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# Effects of packaging atmospheres on shelf-life quality of ground ostrich meat

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**Abstract**

Fresh ground ostrich meat was packaged under high oxygen (O2), high nitrogen (N2), vacuum (VAC) and ambient air (AIR) atmospheres, stored at 4 ± 1 °C and displayed under 1700 ± 100 lux of fluorescent lighting for 9 days. The meat was evaluated for changes in typical shelf-life characteristics consisting of pH, color properties (CIE $L^*$, $a^*$, $b^*$, and total color difference, $\Delta E$), oxidative changes (thiobarbituric acid value and hexanal content) and bacterial counts (total viable cell, coliform, lactic acid bacteria, Enterobacteriaceae, *Pseudomonas* spp.) Initial meat pH was 6.16 and declined slightly during storage. TBA values and hexanal content were highest in O2 and lowest ($P \leqslant 0.05$) in VAC and N2 atmospheres. Surface lightness ($L^*$) and redness ($a^*$) were highest in O2 packaging initially, decreasing ($P \leqslant 0.05$) by day 9. $\Delta E$ of the ground ostrich increased during storage in only $O_2$ and AIR packaging. All packaging methods had generally similar effects on microbial outgrowth. Total aerobic bacteria attained $>10^6$ CFU/g meat between day 3 and day 6. Ground ostrich meat was below saleable quality in less than 6 days based on all of the meat attributes. For O2 packaging however, quality based on lipid oxidation and color properties indicated a shelf-life of less than 3 days. Oxidation is likely the limiting factor for shelf-life of ground ostrich meat.


*Keywords:* Quality; Ostrich; Meat; Shelf-life; Modified atmosphere packaging

## 1. Introduction

Meat from the ostrich (*Struthio camelus*) is presented and marketed as a "new" red meat alternative due to its low intramuscular fat content and high content of polyunsaturated fatty acids (Sales, 1998). Ostrich carcasses are typically chilled for 24–48 h postmortem, fabricated, and immediately vacuum and/or chub packaged before marketing (Sales & Horbanczuk, 1998). Ostrich meat processors sell fresh and frozen meat (cuts and ground) as well as processed meat products to a variety of markets generally utilizing recent retail packaging practices (Alonso-Calleja, Martínez-Fernández, Prieto, & Capita, 2004).

Modern meat packaging techniques are intended to maintain microbial and sensory quality of the product. Product shelf-life can be extended by inhibiting or retarding the growth of undesirable microflora. This can be achieved by manipulation of the meat microenvironment (Hotchkiss, 1988). Vacuum and modified atmosphere packaging (MAP) techniques are used in the food industry to extend the product shelf-life. MAP can be classified into two main categories, namely, low oxygen modified atmosphere (including vacuum packaging, $CO_2$ gas flushing, $N_2$ gas flushing) and high oxygen modified atmosphere (Robertson, 1993).

The relatively high pH of ostrich meat creates an ideal environment for rapid microbial spoilage in some packaging conditions (Alonso-Calleja et al., 2004; Doherty, Sheridan, Allen, McDowell, & Balir, 1996; Sales & Mellet,

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1996). Ostrich meat also contains high amounts of polyunsaturated fatty acids as compared to beef and chicken making it more susceptible to oxidation (Horbanczuk et al., 1998; Sales & Oliver-Lyons, 1996). Several studies have been published on physical properties, chemical composition, sensory properties and nutritive values of ostrich meat (Girolami et al., 2003; Paleari et al., 1998; Sales, 1996; Sales & Hayes, 1996; Sales & Horbanczuk, 1998) whereas shelf-life data for ostrich meat is only available for frozen, vacuum-packaged meat cuts (Otremba, Dikeman, & Boyle, 1999).

The objective of this study was to compare pH changes, color stability, oxidative changes (TBARS and hexanal content) and microbial quality of ground ostrich meat packaged under different atmospheres [vacuum, air, high oxygen MAP (80% $O_2$/20% $CO_2$), and high nitrogen MAP (80% $N_2$/20% $CO_2$)].

## 2. Materials and methods

### 2.1. Experiment overview and sample preparation

Nine 18 month-old ostriches were slaughtered under USDA inspection. Carcasses were chilled at $4 \pm 1$ °C for a minimum of 24 h postmortem. Inside and outside leg (*M. gastrocnemius*), and mid leg (*M. fibularis longus*) muscles of three ostrich carcasses and trim from the same carcasses were obtained from a commercial abattoir for each of 3 replications of the study and packaged within 48 h postmortem.

The muscles were trimmed of external fat and epimysial connective tissues (silver skin), cut into approximately 3–5 cm pieces, and then sequentially ground through plates having 0.96 cm and 0.4 cm diameter orifices, respectively, in a meat grinder (Hobart Manufacturing Co., Troy, OH) and collected in a sterile container. Portions of ground ostrich ($n = 12$/packaging treatment) were weighed to $225 \pm 5$ g, placed on individual barrier foam trays (LLDPE/EVOH multilayer) and either vacuum packaged (VAC) with multilayer polyolefin with PVDC film or placed in modified atmospheres of either: 80% nitrogen and 20% oxygen (AIR), or 80% oxygen and 20% carbon dioxide (O2), or 80% nitrogen and 20% carbon dioxide (N2). All packaging materials possessed barrier properties having oxygen transmission rates of less than 6 ml $O_2$/$m^2$/24 h at 1 atm, 23 °C, 0% RH. Packaging materials were provided by Cryovac, Division of Sealed Air Corporation, Duncan, SC.

AIR, O2, and N2 packages were packaged using a chamber type heat-seal packaging machine (Ross Jr.-InPack, Midland, VA) after flushing with the appropriate gas mixture. Meat-to-gas headspace volume ratio in each package was 1:3. Vacuum packaging was performed using an Ultravac 2100 double chamber vacuum packaging machine (KOCH, Kansas City, MO). The gas concentration in the package headspace was determined after sealing the packages. A 0.5-ml headspace volume was analyzed with a gas chromatograph (Series 200, Gow-Mac Instrument Co., Bethlehem, PA) fitted with AllTech CTR8700 Gas Analysis Column and TC detector. An integrator (Hewlett-Packard, Wilmington, DE) was used to plot chromatograms and calculate gas percentages based on peak areas. For vacuum packages, a sterile, high density polyethylene, open centered ball (HB-02 practice whiffle golf balls, ZxS Sports, Bentonville, AR) was placed in one end of the package to increase ease of sampling. It was assumed that after initial residual oxygen consumption by the fresh ground ostrich meat, the equilibrium headspace provided by the small volume of open space in the ball would reflect the type of air composition changes that would be made by the meat in a vacuum packaged product. Thus the "headspace" sampling is not actually the same as for packages with true headspace atmospheres such as the O2, N2 and AIR packages in this study.

Packaged ground ostrich meat was placed randomly on refrigerator shelves and held at $4 \pm 1$ °C under $1700 \pm 100$ lux of lighting (Sylvania-Cool White Fluorescent light) for 9 days. Two packages for each treatment were randomly selected on sampling days of 0 (~5 h), 3, 6, and 9, for analysis.

### 2.2. pH

Three 10 g samples of ground meat from each of two packages ($n = 6$/treatment) at each sampling day were separately blended with 100 ml distilled-deionized water ($ddH_2O$) at high speed in a blender (Oster, Sunbeam Corp, Boca Raton, FL). The pH of the homogenates was measured using an Ag/AgCl pH electrode (Model 91-05/06 Thermo Orion, Beverly, MA) attached to a pH meter (Model 420A, Thermo Orion, Beverly, MA).

### 2.3. Thiobarbituric acid (TBA) value

TBA values were determined by the extraction method described by Buege and Aust (1978) and modified by Ahn et al. (1998). A 5 g meat sample was placed in a 50 ml test tube and homogenized with 15 ml $ddH_2O$ using a homogenizer (KINEMATICA-POLYTRON, Brinkmann Instruments, Inc., Westbury, NY) with PT 10/35 generator for 10–15 s at speed setting of 7–8. After each sample, the probe was rinsed with $ddH_2O$. A 2 ml aliquot of homogenate was transferred to a screw capped-polypropylene test tube and 4 ml of TBA/TCA solution (0.02 M TBA + 15% trichloroacetic acid) was added. The mixture was vortexed and then incubated in a 95 °C water bath for 15 min. Samples were cooled for 10 min in ice water and then centrifuged for 10 min at 3500*g*. Absorbance of the resulting supernatant was determined at 531 nm against a blank containing 2 ml of $ddH_2O$ and 4 ml TBA/TCA solution in a spectrophotometer (Spectronic 20 GENESYS, Thermo Electron Corporation, Franklin, MA). A standard curve was determined using dilutions of 1 mM 1,1,3,3 tetraethoxypropane (Aldrich, Milwaukee, WI,