Original article

Physicochemical, textural, sensory characteristics and storage stability of goat meat patties extended with full-fat soy paste and soy granules

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Summary The performance of full-fat soy paste (FFSP) with reduced beany flavour made by simple processing technology was compared with the commercially available textured soy granules in goat meat patties. Addition of soy proteins (soy paste and soy granules) did not significantly affect the emulsion stability and product yield. Shrinkage of patties with soy paste was comparable with control. A significant ($P < 0.05$) reduction in redness and increase in yellowness of patties was due to addition of soy proteins than in control. Patties with soy paste had comparable but slightly higher total lipid and cholesterol content with that of control but significantly ($P < 0.05$) higher than patties with soy granules. Lower force was required to compress or shear the sample, as hardness decreased in soy-added patties. Flavour and overall acceptability scores between control and patties with soy paste did not differ significantly, whereas patties with soy granules were rated significantly lower. The patties remained stable with minor changes in physicochemical, microbiological and sensory quality during refrigerated storage (4 ± 1 °C) for 20 days. It is concluded from this study that FFSP had potential application similar to commercially available textured soy granules in comminuted meat products.

Keywords Full-fat soy paste, lipid profiles of goat meat patties, physicochemical quality, soy granules, storage stability, texture profiles.

Introduction

Several non-meat ingredients have been evaluated as lean meat replacements in meat products with the goal of maintaining the products yield and minimising formulation cost while retaining acceptable palatability. Plant-derived proteins from soybeans, corn and wheat have been used in traditional comminuted meat products as meat replacements (Chin *et al*., 1999). Soy proteins such as flours, textured soy protein (TSP), concentrates and isolates are economical source of food proteins, which have been used in meat products as a binder for improving yields, as a gelling agent to enhance emulsion stability and as meat replacement to reduce costs (Lecomte *et al*., 1993; Rentfrow *et al*., 2004). Brewer *et al*. (1992) reported that the addition of soy extenders decreased beefy flavour and increased off-flavour scores in ground beef patties. Sensory hardness and off-flavour intensity of frankfurters increased with incremental levels of soy proteins (< 3%) but cohesiveness, juiciness and saltiness decreased (Matuilis *et al*., 1995).

To develop meat products by adding full-fat soy protein as extender, their objectionable aroma and flavour need to be eliminated or minimised. The major off-flavour and off-notes that occur in ground soy products are the green, grassy or beany notes and the bitter and astringent characteristics (King *et al*., 2001; Mizutani & Hashimoto, 2004). This off-flavour and aroma makes the products containing soy protein unpleasant to the consumer. Wilkens *et al*. (1967) described a process in which soybeans are heated during disruption (hot grinding), which has the duel advantage of minimising the development of beany flavour by heat denaturation of lipoxygenase (Chauhan *et al*., 2003) and of maximising protein extraction.

However, the effect of addition of full-fat soy paste (FFSP) on the quality of ground meat products has not been studied. Our objective was to compare the performance of reduced beany flavour FFSP with that of commercially available textured soy granules on the physicochemical, textural, sensory characteristics and storage stability of goat meat patties.

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Materials and methods

Formulation and processing of patties

Goat meat required for the experiments was procured from retail meat shop. The meat was obtained mainly from hind legs of carcasses of good conformation of non-descript adult female goats slaughtered according to 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 laboratory within 20 min. The samples were hot-boned, trimmed-off separable fat and connective tissue. The experimental samples for each trial were taken from the pooled deboned meat. The samples were kept for conditioning in a refrigerator at 4 ± 1 °C for 6–8 h and then frozen at −18 °C till further use. The samples were used after partial thawing for 15 h at 4 °C. The meat samples were cut into small cubes and minced with Seydelmann meat grinder, Model WD 114 (Maschinenfabrik Seydelmann KG, Stuttgart, Germany) using 8 mm plates. This ground goat meat was used in different product formulations.

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, India. Briefly, soybeans were washed with tap water to remove extraneous dirt, blanched in boiled water for 15 min, soaked in cold water for 12 h and dehulled manually and ground into a fine FFSP with water in a home mixer (Das *et al.*, 2006). FFSP had least beany flavour, better colour and consistency compared with others. It was used to replace lean meat, which had a composition of 77.43% moisture, 13.09% protein and 5.95% fat (Das *et al.*, 2006). In order to evaluate the potential application of soy paste in ground meat products, goat meat was selected for its wide acceptance among meat consumers. The commercial brand textured soy granules 'Nutrela' (Ruchi Soya Industries Limited, Manglia, Madhya Pradesh, India) purchased from local market were hydrated [(1:2.75 (w/w) for 1 h)], according to the composition indicated by the manufacturer to equalise the protein content in the meat products prepared from soy paste. The hydrated and squeezed soy granules were minced in a home mixer for use in meat products.

The formulation and processing of control and treated patties were standardised by preliminary trials (Table 1). Minced meat and all the ingredients were thoroughly chopped in a Seydelmann bowl chopper, Model K20 Ras (Maschinenfabrik Seydelmann KG) to prepare the 5 kg emulsion for each treatment. About 70 g of emulsion was moulded in a Petri dish (75 mm diameter and 15 mm height) to form patties and was cooked in a preheated oven at 180 ± 5 °C for 15 min, after which they were turned and allowed to get cooked for 10 more minutes till internal temperature reached about 75 ± 2 °C recorded by a probe thermometer (Oakton, Shanghai, China). The patties were cooled, weighed and dimensions were measured. The patties were packed in LDPE pouches. Six packets per treatment each containing three patties were stored at refrigerated temperature (4 ± 1 °C). The products were evaluated at an interval of 5 days for physicochemical, microbiological and sensory attributes. The experiment was replicated thrice.

Table 1 Formulations for control and treated goat meat patties

Ingredients (%)	Control	Soy paste	Soy granules
Lean goat meat	70	55	55
Soy paste	–	15	–
Soy granules	–	–	15
Refined mustard oil	10	10	10
Ice flakes	10	10	10
Salt	1.6	1.6	1.6
Dry spices mix	1.8	1.8	1.8
Condiments	3.0	3.0	3.0
Refined wheat flour	3.0	3.0	3.0
Tripolyphosphate	0.3	0.3	0.3
Sugar	0.3	0.3	0.3

Sodium nitrite at the level of 150 ppm was also added in the formulations. Condiments – onion and garlic (4:1).

Physicochemical analyses

Product yield

Product yield was determined by measuring weight of ten patties for each treatment and calculating the ratio of cooked weight to raw weight and expressed as a percentage. The diameter and height of the cooked patties were recorded by use of a Vernier caliper at three different points on each patty. The gain in height and decrease in diameter were expressed as percentage. The shrinkage was determined according to the equation reported by El-Magoli *et al.* (1996).

Emulsion stability was determined as per the method of Kondaiah *et al.* (1985). The emulsion samples (25 g) in polyethylene bags were heated at 80 °C in a thermostatically controlled water bath for 20 min. After draining out the exudate, the cooked mass was cooled, weighed and the yield was expressed as emulsion stability per cent.

Composition

The moisture, protein and crude fat (ether extract) of raw and cooked ground patties were determined in triplicate according to the standard AOAC (1995) procedures.

pH determination
The pH of emulsion and cooked products was determined by blending 10 g of sample with 50 mL of distilled water for 1 min using an Ultra-Turrax T25 tissue homogeniser (Janke and Kunkel, IKA Labortechnik, Staufen, Germany) at 8000 r.p.m. for 1 min. The pH of the suspension was recorded by dipping combined glass electrode of Elico digital pH meter, Model LI 127 (Elico Limited, Hyderabad, India).

Expressible water
The amount of expressible water for each treatment was measured (Ramirez *et al.*, 2002). About 5 g of cooked samples were weighed and put 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 12 577.5 g (Remi-24, Remi Instruments, Bombay, 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 analysed and averages reported for each treatment.

Colour measurements
The colour of cooked meat patties were compared using a Lovibond Tintometer (Model F; The Tintometer Ltd, Salisbury, UK). Samples from three different places of patties were taken in the sample holder and secured against the viewing aperture. The sample colour was matched by adjusting red (a) and yellow (b) units, while keeping the blue units fixed at 2.0. The corresponding colour units were recorded. The hue and chroma (saturation) values were determined using the formula, ($\tan^{-1} b/a$) (Little, 1975) and $(a^2 + b^2)^{1/2}$ (Froehlich *et al.*, 1983), respectively, where, a is the red unit, b the yellow unit.

Texture profile analysis
The textural properties of patties were evaluated using the texturometer (Model TA.XT 2i/25; Stable Micro System, Surrey, 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 × 1.5 × 1.5 cm), which were compressed twice to 80% of the original height. A crosshead speed of 2 mm s^{-1} 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 ($H \times$ Cohesiveness); Chewiness (N cm^{-1}) = work to masticate the sample for swallowing ($S \times$ Gumminess).

Shear force and work of shearing of samples were estimated with a Warner–Bratzler blade attached to the same texture analyser. Five cores (1.5 cm height and 1.5 cm diameter) were taken from patties of each treatment. The crosshead speed was 2 mm s^{-1}. 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.

Sensory evaluation
Sensory evaluation method using an 8-point descriptive scale (Keeton, 1983) was followed with modifications, where 8 = excellent; 1 = extremely poor. The sensory panel consisted of seven experienced scientists and postgraduate students of the division. The panellists were explained about the nature of experiments without disclosing the identity of samples and were asked to rate their preference on 8-point descriptive scale on the sensory evaluation proforma for different traits. Samples were warmed using microwave oven for 1 min, cut across their centre to make eight equal size and shape (triangular) pieces per patty and served to the panellists. Water was provided to rinse mouth between the samples. The panellists judged the samples for general appearance, flavour, juiciness, texture, binding and overall acceptability.

Lipid profile
The fat content of the samples were extracted using the method described by Folch *et al.* (1957) and total lipids were determined gravimetrically. The different components of lipids, including total phospholipids, total cholesterol, glycolipids and free fatty acids (FFA) were measured by standard procedures as described by Hanel & Dam (1955), Marinetti (1962), Raughan & Batt (1968) and Koniecko (1979), respectively, whereas total glycerides were indirectly calculated by subtracting all these from total lipid values.

Thiobarbituric acid reacting substances number
The number of samples of thiobarbituric acid reacting substances (TBARS) was determined using the distillation method described by Tarladgis *et al.* (1960).

Free fatty acids
For the determination of FFA, the method described by Koniecko (1979) was followed.

Total volatile nitrogen
The total volatile nitrogen (TVN) of the samples was determined by the method reported by Herborg & Nijaa (1988).

Microbiological analysis

A 10 g sample of patties was ground in a sterile mortar and pestle 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 using the pour plate method. The following media (Hi-Media, Bombay, India) and incubation conditions were used.

1 Plate count agar: 35 ± 2 °C for 24 h for total plate count and 4 ± 1 °C for 10–14 days for Psychrotrophs count.
2 Violet red bile agar: 35 ± 2 °C for 24 h for coliform count.

The results were expressed as $\log_{10}$ CFU g^{-1} (APHA, 1984).

Statistical analysis

The statistical design of the study was 3 (treatment) × 3 (replication) randomised 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 analysed on the basis of 3 (treatments) × 5 (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).

Results and discussion

Emulsion quality

Addition of paste and soy granules slightly increased the pH of emulsion (Table 2). This is mainly because of the addition of paste and hydrated soy granules with higher pH content (6.8–7.0). Addition of soy paste and soy granules in the formulation did not significantly affect the emulsion stability. Wang & Zayas (1991) found that emulsion stability of frankfurters prepared with soy proteins and corn germ protein was increased. Reichet (1991) reported that soy protein acts as an emulsifier and fat-encapsulating agent by supplementing myosin and actomyosin and that they can prevent fat separation and hold the meat juice while cooking. More recently, Mourtzinos & Kiosseoglou (2005) reported that soy proteins are known for their emulsifying and emulsion-stabilising properties and these functional properties are important in comminuted meat products.

Addition of soy paste markedly increased moisture and decreased protein content compared with control. This was due to higher level of moisture in paste (77.78%) compared with hydrated soy granules (74.86%). Use of soy paste significantly ($P < 0.01$) increased fat content, because of its higher fat content, whereas emulsion with soy granules had lower fat content because of its defatted form.

Table 2 Effect of soy paste and soy granules addition on physico-chemical characteristics of goat meat patties

Parameters	Control	Soy paste	Soy granules
Emulsion			
pH	6.06 ± 0.07	6.09 ± 0.06	6.10 ± 0.07
Emulsion stability* (%)	92.67 ± 0.47	91.31 ± 0.59	91.74 ± 0.23
Moisture (%)	62.80 ± 1.28	64.84 ± 1.25	62.48 ± 1.86
Protein (%)	13.41 ± 0.26	12.81 ± 0.40	12.93 ± 0.13
Fat (%)	13.27 ± 0.46^{ab}	13.98 ± 0.42^{a}	12.66 ± 0.32^{b}
Patties†			
Product yield (%)	90.82 ± 0.53	90.81 ± 0.32	90.67 ± 0.46
Decrease in diameter (%)	7.84 ± 0.49	7.49 ± 0.39	8.53 ± 0.42
Gain in height (%)	35.24 ± 1.35^{a}	27.13 ± 1.48^{b}	30.35 ± 1.77^{b}
Shrinkage (%)	0.753 ± 0.45^{b}	1.65 ± 0.28^{ab}	2.09 ± 0.32^{a}
pH	6.44 ± 0.05	6.46 ± 0.06	6.45 ± 0.06
Moisture (%)	60.85 ± 1.44	62.43 ± 0.53	60.48 ± 0.92
Protein (%)	15.02 ± 0.19	14.37 ± 0.28	14.50 ± 0.23
Fat (%)	14.31 ± 0.62	15.08 ± 0.47	13.55 ± 0.47
Expressible water (%)	11.16 ± 0.67^{b}	14.41 ± 1.32^{a}	9.39 ± 0.58^{b}

Mean values in the same row with different superscript letters are significantly different ($P < 0.05$).
*n = 12; †$n = 32$ for physical properties.

Product yield

The yield of patties added with soy paste was comparable with control and commercially available soy granules. These results were in agreement with the findings of Singh *et al.* (2002), who reported up to 20% TSP; the cooking yield is comparable or higher than control.

Shrinkage

The degree of shrinkage is important in maintaining quality of meat patties prepared for food service establishments. Therefore, change in diameter and thickness must be considered when benefits of meat additives were evaluated. Control patties did not differ significantly ($P < 0.05$) in diameter from treated patties, which could be attributed to improved moisture retention and cooking yield in extended products (Singh *et al.*, 2002; Kumar & Sharma, 2003). Soy paste addition significantly ($P < 0.05$) lowered the gain in height of patties compared with that of control but did not differ from patties with soy granules. Shrinkage of the patties significantly ($P < 0.05$) increased because of soy paste and soy granules addition. Shrinkage of control products was comparable with soy-paste-added patties, which was not significantly different from patties extended with soy granules.

Proximate composition

Moisture, protein and fat of patties were not significantly ($P < 0.05$) different because of addition of both soy paste and soy granules (Table 2). The performance of soy paste produced for use in comminuted meat product is comparable with commercially available textured soy granules.

Expressible water

Water holding capacity (WHC) is directly associated with the per cent water expressed by centrifugation (the lowest per cent of water extracted means the highest WHC). Addition of soy paste had significantly ($P < 0.05$) increased expressible water content than that of control and soy granules, as soy paste contained higher level of added water during grinding, which might influence WHC. Further, it may be due to lower protein content of soy paste compared with meat protein in control group. The higher the protein content of batter, the more water can be absorbed (Alamanou *et al*., 1996). Soy granules hold more water on hydration and at gelatinisation temperature, form a tight gel with water trapped inside upon cooling. Physicochemical 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 (Ramirez *et al*., 2002).

Product colour

Colour measurement is an important parameter in cooked meat products, because consumers associate this product with a bright and characteristic pink colour. Addition of soy granules and soy paste had significantly ($P < 0.01$) lowered the redness of patties (Table 3). The control patties were significantly ($P < 0.01$) higher in redness compared with treated patties, which were different significantly among themselves. The reduction of colour was due to replacement of lean content, consequently dilution of meat pigment present in the patties. Addition of soy paste and soy granules significantly ($P < 0.05$) increased yellowness and hue. Chin *et al*. (1999) reported that replacement of 4% meat protein with soy protein isolate increased lightness and decreased redness (a^*) and increased yellowness (b^* values). Patties with soy paste and soy granules did not differ in saturation (chroma) index and were similar to control.

Table 3 Effect of soy paste and soy granules addition on colour values of cooked goat meat patties

Parameters	Control	Soy paste	Soy granules
Redness	4.37 ± 0.03[a]	3.95 ± 0.04[c]	4.08 ± 0.03[b]
Yellowness	4.87 ± 0.08[b]	5.25 ± 0.09[a]	5.20 ± 0.06[a]
Hue	48.07 ± 0.53[b]	53.08 ± 0.37[a]	51.88 ± 0.35[a]
Saturation/chroma	6.54 ± 0.06	6.57 ± 0.08	6.61 ± 0.06

Mean values in the same row with different superscript letters are significantly different ($P < 0.05$).
$n = 6$.

Lipid profiles of patties

Total lipid and total glycolipids content were significantly ($P < 0.05$) higher in soy-paste-added patties compared with patties with soy granules, but comparable with control as soy paste contains 5–6% fat (Table 4). Use of defatted soy granules significantly decreased the total lipid content of patties. Cholesterol content in patties extended with soy paste was comparable with control, whereas patties with soy granules had significantly ($P < 0.05$) lower cholesterol content. Rhee & Smith (1983) reported that cholesterol content of patties decreased as the amount of TSP increased. Higher cholesterol content in patties with soy paste was due to comparatively high fat content in the product (Kumar & Sharma, 2003). FFA and total glycerides were not significantly ($P < 0.05$) influenced by the addition of soy paste and soy granules.

Texture profiles

Significantly ($P < 0.01$) lower force was required to compress the patties with soy paste. Hardness of control patties was significantly higher than soy-paste-extended patties but comparable to patties with soy granules (Table 5). Lower hardness of soy-paste-extended patties was due to soft texture of soy paste and more moisture content. Chin *et al*. (2004) also reported product hardness decreased with increase in moisture. Significantly ($P < 0.05$) lower springiness in treated patties could be due to lean replacement, hence loss of elasticity. Gumminess and chewiness were significantly

Table 4 Effect of soy paste and soy granules addition on lipid profiles of goat meat patties

Parameters (mg g^{-1})	Control	Soy paste	Soy granules
Total lipid	145.77 ± 0.39[ab]	153.47 ± 0.33[a]	136.90 ± 0.27[b]
Total phospholipid*	44.73 ± 2.38	46.67 ± 0.41	41.73 ± 1.96
Total cholesterol†	1.99 ± 0.07[ab]	2.19 ± 0.06[a]	1.88 ± 0.09[b]
Free fatty acid	3.21 ± 0.11	3.58 ± 0.15	3.07 ± 0.19
Total glycolipids	0.512 ± 0.02[ab]	0.553 ± 0.03[a]	0.447 ± 0.02[b]
Total glycerides	95.33 ± 4.39	100.48 ± 4.21	89.77 ± 3.78

Mean values in the same row with different superscript letters are significantly different ($P < 0.05$).
*$n = 9$, †$n = 6$.

Table 5 Effect of soy paste and soy granules addition on textural properties and sensory attributes of goat meat patties

Parameters	Control	Soy paste	Soy granules
Textural properties*			
Hardness (N cm^{-2})	62.76 ± 4.85^{a}	43.86 ± 2.02^{b}	60.98 ± 5.29^{a}
Adhesiveness (Ns)	−3.24 ± 1.31	−4.95 ± 1.70	−2.36 ± 0.87
Springiness (cm)	0.796 ± 0.01^{a}	0.747 ± 0.02^{b}	0.711 ± 0.02^{b}
Cohesiveness (ratio)	0.221 ± 0.003^{b}	0.239 ± 0.002^{a}	0.229 ± 0.003^{ab}
Gumminess (N cm^{-2})	14.14 ± 1.29^{a}	10.33 ± 0.50^{b}	13.59 ± 1.27^{a}
Chewiness (N cm^{-1})	11.49 ± 1.17^{a}	7.73 ± 0.42^{b}	9.68 ± 0.80^{ab}
Shear force (N)	9.73 ± 0.67^{a}	7.63 ± 0.23^{b}	9.37 ± 0.42^{a}
Work of shearing (Ns)	66.90 ± 3.35	57.59 ± 2.11	64.10 ± 3.81
Sensory attributes†			
Appearance	6.98 ± 0.08	7.05 ± 0.08	7.07 ± 0.07
Flavour	7.02 ± 0.08^{a}	7.07 ± 0.07^{a}	6.59 ± 0.09^{b}
Juiciness	6.84 ± 0.09	6.98 ± 0.06	6.75 ± 0.10
Texture	7.07 ± 0.10	6.84 ± 0.08	7.00 ± 0.08
Binding	7.20 ± 0.13	7.16 ± 0.12	7.11 ± 0.11
Overall acceptability	6.98 ± 0.10^{ab}	7.02 ± 0.08^{a}	6.75 ± 0.08^{b}

Mean values in the same row with different superscript letters are significantly different ($P < 0.05$).

*$n = 15$, †$n = 21$ based on 8-point scale (1 = extremely undesirable; 8 = extremely desirable).

($P < 0.05$) decreased in patties extended with soy paste. But textural properties of patties with soy granules were comparable with control, which might be due to formation of rigid gel with muscle proteins. Matuilis *et al.* (1995) reported that a 3% substitution of soy protein for meat protein resulted in increased frankfurters gel hardness. Myosin of meat could interact not only with native soy 11S proteins but also with dissociated soy 11S components, and the interaction enhanced the formation of a rigid gel structure (Feng & Xiong, 2002). The similar interaction might not exist in case of soy paste, because of difference in physical and chemical properties of paste with that of soy granules.

Shear force

Control patties had significantly ($P < 0.01$) higher shear force value than that of patties with soy paste, which were less firm than control and soy-granules-extended patties. Myofibrillar and stromal proteins are responsible for firmness in ground beef products and addition of soy paste would have a dilution effect on such proteins, resulting in the softness of patties. Deliza *et al.* (2002) reported that addition of TSP made the meat products more tender.

Sensory attributes

Addition of soy paste and soy granules to goat meat patties did not affect their sensory attributes except flavour and overall acceptability (Table 5). Flavour scores between the control and the patties with 15% soy paste did not differ, whereas patties with soy granules were rated significantly ($P < 0.01$) lower for flavour. Sensory panellists felt intense beany flavour of soy in patties containing soy granules. Brewer *et al.* (1992) reported that addition of soy extenders decreased beefy flavour and increased off-flavour scores in ground beef patties. Addition of high concentration of TSP to meat product usually adversely affects flavour and colour (Deliza *et al.*, 2002). Panellists did not identify any odd soy flavour or beany flavour with 15% soy-paste-extended patties and rated similar to control. Patties containing soy paste were markedly juicer and tender than others. Texture analysis and expressible moisture also confirmed the sensory findings. Soy-paste-containing patties had significantly ($P < 0.05$) higher overall acceptability scores than that of patties with soy granules, which was not different with that of control. This lower overall acceptability score of soy-granules-containing patties was due to unpleasant beany flavour. Singh *et al.* (2002) reported that addition of TSP significantly reduced acceptability of cooked samples 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.

Storage study

pH

Addition of soy paste and soy granules did not increase pH value compared with that of control (Table 6). Porcella *et al.* (2001) reported that addition of soy protein isolates (SPI) did not increase pH significantly compared with the control samples. There was a slight increase in pH of patties during refrigerated storage from 0 to 20 days. Lin & Chuang (1999) also found fairly stable pH values during refrigerated (4 °C) storage of sausages for 12 weeks.

Thiobarbituric acid reacting substances number

Patties added with soy paste had TBARS values almost similar to those of control samples (Table 6). But patties with soy granules on day 20 showed significantly ($P < 0.05$) lower TBARS values, which might be due to lower fat content in patties and antioxidative effect of soy granules. Some researchers have reported that soy addition to meat products can inhibit lipid oxidation (Ulu, 2004). Higher lipid oxidation in patties with soy paste than with soy granules might be due to increased fat content in patties, dilution of antioxidant properties with added water during grinding and higher unsaturated lipid present in the soy paste. Choudhury & Ledward (1988) reported that TBARS values of sausages containing heated black gram were higher possibly because of the unsaturated lipids in the flour rapidly oxidised during

Table 6 Effect of addition of soy paste and soy granules on physicochemical and microbial quality of goat meat patties during refrigerated storage (4 ± 1 °C)

Treatments	Storage period (days)				
	0	5	10	15	20
Physicochemical characteristics					
pH					
Control	6.43 ± 0.05	6.45 ± 0.05	6.47 ± 0.06	6.47 ± 0.06	6.45 ± 0.07
Soy paste	6.46 ± 0.05	6.49 ± 0.05	6.53 ± 0.06	6.51 ± 0.06	6.54 ± 0.06
Soy granules	6.45 ± 0.06	6.47 ± 0.04	6.48 ± 0.05	6.49 ± 0.06	6.51 ± 0.05
TBARS number (mg malonaldehyde per kg)					
Control	0.248 ± 0.02^{c}	0.267 ± 0.02^{c}	0.369 ± 0.03^{b}	0.413 ± 0.04^{b}	0.585 ± 0.04^{aA}
Soy paste	0.270 ± 0.05^{b}	0.289 ± 0.02^{b}	0.335 ± 0.05^{b}	0.395 ± 0.05^{b}	0.624 ± 0.06^{aA}
Soy granules	0.193 ± 0.03^{b}	0.220 ± 0.02^{b}	0.342 ± 0.05^{a}	0.385 ± 0.05^{a}	0.460 ± 0.06^{aB}
Free fatty acids (%)					
Control	0.093 ± 0.011^{b}	0.108 ± 0.011^{ab}	0.117 ± 0.008^{ab}	0.129 ± 0.007^{a}	0.137 ± 0.011^{a}
Soy paste	0.106 ± 0.002^{b}	0.117 ± 0.004^{ab}	0.121 ± 0.007^{ab}	0.132 ± 0.006^{a}	0.143 ± 0.013^{a}
Soy granules	0.107 ± 0.002^{b}	0.103 ± 0.007^{b}	0.114 ± 0.007^{ab}	0.128 ± 0.007^{a}	0.142 ± 0.010^{a}
Total volatile nitrogen (g kg^{-1})					
Control	0.135 ± 0.02^{b}	0.182 ± 0.03^{ab}	0.172 ± 0.02^{ab}	0.211 ± 0.02^{a}	0.216 ± 0.02^{a}
Soy paste	0.145 ± 0.01^{b}	0.179 ± 0.03^{ab}	0.174 ± 0.02^{ab}	0.219 ± 0.02^{a}	0.227 ± 0.02^{a}
Soy granules	0.154 ± 0.01^{b}	0.161 ± 0.01^{ab}	0.179 ± 0.02^{ab}	0.201 ± 0.02^{a}	0.210 ± 0.02^{a}
Microbiological characteristics					
Aerobic mesophiles counts (log10 CFU g^{-1})					
Control	2.38 ± 0.18^{c}	3.54 ± 0.16^{c}	3.87 ± 0.15^{b}	4.32 ± 0.23^{ab}	4.59 ± 0.19^{a}
Soy paste	3.52 ± 0.21^{b}	3.69 ± 0.19^{b}	4.26 ± 0.28^{ab}	4.53 ± 0.20^{a}	4.76 ± 0.26^{a}
Soy granules	3.33 ± 0.17^{c}	3.49 ± 0.10^{c}	3.97 ± 0.14^{b}	4.41 ± 0.13^{ab}	4.68 ± 0.21^{a}
Psychrotrophic counts (log10 CFU g^{-1})					
Control	ND	ND	2.34 ± 0.11^{b}	2.59 ± 0.12^{ab}	2.77 ± 0.08^{a}
Soy paste	ND	ND	2.48 ± 0.12^{b}	2.74 ± 0.13^{ab}	2.98 ± 0.14^{a}
Soy granules	ND	ND	2.43 ± 0.18^{b}	2.67 ± 0.18^{ab}	2.94 ± 0.10^{a}

ND, not detected; TBARS, thiobarbituric-acid-reacting substance. $n = 6$.
Values expressed as mean ± SE with different superscript letters row wise (lower case) and column wise (upper case) differ significantly ($P < 0.05$).

preparation and subsequent heating at 90 °C. TBARS values significantly ($P < 0.01$) increased during refrigerated storage period, reaching approximately 0.624 mg malonaldehyde (MDA) per kg sample, after 20 days. Porcella *et al.* (2001), Kumar & Sharma (2003) and Rajkumar *et al.* (2004) also reported a progressive increase in lipid oxidation during storage of chevon patties. In the case of control and patties with soy granules, up to 5 days whereas patties with soy paste up to 15 days, there was no significant increase in TBA values, after which it increased significantly and reached the highest value at day 20 of storage. According to Ockerman (1985), rancid flavour can be detected by sensory evaluation at a TBARS number above 1 mg MDA kg^{-1} sample. In this study, the TBARS numbers were well below 1 mg MDA kg^{-1} sample in all cases and no rancid flavour was detected by the panellists.

Free fatty acids

The FFA contents were comparable between control and treated patties (Table 6). Patties with soy paste had slightly higher FFA compared with others, because of hydrolysis of unsaturated oil/fats present in the soy paste. There was no significant change in FFA up to 10 days of storage in control and treated patties and after that it increased significantly ($P < 0.05$), which might have occurred because of lipolytic activities of microorganisms. Sahoo & Anjaneyulu (1997) reported similar trend of FFA during storage periods.

Total volatile nitrogen

Lean replacement with soy paste and granules had no significant effect on TVN content of meat patties. There was a gradual increase in TVN content of control and treated patties. The increase in TVN levels upon storage might be attributed to bacterial decomposition of tissue protein during storage and were well below the maximum limit prescribed for meat products (<0.9 g kg^{-1}) (Herborg & Nijaa, 1988).

Microbiological quality

Aerobic mesophilic count (AMC) and psychrotrophic counts of the patties were not influenced by the addition of soy proteins. In this study, fresh precooked patties had AMC counts of log 3.28, 3.52 and 3.33 CFU g^{-1} in control and treated patties, respectively (Table 6). The AMC counts were well within the limits of log 6.0 CFU g^{-1} prescribed for cooked meat products

(Shapton & Shapton, 1991). These counts were also comparable with the microbial loads (log 4.25) reported in goat meat products by Rajkumar *et al.* (2004). Psychrotrophs were not detected in control as well as treated groups on days 0 and 5 of storage. It could be due to sufficient heat treatment during cooking, which drastically injured the psychrophilic population in patties. It was detected on day 10 and thereafter showed a significant ($P < 0.01$) increase. However, these values were within the permissible limits of log 4.6 CFU g^{-1} as reported by Cremer & Chipley (1977) in cooked meat products. There was very rare occurrence of coliform counts during storage, indicating uniform and better sanitary measures adopted during processing of patties. Patties with soy paste had slightly higher microbial load compared with control. Higher pH and moisture content conducive for microbial growth are contributing factors for increased microbial load. Aerobic and psychrotrophic counts were not significant between control samples and soy-protein-added samples, similar to the conclusion of Liu *et al.* (1991) and Porcella *et al.* (2001).

Sensory attributes

Patties with soy paste were equally comparable with control patties in all sensory attributes except flavour and texture scores throughout the storage periods (Table 7). Patties with soy granules were rated significantly ($P < 0.01$) lower in flavour scores than control and patties with paste. This was mainly because of the beany flavour of soy granules identified by the panellists. These results suggested that flavour scores of patties with soy paste are comparable with control in refrigerated storage. In the case of control and soy paste patties, there was no significant change in flavour up to 15 days storage whereas after 10-day storage period, flavour scores significantly decreased in patties with soy granules. The progressive decrease in flavour scores could be correlated to an increase in TBARS numbers and FFA content of meat products (Tarladgis *et al.*, 1960). Patties with soy paste were higher in juiciness than that of control and soy granules patties, and significant ($P < 0.05$) difference between control and treated patties was found on 5, 10 and 20 days of storage period. This was due to higher moisture and fat content of patties with soy paste. Juiciness scores followed a decreasing trend with increasing storage periods, which could be due to loss of moisture from the product during storage. Patties added with soy paste had received lower sensory scores for texture than that of others. Texture of the patties also declined consistently with increase of storage period. Patties with soy paste were rated significantly ($P < 0.01$) higher for overall acceptability than that of patties with soy granules. The overall acceptability scores of patties remained almost unchanged up to day 10 of storage,

Table 7 Effect of addition of soy paste and soy granules on sensory attributes* of goat meat patties during refrigerated storage (4 ± 1 °C)

	Storage period (days)				
Treatments	**0**	**5**	**10**	**15**	**20**
Appearance					
Control	6.98 ± 0.09	6.92 ± 0.08	7.03 ± 0.03	6.88 ± 0.07	6.96 ± 0.04
Soy paste	7.05 ± 0.09	7.00 ± 0.07	7.06 ± 0.04	7.00 ± 0.05	6.95 ± 0.04
Soy granules	7.08 ± 0.08	6.92 ± 0.08	6.96 ± 0.09	6.97 ± 0.03	6.96 ± 0.04
Flavour					
Control	7.00 ± 0.09^{aA}	6.92 ± 0.08^{aA}	7.00 ± 0.05^{aA}	6.81 ± 0.08^{abA}	6.64 ± 0.11^{bA}
Soy paste	7.05 ± 0.07^{aA}	6.91 ± 0.07^{aA}	6.96 ± 0.03^{aA}	6.80 ± 0.06^{abA}	6.60 ± 0.08^{bA}
Soy granules	6.57 ± 0.10^{aB}	6.64 ± 0.10^{aB}	6.47 ± 0.42^{abB}	6.28 ± 0.08^{bB}	6.25 ± 0.11^{bB}
Juiciness					
Control	6.83 ± 0.10	6.81 ± 0.11^{AB}	6.72 ± 0.10^{AB}	6.61 ± 0.11	6.59 ± 0.10^{AB}
Soy paste	6.98 ± 0.07	6.97 ± 0.06^{A}	6.94 ± 0.07^{A}	6.82 ± 0.07	6.81 ± 0.09^{A}
Soy granules	6.73 ± 0.11	6.69 ± 0.11^{B}	6.69 ± 0.09^{B}	6.57 ± 0.13	6.47 ± 0.12^{B}
Texture					
Control	7.00 ± 0.10	6.86 ± 0.09^{AB}	6.97 ± 0.03	6.84 ± 0.10	6.93 ± 0.05^{AB}
Soy paste	6.80 ± 0.08	6.61 ± 0.09^{B}	6.75 ± 0.08	6.69 ± 0.09	6.71 ± 0.07^{A}
Soy granules	6.98 ± 0.09	6.92 ± 0.08^{A}	6.91 ± 0.09	6.92 ± 0.06	6.47 ± 0.08^{B}
Overall acceptability					
Control	6.95 ± 0.10^{aAB}	6.92 ± 0.06^{aA}	7.03 ± 0.06^{aA}	6.78 ± 0.08^{bA}	6.68 ± 0.09^{bA}
Soy paste	7.00 ± 0.08^{aA}	6.85 ± 0.08^{abAB}	6.94 ± 0.06^{abA}	6.81 ± 0.06^{bA}	6.67 ± 0.06^{bA}
Soy granules	6.75 ± 0.09^{aB}	6.61 ± 0.10^{abB}	6.59 ± 0.08^{abB}	6.37 ± 0.07^{bB}	6.36 ± 0.08^{bB}

Values expressed as mean ± SE with different superscript letters row wise (lower case) and column wise (upper case) differ significantly ($P < 0.05$).

*$n = 21$, sensory scores based on 8-point scale, where 1 = extremely poor; 8 = extremely desirable.

whereas it decreased significantly ($P < 0.01$) with progressive increase in storage. There was a gradual decline of different sensory quality parameters during refrigerated storage. From the results, it is concluded that the patties added with soy paste had shelf life of 20 days and comparable with the storage stability of control and patties with soy granules under refrigerated (4 ± 1 °C) storage.

Conclusion

From this study, it is concluded that FFSP prepared for use as a non-meat extender contributed significantly better flavour and overall acceptability than that of soy granules to the patties. The quality and shelf life (20 days) during refrigerated storage (4 ± 1 °C) was comparable with that of control and soy-granules-added patties. Hence, FFSP can be used in the formulation of emulsion-type meat products to produce them economically without impairment of palatability.

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