Effect of almond on technological, nutritional, textural and sensory characteristics of goat meat nuggets

V. Rajkumar · Arun K. Das · Arun K. Verma

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Abstract An attempt was made through the present study to develop meat based functional food by incorporating almond nut at two different 2.5 and 5 % (Formulation 1 and 2) levels and observe its impact on the different quality attributes against control goat meat nuggets. Almond improved ($P<0.05$) the emulsion stability of formulation 1 and 2. Product with 2.5 % almond had higher ($P<0.05$) cooking yield than other two products, whereas expressible water was lower. Emulsion and products pH values increased with the addition of almond. Emulsion and products with almond had higher ($P<0.05$) proximate values except moisture content. Textural properties of all the products did not differ significantly. Percent SFAs decreased ($P<0.05$) and MUFAs were increased with the addition of almond. The fatty acids C16:0, C18:1, C18:2 were significantly higher in formulation 1 and 2 products. Almond incorporation can be a very good approach to enhance nutritional profile of the meat products without affecting acceptability.

Keywords Goat meat · Nuggets · Fatty acids · Nutritional profile · Texture quality

Introduction

Diet and nutrition are important factors in the promotion and maintenance of health throughout life. World Health Organization (WHO) and Food and Agriculture Organization (FAO) reported that different dietary aspects along with

those related to lifestyle are the major modifiable risk factors involved in the development of several non-communicable diseases, including cardiovascular disease (WHO 2003). This has led the emergence of optimal nutrition and various new foods have come into the picture with potential beneficial effects on target functions in the organism, in addition to an adequate nutritional effect. When these effects are demonstrated, the products are referred to as functional foods (Diplock et al. 1999).

Epidemiological studies have associated frequent nut consumption like almond with a reduced risk of coronary heart disease (CHD), type II diabetes, or death by all-cause mortality (Kelly and Sabaté 2006). Several clinical trials conducted in healthy, hypercholesterolemic, or diabetic individuals, using different types of nuts and study showed improvement in the plasma lipid profile after nut consumption (Mukuddem-Petersen et al. 2005). Most studies suggest that the putative cardiovascular benefits of almonds reside in their content of monounsaturated fats; their nutrient profile suggests actions and interactions by other bioactive ingredients that may also affect heart disease as well as other health outcomes such as cancer and diabetes (Siriwardhana and Shahidi 2002; Chen et al. 2005).

Almond is a nutrient-dense food and an excellent source of vitamin E (36.4 %) and manganese (36.0 %). It is also good in of magnesium (19.5 %), copper (16.0 %), phosphorus (13.4 %), fibre (13.2 %), riboflavin (13.5 %) and protein (12.1 %) contents. In addition, almond proteins are unusually high in arginine and possess good digestibility. The energy derived largely from their fat content (49.4 % of weight), though it is important to note that its composition is largely (67 %) of monounsaturated fatty acids (Chen et al. 2006). Almonds have been found to have a consistent LDL-C-lowering effect in healthy individuals, and in individuals with high cholesterol and diabetes, in both controlled and free-living settings. Eating about 42 g/day of most nuts, as

V. Rajkumar · A. K. Das · A. K. Verma (✉)
Goat Products Technology Laboratory,
Central Institute for Research on Goats,
Makhdoom, Farah,
Mathura, U.P 281 122, India
e-mail: arun.lpt2003@gmail.com

part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease (King et al. 2008). Almonds are low in saturated fatty acids, rich in unsaturated fatty acids, and contain fibre, phytosterols, and plant protein. Other cardioprotective nutrients unique to almonds include α -tocopherol, arginine, magnesium, copper, manganese, calcium, and potassium (Berryman et al. 2011).

India is second most goat populous nation in the world with about 126 million goats and later has been a source of human nutrition since the very beginnings of human civilization. Goat meat is one of the staple red meats without any religious prohibition and relished by most of the Indian meat consumers. An added advantage with goat meat is that it is leaner than other red meats and its fat is less saturated and higher in desirable fatty acids (Webb et al. 2005). Incorporation of nuts like almond in the goat meat products can be a good approach and vehicle for the additional supply of healthier diet to the consumers. Incorporation of some nuts has been attempted in meat products. Yıldız-Turp and Serdaroğlu (2008) observed the effect of replacing beef fat with hazelnut oil on quality characteristics of sucuk and found that incorporation of oil resulted in significant increase in unsaturated fatty acids. Ilikkan et al. (2009) also investigated quality characteristics of Turkish fermented sausage added with hazelnut oil. Quality evaluation of various meat products added with walnut have also been reported by different workers (Jiménez Colmenero et al. 2003; Serrano et al. 2005; Jiménez Colmenero et al. 2005). However, to our best of knowledge there is no report on incorporation of almond in the meat products particularly in goat meat. Thus the present study was designed to incorporate almond in the goat meat nuggets and observe its effect on various physicochemical, textural, fatty acids and sensory attributes of the product.

Materials and methods

Raw materials and preparation of nuggets

Goat meat was obtained from the Experimental Slaughter House, Goat Products Technology Laboratory, Central Institute for Research on Goats, Makhdoom. After deboning, it was packed in LDPE bags and kept under frozen storage at -18°C till the product processing. The meat was cut into small cubes after partial thawing for 15 h at 4°C and minced with meat grinder (Tallers Ramon, Model P-22, Barcelona) using 10 mm followed by 5 mm plates. This ground goat meat was used in different product preparation.

A batch of five kg was made for control and products with almonds (Control, formulation 1 and 2). In formulation 1 and 2, almond powder at 2.5 % and 5 % levels was

incorporated by replacing the equal amount of lean goat meat. Ingredients in all batches were 67.4 % meat (3.37 kg) in control without almond, 64.9 % meat (3.25 kg) and 2.5 % almond (125 g) in formulation 1 and 62.4 % meat (3.12 kg) and 5 % almond (250 g) in formulation 2. All the batches contained 1.5 % common salt (75 g), 150 ppm sodium nitrite (0.75 g), 0.3 % sucrose (15 g), 12 % ice flakes (600 g), 3 % egg white (150 g), 7 % refined vegetable oil (350 g), 4 % condiment mix (200 g), 3 % refined wheat flour (150 g) and 1.8 % spice (90 g). Meat batter was prepared in a bowl chopper (Seydelmann K20, Ras, Germany). In a minced meat, required amount of sodium chloride and polyphosphate and nitrite was added and chopped for 2–3 min. After addition of ice flakes it was chopped again for 2 min. Almond powder was added and chopping was continued for another 1–2 min. Thereafter, vegetable oil was added with continuous chopping followed by incorporation of condiment, refined wheat flour and spice mix. Chopping ended after formation of uniform batter mix. Meat emulsion (~ 650 g) was placed into stainless steel moulds ($18 \times 12 \times 4$ cm), packed compactly and covered. The emulsion filled moulds from all the treatments were clipped and cooked in a steam oven without pressure for 35 min. The internal temperature of the cooked meat blocks ($90 \pm 1^{\circ}\text{C}$) was measured using a probe type thermometer (Fisher Scientific, USA). The meat blocks were cooled to room temperature, chilled overnight at $4 \pm 1^{\circ}\text{C}$ and cut into slices of 15 mm thickness using a meat slicer (Electrolux, Model H 300, Italy). The slices were manually cut into nuggets. About 200 g nuggets in each LDPE pouches were packed using a Roschermatic packaging machine (Roscher Geba, Germany) for further study. The experiment was replicated thrice and quality parameters of the products were analyzed.

pH, emulsion stability and cooking yield

The pH of the emulsion and nuggets was determined by blending 10 g sample with 50 ml distilled water for a minute in a homogenizer (Model PT-MR-2100, Kintematica AG, Switzerland). The pH values were measured using a standardized electrode attached to a digital pH meter (Systronics, μ pH system 361, Delhi, India). Emulsion stability percent of the samples was estimated by heating approximately 25 g of emulsion in a polypropylene bag at 80°C for 20 min using a thermostatically controlled water bath. After draining out the exudate, the cooked mass was cooled and weighed (Das et al. 2006a). The weight of each meat block was recorded before and after cooking. The cooking yield was calculated and expressed as percentage by weight of cooked meat block/weight of raw meat block $\times 100$.

Proximate analysis and expressible water

The moisture, protein, fat and ash content of almond powder, emulsion and cooked goat meat nuggets were determined by the methods of AOAC (1995). Expressible water was estimated as per the method of Ramirez et al. (2002) with slight modification (Das and Sharma 2009). About 5 g cooked samples were weighed and put between two layers of Whatman No. 1 filter paper. The samples were placed at the bottom of the 50 ml centrifuge tubes and centrifuged at 1500 g (Biofuge Primo R, Heraeus, Germany) for 15 min. Immediately after centrifugation, the meat samples were re-weighed and the amount of expressible water was calculated as $\text{initial weight} - \text{final weight} / \text{initial weight} \times 100$.

Calorific value

Gross energy of samples was determined by using Digital Oxygen Bomb Calorimeter (Parr 6200 Calorimeter, Moline, USA). Approximately 1 g single piece of dried product/sample was taken and weighed along with pre-weighed steel crucible. This crucible was placed on the support pillar in the base of the bomb calorimeter. The firing wire and the sample were connected with the help of cotton thread. The bomb was fired under an oxygen pressure and reading was noted. The calorific value of dried product was converted on the fresh basis and expressed as Kcal/g.

Texture Profile Analysis (TPA)

Textural properties of nuggets were evaluated using the texturometer (Stable Micro System Model TA.XT 2i/25). TPA (Bourne 1978) was performed using central cores of eight pieces of each sample (1.5 cm^3) which were compressed twice to 80 % of the original height (Das et al. 2006b). A crosshead speed of 2 mm/s was used. Following parameters were determined: Hardness (N/cm^2) = maximum force required to compress the sample (H); Springiness (cm) = ability of sample to recover its original form after a deforming force was removed (S); Cohesiveness = extent to which sample could be deformed prior to rupture ($A2/A1$, $A1$ being the total energy required for first compression and $A2$ the total energy required for the second compression); Adhesiveness (Ns) = work necessary to pull the compressing plunger away from sample; Gumminess (N/cm^2) = force necessary to disintegrate a semisolid sample for swallowing ($H \times \text{Cohesiveness}$); Chewiness (N/cm) = work to masticate the sample for swallowing ($S \times \text{Gumminess}$).

Shear force (N/cm^2) and work of shearing (Ns) of samples were estimated with a Warner-Bratzler blade attached to the same texture analyzer. Eight cores (1.5 cm^3) were taken from nuggets of each batch. The crosshead speed was 2 mm/s. Maximum force required to cut the sample (shear force)

and the work needed to move the blade through the samples (work of shearing) were recorded.

Fatty acid analysis

A direct and simple method of O'Fallon et al. (2007) was followed for preparation of fatty acid methyl esters (FAME) of almond powder and goat meat nuggets. Briefly, 1.0 g samples (almond and nuggets) were placed into a 16×125 mm screw-cap Pyrex culture tube to which 1.0 ml of the C13:0 internal standard (0.5 mg of C13:0/ml of methanol), 0.7 ml of 10 N KOH in water, and 5.3 ml of methanol were added. The tube were incubated in a 55°C water bath for 1.5 h with vigorous hand-shaking for 5 s every 20 min to properly permeate, dissolve, and hydrolyze the sample. After cooling below room temperature in a cold tap water bath, 0.58 ml of 24 N H_2SO_4 in water was added. The tubes were mixed by inversion and with precipitated K_2SO_4 present was incubated again in a 55°C water bath for 1.5 h with hand-shaking for 5 s every 20 min. After FAME synthesis, the tubes were cooled in a cold tap water bath. Three milliliters of hexane was added, and the tubes were vortex-mixed for 5 min on a multitube vortex. The tubes were centrifuged for 5 min in a centrifuge at 2500 g (Biofuge Primo R, Heraeus, Germany), and the hexane layer, containing the FAME, was placed into a GC vial and placed at -20°C until GC analysis.

The fatty acid composition of the FAME was determined by capillary GC on a CP-6173, $60 \text{ m} \times 0.25 \text{ mm} \times 0.20 \text{ mm}$ capillary column (Varian) installed on a Thermo Scientific Ceres 800 plus gas chromatograph fitted with Automatic sampler AI3000, integrator and flame ionization detector. The initial oven temperature was 120°C , held for 5 min, subsequently increased to 240°C at a rate of $2^\circ\text{C}/\text{min}$, and then held for 60 min. Nitrogen was used as the carrier gas at a flow rate of 1 ml/min. Both the injector and the detector were set at 260°C . The split ratio was 30:1. Fatty acids were identified by comparing their retention times with the fatty acid methyl standards and were expressed as percentage of total fatty acids.

Sensory evaluation

A ten member experienced panelists evaluated goat meat nuggets using 8 points descriptive scale (Keeton 1983) with slight modification (Das et al. 2008), where eight (8) denoted extremely desirable and one (1) denoted extremely poor. The panelists were explained about the nature of experiments without disclosing the identity of samples and were asked to evaluate the samples on the sensory evaluation proforma for appearance, flavour, juiciness, texture and overall acceptability. Samples were warmed using microwave oven for 1 min and served randomly to the panelists

on plates. The panelists were provided filtered water to rinse mouth between samples.

Statistical analysis

Three replications of the study were performed and measurements of all parameters were made in triplicate. Mean values for various parameters were calculated and were analyzed using one-way ANOVA using the SPSS software for windows (version 14.0). Statistical significance was identified at the 95 % confidence level ($P < 0.05$). The values were presented as mean along with standard error (Mean $\pm$ Standard Error).

Results and discussion

Nutritional profile of almond

Nutritional characteristic of almond is presented in the Table 1. Fat is the highest nutrient present in almond (50.82 %) followed by protein (19.92 %). Moisture and ash contribute about 5.05 % and 3.02 %, respectively. It was observed that oleic acid is the most predominant fatty acid in the almond accounting about 67.68 %. This is followed by linoleic, palmitic and stearic acid. The present results are in agreement with the findings of Garcia-Lopez et al. (1996) who found that the palmitic, stearic, oleic and linoleic acids contents in the 16 almond cultivars in the range of 4.43–7.68, 1.12–2.70, 57.5–73.1 and 8.0–28.8 %, respectively. Almost similar values were also observed by Soler et al. (1988) in developing almond seeds 176 days after fruit set. Martin-Carratala et al. (1998) reported that five fatty acids viz. palmitic, palmitoleic, stearic,

oleic, and linoleic account for >99 % of total esterified fat; their contribution considerably decreases in the following order: C18:1 > C18:2 > C16:0 > C18:0 > C16:1. Barbera et al. (1994) recorded that kernels of Ferragnes and Tuono almond varieties contained 5.88–6.19 % palmitic acid, 0.88–0.93 % palmitoleic acid, 1.85–2.09 % stearic acid, 72.17–71.83 % oleic acid and 19.19–18.91 % linoleic acid. Similar kind of result was also obtained by Askin et al. (2007) in almond kernel. Among different categories of fatty acids, monounsaturated fatty acids (MUFA) showed the highest presence in the almond followed by PUFA and SFA. Almond was found to be the rich source of omega-6 fatty acids containing about 21.23 %.

Physicochemical properties

Being a rich source of fat and protein, almond powder affected the various properties of goat meat nuggets. Effect of adding almond on physicochemical properties of goat meat nuggets is presented in Table 2. Formulation 1 and 2 products had significantly higher ($P < 0.05$) emulsion stability in comparison to control and value increased significantly as the level of almond increased. This could be due to higher amount of fat in almond that have improved formation of three dimensional gel matrix leading to increased stability of meat batter. Marquez et al. (1989) reported an increase in emulsion stability as final fat content in the frankfurter was increased. Goat meat nuggets with 2.5 % almond had significantly higher ($P < 0.05$) product yield than other two products. This could be due to the higher batter stability for the treatment products resulting in lower cooking loss. According to Serrano et al. (2004) addition of walnut generally reduced cooking loss, which was unaffected by chilling storage, irrespective of the treatment. Expressible water in control product and product containing 5 % almond was significantly higher ($P < 0.05$) in comparison to nuggets with 2.5 % almond. The result indicates that incorporation of almond at 2.5 % level resulted in more stable meat batter having improved water as well as fat binding. This could be the main reason for higher cooking yield for this product.

Addition of almond powder significantly increased ($P < 0.05$) the emulsion and products pH. Increase in the pH value of restructured beef steak added with different levels of walnuts was observed (Serrano et al. 2004). The proportion of added almond significantly affected ($P < 0.05$) the proximate composition of control, formulation 1 and 2 emulsions as well as products. Moisture percent in products with almond powder was significantly lower than control where as protein, fat and ash contents followed the reverse trend. The differences in the proximate composition of emulsion and products between control and formulation 1 and 2 could be due to the typical composition of added

Table 1 Nutritional profile of almond (Mean $\pm$ SE)

Characteristics (in Percent)	Amount
Moisture	5.0 $\pm$ 0.03
Fat	50.8 $\pm$ 0.17
Protein	19.9 $\pm$ 0.14
Ash	3.0 $\pm$ 0.05
Palmitic acid	7.3 $\pm$ 0.24
Stearic acid	1.3 $\pm$ 0.22
Oleic acid	68.7 $\pm$ 0.90
Linoleic acid	21.1 $\pm$ 0.77
Saturated Fatty Acids	8.9 $\pm$ 0.45
Monounsaturated Fatty Acids (MUFA)	69.5 $\pm$ 0.88
Polyunsaturated Fatty Acids (PUFA)	21.6 $\pm$ 0.80
n-3 PUFA	0.23 $\pm$ 0.03
n-6 PUFA	21.2 $\pm$ 0.78

$n=6$

Table 2 Effect of almond supplementation on physicochemical quality of goat meat nuggets (Mean $\pm$ SE)

Parameters	Control	Formulation 1	Formulation 2
Emulsion stability * (%)	89.6 $\pm$ 0.62 ^c	92.0 $\pm$ 0.22 ^b	93.5 $\pm$ 0.19 ^a
Product Yield (%)	95.4 $\pm$ 0.31 ^b	97.5 $\pm$ 0.43 ^a	95.7 $\pm$ 0.17 ^b
Expressible water* (%)	10.3 $\pm$ 0.40 ^a	8.6 $\pm$ 0.76 ^b	10.7 $\pm$ 0.20 ^a
Emulsion pH	6.2 $\pm$ 0.03 ^b	6.3 $\pm$ 0.03 ^a	6.3 $\pm$ 0.01 ^a
Product pH	6.4 $\pm$ 0.01 ^b	6.4 $\pm$ 0.01 ^b	6.4 $\pm$ 0.01 ^a
Emulsion moisture (%)	67.0 $\pm$ 0.06 ^a	65.5 $\pm$ 0.13 ^b	64.5 $\pm$ 0.20 ^c
Emulsion protein (%)	9.6 $\pm$ 0.29 ^c	11.7 $\pm$ 0.68 ^b	14.1 $\pm$ 0.36 ^a
Emulsion fat (%)	11.1 $\pm$ 0.08 ^c	12.7 $\pm$ 0.19 ^b	13.2 $\pm$ 0.14 ^a
Emulsion ash (%)	2.3 $\pm$ 0.01 ^c	2.4 $\pm$ 0.01 ^b	2.6 $\pm$ 0.02 ^a
Product moisture (%)	66.4 $\pm$ 0.29 ^a	65.5 $\pm$ 0.58 ^a	63.8 $\pm$ 0.40 ^b
Product protein (%)	10.9 $\pm$ 0.50 ^c	13.6 $\pm$ 0.24 ^b	15.7 $\pm$ 0.71 ^a
Product fat (%)	13.5 $\pm$ 0.20 ^c	14.4 $\pm$ 0.29 ^b	15.4 $\pm$ 0.14 ^a
Product ash (%)	2.4 $\pm$ 0.02 ^b	2.4 $\pm$ 0.02 ^b	2.5 $\pm$ 0.03 ^a
Energy (Kcal/g)	2.6 $\pm$ 0.66 ^b	2.9 $\pm$ 0.29 ^a	2.9 $\pm$ 0.45 ^a

Control: Goat meat nuggets without almond; Formulation 1: goat meat nuggets with 2.5 % almond; Formulation 2: goat meat nuggets with 5 % almond

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

$n = 6$; * $n = 12$

almond. Serrano et al. (2005) reported that added walnut affected the proximate composition of restructured beef steak. They found that although ash contents were similar, addition of walnut increased fat values (by around 13 %) and reduced moisture (in the same proportion in which fat was increased). Similar results have been reported on proximate analysis by Jiménez Colmenero et al. (2003) in restructure beef steak with added walnuts. Addition of almond significantly increased ($P < 0.05$) the calorific value of the product, although value of formulation 1 and 2 did not differ significantly. A significantly higher protein and fat content in the products with almond powder could have been responsible for their calorific value.

Texture profile analysis

Textural properties and shear force value of the products were not affected significantly by the addition of almond (Table 3). However, incorporation of almond resulted in non-significant increase ($P > 0.05$) in the hardness value.

As almond is the rich source of fat and protein, its incorporation might have increased the concentration of the fat and protein in the meat matrix system that are primarily involved in the process of emulsification, leading to the formation of more firm and rigid gel matrix. In contrary to the our results, Jiménez Colmenero et al. (2003) found that addition of walnut had no effect on uncooked restructured steak, but in cooked products, both shear force and bind strength were significantly reduced when 10 % or more of walnut was added. They implicated the dilution effect of non-meat ingredients in meat protein systems (Rocha-Garza and Zayas 1996; Tsai et al. 1998) for such behavior which was absent in our study and the opposite trend was observed.

Fatty acid profile

Incorporation of nuts in meat products can be used to confer potential heart-healthy benefits. In view of the implications of dietary fats for human health and the fact that meat and

Table 3 Effect of almond supplementation on instrumental texture quality of goat meat nuggets (Mean $\pm$ SE)

Parameters	Control	Formulation 1	Formulation 2
Hardness (N/cm ²)	80.2 $\pm$ 2.79	81.4 $\pm$ 3.18	84.2 $\pm$ 2.35
Fracture (N)	44.1 $\pm$ 3.72	31.8 $\pm$ 4.48	43.2 $\pm$ 1.44
Adhesive (Ns)	-0.088 $\pm$ 0.02	-0.074 $\pm$ 0.02	-0.075 $\pm$ 0.02
Springiness (cm)	0.76 $\pm$ 0.01	0.76 $\pm$ 0.02	0.77 $\pm$ 0.01
Cohesiveness (ratio)	0.30 $\pm$ 0.003	0.31 $\pm$ 0.006	0.29 $\pm$ 0.004
Gumminess (N/cm ²)	23.7 $\pm$ 0.97	25.1 $\pm$ 1.20	24.3 $\pm$ 0.89
Chewiness (N/cm)	18.1 $\pm$ 0.87	19.3 $\pm$ 1.14	18.7 $\pm$ 0.79
Shear Force (N/cm ²)	6.9 $\pm$ 0.75	7.6 $\pm$ 0.56	6.2 $\pm$ 0.27
Work of shearing (Ns)	4.4 $\pm$ 0.41	4.9 $\pm$ 0.38	4.4 $\pm$ 0.21

Control: Goat meat nuggets without almond; Formulation 1: goat meat nuggets with 2.5 % almond; Formulation 2: goat meat nuggets with 5 % almond

None of the mean value within a parameter differed significantly

$n = 24$

Table 4 Effect of almond supplementation on fatty acid profile (% of total fatty acids) of goat meat nuggets (Mean $\pm$ SE)

Control: Goat meat nuggets without almond; Formulation 1: goat meat nuggets with 2.5 % almond; Formulation 2: goat meat nuggets with 5 % almond

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

$n = 6$

Fatty acids	Control	Formulation 1	Formulation 2
Palmitic Acid (C16:0)	4.3 $\pm$ 1.98 ^b	8.2 $\pm$ 1.82 ^{ab}	12.8 $\pm$ 1.57 ^a
Stearic Acid (C18:0)	5.2 $\pm$ 1.07	6.1 $\pm$ 1.00	6.4 $\pm$ 0.83
Oleic Acid (C18:1n9c)	22.1 $\pm$ 3.92 ^b	38.2 $\pm$ 6.68 ^{ab}	49.4 $\pm$ 7.82 ^a
Linoleic Acid (C18:2n6)	2.5 $\pm$ 0.21 ^b	9.4 $\pm$ 3.20 ^a	13.6 $\pm$ 1.97 ^a
Linolenic Acid (C18:3n3)	4.8 $\pm$ 2.59 ^a	3.2 $\pm$ 1.63 ^{ab}	1.6 $\pm$ 0.23 ^b
Eicosapentaenoic Acid (C20:5n3)	2.4 $\pm$ 1.23	2.6 $\pm$ 3.85	2.9 $\pm$ 1.48
Cis-Eicosatrienoic Acid (C20:3n3)	0.76 $\pm$ 0.17	0.81 $\pm$ 0.551	0.18 $\pm$ 1.02
Docosahexaenoic Acid (C22:6n3)	0.97 $\pm$ 0.52	1.2 $\pm$ 0.78	1.3 $\pm$ 0.59
SFA (%)	32.7 $\pm$ 2.02 ^a	25.4 $\pm$ 2.43 ^a	21.1 $\pm$ 1.66 ^b
MUFA (%)	33.9 $\pm$ 1.88 ^b	40.4 $\pm$ 1.07 ^a	44.4 $\pm$ 2.46 ^a
PUFA (%)	31.6 $\pm$ 3.81	33.2 $\pm$ 4.10	35.0 $\pm$ 2.12
n-3 PUFA (%)	12.7 $\pm$ 3.54	11.3 $\pm$ 2.27	10.4 $\pm$ 1.55
n-6 PUFA (%)	15.6 $\pm$ 1.37 ^b	17.2 $\pm$ 1.28 ^{ab}	22.0 $\pm$ 1.76 ^a
SFA/MUFA	0.96 $\pm$ 0.09 ^a	0.62 $\pm$ 0.07 ^b	0.47 $\pm$ 0.06 ^b
SFA/PUFA	1.0 $\pm$ 0.08 ^a	0.76 $\pm$ 0.22 ^{ab}	0.60 $\pm$ 0.12 ^b
PUFA/SFA	0.97 $\pm$ 0.16	1.3 $\pm$ 0.28	1.7 $\pm$ 0.13
n-6/n-3 PUFA	1.2 $\pm$ 0.18 ^b	1.5 $\pm$ 0.32 ^b	2.1 $\pm$ 1.31 ^a

meat products are among the principal sources of such fats, various strategies have been used to produce healthier meat product. One of these approaches is the use of plant ingredients, such as almonds, which have a promising lipid profile particularly monounsaturated fatty acids in their formulation. The effect of almond nut incorporation on the fatty acid profile of goat meat nuggets is presented in the Table 4. Saturated fatty acids were higher in control nuggets than in nuggets with almond and these were decreased significantly at 5 % almond level. This could be mainly due to inclusion of unsaturated fatty acids, which are predominant in the almond. However, among saturated fatty acids, C16:0 increased with the addition of almond and significant effect was seen at the level of 5 %.

Almond incorporation in goat meat nuggets significantly increased ($P < 0.05$) monounsaturated fatty acids (MUFA) and among MUFAs, oleic acid (C18:1) increased as the level of almond increased. These MUFAs could be seen as a reflection of functional meat products due to their various health promoting attributes. In our study, increase in the amount of MUFA in the formulation 1 and 2 products is mainly due to added almond nuts, which is a rich source of monounsaturated fatty acids, in particular oleic acid accounting about 67.68 %. The presence of significantly higher amount of MUFA in the products with almond indicates the enrichment of their nutritional and health value. The favourable effect of high-monosaturated-fat diets on serum lipoproteins has been documented (Mattson and Grundy 1985). According to Keys et al. (1986) concentrations of MUFAs were negatively correlated with coronary artery disease (CAD) mortality in the seven countries study.

This negative association has been ascribed primarily to the hypocholesterolemic effect of dietary MUFAs, which, when substituted for saturated fatty acids (SFAs), significantly reduce total and LDL-cholesterol concentrations (Mensink and Katan 1989; Gustafsson et al. 1994).

There were no significant differences ($P > 0.05$) in the polyunsaturated fatty acids (PUFAs) among these products. However, amount of linoleic acid (C18:2) increased with the increasing levels of almond. Incorporation of almond increased the *n*-6 fatty acids with significant effect at the level of 5 %. The ratio of *n*-6/*n*-3 and PUFA/SFA (P/S ratio) in all the products were almost similar ($P > 0.05$) and fallen very close to the recommended values for healthier diet. According to Simopoulos (2009) an adequate ratio or balance between ω -6 and ω -3 FAs to be important for the

Table 5 Effect of almond supplementation on sensory attributes of goat meat nuggets (Mean $\pm$ SE)

Parameters	Control	Formulation 1	Formulation 2
Appearance	6.9 $\pm$ 0.26	6.8 $\pm$ 0.25	6.9 $\pm$ 0.28
Flavour	6.9 $\pm$ 0.17	6.6 $\pm$ 0.24	6.8 $\pm$ 0.28
Juiciness	6.9 $\pm$ 0.26	6.8 $\pm$ 0.23	6.7 $\pm$ 0.34
Texture	7.0 $\pm$ 0.14	7.1 $\pm$ 0.15	7.2 $\pm$ 0.17
Overall acceptability	7.0 $\pm$ 0.14	6.9 $\pm$ 0.18	7.0 $\pm$ 0.29

Control: Goat meat nuggets without almond; Formulation 1: goat meat nuggets with 2.5 % almond; Formulation 2: goat meat nuggets with 5 % almond

None of the mean value within a parameter differed significantly

$n = 30$

prevention and treatment of cardiovascular diseases. For the secondary prevention of cardiovascular disease, a ratio of 4:1 has been associated with a 70 % reduction in total mortality. Serrano et al. (2005) observed that addition of walnuts in restructured beef steak caused a reduction ($P < 0.05$) in percentage of SFA and MUFA, and an increase ($P < 0.05$) of PUFA, mainly essential fatty acids C18:2 n 6 (linoleic acid, LA) and C18:3 n 3 (α -linolenic acid, LNA).

Sensory evaluation

Sensory analysis of all the three products is given in the Table 5. The panelists were not able to detect any difference among the products. Organoleptic evaluation of the products revealed no significant differences in the various attributes among control, formulation 1 and 2. Incorporation of almond also resulted in slight improvement in the texture of the products. In contrast to our results, Serreno et al. (2004) reported detection of slight off-flavour (walnut-like) in the restructured beef steak with walnuts, which was more noticeable ($P < 0.05$) in the product that had the higher percentage of added walnut. Similar results have been reported by Jiménez Colmenero et al. (2003) in beef steak added with walnuts.

Conclusions

Almond, a good source of protein and fat, particularly mono-unsaturated fatty acids, its incorporation in goat meat nuggets made noticeable impact on the technological and nutritional quality. Addition of almond resulted improvement in pH, emulsion stability, cooking yield, protein and fat contents. Textural and sensory characteristics of the products with almond remain similar to the control. As far as fatty acid profile is concerned incorporation of almond results improvement in the MUFAs and the fatty acids such as C16:0, C18:1, C18:2 significantly. The n -6/ n -3 as well as P/S ratio remained close to the recommended values. Thus, the addition of almond in goat meat nuggets makes perceivable improvement in nutritional profile of the products and can be a promising approach for development of functional goat meat nuggets.

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