Effect of Packaging Materials and MAP on Quality of Meat

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Effect of Packaging Materials and MAP on Quality of Meat

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Abstract

Packaging material such as coated Cast Polypropylene (CPP), Oriented Polypropylene (OPP) and whey protein isolate coated Poly Lactic Acid (PLA) film materials were selected and the MAP technique was used to improve the shelf life of meat was evaluated. For the study, the meat samples were packed in different packaging materials with MAP gas levels (80% O₂ and 20%CO₂). These samples were stored at -18°C and 4°C for 21 days for shelf life estimation. From the study, it was observed that the protein content of goat meat was decreasing with increase in storage temperature and storage periods. The protein content of meat packed in CPP, OPP and PLA stored at -18°C on 21 day of storage were found as 6.35, 6.02 and 5.72 per cent respectively. The color values (L*, a* and b*) of goat meat were increasing with increase in storage temperature and storage period. The L*, a* and b* value of meat packed in CPP, OPP and PLA stored at -18°C on 21 days of storage were 67.11, 5.06, 16.65; 68.79, 4.89, 16.98; 68.15, 4.56 and 19.64 respectively. The pH of the meat sample was decreasing with increasing the storage periods. The water activity (aw) value of the meat samples were increasing with increasing the storage temperature and periods. The pH and aW value of the meat samples packed in CPP, OPP and PLA stored at -18°C on 21 day of storage were 6.93, 6.91 and 6.52; 0.98, 0.98 and 0.99 respectively. Among the packaging materials WPI coated PP was found best in maintaining the quality of meat during storage period followed by OPP and coated PLA packaging materials and stored at -18°C.

Keywords: Meat, quality, shelf life, MAP, Packaging.
1. Introduction

As the human population increases, the protein requirement is also increases. Cattle and goat meats are recognized as highly nutritious food, being an excellent source of high quality animal protein. Meat also contains essential amino acids, vitamins and minerals especially iron. So there is surplus meat production in special occasion which needs to be preserved for future consumption (Faisal, et al., 2009). Goats are widely distributed around the world (Webb et al., 2005). Goat meat is popular with the greatest production and consumption in Asia and Africa (Kannnan et al., 2001). The consumption of goat meat is mainly increased by ethnic consumers. Approximately 50% of meat products were purchased by private households in self-service (AMI, 2013).

The export marketing potential for goat meat is increasing and its products for the goat meat industry also increased. It is important to examine the potential uses of goat meat from different supplied sources for producing added-value product (Wattanachant, et al., 2008). Due to increased consumer expectations, innovations in food packaging technologies associated with improved quality, hygiene, and safety of fresh meat have continued to develop (Qing et al., 2013). Modified Atmosphere Packaging (MAP) is a form of packaging where ambient air is removed or replaced with a single gas or gas mixtures. The modified atmosphere surrounds the product within vapor-barrier materials (McMillin, 2008). In fresh meat, the function of MAP is to protect against deteriorative effects, which include discoloration, off-flavor and off-odor development, nutrient loss, texture changes, and pathogenicity (Skibsted, et al., 1994; Siegel, 2001). Mainly MAP is designed to preserve the bright red appearance of meat (Taylor Down and Shaw, 1990), although lipid oxidation and microbial growth are also important factors regarding shelf life and consumer acceptance of fresh meat (Jakobsen and Bertelsen, 2000; Cutter, 2002).

In MAP the most commonly used gases for packaging meat are carbon dioxide (CO₂), nitrogen (N₂) and oxygen (O₂). Typically fresh red meats are stored in MAP within 60-85% O₂, 15-40% CO₂ Meat containing 80% O₂ : 20 % CO₂ and cooked meats are stored in 70% N₂ : 30% CO₂ (Georgala and Davidson, 1970; Watkins, 1984; Smiddy et al., 2002; Seideman and Durland, 1984). The function of carbon dioxide in MAP is to inhibit growth of spoilage bacteria. Nitrogen is used in MAP as an inert filler gas either to reduce the proportions of the other gases or to prevent pack collapse. The major function of
oxygen is to maintain the muscle pigment myoglobin in its oxygenated form, oxymyoglobin (Ledward, 1970).

Considering the packaging materials it should not affect the environmental condition and place in our country. The production and use of non-biodegradable materials or plastics as food packaging materials have significantly increased. These types of materials are usually derived from petroleum products and cause the problem in waste disposal (Avella et al., 2005). Orientated Polypropylene films is a low cost all purpose film ideal for packing bakery products, cakes, confectionery, stationary etc. Its versatility makes it easy to use on many different types of packaging machinery. CPP (cast polypropylene) gives a high gloss finish and is widely used in bagging applications. The most common synthetic biopolymer used in processing industry is Poly Lactic Acid (PLA). PLA is produced from lactic acid which may simply be generated through fermentation of carbohydrate from plant resources such as sugar beet and corn (Sorrentino et al., 2007). Among the advantages of PLA include biodegradability (Letian et al., 2013) and the lifespan of PLA can be tailored accordingly. Previously there were no appropriate techniques of meat packaging without preservation. Hence the aim of study to undergo the above considerations is done by proper packaging materials and technology of for enhancing the shelf life of fresh meat.

2. Materials and Methods

There are three different packaging materials were used to pack goat meat such as CPP film (30µm) collected from ITC Chennai; PLA biodegradable film (25µm) from Natur Tec. Chennai and both the films were coated with Whey Protein Isolate (WPI) in Anna University; and OPP biodegradable film (45µm) from MM Polymer, Chennai. Aim of whey protein isolate coating is to show an excellent oxygen and water vapor barrier properties. (Shin et al., 2002; Hong and Krochta, 2006; Hong et al., 2005 and Joo-Won Lee et al., 2008)

The fresh goat meat was purchased from a local market at Thanjavur, in a sterilized condition all visible fat and connective tissues were trimmed off as far as possible with the help of knife and the sample was prepared into small pieces. Then the meat was washed properly with clean portable water to make it blood free. The excess water was drained off. These meat samples were packed in CPP, PLA and OPP bags using MAP.
technology with gas mixture of 80% CO₂ : 20% O₂ and stored for 21 days at 4°C and -18°C respectively.

2.1 Analysis of Samples

Investigation on quality parameters such as Protein, Color, pH and water activity of goat meat during storage were measured at a 7 days interval throughout the storage periods. Protein was measured by Kjeldahl method (AOAC, 2003). The colour value of goat meat was determined using a Hunter colour lab (HunterLab ColorFlex, Reston, VA.) and reported in the complete International Commission on Illumination (CIE) system colour profile of lightness (L*), redness (a*), and yellowness (b*). The pH was measured using pH meter in meat homogenate, prepared by blending 2 g of meat with 10 ml distilled water. The aw was determined by Aqua lab water activity meter (Model: 4TE). All determinations were done in triplicate and the mean value was recorded. Statistical analysis Data were analyzed using the Analysis of Variance technique in MS Excel 2007 to compare variations between treatments where ANOVA showed significant differences.

3. Result and Discussion

The effect of modified atmospheric packaging, packaging materials and storage temperatures on quality of meat such as protein, colour, pH and water activity has been evaluated at regular intervals are presented here.

3.1 Effect on Protein

The protein content of meat stored at different temperatures with different packaging materials along with MAP is given in Fig. 3.1. From the figure it is observed that the protein content of goat meat was decreasing with increase in storage temperatures and storage period.

Among the packaging materials CPP has found best in maintaining the protein content of meat during storage followed by OPP and PLA. Considering the storage temperature -18°C has retained the protein content then stored at 4°C. The initial protein content of meat was found as 6.57 per cent. The protein content of meat packed in CPP, OPP and PLA and stored at 4°C on 21 days of storage were 5.19, 4.30, 4.03 per cent respectively. Similarly, the meat packed in CPP, OPP and PLA stored at -18°C on 21 day of storage were 6.35, 6.02 and 5.72 per cent respectively. From the analysis it was observed that the
\( F_{\text{crit}}(5.31) \) was lesser than the \( F_{\text{calc}}(7.78) \) value. Hence, from the table value it was observed that there was significant (\( P<0.05 \)) difference occurred between the treatments.

The loss in protein content during storage in the meat samples may be related with loss of \textit{sarcoplasmic} protein probably due to the osmosis and poor water holding capacity. \textit{Sarcoplasmic} protein (water soluble protein) may be lost during frozen storage in the form of drip loss. The result was supported by Baowu \textit{et al.}, (1997) and Konieczny \textit{et al.}, (2007) investigated that protein content of beef decreased during frozen storage.

![Fig 3.1 Effects of Modified Atmosphere Packaging of Meat on Protein Content During Storage](image)

<table>
<thead>
<tr>
<th>Storage Period, Days</th>
<th>Protein content, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0th day</td>
<td>6.3</td>
</tr>
<tr>
<td>7th day</td>
<td>6.1</td>
</tr>
<tr>
<td>14th day</td>
<td>6.0</td>
</tr>
<tr>
<td>21st day</td>
<td>5.8</td>
</tr>
<tr>
<td>7th day</td>
<td>6.2</td>
</tr>
<tr>
<td>14th day</td>
<td>6.1</td>
</tr>
<tr>
<td>21st day</td>
<td>5.9</td>
</tr>
<tr>
<td>7th day</td>
<td>6.2</td>
</tr>
<tr>
<td>14th day</td>
<td>6.2</td>
</tr>
<tr>
<td>21st day</td>
<td>5.8</td>
</tr>
</tbody>
</table>

*Fig 3.1 Effects of Modified Atmosphere Packaging of Meat on Protein Content During Storage*

#### 3.2 Effect on Colour

The Hunter color values (‘L’, ‘a’ and ‘b’) value of MAP meat stored at different temperature with different packaging material is given in Table 3.1. From the table it is observed that the color ‘a’ value of the goat meat was decreasing with increase in storage temperature and storage period.

Among the packaging materials CPP has found best in maintaining the color ‘a’ value of meat during storage followed by OPP and PLA. The ‘L’ and ‘b’ value of the meat was increasing with increasing the storage periods. Considering the storage temperatures -18°C has retained the color values then stored at 4°C. The initial L*, a* and b* value of meat was found as 62.41, 6.39, and 15.13. The L*, a* and b* value of meat packed in CPP, OPP and PLA stored at -18°C on 21 days of storage were 67.11, 5.06, 16.65; 68.79, 4.89, 16.98; 68.15, 4.56 and 19.64 respectively.
The values obtained on initial period were closely related to those found by Arguello et al., (2005) and Morales-delaNuez et al., (2009) for meat and goat meat respectively. The L* value was increased in all packaging treatments throughout the experimental period. Sensory attributes, especially the color of the meat, are of great relevance to the consumer’s choice at the point of sale (Bell, 2001). Balev et al., (2011) has observed that MAP beef has the stability in colour value during storage.

**Table 3.1 Effects of Packaging Materials and Storage Conditions on Color Values of meat during Storage**

<table>
<thead>
<tr>
<th>Packaging materials</th>
<th>Storage periods</th>
<th>0</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>7</th>
<th>14</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>4°C Storage</td>
<td>L*</td>
<td>62.41</td>
<td>63.71</td>
<td>64.52</td>
<td>68.39</td>
<td>64.40</td>
<td>66.57</td>
<td>69.21</td>
<td>65.59</td>
<td>66.11</td>
<td>70.06</td>
</tr>
<tr>
<td></td>
<td>a*</td>
<td>6.39</td>
<td>6.16</td>
<td>5.15</td>
<td>4.15</td>
<td>6.06</td>
<td>4.29</td>
<td>3.56</td>
<td>6.03</td>
<td>4.18</td>
<td>3.36</td>
</tr>
<tr>
<td></td>
<td>b*</td>
<td>15.13</td>
<td>16.07</td>
<td>16.88</td>
<td>17.42</td>
<td>16.94</td>
<td>17.29</td>
<td>18.11</td>
<td>17.19</td>
<td>19.12</td>
<td>20.15</td>
</tr>
<tr>
<td>-18°C Storage</td>
<td>L*</td>
<td>62.41</td>
<td>63.27</td>
<td>64.49</td>
<td>67.11</td>
<td>64.25</td>
<td>64.89</td>
<td>68.79</td>
<td>65.01</td>
<td>65.89</td>
<td>68.15</td>
</tr>
<tr>
<td></td>
<td>a*</td>
<td>6.39</td>
<td>6.05</td>
<td>5.71</td>
<td>5.06</td>
<td>6.24</td>
<td>5.27</td>
<td>4.89</td>
<td>6.21</td>
<td>5.11</td>
<td>4.56</td>
</tr>
<tr>
<td></td>
<td>b*</td>
<td>15.13</td>
<td>15.88</td>
<td>16.07</td>
<td>16.65</td>
<td>15.97</td>
<td>16.56</td>
<td>16.98</td>
<td>17.11</td>
<td>18.23</td>
<td>19.64</td>
</tr>
</tbody>
</table>

**3.3 Effect on pH**

The pH content of MAP meat stored at different temperature with different packaging material is given in Fig. 3.2. From the figure it is observed that the pH content of goat meat was decreasing with increase in storage temperature and storage period.

Among the packaging materials CPP has found best in maintaining the pH content of meat during storage followed by OPP and PLA. Considering the storage temperature -18°C has retained the pH content then stored at 4°C. The initial pH content of meat was found as 7.01. The pH content of meat packed in CPP and stored at -18°C on 21 days of storage were 6.93, 6.91 and 6.52 respectively. From the analysis it was observed that the \( F_{\text{calc}}(5.32) \) was lesser than the \( F_{\text{calc}}(5.39) \) value. Hence, from the table value it was observed that there was significant (P<0.05) difference occurred between the treatments. Similar values of final pH have been reported by Marichal et al., (2003) and Morales-dela Nuez et al., (2009) in the same breed and LWS.
3.4 Effect on Water activity

The water activity content of MAP meat stored at different temperature with different packaging material is given in Fig. 3.3. From the figure, it is observed that the water activity content of goat meat was increasing with increase in storage temperature and storage period.

Among the packaging materials CPP has found best in maintaining the water activity content of meat during storage followed by OPP and PLA. Considering the storage temperature -18°C has maintained the water activity content then stored at 4°C. Considering the interaction between temperature and packaging materials, the differences is not significant. The initial water activity content of meat was found 0.97. The water activity content of meat packed in CPP, OPP and PLA and stored at at -18°C on 21 day of storage were 0.98, 0.98 and 0.99 respectively. From the analysis it was observed that the $F_{calc}$ was lesser than the $F_{crit}$ value. Hence, there was significant (P<0.05) difference occurred between the treatments.
4. Conclusion

Modified atmosphere packaging and low storage temperature of meat enhanced the shelf during storage in different packaging materials. Quality parameters of meat samples degraded significantly (P<0.05) with the elapse of storage period. Quality parameters also varied among the samples. Among the packaging materials coated PP has found best in maintaining the quality parameters such as protein, colour, pH and water activity of meat during storage followed by OPP and coated PLA. Considering the storage temperature -18°C has maintained the protein content and other quality parameters then stored at 4°C.

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