

Research Article

Shelf-life extension of fried battered chicken by modified atmosphere packaging

Punchira Vongsawadi*, Aporn Wongwichan, Nongpanga Khunajakr and Niporn Dejsuk

Department of Microbiology, King Mongkut's University of Technology Thonburi, Bangkok, Thailand

* Author to whom correspondence should be addressed, email: punchira.von@kmutt.ac.th

This paper was originally submitted for presentation at SDSE2008.

Abstract: The objective of this study was to determine the effect of modified atmosphere packaging (MAP) on the quality and shelf-life of chilled fried battered chicken. The fried battered chickens were packed in air (control) and under MAP conditions (20%CO₂+80%N₂, M1; 40%CO₂+60%N₂, M2; 60%CO₂+40%N₂, M3). All treatments were stored under refrigeration at 4±1°C. The results indicated that MAP conditions and storage time had no effects on water activity, moisture content and pH of all samples ($P \geq 0.05$). The samples kept under MAP conditions showed significantly lower thiobarbituric acid (TBA) values as compared to the control sample ($P < 0.05$). MAP was effective for inhibiting growth of total viable counts (TVC) and yeasts and molds. The higher the CO₂ concentration, the higher the inhibition recorded. Counts of *Escherichia coli* and coliforms were less than 2 log cfu/g, whereas no *Salmonella* sp. and *Listeria monocytogenes* were detected in all samples, irrespective of the packaging conditions throughout the storage period. Sensory analysis revealed that the products were better preserved under MAP conditions. Physicochemical, microbiological and sensorial data indicated that the shelf-life of aerobically packaged fried battered chickens was around 10 days. MAP could extend product shelf-life to 20 days under M1 and 60 days under M2 and M3.

Keywords: food, poultry, storage, refrigeration, MAP, contamination, microbiology

Introduction

Chicken production has been growing steadily worldwide since the early 1990s. The increase is attributable to a number of factors, including surging production in emerging markets such as Brazil and Thailand and greater demand in Western countries for high-protein, low-carbohydrate products (http://www.agr.gc.ca/poultry/prindc2_e.htm#sec21). With the outbreak of avian influenza (AI) in early 2004, chicken consumption had been declining steadily. Thai producers have had to innovate by introducing a stream of new products ranging from de-boned ready-to-cook products to further-processed products. Fried battered chicken is one of the more popular recipes. However, the product still contains some oil and this makes its shelf-life short due to lipid oxidation. Though freezing could retard the oxidation process, it does affect the texture, colour, juiciness and flavour of the food [1]. For this reason, a combination of different preservation techniques, such as chilling and gas packaging are used to achieve multi-target, mild but reliable preservation effects. Gas packaging or modified atmospheric packaging (MAP) is successfully used with various types of products, including fruit and vegetables, meat and meat products and seafood [2-4]. The aim of this study was to investigate the effect of modified atmosphere packaging (MAP) on physicochemical, microbiological and sensorial qualities of fried battered chicken during storing at $4\pm 1^{\circ}\text{C}$.

Materials and Methodology

Materials

Fried battered chicken was obtained from Saha Interfood, a major chicken producer based in Lopburi, Thailand.

Sample preparation

Fried battered chicken samples (ca. 150 g) were placed on a polystyrene (PS) tray and packed in a nylon/LLDPE pouch (85 μm in thickness; oxygen transmission rate (OTR) of $101.4\text{ cm}^3/\text{m}^2\text{ day atm}$ at 0%RH 23°C ; carbon dioxide transmission rate (CO_2TR) of $74.5\text{ cm}^3/\text{m}^2\text{ day atm}$ at 0%RH 23°C ; and water vapour transmission rate of $1.64\text{ g}/\text{m}^2\text{ day}$ at 100%RH 23°C). Gas mixtures were prepared by using a gas mixer (WITT MM-2G, Germany). The following MAP conditions were applied: 20% CO_2 +80% N_2 (M1), 40% CO_2 +60% N_2 (M2) and 60% CO_2 +40% N_2 (M3). The gas concentrations in packages were monitored by gas analyzer (Servomex, Model 1450, UK). Pouches were heat-sealed using a vacuum sealer (Multivac C200, Germany) and kept at $4\pm 1^{\circ}\text{C}$. For control, identical fried battered chicken samples were packed in air and kept under the same conditions. Samples from each treatment were randomly taken at 5 day intervals for analysis of quality and storage life.

Physicochemical analysis

Water activity was determined using a_w meter (Novasina, TH-500, Switzerland). Moisture content was determined by oven drying of 5 g of sample for 20-24 hr. according to AOAC [5]. The pH value was recorded using pH meter (Metrohm, Switzerland). Samples were thoroughly homogenized with 10 ml of distilled water and the homogenate

was used for pH determination. TBA was determined according to the method proposed by Pearson [6] and expressed as mg malonaldehyde/kg sample.

Microbiological analysis

A sample (25 g) was removed aseptically and transferred to 225 ml of sterile 0.1% peptone water solution. The sample was homogenized for 30 seconds. A 10-fold dilution was made of the peptone water as needed for plating. For microbial enumeration, 0.1 ml samples of serial dilution of chicken homogenates were spread on the surface of dry media.

Total plate count was performed on plate count agar (Merck, Germany). The samples were incubated at $35\pm 2^{\circ}\text{C}$ for 1-2 days. Yeasts and molds were enumerated using acidified potato dextrose agar (Merck, Germany) after incubating at $30\pm 2^{\circ}\text{C}$ for 3 days. *E. coli*, coliform and *Listeria monocytogenes* were determined on Petrifilm™ E. coli count, Petrifilm™ rapid coliform count, and Petrifilm™ Environmental Listeria plates (3M, Germany), respectively after incubation at $35\pm 2^{\circ}\text{C}$ for 1 day. *Salmonella* sp. was determined by enriching in selenite-cystine broth (Difco, UK) and incubating at $35\pm 2^{\circ}\text{C}$ for 1 day. Isolations were performed on SS agar (Difco, UK), brilliant green agar (Difco, UK) and bismuth sulphite agar (Difco, UK), then incubated at $35\pm 2^{\circ}\text{C}$ for 1 day. Suspected colonies were tested biochemically by the methods as described in the Food and Drug Administration Bacteriological Analytical Manual (<http://www.cfsan.fda.gov/~ebam/bam-5.html>). Three replications of at least three appropriate dilutions were enumerated.

Sensory evaluation

The sensory qualities of batter fried products were evaluated by a ten member trained panel who were trained for a period of 1 month to familiarize them with the sensorial attributes of fried battered chicken. Panelists were asked to evaluate the samples in terms of appearance (1 = extreme discolouration due to microorganism or chemical oxidation, etc.) to 5 = natural fried battered chicken appearance), odour (1 = extremely oily or rancid to 5 = natural fried battered chicken odour), texture (1 = extremely mushy meat with soft crust to 5 = firm meat with crispy crust) and acceptability (1 = dislike very much to 5 = like very much). The acceptability score of 3.0 was taken as the lower limit of acceptability.

Statistical analysis

Data analysis was based on ANOVA and presented as mean values with standard deviations. Duncan's multiple range test was used to determine significant differences between the mean values of treatments ($\alpha=0.05$). All analyses were performed in triplicate.

Results and Discussion

Chemical analysis

Changes in water activity and moisture content during storage of fried battered chickens both in air and under MAP conditions at $4\pm 1^{\circ}\text{C}$ were not significantly different ($P\geq 0.05$). The water activity and moisture content (Figure 1) of all samples were in the range of

0.937-0.955 and 62.83-66.83%, respectively. Gas mixture conditions and storage time did not have significant effects on pH of the precooked chicken ($P \geq 0.05$). The pH of the samples was 6.83 ± 0.01 at the beginning and was 6.52-6.59 at the end of storage time.

TBA values of precooked chicken fillet are presented in Figure 2. The TBA values of fried battered samples increased as storage time progressed. TBA values of fried battered chicken in air packages were significantly higher than those under MAP conditions ($P < 0.05$). They had a TBA value of 8.51 ± 0.08 mg malonaldehyde/kg sample after storing for 50 days, whereas those packed under MAP conditions showed TBA values within the range of 1.56-5.26 mg malonaldehyde/kg sample during the same period. This observation indicates that the presence of oxygen in the package is a critical factor influencing lipid oxidation. The increment of CO_2 from 20% (M1) to 60% (M3) significantly affected this parameter ($P < 0.05$). At the end of the experiment, TBA values were 7.44, 2.85 and 2.51 mg of malonaldehyde/kg, respectively. The increment of TBA values of the samples packed under MAP conditions resulted from O_2 which permeated through the packaging materials. From the experiment, CO_2 concentration of 40% and 60% were effective in inhibition of lipid oxidation. This finding is in agreement with Sawaya *et al.* [7] who reported that the production of free fatty acids in poultry meat was limited when CO_2 concentration ranging from 30-70% was used.

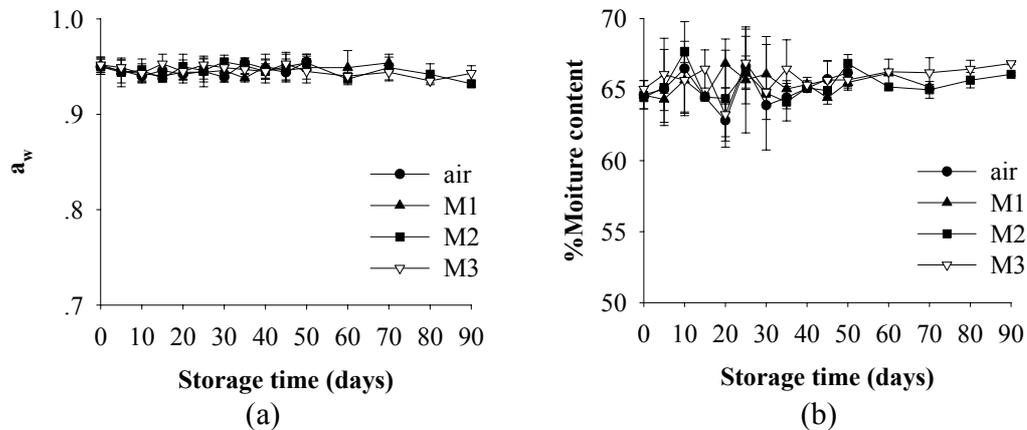


Figure 1. Changes in water activity (a) and moisture content (b) of chilled fried battered chickens packed in air and under MAP conditions (M1 = 20% CO_2 + 80% N_2 , M2 = 40% CO_2 + 60% N_2 and M3 = 60% CO_2 + 40% N_2).

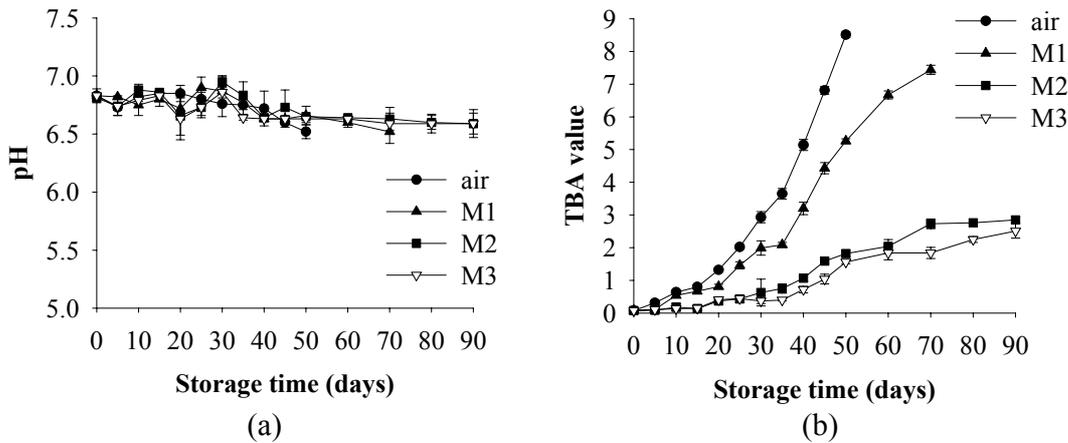


Figure 2. Changes in pH (a) and thiobarbituric acid;TBA value (b) (mg of malonaldehyde/kg) of chilled fried battered chickens packed in air and under MAP conditions (M1 = 20%CO₂ + 80% N₂, M2 = 40%CO₂ + 60% N₂ and M3 = 60%CO₂ + 40% N₂).

3.2. Microbiological analysis

The present study focused on the monitoring of the following species of microorganisms: TVC, yeasts and molds, *E. coli*, coliform, *Listeria monocytogenes* and *Salmonella* sp. The results showed that total plate counts were similar for the sample packed in air and those packed under MAP during 15 days but were lower with CO₂ concentration after 20 days. (Fig. 3a). TVC of the samples packed in air and M1 reached the value of 5 log cfu/g, which is considered as the upper acceptability limit for cooked poultry meat as defined by the International Commission on Microbiological Specifications for Foods (ICMSF) [8] on days 40 and 50 of storage, respectively. The M2 and M3 gas mixture package samples did not reach this value throughout the 90 days of storage period under refrigeration. A similar trend was observed for yeasts and molds, which also were strictly aerobic microorganisms. The microbial counts kept in air packages reached 2.4±0.10 log cfu/g on days 15 of storage while those packed under M1 reached 2.20±0.2 log cfu/g on day 25 of storage (Fig. 3b). In our study, yeasts and molds could not be detected in the samples packed under M2 and M3. According to ICMSF, the upper acceptability limit of yeast and mold for cooked poultry meat is 2 log cfu/g [8]. This indicated that the samples packed in air and under M1 failed to inhibit the growth of yeasts and molds after 10 and 20 days of storage period, respectively. MAP consisting of 40% and 60% CO₂ was effective in extending the lag phase or reducing the growth rate of microorganisms. This observation was in agreement with the previous reports by Layrisse and Matches [9], who found that CO₂ showed a spoilage delay of spotted shrimps by inhibiting psychotrophic, aerobic and gram negative bacteria.

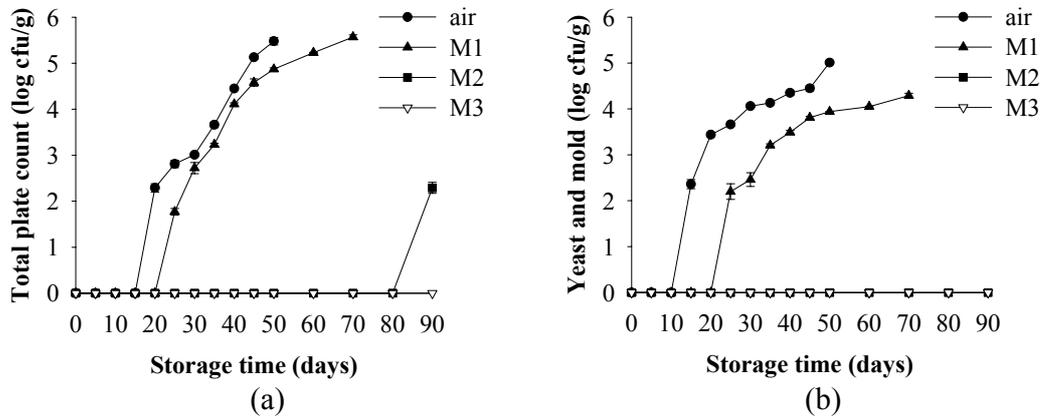


Figure 3. Changes (log cfu/g) in total viable count (a); yeast and molds (b) of chilled fried battered chickens packed in air and under MAP conditions (M1 = 20%CO₂ + 80%N₂, M2 = 40%CO₂ + 60%N₂ and M3 = 60%CO₂ + 40%N₂).

In this study, it was found that the number of *E. coli* and coliforms were less than 2 log cfu/g in all fried battered samples, irrespective of the air and MAP packages throughout the storage period (results not shown). According to Holzapfel [10], *Enterobacteriaceae* is sensitive to extrinsic factors such as heat. Therefore, deep frying at 180-190°C is sufficient to eliminate this microorganism. No *Salmonella* sp. and *Listeria monocytogenes* was found in all samples (results not shown). These findings coincided with the work of Gill and Reichel [11] who reported that cold tolerant pathogens did not grow on high pH meat in oxygen free carbon dioxide packaging atmospheres. The results from this study indicated that MAP could ensure the absence of coliforms and pathogens which in turn could endanger consumer safety.

Sensory evaluation

In comparison with the samples packed in air, MAP samples showed a significant delayed decrease in sensory scores in terms of appearance, odour and texture (Fig.4). Significant decrease in acceptability scores of samples packed in air and under M1 resulted from product appearance along with green and black spots on the surface of the samples (sign of microbial growth). This inspection agreed with TVC and yeast and mold results (Fig.3). On the other hand, the decrement of acceptability scores of samples packed under M2 and M3 which gradually decreased during storage time was mainly due to rancid odour, which agreed well with the changes in TBA values.

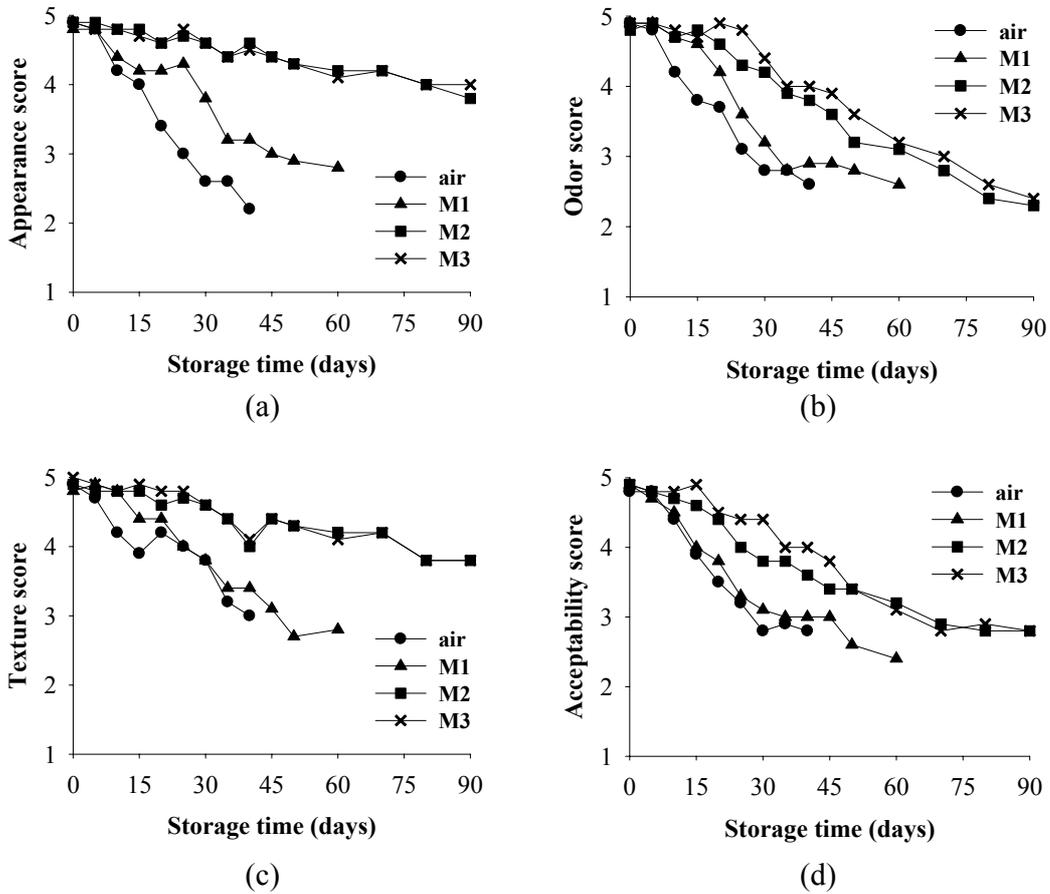


Figure 4. Appearance score (a); odour score (b); texture score (c) and acceptability score (d) of chilled fried battered chickens packed in air and under MAP conditions (M1 = 20%CO₂ + 80%N₂, M2 = 40%CO₂ + 60%N₂ and M3 = 60%CO₂ + 40%N₂).

Conclusions

The limiting factor for the samples packed in air packaging and M1 was microbial spoilage, whereas that for those in modified atmospheric packaging it was lipid oxidation. Based on physicochemical, microbiological and sensorial data, the shelf-life of fried battered chicken in air packaging was around 10 days. Modified atmospheric packaging could extend product shelf-life to 20 days under M1 and 60 days under M2 and M3.

Acknowledgements

The authors would like to thank Saha Interfood, Lopburi, for providing chicken samples. This research was supported by the Faculty of Science, King Mongkut's University of Technology Thonburi.

References

1. Alarcon-Rojo, A.D. 2004. Frozen Poultry: Process flow, equipment, quality and packaging. pp 239-244. In Y.H. Hui, P. Cornillon, I.G. Legaretta, M.H. Lim, K.D. Murrell, and W.K. Nip (eds.). Handbook of Frozen Foods, Marcel Dekker, Inc. New York.
2. Saxena, A., Bawa, A.S. and Raju, P.S. (2008). Use of modified atmosphere packaging to extend shelf-life of minimally processed jackfruit (*Artocarpus heterophyllus* L.) bulbs. **Journal of Food Engineering**. 87: 455-466.
3. Lyver, A., Smith, J. P., Tarte, I., Farber, J.M. and Nattress, F. M.. (1998). Challenge studies with *Listeria monocytogenes* in a value-added seafood product stored under modified atmospheres. **Food Microbiology**. 15: 379-389.
4. Gok, V., Obuz, E. and Akkaya, L. (2008). Effect of packaging method and storage time on the chemical, microbiological, and sensory properties of Turkish pastirma- a dry cured beef product. **Meat Science**. 80: 335-344.
5. AOAC. 1990. Official Methods of Analysis. 15th ed. The Association of Official Analytical Chemists. Arlington. Virginia, USA. 1298p.
6. Pearson, D. (1976). The *chemical analysis of foods*. Chemical Publishing Co. Inc. New York, USA. pp 642-643.
7. Sawaya, W.N., Elnawawy, A.S., Abu-Ruwaida, A.S. Khalafawi, S. and Dashti., B. (1995). Influence of modified atmosphere packaging on shelf-life of chicken carcasses under refrigerated storage conditions. **Journal of Food Safety**. 15: 35-51
8. ICMSF (International Commission on Microbiological Specifications for Foods). (2002). Microorganisms in foods 7. *Microbiological testing in food safety management*. Kluwer academic/Plenum publishers. Springer. London, UK.
9. Layrisse, M.E. and J.R. Matches. (1984). Microbiological and chemical changes of spotted shrimp (*Pandalus platyceros*) stored under modified atmosphere. **Journal of Food Protection**. 47: 453-458.
10. Holzapfel, W.H. (1998). The gram-positive bacteria associated with meat and meat products.. In A. Davis, R. Board (Eds.). *Microbiology of meat and poultry*. Blackie Academic and Professional. London, UK. pp 35-84.
11. Gill, C.O., and M.P. Reichel. (1989). Growth of the cold tolerant pathogens *Yeshinia enterocolitica*, *Aeromonas hydrophila* and *Listeria monocytogenes* on high pH beef packaged under vacuum or carbon dioxide. **Food Microbiology**. 6: 223-230.