Effect of Vacuum Packaging Method on Shelf Life of Chicken

Rufina Mathew1, Dorothy Jaganathan2 & S. Anandakumar2
1Research Scholar, Department of Food Service Management and Dietetics, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore.
2Professor, Department of Food Service Management and Dietetics, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore
2Scientist, Indian Institute of Crop Processing Technology, Thanjavur

Abstract: The effect of vacuum packaged shelf life of chicken is being investigated at different storage temperatures with different Low density polyethylene (LDPE) packaging materials. The study was carried out for 60 days and analysed for chemical and microbial parameters. Vacuum packaging effectively retarded the growth of microbial spoilage at freezing temperature and there was a gradual reduction in protein and fat levels.

INTRODUCTION

Meat is recognized as one of the most perishable foods. This is due to its chemical composition that favours microbial growth to unacceptable levels contributing significantly to meat deterioration or spoilage (Fung et.al., 2010). When large numbers of microorganisms are present in raw meat, there will be changes such that it becomes unappealing and unsuitable for human consumption (Gram et.al., 2002). Microorganisms are known to show greater tolerance to single adverse factors when other environmental conditions are optimal for survival and growth. The microbial spoilage of meat can be classified as aerobic or anaerobic, depending on the conditions under which it occurs and the microorganisms involved (Hedrick et.al., 2001). Packaging of poultry meat and meat based products has always been challenging because of their perishable nature due to high sensitivity of spoilage and pathogenic organisms (Fontes et.al., 2011).

Pale, dry and exudative meat is a meat quality defect that affects important meat physical properties, such as water holding capacity and ultimate pH, which may reduce the quality of further processed chicken meat products (Komiyama, 2006). In order to obtain products with high conservation durability and to increase the refrigeration effect, it is necessary to have as less initial microbial load as possible (Tofan, 2005).

Initially, chicken meat quality was evaluated by determination of microbiological and sensorial attributes. For the identification of the early signs of meat alteration, some chemical indices were proposed: volatile nitrogen basis, composites resulted after breaking the nucleotides, volatile acidity and the biogenic amine content (Halsz et.al., 1994).

The properties of meat that are important in determining shelf life include water binding capacity, color, microbial quality, lipid stability and palatability. The variables that influence the shelf life of packaged fresh meat are: product, package and headspace, packaging equipment, storage temperature, and additives. Plastic film properties, shrinkage, strength, oxygen transmission, moisture transmission, and anti-fog agents are important for meat package materials (Smith, 2001).

Naveena et.al., (2015) studied the effect of aging on the physicochemical, textural, microbial and proteome characteristics of emu (Dromaius novaehollandiae) meat under aerobic packaging (AP) and vacuum packaging (VP) conditions at 4 ± 1°C for 9 and 15 days, respectively. Improvement (P < 0.05) in water-holding capacity, myofibrillar fragmentation index and protein extractability with aging was observed in emu meat cubes under both AP and VP conditions. Reduction (P < 0.05) in Warner-Bratzler shear force values was observed on the 6th and 15th day of aging compared with the 0th day in the AP and VP samples, respectively. The sodium dodecyl sulfate- polyacrylamide gel electrophoresis analysis revealed the appearance of 30-kDa protein bands, indicating extensive proteolysis on the 6th day and 9th day of aging in the AP and VP samples, respectively. Proteome analysis using two-dimensional gel electrophoresis revealed significant (P<0.01) changes in the number of differentially expressed protein spots in the AP and VP samples during aging.
Vacuum packaging is accomplished by evacuating all the air within a package and not replacing with another gas, then sealing that package (Davies, 1995, Brody, 1989). Vacuum packages for fresh meat increase the shelf life and thus improve the distribution efficiency and marketing of the product. Deterioration problems are minimized when the pH of the meat to be packaged is controlled and ideal storage temperatures are accurately maintained. Even at suitable refrigeration temperatures, however, meat may be subject to deterioration by microorganisms that are able to grow under these conditions in the absence of oxygen (Maria Lucila Hernández-Macedo et al., 2010).

Soon after packaging, the population of lactic acid bacteria is generally below the limit of detection (10 CFU / g), but it increases during storage (Jones, 2004). Lactic acid bacteria ferment glucose and other substrates that are present in meat. When these substrates are depleted, growth stops, typically when the population reaches 8 log/cm². The metabolic residues of most lactic acid bacteria are not eliminated, however, and can be identified as slightly acidic or milky tastes (Holley et al., 2005).

Debashis et al. (2013) estimated the optimum storage condition throughout the retail chain of duck sausage. PET/Poly and laminate of metalized PET/Poly with polyethylene pouches under aerobic and vacuum packaging stored in refrigerator (4±1°C) and freezer (-18±1°C) condition were considered in the experiment. They found that TPC, TPSC and YMC of the samples increased with the storage period.

Brown discoloration can be avoided or minimized by vacuum packaging, which is an acceptable method for lightly pigmented cuts of pork and chicken. Vacuum packaged meats have been marketed successfully for years in many countries. Vacuum packaged meats have been marketed successfully for years in many countries. However, the dark-purplish colour of deoxymyoglobin in vacuum packaged retail beef has not been accepted by consumers. To prevent browning, meat package oxygen levels must be less than 0.15 percent. Oxygen levels of 0.15 - 2.0 percent predispose fresh beef products to browning (Mancini and Hunt, 2005).

Davies et al., (1989) described vacuum packaging, in which a pressure differential exists between the package exterior and interior. This differential can cause package collapse of rigid packages, but is well suited for some types of flexible packaging. The gaseous atmosphere is likely to change during storage due to respiration of the fresh food product (meat or plant) or the metabolism of microorganisms. Pavankumar, et al., (2003) investigated the effects of vacuum packaging on the microbiological quality of tandoori chicken stored at 4 ±1°C or -18°C. Chicken stored without vacuum packaging served as a control. Microbiological quality of tandoori chicken under vacuum was unacceptable after 15 days storage at 4 ±1°C, compared to 6 days storage without vacuum packaging.

Naveena, et al., (2014) studied the microbial quality of few emulsion-based meat products from chicken under vacuum packaging conditions during refrigerated storage. They found that Total plate counts and psychrotrophic counts remained lower (P<0.05) throughout the storage for croquettes compared with nuggets or patties. Based on lipid oxidation and microbial quality, it was concluded that moist-cooked nuggets, dry-cooked patties and deep-fat fried croquettes were stable for 40, 60 and 80 days at refrigerated storage under vacuum packaging. Naveena, et al., (2015) found that effect of aging on the microbial characteristics of emu (Dromaius novaehollandiae) meat under aerobic packaging (AP) and vacuum packaging (VP) conditions at 4 ± 1°C for 9 and 15 days, respectively.

Singh et al., (2002) observed that the product packed under vacuum or nitrogen gas remain organoleptically acceptable for 10 and 15 days under refrigerated and frozen storage as against 8 and 10 days long shelf life of aerobically packed samples under same storage conditions. Bhoyar et al., (1998) reported that sensory evaluation of both aerobically packaged and vacuum packaged restructured chicken steak sample showed that the product from both packaging group were quite acceptable at the end of day 60 during frozen storage. However, vacuum packed product was rated higher in colour, flavor, juiciness, texture and overall acceptability, whereas, finding of Rajkumar et al., (2004) proposed that vacuum packaging has definite advantages in preserving the sensory quality of patties but not enable extension of shelf life beyond 15 days.

Sahoo et al., (1998) described the sensory quality of frozen ground buffalo meat by preblending with natural antioxidant and vacuum packaging and they observed that, vacuum packaging samples had lower amount of salt extractable proteins and colour and odour score as compared to aerobically packed samples. Zhao et al., (1996) studied the physical chemical and sensory characteristics of irradiated pork loin cut and reported that improvement of surface colour and odour in irradiated pork can be achieved by suitable packaging environment i.e. vacuum and CO2 atmospheres.

Control of moisture is also important for food preservation. In most cases, the packaging material itself is responsible for the control of...
moisture transfer between the internal and external environment, providing an adequate barrier. There are situations however, where a greater control is needed to avoid the build-up of liquid water inside the package, therefore requiring liquid water control or humidity buffering as in the case of transpiration of fresh produce, melting of ice in fish transportation, temperature fluctuation in high water activity food packages and drip of tissue fluid from cut meats and produce (Rooney et al., 1995).

Under vacuum packaging, the oxygen supply is restricted, and the gas phase is determined by the rate of gas permeation through the film and the rate of oxygen consumption. Consequently, these changes have a selective effect on the microbial population (Cayre’, Garro, & Vignolo, 2005) because the low oxygen supply restricts the growth of some typical spoilage bacteria, such as Pseudomonas (Cayre’, Vignolo, & Garro, 2003).

MATERIALS AND METHODS

A 2.5 kg cut of fresh meat (Chicken without skin) was purchased about 24 hours after slaughter from the local meat shop at Thanjavur, Tamilnadu. Each refrigerated meat cut will be divided into small pieces (each weighing about 10 g) after the superficial meat layer (∼0.5 cm) had been removed to restrict contamination. Cutting was carried out at ambient temperature with a sterile knife, and each piece was immediately placed in a sterile plastic bag sealed. The synthetic materials used for meat packaging is Low Density Polyethylene (LDPE) bags with different gauge thickness (50µm, 62.5µm, 80µm) and final vacuum using a vacuum-packaging machine. Samples were analyzed after 0, 15, 30, 45 and 60 days of storage at 4°C, -18 °C and -24°C, respectively. All experiments were carried out in duplicate.

Samples of meat was collected following specified methods of Indian standards viz. IS/ISO 3100-1:1991 (Meat and Meat Products-method of sampling) and IS 15478. The samples were analysed for microbial profile using standard procedures. Microbiological data was transformed into logarithms of the number of colony-forming units. Crude protein content was calculated by converting the nitrogen content determined by Kjeldahl’s method (6x25 N). Fat was determined by the method described by the AOAC (2003) using a Soxhlet automated system. Water activity of meat was measured by Aqua lab water activity meter.

RESULTS AND DISCUSSION

Table 1. Changes in Total Platelet Count of Vacuum packed Chicken

<table>
<thead>
<tr>
<th>s. No</th>
<th>Thickness, µm</th>
<th>Temperature, °C</th>
<th>0th day</th>
<th>15th day</th>
<th>30th day</th>
<th>45th day</th>
<th>60th day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>50.0</td>
<td>4</td>
<td>10x10⁵</td>
<td>42x10⁵</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-18</td>
<td>10x10⁵</td>
<td>24x10³</td>
<td>18x10²</td>
<td>3x10⁵</td>
<td>3x10³</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-24</td>
<td>10x10⁵</td>
<td>10x10³</td>
<td>10x10³</td>
<td>3x10³</td>
<td>3x10³</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>62.5</td>
<td>4</td>
<td>10x10⁵</td>
<td>30x10³</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-18</td>
<td>10x10⁵</td>
<td>17x10³</td>
<td>30x10⁵</td>
<td>20x10⁴</td>
<td>15x10⁴</td>
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</tr>
<tr>
<td></td>
<td>-24</td>
<td>10x10⁵</td>
<td>15x10³</td>
<td>10x10³</td>
<td>10x10⁵</td>
<td>5x10⁵</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>80.0</td>
<td>4</td>
<td>10x10⁵</td>
<td>30x10³</td>
<td>-</td>
<td>-</td>
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<td></td>
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<td>10x10⁵</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>-24</td>
<td>10x10⁵</td>
<td>18x10²</td>
<td>10x10³</td>
<td>10x10⁵</td>
<td>2x10⁵</td>
<td></td>
</tr>
</tbody>
</table>

It is observed that the microbial load of chicken meat was increasing with increasing the storage temperature and increasing the thickness of packaging materials. The control sample has shelf life of 18 hours and then spoilage occurs. At different thickness studied the chicken packed in LDPE bag at 80µm thickness has less microbial content during the storage periods. Considering the temperature, the chicken stored at -24°C was found less colony counts compared to -18 °C and 4°C. The vacuum packed chicken stored at 4°C has shelf life of 15 days and the TPC was found as 42x10⁵ cfu/ ml. Among the different treatments studied, the highest counts for TPC was noticed in 50µm followed by 62.5 and 80 µm LDPE vacuum packed chicken on 15th days of storage at 4°C were 42x10⁵, 30x10⁵and 30x10⁵ cfu/ ml respectively. The TPC content of 62.5 and 80 µm LDPE vacuum packed chicken on 60th day of storage at -18 °C and -24°C were 15x10⁵, 5x10⁵and 20x10⁴,2x10⁵ cfu/ ml respectively. The initial microbial content of chicken meat was found as 10x10⁵ cfu/ ml.
Figure 1. Effect of LDPE Thickness and Storage Temperatures on Water activity of Vacuum Packed Chicken Meat during Storage periods

The water activity (aw) of meat sample packed in packaging materials with different thickness has not differed significantly. Likewise, in a recent study, there was not much difference in water activity of meat samples kept at different temperatures. Water activity predicts the growth of microorganisms because microorganisms can only use available water, which differs considerably depending on the solute. The water activity increases with temperature. The moisture condition of a product can be measured as the equilibrium relative humidity (ERH) expressed in percentage or as the water activity expressed as a decimal. So aw of meat sample at refrigerated temperature (4°C) was higher than aw of meat sample at freezer temperatures (-18°C,-24°C) (Leistner et al., 1981).
Figure 2. Effect of LDPE Thickness and Storage Temperatures on Protein Content of Vacuum Packed Chicken Meat during Storage Periods

Considering, the temperature the chicken stored at -24°C has maintained protein value followed by -18°C and 4°C. The control sample has shelf life of 18 hours and then spoilage occurs. The vacuum packed chicken stored at 4°C has shelf life of 15 days and the protein value was found as 8.62 per cent.

Among the different treatments studied, the least protein content was noticed in 50µm, 62.5 and 80 µm LDPE vacuum packed chicken on 15th days of storage at 4°C were 8.62, 9.17 and 8.76 per cent respectively. The protein content of 62.5 and 80 µm LDPE vacuum packed chicken on 60th day of storage at -18°C and -24°C were 8.47 and 8.63; 7.64 and 7.85 per cent respectively.
Figure 3. Effect of LDPE Thickness and Storage Temperatures on Fat Content of Vacuum Packed Chicken Meat during Storage Periods

From the figure 1.3, it is observed that the fat content of chicken meat was decreasing with increasing the storage temperature and decreasing the thickness of packaging materials. At different thickness studied the chicken packed in LDPE bag at 80µm thickness has maintain the fat content during the storage periods. Considering, the temperature the chicken stored at -24°C has higher...
fat value followed by -18°C and 4°C. The vacuum packed chicken stored at 4°C has shelf life of 15 days and the fat value was found as 0.7 per cent.

Among the different treatments studied, the least fat content retention (0.7 per cent) was noticed in 50µm, 62.5 and 80 µm LDPE vacuum packed chicken on 15th days of storage at 4°C were 0.7, 0.73 and 1.15 per cent respectively. The fat content of 62.5 and 80 µm LDPE vacuum packed chicken on 60th day of storage at -18°C and -24°C were 1.12 and 1.17; 1.20 and 1.28 per cent respectively. The initial fat content of chicken meat was found as 1.80 per cent.

REFERENCES


