Role of Smoking on the Textural Characteristics and Shelf-life of Buffalo Meat

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ARTICLE INFORMATION

ABSTRACT

Regardless of its origin, smoking, like curing of meat has been practiced since the beginning of recorded history. The study was conducted to evaluate the effect of smoking on Textural characteristics and Shelf-life of Buffalo meat during refrigerated storage condition (0° C and -4° C). Smoking brought improvement in pH, reduces total plate count (TPC) and developed color, odour and texture. Smoking increases pH to 6.14 while it was 5.84 for raw buffalo meat (RBM). Color, odour and texture were also improved. There was continuous and consistent fall in pH values of smoked raw buffalo meat until it reaches the minimum value at 0° C and -4° C storage temperature conditions. Textural studies (peak forces value for firmness/hardness) also shows the texture intactness of the smoked raw buffalo meat and during storage at 0° C and -4° C. These samples spoiled after 60 and 80 days as compared to RBM which spoiled after 40 days at same storage condition packed in Al-foil and HDPE. Smoking developed many positive effects and improved quality of raw meat. Smoking especially improved color, odour and texture (firmness/hardness) of meat. It caused reduction in microbial population. Both smoked and packed in Al-foil and HDPE bags and stored at 0° C and -4° C increased the shelf-life and all textural characteristics of buffalo meat as compared to their controlled counterpart ie raw buffalo meat. The effect of smoking caused the lowest microbial count, compact texture, cherry red color and longest shelf-life of 60 and 80 days respectively packed in Al-foil and HDPE at 0° C and -4° C

Keywords

Raw Buffalo Meat (RBM)
Textural Properties
Smoking
Total Plate Count (TPC)
Refrigerated Storage
Shelf-life

1. Introduction

Texture is the most important palatability factor that affects the acceptability of meat. The amount of connective tissue has a profound effect on the texture of meat (Tabilo et al., 1989). Texture, especially tenderness and juiciness, has a substantial effect on acceptability of intact cuts of meat. It has long been believed that tenderness is the most important attribute, because if meat is tough, other sensory properties become less important. Texture characteristics of foods constitute one of the main sensory attributes perceived by consumers. Instrumental texture analysis is a good tool to assess texture of foods. The knowledge of physical sense and the correct calculation of the parameters allow a good interception of results (Pous & Fiszman, 1996). It seems probable that nomadic humans first discovered the preservative
action and the desirable flavour imparted to meat that was hung near their fires. Curing and smoking of meat are closely interrelated and are often practiced together, that is, cured meat is commonly smoked (Pearson & Gillet, 1997; Wistreich, 1977). The primary purposes of smoking meat are development of aroma and flavour, preservation, creation of new products, development of color, formation of a protective skin on emulsion-type sausages and protection from oxidation (Gill, 1986).

The chemical components most commonly found in wood smoke include phenols, organic acids, alcohol, carbonyls, hydrocarbons, and some gaseous components, such as carbon dioxide (CO₂), carbon monoxide (CO), oxygen (O₂), nitrogen (N₂) and nitrogen oxide (NO₂) (Porter et al., 1965). Phenols appear to play a threefold role in the smoking of meats and other foods as (i) they act as antioxidant (ii) they contribute to the colour and flavour of smoked products, and, (iii) they have a bacteriostatic effect that contribute to preservation (Miles, 1974). The role of phenols in preventing oxidative changes in smoked meat is most important. The antioxidant activity of smoke is one of its most important attributes in smoke are due to the phenols with high boiling point especially 2, 6-dimethoxyphenol, 2-6, dimethoxy-4-methylphenol and 2,6 dimethoxy 4-ethylphenol (Gill, 1986). Colour and flavour are the important sensory attributes to the desirability of smoked meats. Colour development is caused by the interaction of the carbonyls in the vapour phase of the smoke with amino groups on the surface of the foods. Phenols also contribute to the colour development. Colour formation is due to the Maillard reaction (Howard et al., 1966). Colour formation is directly related to the smoke concentration, temperature and the moisture content at the surface of the products, with 12-15% of moisture at the exterior surface of meat resulting in maximum colour development. The desired flavour of smoked meats is primarily due to the phenolic compounds in the vapour phase. The bactericidal action of smoking is due to the combined effects of heating, drying and the chemical components in the smoke. Smoke components such as acetic acid, formaldehyde and creosol prevent microbial growth. The phenols are known to possess strong bacteriostatic activity. The high boiling point phenols have the highest bactericidal activity. The bacteriostatic effect is primarily on the surface, since the amount of smoke penetration is limited. A wide variety of alcohols are also found in wood smoke due to the destructive distillation of wood. Alcohol exerts minor bactericidal effects on meat. Organic acids have little influence on the aroma and flavour of smoked meat. They have only a preservation effect. The gaseous component in smoke that is probably of the greatest significance is nitrous oxide, which has been linked to formation of nitrosamines and nitrates in smoked meats (Schwartzberg, 1976). Smoking can cause some destruction of thiamine, but has little effect on niacin and riboflavin. The antioxidant properties of wood smoke should help stabilize the fat soluble vitamins and would also be expected to prevent surface oxidation of smoked meat products.

The various smoke ingredients differ in their value. Those of the phenol fraction hinder the fat oxidant processes and improve its flavour. Dry wood of deciduous trees (beech, oak, alder, maple and neem) is used for smoking. The smoke time depends on the type and different aspect of the products exclusively the storage periods (Porter et al., 1965). Researchers have reported smoking time and temperatures different for different products, as for hams, it is 18-35°C for 3-5 days, for bacon 30-45°C for 2-14 days. Optimal humidity in the smoke chamber is 30-40%. Higher humidity (70-80%) hampers dehydration and cause quick coagulation of the smoke on the surface of the meat. As soon as the smoke is generated, numerous reactions and condensations occur. Aldehydes and phenols condense to form resins, which represent about 50% of the smoke components and are believed to provide most of the colour in smoked meats. Various biological characteristics influencing the quality of farmed Salmon and Smoked muscles were studied (Gomez-Guillen et al., 2000).

Smoked meats are high calorie products of good eating properties and delicate juicy texture. The gloss formed on the surface of smoked meats is the result of two effects. The pH changes taking place during frozen storage regardless of the temperature, it is unlikely that quality deterioration of these food products can be attributed to changes in pH alone (Miles, 1974). The storage temperature, the degree of fluctuation in the storage and the type of wrapping or packaging in which the meat is stored are generally thought to have the main influence on frozen storage life.

### 2. Material and Methods

Buffalo meat was collected from the local meat shop. Generally, male animals, about 2 years old, were slaughtered according to the traditional halal method at buffalo slaughter house of Aligarh Municipal Corporation, Aligarh after pre-slaughter holding in the lairage for a period of 16-19 hours. Although weight, sex, source, method of slaughtering and time of collection of carcass were same for the entire experiment. Proximate composition of meat especially with respect to moisture and fat content was found to vary from one carcass to the other. 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. Buffalo meat was evaluated for physico-chemical properties soon after obtaining the samples within 5-6 hours of post mortem. 4 kg meat sample were taken and cut into eight small cubes each weighing 500 gm. Each samples weighing 500 grams was cut in to small cubes and made ready for control and treated samples.

2.2 Total plate count:

Microbial quality is considered to be the most important attribute of shelf life of meat. Microbial population exceeding 10⁵/g of meat samples was taken as unsafe for human consumption at which unpleasant odour in raw meat samples was observed (Ranken and Kill, 1993). 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 ). The plates were allowed to set and were incubated (Model: BOD incubator Super Deluxe make Yorco Co.) at 30°C for 40 hours. 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.

2.3 Construction of drum smoke house:

The function of a smoke house is to retain enough heat and smoke for smoking to be completed. The items used in building a smoked house must be capable of providing a source of smoke, create a space which confines the smoke, have provision to hold the meat block, and provide an air passage along which to direct the smoke. An empty oil drum was used for the construction of drum type smoke chamber. A hole was made at the bottom of the drum while the top of the drum was kept open. This drum was then placed over a pit of diameter less than that of drum while the depth of the pit was kept 2'. For smoking, meat samples were hanged in the smoke drum with the help of metallic wires. Properly dried neem (Azadica indica) wood was used as fuel to create smoke, the temperature of which was kept between 50-60°C by manually controlling the draft of wind in the fire pit. Smoking was done for 8-9 hr and smoked meat samples were packed in HDPE and Al -foils and stored at 0°C and -4 °C temperatures respectively. Similarly cured meat and cured and anti-oxidant treated meat samples were also smoked and stored. Textural analysis of raw, treated and preserved meat samples was done by TAHD type texture analyzer.

Texture analyzer is an instrument, which determines the textural properties of food material. In case of meat and meat products guillotine knife was used as the instrument of the probe, for measurement of hardness/tenderness of meat/meat products. Texture expert, a computerized package helpful in texture analysis of meat and meat products. The study on TAHD is automated through computer. Salient features of texture expert include texture analyzer setting probe selection, opening of new file and finally run the test to get the graphical representation between force and time or force vs. distance. In this type of test, the positive peak force measures the hardness of meat samples in gram. Once the probe has reached the sample, force is seen to increase at a steady rate. As the probe moves down further onto the sample the force begin to increase rapidly as the sample begins to deform or rupture or penetrate. After penetrating or rupturing has occurred the subsequent increase in force is as a result of the force required to push. Test results obtained from samples of the approximate same type give the typical average maximum peak force (Firmness/hardness) values.

The results shown in the results and discussion part (in graphs) that the different storage time, treatments with packaging material and storage temperature be repeatably differentiated by both the measured peak force and the area under the curve. The maximum force required to penetrate the sample was reported as the hardness of the sample. The highest peak on the graph was reported as the hardness value of the meat. The textural hardness or fracturability was measured and expressed in shear force as Newton(in gram) (Nordyke et al., 2000).

3. Results and Discussion

Optimization of smoking time and temperature was conducted. During initial hours it was observed that gradual drying at meat surface occurred and there was very little improvement in texture, colour or appearance. However as the smoking proceeded, desirable changes in colour, texture and appearance were observed. During experimentation it was found that raw meat developed optimum level and desirable characteristics of smoking i.e. glossy surface finish, blooming of colour and tenderization of tissues and uniform dehydration nearly after 8 hours of continuous smoking at 50-60 °C
Role of Smoking on buffalo meat

Temperature while cured as well as cured with antioxidants treated samples took 9 hours of smoking in achieving the same desirable characteristics described earlier.

No work has been reported on the beneficial effect of smoking of raw meat on the physico-chemical and textural properties. That is why, the present work cannot be compared with any other results. Raw buffalo meat sample was smoked in drum smoke house for 8 hours and the temperature of smoke was maintained at 50-60°C. After completion of smoking, there was approximately 25% loss of moisture content of the meat sample. It was observed that pH of smoked meat increased to 6.14. It was noticed that unlike raw meat, pH value did not increase during initial days of storage. pH value continuously decreases during storage at 0°C and -4°C until it reached to a minimum value. These values were 5.38 after 50 days storage at 0°C for the samples packed in Al-foil and 5.32 after 60 days storage at 0°C for the samples packed in HDPE. Smoking considerably reduced the microbial population. Logarithmic value of TPC per gram just after smoking was found to be 4.20. During storage at 0°C, the value of TPC for samples packed in Al-foil was 7.58 after 60 days, while the samples packed in HDPE took 70 days to reach the logarithmic value of TPC per gram as 7.86 at 0°C. This microbial count referred to the spoilage condition in both samples. Smoking had antimicrobial effects on meat samples. The antimicrobial activity in smoked meat was developed due to presence of several organic compounds present in hard wood smoke namely phenols, aldehydes, ketones, acids and resins. The sample stored at -4°C was found to have more shelf-life than the sample stored at 0°C. This is due to the fact that lower the temperature more is the microbial growth retardation.

Sensory attributes of the smoked sample just after smoking and during the storage at 0°C and -4°C were evaluated with the help of expert panelists. It was found that smoking brought cherry red colour in raw meat. It also improved texture and odour of sample. However, during storage at 0°C and -4°C, samples started losing colour, texture, and odour. Meat samples developed light red colour, soft texture and smoky odour after 60 and 70 days storage at 0°C and -4°C (Table 1), when packed in Al-foil and HDPE respectively. Smoke obtained from hard wood contains several organic compounds. During smoking fat oozed from the meat, which imparted good odour, glossy surface finish and red colour of meat. During storage colour was not entirely lost even after reaching spoilage condition. This was perhaps due to the surface coating of smoke on meat.

Table 1: Hedonic Scale Rating for Refrigerated Storage in HDPE and Al foils (mean±SD).

<table>
<thead>
<tr>
<th>Packaging</th>
<th>HDPE at (0°C)</th>
<th>Al-foil at (0°C)</th>
<th>HDPE at (-4°C)</th>
<th>Al-foil at (-4°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>0 10 20 30 40 50 60 70 80 90</td>
<td>0 10 20 30 40 50 60 70 80 90</td>
<td>0 10 20 30 40 50 60 70 80 90</td>
<td>0 10 20 30 40 50 60 70 80 90</td>
</tr>
<tr>
<td>Colour</td>
<td>7.0 6.6 6.0 5.6 5.3 5.0 4.3 4.3 4.3 4.0</td>
<td>7.0 6.3 5.3 4.6 4.3 4.0 4.0 4.0 4.0 4.0</td>
<td>7.0 7.6 6.3 6.3 6.0 5.6 5.3 5.0 4.6 4.6</td>
<td>7.0 7.6 6.3 6.3 6.0 5.6 5.3 5.0 4.6 4.6</td>
</tr>
<tr>
<td>Odour</td>
<td>7.3 7.7 6.6 6.6 5.6 5.3 5.0 4.6 4.3 4.3</td>
<td>7.3 6.3 5.6 4.6 4.6 4.3 4.0 4.0 4.0 4.0</td>
<td>7.3 7.6 6.3 6.3 6.0 5.6 5.3 5.0 4.6 4.6</td>
<td>7.3 7.6 6.3 6.3 6.0 5.6 5.3 5.0 4.6 4.6</td>
</tr>
</tbody>
</table>

Texture analysis of raw 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. It was found that the positive peak force measuring the hardness of raw buffalo meat was 13488.0 g (Fig 1) when analysis was made for buffalo meat on second days the sample was packed HDPE bags and kept for storage at 0°C. The counterpart sample packed in Al-foil and kept at 0°C for storage study was found to have positive peak force as 12331.4 g (Fig 1).

Similarly the samples packed in both packaging material and kept for storage study at -4°C had positive peak forces 13728.0 g(Fig-2) and 13488.0 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 (presence and connective tissues). 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
addition of positive peak force up to 500–2000 g. 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. Similarly meat sample packed in both packaging material kept at −4°C storage were found to have shelf life of 60 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 for raw buffalo meat were found to be 7943.0 and 8240.0 8239.4 and 9997.3 (Table 2) respectively after 60 days. Positive peak forces for raw buffalo meat were found to be 9066.0 and 6299.4 5623.3 and 7126.0 (Table 3) respectively after 80 days.

Texture analysis of smoked raw buffalo meat was conducted on 2nd day of storage and during entire refrigerated storage at 0°C and −4°C with different packaging material Al foil and HDPE. Smoking caused dehydration. It is evident from the textural graph that the positive peak force has increased due to dehydration and cooking effect as compared to raw buffalo meat on the very second day when the textural analysis was conducted the positive peak force was found to be 12396.6 g and 13488.0 g for sample packed in Al foil and HDPE at 0°C. At the other hand the positive peak force for raw meat were 11547.4 g and 11571.4 g for sample packed in Al foil and HDPE at 0°C. While the positive peak force of smoked raw meat was found to be 13728 g and 15536.2 g for sample packed in Al foil and HDPE bags at −4°C on the 2nd day of storage. But in the case of simply raw meat, the positive peak force was found to be 11714.2 and 13728.0 g; for samples packed in Al foil and HDPE at −4°C. The samples were kept for storage study and on 20, 40 and 60 days the texture analysis was conducted. It has been found that as usual the samples started loosening its texture with increasing the time. But the peak force shows that the softening in texture is little bit slow for smoked sample as compared to the raw meat samples. Smoking caused the partial denaturation and dehydration effect on meat this was the cause of increment of positive peak force for smoked meat samples. The positive peak force were to be 10299.6 g and 7362.9 g for samples packed in Al foil and HDPE respectively at 0°C after 40th days of storage. The positive peak force was found to be 8195.9 g and 11954.0 g for samples packed in Al foil and HDPE at −4°C. It is very clear from the texture analysis graphs and the value of positive peak force, the smoking has influence the shelf life. It has been found that the temperature also affected the shelf life. Smoking caused the partial denaturation and dehydration effect on meat this was the cause of increment of positive peak force for smoked meat samples. The positive peak force were to be 10299.6 g and 7362.9 g for samples packed in Al foil and HDPE respectively at 0°C after 40th days of storage. The positive peak force was found to be 8195.9 g and 11954.0 g for samples packed in Al foil and HDPE at −4°C. It is very clear from the texture analysis graphs and the value of positive peak force, the smoking has influence the shelf life. It has been found that the temperature also affected the shelf life. Smoking caused the partial denaturation and dehydration effect on meat this was the cause of increment of positive peak force for smoked meat samples. The positive peak force were to be 10299.6 g and 7362.9 g for samples packed in Al foil and HDPE respectively at 0°C after 40th days of storage. The positive peak force was found to be 8195.9 g and 11954.0 g for samples packed in Al foil and HDPE at −4°C. It is very clear from the texture analysis graphs and the value of positive peak force, the smoking has influence the shelf life. It has been found that the temperature also affected the shelf life. Smoking caused the partial denaturation and dehydration effect on meat this was the cause of increment of positive peak force for smoked meat samples. The positive peak force were to be 10299.6 g and 7362.9 g for samples packed in Al foil and HDPE respectively at 0°C after 40th days of storage. The positive peak force was found to be 8195.9 g and 11954.0 g for samples packed in Al foil and HDPE at −4°C. It is very clear from the texture analysis graphs and the value of positive peak force, the smoking has influence the shelf life. It has been found that the temperature also affected the shelf life. Smoking caused the partial denaturation and dehydration effect on meat this was the cause of increment of positive peak force for smoked meat samples. The positive peak force were to be 10299.6 g and 7362.9 g for samples packed in Al foil and HDPE respectively at 0°C after 40th days of storage. The positive peak force was found to be 8195.9 g and 11954.0 g for samples packed in Al foil and HDPE at −4°C.

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### Table 2: 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 Meat</th>
<th>Al-Foil</th>
<th>HDPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0°C</td>
<td>-4°C</td>
<td>0°C</td>
</tr>
<tr>
<td>2</td>
<td>11547.4±465.3</td>
<td>11714.2±631.4</td>
<td>11571.4±236.2</td>
</tr>
<tr>
<td>20</td>
<td>11071.0±532.1</td>
<td>11240.5±547.8</td>
<td>11235.2±456.1</td>
</tr>
<tr>
<td>40</td>
<td>9600.1±254.3</td>
<td>9019.0±478.5</td>
<td>9119.2±158.6</td>
</tr>
<tr>
<td>60</td>
<td>7943.0±198.3</td>
<td>8240.0±542.1</td>
<td>8239.4±634.1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Days</th>
<th>Raw+Smoked</th>
<th>Al-Foil</th>
<th>HDPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0°C</td>
<td>-4°C</td>
<td>0°C</td>
</tr>
<tr>
<td>2</td>
<td>12396.6±365.2</td>
<td>13728.4±190.8</td>
<td>13488.2±258.9</td>
</tr>
<tr>
<td>20</td>
<td>11459.0±652.3</td>
<td>9428.5±358.4</td>
<td>11954.6±634.5</td>
</tr>
<tr>
<td>40</td>
<td>10299.6±198.7</td>
<td>8195.9±456.2</td>
<td>7362.9±842.3</td>
</tr>
<tr>
<td>60</td>
<td>9571.0±426.3</td>
<td>6997.3±536.4</td>
<td>7126.6±630.4</td>
</tr>
<tr>
<td>80</td>
<td>6066.0±321.5</td>
<td>6299.4±520.1</td>
<td>6623.3±523.4</td>
</tr>
</tbody>
</table>

## 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, India to investigate the effects of smoking on various physicochemical, microbiological and textural properties of raw buffalo meat. During experimentation it was found that raw meat developed optimum level and desirable characteristics of smoking i.e. glossy surface finish blooming of colour and tenderization of tissues and...
uniform dehydration nearly after 8 hours of continuous smoking at 50-60°C temperature while cured as well as cured with antioxidants treated samples took 9 hours of smoking in achieving the same desirable characteristics described earlier. Initially, pH of raw buffalo meat was 5.84. Decreasing trends of pH was observed during further storage. 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.

Smoking developed many positive effects and improved quality of raw meat. Smoking especially improved color, odour and texture (firmness/hardness) of meat. It caused reduction in microbial population. Both smoked and packed in Al-foil and HDPE bags and stored at 0°C and -4°C increased the shelf-life and all textural characteristics of buffalo meat as compared to their controlled counterpart i.e. raw buffalo meat. The effect of smoking caused the lowest microbial count, compact texture, cherry red color and longest shelf-life of 60 and 80 days respectively packed in Al-foil and HDPE at 0°C and -4°C

References