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Standardization of corn starch as a fat replacer in buffalo calf meat sausages and its effect on the quality attributes

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ABSTRACT

The present study envisaged optimization and evaluation of corn starch (CS) level as a fat replacer in buffalo calf meat. A total of four treatments of sausages *viz.* Control: 20% fat, T-1: 3% CS, T-2: 6% CS, T-3: 9% CS were tried to select suitable level of fat replacer on the basis of water holding capacity, emulsion stability and sensory evaluation. The sausages with selected level of CS were evaluated for physico-chemical properties, texture profile, thio-barbituric acid reactive substance (TBARS), proximate composition and sensory attributes. The 6% level of CS was found optimum and the cooking yield, pH, moisture content, protein content and sensory scores of selected sausages were significantly ($P<0.05$) higher in comparison to control, however vice-versa for TBARS and fat content. The study concluded that 6% CS level is optimum to develop the low-fat sausages with improved quality and with 43% lower calorie content.

Key words: Buffalo calf meat, Calorie content, Corn starch, Fat replacer, TBARS.

INTRODUCTION

The busy life of consumer demands ready-to-eat food products without compromising nutrition and health. The recently documented health issues related with high fat have made the consumers to focus on low-fat products. Hence, the demand of low-fat meat products has directed the meat technologists to formulate strategies for the development of low-fat meat products. However, reduction of fat in comminuted meat products results in rubbery dry textured products with high shear force due to increase in hardness with low juiciness and cooking yield (Kumar and Sharma, 2004). Thus, these quality problems have necessitated the selection of appropriate fat replacer and optimizing their concentrations to produce low-fat meat products having better consumer acceptability and market value. Corn starch, a carbohydrate fat replacer is known to have water-binding properties. It works well in high moisture systems such as low-fat spreads and meat emulsions by binding water and reducing rubberiness (Giese, 1996). Yang *et al.* (2001) reported that low-fat frankfurters containing modified waxy maize starch had the lowest purge loss (3.8%) with maximum emulsion stability in comparison to control. The beneficial effect of modified waxy maize starch on reducing purge loss was similar to that reported by Dexter *et al.* (1993) who showed that turkey bologna containing 2% modified waxy maize starch had lower purge during refrigerated storage and after freeze/thawing. However, the efficacy of corn starch as a fat replacer in buffalo calf meat has not been accessed so far.

Moreover, in India, buffalo meat comes from spent dairy buffalo after full utilization of their productive life, which is dark, coarse and tough in texture and has poor organoleptic and processing characteristics (Kandeepan *et al.* 2009). This issue can be resolved by using meat of male animals of lower age (below 18 months) with more collagen solubility (Kandeepan *et al.* 2009). The buffalo calf meat is also much leaner than other species meat. But this requires 15-20% fat addition while processing to make better meat emulsion, which further necessitates the maintenance of lean character of buffalo calf meat. Therefore, while considering consumer's demand, the study was undertaken to substitute fat completely with fat replacer, so that consumer can relish the exact lean meat in processed form.

MATERIALS AND METHODS

Three healthy male buffalo calves of 10-12 months of age, weighing around 130 Kg were slaughtered as per standard procedure with the consideration of animal welfare, in the departmental slaughterhouse (Department of Livestock Products Technology, LUVAS, Hisar). After manual removal of fascia, external fat and other connective tissue of 24 h chilled carcass, meat was packaged in LDPE bags and stored at -18±1ºC till further use. The frozen meat was thawed overnight in a refrigerator (4±1ºC) before use. The food grade ingredients of the established brands were procured from local market. The chemicals and readymade media used in the study were procured from reputed firms (CDH Chemicals, Sigma Aldrich and Hi-Media). Corn starch

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(Weikfield; Weikfield Food Pvt. Ltd) was used as fat replacer in the study was purchased from local market.

The formulation (Table 1) and processing of control and low-fat sausages were standardized by preliminary trials. The ingredients were added over and above 100% of lean meat. The deboned meat was minced in an electrical meat mincer (3 mm plate) (Mado Primus Meat Mincer, MEW-613; Dr. Froeb India Pvt. Ltd.) followed by manual mixing of all ingredients and then vacuum tumbled for 2 h to make emulsion. Emulsion was filled in cellulose casings by hand operated sausage filling machine and were steam cooked for 35 min. The cooked sausages were cooled in chilled water for 5 min and casings were peeled off. The low fat sausages were prepared in the similar manner as mentioned for control sausages, except that corn starch was added instead of vegetable fat. Total four treatments were tried viz. Control= with 20% fat, T-1= sausages with 3% corn starch, T-2= sausages with 6% corn starch, T-3= sausages with 9% corn starch. Samples from each batch were analyzed on the same day of preparation. The corn starch level was selected on the basis of water holding capacity (WHC), emulsion stability (ES) and sensory evaluation. The developed low fat sausages were compared to high fat control sausages for the various quality attributes viz. physico-chemical properties {cooking yield, shear press value, pH, thio-barbituric acid reactive substances (TBARS)}, texture profile, proximate composition and sensory evaluation.

WHC was estimated according to Wardlaw *et al.* (1973) and stability of the emulsions was determined using the method of Baliga and Madaiah (1970). For cooking yield, the weight of restructured goat meat product was recorded before and after cooking, and the yield was calculated (cooking yield= weight of cooked product/weight of raw product x 100) and expressed as percentage. Shear press value of cooked sausage was analysed using Texture Analyser. Warner-Bratzler shear probe was used to measure shear force value and the force required to shear a sample of 20 mm diameter transversely was expressed in Newton (N). The pH of sample was determined by Trout *et al.* (1992) using pH meter (CyberScan pH 510, Eutech Instruments; Thermo Fisher Scientific, Navi Mumbai). TBARS was determined as per method described by Witte *et al.* (1970). TBARS value was calculated as mg malonaldehyde/Kg of sample by multiplying O.D. value with K factor of 5.2. The textural properties of sausages were evaluated using Texture Analyser (TA.HD plus), Stable Micro Systems Ltd., Surrey, England with the Texture Exponent Program as per the procedure outlined by Bourne (1978). The proximate composition was estimated using automatic moisture analyser, Kel plus, Socs Plus, and Muffle furnace, respectively as per method described in AOAC (2005). The total calories were calculated on the basis of 100 portions using the Atwater value for fat (9 kcal/g), protein (4.02 kcal/g) and carbohydrate (4 kcal/g). A panel of six-member experienced judges consisting of faculty members and postgraduate students of the Department evaluated the samples for the sensory attributes using 8-point descriptive scale (Keeton, 1983).

Table 1: Formulation of buffalo male calf meat sausages.

Name of ingredients	Percentage (w/w) over			
	C	T-1	T-2	T-3
Lean meat	100.00	100.00	100.00	100.00
Salt	02.00	02.00	02.00	02.00
TSPP	0.40	0.40	0.40	0.40
Sodium nitrite	0.02	0.02	0.02	0.02
Spice mix	02.00	02.00	02.00	02.00
Condiment mix (onion: garlic)2:1	03.00	03.00	03.00	03.00
Albumen	05.00	05.00	05.00	05.00
Refined wheat flour	02.00	02.00	02.00	02.00
Ice flakes	08.00	08.00	08.00	08.00
Vegetable oil	20.00	-	-	-
Corn starch		03.00	06.00	09.00

C: sausages with 20% fat, T-1= sausages with 3% corn starch, T-2= sausages with 6% corn starch, T-3= sausages with 9% corn starch

Each experiment was replicated thrice and the data generated for different quality characteristics were compiled and analysed using 'SPSS-16.0' (SPSS Inc., Chicago, Il USA) software package as per standard methods (Snedecor and Cochran, 1994). The data were subjected to one-way analysis of variance (ANOVA) at 5% level ($P<0.05$). Duplicate samples were drawn for each parameter in each experimental trial except for Texture (n=5) and sensory evaluation (n=6) to have total No. of observations N=6 for all parameters, whereas N=15 for texture profile and N=18 for sensory evaluation.

RESULTS AND DISCUSSION

WHC: The incorporation of corn starch as fat replacers resulted in increase in WHC and with increase in level of incorporation, the values showed increasing trend (Table 2). This increase in WHC with increase in incorporation level might be due to the ability of starch to absorb and bind more of water. The ability of starch to hold moisture in meat samples has favourable implications in the final product quality by preventing excessive moisture loss in products thus avoiding undesirable crunchy and flaky texture (Ali *et al.* 2011). Khalil (2000) also observed significantly higher WHC in low fat buffalo patties with 100% fat replacement (corn starch and water). However, the WHC did not vary significantly as the level increased from 6 to 9% which was might be due to attainment of threshold level of water holding capacity of emulsion.

ES: Perusal of results revealed that with the incorporation of corn starch, the ES increased to a great extent (Table 2). In all treatments, the ES was recorded significantly higher in comparison to control (71.03%), irrespective of level of

Table 2: Effects of different levels of corn starch on WHC and EC of raw male buffalo calf meat emulsion (Mean ± S.D., N=6).

Parameters	Control	T-1	T-2	T-3
WHC (%)	45.06 ± 1.47 a	53.36 ±3.16 b	64.54 ± 2.80 c	65.46 ± 3.13c
ES (%)	62.88 ± 1.83 a	87.26 ± 1.62 b	92.66 ± 1.74c	93.12 ± 0.86c
		Sensory evaluation		
Colour and appearance	7.17 ± 0.24 a	7.94 ± 0.16 b	8.00 ± 0.00 b	7.97 ± 0.12 b
Flavour	7.03 ± 0.32 a	7.86 ± 0.33 b	7.92 ± 0.26 b	7.92 ± 0.19 b
Texture	7.06 ± 0.16 a	7.89 ± 0.27 b	8.00 ± 0.00 b	8.00 ± 0.00 b
Juiciness	7.11 ± 0.21 a	7.42 ± 0.26 b	7.92 ± 0.26 c	7.94 ± 0.16 c
Overall acceptability	7.14 ± 0.23 a	7.72 ± 0.26 b	7.92 ± 0.19 c	7.92 ± 0.19 c

C: sausages with 20% fat, T-1= sausages with 3% corn starch, T-2= sausages with 6% corn starch, T-3= sausages with 9% corn starch
Means with different superscripts in a column differ significantly (P<0.05)

incorporation. The ES of samples also increased with increase in level of incorporation, similar to WHC. The higher ES of emulsions incorporated with starch might be due to the formation of three dimensional solid lattice structure of protein starch gel in the corn starch incorporated sausages as compared to control (Carballo *et al.* 1996). Aktas and Genccelep (2006) also reported that incorporation of modified starches in a meat batter improved the ES and reduced the jelly and fat separation.

Sensory evaluation: Corn starch as a fat replacer had the profound effects on all sensory attributes (Table 2). Incorporation of fat replacers increased the colour and appearance scores, however, these scores did not differ significantly with increase in level of incorporation. The enhancement of colour scores might be due to the decrease in fat content which in turn increase the redness of the product (Hughes *et al.* 1998). Similar enhancement in colour and appearance scores with the incorporation of fat replacers has been documented by Verma *et al.* (2015) in low fat pork patties. The flavour scores remained unaffected with increase in level of incorporation. It might be due to the considerable swelling of the starch granules during cooking. Hughes *et al.* (1998) reported increased flavour intensity of frankfurters incorporated with starch. The texture/tenderness of products did not differ significantly with increase in level of incorporation, though scores were significantly higher than control. Giese (1992) emphasized that modified food starches have been used as binders to maintain tenderness in low -fat meat products. The juiciness scores were observed to be the highest at 6 and 9% level of incorporation amongst the low-fat pork patties which could be due to the greater water binding properties of starch (Verma *et al.* 2015). The low-fat buffalo calf meat sausages incorporated with 6 and 9% were rated highest for overall acceptability by the sensory panellists. The result showed overall acceptability score of the T-3 were comparable to T-2.

Since, T-2 and T-3 sausages were comparable with respect to WHC, ES and sensory attributes, however, better than T-1 and control; T-2 (6% level of incorporation) was selected for further study as we will get statistically comparable product at lower level incorporation, thus would be cost economic in comparison to higher level.

Quality attributes of developed low-fat sausage

Physico-chemical properties: Physico-chemical properties of developed sausages are presented in Table 3. Cooking yield of treated low fat sausages was found significantly higher in comparison to that of high fat sausages. The lower cooking loss in low fat sausages may be attributed to higher protein and lower fat contents of low-fat sausages. Hong *et al.* (2004) reported that cooking loss is affected by the amount of fat contents in meat products. Further, higher cooking yield in developed product was might be due to the increase in moisture binding by the added corn starch. This fact correlates well with the proximate composition given in Table 4. The moisture content of low fat sausages was recorded higher in comparison to control. Similar results were observed by Ali *et al.* (2011) in low-fat beef patties incorporated with potato flakes.

Table 3: Effects of corn starch on physico-chemical properties of low fat buffalo calf meat sausages (Mean±S.D., N=6).

Parameters/Treatments	Cooking yield (%)	Shear press value (N)	pH	TBA (mg malonaldehyde /Kg
High fat sausages	75.38 ± 1.70 a	6.20 ± 0.52 b	5.96 ± 0.01 a	0.592 ± 0.01 b
Low fat sausages	100.61 ± 0.89 b	5.70 ± 0.79 a	6.03 ± 0.01 b	0.531 ± 0.01 a

Means with different superscripts in a column differ significantly (P<0.05)

Table 4: Effects of corn starch on the proximate composition of low-fat male buffalo calf meat sausages (Mean±S.D., N=6).

Treatments	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Calorie content (Kcal/100g)
High fat sausages	64.71 ± 0.92a	11.57 ± 0.40b	17.82 ± 0.60a	1.99 ± 0.05 ab	191.40
Low fat sausage	73.30 ± 1.36b	1.68 ± 0.35a	18.45 ± 0.23b	1.71 ± 0.16a	108.73

Means with different superscripts in a column differ significantly (P<0.05)

The shear force value of low fat products was observed significantly (P<0.05) lower in comparison to high fat products. The softer texture of developed low fat sausages could be attributed to substitution of fat with water which could impart a soft mushy texture to the product (Keeton, 1994; Khalil, 2000).

The pH of the developed low fat sausages was significantly higher in comparison to high fat sausages. The higher pH corroborates with the higher water binding properties of the fat replacers. The pH of low-fat ttoekgalbi (Korean traditional patty) formulated with 100% fat replacer (hydrated potato starch) was significantly higher than control (Muhlisin *et al.* 2012).

TBARS values of fat replacers incorporated sausages were significantly lower. This could be due to the lower fat contents in these sausages compared to high fat products (Muhlisin *et al.* 2012). Highest TBARS value of later can be, attributed to its significantly higher fat (11.57%) content (Table 4). High fat makes the product more susceptible to oxidation, therefore showed higher TBARS value, indicative of oxidation potential.

Texture profile analysis: The hardness of developed low fat sausages was lower in comparison to its counterpart, though did not differ significantly (Table 5). Reduction in hardness value might be due to moisture retention properties of the fat replacers and formation of weaker three dimensional network of protein matrix attributed to incorporation of corn starch. Several authors have reported that the dilution effect of non-meat ingredients in meat protein systems primarily accounted for softer texture (Khalil, 2000; Verma *et al.* 2015). These results are in confirmatory to shear force value (Table 2). The springiness and cohesiveness of all the sausages were comparable, though sausages incorporated with corn starch showed non-significantly lower springiness and cohesiveness in comparison to others. Similar results were observed by Khalil (2000). In general, cohesiveness increases and springiness decreases with decrease in fat content of meat products (Confrades *et al.* 1997). However, incorporation of fat replacer and increase in moisture content in low-fat sausages could have brought the springiness and cohesiveness values closer to the control. Gumminess, chewiness and resilience values of the developed low fat products were comparable to high fat control which showed that fat replacers was able to impart the texture similar to that of high fat sausages.

Table 5: Effects of corn starch on the textural characteristics of low-fat buffalo calf meat sausages (Mean±S.D., N=15).

Textural attributes	High fat sausages	Low fat sausages
Hardness (N)	23.13 ± 2.26[a]	21.99 ± 2.55[a]
Springiness (mm)	0.81 ± 0.02[a]	0.80 ± 0.06[a]
Cohesiveness	0.45 ± 0.04[a]	0.43 ± 0.10[a]
Gumminess (N)	10.34 ± 1.86[a]	9.49 ± 1.78[a]
Chewiness (J)	8.33 ± 1.44[a]	7.63 ± 1.78[a]
Resilience	0.19 ± 0.02[a]	0.18 ± 0.06[a]

Means with different superscripts in a row differ significantly (P<0.05)

Table 6: Effects of corn starch on the sensory attributes of low-fat buffalo calf meat sausages (Mean±S.D., N=18).

Sensory attributes	High fat sausages	Low fat sausages
Colour and appearance	7.17 ± 0.24[a]	8.00 ± 0.00[b]
Flavour	7.03 ± 0.32[a]	7.92 ± 0.26[b]
Texture/Tenderness	7.06 ± 0.16[a]	8.00 ± 0.00[b]
Juicines	7.11 ± 0.21[a]	7.92 ± 0.26[b]
Overall acceptability	7.14 ± 0.23[a]	7.92 ± 0.19[b]

Means with different superscripts in a row differ significantly (P<0.05)

Proximate composition: The moisture content in formulated low-fat sausages was significantly higher. It could be due to better WHC in low-fat sausages due to incorporation of fat replacers and better water binding ability of corn starch (Berry and Wergin, 1993). The fat replacement using fat replacers might have increased the moisture contents of beef patties (Muhlisin *et al.* 2012). The fat content in developed product was less than 10%, which was in accordance with the prescribed limit/standard for low-fat meat products (Keeton, 1994). The fat content was inversely proportional to the moisture i.e. higher moisture in lower fat products. This might was the result of fat substitution by moisture in low-fat products. The protein content showed higher values in low fat products. The ash content was lowest in low-fat products which might be due to relative dilution of ash content due to incorporation of corn starch. The calorie content of developed low fat sausages was 43% lower in comparison to high fat sausages. It may be attributed to the lower fat content in treated group replaced with corn starch.

Sensory evaluation: Corn starch incorporation showed beneficial effect on sensory attributes (Table 6). The colour and appearance attributes of treated sausages were significantly improved with the incorporation of fat replacer than that of high fat sausages. Similar enhancement in colour and appearance scores with the incorporation of fat replacers has been documented by Verma *et al.* (2015) in low fat pork patties. The flavour scores were significantly (P<0.05) higher which could be attributed to the considerable swelling of the starch granules during cooking. Hughes *et al.* (1998) reported increased flavour intensity of frankfurters incorporated with starch. The textural/tenderness scores of low fat sausages were also significantly higher. Berry and Wergin (1993) indicated that improved tenderness of patties containing potato starch was due to extensively hydrated starch granules which opened the fibrous structure of patties. The juiciness scores of low fat sausages were in consonance with their respective water holding capacity. The overall acceptability of developed sausages was significantly higher. Better sensory scores were also observed by Kumar *et al.*

(2004) and Laskar *et al.* (2013) in low fat ground pork patties incorporated with carrageenan and sodium alginate and chevon salamis incorporated with glutinous rice flour.

CONCLUSION

The corn starch at 6% level can be employed as a fat replacer in buffalo male calf meat for the development of sausages. The quality characteristics of the developed product were improved and the product was 43% lower in calorie content in comparison to high fat product.

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