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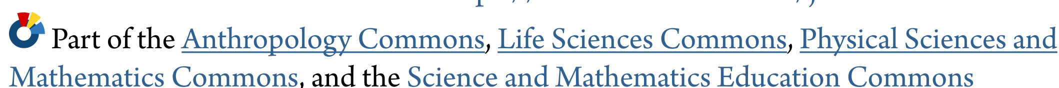
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Hot-Packaging Reduces Lipid Oxidation and Improves Sensory Characteristics of Cooked Turkey Meat[1]

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The effects of two vacuum packaging methods (hot and cold vacuum packaging) on the storage stability and sensory characteristics of cooked meat were compared. Ground turkey breast and leg meat patties were cooked, vacuum packaged appropriately, and stored up to 22 days. Lipid oxidation was measured by the thiobarbituric acid (TBA) test. In addition, Total aerobic count and sensory evaluation (flavor, juiciness, tenderness, overall acceptability) were conducted. There was no significant difference in aerobic plate count by packaging methods; however, panelist rating revealed that hot-packaged turkey leg meat had higher juiciness and overall acceptability scores than cold-packaged ones. Although TBARS (thiobatbituric acid reactive substances) values of all types of patties increased gradually, TBARS values of hot-packaged leg and breast were significantly lower than those of cold-packaged ones. Our results indicate that the hot-packaging method is superiot to the cold-packaging method in controlling lipid oxidation and improving sensory values.

INDEX DESCRIPTORS: packaging, lipid oxidation, sensory characteristics, turkey, TBARS

The consumption of precooked, uncured, poultry products have increased gradually in the past few years. Processed turkey meat products especially have achieved considerable recognition for their uniformly high quality and have gained wide consumer acceptance in the marketplace (Denton et al. 1987). These turkey meat products, however, have a high phospholipid content and can quickly become rancid (Labuza 1971).

Rancidity is an unacceptable flavor that develops from the reaction between oxygen and unsaturated fatty acids. Ahn et al. (1992) and Pikul et al. (1984) showed that phospholipids were responsible for about 90% of lipid oxidation, a major concern of the meat industry because of its deleterious effect on flavor, color, texture, and nutrients. Because lipid oxidation is initiated by oxygen, it is important to reduce oxygen availability for cooked meat products. Many substances and conditions have been used to prevent lipid oxidation.

One of the strategies to limit lipid oxidation is vacuum packaging. Commercially, cooked meat products are packaged after chilling for a few hours in a cold room. During chilling, the quality of these meat products can be adversely affected by the evaporation of moisture or contact with air or microorganisms. This can affect the total yield, degree of lipid oxidation, and microbial load. According to Froning et al. (1971), microbiological flora normally associated with further-processed poultry meats typically increases during refrigerated storage. With hot-packaging, meat is packaged immediately after cooking. So there is less air and microorganism exposure with and less water evaporation than with conventional cold-packaging. Ahn et al. (1993) showed that packaging cooked meat immediately after cooking was effective in preventing lipid oxidation because of reduced oxygen contact with meat.

Although some researchers have studied the effect of vacuum-packaging methods on lipid oxidation of meat products, the effect of these packaging methods on sensory properties and microbial growth are lacking. The objective of this study was to compare the effects of conventional and hot vacuum-packaging methods on lipid oxidation, sensory properties, and microbial growth in cooked turkey meat.

METHODS

Sample preparation

Fresh hand-deboned turkey breast and thigh meat without skin were obtained from a local turkey processor, ground twice in a Hobart meat grinder (Model 841850 through an 8-mm and a 3-mm plate. A total of 64 breast and 64 thigh meat patties (≈100 g each) were prepared for this study. All patties were divided into eight aluminum cooking pan and cooked in a preheated electric oven (350°C). Internal temperature (74°C) was measured by selecting two patties from each pan and inserting a thermomocouple at the center of those patties. After cooking, half of the patties were vacuum packaged immediately ("hot packaging") and another half of the patties were chilled in a refrigerator without any coverings and then vacuum-packaged after ten hours of storage ("cold packaging"). Each of four patties were packaged into one bag during both hot- and cold-vacuum packaging processes. Each bag was used for each experiment, therefore there were four replications in this study. One package from each treatment was used for each experiment day. All samples were stored up to 22 days at 4°C. Lipid oxidation was measured by the thiobarbituric acid (TBA) and fluorescence methods after 0, 7, and 14 days of storage. Total aerobic count and sensory evaluation (flavor, juiciness, tenderness, overall acceptability) were done after 0 and 21 days and 1 and 22 days, respectively.

Butylated hydroxyanisol (BHA), trichloroacetic acid (TCA) and 2-thiobarbituric acid (TBA) were obtained from Sigma. Thiobarbituric acid/tricholoroacetic acid (TCA/TBA) stock solution was prepared by dissolving 15% TCA (w/v) and *20 mM TBA in* DDW. BHA (72mg/mL) was dissolved in 98% ethanol. All chemicals used were reagent grade.

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Table 1. Effect of packaging and storage on the TBARS values (spectrophotometric method) of turkey breast and leg meat patties

Storage (days)	Breast Meat Patties		Leg Meat Patties	
	Hot pkg	Cold pkg	Hot pkg	Cold pkg
	TBARS (mg MDA[2]/kg meat)			
0[1]	1.53[by]	3.72[bx]	3.21[by]	5.30[bx]
7	5.39[a]	6.43[a]	8.66[ay]	11.35[ax]
14	4.34[ay]	6.81[ax]	5.13[by]	11.36[ax]

[1]0 day samples were analyzed 15 h after cooking.
[2]MDA: malondialdehyde.
[ab]Different letters within a column are significantly different ($P < 0.05$).
[xy]Different letters within a row of the same meat type are significantly different ($P < 0.05$).

Table 2. Effect of packaging and storage on the TBARS values (fluorescence method) of turkey breast and leg meat patties

Storage (days)	Breast Meat Patties		Leg Meat Patties	
	Hot pkg	Cold pkg	Hot pkg	Cold pkg
	TBARS (mg MDA[2]/kg meat)			
0[1]	1.10[by]	1.99[ax]	2.02[a]	2.51[b]
7	2.09[a]	1.99[a]	2.77[a]	3.16[a]
14	0.72[by]	1.34[bx]	0.78[by]	2.29[bx]

[1]0 day samples were analyzed 15 h after cooking.
[2]MDA: malondialdehyde.
[ab]Different letters within a column are significantly different ($P < 0.05$).
[xy]Different letters within a row of the same meat type are significantly different ($P < 0.05$).

Total fat and moisture analysis

Meat (2–3 g) was weighed into a test tube with 20 mL Folch solution (chloroform: methanol = 2:1, Folch et al. 1957), and homogenized with a polytron for 5–10 sec at high speed. BHA (7.2%, 100 μL) dissolved in 98% ethanol was added prior to homogenization. The homogenate was filtered through Whatman #1 filter paper into a 100 mL graduated cylinder (with glass stopper), and 5 mL of 0.88% NaCl solution was added, stoppered and mixed. The inside of the cylinder was washed twice with 10 mL of Folch 2 solution (3:47:48/$CHCl_3$:CH_3OH:H_2O). After the phase separation, the volume of lipid layer was recorded, and the top layer (methanol and water) of the solution was completely and carefully siphoned off so as not to contaminate the $CHCL_3$ layer. Organic layer (10 mL) was put in a glass scintillation vial, dried in a block heater (1 hr at 50°C) under nitrogen atmosphere, and used for the calculation of total fat.

Moisture content in meat was determined by using the AOAC method (AOAC 1990). Meat (3–4 g) was dried in a 110 C oven for 17 hr, and the moisture content was calculated as % value of meat.

Thiobarbituric acid reactive substances (TBARS) analysis

TBARS values were measured by spectrophotometric (Buege and Aust 1978) and fluorometric (Yagi 1987) methods with following modifications. Fluorometric method was developed to determine lipid opxidation products in blood and serom. Fluorometric method was reported to have higher sensitivity than spectrophotometric method (Yagi 1987), and was added in this study to find if it could be useful in cooked meat. Each patty was cut and weighed (5 g) into a test tube with 15 mL of deionized distilled water (DDW) and homogenized for 15 s at high speed. For the spectrophotometric method, the homogenate (1.0 mL) was transferred to a disposable test tube and mixed with 2 mL TBA/TCA solution. After heating in a 90°C water bath for 15 min, these samples were centrifuged at 2000× g for 15 min, and the absorbance was determined at 531 nm. For the fluorescence method, the homogenate (500 μL), prepared as previously described, was mixed with 200 μL of 8.1 % (w/v) lauryl sulfate, 1.5 mL of 20% (v/v) glacial acetic acid (pH 3.5), 1.5 mL of 0.53% (w/v) TBA, and 250 μL DDW. Samples were heated at 95°C for 15 min. After mixing with 5 mL n-butanol-pyridine (15:1 v/v), the samples were centrifuged at 3,000× g for 15 min. The upper layer was collected and quantified in a Fluorometer (535 nm excitation and 552 nm emission).

Sensory evaluation

The cooked patties were cut into quarter and warmed in a 700 watt microwave oven at 100% for 15 s, internal temperature of 54°C, before serving. Each wedge of each treatment was presented on a white paper plate coded with three-digit random numbers. Samples were evaluated by 16 panelists (male and female) aged 20 to 65 years in the Department of Animal Science at Iowa State University, who were experienced in sensory evaluation of turkey meat and were familiar with the sensory evaluation procedures. Panelists were carefully instructed the procedures and the definitions of the attributes and then asked to evaluate four sample pieces for flavor or off-flavor, juiciness, tenderness, and overall acceptability. Each panelist was instructed to seat separately to avoid eye contact and conversation. A 15-cm line scale was used, with low degree of the characteristics scored at 0 and high degree of the characteristics scored at 15. All four variations were presented at one time in random order at each session.

Total aerobic plate counts

Total aerobic plate counts were conducted according to Compendium of Methods for the Microbiological Examination of Foods (Swanson et al 1992). Eleven grams of each patty was placed in a sterile plastic bag with 99 mL of peptone dilution and, then, was homogenized with a stomacher for 3 min. The mixture was serially diluted with more dilution blanks to give 10^{-3}, 10^{-4}, and 10^{-5} dilutions. A 0.1 mL aliquot of each dilution was plated in a sterile petri dish and spread on the surface of the tryptic soy agar medium with a sterile glass rod. After incubating at 32°C for two days, the plates were counted.

Statistical Analysis

The experiment was designed primarily to determine the effect of packaging methods on the lipid peroxidation, sensory andmicrobial growth in cooked turkeys. The data from breast and leg meat were analyzed independently by SAS software (SAS Institute, 1986). Analyses of variance were conducted to test the effect of packaging within a meat type, and the effect of storage within a packaging method. The Student-Newman-Keul's multiple range test was used to compare differences among mean values during storage. Student's t-test was used to compare differences in mean values by packaging methods.

Table 3. Effect of packaging on the sensory analysis of turkey breast and leg meat patties on day 1

Descriptors	Breast Meat Patties		Leg Meat Patties	
	Hot pkg	Cold pkg	Hot pkg	Cold pkg
Flavor[1]	5.56 ± 0.54	6.44 ± 0.91	9.45 ± 0.67	8.31 ± 0.69
Juiciness	4.05 ± 0.62	4.12 ± 0.65	8.69 ± 0.68[a]	6.90 ± 0.52[b]
Tenderness	6.23 ± 0.54[b]	6.87 ± 0.72[a]	5.12 ± 0.81[b]	6.61 ± 0.72[a]
Overall acceptability	5.74 ± 0.69	4.86 ± 0.64	9.81 ± 0.84[a]	6.96 ± 0.74[b]

[1]This rating was a measure of good flavor in turkey meat.
[ab]Different letters within a row of the same meat type are significantly different ($P < 0.05$).

Table 4. Effect of packaging on the sensory analysis of turkey breast and leg meat patties on day 22

Descriptors	Breast Meat Patties		Leg Meat Patties	
	Hot pkg	Cold pkg	Hot pkg	Cold pkg
Flavor[1]	4.55 ± 0.65	4.16 ± 0.47	6.56 ± 1.06	7.03 ± 0.70
Juiciness	4.51 ± 0.67	3.78 ± 0.43	9.04 ± 0.92[a]	7.32 ± 0.65[b]
Tenderness	7.88 ± 0.85	8.69 ± 0.76	5.54 ± 0.73[b]	8.39 ± 0.71[a]
Overall acceptability	6.88 ± 0.82	6.28 ± 0.64	8.36 ± 0.73[a]	7.39 ± 0.99[b]

[1]This rating was a measure of off-flavor in turkey meat.
[ab]Different letters within a row of the same meat type are significantly different ($P < 0.05$).

RESULTS AND DISCUSSION

Although the long period of storage usually raise the TBARS value of meat, hot-packaged breast and leg patties for day 7 had abnormally high TBARS values (Table 1). Inappropriate packaging in some of the plastic bags may have allowed oxygen contact with meat. When ignoring the result of day 7, TBARS values of all types of patties except hot-packaged leg increased significantly after 2 weeks of storage; however, TBARS values of hot-packaged leg and breast were significantly lower than those packaged by cold-vacuum (Table 1). On the other hand, TBARS values measured by fluorescence were vary and did not show any significant results (Table 2). Although fluorescence method was useful for detecting lipid peroxidation in serum or plasma (Yagi 1987), it was not suitable for cooked meat. Our recent study indicated that the acid used in Yagi's method could not extract TBARS from cooked meat completely. The results from spectrophotometric method revealed that the hot-packaged cooked turkey meat was more stable than the cold-packaged cooked turkey meat. Because with the hot-packaging, the meat is packaged immediately after cooking, there should be less chance for contact with air.

Because hot-packaged patties were vacuum packaged right after cooking, they were expected to have lower microbial loads than those of cold-vacuum packaged ones. However, the microbial analysis revealed no significant growth at any dilution. Possibly, the low microbial loads of the cold-vacuum packaged patties resulted from the isolation and low level of microbial contamination.

Although cold-packaged breast patties had higher TBARS values than hot-packaged ones, panelists could not detect any sensory differences between these two packaging methods (Table 3 and 4). The leg patties, however, showed remarkable differences between hot and cold packaging. Panelist ratings showed that cold-packaged turkey leg meat had lower juiciness and overall acceptability than hot-packaged meat on both experimental days. Berry et al. (1985) reported that steaks with higher fat levels (18 and 22%) were juicier, moister, and had greater mouth coating than those with lower fat levels (10 and 14%). This could also be true of turkey meat. Generally, the lipid content of turkey dark meat (3.69%) is greater than white meat (1.59%) (Keskinel et al. 1964). The lipid content of our turkey breast and leg meat were 1.91% and 6.43%, respectively. In breast meat, differences in juiciness resulting from packaging methods, if any, could have been masked by the mealy characteristics of the breast meat. The moisture content of our cooked turkey breast meat was higher than that of the leg meat (65.5% and 63.5%). Yet, leg meat had juiciness scores almost twice as high as breast meat (Tables 3 and 4). These results indicated that lipid content is more influencing factor than moisture content in the juiciness of meat. Both cold- and hot-packaged leg meat should have similar scores of juiciness because of high lipid content; however, cold-packaged leg meat had much lower scores than hot-packaged meat. Having more chances for contact with air, cold-packaged leg patties had a greater degree of lipid oxidation (Tables 1 and 2). Therefore this different oxygen availability affected the difference scores in juiciness and overall acceptability of hot and cold leg patties.

Although no differences were found in the microbiological analysis, this study showed that the hot-packaging method was superior to the cold-packaging method in controlling lipid oxidation and improving some of the sensory characteristics of turkey meat. Using hot-vacuum packaging method would be beneficial for both poultry industry and consumers because it provides better storage stability, safety, and sensory properties than conventional packaging.

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