Short Paper

Effect of different dietary fiber-rich extenders on the quality attributes of functional restructured buffalo meat fillets

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Abstract

Background: The ever-increasing market of functional meat products demanded especially by modern health conscious consumers has prompted researchers to develop healthier meat products. **Aims:** This experiment was conducted to improve the dietary fiber-deficient buffalo meat with natural functional fiber-rich extenders. **Methods:** Meat obtained from the carcass of adult female buffalo (>10 years of age) was procured from the local market within 5-6 h of slaughter, conditioned for 24 h, and then processed by incorporating the dietary fiber-rich extenders at their optimum levels *viz.* 12% barley flour, 12% maize flour, 10% pea hull powder, and 8% wheat bran (hydrated as 1:1, w/w) for the development of functional restructured buffalo meat fillets (FRBMF). **Results:** Results revealed higher cooking yield, pH, moisture content, lower protein, and fat percentage for most of the treated samples compared with the control group. The ash percentage of FRBMF prepared with the optimum level of pea hull powder and wheat bran was significantly higher ($P<0.05$) than in control and other treatments. Shear force values for FRBMF were lower than the control. Total dietary fiber (TDF) percentage of all the treatment products was significantly higher ($P<0.05$) than the control. Texture profile analysis revealed no significant differences ($P>0.05$) between FRBMF and the control. The sensory scores for most of the attributes of FRBMF incorporated with the optimum level of extenders were lower but comparable to the control. **Conclusion:** It was concluded that the functionality of the product had improved, especially in terms of total dietary fiber, as compared to the control. Pea hull powder and wheat bran proved to be excellent sources of dietary fibers, followed by barley and maize flours, respectively.

Key words: Buffalo meat, Extenders, Functional, Restructured, Total dietary fiber

Introduction

India is the largest exporter of buffalo meat, with a contribution of 986592 MT valued at Rs. 21337 Crores (APEDA, 2021). Since most buffalo meat is mainly sold as fresh, processing buffalo meat is essential to exploit its full potential for both domestic consumption and export purpose. Restructuring is the suitable technology for processing coarse textured buffalo meat wherein meat is partially or completely disassembled and then reassembled and reformed into same or different shape.

There is a growing concern among meat consumers over nutritional diseases of affluence and the correlation between food habits and health. Consumption of saturated fat, excess salt and calories has been related to the incidences of coronary heart diseases, hypertension, and obesity (Law *et al*., 1991; Jimenez-Colmenero *et al*., 2001). A number of approaches can be followed to enhance the functionality of meat products, including alteration of lipid content, reduction of sodium, reduction of nitrite, enhancement of dietary fiber content, and antioxidant potential, etc. The plant based ingredients like barley flour, maize flour, pea hull powder, and wheat bran have been successfully used to improve the functional value of buffalo meat by various researchers (Ahmad *et al*., 2014; Ahmad *et al*., 2017; Ahmad *et al*., 2020).

Keeping in view the above-mentioned points, improvement in the functionality of low sodium buffalo meat fillets is attempted by increasing their dietary fiber content using ingredients like barley flour, maize flour, pea hull powder, and wheat bran.

Materials and Methods

Source of raw materials

Deboned buffalo meat obtained from the carcass of adult female buffalo (>10 years of age) was procured from the local market of Bareilly within 5-6 h of slaughter. All visible fascia and external fat were trimmed off, and meat portions were made into cuts of approximately 0.5 kg. The cuts were then packaged separately in low density polyethylene (LDPE) pouches and kept at room temperature for about 24 h to complete rigor mortis. After that, the packaged meat cuts were shifted to a deep freezer (Blue Star, FS345, Denmark) for storage at -18 ± 2°C until further use. Extenders (barley flour, maize flour, pea hulls, and wheat bran), condiments as well as spices were purchased from the local market of Bareilly. Pea hulls and wheat bran were dried in a hot air oven at 60°C and grounded to cause the consistency of powder. The proximate composition of the extenders revealed that pea hull powder was the best source of dietary fibers with a mean value of 67.98%, followed by wheat bran (47.55%), barley flour (17.07%), and maize flour (15.01%). This information was taken as evidence of the functionality of these dietary fiber sources.

The spice ingredients were freed from extraneous matter and dried in a hot air oven at 50°C for 4 h. The ingredients were ground and sieved through a fine mesh. The powders were mixed in suitable proportions to obtain a spice mixture. The spice mix was stored in a plastic container for subsequent use. For preparation of the restructured buffalo meat fillets, onion and garlic as condiments were used in a ratio of 2:1.

Control restructured buffalo meat fillets were prepared using 80% lean meat, 2% sodium chloride in the curing solution, 2.5% refined wheat flour, 3.6% condiments, and 1.9% of spice mixture; whereas in treatment recipes (low sodium products) contained only 1% of sodium chloride and the remaining 1% was replaced with potassium chloride (0.8%) and potassium lactate (0.2%). GRAS/Food grade chemicals were used in salt substitute blends. No fat was added to the formulation of the product. All the chemicals (analytical grade) were obtained from standard firms (Qualigen, Hi-Media, Sdefine, etc.).

Method of cooking

The meat batter was stuffed in stainless steel moulds, the moulds closed tightly and placed in pressure cooker filled with 1/3 boiling hot water, and then the product was cooked by steam without pressure. A slow heating rate was ensured by adjusting the flame regulating knob (code: 637470, Regalia, Sun Flame) to low to achieve the required internal temperature of 85°C.

Formulation of pre-standardized restructured buffalo meat fillets

An initial formulation was worked out based on available literature and several preliminary trials. The initial formulation was used to standardize the processing conditions and the level of incorporation of various extenders in restructured buffalo meat fillets. The buffalo meat chunks of 1 cm^3 were massaged in a paddle mixer along with the curing solution, followed by the addition of other ingredients, including dietary fiber sources, for a total of 15 min until a good binding of the mix was obtained. The mix obtained was stuffed in stainless steel moulds and cooked by steam without pressure for 40 min. Based on cooking yield and sensory scores of restructured buffalo meat fillets (RBMF), 12 ml curing solution, 15 min massaging time, and 40 min cooking time were optimized for the processing of restructured buffalo meat fillets. 50% of sodium chloride reduction was standardized by using a salt substitute blend comprising potassium chloride (40%) and potassium lactate (10%).

The dietary fiber sources were added during the massaging of meat chunks and curing solution using a paddle mixer by replacing the lean meat, as indicated in Table 1.

Table 1: Formulation of pre-standardized restructured buffalo meat fillets

Extenders (g)	Control	Treatment		
Barley flour (1:1 hydration, w/w)	0	8	10	12
Maize flour (1:1 hydration, w/w)	0	8	10	12
Pea hull powder (1:1 hydration, w/w)	0	8	10	12
Wheat bran (1:1 hydration, w/w)	0	6	8	10

On the basis of different physicochemical and sensory attributes, the incorporation of 12% barley flour, 12% maize flour, 10% pea hull powder, and 8% wheat bran (hydrated 1:1, w/w), separately were found optimum for the processing of functional restructured buffalo meat fillets.

In the current study, the effect of these already selected optimum levels of different extenders containing dietary fibers on the quality of FRBMF was evaluated.

Analytical procedures

Cooking yield of the product was estimated as a percent of cooked weight against the uncooked weight of the mix. The pH of the cooked fillet was determined by blending 10 g sample with 50 ml of distilled water using a pestle and mortar (Trout *et al*., 1992). The pH of the homogenate was recorded by immersing combined glass electrodes of digital pH meter (Elico India L1 127). Moisture, protein, fat, ash, and total dietary fiber contents of the fillets were determined using AOAC (1995) methods. Shear force value was determined as per the method described by Berry and Stiffler (1981). It is measured as the force required for shearing 1 cm square block on Warner-Bratzler Shear Press (81031307 GR Elec. MFG. Co., USA) and expressed in kg/cm^2.

The texture profile of restructured buffalo meat fillets was measured with the help of instrumental texture profile analyser (TA HD Plus Texture Analyser) as described by Bourne (1978). Chilled samples were tempered to bring to room temperature and then cut into 1 cm squares. The samples were placed on a platform in a fixture and compressed twice to 85% of their original height by a compression probe (P75) at a cross head speed of 10 mm/s through a two-cycle sequence, using a 50 kg load cell.

Sensory characteristics of the cooked product were checked by a method devised by Keeton (1983) using 8-point descriptive scale, where 8 is extremely desirable and one is extremely undesirable. Plain water was provided to rinse the mouth between the samples. A total of seven trained sensory panelists (male and female scientists) were involved in the sensory evaluation of the products. The product was analyzed in three different sittings, making the number of observations (N) equal to 21 (7 panelists multiplied by three sittings). The three digits coding of samples was followed, and the time of analysis was kept at late afternoon.

Statistical analysis

The experimentation was carried out in triplicates, and data for quality parameters was collected in duplicates. The data were analyzed using analysis of variance (ANOVA) with SPSS software version 17.0. Duncan's multiple range post-hoc test at a 95% confidence level (α=0.05) was used to check the significance of the data.

Results

The results of various physicochemical properties of functional restructured buffalo meat fillets containing optimum levels of different extenders are given in Table 2. The results revealed that the dietary fiber content of fillets containing pea hulls was significantly higher than all other fillets, followed by what bran containing fillets.

Most of the textural properties remained unaffected by dietary fiber sources. However, a slight decrease in

Table 2: Comparative physicochemical properties of functional restructured buffalo meat fillets at optimum levels of different extenders (mean±SE)

Parameters	n	Control	Treatment (optimum levels of extenders)			
			Barley flour (12%)	Maize flour (12%)	Pea hull powder (10%)	Wheat bran (8%)
Cooking yield (%)	3	91.36±0.75^b	94.71±0.81^a	94.14±1.29^{ab}	92.83±0.55^{ab}	92.74±1.00^{ab}
Product pH	6	6.15±0.01^b	6.21±0.02^a	6.21±0.02^a	6.20±0.01^{ab}	6.15±0.03^b
Moisture (%)	6	68.01±0.19^b	69.56±0.38^a	69.59±0.53^a	68.50±0.36^{ab}	68.93±0.29^{ab}
Protein (%)	6	21.15±0.22^a	16.36±0.30^c	16.25±0.43^c	17.53±0.36^b	16.77±0.26^{bc}
Moisture protein ratio	6	3.22±0.04^c	4.26±0.10^a	4.30±0.15^a	3.92±0.10^b	4.12±0.08^{ab}
Fat (%)	6	3.24±0.11^a	2.81±0.09^b	2.87±0.07^b	2.97±0.09^b	3.30±0.07^a
Ash (%)	6	2.30±0.03^b	2.32±0.05^b	2.26±0.04^b	2.72±0.06^a	2.68±0.05^a
Total dietary fiber (%)	6	0.84±0.05^d	1.84±0.07^c	1.68±0.07^c	4.10±0.07^a	2.69±0.09^b
Shear force value (kg/cm^2)	30	0.74±0.03^a	0.67±0.04^a	0.70±0.04^a	0.65±0.03^a	0.69±0.04^a

Mean±SE with different superscripts in a row differ significantly (P<0.05)

Table 3: Comparative texture profile of functional restructured buffalo meat fillets at optimum levels of different extenders (mean±SE)

Textural properties	n	Control	Treatment (optimum levels of extenders)			
			Barley flour (12%)	Maize flour (12%)	Pea hull powder (10%)	Wheat bran (8%)
Hardness (N/cm^2)	6	47.37±2.08^a	47.07±1.65^a	44.87±1.38^a	46.05±2.36^a	45.13±1.68^a
Adhesiveness (Ns)	6	-0.17±0.01^a	-0.19±0.02^a	-0.18±0.01^a	-0.18±0.01^a	-0.16±0.01^a
Springiness (cm)	6	0.44±0.02^a	0.46±0.04^a	0.43±0.03^a	0.45±0.03^a	0.46±0.02^a
Cohesiveness (ratio)	6	0.36±0.03^a	0.27±0.02^a	0.29±0.02^a	0.27±0.01^a	0.33±0.05^a
Gumminess (N/cm^2)	6	16.79±1.03^a	12.88±1.01^a	13.07±1.35^a	12.60±0.72^a	14.78±2.11^a
Chewiness (N/cm)	6	7.37±0.58^a	5.95±0.77^a	5.67±0.83^a	5.67±0.32^a	6.68±1.00^a

Mean±SE with different superscripts in a row differ significantly (P<0.05)

Table 4: Comparative sensory quality of functional restructured buffalo meat fillets at optimum levels of different extenders (mean±SE)

Sensory attributes	n	Control	Treatment (optimum levels of extenders)			
			Barley flour (12%)	Maize flour (12%)	Pea hull powder (10%)	Wheat bran (8%)
General appearance	21	7.30±0.06^a	7.14±0.08^{ab}	7.11±0.10^{ab}	7.06±0.05^b	7.08±0.06^b
Flavour	21	7.31±0.09^a	7.10±0.07^{ab}	7.13±0.07^{ab}	7.05±0.08^b	7.09±0.05^{ab}
Juiciness	21	7.23±0.11^a	7.08±0.07^a	7.17±0.08^a	7.07±0.07^a	7.09±0.03^a
Texture	21	7.19±0.08^a	7.18±0.05^a	7.09±0.08^a	7.00±0.10^a	7.04±0.08^a
Binding	21	7.24±0.08^a	7.11±0.07^a	7.13±0.07^a	7.04±0.08^a	7.08±0.08^a
Saltiness	21	7.20±0.11^a	7.10±0.06^a	7.17±0.06^a	7.11±0.09^a	7.09±0.05^a
Overall acceptability	21	7.24±0.08^a	7.12±0.08^a	7.17±0.05^a	7.04±0.07^a	7.09±0.08^a

Mean±SE with different superscripts in a row differ significantly (P<0.05) hardness and shear force was observed (Table 3). The sensory attributes were mildly affected by the use of extenders. All the attributes were within acceptable limits in all the products (Table 4).

Discussion

Physicochemical properties

Cooking yield and moisture percent of functional restructured buffalo meat fillets (FRBMF) containing extenders were higher than control. This might be attributed to the increased water holding capacity of extenders and gelatinizing property of starch on heating, which reduced evaporative moisture loss during cooking. This increase might be due to higher moisture retention by non-meat additives (Reitmer and Prusa, 1991). The neutral nature of extenders might be responsible for somewhat higher pH values of FRBMF. Malav (2011) observed similar trend for cooking yield and pH values of functional restructured chicken meat blocks extended with various vegetative extenders. Protein and fat percentages of all the extended FRBMF were significantly lower ($P<0.05$) than control, probably due to carbohydrate rich vegetative extenders used. Mineral rich pea hulls might have increased the ash content in FRBMF. Total dietary fiber (TDF) percentage of all the treatment products were significantly higher ($P<0.05$) than control with the highest values being reported for pea hull powder added products (4.10 ± 0.07), followed by wheat bran added fillets (2.69 ± 0.09). This proved our findings of pea hulls and wheat bran being rich sources of dietary fibers (Table 1). Corn bran (Mendonca *et al*., 2000), pea flour (Rzedzicki *et al*., 2004), wheat bran (Talukder and Sharma, 2010), barley flour (Brijesh, 2013), and oats (Gramza-Michałowska *et al*., 2018) have been reported as efficient dietary fiber sources in different meat products. The functional properties of pea fiber can be improved by reducing the size of these fibers using pulverization or other novel techniques (He *et al*., 2022).

Instrumental texture profile analysis

A slight decrease in hardness and shear force could be attributed to somewhat softening effect by more carbohydrates and lowered amount of sodium chloride in FRBMF. The decrease in the hardness value with increasing levels of cellulose has also been reported by Lin and Lin (2004) in meat balls, Grigelmo-Miguel *et al*. (1999) in low fat, high dietary fiber frankfurters incorporated with peach dietary fiber and Garcia *et al*. (2002) in low fat dry fermented sausages extended with different cereal and fruit-based fibers. The findings agreed with the results for various textural parameters observed by various workers in different meat products containing dietary fibers of plant origin (Yang *et al*., 1995; Pietrasik, 1999; Todd *et al*., 2006; Das *et al*., 2008; Verma, 2008; Giriprasad, 2012; Brijesh, 2013). Tsai *et al*. (2007) observed reduced shear force (N) and hardness values in restructured beef products incorporated with oat flour. Crehan *et al*. (2000) reported that the gumminess of frankfurters was unaffected by the addition of maltodextrin. Bond *et al*. (2001) found low-fat ground beef burgers treated with hydrated barley less chewy, springy, cohesive, gummy, and hard than control. In contrast, texture profile analysis of beef burgers showed a significant ($P<0.05$) reduction in hardness, springiness, gumminess, and chewiness at all levels of substituting beef with carbohydrate rich hydrated gari (Akwetey and Knipe, 2012). As observed in our case and also supported by Hsu and Chung (1998), the overall acceptability of the product indicated a positive correlation between hardness and overall acceptance.

Sensory evaluation

The decline in appearance scores could be attributed to the dilution of meat pigments with the incorporation of extenders. The reduction in the flavour of FRBMF might be due to the dilution of meaty flavour by fiber sources (Kumar and Sharma, 2006). No significant difference ($P>0.05$) was observed in the juiciness, texture, and binding scores of control and FRBMF treated with extenders, correlating with the findings of texture analysis. It might be due to the ability of different hydrocolloidal fibers of extenders to absorb and retain higher amounts of moisture. Higher saltiness scores in the control product might be due to a higher amount of NaCl as well as lean meat in its formulation. A similar trend in sensory findings has also been reported by various workers for different meat products added with vegetative extenders (Bond *et al*., 2001; Yilmaz, 2005; Kumar and Sharma, 2006; Khate, 2007; Brijesh, 2013). An overall decline in sensory scores can be attributed to the use of potassium chloride in functional buffalo fillets as has also been reported by Gelabert *et al*. (2003) in sausages.

A similar trend for all the sensory attributes was reported by Kumar and Sharma (2006) in chicken patties incorporated with different levels of hydrated barley flour, Ahamed *et al*. (2007) in enrobed beef cutlets treated with corn flour, and Yasarlar *et al*. (2007) in meatballs added with wheat and oat bran. Pietrasik and Janz (2010) could make beef bologna with pea fiber without compromising the acceptability of the product. Steamed wheat bran-treated meat patties prepared by Talukder and Sharma (2010) were acceptable even at a 15% level of extension, however, the baked wheat bran-added patties were acceptable only up to 10% level of extension. Similarly, Verma (2008) and Malav (2011) prepared acceptable designer chicken nuggets and restructured chicken meat blocks, respectively, incorporating different vegetative extenders. Brijesh (2013) found similar results for restructured chicken meat rolls extended with barley and pea hull flour. Besides, Raja *et al*. (2014) could also prepare acceptable fish curls incorporated with corn and rice flour.

The restructuring technology was effectively used to develop low sodium functional restructured buffalo meat fillets with excellent sensory quality. The functionality of the product was improved, especially in terms of total dietary fiber using natural ingredients like pea hull powder and wheat bran. It was concluded that the less valued buffalo meat could be made valuable for large sections of consumers, especially health-conscious consumers.

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Conflict of interest

There was no conflict of interest.

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