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Research Article

EFFECT OF OMEGA 3 FATTY ACID ENRICHMENT ON QUALITY CHARACTERISTICS OF PROTEIN ENRICHED CHEVON NUGGETS

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Abstract: Study was conducted on quality characteristics of chevon nuggets prepared using canola and flaxseed oil (CFSO) to optimize ratio of omega -6/3 fatty acid and Polyunsaturated fatty acid/Saturated Fatty Acid (PFA/SFA) in product standardized with freeze-dried liver and kidney (FDLK) having enriched protein. Four different treatments of combination of CFSO (25, 50, 75 and 100%) replacing refined sunflower oil (RSO), were evaluated against control 1 (10% RSO of total product formulation) and 2 (10% RSO of total product formulation along with FDLK) nuggets. No significant effect on pH of emulsion and product, emulsion stability and cooking yield. Moisture, protein, ash content and moisture protein ratio were like control 2 nuggets but had significantly ($P<0.01$) reduced fat content (13.80 to 11.78%) when compared with control (1 and 2) nuggets. Sensory evaluation revealed, 100% CFSO treated nuggets had significantly ($P<0.05$) high score for colour and appearance and overall acceptability than control and other treatments. SFA (28.36-17.41%), monounsaturated fatty acid (42.07- 37.41%) and omega -6 FA (17.89-10.87%) was significantly ($P<0.05$) reduced but increased the omega-3 FA (10.58-34.29%) as level of incorporation increases. However, FA composition of 100% CFSO treated nuggets had ideal omega- 6/3 FA ratio but slightly increased PUFA/SFA. CFSO can be used as a sources of omega- 3 fatty acid in chevon nuggets to enhance their health value and functionality. Food including chevon nuggets enriched with goodness of functional ingredients like Omega-3 fatty acid gaining consumers preference globally. Inclusion of CFSO significantly increases the omega-3 fatty acid and have ideal omega-6/3 fatty acid, making chevon nuggets healthier. Consumption of chevon nuggets enriched with omega -3 fatty acid is expected to prevent the incidence of cardiovascular diseases.

Keywords: *Chevon nuggets, Omega 3 fatty acid, Physicochemical properties*

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Introduction

Meat is a major source of protein and valuable nutrients like minerals and vitamins, in processed meat products their associated nutrients, causes negative health effects due to high levels of saturated fatty acids, cholesterol, sodium, fat and caloric contents [1]. Due to these negative health effects, the consumers demand on meat and meat products has been changed and it should, not only satisfy the hunger, but also to prevent nutrition related diseases, to improve physical and mental wellbeing. Therefore, meat industry is compelled to produce functional meat products and have witnessed a tremendous increase in interest due to their potentials of providing health and nutritional benefits which is going to fetch a higher demand by the consumer in future. As the meat and meat product contains higher amount of fat, especially saturated fatty acid (SFA), the ratio of n-6: n-3 polyunsaturated fatty acids (PUFAs) which can have an impact on Low Density Lipoprotein (LDL) and cholesterol level. LDL is associated with cardiovascular diseases. The ratio of polyunsaturated fatty acid to saturated fatty acids in meat should be more than 0.4 [2]. Most of the meats have PUFAs to SFA ratio around 0.1. In addition, fat in meat products play an important role in stabilizing meat emulsions, reducing cooking loss, improving water holding capacity, providing juiciness of the meat products [3]. The reduction of fat can increase the toughness and significantly alter their acceptability of the meat products [4].

The use of vegetable oil as replacement of animal fat, enriched with omega-3 fatty acid becomes a recent trend in formulating low-fat/low-cholesterol meat products [5]. Of these, canola and flaxseed oil are a rich source of α-linolenic acid with concentrations ranging 10 to 12% and 52 to 58 % respectively [5]. The α-linolenic acid can act as the precursor of long chain omega-3 polyunsaturated fatty acids, helpful for reducing the incidence of diabetes and cardiovascular diseases [7]. In view to meet the higher demand of consumers for omega-3 fatty acid requirement in meat products for the healthy wellbeing of human, it was envisaged to study the enrichment levels of omega-3 fatty acid from different sources of vegetable oils to enhance the product with nutrients and to tailor it with healthier characteristics.

Materials and Methods

The studies were carried out in the National Referral Laboratory for Testing of Animal Products, Goat Products Technology Laboratory, ANMPT Division, ICAR - Central Institute for Research on Goats, Makhdoom, Farah, Mathura, Uttar Pradesh during the year 2020.

Raw materials

Boneless chevon from neck and shoulder cut of 12 months old male Barbari goat, procured from the experimental slaughter unit of the Institute was used for product preparation.

Table-1 Formulations for the canola and flaxseed oil incorporated goat meat nugget with optimized level of FDLK (1:1)

SN	Ingredients	Control	Different levels of CFSO (%)				
		1	2	25	50	75	100
1	Minced goat meat	68	65	65	65	65	65
2	Freeze dried edible byproducts liver and Kidney – (1:1)	0	3	3	3	3	3
3	Salt	1.5	1.5	1.5	1.5	1.5	1.5
4	Sodium tripolyphosphate	0.5	0.5	0.5	0.5	0.5	0.5
5	Sodium nitrite	0.015	0.015	0.015	0.015	0.015	0.015
6	Sucrose	0.3	0.3	0.3	0.3	0.3	0.3
7	Ice	9	9	9	9	9	9
8	Whole chicken Egg	3	3	3	3	3	3
9	Refined sunflower oil	10	10	7.5	5	2.5	0
10	Refined canola and flaxseed oil (1:1)	0	0	2.5	5	7.5	10
11	Condiments	3	3	3	3	3	3
12	Maida	3	3	3	3	3	3
13	Dried spice mix	1.7	1.7	1.7	1.7	1.7	1.7

Table-2 Fatty acid composition (% of total fatty acid) of three different oils (Mean ± SE)

SN	Fatty acids (%)	Sunflower oil	Flaxseed oil	Canola oil	F value
1	Myristic acid (C14:0)	0.53 ± 0.12	0.20 ± 0.09	0.81 ± 0.35	1.84^{NS}
2	Pentadecanoic acid (C15:0)	0	0.13 ± 0.05^{a}	0	6.09*
3	Palmitic acid (C16:0)	7.01 ± 0.73^{a}	4.94 ± 0.50^{ab}	4.18 ± 0.83^{b}	4.29*
4	Palmitolic acid (C16:1)	0.57 ± 0.13	0.45 ± 0.05	0.36 ± 0.14	0.86^{NS}
5	Heptadecanoic acid (C17:0)	0.52 ± 0.10	0.11 ± 0.08	0.53 ± 0.17	3.59^{NS}
6	Cis – Heptadecanoic acid (C17:1)	0	0.11 ± 0.08^{ab}	0.52 ± 0.23^{a}	3.71*
7	Stearic acid (C18:0)	5.46 ± 0.59^{a}	4.92 ± 0.34^{a}	1.05 ± 0.19^{b}	33.64**
8	Eladic acid (C18:1N9T)	2.29 ± 0.43^{b}	0.49 ± 0.08^{b}	50.61 ± 1.50^{a}	987.5**
9	Oleic acid (C18:1N9C)	28.53 ± 1.21^{a}	18.09 ± 0.88^{b}	5.99 ± 0.57^{c}	147.19**
10	Linoleic acid (C18:2N6C)	45.79 ± 0.71^{a}	13.35 ± 0.35^{c}	18.74 ± 1.12^{b}	475.66**
11	Linoleic acid (C18:2N6T)	0.87 ± 0.20^{a}	0	0	17.27**
12	Alpha-Linolenic acid (C18:3N3)	0.69 ± 0.01^{c}	54.58 ± 0.78^{a}	13.06 ± 0.87^{b}	1725.71**
13	Gamma-linolenic acid (C18:3N6)	5.49 ± 0.55^{a}	1.11 ± 0.08^{b}	0.78 ± 0.06^{b}	65.59**
14	Arachidic acid (C20:0)	0.42 ± 0.09^{b}	0.31 ± 0.05^{b}	0.87 ± 0.19^{a}	5.161*
15	Cis- Eicosenoic acid (C20:1)	0.54 ± 0.10^{a}	0	0.20 ± 0.20^{a}	4.33*
16	Behenic acid (C22:0)	0.78 ± 0.10^{ab}	0.20 ± 0.09^{b}	1.35 ± 0.43^{a}	4.65*
17	Erucic acid (C22:1N9)	0	0	0.07 ± 0.07	1.0^{NS}
18	Lignoceric acid (C24:0)	0.43 ± 0.14	0	0.75 ± 0.33	3.32^{NS}
19	Nervoic acid (C24:1)	0	0	0.03 ± 0.03	1.0^{NS}
20	SFA	15.18 ± 0.76^{a}	10.85 ± 0.50^{b}	9.57 ± 0.39^{b}	26.13**
21	PUFA	47.35 ± 0.68^{b}	69.05 ± 0.82^{a}	32.60 ± 1.57^{c}	277.27**
22	MUFA	31.95 ± 1.00^{b}	20.08 ± 1.05^{c}	57.81 ± 1.47^{a}	259.27**
23	Omega - 3 fatty acid	0.69 ± 0.01^{c}	54.58 ± 0.78^{a}	13.06 ± 0.87^{b}	1725.71**
24	Omega - 6 fatty acid	52.16 ± 0.87^{a}	14.46 ± 0.35^{a}	19.53 ± 1.09^{b}	601.26**
25	PUFA/SFA ratio	3.16 ± 0.18^{b}	6.42 ± 0.27^{a}	3.44 ± 0.25^{b}	56.18**
26	Omega – 6/3 fatty acid ratio	75.30 ± 0.60^{a}	0.26 ± 0.00^{c}	1.52 ± 0.10^{b}	14858.12**

Table-3 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the physicochemical properties of goat meat nuggets with optimized level of FDLK (1:1) (Mean ± SE)

SN	Parameters	Control	CFSO (%)					F value
		1	2	25	50	75	100	
1	Emulsion pH	6.35 ± 0.03	6.37 ± 0.03	6.36 ± 0.01	6.36 ± 0.02	6.37 ± 0.01	6.38 ± 0.03	0.13^{NS}
2	Product pH	6.54 ± 0.03	6.55 ± 0.03	6.57 ± 0.03	6.56 ± 0.03	6.55 ± 0.03	6.55 ± 0.03	0.12^{NS}
3	Emulsion stability (%)	96.42 ± 0.47	97.02 ± 0.29	97.15 ± 0.30	97.18 ± 0.18	97.29 ± 0.24	97.05 ± 0.43	0.81^{NS}
4	Cooking yield (%)	97.74 ± 0.45	97.52 ± 0.19	97.93 ± 0.38	98.59 ± 0.09	97.40 ± 0.58	97.34 ± 0.15	1.70^{NS}
5	Moisture (%)	66.05 ± 0.38^{a}	63.40 ± 0.25^{b}	63.69 ± 0.35^{b}	63.47 ± 0.32^{b}	63.32 ± 0.27^{b}	63.25 ± 0.38^{b}	10.54**
6	Protein (%)	14.71 ± 0.16^{b}	18.27 ± 0.10^{a}	18.34 ± 0.10^{a}	18.30 ± 0.11^{a}	18.37 ± 0.11^{a}	18.29 ± 0.21^{a}	107.51**
7	Fat (%)	13.80 ± 0.09^{a}	13.14 ± 0.13^{b}	12.20 ± 0.16^{c}	12.12 ± 0.13^{c}	11.87 ± 0.10^{c}	11.78 ± 0.23^{c}	27.97**
8	Ash (%)	2.71 ± 0.03^{a}	2.92 ± 0.02^{b}	2.94 ± 0.04^{b}	2.93 ± 0.03^{b}	2.95 ± 0.02^{b}	2.97 ± 0.03^{b}	6.91**
9	Carbohydrate (%)	2.71 ± 0.41^{bc}	2.26 ± 0.22^{c}	2.80 ± 0.25^{abc}	3.16 ± 0.38^{abc}	3.46 ± 0.24^{ab}	3.69 ± 0.20^{a}	3.11*
10	Moisture protein ratio	4.49 ± 0.05^{a}	3.47 ± 0.02^{b}	3.47 ± 0.03^{b}	3.46 ± 0.01^{b}	3.44 ± 0.03^{b}	3.46 ± 0.05^{b}	108.62**
11	Energy (Kcal/gm)	193.87 ± 1.54	200.46 ± 1.44	194.48 ± 1.82	194.94 ± 1.53	194.15 ± 1.10	193.93 ± 2.36	2.30^{NS}

Other food grade non-meat ingredients and additives like common salt, sodium nitrite, sodium tripolyphosphate, sucrose, refined vegetable oil (sunflower oil, canola and flaxseed oil), condiments, whole egg liquid, refined wheat flour and spices used for the preparation of chevon nuggets were procured from local market and CDH Chemicals, India. Analytical grade chemicals were purchased from, Sigma-Aldrich, USA; Himedia, India, s.d. Fine-Chem Limited, India to evaluate various parameters.

Preparation of chevon nuggets

Processing of chevon

The lean chevon which is devoid of bone was kept for conditioning in a refrigerator at 4±1°C for 6 to 8 hrs, packed in UV sterilized LDPE bags and frozen at-18±1°C till further use. Whenever needed the required quantity of frozen chevon was thawed at 4±1°C for 16 to 18 hrs. The thawed meat was cut into small pieces of size 10 to 12 cm and ground by double mincing through 8 mm plate using a meat mincer (Model P-22, M/S Tallers Ramon, Barcelona, Spain) and kept at 4±1°C in a refrigerator until the preparation of all treatments of chevon nuggets.

Preparation of meat emulsion

A batch of 500 gm for each of the product mix for the control and different treatment groups, was prepared separately by pre weighing the ingredients as per the formulations. The FDLK (1:1 ratio) at 3% optimized level as a lean chevon replacer along with the different levels of combination of canola and flaxseed oil (1:1 ratio) were incorporated at 0, 25, 50, 75 and 100% replacing refined

Table-4 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the instrumental colour properties of goat meat nuggets with optimized level of FDLK (1:1) (Mean ± SE)

SN	Parameters	Control	CFSO (%)					F value
		1	2	25	50	75	100	
1	Lightness *(L)*	45.16 ± 0.27	44.89 ± 0.59	44.74 ± 0.59	44.69 ± 0.52	44.87 ± 0.43	44.64 ± 0.64	1.83 ^{NS}
2	Redness *(a*)*	9.19 ± 0.16^{a}	9.29 ± 0.23^{a}	9.24 ± 0.27^{a}	8.73 ± 0.28^{ab}	8.54 ± 0.30^{ab}	8.17 ± 0.39^{b}	2.55*
3	Yellowness *(b*)*	12.58 ± 0.54^{b}	11.52 ± 0.53^{c}	13.82 ± 0.31^{a}	13.65 ± 0.23^{a}	14.11 ± 0.35^{a}	14.52 ± 0.26^{a}	7.99**
4	Hue	53.48 ± 1.40^{cd}	50.82 ± 1.32^{d}	56.18 ± 1.13^{bc}	57.45 ± 0.77^{ab}	58.75 ± 1.14^{ab}	60.65 ± 1.49^{a}	8.41**
5	Chroma	15.63 ± 0.42^{bc}	14.84 ± 0.48^{a}	16.66 ± 0.25^{ab}	16.22 ± 0.29^{ab}	16.54 ± 0.32^{ab}	16.73 ± 0.18^{a}	4.64**

Table-5 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the texture profile properties of goat meat nuggets with optimized level of FDLK (1:1) (Mean ± SE)

SN	Parameters	Control	CFSO (%)					F value
		1	2	25	50	75	100	
1	Hardness (N/cm^2)	37.08 ± 0.68	35.74 ± 0.53	35.58 ± 0.90	35.41 ± 1.10	35.08 ± 1.27	35.41 ± 0.90	0.177 ^{NS}
2	Adhesiveness (Ns)	0.09 ± 0.05	-0.25 ± 0.16	-0.16 ± 0.09	-0.13 ± 0.12	-0.31 ± 0.15	-0.25 ± 0.13	0.448 ^{NS}
3	Springiness (cm)	0.78 ± 0.095	0.76 ± 0.183	0.79 ± 0.092	0.78 ± 0.077	0.77 ± 0.104	0.77 ± 0.087	0.007 ^{NS}
4	Cohesiveness (ratio)	0.39 ± 0.045	0.40 ± 0.051	0.40 ± 0.090	0.40 ± 0.086	0.38 ± 0.087	0.41 ± 0.060	0.025 ^{NS}
5	Gumminess (N/cm^2)	14.64 ± 1.73	14.63 ± 1.85	14.09 ± 2.92	14.43 ± 3.05	13.58 ± 3.38	14.76 ± 2.34	0.026 ^{NS}
6	Chewiness (N/cm)	11.39 ± 1.84	11.88 ± 3.76	11.52 ± 2.78	11.42 ± 2.44	11.79 ± 4.58	11.58 ± 2.62	0.007 ^{NS}

Table-6 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the sensory qualities of goat meat nuggets with optimized level of FDLK (1:1) (Mean ± SE)

SN	Parameters	Control	CFSO (%)					F value
		1	2	25	50	75	100	
1	Color and appearance	6.71 ± 0.25^{b}	7.13 ± 0.17^{ab}	7.18 ± 0.18^{ab}	7.27 ± 0.14^{a}	7.37 ± 0.08^{a}	7.47 ± 0.13^{a}	2.38*
2	Flavor	6.60 ± 0.32^{b}	7.06 ± 0.20^{ab}	7.22 ± 0.28^{ab}	7.37 ± 0.17^{a}	7.49 ± 0.12^{a}	7.61 ± 0.16^{a}	2.58*
3	Texture	7.22 ± 0.18	7.21 ± 0.17	7.27 ± 0.19	7.29 ± 0.11	7.30 ± 0.12	7.33 ± 0.18	0.083 ^{NS}
4	Juiciness	7.20 ± 0.14	7.22 ± 0.15	7.29 ± 0.17	7.27 ± 0.15	7.31 ± 0.19	7.38 ± 0.15	0.160 ^{NS}
5	Overall acceptability	6.70 ± 0.29^{b}	6.98 ± 0.18^{ab}	7.26 ± 0.19^{ab}	7.29 ± 0.15^{ab}	7.34 ± 0.17^{a}	7.55 ± 0.09^{a}	2.39*

sunflower oil in 500 gm of batter mix was used for each of the treatments as per the formulations mentioned in [Table-1]. The meat emulsion was prepared in a kitchen mixer grinder (Model Philips HR7629/90 650W Food processor) by orderly mixing of all ingredients with the room temperature maintained at 7 ± 2°C to prepare the emulsion. Double minced chevon mixed with FDLK 3 % (optimized level) was first added with dry ingredients like common salt, sodium tripolyphosphate and sodium nitrite (dissolved with ice flakes) was mixed at 800 RPM speed for first 30 sec. To this ice flakes were added the speed of the mixer was slowly increased to 1,000 RPM for up to 1.15 min to extraction of salt and water soluble protein for binding with water and fat. Then whole egg followed by refined sunflower oil for control and different levels of combination of canola and flaxseed oil along with refined sunflower oil for treatment groups was added by maintaining the speed at 1,500 RPM for up to 2.30 min for making proper emulsion and after which the speed of it was reduced to 800 RPM. Finally, condiments, refined wheat flour and dried spice mix were added and mixed at 1,700 RPM speed for up to 3 min for the proper binding, mixing of all ingredients and for the formation of emulsion batter.

Preparation of chevon nuggets

Meat emulsion obtained was filled into the stainless steel molds (size 14.5 x 9.5 cm) and steam cooked for 35 min in the pressure cooker to get a core temperature of 80 ± 2°C in the meat blocks for proper cooking. The nugget blocks after it is cooled were sliced and cut into nuggets of size 15 mm thickness and packed in UV sterilized LDPE pouches were used for determining the various quality characteristics.

Analytical procedures

Physicochemical properties

pH

The pH of the meat emulsion and nugget was determined by blending 10 gm sample with 50 ml distilled water and thoroughly homogenized by using the homogenizer (Model PT-MR-2100, Kinematica AG, Luzern, Switzerland) for 1 min. The pH of the suspension was recorded by immersing the electrode of the digital pH meter (Model Mettler Toledo, Columbus, Ohio, USA). The pH meter was calibrated using standard buffers at a pH 4, 7 and 10 before measuring the pH of the sample [8].

Emulsion stability

The emulsion stability was determined by taking 25 gm of the meat emulsion from each treatment groups in LDPE pouches and heated at 80°C for 20 min in thermostatically controlled water bath by turning the sample for every 10 min. The exudates were drained out, the cooked samples were weighed after it is cooled and the yield of the sample was expressed as the emulsion stability [9].

Emulsion stability (%) = [(Weight of the cooked sample) / (Weight of the emulsion)] x 100

Cooking yield

The weight of the emulsion and weight of the product after cooking was recorded and the cooking yield of the product was calculated as mentioned below.

Cooking Yield (%) = [(Weight of the cooked product) / (Weight of the emulsion)] x 100

Proximate composition

Moisture, protein, fat and ash percentage of different treatment groups of chevon nugget were estimated as per the procedure AOAC [10].

Carbohydrates (%)

The carbohydrate was calculated as below.

Carbohydrate (%)-(100-[Moisture (%) + Fat (%) + Ash (%)]) [11].

Energy/Calorie value (kcal/100 g)

The total calorie of the sample was calculated based on 100 gm portions using water value for fat (9kcal/gm), protein (4.02 kcal/gm) and carbohydrate (3.87 kcal/gm) [12]. However, the calorie contributed by the addition of other functional ingredients in meat products was not known. Therefore, the calorie value were only the estimates and not the actual value of the product [13].

Instrumental colour properties

The colour values of the chevon nugget were monitored by evaluating Hunter L (lightness), a* (redness) and b*(yellowness) values using Color Tech PCM+ (ColorTec Associates, Inc, Clinton, NJ). Colorimetry measures colour by quantitative physical methods and can define them well within established numerical values. They are expressed using standard Hunter L a b system [14]. L, a*, b* values (non-dimensional units) refer to the three axes of the system lightness axis (white-black, L); and two axes representing both hue and chroma, one red-green (a*) and other blue-yellow (b*). This system provides an unambiguous description and differentiation of colour between sample can be differentiated using a simple computer programme [9]. The colour values of the chevon nuggets were measured by choosing the four random spots on both sides of the product slices to measure the lightness, yellowness and redness values. The hue (relative position of colour between redness and yellowness) and chroma (saturation/colour intensity) values were determined by using the formula, Tan-1(b*/a*) and (a2 + b2)1/2, respectively.

Texture profile properties

The textural properties of nuggets were evaluated using Stable Microsystem (Model TA.XT 2i/25 Surrey, U.K.) as per the method Bourne (1978) [15]. The central core of the sample of each of the sample in duplicates of size 1.5 cm3, were placed in the centre of the base plate or sample platform was compressed twice to 60% of the original height to form two bite workforce compression curves.

Sensory evaluation

Twelve members of trained sensory panel comprising researchers of the institute evaluated chevon nuggets using 8 points descriptive scale, whereas 8 denoted extremely desirable and 1 denoted extremely poor, 5 to 8 were considered acceptable [16]. The treatments of the nugget sample experiment were explained to the panellist without revealing the sample identity. The prewarmed 3 digits coded samples were randomly served to the panellists at respective booth and they were asked to evaluate for appearance and colour, flavour, juiciness, texture and overall acceptability on the sensory evaluation scorecard. The panellists were provided portable water to rinse their mouth between samples. The panellist judged the nugget samples for general appearance and colour, flavour, texture, juiciness, and overall acceptability.

Fatty acid composition

The fatty acid composition of refined sunflower oil, canola oil, flaxseed oil and different treatments of canola and flaxseed oil incorporated chevon nuggets with optimized level of freeze-dried liver and kidney were estimated by Fatty acid methyl ester synthesis (FAME) O' Fallon *et al.,* (2007) [17] by using the GC-MS triple quadrupole (GC-MS TQ8030, Shimadzu Corp., Japan).

Reagents

1. 10 N KOH was prepared by adding 560 gm of KOH pellets to one litter of D.W
2. Methanol (SRL Chem) assay of 99.8%
3. 24 N H_2SO_4 was prepared by adding 162 ml of conc H_2SO_4 (97%) in 250 ml of D.W
4. Hexane of HPLC grade
5. Fatty acid internal standard - Supelco 37 component FAME mix supplied by Sigma Aldrich which contain 37 fatty acids were mentioned below was stored at -15°C.

Butyric acid (C4:0), Caproic acid (C6:0), Caprylic acid (C8:0), Capric acid (C10:0), Undecanoic acid (C11:0), Lauric acid (C12:0), Tridecanoic acid (C13:0), Myristic acid (C14:0), Myristoleic acid (C14:1), Pentadecanoic acid (C15:0), Cis-10-pentadecanoic acid (C15:1), Palmitic acid (C16:0), Methyl-cis-9-hexadecenoate (16:1) pamitolic acid, heptadecanoic acid (C17:0), Cis-10-heptadecanoic acid (C17:1), Stearic acid (C18:0), Methyl trans-9-octadecanoate (C18:1n9t) Eladic, methyl cis-9-octadecanoate (18:1n9c) Oleic acid, Methyl linoelaidate (18:2n9t) linoleic acid, Linoleic acid (C18:2) n 6, Arachidic acid (C20:0), Methyl-g-linolenate (18:3n6) Gama linolenic acid, Cis-11-eicosenoic acid (C20:1) n9, Linolenic acid (C18:3) n3, Heneicosanoic acid (C21:0) methyl cis-11,14-eicosadienoate (C20:2n6), Behenic acid (C22:0), Methyl cis-8,11,14-eicosatrienoate (C20:3) n 6, Erucic acid ME (C22:1) n 9, Methyl cis-11,14, 17-Eicosatrienoate (C20:3) n3, Arachidonic acid (C20:4) n 6, Tricosanoic acid ME (C23:0), Methyl cis-13,16-docosadienoate (C22:2), Lignoceric acid (C24:0), Cis-5,8,11,14,17 eicosapentaenoic acid (C20:5) n 3, Methyl cis-15-tetracosenoate (24:1n9) nervoic acid and Cis-4,7,10,13,16,19-docosahexaenoic acid (C22:6) n 3.

Preparation of sample

A 500 mg of finely chopped nugget sample was taken in a 16 x 125 mm screw-cap pyrex culture tube to which 700 µl of 10 N KOH and 5.3 ml of methanol was added. The pyrex culture tubes were incubated at 55°C in a water bath for 90 min with vigorous handshaking for 5 sec at an interval of every 20 min in order to properly permeate, dissolve and hydrolyze the sample. The tubes were cooled below the room temperature by passing in cold tape water. To this 580 µl of 24 N H_2SO_4 was added. The tubes were mixed well by inversion and with precipitated K_2SO_4, were again incubated at 55°C in a water bath for 90 min with vigorous handshaking for 5 sec at an interval of every 20 min and cooled in running tape water after FAME synthesis. 3 ml of hexane was added and the tubes were thoroughly mixed for 5 min in a multitube vortex. The tubes were centrifuged at 2000 gms for 10 min (Biofuge Prime OR, Heraeus, Germany), the hexane layer present at the top of the tubes were collected in a GC vial by using Pasteur pipette and kept at-15°C until further running in GC-MS/MS.

Quantification of fatty acid composition by GC- MS/MS

The fatty acid composition of the FAME was determined by using the GC-MS/MS on a stable wax 5ms x 0.25 mm x 30 m capillary column installed as a Hewlett Packard gas chromatogram equipped with a Hewlett Pakard Series II integrator and controller, a flame ionization detector and split injection. The initial oven temperature was 120°C with the holding time of 2 min, subsequently, temperature was increased to 240°C at a rate of 2°C min-1 and was maintained for 70 min. Nitrogen was used as a carrier gas at a flow rate of 1 ml/min. The injector and the detector temperature were set at 260°C.

The split ratio of 1:30. Solvent vial of acetonitrile was used sequentially as cleaning solvents for the autosampler injection syringe. The fatty acids were identified by comparing their retention time with the fatty acid methyl standard (Supelco 37 component FAME mix) and were expressed as percentage of total fatty acid.

Results and Discussion

In this part of study, a series of experiments were conducted with different levels of incorporation of canola and flaxseed oil (CFSO) at 1:1 ratio, replacing refined sunflower oil for enrichment of omega-3 fatty acid in chevon nuggets standardized with FDLK (1:1 ratio) at 3% were analysed for the quality characteristics. The results were statistically analysed and presented in tables and are critically discussed.

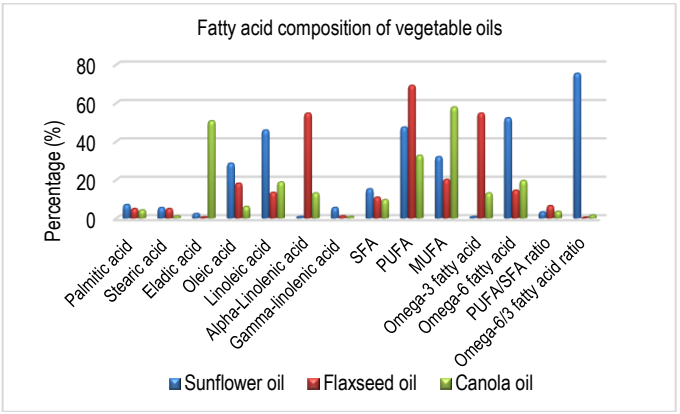

Fig-1 Fatty acid composition (% of total fatty acid) of three different oils

Fatty acid composition of three different vegetable oils

The fatty acid composition three different vegetable oil were presented in [Table-2] and [Fig-1]. Fatty acid composition of sunflower oil, canola and flaxseed oil used in the study revealed that sunflower oil contains significantly higher ($P<0.05$ and $P<0.05$) amount of palmitic acid (C16:0) (7.01%), stearic acid (C18:0) (5.46%) which proportioned for highest amount of saturated fatty acid (SFA of 15.18%) when compared to canola (9.57%) and flaxseed oil (10.85%). Among saturated fatty acids, there was no significant difference ($P>0.05$) noticed in myristic acid (C14:0), heptadecanoic acid (C17:0) and lignoceric acid (C24:0). Pentadecanoic acid (C15:0), arachidic acid (C20:0) and behenic acid (C22:0) were present in lesser proportion with significant difference ($P<0.05$) in three different vegetable oils. Similar values of individual fatty acids of SFA in sunflower and canola oil was reported by Vingering *et al.,* (2010) [18].

Significantly high ($P<0.01$) amount of polyunsaturated fatty acid (PUFA of 69.05%) was found in flaxseed oil. That was constituted by 54.58% α-linolenic acid (C18:3N3) (ALA). ALA content (%) of canola and sunflower oil were 13.06 and 0.69 respectively. Bayrak *et al.,* (2010) [19] reported flaxseed oil was the rich source of ALA that contains 45-59% of ALA. Our reports agree with the above findings. In sunflower oil, the PUFA constituted highly of linoleic acid (C18:2N6C) of 45.79% when compared with flaxseed (13.35%) and canola oil (18.74%).

Table-7 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the fatty acid profile (% of total fatty acid) of goat meat nuggets with optimized level of FDLK (1:1) (Mean ± SE)

SN	Parameters	Control	CFSO (%)					F value
		1	2	25	50	75	100	
1	Myristic acid (C14:0)	1.03 ± 0.10	0.96 ± 0.10	0.99 ± 0.14	0.95 ± 0.13	0.76 ± 0.05	0.60 ± 0.03	2.06^{NS}
2	Pentadecanoic acid (C15:0)	0.15 ± 0.07^{a}	0.22 ± 0.07^{a}	0	0	0	0	5.87**
3	Palmitic acid (C16:0)	13.46 ± 0.70^{a}	13.53 ± 1.05^{a}	12.59 ± 0.70^{a}	11.91 ± 0.40^{ab}	10.10 ± 0.37^{bc}	8.64 ± 0.63^{c}	9.12**
4	Palmitolic acid (C16:1)	0.96 ± 0.07	0.91 ± 0.08	0.86 ± 0.07	0.82 ± 0.04	0.81 ± 0.04	0.71 ± 0.04	1.90^{NS}
5	Heptadecanoic acid (C17:0)	0.72 ± 0.03^{a}	0.64 ± 0.06^{abc}	0.70 ± 0.05^{ab}	0.48 ± 0.10^{abc}	0.45 ± 0.09^{bc}	0.40 ± 0.05^{c}	3.66*
6	Cis – Heptadecanoic acid (C17:1)	0.36 ± 0.07	0.41 ± 0.09	0.30 ± 0.10	0.28 ± 0.12	0.21 ± 0.09	0.14 ± 0.09	0.75^{NS}
7	Stearic acid (C18:0)	11.11 ± 1.00^{a}	11.16 ± 0.98^{a}	9.41 ± 0.57^{ab}	9.13 ± 0.48^{ab}	7.66 ± 0.58^{b}	7.35 ± 0.46^{b}	5.35**
8	Eladic acid (C18:1N9T)	1.08 ± 0.10^{e}	0.97 ± 0.09^{e}	4.01 ± 0.27^{d}	6.52 ± 0.43^{c}	11.44 ± 0.63^{b}	12.64 ± 0.53^{a}	158.25**
9	Oleic acid (C18:1N9C)	38.46 ± 1.03^{a}	37.90 ± 0.79^{a}	34.29 ± 0.98^{b}	32.61 ± 1.31^{b}	24.99 ± 1.03c	23.76 ± 0.72c	39.75**
10	Linoleic acid (C18:2N6C)	13.75 ± 0.54^{a}	14.23 ± 0.37^{a}	15.55 ± 0.40^{a}	14.79 ± 0.84^{a}	12.62 ± 0.50b	10.31 ± 0.73c	9.86**
11	Linolenic acid (C18:3N3)	8.98 ± 0.27^{e}	8.81 ± 0.48^{e}	13.41 ± 0.42^{d}	16.94 ± 0.42^{c}	28.03 ± 1.07^{b}	34.29 ± 1.19^{a}	238.96**
12	Cis- Eicosenoic acid (C20:1)	0.76 ± 0.04^{a}	0.79 ± 0.04^{a}	0.53 ± 0.02^{b}	0.49 ± 0.05^{b}	0.34 ± 0.07^{c}	0.25 ± 0.11^{c}	12.11**
13	Gama-linolenic acid (C18:3N6)	4.15 ± 0.14^{a}	4.32 ± 0.42^{a}	2.94 ± 0.14^{b}	2.11 ± 0.09^{c}	1.17 ± 0.02^{d}	0.55 ± 0.03^{e}	60.33**
14	Heneicosanoic acid (C21:0)	1.00 ± 0.05^{a}	1.02 ± 0.09^{a}	0.80 ± 0.07^{a}	0.30 ± 0.10^{b}	0.13 ± 0.09^{c}	0	33.70**
15	Behenic acid (C22:0)	0.85 ± 0.05^{a}	0.89 ± 0.04^{a}	0.82 ± 0.10^{a}	0.71 ± 0.02^{ab}	0.60 ± 0.03^{bc}	0.41 ± 0.10^{c}	6.81**
16	Cis -Docosadienoate (C22:2)	1.08 ± 0.34^{a}	1.17 ± 0.11^{a}	0.99 ± 0.08^{a}	0.87 ± 0.14^{a}	0.13 ± 0.08^{b}	0	9.10**
17	Nervoic acid (C24:1)	0.42 ± 0.14^{a}	0.43 ± 0.14^{a}	0.39 ± 0.14^{a}	0.13 ± 0.08^{ab}	0.07 ± 0.04^{ab}	0	3.25*
18	Cis- Docosahexaenoic acid (C22:6N3)	1.60 ± 0.51^{a}	1.55 ± 0.49^{a}	1.33 ± 0.28^{ab}	1.04 ± 0.11^{ab}	0.40 ± 0.14^{bc}	0	4.08**
19	SFA	28.36 ± 1.75^{a}	28.44 ± 1.59^{a}	25.34 ± 1.41^{ab}	23.34 ± 1.00^{bc}	19.73 ± 0.59^{d}	17.41 ± 0.93^{d}	13.16**
20	PUFA	29.56 ± 0.73^{d}	30.10 ± 0.84^{d}	34.25 ± 0.40^{c}	35.77 ± 0.36^{c}	42.38 ± 1.25^{b}	45.16 ± 0.61^{a}	73.13**
21	MUFA	42.07 ± 1.06^{a}	41.44 ± 0.79^{a}	40.40 ±1.02^{ab}	40.87 ± 1.12^{abc}	37.88 ± 1.05^{bc}	37.41 ± 0.84^{c}	3.68*
22	Omega - 3 fatty acid	10.58 ± 0.74^{e}	10.37 ± 0.88^{e}	14.75 ± 0.64^{d}	17.98 ± 0.51^{c}	28.44 ± 1.07^{b}	34.29 ± 1.19^{a}	140.92**
23	Omega - 6 fatty acid	17.89 ± 0.48^{a}	18.55 ± 0.20^{a}	18.50 ± 0.66^{a}	16.90 ± 0.77^{a}	13.80 ± 0.48^{c}	10.87 ± 0.71^{d}	35.56**
24	PUFA/SFA ratio	1.06 ± 0.08^{d}	1.08 ± 0.08^{d}	1.37 ± 0.08^{cd}	1.54 ± 0.07^{c}	2.16 ± 0.11^{b}	2.62 ± 0.17^{b}	38.14**
25	Omega – 6/3 fatty acid ratio	1.74 ± 0.17^{a}	1.86 ± 0.18^{a}	1.26 ± 0.06^{b}	0.94 ± 0.06^{b}	0.48 ± 0.02^{c}	0.32 ± 0.03^{c}	33.23**

Zambiazi *et al.,* (2007) [20] and Chowdhury *et al.,* (2007) [21] reported that linoleic acid (C18:2N6C) and ALA content of 59.5 ± 7.5 % and 0.12-0.45% respectively in sunflower oil.

Monounsaturated fatty acid (MUFA) content of sunflower and canola oil was 31.95 and 57.81% respectively. Higher amount was due to high amount of oleic acid (C18:1N9C) of 28.53% and elaidic acid (C18:1N9T) of 50.61% respectively, as compared to flaxseed oil. Vingering *et al.,* (2010) [18] reported 43.3% of oleic acid in sunflower oil and 55.2% of elaidic acid, was the principle trans-unsaturated fatty acid (USFA) and was determined only in rapeseed oil. Significant difference (P<0.01) was observed in PUFA/SFA ratio and that was found high in sunflower and canola oil and omega-6/3 ratio was found high in sunflower oil. The oils and fat with higher value of PUFA/SFA ratio of more than 1 are considered to have higher nutritional value and deposits minimum amount of lipids in the body [22]. Similar value of omega-6/3 ratio in canola and sunflower oil was reported by Vingering *et al.,* (2010) [18]. Several studies on vegetable oils revealed that the fatty acid composition may change due to genetic, ecological, morphological, physiological, cultural practices and climatic conditions.

In the present study, flaxseed and canola oil contains ideal PUFA/SFA and omega-6/ 3 ratio as per the recommendations of several health agencies. Due to higher amount of PUFA and omega-6 fatty acids, canola and flaxseed oil can be effectively used for enrichment of ALA content by replacing sunflower oil in chevon nuggets to enhance its nutritional quality in chevon nuggets.

Physicochemical properties of chevon nuggets

The physicochemical properties of chevon nuggets incorporated with different levels of combinations of canola and flaxseed oil (CFSO) at 1:1 ratio is presented in [Table-3].

pH

There were no significant (P>0.05) differences was noticed in the pH of the emulsion and product in control 1, 2 and treated groups irrespective of the levels of CFSO at 1:1 ratio. Similar findings were observed by Singh *et al.,* (2011) [23], Kamal *et al.,* (2017) [24] in chicken meat patties and chevon nuggets incorporated with linseed and poppy seed oil respectively, as a replacement of vegetable oil. However, decrease in pH of emulsion and product was reported by Baek *et al.,* (2016) [25] and Rajkumar and Verma [26] and that could be due to the effect of complete or partial replacement of animal fat with vegetable oil.

Emulsion stability and cooking yield

Addition of different levels of CFSO at 1:1 ratio had no effect on the emulsion stability and cooking yield of chevon nuggets which corroborates with the findings of Singh *et al.,* (2011) [23]. However, Rajkumar and Verma [26] and Kamal *et al.,* (2017) [24] reported increase in emulsion stability and cooking yield of products. This could be due to the complete or partial replacement of animal fat with vegetable oil as well as due to difference in fat globular size and melting point of vegetable oils and animal fat.

Proximate composition

The proximate composition of chevon nuggets incorporated with different levels of combinations of CFSO at 1:1 ratio is presented in [Table-3]. Highly significant difference (P<0.01) was noticed in the moisture, protein, ash content and moisture protein ratio of treatment nuggets when compared with control 1 nuggets. But there was no significant difference (P>0.05) was noticed among the treatment nuggets when compared with control 2 nuggets. This indicated that addition of different levels of CFSO had no effect on the moisture, protein, ash content and moisture protein ratio of chevon nuggets. Similar findings were reported by Singh *et al.,* (2011) [23] and Rajkumar and Verma [26]. On the other hand, Deepak *et al.,* (2018) [27] and Barros *et al* [28] reported significant effect of incorporation of flaxseed and chia flour for the enrichment of omega-3 fatty acid respectively in chicken nuggets.Highly significant (P<0.01) reduction in fat content in treated nuggets compared with control 1 and 2 nuggets. Similar reduction in fat content was reported by Singh *et al.,* (2011) [23], Barros *et al.,* (2017) [28] and Kamal *et al.,* (2017) [24]. However, Rajkumar and Verma [28] observed increase in fat content and that might be due to the addition of vegetable oil as partial or complete replacement of animal fat in the meat product formulation.

Instrumental colour properties of chevon nuggets

The instrumental colour properties of chevon nuggets incorporated with different levels of combinations of CFSO at 1:1 ratio is presented in [Table-4] and [Fig-2]. Significant (P<0.01 and P<0.05) differences in instrumental colour properties of chevon nuggets incorporated with different levels of CFSO at 1:1 ratio was observed. L value of treatment groups was not significant (P>0.05) from that of control (1 and 2) nuggets which contradicts the findings of Rajkumar and Verma [28], Singh *et al.,* (2011) [23] and Baek *et al.,* (2016) [25]. These authors observed that addition of canola oil and flaxseed oil increased and decreased L value respectively, as an effect of individual oil in meat products.

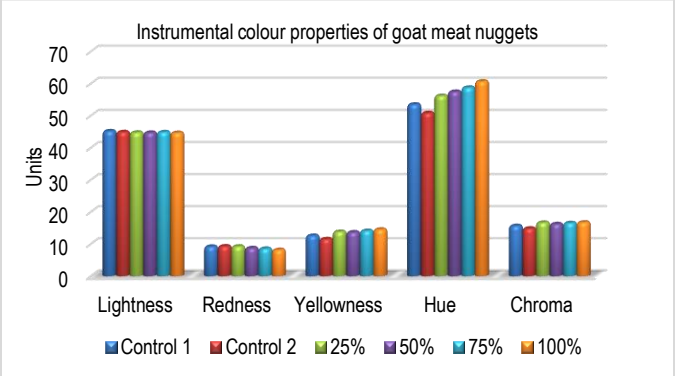

Fig-2 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the instrumental colour properties of goat meat nuggets with optimized level of FDLK (1:1)

In the present study when these oils were added in combinations evinced no effect on L value of nuggets. Significant (P<0.05) decrease in a* value was observed in the present study concurred with the findings of Singh *et al.,* (2011) [23] and Baek *et al.,* (2016) [25]. Dissimilar findings of increase in a* value reported by Rajkumar and Verma [26] in chevon nuggets prepared with 100% linseed oil. Significantly (P<0.01) higher b* and hue values were found in nugget incorporated with canola and flaxseed oil as compared with control. Many researchers also reported that when meat product prepared with vegetable oils replacing animal fat increased yellowness values due to yellowness of vegetable oils [23, 26].

Texture profile properties of chevon nuggets

The texture profile properties of chevon nuggets incorporated with different levels of combinations of CFSO at 1:1 ratio is presented in [Table-5]. No significant differences (P>0.05) in textural properties of chevon nuggets incorporated with incorporated with different levels of CFSO at 1:1 ratio was observed. The textural characteristics might be due to comparable moisture content and emulsion stability characteristics [13]. The textural characteristics of chevon nuggets recorded in the present study agreed with the findings of Singh *et al.,* (2011) [23] and Baek *et al.,* (2016) [25] in chicken meat patties and chicken sausage incorporated with linseed oil respectively. Rajkumar and Verma [26] reported decrease in hardness and gumminess value in chevon nuggets with total replacement of goat fat with linseed oil due to difference in physicochemical characteristics of solid phase goat fat and versus liquid phase linseed oil.

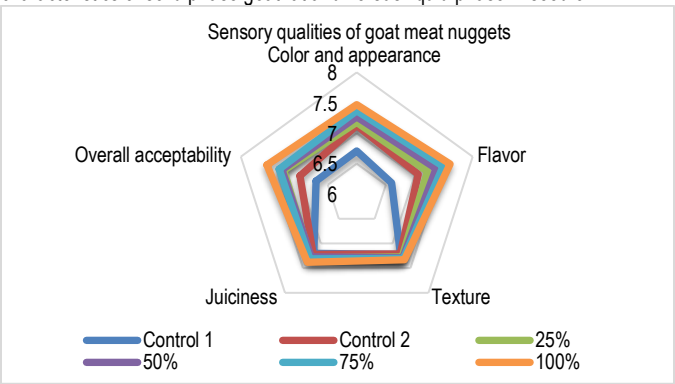

Fig-3 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the sensory qualities of goat meat nuggets with optimized level of FDLK (1:1)

Sensory properties of chevon nuggets

The sensory properties of chevon nuggets incorporated with different levels of combinations of CFSO at 1:1 ratio is presented in [Table-6] and [Fig-3]. No significant differences (P>0.05) in sensory qualities of chevon nuggets incorporated with different levels of CFSO was observed at 1:1 ratio. The product with combination of CFSO (1:1) had significantly (P<0.05) higher score for colour and appearance and flavour when compared with control 1 and 2 nuggets. Texture and juiciness attributes of all the treatment nuggets were comparable (P>0.05) to control (1 and 2) chevon nuggets. Over all, there was gradual increase in colour and appearance, flavour and overall acceptability in treated nuggets. The results of the present study indicated that substitution of sunflower oil with CFSO at 1:1 ratio for the enrichment of omega-3 fatty acid in chevon nuggets resulted in improvement in appearance, flavour and over all acceptability scores, of which 100% replacement of CFSO had significantly higher (P<0.05) score upon sensory evaluation.

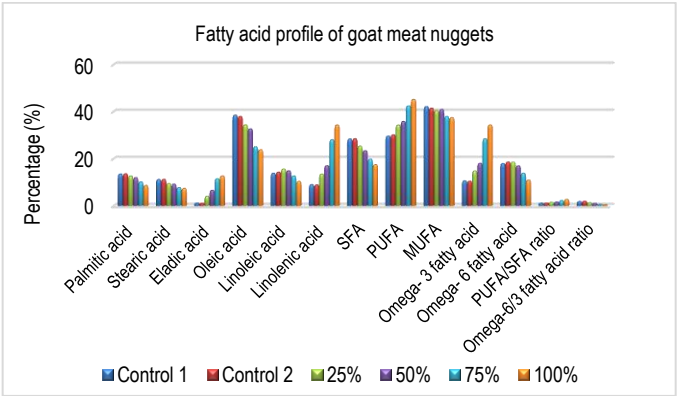

Fig-4 Effect of different levels of canola and flaxseed oil (CFSO) at 1:1 on the fatty acid profile (% of total fatty acid) of goat meat nuggets with optimized level of FDLK (1:1)

Fatty acid composition of chevon nuggets

The fatty acid composition of chevon nuggets incorporated with different levels of combinations of CFSO at 1:1 ratio is presented in [Table-7] and [Fig-4]. Fatty acid composition of all the products revealed that significant differences (P<0.01) were observed in various categories of fatty acids of chevon nuggets incorporated with different levels of CFSO at 1:1 ratio. The significantly higher (P<0.01) SFA consist mainly of palmitic acid (C16:0), stearic acid (C18:0) were observed in control (1 and 2) which was manufactured with sunflower oil. There was a gradual decrease (P<0.01) in SFA, were noticed in emulsion sausage due to decreased amount of these fatty acids in treated nuggets. Similar reduction in total SFA, palmitic and stearic acid content was reported by Baek *et al.,* (2016) [25]. There was a significant (P<0.01) increase in PUFA content in treated nuggets, due to the increase in content of alpha-linolenic acid (C18:3n-3) (ALA) which may be attributed to the presence of high quantity of these fatty acids in canola and flaxseed oil. On the other hand, in control 1 and 2 nuggets the PUFA constituted mostly of linoleic (C18:2N6C) and gamma-linolenic acid (C18:3n-6) and significantly (P<0.01) lower amount of ALA. According to Singh *et al.,* (2011) [23], linseed oil replaced with soybean oil increased the ALA up to 8.5% of total fatty acid in chicken meat patties. Similar increase in ALA were also reported earlier [29]. MUFA content was significantly high (P<0.05) in control 1and 2 as compared to treatment nuggets. Significantly high (P<0.01) amount of oleic acid in control 1 and 2 nuggets which was gradually decreased whereas, elaidic acid increased in treatment nuggets as it was high in canola oil. The PUFA/SFA ratio of, 2.62 in nuggets made with 100% CFSO incorporation level was significantly higher (P<0.01) and were in the range of 1 in control 1 and 2 nuggets. The ratio of omega - 6 to 3 fatty acid was significantly lower in treatment than control 1and 2 nuggets as consequence of increase in content of ALA. The results agree with the findings of Rajkumar and Verma [26]. They reported that, in chevon meat nuggets with PUFA/ SFA ratio of 2.82 and omega-6 to 3 ratios of 0.27 with 100% linseed oil replacing goat fat. The 100% replacement of sunflower oil by combination of canola and flaxseed oil had PUFA to SFA and omega - 6 to 3 fatty acid ratios were within range of values as recommended by various health agencies which is regarded as healthier nuggets enriched with ALA.

Conclusion

Different levels of combination of canola and flaxseed oil (CFSO) at 1:1 ratio of 25, 50, 75 and 100% level replacing refined sunflower oil had no effect on the pH of the emulsion, product, emulsion stability and cooking yield of chevon meat nuggets were comparable with control 1 and 2.

The moisture, protein, ash content and moisture protein ratio were like control 2 nuggets, and this indicates addition of different levels of CFSO had no effect on these parameters but reduced the fat content when compared with control 1 and 2 nuggets. The carbohydrate content was increased without affecting the energy value as compare to control 2 nuggets. Addition of different levels of CFSO (1:1) had reduced the redness value, increased the yellowness, hue and chroma value as compared to control 1 and 2 nuggets, but had no effect on texture profile properties. Sensory evaluation revealed addition up to 100% CFSO treated nuggets had received higher score for colour and appearance and overall acceptability than control 1,2 and other treated nuggets. However fatty acid composition of 100% CFSO treated nuggets had ideal omega-3 fatty acid ratio but PUFA/SFA ratio was slightly higher which is considered as healthier nuggets enriched with omega-3 fatty acid.

Application of research:
To meet the demand of consumer for healthier meat products enriched with omega-3 fatty acid for their wellbeing. The desired ratio of n-6: n-3 polyunsaturated fatty acids (PUFAs) and PUFA/SFA in meat products will reduce the impact on Low Density Lipoprotein (LDL) and cholesterol level helps to prevent the incidence of cardiovascular diseases.

Research Category: Functional chevon nuggets

Abbreviations: CFSO-Canola and flaxseed oil
RSO-Refined sunflower oil
FDLK-Freeze dried liver and kidney
PUFA-Polyunsaturated fatty acid
SFA-Saturated fatty acid
LDL-Low density lipoprotein
MUFA-Monounsaturated fatty acid
ALA-Alpha linolenic acid
USFA- Unsaturated fatty acid
GC-MS/MS-Gas chromatography-Mass spectrophotometer/Mass spectrophotometer

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****Research Guide or Chairperson of research: Dr V. Rajkumar**
University: ICAR- Central Institute for Research on Goats, Makhdoom, Farah, 281122, India
Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: ICAR- Central Institute for Research on Goats, Makhdoom, Farah, 281122, India

Breed name: Barbari goat

Conflict of Interest: None declared

Ethical approval: Ethical approval taken from National Referral Laboratory for testing of Animal Products, Goat Products Technology Laboratory ANMPT Division, ICAR- Central Institute for Research on Goats, Makhdoom, Farah, 281122, India.
Ethical Committee Approval Number: Nil

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