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Nutritive and Sensory Quality of Buffalo Meat Dried by Hot Air and Combination of Hot Air – Microwave Stored Under Different Packaging Systems

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ABSTRACT

India ranks first in buffalo population and ranks top in buffalo meat export. Buffalo meat is lean with less fat, contains crucial amino acids, good functional properties and blends well with other ingredients. Since meat is a perishable product it can be converted into shelf stable product by drying, which is the simplest and oldest preservation technique. The present study was aimed to standardise the drying techniques in hot air and hot air- microwave combination drying. Round portion of buffalo carcass was subjected to drying techniques such as hot air and hot air-microwave combination drying and subjected to different packaging systems viz T1- Aerobically packed hot air dried buffalo meat, T2- vacuum packaged hot air dried buffalo meat, T3- aerobically packed hot air – microwave combination dried buffalo meat and T4-vacuum packaged hot air- microwave combination dried buffalo meat. Treatments were stored at ambient temperature and their proximate principles and sensory attributes were assessed. Moisture content was significantly higher for T1 and T2 and no significant difference was observed in protein, fat, ash, carbohydrate and calorific values of treatments. Sensory attributes did not differ significantly between treatments and were acceptable upto 90 days storage. Combination drying technique can be adopted as an efficient fast method of drying in small and large scale production of dried meat products.

HIGHLIGHTS

- Hot air drying and hot air – microwave combination drying of buffalo meat showed no significant difference in proximate composition and sensory attributes.
- Combination drying reduces the drying time for buffalo meat.

Keywords: Buffalo meat, hot air drying, microwave drying, proximate composition, sensory attributes

The increasing human population demands a nutritional security and as buffalo meat possesses superior nutritional value it is a viable option for meeting growing demand of meat. Buffalo meat from India is leading among foreign markets because of its organic nature, and freedom from rinderpest and bovine spongiform encephalopathy.

Drying is practiced since ancient times for preserving foods especially meat. Dried meat products have shelf stability, less weight and volume and can be distributed to people during natural calamities and to malnourished people. Dried buffalo meat can be used in a variety of dishes or can be consumed as a protein rich chewy snack.

Drying is the process of removing moisture and lowering its water activity. Convective hot air drying is a common method for drying large scale of meat products.

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Convective hot air drying requires more time and power for drying. By convection the heat is getting transferred from surrounding hot air to meat surface, followed by conduction to the inner parts of meat, causing myofibrillar shrinkage and providing channels for moisture migration from intra- myofibrillar spaces towards the surrounding hot air (Shi *et al.,* 2021).

Microwave drying is a comparatively novel technology used for wide variety of applications in food sector such as thawing, cooking, pasteurization, drying, baking etc. (Chandrasekaran *et al.,* 2013). The frequency range for microwaves lies between 300 MHZ and 300 GHZ. Volumetric heating is the process by which microwaves induce internal heating in a material based on the dielectric characteristics of the target substance. Dipolar and ionic processes are primarily responsible for the microwave heating of food components. Long drying time required by hot air drying can be shortened by combining it with microwave drying. Low energy consumption, high efficiency, short processing time and low operation cost are the main advantages of microwave drying over conventional drying (Wei *et al*., 2020).

Because of its affinity to excite water molecules and its effect on volumetric heating, microwave heating is a good choice for use in final drying. The wet inner core of the sample is selectively heated as the microwaves enter it and hit water molecules, causing an internal pressure that forces water out of the sample's core (Wray and Ramaswamy, 2015). Hot air-microwave combined drying had been attempted in banana (Maskan, 2000), soy fortified paneer (Uprit and Mishra, 2003), oregano (Soysal *et al.,* 2009), longan (Chaikaham *et al.,* 2013), peeled litchis (Song *et al.,* 2015), red tomatoes (Izli and Isik, 2015), ginger (An *et al.,* 2016), mango (Pu and Sun, 2017), persimmon (Jia *et al*. 2019), pomelo (Yildiz and İzli, 2019), tilapia fillet (Wei *et al.*, 2020), and dragon fruit (Raj and Dash, 2022).

MATERIALS AND METHODS

Meat from round portion of buffalo carcasses was procured from local meat retail shop, Vythiri (Kerala, India); deboned, washed to remove blood clots and extraneous matter, all external fat and, fascia were trimmed off. Then the muscles were cut into thin strips of approximately (6 cm length × 4 cm breadth × 0.5 cm thickness) manually along the direction of muscle fibres. Salt at the level of 2% was added to the strips, 15 minutes prior to drying. Hot air drying was carried out in a cabinet drier (Kraft work, Kochi) at 60 ˚C and air flow was generated by a fan with an air flow rate of 85 cubic flow per minute (CFM). The buffalo meat strips were spread out in a single layer on perforated trays and were placed in the preheated drier at 60 ˚ C for 14 hours. For combination drying, buffalo meat strips were subjected to hot air drying in a preheated cabinet drier (Kraft work, Kochi) at 60 ˚C for 3 hours and air flow was generated by a fan at an airflow rate of 85 cubic flow per minute (CFM) followed by drying in a microwave oven (Murphy Richards-Solo) at high power (800 W) for 5-10 minutes. Dried meat was allowed to cool and was divided into two batches, one set was subjected to aerobic packaging using low density polyethylene pouches (LDPE) and the other set was vacuum packaged using polyester- polyethylene films (Gregory Polymers Pvt. Ltd., Ernakulam) and stored at ambient temperature (25-30 ˚C). Treatments included, T1- aerobically packaged hot air dried buffalo meat, T2- vacuum packaged hot air dried buffalo meat, T3- aerobically packaged hot air – microwave combination dried buffalo meat, T4- vacuum packaged hot air- microwave combination dried buffalo meat. All the packets were stored at ambient temperature (25-30 ºC) and proximate analysis and sensory evaluation were carried out on days 0, 30, 60 and 90.

PROXIMATE ANALYSIS

Moisture

Moisture content of representative samples was estimated as per AOAC (2016). About 20 g of accurately weighed sample in an evaporating dish was kept in a hot air oven (Rotek, Mumbai) set at 100 ± 2 ºC for 16 h. The weight of the dried sample was taken after cooling in a desiccator. The difference in the weight was the moisture content of the sample and it was expressed as percentage weight of the sample.

$$\text{Moisture (\%)} = \frac{W2 - W3}{W2 - W1} \times 100$$

W1 = Weight of empty dish; W2 = Weight of dish + sample; W3 = Weight of dish + dried sample

Fat

Fat content of dried meat was estimated as per AOAC (2016). Fat content of about three grams of accurately weighed moisture free sample was extracted with petroleum ether (Boiling range 60 – 80 °C) using Soxhlet solvent extraction system (SocsPlus - SCS 06E, Pelican Equipment, Chennai) for a period of 2.5h. Ether extract obtained was dried to a constant weight at 100°C, cooled and weighed. Fat content on dry matter basis was converted to wet matter basis and expressed as percentage weight of the sample.

$$\text{Fat (\%)} = \frac{W2 - W1}{W3} \times 100$$

W1 = Weight of empty oil flask; W2 = Weight of oil flask + fat; W3 = Weight of sample taken

Protein

Protein content was estimated as per AOAC (2016). Accurately weighed sample (approximately 2 g) was digested using Micro–Kjeldhal digester (Kelplus KES06LE, Pelican Equipment, Chennai) in the presence of catalyst (90 parts sodium sulphate + 10 parts copper sulphate) and 25 ml concentrated (36 N) sulphuric acid. Tubes were heated gently until frothing ceased, then boiled rapidly until solution became clear. The samples were cooled and transferred to 250 ml volumetric flask and made up the volume using distilled water. Ten millilitres of diluted sample was distilled with 20 ml of 40 per cent sodium hydroxide using Micro Kjeldhal distillation unit (Kelplus Distyl-EMBA, Pelican Equipment, Chennai). Steam was distilled over 2 per cent boric acid (5ml) containing mixed indicator (1 part 0.2 per cent methyl red + 2 parts 0.2 per cent bromocresol green dye in ethanol) for collecting 35 ml of distillate. The ammonia trapped in boric acid was determined by titrating with 0.1N sulphuric acid. The nitrogen percentage was calculated using the following formula:

Nitrogen (%) =

$$\frac{(A - B) \times 0.0014 \times \text{Total volume made}}{\text{Weight of sample taken} \times \text{Volume distilled}} \times 100$$

A = Titrated value for sample; B = Titrated value for blank

Protein percentage was determined by conversion of nitrogen to protein by using conversion factor (6.25), assuming that all the nitrogen in meat was present as protein *i.e.* protein (%) =Nitrogen (%) ×conversion factor

Ash

Ash percentage was determined by gravimetric method as described by AOAC (2016) using muffle furnace (Rotek, Mumbai). Accurately weighed crushed sample of dried meat (around 10g) was transferred to pre weighed crucible, charred on a hot plate at 100°C for 30 min and transferred to muffle furnace at 550 °C for 5 h. The sample was then transferred to desiccator having fused calcium chloride as desiccant. After 1 h the crucible was weighed.

The ash content was calculated by the following formula:

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample taken}}$$

Carbohydrate

Carbohydrate content of dried meat was calculated by subtracting the sum of moisture, protein, fat and ash contents from 100.

$$\text{Carbohydrate (\%)} = 100 - (\text{Moisture \%} + \text{Fat \%} + \text{Protein \%} + \text{Ash \%})$$

Energy Value

The energy content of dried meat was determined on wet matter basis as per FAO (2003).

$$\text{Energy (kcal)} = (\text{fat percent} \times 9\ \text{kcal}) + (\text{protein percent} \times 4\ \text{kcal}) + (\text{carbohydrate percent} \times 4\ \text{kcal})$$

SENSORY ATTRIBUTES

Sensory evaluation of dried meat was conducted by a semi-trained panel consisting of eight panelists drawn from the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, Pookode using an eight-point Hedonic score card as presented in Annexure for appearance/colour, flavour, texture, juiciness, after taste and overall acceptability. Uniform samples from each batch were taken and served to the panelists with code number and score card and asked to rate in the eight-point Hedonic scale (Badr *et al*., 2004). Dried meat was crushed in the mixer-grinder for one second and was sauteed in oil before sensory evaluation.

STATISTICAL ANALYSIS

Data recorded were analysed statistically using SPSS Software Version 21.0. One way ANOVA, Duncan Multiple range Test, repeated measures ANOVA, least significant difference (LSD), Kruskal Wally's ANOVA, Friedman's test and independent t- test were used.

RESULTS AND DISCUSSION

Proximate composition of dried buffalo meat

Proximate analysis for fat, protein and ash was done for hot air dried buffalo meat and hot air- microwave combination dried buffalo meat on day 0 and moisture was analysed on all storage periods. Energy and carbohydrate values of treatments were derived by calculation. The result of proximate analysis is given in Tables 1 and 2.

Moisture content was significantly ($p<0.05$) lower for combination dried treatments, T3 and T4 when compared to hot air dried treatments, T1 and T2 on all days of analysis except the day of preparation. Lower moisture content in T3 and T4 might be due to greater microwave power that facilitated faster moisture removal. This was in agreement with Viji *et al.* (2021) who observed faster moisture removal in microwave vacuum dried tuna with greater microwave power. Moisture content significantly increased ($p<0.01$) for T1 and T2, whereas for T3 and T4 it remained more or less similar. The increase in moisture content might be due to absorption of moisture from environment and also variation in storage temperature and humidity. Kharb and Ahlawat (2010) observed that moisture content of dehydrated spent hen mix increased

Table 1: Moisture (%) of hot air and hot air- microwave combination dried buffalo meat on different storage days

	Storage days				
Treatments	**Day 0**	**Day 30**	**Day 60**	**Day 90**	**F-value (P-value)**
T1	12.80± 0.59^{aB}	15.03 ±0.56^{aA}	14.43 ±0.87^{aAB}	14.78 ±0.45^{aA}	6.077**(0.004)
T2	12.80± 0.59^{aB}	14.45 ±0.59^{aA}	13.58 ±0.77^{abAB}	14.06 ±0.57^{aA}	5.425**(0.006)
T3	11.66 ± 0.11^{aC}	13.26±0.26^{bA}	12.13 ±0.22^{bcBC}	12.29±0.16^{bBC}	12.522**(<0.001)
T4	11.66 ± 0.11^{aC}	12.91±0.16^{bA}	11.83 ±0.1^{cBC}	11.93 ±0.2^{bBC}	11.687**(<0.001)
F-Value (P- Value)	0.97^{ns} (0.419)	6.94** (<0.001)	3.97* (0.018)	7.367** (0.001)	

T1- Aerobically packed hot air dried buffalo meat; T2- Vacuum packed hot air dried buffalo meat; T3- Aerobically packed hot air- microwave combination dried buffalo meat; T4- Vacuum packed hot air- microwave combination dried buffalo meat; ***significant at the 0.01 level; * Significant at 0.05 level; ns non-significant; Means having different small letter as superscript differ significantly within a column; Means having different capital letter as superscript differ significantly within a row.*

Table 2: Proximate composition (%) and energy value (kcal/100g) of hot air and hot air- microwave combination dried buffalo meat on day 0

Treatments	**Hot air dried buffalo meat**	**Hot air- microwave combination dried buffalo meat**	**t-value**	**P-value**
Protein	65.09 ± 0.81	66.69 ± 0.69	1.505^{ns}	0.154
Fat	5.23 ± 0.24	4.62 ± 0.21	1.922^{ns}	0.075
Ash	9.29 ± 0.39	9.67 ± 0.28	0.785^{ns}	0.446
Carbohydrate	7.59 ± 0.58	7.36 ± 0.26	1.006^{ns}	0.125
Calorific value	337.75 ± 4.22	337.14 ± 1.69	0.795^{ns}	0.447

ns non-significant.

significantly during 15 days of storage which might be due to absorption of moisture by samples, and after that the moisture content stabilized. Ajiboye *et al*. (2011); Choudhry *et al.* (2019) stated increase in moisture content as storage period advanced in dried meat and dry pork cubes respectively. On contrary to this Singh *et al*. (2009) observed a decrease in moisture content of chicken snacks during storage. There was no significant difference in moisture contents of aerobically and vacuum packed samples in both methods of drying.

No significant difference was observed in protein, fat, ash, carbohydrate and calorific values of hot air dried buffalo meat and hot air- microwave combination dried buffalo meat. This was in agreement with Pankyamma *et al.* (2019) who found that there was no significant difference in moisture, protein ash, fat and carbohydrate levels of squid shreds dried by different methods. Similarly Deng *et al*. (2014); Dewi *et al*. (2011); Engez *et al.* (2012); Ayanwale *et al*. (2007) observed no significant difference in proximate composition of squid fillets, shark *dendeng,* biltong, dried beef and chicken dried by different methods. Viji *et al.* (2019) observed significantly higher ash in microwave vacuum dried fish when compared to hot air dried fish and other proximate parameters showed no significant difference. Nayar *et al.* (2014) evaluated hot air dried dehydrated and extended goat meat cubes had higher fat content than microwaved sample.

Sensory attributes

The scores for sensory attributes are given in Table 3.

Sensory scores for appearance did not vary significantly between treatments. Dewi *et al*. (2011) observed no significant difference in sensory attributes (colour, odour, texture, taste and overall acceptability) of shark *dendeng* dried by different methods The appearance scores of all treatments reduced significantly (p<0.01) during storage irrespective of the method of drying and

Table 3: Effect of ambient storage on sensory parameters of dried buffalo meat

Attributes	Treatments	Day 0	Day30	Day 60	Day 90
Appearance/ Color	T1	7.36 ± 0.08 ^{A}	7.08 ± 0.13 ^{AB}	6.94 ± 0.11 ^{AB}	6.77 ± 0.09^{B}
	T2	7.36 ± 0.08 ^{A}	7.09 ± 0.12^{AB}	6.98 ± 0.09^{AB}	6.78 ± 0.13^{B}
	T3	7.31 ± 0.14^{A}	7.17 ± 0.09^{AB}	6.97 ± 0.11^{AB}	6.83 ± 0.13^{B}
	T4	7.31 ± 0.14^{A}	7.20 ± 0.1^{A}	6.97 ± 0.1^{AB}	6.86 ± 0.15^{B}
Flavour	T1	7.45 ± 0.08^{A}	7.0 ± 0.13^{AB}	6.72 ± 0.11^{B}	6.58 ± 0.11^{B}
	T2	7.45 ± 0.08^{A}	7.02 ± 0.12^{AB}	6.75 ± 0.16^{B}	6.59 ± 0.14^{B}
	T3	7.42 ± 0.1^{A}	7.22 ± 0.12^{AB}	6.97 ± 0.11^{B}	6.72 ± 0.09^{B}
	T4	7.42 ± 0.1^{A}	7.22 ± 0.07^{ABB}	6.92 ± 0.12^{B}	6.73 ± 0.11^{B}
Texture	T1	7 ± 0.13	6.92 ± 0.13	6.8 ± 0.12	6.66 ± 0.1
	T2	7 ± 0.13	6.94 ± 0.13	6.78 ± 0.1	6.66 ± 0.12
	T3	7 ± 0.13	6.86 ± 0.11	6.78 ± 0.1	6.67 ± 0.11
	T4	7 ± 0.13	6.88 ± 0.1	6.83 ± 0.08	6.69 ± 0.11
Juiciness	T1	7.08 ± 0.13	6.91 ± 0.14	6.86 ± 0.13	6.72 ± 0.13
	T2	7.08 ± 0.13^{A}	6.89 ± 0.13^{AB}	6.83 ± 0.13^{AB}	6.6 ± 0.08^{B}
	T3	6.91 ± 0.13	6.81 ± 0.13	6.73 ± 0.11	6.63 ± 0.08
	T4	6.91 ± 0.13	6.8 ± 0.13	6.66 ± 0.09	6.61 ± 0.12
Overall acceptability	T1	7.06 ± 0.1	6.92 ± 0.12	6.83 ± 0.11	6.77 ± 0.1
	T2	7.06 ± 0.1	6.96 ± 0.12	6.81 ± 0.12	6.78 ± 0.12
	T3	7.14 ± 0.13	7.11 ± 0.14	6.91 ± 0.12	6.81 ± 0.13
	T4	7.14 ± 0.13	7 ± 0.13	6.92 ± 0.09	6.84 ± 0.13

T1- Aerobically packed hot air dried buffalo meat; T2- Vacuum packed hot air dried buffalo meat; T3- Aerobically packed hot air- microwave combination dried buffalo meat; T4- Vacuum packed hot air- microwave combination dried buffalo meat; *Means having different capital letter as superscript differ significantly within a row* (p<0.01).

type of packaging. This might be due to lipid oxidation, and subsequently, oxidised chemicals combining with amino acids to cause non-enzymatic browning in the product. This was in accordance with the result of Das and Jayaraman (2003) who reported a significant decrease in colour of dehydrated chicken *pulav* during storage at ambient temperature. Karthikeyan *et al.* (2000) and Mishra *et al*. (2014) also reported reduction in colour/appearance scores of vacuum packaged hurdle treated caprine *keema* and extended and dehydrated chicken meat rings during ambient temperature storage and attributed it to the lipid oxidation and non enzymatic browning.

Flavour score was found to be non significant between the treatments. Flavour score decreased significantly ($p<0.01$) as storage period advanced and this might be due to lipid oxidation and proteolytic changes in the product. Mishra *et al*. (2015) and Das and Jayaraman (2003) observed progressive decrease in flavour scores of aerobically packed extended dehydrated chicken meat rings and dehydrated chicken *pulav* during storage at ambient temperature whereas Kharb *et al*. (2008) observed a non significant decrease of flavour scores for dehydrated spent hen meat mince on storage.

Texture scores did not vary significantly between treatments and storage periods. This was in accordance with Dewi *et al.* (2011) who observed no significant difference in texture of Shark *dendeng* prepared by different methods. Mishra *et al*. (2014) and Singh *et al*. (2009) noticed that there was no significant change in texture scores of vacuum packaged extended and dehydrated chicken meat rings and chicken snacks, respectively on storage. Contrary to this, Mishra *et al*. (2015) observed significant decrease in texture score of aerobically packed extended and dehydrated chicken meat rings during storage.

No significant difference was observed in juiciness between treatments and between storage periods except in T2 where the scores significantly reduced on storage. Similar to this Modi *et al*. (2007) observed no significant changes in juiciness score of dehydrated chicken *kebab* mix during storage period. In contrary to this Zargar *et al*. (2014) reported a decrease in juiciness of aerobically packed chicken sausages during storage period.

There was no significant difference in overall acceptability attribute between treatments and during storage period. Ayanwale *et al.* (2007) observed that sun and oven drying methods did not significantly affect the organoleptic properties of chicken meat and chevon. Dewi *et al*. (2011) observed that there was no significant difference in sensory scores of overall acceptability of shark *dendeng* dried by different methods. Kharb *et al.* (2008) observed that the overall acceptability score of dehydrated chicken meat mince remained unchanged during storage. In contrary to this, Mishra *et al.* (2015), Das and Jayaraman (2003) and Gök *et al*. (2008) reported a significant decrease in overall acceptability of aerobically packed extended and dehydrated chicken meat rings dehydrated chicken *pulav* and Turkish *pastirma,* respectively during storage.

Sensory scores were between ‘moderately acceptable and very acceptable” for all treatments on all days of storage upto day 90.

CONCLUSION

Drying time can be reduced by hot air-microwave combination drying method. The moisture content was lower in hot air- microwave combination drying and the proximate composition was found to be similar for both drying methods. Both drying methods achieved similar sensory scores irrespective of packaging system employed. Hot air- microwave combination drying can be adopted as an efficient fast method of drying in small and large scale production of dried meat products. Overall acceptability score of dried meat were in “very acceptable to moderately acceptable” range during storage period of 90 days at ambient temperature.

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