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Comparative Study of Different Fat Replacer in the Development of Low Fat Chevon Patties

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ABSTRACT

Background: Since last decade demand for healthy and nutritious foods with additional health promoting functions has continuously been increased. Although meat and meat products traditionally have higher levels of fat therefore these products offer the good opportunity to develop low fat functional meat products. Fat replacements should contribute a minimum of calories to a product and should not be detrimental to organoleptic qualities. Therefore, the current study was undertaken to assess suitability of various functional ingredients for the development of low fat chevon patties.

Methods: Pre-weighed quantity of minced chevon meat, along with other ingredients were added and chopped in a bowl chopper till desired consistency of the emulsion was achieved. Weighed quantity of emulsion was taken and molded in to patties shape and cooked at specified time and temperature combination. Three selected variant *i.e* carrageenan (CG), poppy seed (PS) and sago flour (SF) were used for the study. All samples were processed for physicochemical, mineral estimation, instrumental texture, color and sensory analysis.

Result: Significantly (P<0.05) lower fat and cholesterol contents and higher moisture and fat retention were observed in carrageenan incorporated chevon patties. However, calcium, iron, manganese and zinc contents were significantly (P<0.05) higher in poppy seed incorporated low fat chevon patties. The instrumental textural and color profile were also differ significantly (P<0.05). The flavor score was significantly (P<0.05) higher for chevon patties with carrageenan. The carrageenan added low fat chevon patties (CG) were found superior and widely acceptable among the sensory panelists. Hence, 0.6% carrageenan added chevon patties were selected to develop low fat chevon patties.

Key words: Carrageenan, Chevon patties, Fat replacer, Poppy seed, Sensory attribute, Sago flour.

INTRODUCTION

Since last decade demand for healthy, nutritious foods with additional health promoting functions has continuously been increased. Meat products have come under increasing scrutiny by medical and nutritional consumer groups because of the associations established between their consumption (Low fat, cholesterol and high fiber) and the risk of some of the major degenerative and chronic diseases (heart disease, hypertension, obesity and colon cancer). The contribution of fat to obesity is due to the well known fact that fat is energy dense providing 2.25 times as much energy per unit as carbohydrate and protein. Nutritional guidelines suggest that dietary fat should provide between 15 and 30 percent of total calories and that saturated fats should be limited between 0 and 10 per cent of caloric intake (WHO 2003). Diet serves as a driving force for health and quality of life. Although meat and meat products traditionally have higher levels of fat therefore these products offer the good opportunity to develop low fat functional meat products (Chauhan *et al.*, 2021). Fat replacements should contribute a minimum of calories to a product and should not be detrimental to organoleptic qualities.

Fat content is essential to meat product characteristics such as flavor, juiciness and texture and therefore fat content cannot be reduced simply by using less fat or direct replacement with another type of fat (Jimenez-Colmenero, 2000). Reduction of fat in comminuted meat products results in rubbery and dry textured products (Keeton 1994) and poses difficulties in terms of flavor and texture. Hence, there is a need for using suitable ingredient which is able to replace fat without affecting quality. Fat replacers are generally categorized into two groups: fat substitutes and fat mimetics. Fat substitutes are ingredients that have a chemical structure somewhat close to fats and have similar physiochemical properties (Lipp and Anklam, 1998; Kosmark, 1996; Peters *et al.*, 1997). They are usually either indigestible or contribute lower calories on a per gram basis. Fat mimetics are ingredients that have distinctly different chemical structures from fat. They are usually carbohydrate and/or protein-

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based. They have diverse functional properties that mimic some of the characteristic physiochemical attributes and desirable eating qualities of fat: viscosity, mouth feel and appearance (Duflot, 1996; Harrigan and Breene, 1989). An alternative is to use functional ingredients that mimic or substitute the properties of fat in emulsified cooked meat products. Looking to the facts and overcome the problem associated with health of consumer the present study was undertaken.

MATERIALS AND METHODS

Source of raw material

Goat meat (chevon) from hind legs of adult male goats (9-11 months old) was procured from local market of Mathura (U.P.). The meat was deboned, trimmed-off separable fat and connective tissue. Approximately four kg meat were kept for conditioning in a refrigerator at 4±1°C for 6-8 h and then frozen at -18°C for a period of three months to conduct various trials of the study. The samples were used after partial thawing for 15 h at 4°C. The study was carried out during the period of April, 2013 to February, 2015, in the Department of Livestock Products Technology, College of Veterinary Science, DUVASU, Mathura, (U.P.).

Spice mix

The ingredients in desired ratio

Anise (10%), black pepper (5%), capsicum (10%), caraway (10%), cardamom (4%), cinnamon (4%), cloves (2%), coriander (15%), cumin (20%), dry ginger (10%) and turmeric (10%) were procured from local market, dried at 45±2°C for 2 hours followed by grinding and sieving through 100 meshes. The spice mix was stored in low density polyethylene bags and used as per requirement.

Chemicals and other ingredients

All the chemicals used in the study were of analytical grade and procured from Hi Media laboratories (P) Ltd, Mumbai. Ingredients used in the study were procured from standard firm and local market as per availability and requirement of the study. Low density Polyethylene (LDPE) bags of 250 gauge thickness were sourced from local market for packaging and were pre-sterilized by exposing to U.V. light for 30 minutes before use.

Preparation of chevon patties

Lean meat was cut into smaller chunks and minced in a Sirmen mincer (MOD- TC 32 R10 U.P. INOX, Marsango, Italy) with 6 mm plate followed by 4 mm plate. Meat emulsion for patties were prepared in Bowl Chopper [MOD C 15 2.8G 4.0 HP, Marsango, Italy] as per the Formulation (Table 1). Adequate care was taken to keep the end point temperature below 18°C by preparing the emulsion in cool hours of morning, by addition of meat and other ingredients in chilled/ partially thawed form and by addition of crushed ice or ice water. About 50 g of emulsion was moulded on steel plate with circular ring (55×20 mm). Patties were cooked in a pre-heated convection oven at 180°C for 14 min. after which they were turned and allowed to get cooked for 4 more minutes to get internal temperature about 75°C. The patties were packed in 0.002 inches thickness of LDPE (low-density polyethylene) pouches and stored at refrigerated temperature (4±1°C) for further study.

Analytical procedure

Physico-chemical properties

pH

pH was determined by using digital pH meter (WTW, Germany, model pH 330i) by immersing the spear type combination electrode (Sentix®, Germany) directly into minced meat sample.

Prior to measurement, pH meter was calibrated every time as per the manufacturer's instructions using known buffers of pH 7.0 and 4.01. Reading was taken twice for each sample and average of reading was taken as pH of sample.

Emulsion stability

The emulsion stability was determined by the method of Baliga and Madaiah (1970) with minor modifications. Twenty five grams of meat emulsion was taken in polyethylene bag and heated in thermostatically controlled water bath at 80°C for 20 min. after cooling and draining the exudates, the cooked mass was weighed. The percentage of cooked mass was expressed as emulsion stability.

Cooking yield

The weights of chevon patties were recorded before and after cooking. The cooking yield was calculated as under and expressed as percentage (Murphy *et al.,* 1975).

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked chevon patties}}{\text{Weight of raw chevon patties}} \times 100$$

Proximate analysis

Moisture, protein fat, fiber and ash contents were determined as per AOAC (1995) method.

Table 1: General formulation of low fat functional chevon patties.

Ingredient	CG	PS	SF
Lean goat meat	70	70	70
Refined vegetable oil	5.0	5.0	5.0
Ice flakes	14.4	10.0	12.0
Salt	1.6	1.6	1.6
Dry spices mix	2.0	2.0	2.0
Condiments	3.0	3.0	3.0
Refined wheat flour	3.0	3.0	3.0
STTP	0.4	0.4	0.4
Carrageenan	0.6	0.0	0.0
Poppy seed	0.0	5.0	0.0
Sago flour	0.0	0.0	3.0

CG= Chevon patties with 0.6% Carrageenan; PS = Chevon patties with 5% Poppy Seed SF= Chevon patties with 3% Sago flour.

Moisture protein ratio

This was calculated by ratio of the moisture and protein content in the sample by using formula for 100 g of samples.

Moisture protein ratio = Moisture% / Protein%

Moisture-retention and fat retention

Moisture retention and Fat retention were determined according to equation by El-Magoli *et al.* (1996) and Murphy *et al.* (1975) respectively.

Cholesterol content

Total cholesterol was determined as per Zlatkis *et al* (1953) with slight modifications. Lipid extract was prepared by mixing one gram of sample with 10 ml of freshly prepared 2:1 Chloroform: Methanol solution and homogenizing it in a blender. Homogenate was filtered using Whatman filter paper No. 42 and 5 ml of filtrate was added with equal quantity of distilled water, mixed and centrifuged at 3000 rpm for 7 min. Top layer (methanol) was removed by suction. Volume of bottom layer (Chloroform) having cholesterol was recorded. The O.D. of standard and sample against blank was taken at 560 nm. Total cholesterol mg per cent was recorded as follows:

$$\text{Cholesterol 1 (mg/100 gm)} = \frac{\text{O.D. of sample}}{\text{O.D. of standard}} \times \frac{\text{Vol. of cholesterol (ml)}}{\text{Weight of the sample taken (gm)}} \times \text{Conc. of standard}$$

Estimation of mineral

The mineral contents were estimated as method described by Horowitz (1965). The digested samples were analyzed on atomic absorption spectrophotometer (AAS 400 Perkin Elmer, USA) for calcium (Ca), iron (Fe), manganese (Mn) and zinc (Zn) estimation, while sodium (Na) and potassium (K) were estimated by a flame photometer for which the volume was made up to 1000 ml.

Texture profile analysis

Texture profile analysis (TPA) was performed (Bourne, 1978) using homogeneous sample (1.5 mm × 1.5 mm × 1.5 mm) for each treatment which was compressed to 10 mm (1 cm) of original height through miniature Ottowa and Kramer shear cell platen probe. Cross head speed of 2.00 mm per second, post test speed 10.00 mm per sec. target mode distance 10.00 mm was used. The following parameters were determined *viz*. Hardness (N/cm^2) = maximum force required to compress the sample(H); Adhesiveness (Ns/g sec) = work necessary to pull the compressing plunger away from the sample; Cohesiveness (Ratio) = Extent to which samples could be deformed prior to rupture (A2/A1, A1 being the total energy required for first compression and A2 total energy required for second compression) and Gumminess (N/cm^2 or g/mm^2) = force necessary to disintegrate a semi solid sample for swallowing (H × Cohesiveness).

Instrumental color

Color profile was measured using Lovibond Tintometer (Model: RT-300, UK) set at 2 of cool white light (D65) and known as L*, a* and b* values. L* value denotes (brightness 100) or lightness (0), a* (redness/greenness), b* (yellowness/blueness) values (Hunter and Harold, 1987).

Sensory evaluation

Panelists were selected from post-graduate students and staff of Veterinary College based on performance in screening test. Four training sessions were held to familiarize the panelists with the developed product characteristics to be evaluated and the scale to be used. Sensory evaluation was carried out in forenoon session (one hour before lunch) by an experienced seven member panel. Panelists were asked to evaluate the samples for general appearance, flavor, texture, saltiness, juiciness, mouth coating and express their overall acceptability using 8-point hedonic scale (Keeton, 1983), where 8 denoted extremely desirable and 1 denoted extremely undesirable. Samples were internally cooked to 75°C and were served in random order at a temperature of approximately 50°C. At a time total of three samples (one from each treatment) were served to each panelist to compare the products.

Statistical analysis

The data obtained in the study on various parameters were statistically analyzed on 'SPSS-16.0' software package as per standard methods of Snedecor and Cochran (1995). Duplicate samples were drawn for each parameter and the experiment was replicated thrice (n=6). Sensory evaluation was performed by a panel of seven member judges three times, so total observations being 21 (n=21) Data were subjected to one way analysis of variance, homogeneity test and Duncan's multiple range test (DMRT) for comparing the means to find the effects between samples.

RESULTS AND DISCUSSION

The following abbreviations were used for the present experiment: CG- low fat chevon patties with 0.6% Carrageenan; PS- low fat chevon patties with 5% poppy seed paste and SF - low fat chevon patties with 3% sago flour.

Physico-chemical properties

The mean values for various physicochemical parameters of low fat chevon patties incorporated with different fat replacer are presented in Table 2 revealed that the moisture, fat, carbohydrate, moisture retention, fat retention and cholesterol contents differed significantly ($P<0.05$) between treatments. However, results of rest of the physicochemical parameters between treatments were comparable to each other. The pH value for carrageenan was higher compared to sago flour and poppy seed incorporated chevon patties. Nayak and Pathak (2016) also reported higher pH value in carrageenan incorporated chevon patties.

Table 2: Physico-chemical properties (Mean±SE) of low fat chevon patties incorporated with different fat replacers.

Parameter	Treatments		
	CG	PS	SF
Emulsion pH	6.14±0.02	6.10±0.02	6.10±0.01
Emulsion stability (%)	94.58±0.62	94.14±0.55	94.42±0.65
Cooking yield (%)	93.23±0.47	93.21±0.91	94.12±0.76
Product pH	6.31±0.02	6.31±0.02	6.28±0.03
Moisture (%)	63.36^{b}±0.58	62.01^{ab}±0.64	60.38^{a}±0.81
Protein (%)	16.61±0.44	17.20±0.50	16.52±0.39
Fat (%)	8.86 ^{a}±0.20	10.19^{b}±0.41	8.91^{a}±0.17
Ash (%)	2.81±0.10	3.02±0.06	2.99±0.12
Carbohydrate (%)	8.37^{a}±0.66	7.58^{a}±1.05	11.22^{b}±0.93
Moisture protein ratio	3.83±0.12	3.61±0.10	3.66±0.10
Moisture retention%	59.08^{b}±0.76	57.80^{ab}±0.74	56.80^{a}±0.63
Fat retention (%)	93.33^{b}±0.74	92.02^{ab}±0.92	90.28^{a}±0.73
Cholesterol (mg/100 gm)	105.32^{a}±0.41	121.18^{b}±0.76	105.96^{a}±0.47

Means bearing different superscripts (a, b, c, d, …) in a row differ significantly (P<0.05).

CG= Chevon patties with 0.6% Carrageenan; PS = Chevon patties with 5% Poppy Seed SF= Chevon patties with 3% Sago flour.

The moisture content was significantly (P<0.05) higher in chevon patties with carrageenan compared to other two treatments and lowest moisture content was recorded in patties with sagoflour. This might be due to addition of compensatory water in the formulation of respective functional chevon patties. The higher moisture content was also reported by Nayak and Pathak (2016) in carrageenan incorporated low fat chevon patties.

The fat and cholesterol contents were significantly (P<0.05) lower in patties with carrageenan and sago flour compared to poppy seed incorporated chevon patties. However, lowest was in carrageenan incorporated chevon patties. Higher fat content in low fat chevon patties incorporated with poppy seed may be due to presence of 44% fat (Nergiz and Otles, 1994) in poppy seed. However, carrageenan and sago flour are considered as fat free fat replacer. Nayak *et al* (2015) noticed significantly (P<0.05) lower fat content in carrageenan incorporated chicken nuggets.

Moisture and fat retention was also significantly (P<0.05) higher in carrageenan incorporated chevon patties and lowest value was reported for patties with sago flour. This might be due to water binding nature of carrageenan. Huffman *et al.* (1991) also reported that carrageenan had great ability to retain moisture in meat products. These finding are supported by Garcıa *et al.* (2008) who also concluded that starch granules were not able to completely gelatinize and swell, which negatively affected water retention. The carrageenan /locust bean gum interaction improved texture and water retention.

Mineral profile analysis

The mean values for mineral profile analysis of low fat chevon patties incorporated with different fat replacer are presented in Table 3. Sodium and potassium content between treatments were comparable to each other. However, marginally higher potassium content was reported in patties incorporated with poppy seed. This might be due to higher potassium content in the poppy seed composition.

Table 3: Mineral profile (Mean±SE) of low fat chevon patties incorporated with different fat replacers.

Minerals	Treatments		
(mg/100 gm)	CG	PS	SF
Sodium	718.87±12.67	717.00±16.23	717.22±14.17
Potassium	243.82±13.82	280.75±11.76	242.78±12.74
Calcium	7.01^{a}±0.21	14.68^{b}±0.18	7.25^{a}±0.17
Iron	2.97^{a}±0.10	3.45^{b}±0.09	3.01^{a}±0.11
Manganese	0.089^{a}±0.003	0.401^{b}±0.008	0.099^{a}±0.006
Zinc	2.41^{a}±0.10	2.7^{b}±0.09	2.41^{a}±0.06

Means bearing different superscripts (a, b, c, d, …) in a row differ significantly (P<0.05).

CG= Chevon patties with 0.6% Carrageenan; PS = Chevon patties with 5% Poppy Seed SF= Chevon patties with 3% Sago flour.

Calcium, iron, manganese and zinc contents were significantly (P<0.05) higher in poppy seed incorporated low fat chevon patties compared to low fat chevon patties added with carrageenan and sago flour. However, lowest value for these mineral contents was estimated in patties incorporated with carrageenan. Poppy seed is reported to have 719 mg/ 100 gm potassium and predominant in other minerals (Ozcan and Atalay, 2006).

Texture profile analysis

The mean values for texture profile analysis of low fat chevon patties incorporated with different fat replacer are presented in Table 4 revealed significant (P<0.05) difference in the texture profile of low fat chevon patties added with different fat replacer.

Table 4: Texture profile (Mean±SE) of low fat chevon patties incorporated with different fat replacers.

Parameter	Treatments		
	CG	PS	SF
Hardness (N/cm_2)	50.14^b±0.54	39.04^a±1.81	53.98^b±1.28
Adhesiveness (Ns)	-3.58±0.23	-3.35±0.10	-3.78±0.24
Springiness (cm)	0.857^a±0.004	0.858^a±0.009	0.888^b±0.007
Cohesiveness (Ratio)	0.703^b±0.004	0.651^a±0.012	0.711^b±0.009
Gumminess (N/cm_2)	35.13^b±0.57	25.95^a±1.80	38.26^b±1.09
Chewiness (N/cm)	28.50^b±0.81	22.23^a±1.39	32.58^c±0.95

Means as bearing different superscripts (a, b, c, d, …) in a row differ significantly (P<0.05).

CG= Chevon patties with 0.6% Carrageenan; PS = Chevon patties with 5% Poppy Seed SF= Chevon patties with 3% Sago flour.

The mean values for hardness, adhesiveness, springiness, cohesiveness, gumminess and chewiness were significantly (P<0.05) higher for patties incorporated with sago flour compared to patties incorporated with poppy seed and it was comparable to patties with carrageenan However, adhesiveness value differed no significantly (P>0.05) among the treatments. Garcıa and Totosaus (2008) also reported higher hardness value for potato starch compared to carrageenan added sausages. High starch levels (>5%) in low-fat meat products give more hardness and cohesiveness than products with no added starch (Beggs *et al.,* 1997; Pietrasik, 1999). Higher hardness value was also reported by Badole *et al.* (2021) in guargum added kadaknath chicken patties and Nayak and Pathak (2018) in sago flour incorporated chevon patties.

Instrumental color analysis

The mean values for instrumental color analysis of low fat chevon patties incorporated with different fat replacer are presented in Table 5. The redness (a*) and yellowness (b*) value was significantly (P<0.05) higher for patties incorporated with poppy seed compared to other treatments. Nayak and Pathak (2017) also reported higher redness (a*) and yellowness (b*) value for poppy seed incorporated chevon patties compared to control. Redness (a*) as well as yellowness (b*) values were comparable between patties incorporated with carrageenan and sago flour. Fat reduction results in darker meat products with less red color (Beggs *et al*., 1997; Hughes *et al*., 1998; Morin *et al*., 2002; Pietrasik, 1999: Nayak and Pathak, 2018).

Lightness (L*) value was highest for carrageenan and lowest for poppy seed incorporated chevon patties. This might be due to moisture content of the respective treatment. A significant (P<0.05) difference between chevon patties developed with carrageenan and Sago flour have been reported. Similar findings for lightness value in carrageenan and potato starch added in sausages by Garcia and Totosaus (2008). Ibrahim *et al*, (2011) also reported comparable results between carrageenan and potato starch added chicken burger.

Sensory evaluation

The mean scores for various sensory attributes of low fat chevon patties incorporated with different fat replacers are presented in Table 6. The significant (P<0.05) difference was observed between treatments for all the sensory attributes except general appearance. Ibrahim *et al*. (2011) observed no significant (P>0.05) difference for general appearance between carrageenan and potato starch added chicken burger. The flavor score was significantly (P<0.05) higher for patties incorporated with carrageenan compared to other treatments. The higher flavor score in carrageenan added patties might be due to higher fat retention capacity of carrageenan. The mean texture score for poppy seed incorporated patties was significantly (P<0.05) lower compared to carrageenan and sago flour incorporated chevon patties. However, the highest score of texture was

Table 5: Instrumental color (Mean±SE) of low fat chevon patties incorporated with different fat replacers.

Parameter	Treatments		
	CG	PS	SF
Lightness (L*)	43.25±0.41	42.63±0.31	42.87±0.36
Redness (a*)	3.27^a±0.13	3.92^b±0.13	3.22^a±0.32
Yellowness (b*)	10.45^a±0.35	11.78^b±0.22	10.27^a±0.30

Means bearing different superscripts (a, b, c, d, …) in a row differ significantly (P<0.05).

CG= Chevon patties with 0.6% Carrageenan; PS = Chevon patties with 5% Poppy Seed SF= Chevon patties with 3% Sago flour.

Table 6: Sensory attributes (Mean±SE) of low fat chevon patties incorporated with different fat replacer.

Attributes	Treatments		
	CG	PS	SF
General appearance	6.94±0.04	6.92±0.07	7.07±0.08
Flavour	7.13^b±0.03	6.94^a±0.08	6.99^a±0.07
Texture	7.05^b±0.03	6.76^a±0.06	7.21^b±0.05
Saltiness	7.13^b±0.06	6.86^a±0.05	6.96^{ab}±0.11
Juiciness	7.16^b±0.03	6.98^a±0.05	6.94^a±0.12
Mouth coating	6.96^b±0.04	6.70^a±0.07	6.95 ^{b}±0.08
Overall acceptability	7.12^b±0.04	6.89^a±0.05	7.07^{ab}±0.08

Means bearing different superscripts (a, b, c, d, …) in a row differ significantly (P<0.05).

CG= Chevon patties with 0.6% Carrageenan; PS = Chevon patties with 5% Poppy Seed SF= Chevon patties with 3% Sago flour.

reported for patties with sago flour. The higher score for texture in potato starch added compared to carrageenan added chicken burger was also reported by Ibrahim *et al.* (2011).

Mean saltiness and juiciness scores were also significantly ($P<0.05$) superior for carrageenan incorporated chevon patties among all variants. The lowest score for saltiness in poppy seed incorporated chevon patties and for juiciness in patties with sago flour was recorded. Superiority in juiciness might be due to significantly higher moisture content in the respective treatment and higher moisture retention capacity of carrageenan. No significant difference between poppy seed and sago flour incorporated low fat chevon patties were estimated for saltines as well as juiciness. Mouth coating score was significantly ($P<0.05$) lower in poppy seed incorporated chevon patties.

Mean score for overall acceptability was highest for low fat chevon patties with carrageenan and lowest for patties with poppy seed Sensory attributes of low fat formulation supplemented with 0.5% gum had quality characteristics that were similar to those of control (Rather *et al.,* 2017). The sensory panelist most accepted the carrageenan added low fat chevon patties compared to other treatments.

CONCLUSION

On the basis of physicochemical properties, mineral profile, texture profile, instrumental color analysis and finally sensory evaluation, the carrageenan added low fat chevon patties (CG) was found superior and most acceptable by the sensory panelists. There fore carrageenan may consider a excellent fat replacer for the development of low fat chevon patties.

Conflict of Interest: None.

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