs (n=3) weighing 60-70 kg were humanely slaughtered at the Divisional Experimental Abattoir of the Indian Veterinary Research Institute, Bareilly. Prerigor raw materials were brought to laboratory within 1 h post mortem by fabricating each carcass into boston butt, picnic shoulder, loin and ham. In the laboratory, all skin, subcutaneous fat, bone, seam fat and necessary connective tissue were manually removed. Lean trimmings and back-fat free from skin were frozen stored separately at -18±2°C in low density polyethylene (LDPE) packs till use and after partial thawing at 5°C for 12hr were used for the preparation of ground pork patties.

The spice mixture, condiments and other additives were purchased from the local market. The refined wheat flour used as binder contained 18.73±2.11 per cent moisture, 74.43±0.85 per cent carbohydrates.

The milk co-precipitates were prepared by heat and salt coagulation of milk proteins (Muller, 1982). Skim milk was heated to 90±2°C with continuous stirring and 0.2 per cent calcium chloride (on weight basis) was added. The solid milk co-precipitates were separated from whey by using muslin cloth with pressure. Milk co-precipitate so prepared had a mean moisture content of 65.74±0.88 per cent.

The lean meat and back fat were minced separately through a 3 mm plate in an Electrolux meat mincer (Model 9512). The formulation and processing of control and low-fat patties were standardized on the basis of literature and series of standardization experiments conducted by Manish Kumar (2001).

All the ingredients and minced meat constituents (Table 1) were thoroughly mixed by an electrically operated meat mixer (Hobart Paddle Mixer, N-50) for 3 min. Immediately after mixing, the 75 g of patty mixture was molded to a defined size with the help of a Petri dish of 75mm×15 mm internal size. The molded patties were cooked in a preheated hot air oven at 190±5°C to an internal end point temperature of 75±2°C recorded at the geometrical center of each patty using a probe thermometer. The patties were turned upside down twice at 5 min intervals for better color and texture. Samples from each batch were analyzed on the same day.

Cooking characteristics

Cooking yield of patties were determined by measuring the weight of 9 patties for each treatment and was calculated as the ratio of cooked weight to raw weight expressed as a percentage. The percent cooking loss was calculated as the differential weight between individual raw and cooked patties. The moisture and fat retention was calculated according to the following equations:

$$\text{Fat retention (\%)} = \frac{\text{Cooked weight} \times \text{Per cent fat in cooked patties}}{\text{Raw weight} \times \text{Per cent fat in raw patties}} \times 100$$

$$\text{Moisture retention (\%)} = \frac{\text{Per cent yield} \times \text{Per cent moisture in cooked patties}}{100}$$

Table 1. Product formulation and composition (% w/w) (Mean±S.E.)*

	Control	Low-fat ground pork patties		
		I	II	III
Ingredients				
Lean meat	70.0	67.0	64.0	61.0
Added fat	15.0	4.0	4.0	4.0
Added water	5.0	15.0	15.0	15.0
Refined flour	4.0	4.0	4.0	4.0
Condiments	3.0	3.0	3.0	3.0
Spice mix.	1.5	1.5	1.5	1.5
Salt	1.5	1.5	1.5	1.5
Sodium nitrite, ppm	150	150	150	150
Milk Co-precipitate	-	4.0	7.0	10.0
Characteristics				
pH	5.95±0.009^{b}	5.97±0.002^{ab}	6.01±0.008^{a}	6.02±0.02^{a}
Moisture (%)	59.04±0.07^{b}	68.45±0.19^{a}	68.74±0.09^{a}	68.63±0.06^{a}
Fat (%)	19.00±0.26^{a}	8.64±0.04^{b}	8.76±0.08^{b}	8.89±0.08^{b}
Protein (%)	15.44±0.05^{b}	16.28±0.08^{a}	16.43±0.07^{a}	16.49±0.09^{a}
Moisture to protein ratio	3.82±0.03^{b}	4.21±0.03^{a}	4.18±0.02^{a}	4.17±0.02^{a}

* Mean± S.E in the same row with same superscripts are not different significantly ($p<0.05$).

N=6 for each treatment.

The moisture retention value represents the amount of moisture retained in the cooked product per 100 g of raw sample. The diameters and heights of the cooked patties were recorded with the help of vernier caliper at three different points on each patty. The per cent gain in height and per cent decrease in diameter was calculated in accordance with the methods of Chowdhary et al. (1994). The shrinkage was determined according to the equation of El-Magoli et al. (1996):

$$\text{Shrinkage (\%)} = \frac{(\text{Raw thickness-Cooked thickness})+(\text{Raw diameter-Cooked diameter})}{\text{Raw thickness+Raw diameter}}$$

Physico-chemical analysis

Composition : Moisture, fat (ether extractable) and protein content of raw and cooked patties were determined according to standard AOAC (1995) procedures using a hot air oven, a soxhlet extraction apparatus and a Kjeldahl assembly, respectively. All analyses were performed in triplicate.

pH determination : Homogenates were prepared by blending 20 g of raw or cooked patties with 80 ml of distilled water in Ultra Turrex T25 tissue homogenizer at 7,000-10,000 rpm for 1 min. The pH of the suspension was measured using a digital pH meter (Model CP901 Century Instruments Limited, India).

Shear force value : The shear force value of cooked patties cut into 1 cm^2 size pieces was recorded as per method of Berry and Stiffler (1981) using Warner- Bratzler Shear press (Model: 810310307 G.R Elect. Mfg. Co. USA) and expressed as kg/cm^2.

Sensory evaluation

Patties at a temperature of 30-35°C were assessed under incandescent light for their appearance and color, flavor, juiciness, texture and overall acceptability by a seven member experienced panel of judges using an 8-point hedonic scale, where 8 denoted extremely desirable and 1 denoted extremely poor. Tap water was provided between samples to cleanse the palate.

Texture profile analysis (TPA)

Patties samples were cut into 1 cm^2 and subjected to a two cycle compression test performed using a universal Testing Machine (Model-1000, Instron corp., Canton MA). Six samples per treatment were compressed to 50% of their height with a 0.5 inch flat surface plunger attached to 50 N load cell and cross head speed of 50 mm/min. Hardness, chewiness, cohesiveness, springiness and gumminess were calculated from the curve adopting the method described by Bourne (1982) and Brady et al. (1985).

Storage studies

Cooked patties samples were packed in low density polyethylene cling pouches for aerobic storage at a refrigeration temperature of 4±1°C for 21 days. The samples were drawn on Days 0,7,14 and 21 for assessment of physico-chemical (pH, TBA), microbiological (TPC, Coli form, Psychrophilic count) and sensory attributes.

Thio barbituric acid value : TBA value of samples was determined in accordance with the TBA distillation method described by Tarladgis et al. (1960).

Microbiological analysis

A 10 g sample of patties taken under sterilized conditions was triturated in a sterilized pestle and mortar with 90 ml sterile 0.1% peptone water. Appropriate dilutions of samples were prepared in sterile 0.1% peptone water blanks and plated in duplicate on the growth media by the pour-plate method. The following media and incubation conditions were used

a) Plate Count Agar at 35±2°C for 24 h for total plate count and 4±1°C for 10-14 days for psychrophilic count.
b) Violet Red Bile Agar Media at 35±2°C for 24hr for coliform count.

The results were expressed as $\log_{10}$cfu/g.

Statistical analysis

The statistical design of this study was 4 (treatment)×3 (replication) randomized block design. All chemical and physical determinations were conducted in triplicate. There were seven sensory determinations (judges) for each treatment×replication combination. Data were subjected to one way analysis of variance. The storage data were analyzed on the basis of 2 (treatments)×4 (storage days)×3 (replications) with two way analysis of variance. Duncan's Multiple Range test and critical difference were determined at 5% significance level. (Snedecor and Cochran, 1989).

RESULTS AND DISCUSSION

Physico-chemical analyses of low-fat ground pork patties incorporated with varying levels of milk co-precipitate are presented in Table 1. The pH of raw low-fat patties was significantly higher ($p<0.05$) at 7 and 10 per cent levels than the control. It could be due to higher initial pH value (6.6) of milk co-precipitate (Rogov et al., 1980). The per cent moisture, protein and moisture to protein ratio were significantly ($p<0.05$) higher, while fat per cent was significantly ($p<0.05$) lower in raw low-fat ground pork patties at all levels of milk co-precipitate incorporation as compared to the high-fat control as expected.

The proximate analysis of cooked patties (Table 2) revealed that fat content of low-fat patties 8.90-9.17% was below the limits (10%) prescribed for low-fat meat products

Table 2. Effect of milk co-precipitate incorporation on physico-chemical properties of cooked low-fat ground pork patties (Mean±S.E.)*

Parameters	Control	Level of incorporation (%)		
		4.0	7.0	10.0
pH	6.10±0.017[b]	6.12±0.007[ab]	6.14±0.009[ab]	6.15±0.007[a]
Moisture (%)	54.86±0.15[b]	61.29±0.28[a]	61.51±0.04[a]	61.65±0.28[a]
Fat (%)	18.44±0.27[a]	8.90±0.03[b]	9.10±0.03[b]	9.17±0.04[b]
Protein (%)	18.54±0.07[a]	19.62±0.03[b]	20.08±0.25[ab]	20.28±0.27[a]
Moisture protein ratio	2.96±0.01[b]	3.12±0.02[a]	3.07±0.01[ab]	3.05±0.05[ab]
Cooking yield (%)	75.61±0.17[c]	76.81±0.34[b]	79.35±0.42[a]	79.74±0.28[a]
Cooking loss (%)	24.39±0.17[a]	23.19±0.34[b]	20.65±0.42[c]	20.26±0.28[c]
Decrease in diameter (%)	22.50±0.42[a]	18.67±0.11[b]	17.46±0.33[c]	16.67±0.29[c]
Gain in height (%)	33.62±0.68[a]	22.49±0.73[b]	23.99±0.41[bc]	24.97±0.57[c]
Shrinkage (%)	13.35±0.31[a]	11.81±0.08[b]	10.55±0.30[c]	9.73±0.30[c]
Moisture retention (%)	41.48±0.19[c]	47.08±0.14[b]	48.81±0.26[a]	49.15±0.25[a]
Fat retention (%)	73.77±0.54[c]	79.07±0.36[b]	82.50±0.51[a]	82.17±0.40[a]
Shear force value (kg/cm^2)	0.45±0.009	0.48±0.005	0.47±0.003	0.48±0.006

* Mean±S.E in the same row with same superscripts are not different significantly ($p<0.05$).
N=6 for each treatment.

(Keeton, 1994). The moisture content in formulated low-fat patties remained comparable at all level of incorporation of milk co-precipitate. However, it was significantly ($p<0.05$) higher than control. It could be due to obvious difference in added water level in both the groups and better water holding capacity in low-fat patties due to incorporation of milk co-precipitate (Muller, 1982). The per cent protein of low-fat patties formulated with 10 per cent milk co-precipitate was significantly ($p<0.05$) higher than patties with 4 per cent level. The protein content was significantly ($p<0.05$) higher in low-fat patties than the control due to the high protein content in milk co-recipitate. Rudolph and Hansen (1986) and Patil (2000) also observed significant ($p<0.05$) increases in the protein content of meat products at 10 and 7.5 per cent levels of milk co-precipitate incorporation respectively. The product pH followed a gradual increasing trend and was significantly ($p<0.05$) higher at the 10 per cent level of incorporation than control. It could be due to the use of calcium chloride for the precipitation of milk proteins which in turn increases the pH of milk co-precipitates. Rogov et al., (1980) also reported similar findings in pork sausages. Results of cooking determinants (Table 2) indicated that cooking yield followed a linear increasing trend in low-fat patties and was significantly better at 7 and 10 per cent level of incorporation than the 4 per cent level. However, it was significantly ($p<0.05$) higher than the control at all levels of incorporation. It could be due to water binding nature of milk co-precipitates as reported by several workers (Hynd, 1970; Rudolph and Hansen, 1986; Sen et al., 1994). Our results are also consistent with the observations of Kesava Rao et al. (1998) in low-fat mutton balls. The per cent decrease in diameter was maximum in control and minimum in low-fat patties formulated with 10 per cent milk co-precipitate whereas gain in height of patties was increased with increasing level of incorporation amongst the low-fat products. The shrinkage per cent was indirectly proportional to the level of incorporation of milk co-precipitates with maximum shrinkage in the control group and minimum in the low-fat patties with 10 per cent milk co-precipitates. The maintenance of dimensional parameters in low-fat ground pork patties could be due to the adhesion/ cohesion and the binding nature of milk co-precipitates (Rogov et al., 1980). Moisture and fat retention also followed a linear increasing trend with increases in level of milk co- precipitates in the product. Similar findings were observed by Muller (1982); Kullikova and Osipov (1981) and Sen et al., (1994). Shear-force values did not show any significant differences amongst products with milk co-precipitate variables and control, though it was marginally higher in the treatment groups than the control possibly due to the presence of calcium in the milk co-precipitate.

Mean sensory scores (Table 3) revealed that appearance and juiciness scores were comparable in all groups. However, appearance scores were slightly higher for low-fat patties incorporated with 7.0 per cent milk co-precipitate but this was not statistically significant. Flavor scores of all products were comparable although these were significantly ($p<0.05$) higher at 10 per cent level than control. This could have been due to the presence of lactose in the milk co-precipitate which acted as flavor enhancer (Santos et al., 1994; Kesava Rao et al., 1998). Patil (2000) also reported an improvement of flavor of chicken patties with incorporation of milk co-precipitate at the 15 percent level. Texture scores were comparable in all groups. The sensory panelists rated low-fat ground pork patties incorporated with milk co-precipitate and high-fat control comparable with respect to overall acceptability. The low-fat ground

Table 3. Effect of milk co-precipitate incorporation on sensory attributes of low- fat ground pork patties (Mean±S.E.)*

Attributes	Level of incorporation (%)			
	Control	4.0	7.0	10.0
Appearance	6.98±0.06	7.02±0.04	7.12±0.06	6.98±0.07
Flavor	6.98^{b}±0.10	7.16^{ab}±0.12	7.19^{ab}±0.08	7.28^{a}±0.07
Juiciness	6.88±0.06	6.98±0.07	6.83±0.31	6.91±0.07
Texture	6.96±0.07	7.03±0.05	7.07±0.08	6.98±0.09
Overall acceptability	7.02^{ab}±0.05	7.05^{ab}±0.05	7.14^{a}±0.06	6.92^{b}±0.08

* Mean±S.E. with same superscript in a row do not differ significantly ($p<0.05$).
Means are scores given by sensory panelists on an 8-point Hedonic scale where 1: extremely poor and 8: extremely desirable. n=21 for each treatment

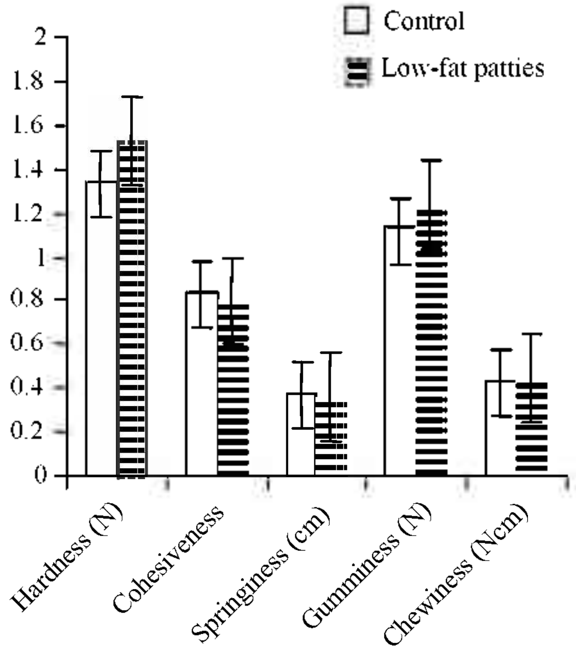

Figure 1. Comparative instrumental texture profile of control and formulated low-fat patties.

pork patties with 7 per cent milk co-precipitate scored significantly ($p<0.05$) higher for overall acceptability than other levels of incorporation. Our results confirm the reports of other workers (Malyshko, 1986; Santos et al., 1994; Kesava Rao et al., 1998). Bhoyar et al., (1998) further established that incorporation of milk co-precipitate up to the 20 per cent level enhanced color, juiciness, flavor and overall acceptability of chicken steaks.

Since cooking yield, moisture retention, flavor, texture and overall acceptability of low-fat ground pork patties were better at the 7 per cent level of milk co-precipitate incorporation, it was adopted as the optimum level and compared for texture profile and storage stability to the high-fat control.

Instrumental texture profile

Figure 1 shows that hardness of the low-fat product was slightly higher but it was statistically non significant. However, various workers have reported that reduction in fat content resulted in increased hardness of meat products (Keeton, 1994; Barbut and Mittal, 1996; El-Magoli et al., 1996; Mendoza et al., 2001). This comparable textural variable in experimental low-fat patties and high-fat (control) can be attributed to optimum level of incorporation of the fat replacer (7% milk co-precipitate) and high moisture content. Cohesiveness and springiness were comparable in low-fat ground pork patties formulated with 7 per cent milk co-precipitate and the control. In general, cohesiveness increases and springiness decreases with decrease in fat content of meat products (Gregg et al., 1993; Confrades et al., 1997). However, incorporation of fat replacer and increases in the proportion of added water in low-fat pork patties could have brought the cohesiveness values close to the control. Moreover, there are protein-protein and protein-water interactions in milk co-precipitate incorporated product, which bring about a better texture (Hynd, 1970; Rao et al., 1997). Yang et al. (1995) observed no significant effect on cohesiveness with variation in fat content even as much as 16 per cent. Gumminess values were increased for low-fat meat products. Chewiness values were comparable in both groups. Disparate results are recorded in the literature for the effect of fat level on chewiness and gumminess (Bloukas and Paneras, 1996; Confrades et al., 1997; Pietrasik, 1999). Mendoza et al. (2001) also observed significant ($p<0.05$) increases in gumminess in low-fat sausages relative to a control. Manish Kumar (2001) also reported that chewiness in low-fat meat patties containing a protein based fat replacer (texturized soy protein,TSP) were similar to a high-fat control.

Storage quality and shelf life studies

Changes in physico-chemical, microbiological and sensory properties of control (high-fat) and low-fat ground pork patties formulated with 7 per cent milk co-precipitate, aerobically packaged in low density polyethylene (LDPE) films at refrigeration temperature (4±1°C) for 21 days are presented in Table 4.

Thiobarbituric acid (TBA) values increased steadily throughout the 21 days aerobic storage period in both groups. However, the TBA value was significantly ($p<0.05$) lower in low-fat product than the control. The apparent differential effect on TBA value was due to the greater moisture/lower fat percentages in cooked developed product. TBA values increase during storage due to lipid oxidation and production of volatile metabolites in the presence of oxygen during aerobic packaging (Jo et al., 1999). Though milk co-precipitate is rich in salts (10% ash on a dry weight basis) which act as prooxidants, TBA values in low-fat patties still remain below control products due to less

Table 4. Effect of refrigerated storage on physico-chemical, microbiological containing 7% milk co-precipitate and sensory characteristics of aerobically packaged low-fat ground pork patties (Mean±S.E.)*

Treatments	Storage period (days)			
	0	7	14	21
Physico-chemical characteristics				
		TBA value (mg malonaldehyde/kg)		
Control	0.42 ± 0.018^{d1}	0.59 ± 0.01^{c1}	0.81 ± 0.02^{b1}	0.98 ± 0.01^{a1}
Low-fat patties	0.29 ± 0.013^{d2}	0.37 ± 0.01^{c2}	0.54 ± 0.02^{b2}	0.72 ± 0.05^{a2}
		pH		
Control	6.10 ± 0.009^{c}	6.16 ± 0.007^{bc}	6.23 ± 0.004^{b}	6.29 ± 0.008^{a}
Low-fat patties	6.14 ± 0.002^{c}	6.18 ± 0.004^{bc}	6.21 ± 0.004^{b}	6.33 ± 0.012^{a}
Microbiological characteristics				
		Total plate count (log cfu/g)		
Control	1.68 ± 0.03^{d}	1.94 ± 0.02^{c}	2.21 ± 0.05^{b}	2.74 ± 0.04^{a}
Low-fat patties	1.76 ± 0.11^{d}	1.98 ± 0.08^{c}	2.25 ± 0.06^{b}	2.69 ± 0.02^{a}
		Psychrophilic count (log cfu/g)		
Control	ND	ND	1.16 ± 0.02^{b}	1.40 ± 0.09^{a}
Low-fat patties	ND	ND	1.18 ± 0.01^{b}	1.37 ± 0.05^{a}
		Coliform count (log cfu/g)		
Control	ND	ND	ND	ND
Low-fat patties	ND	ND	ND	ND
Sensory characteristics**				
		Appearance		
Control	7.02 ± 0.06^{a}	6.91 ± 0.10^{ab}	6.78 ± 0.12^{b}	6.69 ± 0.12^{b}
Low-fat patties	7.12 ± 0.08^{a}	7.06 ± 0.07^{a}	6.88 ± 0.11^{ab}	6.76 ± 0.12^{b}
		Flavor		
Control	7.04 ± 0.07^{a}	6.92 ± 0.09^{a}	6.71 ± 0.10^{b}	6.59 ± 0.11^{c2}
Low-fat patties	7.16 ± 0.09^{ab}	7.12 ± 0.08^{a}	7.02 ± 0.09^{ab}	6.87 ± 0.12^{b1}
		Juiciness		
Control	6.98 ± 0.09^{a}	6.84 ± 0.08^{ab}	6.69 ± 0.10^{bc}	6.57 ± 0.12^{c}
Low-fat patties	6.91 ± 0.08^{a}	6.83 ± 0.07^{a}	6.78 ± 0.09^{ab}	6.61 ± 0.13^{b}
		Texture		
Control	7.07 ± 0.09^{a}	7.00 ± 0.09^{a}	6.86 ± 0.09^{ab}	6.74 ± 0.08^{b}
Low-fat patties	7.11 ± 0.08^{a}	7.01 ± 0.06^{a}	6.92 ± 0.09^{ab}	6.79 ± 0.12^{b}
		Overall acceptability		
Control	7.05 ± 0.09^{a}	6.98 ± 0.08^{ab}	6.76 ± 0.09^{bc}	6.64 ± 0.12^{c}
Low-fat patties	7.09 ± 0.07^{a}	7.02 ± 0.09^{a}	6.89 ± 0.10^{ab}	6.77 ± 0.12^{b}

*Mean=S.E. with different superscripts row wise (alphabet) and column wise (numeral) differ significantly ($p<0.05$), ND=Not Detected.

** Means are scores given by sensory panelists on an 8-point Hedonic scale where 1: extremely poor and 8: extremely desirable, n=21 for each treatment.

availability of substrate for oxidation. TBA values increased significantly ($p<0.05$) in the control from Day 0 to Day 21, yet it remained below the threshold level of 1.0 (Labuza, 1971). The products were acceptable and did not show any perceivable rancidity or off odor/ aroma up to 21 days. Our findings confirm the results of Bullock et al. (1994); Kulshreshta and Rhee (1996) and Patil (2000).

The pH of both the low and high-fat product followed a similar increasing trend at progressive storage intervals with no significant difference between the two groups at any sampling day during storage. This increase in pH might be due to the accumulation of metabolites of bacterial action on meat and meat products and deamination of meat proteins (Jay, 1996). The reports regarding variation of pH during storage are conflicting. Some workers observed increases in pH (Moon et al., 1996), stable pH (Lin and Chuang, 1999) and decreases in pH (Keeton, 1983 and Yin et al., 1998).

Microbiological characteristics : Total Plate Counts followed a significant linear increasing trend from Day 0 to Day 21 in low-fat and control products, however these were well below the permissible limits for cooked meat products (Jay, 1996). Bhoyar et al. (1998) also reported that incorporation of co-precipitate did not increase the number of total aerobes in chicken sausages and chicken steaks, respectively. Psychrophilic counts were not detected on Day 0 and 7 of storage in low-fat patties and controls. Thereafter, it increased significantly ($p<0.05$) on Day 21 of storage in both groups. Cremer and Chipley (1977) described permissible level of psychrophilic count as 4.6 log cfu/g in cooked meat and meat products. Coliforms were not detected throughout the period of storage in any sample due to heat treatment up to 75°C and good hygienic practices during experimentation.

Appearance scores (Table 4) followed a decreasing trend with increase in storage days possibly due to pigment and lipid oxidation resulting in non-enzymatic browning. It could also be partly attributed to the surface dehydration in aerobic packaging. Flavor scores remain stable up to Day 14 in low-fat patties and decreased significantly ($p<0.05$) on Day 21, whereas, flavor scores decreased significantly ($p<0.05$) on Day 14 and 21 in the control product. This progressive decrease in flavor can be correlated with TBA values of meat (Tarladgis et al., 1960) stored under aerobic conditions. Juiciness and texture scores followed a decreasing trend in low-fat and control patties during the entire period of storage due to moisture loss through air permeable films. The overall acceptability of developed low-fat patties remained stable up to Day14, whereas for the high-fat control it remained stable only up to Day 7 of storage. Thereafter, it decreased significantly ($p<0.05$) with progressive increase in period of storage. It could be due to an increase in lipid oxidation, pigment oxidation and degradation of protein in patties over the storage period. The sensory panelists rated overall acceptability between good to very good even after 21 days of aerobic refrigerated storage.

CONCLUSIONS

Milk co-precipitate at the 7 per cent level can be effectively used as a functional ingredient in low-fat ground pork patties due to its water and fat binding properties which results in better cooking yield, improved fat and moisture retention and increased resistance to shrinkage. Sensory panel and instrument texture profiles revealed that the reduction of fat in developed patties did not result in deterioration in texture quality. Low-fat ground pork patties can be safely stored at refrigeration temperature (4±1°C) for 21 days in air permeable films without any adverse changes in sensory, microbiological or physico-chemical properties.

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