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Effects of modified atmosphere packaging on shelf life of roasted spicy chicken (*ayam percik*)

(Kesan pembungkusan atmosfera terubah suai terhadap jangka hayat ayam percik)

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Abstract

The effects of various gas compositions on roasted spicy chicken (*ayam percik*) during chill storage under modified atmosphere conditions were studied. Oriented nylon laminated with low density polyethylene (ONy/LLDPE) with 8 μm thickness was used as packaging materials for the *ayam percik*. To create the modified atmosphere conditions the packages were flushed with normal air (control, T1), 30% CO_2 + 70% N_2 (T2) and 40% CO_2 + 60% N_2 (T3). Evaluations were conducted at weekly intervals for microbiological and chemical analysis during chill storage at 2 ± 2 °C. *Ayam percik* packed in normal air spoiled after 4 weeks as indicated by high microbial counts. When the level of CO_2 was increased to 30% and 40% in the headspace of the packages, the shelf life of *ayam percik* was extended to 7 weeks.

Introduction

Consumer markets are showing an increased demand for a new class of processed foods such as ready-to-eat products. These products are most often consumed without further cooking, and therefore, the presence of pathogens is a considerable food safety threat (Muriana et al. 2002). There is great demand for a*yam percik*, an ethnic roasted spicy chicken, as a cooked product in ready-to-eat form. The product undergoes various stages of processing which include marinating, pre-cooking, grilling, basting and blast freezing. Ready-to-use *ayam percik* sauce has been developed both in paste and dehydrated form to be used either with fresh, chill or frozen chicken, either whole or chicken cuts. Faced with this demand, there is a need to develop techniques to maintain the natural qualities of ready-to-eat foods without chemical preservatives by using, for example, vacuum packaging or modified atmosphere packaging (MAP).

The elimination of O_2 from the packages and the introduction of different concentrations of CO_2 and N_2, together with adequate refrigeration, inhibit the growth of aerobic micro-organisms, proteolytic bacteria, yeasts and fungi. Initial bacterial population, temperature and gases are also important factors which affect shelf life. It has also been reported that nitrogen, an inert tasteless gas used as filler gas to replace O_2 (Church 1994) and CO_2 are probably related with a reduction in intra- and extracellular pH and the direct inhibition of enzymatic processes. This effect generally increases at lower temperature since solubility of

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CO_2 is enhanced, delaying spoilage by psychrotrophic, aerobic and gram negative bacteria (Lopez-Caballero et al. 2000; Ozogul et al. 2000).

This study was carried out to develop *ayam percik* in ready-to-eat form by using modified atmosphere packaging. The product was kept chilled at 2 ± 2 °C and needs to be reheated prior to consumption. It is targeted for consumers who are looking for convenience in preparation as well as familiar and identifiable flavour of *ayam percik*. The aim of this study was to investigate the shelf life of *ayam percik* stored in modified atmosphere packaging under chill condition.

Materials and methods

Preparation of ayam percik

Chicken portions were obtained from the local chicken suppliers. Raw materials and ingredients used in the basting sauce formulation consisted of coconut milk (68%), onion (6%), garlic (0.8%), dried chilli (0.8%), ginger (0.8%), lemon grass (0.4%), prawn paste (0.2%), tamarind paste (0.8%), flour (1.4%), sugar (3.7%), salt (1.1%) and water (16%). The raw chicken portions were deskinned, washed and marinated with spices consisting of 8% dried chilli, 66% onion, 8% garlic, 8% ginger, 4% lemon grass and 6% salt for 30 min prior to cooking. The marinated chicken meats were pre-cooked for 30 min. Convotherm oven was used to grill the *ayam percik* at 180 °C and the products were dipped in the basting sauce three times during the grilling process.

Packaging and storage of ayam percik

Oriented nylon laminated with linear low density polyethylene (ONy/LLDPE)(80 μm) was used in the study. The gas permeability of this film was measured using the Gas Transmission Rate Tester (Toyo Seiki MC 571, Japan). Prior to sealing, two pieces of the grilled chicken meat were packed in each bag after they had cooled down and then flushed with different combinations of carbon dioxide and nitrogen gases. The products were stored for 7 weeks at 2 ± 2 °C and reheated in the microwave oven at medium heat for 5 min prior to serving and further analysis.

Gas flushing system

The combination of gases flushed into the packages was obtained using a gas flushing system which has been set up in the Packaging Laboratory, Food Technology Research Center, MARDI (*Figure 1*). This system consists of nitrogen, carbon dioxide and oxygen tanks connected to the gas mixer

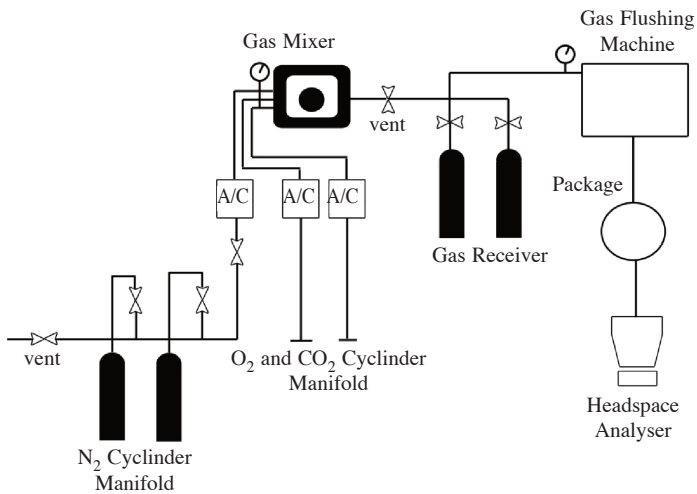

Figure 1. Gas flushing system for modified atmosphere packaging

with high pressure stainless steel tubing. The system allows continuous gas mixing and a constant concentration of gases was flushed into the package. The final ratio of gases was measured by Mocon Pack Check 400 (Modern Controls Inc., USA). The samples were packed in ONy/LLDPE with different gas ratio. The packages were flushed with normal air (T1) and mixture of gases which were 30% CO_2 + 70% N_2 (T2) and 40% CO_2 + 60% N_2 (T3).

Temperature profile of ayam percik

The temperature profile of *ayam percik* during storage in the chiller at 2 ± 2 °C was measured using thermocouples inserted into the middle part of the *ayam percik* flesh. All the data collected were stored in Channel Data Logger, Datataker DT5TK.

Quality analysis

pH The pH of the samples was determined using a portable pH meter (Metrohm Model 744, Herisau, Switzland). The readings were taken in duplicate immediately after flushing with gases and at weekly intervals during the 7 weeks storage period. Five g of *ayam percik* flesh was mixed with distilled water and blended prior to the analysis.

Free fatty acid (FFA) and peroxide value (PV) FFA and PV were determined using the AOAC method (1990). Each analysis was carried out in duplicate on one batch of freshly prepared samples and at weekly intervals for samples stored in modified atmosphere packaging.

Microbiological analyses Microbiological examination (total aerobic counts, yeast and mould, coliform count and *E. coli*) was carried out both on freshly prepared and stored samples. Analysis of freshly prepared samples was done immediately after gas flushing while the stored samples were done at weekly intervals. Duplicate samples (about 10 g) were taken and analysed separately. Samples were placed in sterile stomacher bags and homogenized with 90 ml Ringer's solution using a laboratory blender (Seward Stomacher Model 400, UK). From the homogenate, serial dilutions were prepared in Ringer's solution, and each dilution was poured into duplicate plates. Total aerobic bacterial counts were determined by poured plate methods using standard Plate Count Agar (ICMSF 1978). Yeast and mould counts were determined by the same method using Potato Dextrose Agar. Total coliform and *E. coli* in the homogenate were estimated by a poured plate method using Violet Red Bile Agar (AOAC 1990). All plates were incubated at 37 °C for 48 h. The microbes were counted and expressed as log cfu/g sample. Standard microbiological procedures were used for the detection of *Salmonella* sp. in the samples (ICMSF 1978).

Statistical analysis

All determinations were statistically analysed by analysis of variance (ANOVA) to determine significant differences between treatments and storage times. The analysis was conducted using the SAS computer programme statistical analysis system (SAS Inst. 1999). Means and standard deviations were calculated, and when F-values were significant at $p < 0.05$ level, the mean differences were separated by the least significance difference (LSD).

Results and discussion

Introduction of modified atmosphere packaging (MAP) techniques has solved some of the problems associated with the distribution of oxygen-sensitive foods (Brody 1989). *Figure 1* shows the gas flushing system that has been set up in Packaging Laboratory, Food Technology Research Centre, MARDI, Serdang and has been used for MAP of processed food products. Normal air (T1) and mixture of gases [30% CO_2 + 70% N_2 (T2) and 40% CO_2 + 60% N_2 (T3)] were flushed into the headspace of ONy/LLDPE packages containing roasted *ayam percik*. In MAP of poultry meat, oxygen is ideally excluded

since it can produce oxidative rancidity as well as permits aerobic spoilage organisms to grow (Smolander et al.1997). The packaging material (ONy/LLDPE) used in this study is considered as a high barrier two layered film. It has O_2 and CO_2 permeability at 1.2 and 5.6 cc.mil/100in^2.day.atm respectively.

Figures 2 and *3* show the results obtained for free fatty acids and peroxide value of *ayam percik* in different packaging conditions (T1, T2 and T3) up to 49 days storage at 2 ± 2 °C. There were significant differences between T1, T2 and T3 at week 1, between T1 and T2 at week 3, T2, T1 and T3 at week 5 and T2 and T3 at week 7. There was a slight increase in the oxygen content in MAP probably due to permeation of oxygen through the packaging material. Diffusion of residual oxygen trapped in *ayam percik*, even after flushing process may also contribute to slight increase in oxygen levels in the headspace of the packages which may contribute to the lipid oxidation process in *ayam percik*.

The conversion of hydroperoxide to peroxide from lipid oxidation is also used in monitoring the quality of meat products. Miller et al. (1980) reported that the thawing process leads to oxidation of lipid causing the development of peroxide. The quality of oil decreases and becomes rancid when peroxide value (PV) exceeds 10 mEq/kg sample (Pearson 1973). *Figure 3* shows the PV increased significantly at the $p < 0.05$ level for samples treated with T2 (1.39 to 1.99 mEq/kg), T1 (1.39 to 3.99 mEq/kg) and T3 (1.39 to 4.79 mEq/kg) until 3 weeks of storage. After that no significant differences ($p > 0.05$) were observed between normal air (T1) and modified packaging conditions (T2 and T3) until 7 weeks of storage. The PV for all treatments throughout the storage period did not exceed 10 mEq/kg sample.

No significant differences ($p > 0.05$) were found in pH of roasted *ayam percik* stored both in modified atmosphere and conventional packaging for 49 days at 2 ± 2 °C (*Figure 4*). At the end of the 7 weeks

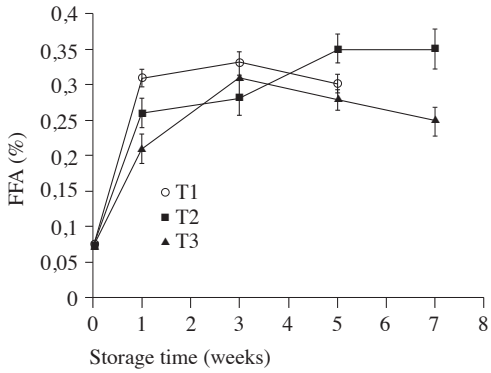

Figure 2. Changes in free fatty acids of ayam percik during storage

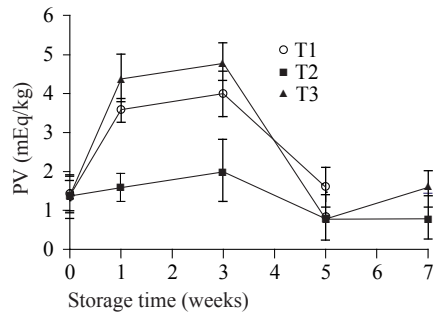

Figure 3. Changes in peroxide value of ayam percik during storage

storage period, the mean pH value for T1 decreased slightly from 7.63 to 7.5, T2 increased slightly from 7.57 to 7.62 and T3 decreased slightly from 7.59 to 7.53. The pH decreased during the first 2 weeks of storage due to reaction between CO_2 and H_2O to form carbonic acid. This explained why total plate count (TPC) for T2 and T3 did not increase for the first 2 weeks (*Figure 5*)

Modified atmosphere packaging offered an improvement in shelf life of roasted *ayam percik* as shown by the microbiological data in *Figure 5*. The combination of low temperature and the various gases replacing air in the storage atmosphere have proven to be effective in reducing the growth of normal aerobic spoilage bacteria (Farber 1991; Smiddya et al. 2002; John et al. 2005).

Figure 5 shows the TPC of modified atmosphere packaging of *ayam percik*

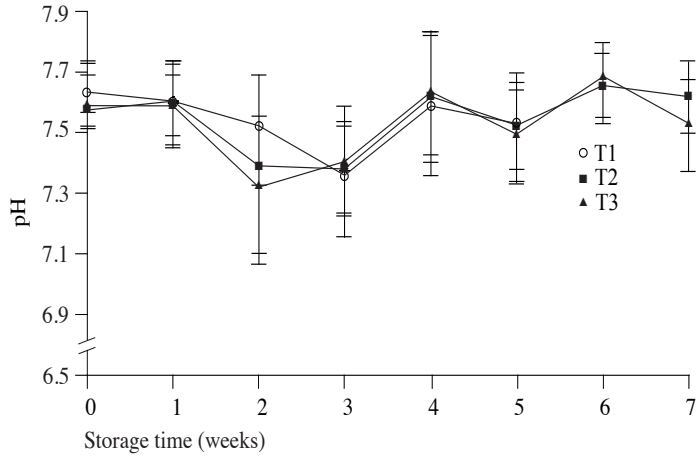

Figure 4. Changes in pH of ayam percik during storage

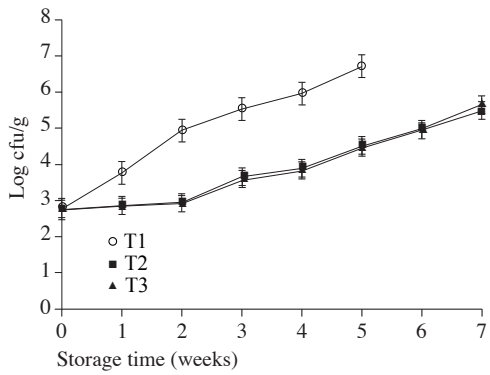

Figure 5. Changes in total plate counts of ayam percik during storage

Table 1. Microbiological evaluation of *ayam percik* during chill storage

Time (week)	Yeast and mould (cfu/g)	Coliform & *E. coli* (cfu/g)	*Salmonella* (cfu/g)
	T1, T2, T3	T1, T2, T3	T1, T2, T3
0	<1.0 x 10	-ve	-ve
1	<1.0 x 10	-ve	-ve
2	<1.0 x 10	-ve	-ve
3	<1.0 x 10	-ve	-ve
4	<1.0 x 10	-ve	-ve
5	<1.0 x 10	-ve	-ve
6	<1.0 x 10	-ve	-ve
7	<1.0 x 10	-ve	-ve

samples (T2 and T3 treatment) compared to control samples (T1). Initially no significant differences (p >0.05) were found between samples T1, T2 and T3. The initial TPC were low at 2.68 log cfu/g for all samples (T1, T2 and T3). No pathogens were found in any of the treatments. Coliform, *E. coli* and *Salmonella* were undetectable for all the different combination of gases throughout the studies as shown in *Table 1*. Mould growth which is an important microbial problem limiting the shelf life of high moisture products, can tolerate a low oxygen concentration and is simply delayed by MAP (Smith 1996). *Table 1* shows that yeast and mould counts were consistently <10 cfu/g sample for all treatments throughout the storage period. Low initial microbial counts are necessary to help ensure low contamination levels to successfully store processed products for extended periods of time.

The use of modified atmosphere in the headspace of the packages resulted in low growth of microbes as shown in *Figure 5*. After 28 days of storage, samples of *ayam percik* in T2 and T3 packages had significantly lower (p <0.05) TPC than the control (T1) samples. The TPC of T1 had reached 5.94 log cfu/g after 28 days of

storage, while counts for T2 and T3 were about 3.7 log cfu/g each. Even after 49 days of storage the TPC of T2 and T3 were 5.38 log cfu/g and 5.49 log cfu/g respectively which never exceeded T1. The significantly lower TPC (p <0.05) of samples packed in modified atmosphere indicated the advantage of this packaging method in extending shelf life.

Conclusion

The combination of modified atmosphere packaging and low storage temperature (2 ± 2 °C) can prolong the shelf life of *ayam percik* up to 7 weeks compared to 4 weeks when stored in normal air. The mixture of gases at 30% CO_2 + 70% N_2 and 40% CO_2 + 60% N_2 in the headspace of the packages resulted in low growth of microbes during the 7 weeks storage period. Therefore, ready-to-serve *ayam percik*, an ethnic dish, has been successfully developed in chilled form using modified atmosphere packaging.

References

AOAC (1990). *Official methods of analysis*.15th ed., Washington, DC: Association of Official Analytical Chemist

Brody, A.L. (1989). Modified atmosphere packaging of seafoods. In: *Controlled/ modified atmosphere/vacuum packaging of foods*. (Brody, A.L., ed.), p. 59–81. Trumbull, Connecticut: Food and Nutrition Press

Church, N. (1994). Developments in modified-atmosphere packaging and related technologies. *Trends in Food Science and Technology* 5: 345–352

Farber, J.M. (1991). Microbiological aspects of modified atmosphere packaging technology; a review. *J. Food Protection* 54: 58

ICMSF (1978). Microorganisms in food 1. In: *International commission on microbiological specifications for food* 2nd ed., p. 115–118, 158–159. Toronto, Buffalo, London: University of Toronto Press

John, L., Cornfortd, D., Carpenter, C.E., Sorheim, O., Pettee, B.C. and Whittier, D.R. (2005). Color and TBA values of cooked top sirloin steaks packaged in modified atmospheres of 80% oxygen, or 0.4% carbon monoxide, or vacuum. *Meat Science* 69: 441–449

Lopez-Caballero, M.E., Plerez-Mateos, M., Border!ıas, J.A. and Montero, P. (2000). Extension of the shelf life of prawns (*Penaeus japonicus*) by vacuum packaging and high-pressure treatment. *J. Food Prot*. 63: 1381–1388

Miller, A.J., Ackerman, S.A. and Palumbo, S.A. (1980). Effect of frozen storage on functionality of meat for processing. *J. Food Sci*. 45: 1466–1471

Muriana, P.M., Quimby, W., Davidson, C.A. and Grooms, J. (2002). Postpackage pasteurization of ready-to-eat deli meats by submersion heating for reduction of *Listeria monocytogenes*. *J. Food Prot*. 65: 963–969

Ozogul, F., Taylor, K.D.A., Quantick, O. and Zogul, Y. (2000). Chemical, microbiological and sensory evaluation of atlantic herring (*Clupea harengus*) stored in ice, modified atmosphere and vacuum pack. *Food Chem*. 71: 267–273

Pearson, D. (1973). *Laboratory techniques in food analysis*. London: Butterworth

SAS Inst. (1999). *Statistical analysis system,* version 8.0. Cary, N.C., USA: SAS Institute, Inc.

Smiddya, M., Papkovskaiab, N., Papkovskyb, D.B. and Kerrya, J.P. (2002). Use of oxygen sensors for the non-destructive measurement of the oxygen content in modified atmosphere and vacuum packs of cooked chicken patties: impact of oxygen content on lipid oxidation. *Food Research International* 35: 577–584

Smith, J.P. (1996). Improving shelf life of packaged baked goods by oxygen absorbents. *Technical Bulletin, American Institute of Baking* XVIII (4)

Smolander, M., Hurme, E. and Ahvenainen, R. (1997). Leak indicators for modified-atmosphere packages. *Trends in Food Science and Technology* 8 (April): 101–106

Abstrak

Kesan beberapa komposisi gas di dalam atmosfera yang diubah suai terhadap kualiti ayam percik pada penyimpanan sejuk dingin telah dikaji. Nilon berorientasi berlamina dengan polietilena ketumpatan rendah linear (ONy/LLDPE) dengan ketebalan 8 μm telah digunakan sebagai bahan pembungkus ayam percik. Untuk mewujudkan keadaan atmosfera terubah suai pembungkus ayam percik dipancut-cuci dengan udara sebagai kawalan (T1), 30% CO_2 + 70% N_2 (T2) dan 40% CO_2 + 60% N_2 (T3). Penilaian mikrobiologi dan kimia dijalankan setiap minggu ketika penyimpanan sejuk dingin pada 2 ± 2 °C. Ayam percik yang dibungkus dalam udara normal telah rosak selepas 4 minggu penyimpanan sebagaimana ditunjukkan oleh kiraan mikrob yang tinggi. Apabila tahap CO_2 di dalam ruang udara pembungkusan dinaikkan sehingga 30–40%, tempoh penyimpanan ayam percik dilanjutkan sehingga 7 minggu.

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