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Effect of full-fat soy paste and textured soy granules on quality and shelf-life of goat meat nuggets in frozen storage

Arun K. Das [a,*], A.S.R. Anjaneyulu [a], Y.P. Gadekar [a], R.P. Singh [b], H. Pragati [a]

[a] Division of Livestock Products Technology, Indian Veterinary Research Institute, Izatnagar, Bareilly 243 122, India
[b] PHT Division, Central Avian Research Institute, Izatnagar, Bareilly 243 122, India

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Abstract

Goat meat nuggets were prepared using commercially available textured soy granules and reduced beany flavour full-fat soy paste (FFSP) made by simple processing technology to compare the performance of these proteins in a comminuted meat system. Addition of soy proteins (soy paste and soy granules) did not significantly affect the product yield, pH, moisture and fat percentage whereas protein content and water holding capacity (% expressible water) were significantly ($p > 0.05$) lower in nuggets with 15% soy paste. Lower force was required to compress or shear the sample as hardness, springiness, gumminess and chewiness decreased in soy paste incorporated nuggets. Soy proteins either paste or granules, did not affect sensory attributes except flavour and overall acceptability. Nuggets with soy paste and control ones did not differ significantly for flavour and overall acceptability whereas nuggets with soy granules were rated significantly ($p > 0.05$) lower. The nuggets remained stable with minor changes in physico-chemical, microbiological and sensory quality during frozen storage (-18 ± 1 °C) for 90 days. It is concluded from this study that FFSP could be successfully incorporated in comminuted meat systems for producing quality products similar to commercially available soy granules.

Keywords: Full-fat soy paste; Soy granules; Goat meat nuggets; Texture profiles; Storage stability

1. Introduction

Soybean is a highly nutritious food material that contains well balanced amino acids and desirable fatty acids and it plays an important role as a protein resource for Asian people. Recently, many functions of soybeans have been in the spotlight, for example, reducing the risk of heart disease, cancer, and so on (FDA, 1999). Despite the many advantages of soybean, its use as a food material has been limited because of off-flavour such as ''beany flavour'' or ''green beany flavour'' generated during processing (King et al., 2001; Mizutani & Hashimoto, 2004). The lipoxygenases in soybean catalyze the hydroperoxidation of polyunsaturated fatty acids by molecular oxygen which results in the generation of off-flavours associated with compounds such as *n*-hexanal and *n*-hexanol (Matoba, Hidaka, Kitamura, Kaizuma, & Kito, 1985). It is important to prevent lipid peroxidation to reduce off-flavour and to make the products containing full-fat soy protein pleasant to consumers. Many attempts have been made to control such off-flavour generation during soybean processing. Wilkens, Mattick, and Hand (1967) reported that grinding soybean at high temperature is effective to control lipoxygenase activities and results in a reduction of off-flavour generation and maximizes protein extraction. The objectionable aroma and flavour of full-fat soy protein need to be eliminated or minimized before its use as an extender in meat systems.

Recently, Das, Anjaneyulu, and Kondaiah (2006) standardized a simple processing technique to make reduced beany flavour full-fat soy paste (FFSP) as a non-meat pro-

* Corresponding author. Present address: Goat Products Technology Laboratory, Central Institute for Research on Goats, Makdhom, Farah 281 122, Mathura, UP, India. Fax: +91 565 2763246.
E-mail address: arunlpt@gmail.com (A.K. Das).

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tein source. They also evaluated the potential application of FFSP in goat meat patties and the resultant product was more tender and juicy and highly acceptable. Soy proteins being an economical source of food protein have been used extensively in meat products as a binder for improving yields, as a gelling agent to enhance emulsion stability and as a meat replacement to reduce costs (Lecomte, Zayasm, & Kastner, 1993; Rentfrow, Brewer, Weingartner, & Mckeith, 2004). However, addition of soy extenders decreased beefy flavour and increased off-flavour scores in ground beef patties (Brewer, McKeith, & Britt, 1992).

The objectives of the studies were to determine the effect of incorporation of reduced beany flavour full-fat soy paste (FFSP) on the quality of goat meat nuggets and to compare the performance of FFSP with that of commercially available textured soy granules on the physico-chemical, textural, sensory characteristics and stability of goat meat nuggets under frozen storage.

2. Materials and methods

2.1. Goat meat

Goat meat was procured from a selected retail meat shop located at Izatnagar, Bareilly. About 10 kg goat meat was obtained from both hind legs of carcasses of good conformation of non-descriptive adult female goats slaughtered according to the traditional halal method. The required quantity for each trial was purchased within 2–3 h of slaughter, packed in low density polyethylene (LDPE) bags and brought to the Livestock Products Technology Division, Izatnagar within 20 min. The meat was hot boned, trimmed of separable fat and connective tissue and conditioned in a refrigerator at 4 ± 1 °C for about 6–8 h and frozen at -18 °C till further use. The meat was cut into small cubes after partial thawing for 15 h at 4 °C and minced with a Seydelmann Meat Grinder (Model WD 114, Germany) using a 13 mm followed by an 8 mm plate. This ground goat meat was used in product formulations.

2.2. Preparation of soybean paste

Soybeans (variety – PS 1241) used in the study was purchased from the “Seed Production Centre”, G.B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttaranchal. Soybean paste was prepared according to the procedure developed by Das et al. (2006). Briefly, soybeans were washed with tap water to remove extraneous dirt, blanched in boiling water for 15 min, soaked in cold water for 12 h, dehulled manually and ground into a fine paste with water in a home mixer. Das et al. (2006) conducted sensory analysis of full-fat soy paste and reported that it had a low beany flavour, better colour and consistency with a composition of 77.43% moisture, 13.09% protein and 5.95% fat (Das et al., 2006).

The commercial brand textured soy granules “Nutrela” (Ruchi Soya Industries Limited, Manglia, Madhya Pradesh, India) were hydrated [(1:2.75 (w/w) for 1 h)] as per the composition indicated on the label to equalize the protein content in the meat products prepared with soy paste. The hydrated soy granules were minced in a home mixer for use in meat products.

2.3. Nuggets preparation

Five kg formulation was made for each treatment. Control formulation consisted of lean goat meat 70%, refined mustard oil 10%, ice flakes 10%, salt 1.6%, tripolyphosphate 0.3%, sugar 0.3%, dry spices powder 1.8%, condiments (4 parts onion and 1 part garlic) 3%, refined wheat flour 3%. Sodium nitrite at 150 ppm was also added to the above formulations. In treated formulations, soy paste or textured soy granules at 15% were incorporated by replacing an equal amount (15%) of lean goat meat in the control formulation. The emulsions were made in a Seydelmann bowl chopper, Model K20 Ras (Maschinenfabrik Seydelmann KG, Stuttgart, Germany). Minced goat meat, salt, sodium tripolyphosphate and sodium nitrite were added and chopped for about 1–2 min. After addition of ice flakes it was chopped again for 2 min. Soy paste or textured soy granules were added for uniform dispersion in the meat system and chopping was continued for another 1–2 min. Refined mustard oil was slowly added while chopping for proper dispersion. Condiment paste, dry spice powder and refined wheat flour were added and chopping continued until a uniform dispersion of all ingredients and the desired emulsion consistency was obtained. Final temperature of the meat emulsion was 10–12 °C. Meat emulsion (~750 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 at atmospheric pressure for 35 min. The temperature of the steam oven during cooking was over 100 °C. The internal temperature of the cooked meat blocks was 90 ± 1 °C measured using a probe type thermometer (Oakaton, China). The meat blocks were cooled to room temperature, chilled overnight at 4 ± 1 °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, were vacuum packed in nylon/LDPE pouches using a Roschermatic packaging machine (Model A-NG 91173, Germany). The products were kept at -18 ± 1 °C and analyzed at monthly interval after thawing in a refrigerator (4 ± 1 °C) for 5–6 h. The experiment was replicated thrice.

2.3.1. Product yield

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.

2.3.2. pH

pH of goat meat nuggets was determined by blending 10 g of sample with 50 ml of distilled water for 1 min using an Ultra Turrax T25 tissue homogenizer (Janke and Kenkel, IKA Labor Technik, Germany). The pH of the suspension was recorded by using a combined glass electrode with a digital pH meter (Elico, Model LI 127, India).

2.3.3. Proximate composition

Moisture, crude fat and protein of meat products were determined by standard procedures of Association of Official Analytical Chemists (AOAC, 1995).

2.3.4. Expressible water

Expressible water of the nuggets was measured using the method of Ramirez, Uresti, Tellez and Vazquez (2002). About 5 g cooked samples were weighed onto 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 rpm (Remi-24, India) for 5 min. Immediately, after centrifugation, the meat samples were re-weighed and the amount of expressible water was calculated as initial weight − final weight/initial weight × 100. Duplicate samples were analyzed and averages reported for each treatment. The expressible water is inversely related to the water holding capacity (WHC). The lowest percent of water extracted means the highest WHC.

2.3.5. Texture profile analysis (TPA)

The textural properties of nuggets were evaluated using a texture analyzer (Stable Micro System, Model TA.XT 2i/25, UK) at Post Harvest Technology, Central Avian Research Institute, Izatnagar. Texture profile analysis (Bourne, 1978) was performed using central cores of five pieces of each sample (1.5 cm × 1.5 cm × 1.5 cm), which were compressed twice to 80% of the original height (Feng, Xiong, & Mikel, 2003) by a compression probe (P 75). A crosshead speed of 2 mm/s was used. The 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 (A_2/A_1, A_1 being the total energy required for first compression and A_2 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 × cohesiveness); chewiness (N/cm) = work to masticate the sample for swallowing (S × gumminess).

2.3.6. Shear force

Shear force and work of shearing of five cores (1.5 cm height and 1.5 cm diameter) of nuggets of each treatment were determined with a Warner-Bratzler blade attached to the same texture analyzer. 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.

2.3.7. Sensory evaluation of nuggets

Sensory evaluation used an eight point descriptive scale (Keeton, 1983) with some modifications by Das, Anjaneyulu, Verma, and Kondaiah (2008), where 8 = excellent; 1 = extremely poor. The sensory panel consisted of seven experienced scientists and postgraduate students of the division. The panelists were told the nature of the experiments without disclosing the identity of the samples and were asked to rate them on eight point descriptive scale on the sensory evaluation proforma for different attributes. Nuggets were warmed (45 °C) in a microwave oven for 1 min and served to the panelists. Water was provided to rinse the mouth between tasting the samples. The panelists judged the samples for general appearance, flavour, juiciness, texture, binding and overall acceptability.

2.3.8. Thiobarbituric acid reacting substances (TBARS) number and free fatty acids (FFA)

The TBARS of samples was determined by using the distillation method described by Tarladgis, Watts, Younathan, and Dugan (1960). The method described by Koniecko (1979) was followed for the determination of free fatty acids (as % oleic acid).

2.3.9. Microbiological analysis

Samples of nuggets (10 g) were ground in a sterile pestle and mortar with 90 ml sterile 0.1% peptone water. Appropriate dilutions of samples were prepared in sterile 0.1% peptone water and plated, in duplicate, on the growth media by using the pour plate method. The following media (Hi-Media, India) and incubation conditions were used. (a) Plate Count Agar (PCA): 35 ± 2 °C for 24 h for total plate count and 4 ± 1 °C for 10–14 days for Psychrotrophic count. (b) Violet Red Bile Agar (VRBA): 35 ± 2 °C for 24 h for coliform count (APHA, 1984). The microbial counts were expressed as log10 cfu g^{-1}.

2.4. Statistical analysis

The statistical design of the study was 3 (treatment) × 3 (replication) randomized block design. All chemical and physical determinations were in triplicate. There were seven sensory determinations for each treatment – replication combination. Data were subjected to one way analysis of variance. The storage data were analyzed on the basis of 3 (treatments) × 4 (storage days) × 3 (replications) with two-way analysis of variance. Duncan's multiple range test and critical difference were determined at the 5% significance level (Snedecor & Cochran, 1995).

3. Results and discussion

3.1. pH

Incorporation of soy paste and soy granules slightly ($p > 0.05$) increased pH of nuggets (Table 1), which was mainly due to the higher pH values of soy proteins. Porcella et al. (2001) reported that addition of soy protein isolate (SPI) did not increase the pH significantly compared to control samples.

3.2. Product yield

The yield was comparable between control and treated nuggets (Table 1). Performance of prepared soy paste in the meat system was found to be almost equal to that of commercially made textured soy granules. Despite textured soy protein (TSP) addition up to 20%, the cooking yield was reported similar or higher than that of control due to more water binding during cooking (Deliza, Serna-Saldivar, Germani, Benassi, & Cabral, 2002).

3.3. Proximate composition

Moisture and fat contents were slightly higher whereas protein content was significantly ($p < 0.05$) lower in nuggets with 15% soy paste addition (Table 1). It was due to higher fat and moisture content of the soy paste as compared to the replaced meat. Obviously the nuggets had significantly ($p < 0.05$) higher moisture: protein ratio compared to other groups.

Table 1
Effect of soy paste and soy granules incorporation on physico-chemical, textural properties and sensory attributes of goat meat nuggets

Parameters	Control	Soy paste	Soy granules
pH of emulsion	6.05 ± 0.05	6.08 ± 0.03	6.09 ± 0.04
Product yield (%)	97.69 ± 0.15	97.48 ± 0.16	97.33 ± 0.19
pH	6.38 ± 0.04	6.43 ± 0.03	6.42 ± 0.04
Moisture (%)	62.34 ± 0.74	63.25 ± 0.58	62.60 ± 0.97
Protein (%)	14.86 ± 0.50^{a}	13.46 ± 0.23^{b}	14.75 ± 0.52^{ab}
Fat (%)	14.22 ± 0.41	14.45 ± 0.53	13.14 ± 0.45
Expressible water (%)*	10.24 ± 0.36^{b}	12.74 ± 1.25^{a}	10.13 ± 0.45^{b}
Textural properties (n = 15)			
Hardness (N/cm^2)	55.74 ± 3.23^{a}	43.43 ± 2.20^{b}	49.55 ± 2.95^{ab}
Adhesiveness (Ns)	-6.58 ± 2.28	-11.85 ± 3.02	-8.06 ± 3.01
Springiness (cm)	0.808 ± 0.01^{a}	0.743 ± 0.02^{b}	0.721 ± 0.02^{b}
Cohesiveness (ratio)	0.229 ± 0.01	0.237 ± 0.01	0.226 ± 0.01
Gumminess (N/cm^2)	12.81 ± 0.87^{a}	10.01 ± 0.44^{b}	11.00 ± 0.48^{a}
Chewiness (N/cm)	10.29 ± 0.63^{a}	7.45 ± 0.42^{b}	7.92 ± 0.45^{b}
Shear force (N)	10.68 ± 0.76^{a}	7.20 ± 0.30^{b}	9.38 ± 0.71^{a}
Work of shearing (Ns)	68.95 ± 3.61^{a}	49.86 ± 2.59^{b}	62.48 ± 5.04^{a}
*Sensory attributes***			
Appearance	7.09 ± 0.04	7.09 ± 0.05	7.11 ± 0.06
Flavour	7.05 ± 0.05^{a}	7.05 ± 0.06^{a}	6.59 ± 0.08^{b}
Juiciness	6.93 ± 0.07	7.02 ± 0.05	6.82 ± 0.08
Texture	7.05 ± 0.03	6.90 ± 0.05	6.98 ± 0.08
Binding	7.11 ± 0.06	7.09 ± 0.06	7.02 ± 0.06
Overall acceptability	6.98 ± 0.06^{a}	6.93 ± 0.05^{a}	6.68 ± 0.06^{b}

Means in the same row with different letters are significantly different ($P < 0.05$), *$n = 12$, **$n = 21$ based on eight point scale (1 = extremely undesirable; 8 = extremely desirable).

3.4. Expressible water

Water holding capacity (WHC) is inversely associated with the percent water expressed by centrifugation (the lowest percent of water extracted means the highest WHC) (Das et al., 2008). Soy paste addition significantly ($p < 0.05$) increased expressible water (decrease water holding capacity) on centrifugation (Table 1). These results indicated that water molecules interacted weakly with protein in nuggets containing soy paste compared to tight protein–water interaction in control and nuggets with soy granules, as soy paste contained a higher level of added water during grinding, which might influence WHC (Das et al., 2006). This significant difference might be due to type and physico-chemical nature of proteins used. Again, it may be due to lower protein content in soy paste as well as nuggets with soy paste. The higher the protein content of batter, the more water can be absorbed (Alamanou, Bloukas, Paneras, & Doxastakis, 1996). Ramirez, Uresti, Tellez, and Vazquez (2002) also reported the protein–protein and protein–water interactions that influence water holding capacity in meat and meat products.

3.5. Texture profiles

Soy paste incorporation significantly lowered hardness, springiness, gumminess and chewiness in nuggets (Table 1). These textural parameters were also comparable to the nuggets containing soy granules. However, gumminess of nuggets with paste was significantly ($p < 0.05$) lower than that of nuggets containing soy granules. Das et al. (2006) reported that addition of FFSP markedly decreased the hardness of goat meat patties. The soft texture of soy paste and higher moisture content might be a contributing factor to the lower hardness in soy paste extended nuggets. Products hardness decrease with increase in moisture content (Chin, Lee, & Chun, 2004). Significantly lowers springiness in treated nuggets could be due to replacement of lean with soy paste, hence loss of elasticity. Soft texture of soy paste significantly affected the chewiness and gumminees of paste extended nuggets. Verma, Ledward, and Lawrie (1984) found that sausages containing chickpea flour were softer in texture with increasing levels. Nuggets with soy paste incorporated had significantly ($p < 0.01$) lower shear force and work of shearing values than control and other treated patties indicating their softer texture. Similarly, a decline in shear force value with lower lean meat content was reported by Devatkal, Mendiratta, and Kondaiah (2004) and Das et al. (2006).

3.6. Sensory attributes

There was no significant difference in the sensory scores of appearance, juiciness, texture and binding between control and treated nuggets (Table 1). Incorporation of soy granules significantly ($p < 0.01$) decreased flavour and overall acceptability score of nuggets due to a perceived more beany flavour than that of others. However, nuggets containing soy paste and control products were almost similar in flavour and overall acceptability. Addition of heat treated full-fat soy paste in goat meat patties also did not significantly affect their flavour and overall acceptability (Das et al., 2006). Moreover, Singh, Kaur, Singh, and Singh (2002) also reported that addition of TSP significantly reduced acceptability of goat meat patties in a dose dependent manner. Aroma and flavour are probably the most important attributes that influence the sensory properties of comminuted meat products extended with non-meat protein additives. Sensory scores indicated that nuggets with soy paste were tender and also reflected by lower shear force values compared to that of other groups. Brewer et al. (1992) reported that soy extenders decreased beefy flavour and increased off-flavour scores.

4. Quality changes in vacuum packed nuggets during frozen storage

4.1. pH

Incorporation of soy paste did not significantly affect the pH of nuggets (Table 2). The pH of the samples remained almost similar up to 90 days of frozen storage (-18 ± 1 °C). This might be due to inhibition of microbial growth at frozen storage. Sahoo and Anjaneyulu (1996) found no significant change in pH during frozen storage of buffalo meat nuggets. Porcella et al. (2001) also reported that addition of SPI did not increase pH significantly compared to control samples.

4.2. TBARS

When meat and meat products are stored under frozen conditions, microbial spoilage may be delayed but fat deterioration occurs and the meat constituents may be oxidized. Nuggets with soy granules had significantly lower TBARS after 30 days of frozen storage than the nuggets with soy paste (Table 2). This could be due to lower fat content in the product and an antioxidant effect of components of soy granules. During the storage period, TBARS increased significantly ($p < 0.01$) in the control as well as treated nuggets. A general trend of increase in TBARS during refrigerated and frozen storage of meat and meat products has been reported by many workers (Devatkal et al., 2004; Rajkumar et al., 2004). Fat oxidation in frozen meats proceeds at a slower rate than in refrigerated meat (Tan & Shelef, 2002). But the values of TBARS remained lower than the acceptable level for rancidity (1.0 mg/kg). Off-flavour was not detected by the taste panelists during 90 days frozen storage.

4.3. Free fatty acids (FFA)

Free fatty acids are the products of enzymatic or microbial degradation of lipids. Determination of FFA gives information about stability of fat during storage. There was significantly ($p < 0.01$) higher FFA in nuggets containing soy paste, which might be due to its unsaturated fatty acids (Table 2). Significant ($p < 0.01$) increase in FFA con-

Table 2
Effect of incorporation of soy paste and soy granules on physico-chemical parameters of goat meat nuggets during frozen storage (-18 ± 1 °C)

Treatments/parameters	Storage period (days)				Treatment mean ± SE ($n = 12$)
	0	30	60	90	
pH					
Control	6.39	6.42	6.46	6.45	6.43 ± 0.03
Soy paste	6.43	6.45	6.46	6.48	6.45 ± 0.02
Soy granules	6.43	6.43	6.45	6.47	6.44 ± 0.02
Day mean ± SE	6.41 ± 0.02	6.43 ± 0.02	6.45 ± 0.03	6.47 ± 0.01	
TBARS number (mg malonaldehyde/kg)					
Control	0.251	0.369	0.515	0.582	0.429 ± 0.03^{a}
Soy paste	0.255	0.433	0.501	0.591	0.445 ± 0.03^{a}
Soy granules	0.204	0.339	0.408	0.498	0.362 ± 0.03^{b}
Day mean ± SE	0.237 ± 0.01^{d}	0.380 ± 0.03^{c}	0.475 ± 0.02^{b}	0.557 ± 0.02^{a}	
Free fatty acids (%)					
Control	0.101	0.110	0.124	0.143	0.120 ± 0.004^{b}
Soy paste	0.114	0.127	0.141	0.150	0.133 ± 0.004^{a}
Soy granules	0.106	0.113	0.126	0.141	0.122 ± 0.004^{b}
Day mean ± SE	0.107 ± 0.002^{d}	0.117 ± 0.002^{c}	0.131 ± 0.003^{b}	0.145 ± 0.004^{a}	
Expressible water (%) (n = 12)					
Control	11.72	13.09	15.94	18.84	14.89 ± 0.86^{b}
Soy paste	12.54	15.13	17.58	21.33	16.65 ± 0.89^{a}
Soy granules	12.12	12.21	15.93	19.09	14.84 ± 0.73^{b}
Day mean ± SE	12.13 ± 0.34^{c}	12.48 ± 0.40^{c}	16.48 ± 0.68^{b}	19.75 ± 1.06^{a}	

Mean ± SE with different superscripts differ significantly ($P < 0.05$), $n = 6$; TBARS – thiobarbituric acid reacting substance.

tent of nuggets was observed during frozen storage. The significant increase in levels of FFA in meat products during 90 days frozen storage might be due to growth inhibition of lipolytic microorganisms in frozen storage. However, Sahoo and Anjaneyulu (1997) reported similar trend but higher value of FFA in buffalo meat nuggets during refrigerated storage. Similarly freshly prepared dehydrated chicken kebab mix had FFA values of 0.99 ± 0.205, which gradually ($p < 0.05$) increased to 1.74 ± 0.073 during 6 months of storage (Modi, Sachindra, Nagegowda, Mahendrakar, & Rao, 2007).

4.4. Expressible water (EW)

Water holding capacity is inversely associated with the percent water expressed by centrifugation. Nuggets with soy paste had significantly ($p < 0.05$) higher expressible water content, indicating lower WHC than that of control and nuggets with soy granules (Table 2). Textured soy protein is well known for fat holding and water binding in meat systems (Deliza et al., 2002). Lower expressible water could be due to higher protein water interaction in soy granules extended products. Significantly ($p < 0.05$) lower WHC in nuggets with soy paste might be due to its higher moisture content and weak protein–water interactions. The decrease in water holding capacity during storage was indicated by significantly increased expressible water content after 30 days. Expressible water content was comparable up to 30 days, later decreased significantly. The loss of WHC might be due to degradation of proteins responsible for water holding. On the other hand, physico-chemical properties of paste and granules are different, which may be explained as soy paste addition causes an increase in protein–protein interactions with a decrease in protein–water interactions, which induces a decrease in WHC (Das et al., 2008; Ramirez et al., 2002).

4.5. Microbiological quality

All microbial counts of goat meat nuggets determined during frozen storage were low in number and can be categorized as satisfactory and within the acceptable values for cooked meat products (Figs. 1 and 2). Soy protein extended products had slightly higher microbial counts than that of the control. This could be due to higher pH and available nutrients favourable for microbial growth. There was no significant change in total plate counts (TPC) till 30 days, thereafter it increased significantly ($p < 0.01$). However, TPC of nuggets had not exceeded the permissible level of microbial standards (log 10^6 cfu g^{-1} of sample) in cooked meat products as reported by Jay (1996). The TPC observed during the present study were comparable to the observations made by Sahoo and Anjaneyulu (1996) in buffalo meat nuggets during frozen storage. The initial psychrotrophic counts were 2.20, 2.37, 2.18 log cfu g^{-1}, respectively which increased significantly ($p < 0.01$) between storage periods. However, the counts did not exceed the limit of 4.6 log cfu g^{-1} (Cremer & Chipley, 1977) suggesting that the nuggets were kept well without microbial spoilage up to 90 days of frozen storage. The occurrence of coliform counts during storage was very rare, indicating better sanitary measures adopted during processing. Das et al. (2008) also reported similar results.

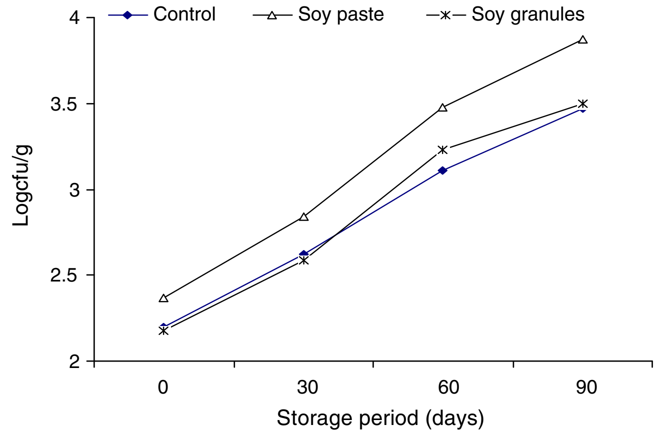

Fig. 1. Psychrotrophs count of goat meat nuggets during 90 days of frozen storage.

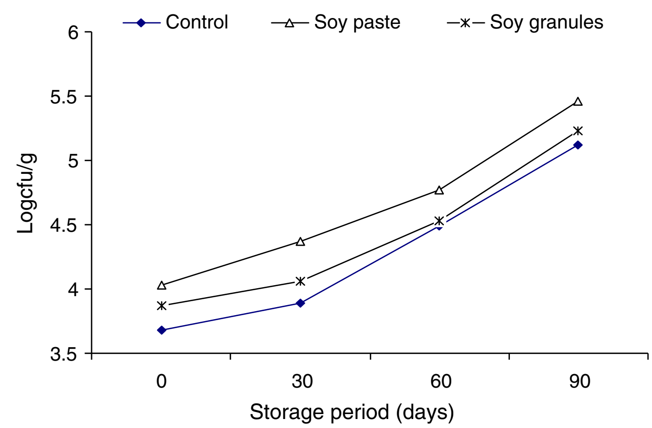

Fig. 2. Total plate count of goat meat nuggets during 90 days of frozen storage.

4.6. Sensory attributes

Sensory scores for appearance, flavour, texture, binding and overall acceptability of the nuggets remained similar till 30 days (Table 3). Thereafter, sensory scores significantly decreased for all the parameters except juiciness, which remained unchanged up to 60 days. Decline in flavour scores of meat products during storage was reported in buffalo meat nuggets (Sahoo & Anjaneyulu, 1997; Thomas et al., 2006). A gradual decline of flavour might be due to the expected loss of volatile flavour components from spices and condiments on storage of meat products. All the sensory attributes of nuggets were good to very good till 90 days of frozen storage. Nuggets with soy granules rated a significantly ($p < 0.01$) lower value for overall

Table 3
Effect of incorporation of soy paste and soy granules on sensory attributes* of goat meat nuggets during frozen storage (-18 ± 1 °C)

Treatments/parameters	Storage period (days)				Treatment mean ± SE ($n = 12$)
	0	30	60	90	
Appearance					
Control	7.08	7.04	6.83	6.85	6.95 ± 0.04
Soy paste	7.08	7.04	6.93	6.77	6.95 ± 0.03
Soy granules	7.11	7.04	6.90	6.88	6.98 ± 0.03
Day mean ± SE	7.09 ± 0.03^a	7.04 ± 0.02^a	6.89 ± 0.04^b	6.83 ± 0.05^b	
Flavour					
Control	7.03	6.96	6.83	6.50	6.83 ± 0.04^a
Soy paste	7.03	6.93	6.77	6.50	6.81 ± 0.04^a
Soy granules	6.53	6.64	6.50	6.12	6.45 ± 0.05^b
Day mean ± SE	6.86 ± 0.05^a	6.84 ± 0.04^a	6.70 ± 0.05^b	6.37 ± 0.06^b	
Juiciness					
Control	6.92	6.79	6.80	6.69	6.80 ± 0.04^b
Soy paste	7.00	7.07	6.93	6.81	6.95 ± 0.03^a
Soy granules	6.84	6.75	6.70	6.46	6.69 ± 0.05^b
Day mean ± SE	6.92 ± 0.04^a	6.87 ± 0.05^a	6.81 ± 0.05^a	6.65 ± 0.06^b	
Texture					
Control	7.03	7.04	6.87	6.81	6.93 ± 0.03^a
Soy paste	6.88	6.84	6.70	6.65	6.78 ± 0.04^b
Soy granules	6.87	7.07	6.75	6.65	6.82 ± 0.05^b
Day mean ± SE	6.93 ± 0.04^a	6.98 ± 0.04^a	6.77 ± 0.05^b	6.71 ± 0.07^b	
Overall acceptability					
Control	6.95	7.00	6.88	6.58	6.84 ± 0.04^a
Soy paste	6.92	6.88	6.85	6.60	6.81 ± 0.03^a
Soy granules	6.68	6.71	6.51	6.19	6.52 ± 0.05^b
Day mean ± SE	6.85 ± 0.04^a	6.86 ± 0.05^a	6.73 ± 0.04^b	6.46 ± 0.06^c	

Mean ± SE with different superscripts differ significantly ($P < 0.05$).
*$n = 21$, sensory scores based on eight point scale where 1: extremely poor and 8: extremely desirable.

acceptability than that of control and nuggets with soy paste, which might be due to beany flavour detected by taste panelists.

5. Conclusion

The performance of soy paste prepared for use as a non-meat protein extender to replace costly lean meat was comparable with commercially available textured soy granules and the nuggets had no beany flavour at the level used compared to the beany flavour imparted by the soy granules. Higher flavour and overall acceptability scores indicated the preference of nuggets containing soy paste over soy granules extended products. Despite, nuggets with textured soy granules having significantly lower TBARS numbers, FFA and expressible water than the products with soy paste which were more tender and comparable with control ones in terms of sensory and microbial qualities during 3 months frozen storage. So the FFSP has a great potential use in the manufacture of emulsion type meat products with good acceptability and cost benefit.

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