Development and comparison of shelf stable extended and dehydrated goat meat cubes containing four different legume based binder mixes

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Abstract A study was undertaken to develop shelf stable hot air oven dried goat meat cubes extended with different legume based binder mixes. Based on preliminary trials, four different formulations containing 80 % meat mince+10 % Bengal gram based binder mix (HBE), 70 % meat mince+20 % green gram based binder mix (HGR), 80 % meat mince+10 % black gram based binder mix (HBL) and 80 % meat mince+10 % lentil based binder mix (HLE) were selected and subjected to physico-chemical, microbiological and sensory characteristics. Among treatments, HGR showed a significantly higher pH (6.53 ± 0.01), whereas there was no significant difference in other physico-chemical parameters. Moisture content (10.37 ± 1.06 %) was highest in HLE, while protein (49.68 ± 1.78 %) and ash (8.71 ± 0.30 %) contents were higher in HBL. On texture profile analysis, hardness, gumminess and chewiness parameters were highest for HLE and lowest for HBL. In all treatments, total

plate, *Staphylococcus aureus* and yeast and mold counts were in acceptable range and coliforms were not detected. Scores for sensory attributes of rehydrated cubes were in good to very good range in all treatments, however, higher scores for appearance, flavour, texture, juiciness and overall acceptability were observed in HBL. The dehydrated cubes could be used to prepare curry within few minutes and is a boon to busy housewives.

Keywords Extended and dehydrated goat meat cubes · Legumes · Shelf stable · Quality characteristics

Introduction

India has a huge goat population of 126 million with an annual meat production of 0.47 MMT (FAO, 2009). Goat meat has a high demand in India and is well accepted without religious taboos and personal aestheticism. It is attractive to health conscious consumers due to its lower fat (McMillin and Brook 2005) and higher levels of desirable fatty acids and PUFA/SFA ratio (Banskalieva et al. 2000).

The demand for processed meat products in India is increasing due to the faster urbanization, improving living standards and changing life styles of the people. Like any other meat, goat meat can be used in the preparation of shelf stable products like dried meat products which are preserved by lowering the water activity. Dried meat and meat products are rich in protein and serve as nutrient dense foods especially to malnourished people in under developed, and developing countries.

Processed meat products often contain many non-meat ingredients that improve the yield, texture, palatability and protein content and reduce cost of production. Legumes can be used in extending dried meat products and are good sources of slow release carbohydrates and are rich in protein (Serdaroglu et al. 2005). Inclusion of legumes in daily diet has many physiological effects in controlling and preventing various metabolic

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diseases such as diabetes mellitus, coronary heart disease and colon cancer (Tharanathan and Mahadevamma 2003).

Dried meat products can be prepared by different methods. Conventional mechanical drying of food in cabinets involves convection followed by conduction of heat that diffuses in from food surface. These dryers are relatively easy to set and control the optimum process conditions. Even though many studies had been carried out in the area of dehydrated meat products, there are only a few works carried out on the development of extended and dehydrated meat products that could be rehydrated and used (Modi and Prakash 2008). Hence, a study was envisaged to develop dehydrated goat meat cubes extended with four different legume based mixes and dehydrated by hot air oven. This can be rehydrated and used as an adjunct in curries and requires only few minutes for preparation. Four formulations of dehydrated cubes developed were compared and evaluated based on physico-chemical, microbiological and sensory characteristics.

Materials and methods

The following materials were used for the experiments. Hind leg cuts from spent goats were obtained from experimental abattoir of Livestock Products Technology Division, IVRI or from local market. All bones, separable fat, fascia and connective tissue were trimmed off and meat was kept in refrigerator ($4\pm 1^\circ\text{C}$) overnight. Next day, meat was minced twice through 8.0 mm grinder plate in a meat mincer (Santos, France), packed in low density polyethylene (LDPE, 62.5 μm) bags, and frozen at -18 to -20°C till further use. Split dehulled gram like Bengal gram, green gram, black gram, lentil, texturized soy granules (Nutrela, Ruchi Soya Industries, M.P.), refined wheat flour, salt, refined soy bean oil (Fortune, Gujarat), mono sodium glutamate (Solar Sales, India), condiments like ginger and garlic were purchased from local market of Bareilly. Sodium tripolyphosphate (Central Drug House (P) Ltd, New Delhi) was also used in the product formulations. Spices were procured from local market of Bareilly and after removal of extraneous materials, were oven dried at $50\pm 1^\circ\text{C}$ temperature for four hours and ground mechanically in a domestic mixer (Lumix International, H.P., India) to make spice mix.

Preliminary trials

Preliminary trials were conducted to formulate the levels of goat meat mince and binder mixes in the preparation of extended and dehydrated goat meat cubes. Four legumes, Bengal gram, green gram, black gram and lentils and texturised soy protein at three levels were used in binder mix to develop dehydrated goat meat cubes of 15 different formulations. Meat was cooked with sodium tripolyphosphate (0.3 % of the weight of meat mince), with no added water in

a pressure cooker (after putting weight) for 30 min. The cooking was done on medium flame till two whistles and then kept on low flame for the remaining period. Legumes were soaked in water for 2 h, ground into a thick paste and was kept in an incubator (Scientific Equipment Works, Delhi) at 25°C for 5 h for natural fermentation. Texturised soy granules were soaked in boiling water for 5 min, washed in cold water twice and the excess water was squeezed out. Then it was ground to a paste in domestic mixer grinder at low speed for 1 min. Binder mix was prepared by mixing fermented legume/texturised soy granule paste, refined wheat flour, salt, spice mix, condiment paste and monosodium glutamate as per Table 1.

Cooked meat mince was chopped using a hand blender for 30 s; binder mix was added as per Table 1 and again blended for 1 min. The thick batter was taken in circular glass dishes (18 cm diameter X 3.5 cm high), steam cooked (without weight) for 40 min, and was cut into cubes of approximately 1.5X1.5X1.5 cm size. Drying was done at a temperature of 60°C for 18 h in a hot air oven.

Rehydration of cubes was done in water (1:3 v/v) by steaming in a pressure cooker (without weight) for 5 min. The rehydrated cubes were then simmered in onion-tomato gravy (Onion-tomato gravy was prepared by sautéing chopped onion and tomato in 1:1 proportion in refined soy bean oil for 3 min) for 1.5 min for sensory evaluation.

The results of sensory evaluation of preliminary trials are shown in Table 2. Based on these results, four formulations viz. 80 % goat meat mince+20 % Bengal gram based binder mix (HBE), 70 % goat meat mince+30 % green gram based binder mix (HGR), 80 % goat meat mince+20 % black gram based binder mix (HBL) and 80 % goat meat mince+20 % lentil based binder mix (HLE) were selected and used for preparation of extended and dehydrated goat meat cubes.

The four treatments of extended and dehydrated goat meat cubes, HBE, HGR, HBL and HLE were subjected to analysis for physico-chemical, microbiological and sensory analysis.

Analysis of physico-chemical characteristics

Product yield and dehydration ratio

Weight of the batter prepared and the weight of the meat cubes after drying were recorded to calculate the product yield and dehydration ratio as follows.

$$\text{Product yield} = \frac{\text{Weight of the dried cubes}}{\text{Weight of the batter}} \times 100$$

$$\text{Dehydration ratio} = \frac{\text{Weight of batter}}{\text{Weight of the dried cubes}}$$

Table 1 Formulations of extended and dehydrated goat meat cubes for preliminary trials

Sl. No	Ingredients (%)	70%M+ 30%BE	80%M+ 20%BE	90%M+ 10%BE	70%M+ 30%GR	80%M+ 20%GR	90%M+ 10%GR	70%M+ 30%SG	80%M+ 20%SG	90%M+ 10%SG	70%M+ 30%BL	80%M+ 20%BL	90%M+ 10%BL	70%M+ 30%LE	80%M+ 20%LE	90%M+ 10%LE
1.	Meat mince	70	80	90	70	80	90	70	80	90	70	80	90	70	80	90
2.	Binder mix	30	20	10	30	20	10	30	20	10	30	20	10	30	20	10
a.	Bengal gram	20	10	4												
b.	Green gram				20	10	4									
c.	Reconst. soy granule							20	10	4						
d.	Black gram										20	10	4			
e.	Lentil													20	10	4
f.	Refined wheat flour	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g.	Salt	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
h.	Spice mix	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
i.	Condiment paste	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

In addition, sodium tripolyphosphate, 0.3 % of meat mince and monosodium glutamate, 0.5 % of final product were added. M denotes goat meat mince, BE, GR, SG, BL and LE denote Bengal gram, green gram, reconstituted soy granule, black gram and lentil based binder mixes

Rehydration ratio

For determining rehydration ratio, weight of around 20 g of dried cubes was recorded and they were rehydrated in water (1:3 v/v) by steaming in a cooker (at atmospheric pressure) for 5 min. The rehydrated cubes were weighed after mopping the excess water on surface by tissue paper and calculation was done as follows.

$$\text{Rehydration ratio} = \frac{\text{Weight of rehydrated cubes}}{\text{Weight of dry cubes}}$$

pH

The pH was measured as per the procedure of AOAC (1995). Ten grams of sample (after grinding in the home mixer for 1 min) was blended with 50 ml of distilled water for 1 min using an Ultra Turrax tissue homogenizer (Model T25, Janke and Kenkel, IKA Labor Technik, Germany). The pH of the homogenate was recorded by immersing a combined glass electrode of a digital pH meter (Eutech Instruments, pH 510, Merck, Singapore).

Water holding capacity

Water holding capacity was measured as per the procedure of Wardlaw et al. (1973) with slight modifications. To 15 g of ground sample (ground in home mixer for 1 min) taken in a centrifuge tube (100 ml capacity), 50 ml of 0.6 M sodium chloride solution was added and the mixture was stirred for 1 min with a glass rod. The tube was then kept at refrigerator temperature (4 ± 1 °C) for 15 min, stirred for 1 min and then centrifuged at 1,500 g for 15 min. The supernatant was measured and water holding capacity (as ml of 0.6 M sodium chloride solution retained by 100 g of sample) was expressed in percentage.

Water activity

Water activity was measured with the help of a water activity meter (Hygrolab 3, Rotronics, Switzerland). Ground sample was taken in a sample container and placed inside sample holder of the water activity meter and reading was taken in 'quick mode' after the beep sound. It took approx. 5–6 min for single reading.

Texture profile analysis

Texture profile analysis of rehydrated and cooked meat cubes was done using the texturometer (TA-XT 2i/25, Texture Analyzer, Stable Microsystem Ltd, Surrey, England). Rehydrated cubes of approximately 1.5 cm³ size were used for testing. The test sample was placed on the platform fixture

Table 2 Sensory scores of extended and dehydrated goat meat cubes (after rehydration and cooking) prepared by using different levels of meat and different types of binder mixes (Mean $\pm$ SE)

Treatments	Attributes						
	Appearance (Dried)	Appearance (Cooked)	Flavour	Texture	Meat flavour intensity	Juiciness	Overall acceptability
70 %M+30 %BE	6.70 $\pm$ 0.10 ^b	6.97 $\pm$ 0.09 ^{bcd}	6.73 $\pm$ 0.10 ^{bcd}	6.75 $\pm$ 0.10 ^{cd}	6.69 $\pm$ 0.09 ^{bc}	6.68 $\pm$ 0.11	6.70 $\pm$ 0.11 ^{abcde}
80 %M+20 %BE HBE	6.63 $\pm$ 0.08 ^b	6.88 $\pm$ 0.09 ^{bcd}	6.80 $\pm$ 0.07 ^{bcd}	6.81 $\pm$ 0.10 ^d	6.73 $\pm$ 0.08 ^{bc}	6.85 $\pm$ 0.07	6.82 $\pm$ 0.07 ^{de}
90 %M+10 %BE	6.67 $\pm$ 0.10 ^b	6.74 $\pm$ 0.09 ^{abc}	6.81 $\pm$ 0.08 ^{bcd}	6.71 $\pm$ 0.08 ^{cd}	7.00 $\pm$ 0.09 ^e	6.80 $\pm$ 0.08	6.75 $\pm$ 0.07 ^{bcde}
70 %M+30 %GR HGR	6.54 $\pm$ 0.13 ^{ab}	6.74 $\pm$ 0.09 ^{abc}	6.83 $\pm$ 0.10 ^{bcd}	6.96 $\pm$ 0.09 ^d	6.79 $\pm$ 0.11 ^{bc}	6.85 $\pm$ 0.11	6.82 $\pm$ 0.12 ^{de}
80 %M+20 %GR	6.77 $\pm$ 0.12 ^b	6.83 $\pm$ 0.07 ^{bcd}	6.64 $\pm$ 0.08 ^{abc}	6.85 $\pm$ 0.09 ^d	6.67 $\pm$ 0.09 ^{abc}	6.56 $\pm$ 0.09	6.79 $\pm$ 0.07 ^{cde}
90 %M+10 %GR	6.30 $\pm$ 0.17 ^a	6.50 $\pm$ 0.12 ^a	6.62 $\pm$ 0.10 ^{abc}	6.73 $\pm$ 0.09 ^{cd}	6.80 $\pm$ 0.13 ^{bc}	6.52 $\pm$ 0.10	6.62 $\pm$ 0.10 ^{abcd}
70 %M+30 %SG	6.81 $\pm$ 0.12 ^b	7.00 $\pm$ 0.10 ^{cd}	6.86 $\pm$ 0.11 ^{cd}	6.34 $\pm$ 0.10 ^a	6.65 $\pm$ 0.15 ^{abc}	6.62 $\pm$ 0.16	6.63 $\pm$ 0.15 ^{abcd}
80 %M+20 %SG	6.71 $\pm$ 0.10 ^b	6.97 $\pm$ 0.08 ^{bcd}	6.71 $\pm$ 0.07 ^{abcd}	6.35 $\pm$ 0.10 ^a	6.71 $\pm$ 0.14 ^{bc}	6.72 $\pm$ 0.10	6.58 $\pm$ 0.10 ^{abcd}
90 %M+10 %SG	6.57 $\pm$ 0.10 ^{ab}	6.88 $\pm$ 0.09 ^{bcd}	6.66 $\pm$ 0.11 ^{abcd}	6.39 $\pm$ 0.10 ^{ab}	6.74 $\pm$ 0.12 ^{bc}	6.68 $\pm$ 0.11	6.47 $\pm$ 0.07 ^{ab}
70 %M+30 %BL	6.73 $\pm$ 0.09 ^b	6.84 $\pm$ 0.07 ^{bcd}	6.52 $\pm$ 0.15 ^{ab}	6.41 $\pm$ 0.15 ^{ab}	6.32 $\pm$ 0.13 ^a	6.50 $\pm$ 0.13	6.50 $\pm$ 0.12 ^{abc}
80 %M+20 %BL HBL	6.70 $\pm$ 0.07 ^b	7.04 $\pm$ 0.06 ^d	6.98 $\pm$ 0.09 ^d	6.87 $\pm$ 0.09 ^d	6.77 $\pm$ 0.11 ^{bc}	6.86 $\pm$ 0.09	6.95 $\pm$ 0.07 ^e
90 %M+10 %BL	6.74 $\pm$ 0.10 ^b	6.88 $\pm$ 0.06 ^{bcd}	6.85 $\pm$ 0.11 ^{bcd}	6.65 $\pm$ 0.10 ^{bcd}	6.95 $\pm$ 0.10 ^{bc}	6.67 $\pm$ 0.09	6.40 $\pm$ 0.07 ^a
70 %M+30 %LE	6.56 $\pm$ 0.09 ^{ab}	6.84 $\pm$ 0.08 ^{bcd}	6.82 $\pm$ 0.10 ^{bcd}	6.78 $\pm$ 0.09 ^d	6.57 $\pm$ 0.11 ^{ab}	6.75 $\pm$ 0.10	6.50 $\pm$ 0.10 ^{abc}
80 %M+20 %LE HLE	6.49 $\pm$ 0.09 ^{ab}	6.88 $\pm$ 0.09 ^{bcd}	6.78 $\pm$ 0.07 ^{bcd}	6.80 $\pm$ 0.08 ^d	6.82 $\pm$ 0.12 ^{bc}	6.84 $\pm$ 0.07	6.88 $\pm$ 0.10 ^{de}
90 %M+10 %LE	6.48 $\pm$ 0.06 ^{ab}	6.71 $\pm$ 0.07 ^{ab}	6.40 $\pm$ 0.10 ^a	6.45 $\pm$ 0.10 ^{abc}	6.66 $\pm$ 0.11 ^{abc}	6.54 $\pm$ 0.10	6.43 $\pm$ 0.07 ^a

Mean with different superscripts (column-wise) differ significantly ($p < 0.05$). Values are means and standard errors of six readings (Mean $\pm$ SE). Score on 8 point descriptive scale 8=excellent 1=extremely poor. *M* Goat meat mince, *BE* Bengal gram based binder mix, *GR* Green gram based binder mix, *SG* reconstituted soy granule based binder mix, *BL* Black gram based binder mix, *LE* Lentil based binder mix

and compressed to 80 % of their original height at a cross head speed of 2 mm per sec through two-cycle sequence, using 50 kg load cell and 75 mm compression platen probe (P75). Average of six readings was taken for each sample. The TPA parameters computed were: hardness (N/cm²), adhesiveness (Ns), springiness (cm), cohesiveness, gumminess (N/cm²), chewiness (N/cm) and resilience.

Lovibond Tintometer Colour Units

The colour of the meat cubes was measured using a Lovibond Tintometer (Model F, Greenwich, UK). Samples were ground for 1 min in the home mixer, taken in the sample holder and secured against the viewing aperture. The sample colour was matched by adjusting the red (a) and yellow (b) units, while keeping the blue unit fixed at 0.1. The corresponding colour units were recorded. The hue and chroma values were determined by using the formulae, $(\tan^{-1}) b/a$ (Little, 1975) and $(a^2 + b^2)^{1/2}$ (Froehlich et al., 1983), where a=red unit, b=yellow unit.

Proximate analysis

Moisture, protein, fat and ash contents of dried cubes were determined by procedures prescribed by AOAC (1995).

Analysis of microbiological parameters

Microbiological parameters like total plate count, coliform count, *Staphylococcus aureus* count, yeast and mold count were assessed as per the procedure of APHA (2001).

Analysis of sensory attributes

Sensory evaluation of rehydrated and cooked goat meat cubes was conducted using an eight point descriptive scale (Keeton 1983) with slight modifications, where 8=excellent and 1=extremely poor. The sensory panellists consisted of scientists and postgraduate students of Division of Livestock Products Technology.

Statistical analysis

Each experiment was replicated thrice and data obtained were analysed by one way- ANOVA technique as per the standard statistical methods (Snedecor and Cochran 1995) using Statistical Package for the Social Sciences (SPSS) and interpreted. Level of significance was 5 %.

Results and discussion

Mean $\pm$ SE values of the sensory attributes of extended and dehydrated goat meat cubes prepared by using different levels of

Table 3 Comparison of physico-chemical characteristics and proximate composition of extended and dehydrated goat meat cubes

Parameters	Treatments			
	HBE	HGR	HBL	HLE
Yield (%)	36.92±1.00	37.69±1.20	37.66±2.36	38.30±1.52
Dehydration ratio	2.71:1±0.07	2.66:1±0.09	2.68:1±0.17	2.62:1±0.10
Rehydration ratio	1.97:1±0.04	1.90:1±0.10	1.92:1±0.09	1.92:1±0.07
pH	6.44±0.01 ^a	6.53±0.01 ^b	6.45±0.02 ^a	6.43±0.02 ^a
Water holding capacity (%)	188.89±6.97	193.34±6.15	190.00±4.39	188.89±3.62
Water activity	0.59±0.01	0.59±0.01	0.58±0.00	0.60±0.01
Moisture (%)	9.12±0.57	9.02±0.90	8.83±0.35	10.37±1.06
Protein (%)	44.91±0.44 ^b	40.09±0.76 ^a	49.68±1.78 ^c	39.54±1.65 ^a
Fat (%)	8.86±0.56 ^b	7.03±0.37 ^a	8.49±0.08 ^b	6.29±0.37 ^a
Ash (%)	7.72±0.40 ^a	7.71±0.15 ^a	8.71±0.30 ^b	8.66±0.14 ^b

Values are means and standard errors of six readings (Mean ± SE)

Mean with different superscripts (row-wise) differ significantly ($p<0.05$)

HBE-80 %M+20 %BE dried in hot air oven, HGR-70 %M+30 %GR dried in hot air oven, HBL-80 %M+20 %BL dried in hot air oven and HLE-80 %M+20 %LE dried in hot air oven

goat meat and binder mixes are presented in Table 2. Based on these results, 80 %M+20 %BE, 70 %M+30 %GR, 80 %M+20 %BL and 80 %M+20 %LE were selected for further studies, since they had higher scores for most sensory attributes.

Mean ± SE values of yield, dehydration ratio, rehydration ratio, pH, water holding capacity and water activity of the four selected formulations are presented in Table 3. Yield of shelf stable extended and dehydrated goat meat cubes ranged between 36.92±1.00 % for HBE and 38.30±1.52 % for HLE and dehydration ratio varied from 2.62:1±0.10 in HLE to 2.71:1±0.07 in HBE. HLE had the highest yield and the lowest

dehydration ratio among the four formulations; however the difference was not significant. The higher yield and lower dehydration ratio of HLE might be due to the lower moisture loss from the product during the drying process. This agreed with the results of Serdaroglu et al. (2005) who observed that black eye bean and lentil flours bound water to meatballs much more strongly than chick pea/Bengal gram flour and rusk. Rehydration ratios ranged from a 1.90:1±0.10 in HGR to 1.97:1±0.04 in HBE, the values falling in the range reported by Uprit and Mishra (2003) for microwave convective dried soy-fortified paneer. The rehydration of the product increased

Table 4 Comparison of texture profile and colour parameters of extended and dehydrated goat meat cubes

Parameter	Treatments			
	HBE	HGR	HBL	HLE
Hardness (N/cm ²)	1335.76±27.98 ^{ab}	1270.23±92.47 ^a	1215.88±43.40 ^a	1562.18±129.10 ^b
Adhesiveness (Ns)	-17.17±0.56 ^b	-7.28±1.07 ^a	-20.32±0.94 ^c	-15.64±1.01 ^b
Springiness (cm)	0.47±0.03	0.56±0.01	0.46±0.02	0.51±0.04
Cohesiveness (Ratio)	0.20±0.01	0.20±0.01	0.20±0.01	0.20±0.00
Gumminess (N/cm ²)	260.38±14.45	298.96±12.45	258.44±9.97	304.05±31.10
Chewiness (N/cm)	119.84±3.46 ^a	166.17±7.23 ^b	119.58±6.85 ^a	172.63±17.53 ^b
Resilience (Ratio)	0.08±0.00 ^a	0.10±0.01 ^b	0.08±0.00 ^a	0.07±0.00 ^a
Redness	1.48±0.17	1.25±0.02	1.32±0.09	1.25±0.06
Yellowness	2.17±0.17	2.50±0.22	2.23±0.16	2.52±0.23
Hue	55.93±2.36	60.86±2.39	63.93±0.66	62.88±2.63
Chroma	2.64±0.21	2.81±0.19	2.60±0.15	2.82±0.20

Values are means and standard errors of six readings (Mean ± SE)

Mean with different superscripts (row-wise) differ significantly ($p<0.05$)

HBE-80 %M+20 %BE dried in hot air oven, HGR-70 %M+30 %GR dried in hot air oven, HBL-80 %M+20 %BL dried in hot air oven and HLE-80 %M+20 %LE dried in hot air oven

Table 5 Comparison of microbiological qualities of extended and dehydrated goat meat cubes

Parameters	Treatments			
	HBE	HGR	HBL	HLE
Total plate count (log cfu/g)	3.61±0.04 ^a	4.56±0.14 ^c	3.64±0.06 ^a	3.98±0.05 ^b
<i>Staphylococcus aureus</i> count (log cfu/g)	2.49±0.03 ^c	2.63±0.05 ^c	2.09±0.06 ^a	2.31±0.05 ^b
Coliform count (log cfu/g)	ND	ND	ND	ND
Yeast and mould count (log cfu/g)	1.93±0.08 ^a	2.18±0.08 ^b	1.80±0.06 ^a	1.85±0.07 ^a

Values are means and standard errors of six readings (Mean±SE)

Mean with different superscripts (row-wise) differ significantly ($p<0.05$)

HBE - 80 %M+20 %BE dried in hot air oven, HGR - 70 %M+30 %GR dried in hot air oven, HBL - 80 %M+20 %BL dried in hot air oven, HLE - 80 %M+20 %LE dried in hot air oven and ND - not detected

to a certain extent with increase in dehydration ratio and it was in agreement with the results of Uprit and Mishra (2003). Water absorption capacity of dehydrated products depends on processing conditions, sample composition and extent of structural and chemical disruptions induced by drying (Vadivambal and Jayas 2007) and content of polar amino acids and other polar groups present in the product (Kuntz 1971).

ANOVA showed a significant difference ($p<0.01$) in pH among treatments. pH of HGR (6.53±0.01) was significantly higher ($p<0.01$) than those of other treatments and might probably be due to the lower level of meat in it when compared to other treatments. This was in agreement with the results of Singh et al. (2002) who observed that the pH of chicken snack was inversely related to the level of meat. The higher pH of HGR might probably have resulted in higher water holding capacity (193.34±6.15 %), but the value was not significantly different from those of HBE, HBL and HLE. These results were in agreement with those of Rahman et al. (2005) who observed an increase in expressed juice from dried meat with lowering of pH when goat *L.dorsi* muscle was dried by different methods. Water activity values ranged from a minimum of 0.58±0.00 in HBL to a maximum of 0.60±0.01 in HLE even though there was no significant difference among treatments. The higher water activity of HLE was reflected in the higher moisture content also.

Proximate analysis of the four treatments was done and moisture, protein, fat and ash contents were assessed. Mean ± SE values of moisture, protein, fat and ash contents are also presented in Table 3.

ANOVA did not show a significant difference in the moisture content between treatments. Moisture content was highest for HLE (10.37±1.06 %) and lowest for HBL (8.83±0.35 %), which also had the lowest water activity. The results were in agreement with that of Thomas et al. (2008), who observed a lowered water activity with lowering of moisture content. According to Lewicki (2004) and Rahman and Labuza (2007), lowering of water content resulted in lowered water activity, but both were not directly proportional. Protein, fat and ash contents showed significant difference ($p<0.01$) among the four treatments. Protein content was highest for

HBL (49.68±1.78 %) and least for HLE (39.54±1.65 %). This might probably be due to the higher protein content of black gram (25 %) than lentil (24 %) and Bengal gram/chick pea (19 %) as reported by Sosulski and Sosulski (2006). The higher moisture content in HLE might also have resulted in relatively lower protein content. Fat content was highest for HBE (8.86±0.56 %) and lowest for HLE (6.29±0.37 %). This might be due to the higher lipid level of 6 % in Bengal gram and a lower lipid level of 1 % in green and black grams and lentils as reported by Sosulski and Sosulski (2006). Ash content values ranged from 7.71±0.15 % in HGR to 8.71±0.30 % in HBL.

Texture profile analysis of the rehydrated and cooked goat meat cubes was carried out and following parameters viz. hardness, adhesiveness, springiness, cohesiveness, gumminess, chewiness and resilience were assessed. Mean ± SE values of the above attributes are presented in Table 4. ANOVA showed a significant difference ($p<0.05$) in the hardness among treatments. Values for hardness ranged from 1215.88±43.40 N/cm² in HBL to 1562.18±129.10 N/cm² in HLE. This is contrary to the findings of Serdaroglu et al.

Table 6 Comparison of sensory attributes of extended and dehydrated goat meat cubes (after rehydration and cooking) (Mean±SE)

Attributes	Treatments			
	HBE	HGR	HBL	HLE
Appearance (Dried)	6.55±0.14	6.67±0.11	6.86±0.12	6.55±0.16
Appearance (Cooked)	6.99±0.07	6.85±0.07	6.92±0.06	6.86±0.08
Flavour	6.70±0.13	6.62±0.13	6.91±0.05	6.77±0.10
Texture	6.63±0.14	6.70±0.12	6.77±0.10	6.66±0.13
Meat flavour intensity	6.71±0.14	6.65±0.10	6.72±0.11	6.73±0.11
Juiciness	6.69±0.11	6.48±0.10	6.74±0.12	6.68±0.11
Overall acceptability	6.68±0.14	6.60±0.09	6.84±0.11	6.77±0.12

Values are means and standard errors of six readings (Mean ± SE)

Mean with different superscripts (row-wise) differ significantly ($p<0.05$)

HBE - 80 %M+20 %BE dried in hot air oven, HGR - 70 %M+30 %GR dried in hot air oven, HBL - 80 %M+20 %BL dried in hot air oven and HLE - 80 %M+20 %LE dried in hot air oven

(2005) who reported a higher penetration value (softer texture) for meatballs with lentil flour as binder when compared to meatballs with chick pea/Bengal gram and black eye bean flours as binders. Adhesiveness was significantly higher ($p<0.01$) for HBL ($-20.32\pm0.94\text{Ns}$) than those of other treatments, the least adhesiveness being for HGR ($-7.28\pm1.07\text{Ns}$). Springiness, cohesiveness and gumminess values did not show a significant difference among treatments. ANOVA showed a significant difference ($p<0.01$) in chewiness among treatments. Gumminess and chewiness parameters were highest for HLE and lowest for HBL. These parameters are mostly dependent on hardness and the higher hardness might have resulted in higher gumminess and chewiness in HLE. These findings are in agreement with those of Thomas et al. (2008) who observed a direct correlation between gumminess and chewiness with hardness in hurdle treated sausages. Resilience values ranged from 0.07 ± 0.00 in HLE to 0.10 ± 0.01 in HGR and the difference was significant ($p<0.05$).

Colour parameters like redness and yellowness were measured and hue and chroma values were calculated. Mean $\pm$ SE values of the above parameters are also presented in Table 4. There was no significant difference in the redness, yellowness, hue and chroma values among the treatments.

Microbiological parameters like total plate count, *Staphylococcus aureus*, coliform, yeast and mould counts were evaluated. Mean $\pm$ SE values of the above counts are presented in Table 5. Total plate count (log cfu/g) ranged from 3.61 ± 0.04 in HBE to 4.56 ± 0.14 in HGR and the difference was significant ($p<0.01$). Significant difference ($p<0.01$) was observed in the *Staphylococcus aureus* count of HBL (2.09 ± 0.06) and HGR (2.63 ± 0.05). The lowest yeast and mold count (log cfu/g) was in HBL (1.80 ± 0.06) and highest in HGR (2.18 ± 0.08) and the difference was significant ($p<0.01$). The total plate counts obtained for the treatments were slightly higher, but the yeast and mold counts were lower than the values reported by Das and Jayaraman (2003) in dehydrated chicken *pulav*. Results of *Staphylococcus aureus* counts obtained in the study were in agreement with the results reported by the above authors. Nevertheless, the counts obtained were well below the values reported by Modi et al. (2007) in dehydrated chicken *kebab* mix. Coliforms were not detected in any of the samples. This is in accordance with the results of Modi et al. (2007) who also had reported absence of coliforms in dehydrated chicken *kebab* mix.

There was no significant difference in the scores of appearance of dried and cooked cubes, flavour, texture, meat flavour intensity, juiciness and overall acceptability among the treatments (Table 6). However, higher scores for appearance of dried cubes, flavour, texture, juiciness and overall acceptability were observed in HBL. The higher texture score of HBL might probably be due to the lower hardness value as evaluated by texture profile analysis. The difference in hardness might be due to the different binder mixes as

reported by Modi and Prakash (2008) in extended and dehydrated meat cubes. The marginally lower meat flavour intensity score for HGR might probably be due to lower level of meat in it. This is in accordance with the findings of Sharma and Nanda (2002) who had reported an increasing intensity of meat flavour in chicken chips with increase in level of meat. The lowest rehydration ratio of HGR might have contributed to the lowest juiciness score of the product. Differences in juiciness scores might also be due to the binder mixes present in the product as reported by Modi et al. (2007) in chicken *kebabs* prepared from dehydrated mix and Modi and Prakash (2008) in extended and dehydrated meat cubes on rehydration. Overall acceptability scores were not significantly different among the treatments, however, HBL had the highest score (6.84 ± 0.11) and HGR, the lowest (6.60 ± 0.10).

Conclusion

Dehydrated goat meat cubes containing four different legume based binder mixes were successfully prepared by drying in a hot air oven. The water activity of all four treatments was around 0.60 and hence shelf stable. Proximate analysis revealed that all the four treatments had high protein contents, with 80 % meat mince+10 % black gram based binder mix (HBL) showing the highest protein and ash contents. Rehydrated cubes scored 'good' to 'very good' for all attributes in all the four treatments during sensory evaluation. However, the highest flavour, texture, juiciness and overall acceptability scores were reported for HBL. Dried cubes extended with legume based binder mixes as a curried adjunct can add convenience and variety for busy housewives and to meat processors for effective utilization of tough goat meat.

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