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Physico-chemical and microbiological characteristics of buffalo meat dried by hot air

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Abstract
India has a huge buffalo population and buffalo meat is a nutrient rich food. The perishable commodity of meat can be converted to shelf stable products by different techniques, of which the simplest method is drying. The present study was aimed to develop dried buffalo meat by hot air and to study its physico-chemical and microbiological characteristics at ambient temperature (25-30 ºC) for a storage period of 90 days. Round portion of buffalo carcass was cut into strips and dried in hot air drier at 60 ºC for 14 hours and then packed in aerobic (T_1) and vacuum (T_2) conditions. Both T_1 and T_2 showed a significant increase in pH during storage period. Water activity of both T_1 and T_2 decreased whereas thiobarbituric acid reacting substances and tyrosine values increased significantly during storage period. Significant decrease in hardness value was observed. L* values showed no significant difference whereas T_2 showed a significant difference in a * value across storage period. B*, C* and hue values increased significantly during storage period. T_2 showed a lower aerobic plate count than T_1. Significant increase in yeast and mould count was observed on day 30 in both treatments. Hot air drying significantly increased the shelf life of buffalo meat and vacuum packaging significantly enhanced the microbial quality of dried meat.

Keywords: Buffalo meat, hot air drying, aerobic and vacuum packaging, ambient storage temperature

1. Introduction
Buffalo meat is lean with less fat, has good functional properties, good concentration of crucial amino acids, and mix well with other ingredients and also it meets the protein requirement of growing population. By practising drying technique, perishable meat commodity is converted into shelf stable one, and drying had been practiced since ancient times to preserve the food. Drying removes water from the product thereby reducing the water activity. Advantages of dried meat include less weight, requirement of less storage space and less cooking time. Convective hot air drying is common and easy to operate and is followed commercially. In convective hot air drying the heat is getting transferred from surrounding hot air to meat surface by convection which is followed by conduction to the inner parts of meat, causing myofibrillar shrinkage. Efficient moisture removal is necessary to enhance the keeping quality of meat. Most common cured air-dried products include cured hams, *biltong* (South Africa), *pastirma* (Turkey), *bundner fleisch* (Switzerland), *beef jerky* (USA), *serano ham* (Spain), *pancetta* (Italy), *rougan and shafu* (PR China) etc. *Kargyong*, *satchu*, *suka ko masu* from north-east India, beef *idichathu*, *idiyirachi* or *unakka irachi* from Kerala and *uppukandam* from Tamil Nadu are a few dried meat products in India. Packaging helps in maintaining the keeping quality of a product during transport and storage. Lipid oxidation and mold growth are the two threats that spoil the dried meat and vacuum packaging may retard lipid oxidation and microbial growth resulting in enhanced shelf life of dried meat products.

2. Materials and Methods
Round portion of meat from 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 x 4 cm breadth x 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 ºC 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 ºC for 14 hours.

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). The aerobic packets were sealed using an impulse sealer (Thejus, India) and vacuum pouches were sealed in vacuum packaging machine (Sevana, Quick seal-4QS400VS3G, Kochi). Treatments included, T_1- aerobically packaged hot air dried buffalo meat, T_2- vacuum packaged hot air dried buffalo meat; the packets were stored at ambient temperature (25-30 ^oC) and physico-chemical and microbiological characteristics were assessed on days 0, 30, 60 and 90.

Physico-chemical characteristics

pH of the samples was measured by using a digital pH meter as per the method described by AOAC (2016) [2]. The water activity (aw) of the samples was measured using a digital aw meter (Novasina AG CH-8853 Lachen, Switzerland) as described by Ambrosiadis *et al.* (2004) [3]. TBARS numbers of samples was determined as per Witte *et al.* (1970) [20] with modifications. Tyrosine values of samples were estimated as per the method described by Pearson (1968) [17]. Colour values of the dried meat samples were determined objectively as per Page *et al.* (2001) [16] using Hunter Lab Mini Scan XE plus Spectrophotometer (Hunter Lab, Virginia, USA) with diffuse illumination. The hardness of rehydrated dried meat samples was evaluated as per Bourne (1978) [7] using a Universal Testing Machine (TRAPEZIUMEZ-SX, Shimadzu, Japan) by using an Allo Kramer shear cell with a cross head speed of 50mm/min, applying 500 Newton load cell.

Microbiological characteristics

All the microbiological characteristics were determined by following standard methods of American Public Health Association. Readymade media (Hi-Media and Sisco Research Laboratories, India) were used for all the microbiological examination. Aerobic plate count (APC) was evaluated as per the procedure of Morton (2001) [14]. Yeast and mould count was expressed as per the procedure of Beuchat and Cousin (2001) [6].

Statistical analysis

The data obtained were statistically analyzed by one-way ANOVA, Duncan Multiple Range Test (DMRT), Repeated measures of ANOVA, least significant difference (LSD) using SPSS software (VERSION 21) as per Snedecor and Cochran (1994) [19].

3. Results and Discussion

There was a significant increase ($p < 0.001$) in pH of both treatments, T_1 and T_2 during storage periods. The lowest pH was observed on day 0 and highest pH was observed on day 90. The increased pH might be due to proteolytic changes in the product that are alkaline in nature. Similarly, Sarkar *et al.* (2021) [18] observed an increase in pH of dried spent hen meat powder during storage and it was attributed to production of alkaline metabolites from meat proteins. Different packaging systems had no influence on pH. This was in contrast to Gök *et al*. (2008), who discovered that vacuum packed Turkish *pastirma* had a lower pH than aerobically packed *pastirma*.

Water activity reduced significantly ($p < 0.01$) in both T1 and T_2 during storage period and the lowest water activity was observed on day 90 (T_1- 0.575±0.007; T_2- 0.561±0.009), however there was no significant difference in water activity between treatments. Similarly, Choi *et al.* (2007) [8] observed that hot air-dried jerky packed in plastic packaging exhibited decreased water activity as the storage period advanced.

TBARS number of T_1 and T_2 increased ($p < 0.001$) during storage period, with lowest value on day 0 and highest on day 90 and the increase was significant from day 30 onwards. The results are in agreement with that of Kharb and Ahlawat (2010) [10] who observed an increase in TBARS value of dehydrated spent hen mix up to 60 days of storage. In the present study it was observed that packaging system did not have an effect on TBARS number. Contrary to this, Mishra *et al.* (2014) [11, 12] found that vacuum packaging resulted in lower TBARS number than aerobic packaging in dehydrated meat rings.

A significant ($p < 0.001$) difference in tyrosine values was observed between storage days with the lowest value on day 0 and highest value on day 90 and the increase was significant from day 30 onwards. Anandh and Lakshmanan (2014) [4] and Dange *et al.* (2014) observed significant increase in tyrosine value in smoked rumen meat and dehydrated low sodium chicken strips, respectively during storage at ambient temperature. No significant difference was observed in tyrosine values between aerobic and vacuum-packed products (T_1 and T_2). Contrary to this, Muthulakshmi *et al.* (2020) [15] noticed a lower tyrosine value in vacuum packaged buffalo meat sausage when compared to aerobic packed sausage.

No significant difference in L* values was observed between treatments and between storage periods. Similar report was observed by Sarkar *et al.* (2021) [18] who observed no significant difference in L* value of solar and oven dried spent hen meat powder under different packaging systems. On contrary to this, Modi *et al.* (2007) [13] observed that L* increased marginally during storage of dehydrated chicken *kebab* mix.

A* value of T_2 showed a significant ($p < 0.05$) difference between storage period, whereas T_1 exhibited no significant difference. The type of packaging did not have any effect on a* and b* values. In both treatments, b* value increased ($P<0.001$) significantly during storage period with lowest value on day 0 and highest value on day 90. The, a* and b* values of *pastirma* decreased with storage in aerobic, vacuum and modified atmosphere packaging methods.

Chroma values increased significantly ($p < 0.01$) during storage period and might be due to increase in b* values. The difference in hue values, H* between different storage days was found to be significant ($p < 0.01$) with highest H* on day 90 and lowest on day 0 in all the treatments and might be due to more met myoglobin formation. Increase in hue angle on storage might be due to increase in b* as storage advanced.

Significant difference ($p < 0.01$) in hardness value was noticed between storage periods with the highest hardness value on day 0 and lowest on day 90. The decrease in hardness might be due to change in moisture content of the products and proteolysis. Yang *et al.* (2009) [21] noticed that the shear force values decreased in beef jerky during storage.

Vacuum packed treatment (T_2) had significantly ($p < 0.01$) lower aerobic plate count than aerobic packed treatment (T_1) on all storage days which might be due to absence of air in vacuum packaging. Similar result was obtained by Mishra *et al.* (2014) [11, 12] who observed decreased total plate count in

vacuum packaged extended dehydrated chicken meat rings when compared to aerobic packaging. In T_1 and T_2, aerobic plate count showed a significant ($p < 0.01$) increase on day 30 and thereafter it decreased progressively. On day 90, vacuum packaged dried buffalo meat (T_2) showed a decreased yeast and mould count than aerobic packed (T_1). Significant ($p < 0.01$) increase in mold count was observed on day 30 in both treatments and thereafter counts decreased. The decrease in yeast and mold count as storage period progressed might be due to decrease in water activity. Aksu *et al.* (2005) [1] reported that yeast and mold growth decreased during storage period in sliced and modified atmosphere packaged *Pastırma* as the growth was affected by gaseous atmosphere.

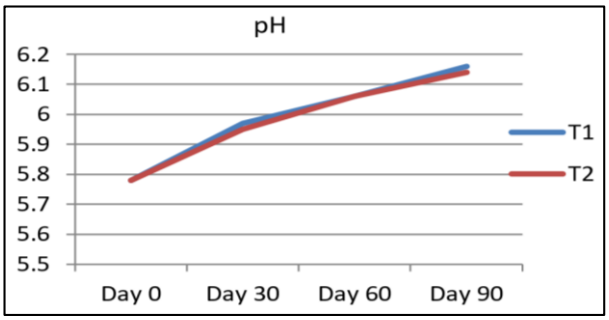

Fig 1: pH values of treatments on different Storage days

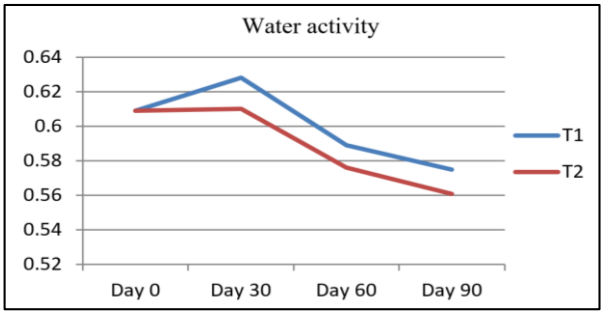

Fig 2: Water activity of treatments on different storage days

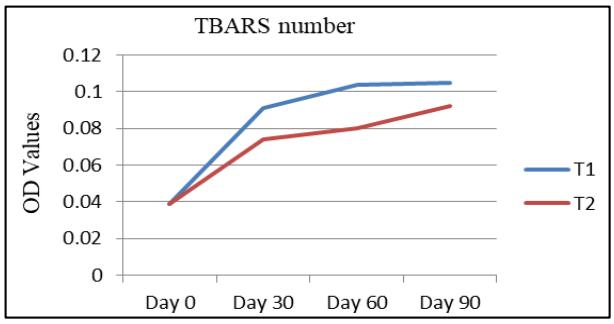

Fig 3: TBARS number of treatments on different storage days

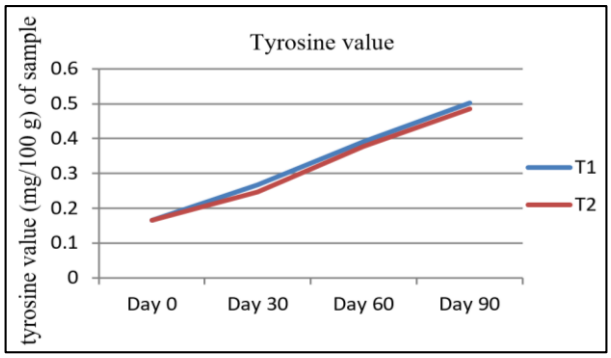

Fig 4: Tyrosine value of treatments on different storage days

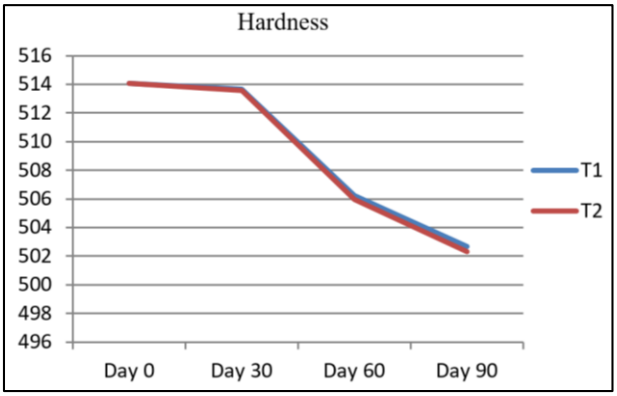

Fig 5: Hardness value (N/cm^2) of treatments on different storage days.

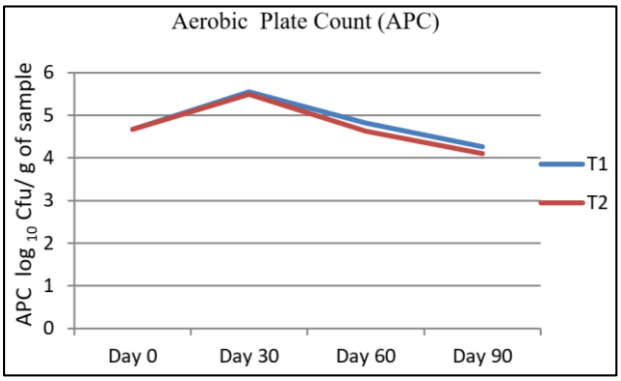

Fig 6: Aerobic plate count of Treatments on different storage days

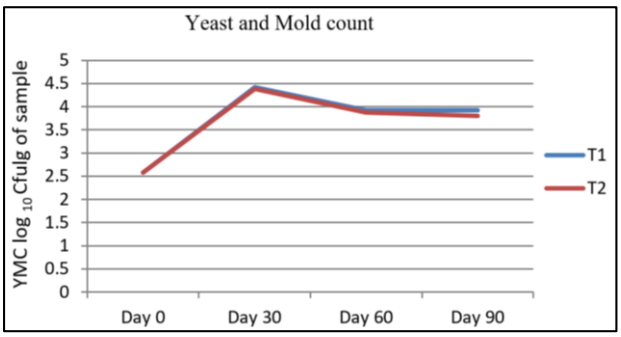

Fig 7: Yeast and mold count of treatments on different storage days.

4. Conclusions

Buffalo meat dried by hot air and packaged in aerobic and vacuum packaging did not vary significantly in physico-chemical characteristics. However, vacuum packaging of dried buffalo meat showed an enhanced microbial quality. Drying converts the perishable product into shelf stable product, which can be stored at ambient temperature (25-30 ^oC) without much change in their characteristics.

5. Acknowledgement

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