Effects of packaging materials on the shelf-life and sensory characteristics of buffalo meat during refrigerated storage

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ARTICLE INFORMATION

ABSTRACT

The study was conducted to evaluate the effect of different packaging materials on Textural characteristics and Shelf-life of Buffalo meat during refrigerated storage condition (0° C and -4° C). The meat samples were packed in Al-foil and HDPE to study the effectiveness of packaging material on sensory characteristic and extending the shelf life of buffalo meat. Samples packed in HDPE brought more improvement in pH, reduces total plate count (TPC) and developed color, odour and texture in comparison of samples packed in Al-foil. Logarithmic value of TPC per gram of raw buffalo meat samples was 4.29. After 40 days of storage it went to 5.97 & 6.91 for HDPE and Al-foil packed at -4°C. The meat sample had desirable colour, texture and aroma. The colour started fading with storage. The cured meat samples were packed in HDPE & Al-foils and kept for storage study at 0°C and -4°C. From the results of storage study, it was found that the logarithmic value of TPC per gram started increasing slowly and the cured meat samples were found to be in spoiled condition after 50 & 40 days for HDPE bags & Al-foil packaging respectively at 0°C and samples at -4°C has shelf-life 60 & 50 days respectively for HDPE & Al-foils. The shelf life of sample under both packaging material was found to be 60 & 70 days respectively.

Keywords
Raw Buffalo Meat (RBM), Textural Properties, Packaging material, Total Plate Count(TPC), Refrigerated Storage, HDPE, Al-foil

1. Introduction
People eat foods they like. The food may include muscle foods also. Sensory properties impact on these liking (Booth, 1990). A broad spectrum of sensory input, including appearance, aroma, flavor and texture is used by consumers to make purchasing and eating decisions related to muscle foods. In 1982, Charles described the important sensory qualities of meat as flavor, colour, texture, nutritive value and wholesomeness. For meat selection in a retail supermarket, consumers generally evaluate the sensory properties in terms of colour, surface characteristics, size and shape (Rhodes, 1979). The effect of meat colour on acceptance of red meats is well established (Jeremiah et al, 1972). Size and shape also play roles in selection and purchase of muscle food. During storage, consumers continue to use visual characteristics as cues to quality and acceptance. Colour loss, especially the loss of red colour in meat, is perceived negatively by consumers, hence the practice of packaging meat in wraps that preserve the fresh colour. The red colour meat is due to the presence of heme protein, myoglobin. The degree of meat pigmentation is directly related to myoglobin content. Meat colour is an extremely important sensory characteristic by which consumers make judgments of meat quality. Meat
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colour determines the shelf-life of meat (Hamm and Deathorge, 1960). Microbial safety of meat and meat products is of great public and industrial significance (Bendall, 1954). The question then arises why are more problems surfacing in meat and meat products which are presumably cleaner than product more contaminated. Murphy (1996), in his article of “how clean is to clean?” reported and Jay (1996) suggested that the current approach to food safety should be achieving the goal of safe meat, not just in reducing the number of microorganisms”. Jay (1996) asked a thought provoking question “Is our meat too clean?” which is based on the hypothesis that lack of microbial interference and competition might be encouraging pathogens growth and causing food poisoning.

Microbiological analysis in the meat industry is mainly targeted to count total microorganisms or a specific past of the microflora, or to detect the presence of selected genera or species of microorganisms (Herbert and Smith, 1980). Packaging must allow the meat product to be produced and distributed efficiently and economically (Brody, 1989). The effects of different packaging systems are best studied by first considering the behavioral properties of meat which are directly influenced as; (i) Water loss (ii) Tissue respiration (Kennedy, et al., 1982). (iii) Microbiology – After dressing, the surface of a carcass may carry between 10^5 and 10^6 bacteria/ cm^2 and after butchery (Pennington, 1997). They may comprise a large range of different bacteria some of which can grow between 0°C and 5°C, (Emswiler and Kotula, 1979) (iv) Colour. However, packaging may also be used in a wider context to improve storage life, attract the customer and more recently, to extend the period of attractive display (Hothkiss, 1989) (Brody, 1989). The choice of films for packaging meat is largely determined by their moisture and gas permeability (Daint, et al., 1983).

2. Material and Methods

Generally, male animals of about 2 years age was slaughtered according to the traditional halal method at buffalo slaughter house. Meat samples from round portions (Comprising mostly semimembranosus, semitendinosus, bicepsfemoris and quadriceps muscles) part of carcasses of good finish were obtained from meat shop within 3 hours of slaughter. For each trial of the experiments similar meat samples in required quantity were procured from round cut of a carcass. The meat chunks were packed in low-density polyethylene (LDPE) bags and brought to the laboratory within 10 minutes. The temperature of meat was 25°C±3 on arrival at the laboratory. For curing of meat, a curing solution was made of 80 gram common salt (Iodine free), 20 gram sugar, 1.16 gram salt peter (Potassium nitrate) and 540 ml distilled water. The solution was thoroughly mixed to dissolve the ingredients. The meat samples were submerged into solution and curing was allowed for 48 hours at 4°C in an ultra low temperature cabinet. After curing, the meat pieces were removed, and left for 2 hours in open to allow the meat surface to dry off. Cured meat samples were packed in HDPE and Al foil bags, and stored at 0°C and –4°C as described earlier.

Total plate count:

In each test 1 g of meat was taken with the help of sterile knife spatula and forceps from samples and mixed in the cyclo mixer (Make Remi model CM-101). 9 ml of distilled water was added in the sample. Serial dilutions were made and suitable dilutions were poured using plate count agar medium (Composition: Peptone 5g, Yeast extract 2.5 g, meat extract 2.5 g,(High Media Lab.) NaCl 5 g, Agar 10 g, Distilled water 500 ml ).Duplicate plating of sample was followed. Viable colony forming units were counted under digital colony counter from suitable dilution and the average counts were expressed in log number per gram of samples. Colour, odour and texture of meat samples were evaluated organoleptically for all samples based on 8 point hedonic scale where in 8 was extremely desirable and 1 was extremely undesirable. The odour of the stored meat was observed soon after opening of the packets taken out from the refrigerator. The test Performa was also developed and supplied to experts at the time of evaluation. The test Performa is like this ie., for Excellent-8, Very good-7, Good-6, Fair-5, Slightly poor-4, Moderately poor-3, Very poor-2, Extremely poor-1

3. Results and Discussion

Studies on raw buffalo meat packed in Al-foil and HDPE and stored at 0°C and –4°C temperature was also conducted. Initially ultimate pH of raw buffalo meat was 5.84. Decreasing trend of pH was observed during further storage. It was found that pH of raw buffalo meat packed in HDPE bags and Al-foil stored at 0°C reached to a value of 5.11 and 5.01 respectively after 40 days in each case. The meat sample was found to be in almost spoiled condition as indicated by TPC and sensory characteristics (Table-1). Initially logarithmic value of TPC per gram of raw buffalo meat samples was 4.29. Storage study at 0°C revealed that the microbial population increased more rapidly at 0°C as compared to –4°C. It was noted that logarithmic value of TPC per gram of raw buffalo meat packed in HDPE and Al-foil reached to a value of 7.47 and 7.81 respectively after 40 days storage at 0°C. The counter part samples stored at –4°C had logarithmic value of TPC per gram 5.97 and 6.91 respectively after 40 days storage. The initial increase in value of
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Table-1: Hedonic Scale Rating of sensory characteristics for Refrigerated (raw) Meat Storage in HDPE and Al foils Packaging (mean ± SD).

<table>
<thead>
<tr>
<th>Packaging</th>
<th>Raw meat HDPE at (0°C)</th>
<th>Cured meat HDPE at (0°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Colour</td>
<td>7</td>
<td>6.6</td>
</tr>
<tr>
<td>Odour</td>
<td>7</td>
<td>6.6</td>
</tr>
<tr>
<td>Packaging</td>
<td>Al-foil at (0°C)</td>
<td>HDPE at (-4°C)</td>
</tr>
<tr>
<td>Colour</td>
<td>7</td>
<td>6.3</td>
</tr>
<tr>
<td>Odour</td>
<td>7</td>
<td>6.3</td>
</tr>
<tr>
<td>Packaging</td>
<td>HDPE at (-4°C)</td>
<td>AI-foil at (0°C)</td>
</tr>
<tr>
<td>Colour</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Odour</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Packaging</td>
<td>AI-foil at (0°C)</td>
<td></td>
</tr>
<tr>
<td>Colour</td>
<td>7</td>
<td>6.6</td>
</tr>
<tr>
<td>Odour</td>
<td>7</td>
<td>6.6</td>
</tr>
</tbody>
</table>

In this case also the colour of meat samples packed in both HDPE and Al-foils and stored at 0°C started fading. The colour of meat samples packed in HDPE bags were maintained for longer time as compared to samples packed in Al-foils. Similar effects were observed for meat samples packed in HDPE bags and Al-foils but stored at –4°C.

Although a lot of work has been reported on the effect of addition of curing solution on physicochemical and functional properties such as increased pH, water holding capacity (WHC), protein solubility, emulsifying capacity (EC) (Bendall, 1954) (Herbert and Smith, 1980) on various types of meat. Study on curing of raw buffalo meat was also conducted. Cured meat samples were packed in HDPE bags and Al-foil and kept for storage study at 0°C and -4°C. It was found that pH of cured meat did not change after 10 days sample packed in HDPE bags kept at 0°C and -4°C. On further storage decreasing trend of pH was noted and cured meat sample kept at 0°C packed in HDPE and Al-foil finally had pH value 5.21 and 5.08 after 50 days. The spoilage condition in the sample was characteristic. Initially the logarithmic value of TPC

pH during refrigerated storage of buffalo meat was due to ripening phenomenon of meat. However, in this case, the pH increased during initial days of storage by which time ripening process might have been completed after which the pH again started decreasing till it reached minimum value. As higher pH value of meat is indicative of better functional properties of meat, HDPE bags were found to be better packaging material as compared to Al-foil with respect to maintenance of quality of raw buffalo meat. At this stage the meat samples were in spoiled condition as indicated by TPC studies and sensory evaluation.

Sensory characteristics viz. colour, texture and odour of raw buffalo meat were also evaluated. Table-1 shows the results. Initially the meat sample had desirable colour, texture and aroma. The colour started fading at 0°C storage for both samples packed in HDPE and Al-foil. The colour of meat samples packed in HDPE bags was maintained for longer time as compared to the sample packed in Al-foil. Similar effects were also observed for the counter parts samples stored at –4°C.
noted at this stage as indicated by TPC and sensory per gram of cured meat sample was 4.11. The cured meat samples were packed in HDPE bags and Al-foil and kept for storage study at 0°C and –4°C.

From the results of storage study, it was found the logarithmic value of TPC per gram started increasing slowly and the cured meat sample was found to be in spoiled condition after 50 and 40 days for HDPE bags and Al-foil packaging, while the storage temperature was 0°C. Similar effects were noted for both the samples kept at –4°C for storage study. Both the samples have prolonged shelf-life 60 and 50 days respectively as indicated by logarithmic value of TPC per gram 6.88 and 6.90 respectively. All meat samples were considered very acceptable after curing and at two months of storage however, about one quarter of samples were considered to be unacceptable by the taste panelists after four months of storage, due to the bacterial spoilage.

Sensory characteristics are important parameter for reporting the actual quality of meat samples. The attributes taken for sensory evaluation are colour, odour and texture (Rhodes, 1979). Colour of the meat is very important in describing the excellent and poor condition of meat. Cured meat was improved in colour, texture and odour as compared to raw buffalo meat (Table-2). Score value of raw 7,7,7 and 8,8,8 for cured colour, texture and odour respectively. Colour scores were significantly affected by nitrate only. Flavour, Saltiness and overall acceptability scores were not significantly affected by nitrate but were significantly affected by storage time. During storage, cured meat sample packed in HDPE and Al-foil and kept at 0°C and –4°C started losing the colour, texture and odour. Cured meat loses its texture, colour and odour after 50 days for both samples at 0°C and 60 days at –4°C. Loss in texture was noted by slimy condition and off odour was also noticed. The changes occurred due to microbial load increased beyond limit and protein and fat were degraded by microorganism. Curing brought colour in meat. Salt and sugar also have positive effect on sensory characteristics of meat especially on colour. It also improved texture and flavour of meat.

Texture analysis of raw as well as treated buffalo meat was conducted on 2nd days of storage and refrigerated storage condition at 0°C and –4°C at regular interval of 20, 40 and 60 days under different packaging material i.e. Al-foil and HDPE bags (Table-3). It was found that the positive peak force measuring the hardness of raw buffalo meat was 11547.40 g (Fig. 1) when analysis was made for buffalo meat on second days the sample was packed Al foil and kept for storage at 0°C. The counterpart sample packed in HDPE bags and kept at 0°C for storage study was found to have positive peak force as 12331.4 g (Fig. 3). Similarly the samples packed in both packaging material and kept for storage study at –4°C had positive peak forces 11714.0 g and 13728.0 g (Fig. 2) respectively. The measurement of hardness of these samples in fresh condition from positive peak forces obviously was differing. This difference was due to difference in composition of muscle. The presence of connective tissue adds hardness and leads to increment in positive peak forces. The effort was made to maintain the uniformity of sample and perhaps it was the reason that the positive peak forces did not differ greatly. Some time it happens that the presence of connective tissues lead to increment in positive peak force up to 500-2000 g.

Table-3: Texture Analysis for measurement of hardness (mean peak force in ‘g’±S.D) of raw and treated meat samples kept under refrigerated conditions during storage.

<table>
<thead>
<tr>
<th>Days</th>
<th>Raw 0°C</th>
<th>Raw -4°C</th>
<th>HDPE 0°C</th>
<th>HDPE -4°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>11547.4±465.3</td>
<td>11714.2±631.4</td>
<td>12331.1±236.2</td>
<td>13728.0±473.6</td>
</tr>
<tr>
<td>20</td>
<td>11071.0±532.1</td>
<td>11240.5±547.8</td>
<td>11235.2±456.1</td>
<td>12052.0±284.4</td>
</tr>
<tr>
<td>40</td>
<td>9019.1±254.3</td>
<td>9600.0±478.5</td>
<td>9119.2±158.6</td>
<td>8195.9±613.5</td>
</tr>
<tr>
<td>60</td>
<td>7943.0±198.3</td>
<td>8240.0±542.1</td>
<td>6997.3±634.1</td>
<td>8239.3±465.8</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td>120</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Days</th>
<th>Cured 0°C</th>
<th>Cured -4°C</th>
<th>HDPE 0°C</th>
<th>HDPE -4°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>13620.5±368.9</td>
<td>16680.7±365.2</td>
<td>17315.4±452.1</td>
<td>20926.2±359.4</td>
</tr>
<tr>
<td>20</td>
<td>10299.6±541.3</td>
<td>13620.5±351.2</td>
<td>15252.9±364.8</td>
<td>18525.2±684.2</td>
</tr>
<tr>
<td>40</td>
<td>9171.6±426.3</td>
<td>11459.0±957.2</td>
<td>15133.3±741.3</td>
<td>17519.6±456.8</td>
</tr>
<tr>
<td>60</td>
<td>9069.0±452.0</td>
<td>9747.4±624.5</td>
<td>11400.3±684.2</td>
<td>12664.7±960.2</td>
</tr>
<tr>
<td>80</td>
<td>10225.1±357.0</td>
<td>10225.1±351.9</td>
<td>8239.0±536.3</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>9806.4±258.3</td>
<td>7224.1±364.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Effects of packaging materials on buffalo meat:

Fig. 1. Effect of packaging material (Al foil) and storage condition (0°C) on hardness of buffalo meat.

Fig. 2. Effect of packaging material (Al-foil) and storage condition (-4°C) on hardness of raw buffalo meat.

Fig. 3. Effect of packaging material (HDPE) and storage condition (0°C) on hardness of raw buffalo meat.

Fig. 4. Effect of packaging material (HDPE) and storage condition (-4°C) on hardness of raw buffalo meat.

Fig. 5. Effect of packaging material (Al-foil) and storage conditions (0°C) on hardness of cured buffalo meat.

Fig. 6. Effects of packaging material (Al-foil) and storage conditions (-4°C) on hardness of cured buffalo meat.
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It was found that the hardness of meat started decreasing during storage at 0°C and −4°C for the samples either packed in Al-foil or HDPE bags.

Texture measurement was conducted consecutively after 20, 40, 60 and 80 days. The meat sample packed in Al-foil and HDPE bags was found to be in spoiled condition after 40 days. The positive peak forces of both samples in spoiled condition (after 40 days) were measured as 9019.0 g and 9600.0 g respectively (Fig.1 & 2). Similarly meat sample packed in both packaging material kept at −4°C storage were found to have shelf life of 50 days each. These samples were found to be spoiled when measurement of TPC and texture analyses were carry out after 60 days. (Positive peak forces were found to be 6997.3 g (Fig. 3) and 8239.4 g (Fig. 4) respectively.

Texture analysis of cured buffalo meat was also conducted after treatment and during the refrigerated storage conditions (at 0°C and −4°C) under different packaging material (Al foil and HDPE bags) It was found that the positive peak force measuring the hardness of cured samples on 2nd day of storage were 13620.5 g (Fig. 5) 16680.7 g (Fig. 6) for samples packed in Al foil at 0°C and −4°C. While the peak forces were 17315.1 g (Fig. 7) and 20926.7 g (Fig. 8) for sample packed in Al foil and HDPE bags at 0°C −4°C. The increased values of positive peak force are due to the treatment of curing solution and storage temperature i.e. −4°C.

Storage at −4°C temperature produced hardness in the meat sample after 24 h which caused increment in positive peak forces. During storage study, it was found that hardness started decreasing for samples packed in Al foil and HDPE at storage temperature 0°C and −4°C results of texture analysis revealed that sample had higher positive peak forces on 2nd day of storage in comparison to raw meat. Texture measurement for cured meat was conducted regularly after 20, 40, 60 and 80 days the meat samples packed in Al foil and HDPE after 40 days.

The positive peak forces of both samples in spoiled condition (after 60 days) were measured as 9069.5 g (Fig. 5) and 11400.3 g (Fig. 7) for samples packed in Al foil and HDPE bags and stored at 0°C respectively while its counterpart samples packed in Al foil and HDPE bags stored at −4°C had positive peak forces value were 9747.4 g (Fig. 6) and 12664.7 g (Fig. 8) after 60 days respectively.

4. Conclusion

Keeping all the stated points in mind, discussed in the literature review, the present study was conducted in the Department of Post Harvest Engg. and Technology of A.M.U. Aligarh to investigate the effects of packaging material and storage condition on sensory characteristics and shelf life of buffalo meat was investigated. It was found that pH of raw meat packed in HDPE bags and Al-foils stored at 0°C reached to a value of 5.11 and 5.01 respectively after 40 days in each case.

Logarithmic value of TPC per gram of raw buffalo meat samples was 4.29. After 40 days of storage it went to 5.97 & 6.91 for HDPE and Al-foil packed at −4°C. The meat sample had desirable colour, texture and aroma. The colour started fading with storage. The cured meat samples were packed in HDPE & Al foils and kept for storage study at 0°C and −4°C. From the results of storage study, it was found that the logarithmic value of TPC per gram started increasing slowly and the cured meat samples were found to be in spoiled condition after 50 & 40 days for HDPE bags & Al foil packaging respectively at 0°C and samples at −4°C has shelf-life 60 & 50 days respectively for HDPE & Al foils. The shelf life of sample under both packaging material was found to be 60 & 70 days respectively.

Study on effect of packaging materials on raw and treated meat samples suggested that packaging material played an important role in improving meat quality during storage. The most suitable packaging material for raw and treated meat was found to be HDPE as compare to Al-foil. The packaging material HDPE therefore allowed the permeation of required oxygen for maintaining the colour of meat.

Fig. 7. Effect of packaging material (HDPE) and storage conditions (0°C) on hardness of cured buffalo meat

![Figure 7](image7.png)

Fig. 8. Effect of packaging material (HDPE) and storage conditions (-4°C) on hardness of cured buffalo meat

![Figure 8](image8.png)
HDPE showed better performance as compared to Al foil in maintaining physico-chemical, microbiological, sensory and textural characteristics of meat samples. This was due to the barrier properties and better sealability of HDPE films as compared to Al foils, which is being used as a wrapping not packing with seal. As far as storage temperature is concerned, it is very much evident from this work and has been supported by many previous researchers that lower storage temperature increases the shelf life.

References