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Comparison of hot air oven dried and microwave dried extended and dehydrated goat meat cubes

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Abstract

A study was conducted to compare two methods of drying of shelf stable extended and dehydrated goat meat cubes. The formulation of the cubes was standardized after preliminary trials. The meat cubes contained 80% minced, cooked goat meat and 20% black gram based binder mix. The cubes were dried by two methods: hot air oven (HBL) and microwave (MBL) and compared them based on physicochemical, microbiological and sensory characteristics. There was no significant difference in yield, water holding capacity, dehydration and rehydration ratios between the two methods. pH of HBL was significantly higher than that of MBL. Water activity of HBL was significantly higher than that of MBL and this was reflected in the comparatively higher moisture content of HBL. HBL had significantly higher fat content than MBL. All texture parameters except adhesiveness were significantly higher for MBL than HBL. Redness value was significantly higher in MBL than in HBL. Microbial quality of MBL was significantly higher than that of HBL. All sensory attributes were higher in HBL than MBL with significant difference in flavour and overall acceptability. Microwave drying was found to cause an uncontrolled drying with development of burnt flavours which resulted in lower sensory scores and reduced acceptability than HBL.

Keywords: Goat meat; oven drying; microwave; characteristics; acceptability

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Introduction

The demand for processed meat products in India is increasing due to the rapid urbanization, improving living standards and changing life styles of the people. Goat meat (*Chevon*) is well accepted in India and other South Asian countries and is in high demand without any religious taboos and personal aestheticism. The annual goat meat production of India was pegged at 0.597 million metric tonnes (FAO, 2011).

Chevon commands premium price in Indian market. Market segmentation for *Chevon* products is indistinct with predominant mode of consumption being hot meat purchased from neighbourhood butcher shops/ meat stalls. The value addition of meat is practically absent. The hygienic aspects of marketing are primitive; making further cleaning and preparation of meat difficult at home. The rapidly increasing double income households with working women are no longer able to afford such long time involved in purchasing and preparing meat products. This is reflected in long queues for dinner at restaurants on weekend days especially, in big cities.

Value addition is an important aspect of meat processing industry where in market segmentation for different products ensures convenience, variety and

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hygiene for consumers and better profits for the industry. Among different value added products, extended and dehydrated products can play an important role in developing countries of tropical region. The advantages of dried products are shelf stability, less storage space, ease of transport and most importantly, convenience. Specialized goat meat production on the lines of broiler industry is almost nil in India. Goat meat available is mostly from spent animals and hence the meat is tough; and reducing the meat particle size may enhance the textural characteristics especially, for children and elderly people. Dried meat products incorporated with non-meat ingredients are called as extended and dehydrated meat products. These nutrient dense foods rich in proteins could help to make *Chevon* more affordable to poor people and thus helps to combat malnutrition in developing countries.

Even though many studies have been conducted on the development of extended and dehydrated meat products like chips, snacks etc. (Sharma and Nanda, 2002; Singh et al., 2011), there are only a few works carried out on the development of such meat products that can be rehydrated and used (Modi and Prakash, 2008).

Inclusion of legumes in daily diet has many physiological effects in controlling and preventing various metabolic diseases such as diabetes mellitus, coronary heart disease and colon cancer (Tharanathan and Mahadevamma, 2003). A diet including legumes is found to be associated with reduced levels of clinical and biological markers linked to metabolic syndrome (Grains and Legumes Nutrition Council, 2013). Incorporating fermented legumes in meat products can not only improve nutritional status of the products but can also enhance the binding and palatability characteristics. Black gram is a good source of protein, essential amino acids, essential fatty acids, minerals and vitamins like niacin and ascorbic acid (Soris et al., 2010) and is widely used in various food products in India. However, use of fermented black gram paste in a shelf stable comminuted goat meat product has not been reported.

Hot air convection drying and microwave drying are two among the varied and numerous drying techniques. Hot air convection drying is a conventional technique where in drying is achieved by circulating hot air in closed cabinets. In this, heat is transferred from hot air to solid surface (Lewicki, 2004; Ratti, 2001) which is then transferred from the surface to the inside by conduction and here, shrinkage is excessive, around 80% (Ratti, 2001). Microwave drying is a faster method in which the main feature is volumetric heating wherein the microwave energy is absorbed by the food material and is directly and internally converted into heat. Microwave heating demonstrates significant advantages over conventional methods in reducing process time and improving food quality (Dar et al., 2010). Vadivambal and Jayas (2007) stated that this drying resulted in a higher thermal efficiency, shorter drying time and improved product quality when compared to hot air drying.

Microwave drying has been attempted in many products like fruits (Drouzas and Schubert, 1996), tomatoes (Durance and Wang, 2002), garlic (Cui et al., 2003), button mushrooms (Giri and Prasad, 2006), *Tilapia* fish fillets (Duan et al., 2011) etc., but studies in meat are very few (Matashige and Akahoshi, 2002). Hence, the present investigation was carried out with the objective of comparing the quality attributes of extended goat meat cubes dehydrated by microwave drying with those dehydrated by hot air convection drying.

Materials and Methods

Hind leg cuts from spent/adult goat were obtained from local market of Bareilly (Uttar Pradesh, India); deboned and all separable fat, fascia and connective tissue were trimmed off and meat was kept in refrigerator (4±1°C) overnight. Meat was minced twice through 8.0 mm plate in a meat mincer (Santos, France) and was cooked with sodium tri polyphosphate in a pressure cooker (after putting weight) for 30 min. Black gram (decorticated) was soaked in water for 2 h, ground into a thick paste and was allowed to naturally ferment in an incubator (Scientific Equipment Works, Delhi) at 25°C for 5 h. Refined wheat flour, salt, spice mix, condiment paste and monosodium glutamate were added to fermented black gram paste and the binder mix was prepared as per Table 1. The binder mix was added to the cooked meat mince and blended using a hand blender for 1 min. The thick batter was taken in circular glass dish (18 cm diameter × 3.5 cm high), steam cooked (in a domestic pressure cooker without weight) for 40 min, and was cut into cubes of approximately 1.5×1.5×1.5 cm size. The cubes were divided into two portions, one portion was dried at a temperature of 60°C for 18 h in a hot air convection oven (HBL) and the other portion was dried in a microwave oven at 540 W for 20 minutes (MBL). HBL and MBL were subjected to analysis for physicochemical, microbiological and sensory characteristics.

Analysis of physicochemical 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.

Product yield = Weight of the dried cubes/Weight of the batter × 100

Dehydration ratio = Weight of batter/Weight of the dried cubes

Rehydration ratio

For determining rehydration ratio, weight of around 20 g dried cubes was recorded and they were rehydrated in water (1:3 v/v) by steaming (in a domestic pressure cooker without weight) for 5 min. The rehydrated cubes were weighed after mopping the excess water on surface by tissue paper and calculation was done as follows.

Rehydration ratio = Weight of rehydrated cubes/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 0.6M 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 1500 g for 15 min. The supernatant was measured and water holding capacity (as ml of 0.6 M sodium chloride solution retained by 100g 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 approximately 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, Surray, England). Rehydrated cubes of approximately 1.5 cm cubic size were used for testing. The test sample was placed on the platform fixture 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/cm^2), adhesiveness (Ns), springiness (cm), cohesiveness, gumminess (N/cm^2), 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 repeated thrice and data obtained were analysed by paired t-test technique as per the standard statistical methods (Snedecor and Cochran, 1995) using Statistical Package for the Social Sciences (SPSS) and interpreted.

Results

Physicochemical characteristics of HBL and MBL

The results of comparison of physicochemical characteristics of HBL and MBL are given in Table 2. The yields, dehydration and rehydration ratio of both samples did not differ significantly. pH of HBL was significantly high ($P<0.01$) from MBL, however, there was no significant difference in water holding capacity.

Water activity was significantly high (P<0.01) in HBL than MBL. HBL had significantly higher (P<0.01) fat content than MBL. Regarding ash and protein contents there was no significant difference between the two treatments.

Texture and colour parameters of HBL and MBL

The results of comparing texture and colour parameters of hot air oven dried and microwave dried meat cubes are given in Table 3. Significantly higher values for hardness, springiness, cohesiveness, gumminess, chewiness and resilience were observed in MBL when compared to HBL. Among colour parameters, redness value of MBL was significantly high (P<0.01) compared to HBL. No significant difference was noticed in the yellowness value. Hue value was significantly higher (P<0.01) for HBL than MBL. There was no significant difference in the chroma values of the two groups.

Microbiological characteristics of HBL and MBL

The results of comparing microbiological characteristics of hot air oven dried and microwave dried meat cubes are given in Table 4. There was significant difference between HBL and MBL with respect to total viable count and *Staphylococcus aureus* count; however, there was no significant difference in the yeast and mold counts between the two treatments.

Sensory attributes of HBL and MBL

Sensory attributes of HBL and MBL are compared in Table 5. Significantly higher scores for flavour (P<0.01) and overall acceptability (P<0.05) were observed for HBL in comparison to MBL. There was no significant difference in any other sensory attribute.

Discussion

The lower yield of MBL was reflected in its higher dehydration ratio on comparison to HBL, but the difference was not significant. Although rehydration ratio of MBL was higher than that of HBL, the difference was not significant. This is in agreement with Uprit and Mishra (2003) who observed an increase in rehydration of microwave dried soy fortified paneer with increase in dehydration ratio. Duan et al. (2011) observed an increased rehydration of *Tilapia* fish fillets, when higher microwave power was used and attributed it to the outward flux of vapour that prevented collapse of tissue structure. pH of HBL was significantly higher (P<0.01) than that of MBL. Rahman et al. (2005) also observed a higher pH for air-dried goat meat when compared to that of sun/vacuum/freeze-dried samples and attributed it to the loss of acidic groups due to different drying procedures. MBL had slightly higher

Table 1: Formulation of extended and dehydrated goat meat cubes

Sr. No	Ingredient	Level (%)
1	Meat Mince	80
2	Black gram (Decorticated)	10
3	Refined wheat flour	4
4	Salt	2
5	Spice mix	1.5
6	Condiment paste	2.5

In addition, sodium tri polyphosphate at the level of 0.3% of meat mince and monosodium glutamate at the level of 0.5% of the final product were added.

Table 2: Comparison of physico-chemical characteristics and proximate principles of extended and dehydrated goat meat cubes prepared by hot air convection drying and microwave drying (HBL and MBL).

Parameters	Treatments		t value
	Hot air oven (HBL)	Microwave oven (MBL)	
	Mean±SE	Mean±SE	
Yield (%)	37.66±2.36	34.81±1.71	1.556
Dehydration ratio	2.68±0.17	2.89±0.14	1.450
Rehydration ratio	1.92±0.09	1.94±0.10	1.41
pH	6.45±0.02	6.15±0.01	17.741**
Water holding capacity (%)	190.0±4.39	195.56±3.72	0.889
Water activity	0.58±0.00	0.55±0.00	17.801**
Moisture (%)	8.83±0.35	8.10±0.12	1.978
Protein (%)	49.68±1.78	49.86±0.63	0.095
Fat (%)	8.49±0.08	5.45±0.43	7.382**
Ash (%)	8.71±0.30	8.48±0.21	0.530

*Significant P<0.05; **Highly significant P<0.01; HBL- Extended and dehydrated goat meat cubes dried in hot air convection oven. MBL- Extended and dehydrated goat meat cubes dried in microwave oven.

Table 3: Comparison of texture and colour parameters of extended and dehydrated goat meat cubes prepared by hot air convection drying and microwave drying (HBL and MBL).

Parameters	df	Treatments		t value
		Hot air oven (HBL)	Microwave oven (MBL)	
		Mean±SE	Mean±SE	
Hardness (N/cm^2)	5	1215.88±43.40	1567.80±7.96	7.777**
Adhesiveness (Ns)	5	-20.32±0.94	-4.62±0.22	14.997**
Springiness (cm)	5	0.46±0.02	0.70±0.04	4.404**
Cohesiveness(Ratio)	5	0.21±0.01	0.28±0.02	3.366*
Gumminess (N/cm^2)	5	258.44±9.97	444.51±24.50	5.846**
Chewiness (N/cm)	5	119.58±6.85	349.19±17.15	10.847**
Resilience (Ratio)	5	0.08±0.00	0.11±0.01	2.966*
Redness	5	1.32±0.09	2.27±0.08	5.911**
Yellowness	5	2.23±0.16	2.12±0.05	0.630
Hue	5	63.93±0.66	43.09±1.16	15.617**
Chroma	5	2.60±0.15	2.99±0.07	2.131

*Significant P<0.05; **Highly significant P<0.01; HBL- Extended and dehydrated goat meat cubes dried in hot air convection oven. MBL- Extended and dehydrated goat meat cubes dried in microwave oven.

Table 4: Comparison of microbiological parameters of extended and dehydrated goat meat cubes prepared by hot air convection drying and microwave drying (HBL and MBL).

Parameters	Treatments		t value
	Hot air oven (HBL)	Microwave oven (MBL)	
	Mean±SE	Mean±SE	
Total plate count (log cfu/g)	3.64±0.06	1.45±0.14	18.771**
Staphylococcus aureus (log cfu/g)	2.09±0.06	ND	37.427**
Yeast and mold count (log cfu/g)	1.80±0.06	1.46±0.13	2.417

** Highly significant P<0.01; HBL- Extended and dehydrated goat meat cubes dried in hot air convection oven. MBL- Extended and dehydrated goat meat cubes dried in microwave oven

Table 5: Comparison of sensory attributes of extended and dehydrated goat meat cubes prepared by hot air convection drying and microwave drying (HBL and MBL)

Attributes	Treatments		t value
	Hot air oven (HBL)	Microwave oven (MBL)	
	Mean±SE	Mean±SE	
Appearance (Dried)	6.92±0.08	6.81±0.10	0.993
Appearance (Cooked)	6.90±0.06	6.96±0.08	0.739
Flavour	6.88±0.04	6.47±0.10	3.684**
Texture	6.75±0.10	6.50±0.11	1.846
Meat flavour intensity	6.68±0.11	6.61±0.10	0.498
Juiciness	6.71±0.13	6.70±0.08	0.131
Overall acceptability	6.80±0.11	6.49±0.08	2.508*

*Significant P<0.05; **Highly significant P<0.01; HBL- Extended and dehydrated goat meat cubes dried in hot air convection oven. MBL- Extended and dehydrated goat meat cubes dried in microwave oven

water holding capacity than HBL, nevertheless, the difference was not significant. This is in agreement with the findings of Feng and Tang (1998), Lin et al. (1998) and Maskan (2001) who observed a higher water absorption capacity in microwave dried apple dices, carrot slices and kiwi fruits respectively. Water activity of HBL was significantly different (P<0.01) from that of MBL and this was reflected in the comparatively higher moisture content of HBL. The results were in agreement with that of Thomas (2007), who observed a lowered water activity with lowering of moisture content and addition of humectants in shelf stable pork sausages. Protein and ash contents of HBL and MBL were not significantly different. The high contents of these proximate principles in both the treatments might be due to their higher levels in black gram (Soris et al., 2010). Significantly lower fat percentage in MBL might be due to the oozing of fat like liquid from the meat cubes noticed in the final stages of drying in microwave oven. Zhang et al. (2006) stated that in the final 'reduced drying rate period' in microwave oven, local temperature rises above the boiling temperature of water, the product temperature continuing to rise resulting in overheating.

Higher hardness value of MBL might have been one of the reasons for its lower texture scores during sensory evaluation. In contrast to these findings, Yongsawatdigul and Gunasekaran (1996) obtained comparable firmness values for microwave dried and hot air dried cranberries. Funebo et al. (2002) observed that in microwave convective drying, firmness of dehydrated apple pieces increased with increase in temperature. On the other hand, Cui et al. (2003) observed that the cutting force required for microwave vacuum dried garlic slices was less than that for air-dried slices. Gumminess and chewiness values were significantly higher for MBL than HBL and could be due to the higher hardness, cohesiveness and springiness values. De Pilli et al. (2009) also reported a higher firmness value for microwave dried (900 W power) pasta when compared to hot air dried one.

The microwave dried cubes were darker brown especially the cubes placed on the edges of the glass plate. This is contradictory to the reports of Vadivambal and Jayas (2007) in dried fruits and vegetables where increase in redness value was less in microwave dried samples when compared to conventional air-dried ones, the increase in redness indicative of browning reactions.

Higher microbial quality of MBL in comparison to HBL might be due to the destruction of bacteria by microwaves. Bajpai et al. (2003) reported a very low total plate count; absence of coliforms, yeast and molds in microwave dehydrated soy paneer. Decareau (1995) observed a 15 times less bacteria in products dried by microwaves when compared to those dried by conventional methods. However, the microbial counts were well below the acceptable limits in HBL and MBL.

Significantly lower score for flavour for MBL might be due to the off flavours observed after microwave drying. This might probably be due to the reasons given by Zhang et al. (2006) who observed that final product temperature in microwave drying is difficult to control and excessive temperature along edges and corners of product may lead to overheating, scorching and development of off flavours. Even though not significant, texture score of HBL was higher than that of MBL and might be due to the increased hardness of MBL, as revealed by the texture profile test, despite its better rehydration. Though not significant, meat flavour intensity and juiciness scores were higher for HBL than those for MBL. Regarding

overall acceptability, HBL had a significantly higher ($P<0.05$) score than MBL and was preferred by sensory panellists. It might be due to the over drying of MBL cubes resulting in a scorched flavour and burnt taste as discussed above.

Conclusion

Extended goat meat cubes dried by hot air convection and microwave were compared and analysed. Both microwave and hot air oven drying have their advantages as well as disadvantages. In the study, microwave drying resulted in reduced preparation time of extended and dehydrated goat meat cubes, with the cubes having better rehydration capacity and lower water activity. Also, microwave dried cubes had better microbial quality than hot air dried cubes. However, hot air convection dried meat cubes scored higher in texture profile analysis and sensory evaluation. A combination drying involving microwave and convection drying may be tried in the future work where by the advantages of both may give better results.

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