

OSTRICH MEAT INDUSTRY DEVELOPMENT

Final Report to:

American Ostrich Association

from:

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EXECUTIVE SUMMARY

The ostrich industry in the United States has considerable potential for producing meat and by-products. The ostrich breeders should be commended for the forethought of conducting product related research prior to entering meat production on a large scale.

In the fall of 1992, eighteen ostriches were transported to H&H Foods, Inc. in Mercedes, Texas for processing. During this portion of the study, a slaughter process, carcass cutting procedure and inspection system for ostrich was developed. Weights of by-products, carcass, carcass components and meat cuts were obtained during the processing phase of the study. Also, during this portion of the study microbiological samples were taken. Several meat cuts from the ostrich carcass were further examined for sensory attributes and nutrient profile. Finally the lean trim from the carcasses were processed into one of three value-added meat products, which were examined for general appearance and taste.

On a live weight basis, 7.04% of the live weight is hide, 1.85% is feathers, and 58.59% is in the form of carcass (lean, fat, and bone). The knife separable components of the carcass consisted of 62.5% lean, 9.2% fat, and 26.9% bone. From each carcass ten major muscles were identified as potential meat cuts, because of their size. The ten muscles made up 41.3% of the carcass and represented 23.6% of the live weight. The *M. gastrocnemius* was the largest muscle followed by the *M. iliotibialis lateralis* and the *M. iliofibularis* muscles.

The microbiological samples taken from the carcass immediately after evisceration (immediately before the carcass was placed in the walk-in cooler) showed the level of bacteria to be within acceptable ranges. Furthermore, one carcass and one fecal sample was positive for *Salmonella* spp. (pathogenic) and three ostrich carcasses were positive for *Listeria innocua* (nonpathogenic). The recovery of foodborne pathogens from the ostrich carcass indicates that the same precautions must be taken on this product as would be taken with raw food of other animal origin.

When four ostrich meat cuts were compared to a beef top loin steak, in a blind taste test, the consumer panelists tended to score the beef steak slightly higher for palatability traits. Although consumers found slight differences in the palatability attributes of ostrich steaks when compared to Choice beef top loin steaks, these slight differences in palatability did not significantly affect overall acceptability of ostrich steaks versus a Choice beef top loin steak. Further research is needed to examine the impact of ostrich diet and age on taste appeal and on the development and elimination of off-flavors.

With regard to the nutrient profile of cooked lean from ostrich carcasses, the meat is low in fat. The cholesterol level in cooked lean from ostrich carcasses in this study was

found to be similar to the USDA figures reported for beef and chicken cholesterol levels. These levels are expected as the cell membranes in all muscles, regardless of species, have cholesterol inside the membrane. The iron content of ostrich is closer to the content found in beef than that found in cooked lean from chicken. That is one reason why ostrich meat is more red in appearance than meat from poultry.

The two cured ostrich value-added meat products manufactured in this study show potential for future marketing, while the uncured restructured ostrich roast was undesirable in appearance and taste. The cured ostrich meat products had an excellent color and good taste.

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INTRODUCTION

As the ostrich industry turns from sales of breeding stock to the production of ostrich products for revenue, it is important for that industry to know as much as possible about the products that can be derived from these birds. The products produced from ostriches include the hide, feathers, variety meats (example: liver and heart), fresh meat (example: steaks and roasts), processed meats (example: sausage and ham type products) and health care products. Unfortunately very little information is known about the products that come from the ostrich, particularly the meat and processed meat products. Furthermore, the consumer acceptance and preparation of ostrich meat has not been clearly defined. Therefore, the purpose of the Ostrich Meat Industry Development Project was to provide the ostrich industry with scientific findings which will help in the production and marketing of ostrich meat.

OBJECTIVES

The major objectives of this study were to:

- 1) Determine the weight and percentage of the ostrich that is in the form of hide, feathers, by-products, meat, fat and bone (% calculated on a live weight and carcass weight basis).
- 2) Examine the sensory attributes (taste appeal) of ostrich using a consumer taste panel.
- 3) Investigate the nutritional profile of the meat from ostriches.
- 4) Review the numbers of bacteria that could be found on the carcasses after slaughter and test for the presence of Salmonella, Listeria, and Campylobacter.

Other beneficial knowledge was gained through this study, which will be discussed further in this final report.

EXPERIMENTAL PROCEDURES

Animal and Carcass Procedures

Animal History

During the fall of 1992, eighteen ostriches were transported to H&H Foods, Inc., in Mercedes, Texas for slaughter. The ostriches originated from Texas, Louisiana, Oklahoma, and Indiana and ranged in age from 10 months to 24 months of age. Because of the range in age, 14 of the 18 ostriches were segmented out for the by-product, carcass, and carcass fabrication portions of the study. The meat from 17 of the 18 ostriches was utilized for the consumer taste panel and the meat from 12 ostriches were examined for the nutritional analyses portion of the project. The beef cattle slaughter facility at H and H Foods, Inc. was adapted for the purpose of processing these ostriches.

Slaughter Process

The ostriches were inspected before slaughter by USDA-FSIS to identify any abnormal conditions. Having detected none, the ostriches were brought into the slaughter facility and stunned with a Schermer stunner. The unconscious ostriches were shackled by one leg immediately after stunning, hoisted to a height not to allow the carcass to touch the floor, and bled by severance of the heart, carotid artery, and jugular vein through the thoracic inlet, anterior to the sternum plate. Blood was collected and weighed. At the beginning of the study, the incision for bleeding was made at a point immediately below the head, however, blood flow was not adequate; therefore, the procedure described above was implemented, with positive results. Feathers were removed with the aid of mechanical clippers, then collected and weighed. To aid in hide removal, compressed filtered air was pumped under the skin through a small knife incision along the leg. The esophagus was exposed by a transverse cut into the neck, separated from the trachea, and tied to prevent microbial contamination from the gastrointestinal tract. The head was removed by a transverse cut through the joint of the occipital condyles and atlas joint, presented for inspection and weighed. The wing tips, feet, and tail set were removed and weighed. Carcasses were transferred from chains to hooks by gambrel suspension on rails of sufficient height not to contaminate the carcass by contact with the floor. The anal tissue and cloaca were loosened by a knife and tied to prevent fecal material contamination during hide removal. After opening the hide along the neck and legs with an adjoining cut on the ventral side, the hide was removed by a mechanical hide puller and weighed.

Evisceration

Carcasses were moved into the evisceration area and the pluck and viscera removed and presented for inspection. Eviscerated carcasses, heart, lung and trachea, empty and full gizzard and crop, caul fat, liver, viscera, abdominal fat, kidney, testis, ovary, sternum plate, spleen, and miscellaneous fat, were weighed. All weights taken on the slaughter and evisceration floor were calculated as a percentage of live weight. Live weight was determined by summing the carcass weight and the weight of all the items removed during the slaughter procedure (i.e. hide, feathers, feet, liver etc.). Carcasses were weighed and then placed into a cooler and chilled at 32°F for approximately 20 hours before fabrication.

Microbiology Sampling

Each ostrich carcass was evaluate immediately following evisceration for total bacterial numbers, as well as, the presence of *Salmonella* spp. *Listeria* spp., and *Campylobacter* spp. Four areas of each carcass were swabbed for each microbiological analysis (the right and left thigh and the right and left sides of the carcass back—distal to the thighs). Care was taken to swab areas that had not been previously sampled.

Total bacterial numbers were determined by sampling four 25-cm² areas from each carcass using sterile cotton swabs that had been moistened with sterile 0.1% peptone diluent for a total surface area of 100 cm² per carcass. The samples were shaken vigorously for 30 s to dislodge the bacteria from the swabs and distribute them throughout the diluent. Samples were then appropriately diluted and plated on Tryptic Soy Agar (TSA, Difco) by spreading with a sterile bent glass rod. The plates were incubated at 25°C for 48h. Aerobic Plate Counts (APC) were established from countable plates. Types of organisms were determined for five carcasses. Three representative colonies of each type appearing on each countable plate were selected, described and the number of times each colony type appeared on the plate was counted for use in determination of the microbial distribution. Isolates of each colony type were transferred to and maintained on TSA slants at 25°C for analysis. Bacterial isolates were then identified using identification and diagnostic schemes described by Vanderzant and Nickelson (1969) and Holt(1984, 1986).

The carcasses were evaluated for the presence of *Salmonella* spp. by sampling four 25-cm² areas using sterile cotton swabs that had been moistened with sterile lactose broth. The four swabs were pooled into 50 ml of sterile lactose broth and stored on for 24-48 hour for transport to the Texas A&M Food Microbiology Laboratory for analysis. For five birds (#4-8), segments of the rectum prior to the cloaca were tied and aseptically removed in order to determine the presence of *Salmonella* spp. in fecal material. ten grams of fecal material was aseptically removed from each segment and placed into 50 ml of lactose broth and stored

on ice for 48 hours for transport to the laboratory. The presence of *Salmonella* spp. in surface and fecal samples was evaluate using FDA procedures (Andrews et al. 1984).

Sterile cotton swabs were moistened with sterile UVM broth (Difco) and used to sample four 25-cm² areas for the presence of *Listeria* spp. The four swabs were pooled into 50 ml of sterile UVM broth and stored on ice for 24-48 hour for transport to the laboratory for analysis. *Listeria* spp. were identified using FSIS procedures (McClain and Lee, 1989).

Carcasses were examined for the presence of *Campylobacter* spp. by sampling four 25-cm² areas using sterile cotton swabs that had been moistened with sterile Brucella-FBP broth. The four swabs were pooled into 50 ml of sterile Brucella FBP broth and stored for 24-48 hour for transport to the laboratory for analysis. Fecal material was obtained from five birds by tying and aseptically removing segment of cecum. Ten ml of cecal fluid was pipetted into 50 ml of sterile Brucella FBP broth and stored on ice for 48 hour transport to the laboratory for analysis. *Campylobacter* spp. were identified using procedures described by Acuff et al. (1982).

Carcass Fabrication

Chilled carcasses were weighed and the neck was removed at the joint between the last cervical vertebra and first thoracic vertebra. The carcasses were then split down the midline of the back bone using a band saw. The "tenderloin" (*M. obturatorius medialis*) was removed from the carcass and weighed, as was the tibia which was removed immediately below the major muscles of the leg. The major leg muscles were left attached to the femur and the major thigh muscles attached to the pelvis, but both were removed from the vertebral column and weighed as a semi-boneless leg and thigh portion. The fat and lean from the vertebral column, ribs, and wings were removed, and weighed as fat, lean trim, and bone. All carcass fabrication weights were calculated as a percentage of live weight and of carcass weight.

The fat, lean trim, tenderloin, and semi-boneless thigh and leg portion of the carcass were vacuum packaged and shipped to Texas A&M University for further research. Upon arriving at the TAMU Rosenthal Meat Science and Technology Center, the fresh meat products were aged in the vacuum packaged bag for seven days and then frozen at 14°F. Then, the semi-boneless leg and thigh portion was thawed and further fabricated into ten major muscles, lean trim, bone and fat. These ten major muscles and the tenderloin were given a subjective color score and then vacuum packaged and frozen at 14°F until the sensory and nutritional analyses could be performed. Muscle names were identified using Mellett 1994, Journal of the South African Veterinary Association 65(1):5-9.

Subjective Color Evaluation

Following the fabrication of the semi-boneless leg and thigh portion, the 10 major muscles were allowed to bloom for an additional 5 minutes. Following this bloom time, color scores from 1 (very dark red) to 8 (bright cherry red) were assigned to each muscle by trained personnel from Texas A&M University.

Sensory Analyses

Objective Tenderness Evaluation

For evaluating tenderness one steak was randomly removed from the *M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius*. Each steak was cooked to 145°F (63°C) internal temperature. The steaks then were allowed to cool to room temperature at which time 4 to 10, 0.5 in. cores were removed from the steak at an orientation parallel to the fiber direction of the muscle (with the grain of the muscle). Each core was placed in the Warner-Bratzler Shear Force Machine and the amount of force (in pounds) required to shear the one core in half, across the grain was recorded. The final shear force value for a muscle was determined by taking the mean of the 4 to 10 cores that had been excised from the muscle.

Consumer Sensory Evaluation

A total of 122 consumers evaluated four ostrich muscles (*M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius*). Cooked meat samples from a USDA Choice beef top loin steak (IMPS # 1180) were used as a study control. All cuts were trimmed free of surface fat and any visible connective tissue, then cooked to an internal temperature of 145°F (63°C). After cooking the steaks were cut into 0.125cm cubes. Three cubes were placed in a plastic weigh boat, covered with saran wrap, and stored in a holding oven at 120°F for a maximum time of 20 minutes before serving to the consumers. Consumers were asked to evaluate the samples based on overall like/dislike, flavor, flavor intensity, tenderness, and texture like/dislike. In addition, consumers were asked to give their comments and opinions of the samples overall flavor and texture. This was a blind taste evaluation, in that the consumers making-up the taste panel were not informed that the cooked meat samples were from ostrich.

Sample preparation and consumer testing was completed at the Texas A&M Sensory Laboratory. During the consumer evaluation, consumers were placed in cubicles illuminated with red light to eliminate color bias. Consumers received samples in randomized order to eliminate any order bias.

Nutritional Analyses

Sampling Plan

Cooked ostrich meat composition was conducted on an as consumed basis. Two steaks were randomly removed from four different muscles (*M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius*) from each of twelve ostrich carcasses. All of the steaks were trimmed of fat and connective tissue with a knife before cooking. Each steaks was cooked to 145°F internal temperature on a Faberware Open Hearth Grill. Samples then were homogenized in a Cuisinart Food Processor and placed in amber snap cap vials and frozen (14°F) until subsequent analyses. Analyses performed included protein, moisture, total fat, fatty acid, cholesterol, calcium, sodium, and iron content.

Fatty Acid Analysis, Cholesterol, Calcium, Iron, and Sodium

Fatty acid, cholesterol, calcium, iron, and sodium analyses were performed by Silliker Laboratories of Texas Inc. (College Station, Texas). Silliker Laboratories is an United States Department of Agriculture- Food Safety and Inspection Service approved facility.

Percentage Chemical Fat

Percentage fat was determined by the Lipid Extraction-Modified Folch Method (Folch et al., 1957). To determine percentage fat, 5g of sample was homogenized with 75ml of chloroform:methanol (C:M) (2:1, v/v) for 3 minutes. The sample then was vacuum filtered through a Whatman #2 filter paper. Next, the sample and paper were rehomogenized in the same blender cup for 3 minutes with 50 ml of C:M. The homogenate was filtered through a new filter paper into the first filter flask. The combined filtrates then were transferred into a separatory funnel and 25 ml of distilled water was added. Water and filtrate were gently swirled and allowed to separate at refrigerated temperatures. Upon complete separation, the lower non-polar phase was transferred into a 100 ml volumetric flask and allowed to sit at refrigerated temperatures overnight. The following day, the filtrate was allowed to rise to room temperature, and any accumulated water layer at the top of the flask was drawn off. The flask was filled to volume using pure chloroform, not C:M. Then 5g of anhydrous NaSO₄ was added to the filtrate and transferred to large screw-top test tubes and sealed with parafilm. Tubes were placed in freezer until fat determination step.

Actual fat determination was accomplished by allowing filtrate to come to room temperature and placing 10 ml into dried and weighed 30 ml beakers. The beakers were placed in a clean tray and covered with cheese cloth. The filtrate was allowed to evaporate off overnight. The beakers were dried after all the filtrate was evaporated off, and reweighed to determine total fat content.

Percentage Moisture and Ash Determination

Percent moisture was determined by the oven dry method (AOAC, 1990). First, thimbles were dried overnight and placed in a desiccator for 30 minutes. Empty thimble weights were recorded and 2 g of sample was added and allowed to dry overnight in oven at 100°C. Samples were removed and placed into the desiccator for 30 minutes. Samples then were reweighed and percent moisture calculated.

Percentage ash was determined according to AOAC methods (AOAC, 1990). After crucibles were dried for 2 hours and cooled in a desiccator for 1 hour, 1.5 g sample was placed in each. Samples then were placed in a 100°C oven for 1 hour to dry. Then they were placed in a 600° muffle furnace overnight. Samples then were placed in a desiccator for 2 hours and final weights were recorded to determine the percentage ash.

Percentage Protein

Percent protein was determined by the Kjeldahl Block Determination Method (AOAC, 1990). The block digester was preheated to 410°F. In the digestion tube 2 g of sample in nitrogen free weigh paper, 2 Kjeltabs, and 15 ml of concentrated sulfuric acid were added. Tubes were placed in digestion block and covered with exhaust caps. Tubes were allowed to digest for 45 minutes. Tubes then were allowed to cool with exhaust caps in place. After cooling, 50-75 ml of water was added. Digestion tubes were seated in distillation unit and 50 ml of NaOH was dispensed. A 250 ml collecting flask with 25 ml of boric acid indicator solution was placed on the receiving platform. The sample was distilled until 100-125 ml was collected in collection flask (5 min.). The collection flask was removed and titrated to a steel gray endpoint using .2 N hydrochloric acid. The acid amount was recorded and used to calculate the final percentage protein.

Calculating Calories

The number of calories in a 100 gram sample of cooked Ostrich meat was determined by a routine and approved procedure, which includes summing the calories from fat with the calories from protein. The calories from carbohydrates in fresh meat products is assumed to be zero.

Value-Added Meat Products

Lean Trim Preparation

Frozen ostrich lean trim was thawed at 45°F for processing into value-added products. Visible connective tissue was removed from lean trim and three value-added products were produced — uncured ostrich roast, cured ostrich ham-type product, and cured ostrich/pork polish sausage.

Uncured Ostrich Roast

The uncured roast was produced by the following processing sequence:

- 1) Fifty pounds of ostrich lean trim was ground through a kidney plate (chunked ostrich lean).
- 2) Chunked ostrich lean was mixed with 0.75 lb (1.5%) Salt (NaCl), 0.15 lb (0.3%) Sodium Tripolyphosphate, and 7.50 lb (15%) water. The combined ingredients were mixed in a paddle mixer for 15 minutes.
- 3) The mixed product was vacuum stuffed into 6" diameter plastic coated fibrous casings, pressed and tied between screens and placed in an Alkar two truck smokehouse on racks.
- 4) The product was cooked by the following sequence:
 - a) One hour at 130°F dry bulb, 0°F wet bulb.
 - b) Two hours at 140°F dry bulb, 0°F wet bulb.
 - c) Two hours at 155°F dry bulb, 125°F wet bulb, 41% relative humidity.
 - d) One hour at 170°F dry bulb, 140°F wet bulb, 43% relative humidity.
 - e) Three hours at 185°F dry bulb, 155°F wet bulb, 46% relative humidity.
 - f) The final endpoint internal core temperature was 156°F.

The cooked product was cold showered for one hour until a 90°F internal core temperature was reached. The finished product then was refrigerated at 35°F for twelve hours before slicing and packaging.

Cured Ostrich Ham-Type Product

The cured ostrich ham-type product was produced by the following sequence:

- 1) 50 lb of large ostrich trim pieces free of connective tissue were pumped to 120% of their original weight with a solution of 1.0 lb (2.0%) salt (NaCl), 0.12 lb Prague ® powder (156 ppm NaNO₂), 0.0275 lb (550 ppm) Sodium Erythorbate, 0.25 lb (0.5%) Dextrose, 0.15 lb (0.3%) Sodium tripolyphosphate, and 10.0 lb (20%) water.
- 2) Pumped ostrich muscle pieces were chunked through a kidney plate and vacuum-tumbled for one hour.

- 3) The ostrich trim was vacuum-stuffed into fibrous 3" diameter casings, held at 35°F 8 hour for cure development, and hung in the smokehouse.
- 4) The ostrich ham product was cooked by the following sequence:
 - a) One hour at 130°F dry bulb, 0°F wet bulb, dampers open, smoke off.
 - b) One hour at 140°F dry bulb, 0°F wet bulb, dampers closed, smoke on.
 - c) 15 minutes at 155°F dry bulb, 130°F wet bulb, 48% relative humidity, dampers closed, smoke on.
 - d) 15 minutes 165°F dry bulb, 145°F wet bulb, 58% relative humidity, dampers closed, smoke on until 140°F internal core temperature and desired color is reached.
 - e) And a 10 minutes steam cook increased the core temperature to 150°F.

The cooked product was followed by a 15 minutes cold shower to decrease internal core temperature to 90°F. And the product was chilled overnight at 35°F before slicing and packaging.

Ostrich/Pork Polish Sausage

The ostrich/pork polish sausage product was produced by:

- 1) 15.63 lb ostrich lean trim and 9.37 lb 50/50 pork fat were ground separately through a meat grinder with a 1/2" grinding plate.
- 2) Ostrich lean and pork fat were mixed with 0.062 lb sodium nitrite as Prague ® powder, A.C. Legg ® polish sausage seasoning (A.C. Legg ® polish sausage seasoning contains salt, dextrose, MSG (4.55%), garlic powder, and sodium erythorbate (7/32 oz)) and 0.75 lb (3%) ice water to yield a 50 lb product. The above ingredients were mixed in a paddle mixer for 15 minutes.
- 3) The mixed product was ground through a 1/8" plate, vacuum-stuffed into natural pork casings, held for 8 hour at 35°F for cure development, and hung in the smokehouse for cooking.
- 4) The product was cooked by the same schedule as the ostrich ham product to an internal temperature of 160°F.

The product was held overnight at 35°F before slicing and packaging.

Product Evaluation

During the slicing operation each product was evaluated and taste tested by three meat technologists and general observations were made with regard to appearance and sensory characteristics.

RESULTS AND DISCUSSION

By-products and Carcass Yield and Carcass Composition

By-product Yields

From the Ostrich there are many valuable by-products harvested during the slaughter process. The hide and feathers may in fact generate more total revenue than the meat products derived from the ostrich carcass. Table 1 presents the weights of the live animals utilized in the study, the weight of the carcass, and the weights of the parts removed during the slaughter process. The viscera (digestive track including ingesta) (18.27 lbs.), hide (14.79 lbs.), crop and gizzard (including ingesta, 12.79 lbs.) and abdominal wall and fat layer (9.05 lbs.) accounts for a substantial portion of the weight of products removed during slaughter.

The average percent of carcass weight on a live weight basis was 58.59%. The term *dressing percent* is often referred to represents the percent of the ostrich that is in the form of carcass (which includes lean, bone and fat) after the slaughter process (Table 2). The hide and feathers were 7.04% and 1.85%, respectively, on a live weight basis. As shown by the standard deviation in both Table 1 and 2 there was considerable variation in the weight of blood, viscera, and full crop and gizzard. The blood weight varied primarily because of the two different methods that were used to bleed the ostrich, as described in the experimental procedure section. The weight and percent of the viscera and full gizzard and crop varied considerably because the length of time each ostrich was held off of feed and water before slaughter varied; therefore, creating different amounts of ingesta in the digestive tracts of these ostriches.

Table 1: The mean weight, standard deviation, minimum weight, and maximum weight of the live ostrich, carcass and by-products.

Item, lbs	n ^a	Mean (lbs.)	Standard Deviation (lbs.)	Minimum (lbs.)	Maximum (lbs.)
Live	14	210.63	21.00	169.52	229.87
Hot Carcass	14	123.25	13.53	100.84	143.00
Feather	14	3.84	1.04	2.30	5.80
Blood	14	6.58	3.05	2.25	10.52
Wing	14	1.63	0.46	0.70	2.30
Feet	14	5.54	1.33	2.20	7.74
Tail	14	0.80	0.23	0.50	1.30
Head	14	1.71	0.23	1.40	2.20
Hide	14	14.79	2.06	11.10	17.50
Heart	14	2.08	.45	1.44	3.34
Lung and Trachea	14	2.85	0.39	2.20	3.62
Full Gizzard & Crop ^c	14	12.79	4.26	7.60	19.72
Empty Gizzard & Crop ^c	14	4.74	0.78	3.20	5.64
Caul Fat	14	1.91	1.19	0.76	5.04
Liver	14	3.14	.69	2.20	4.68
Viscera	14	18.27	3.75	13.62	23.34
Abdominal fat	14	9.05	3.27	2.80	14.96
Kidney	14	0.87	0.15	0.64	1.18
Testis	7	0.18	0.16	0.02	0.42
Ovary	7	0.39	0.34	0.02	1.04
Sternum Plate	14	2.70	0.84	1.50	4.42

a - "n" is an abbreviation for *number of observations* and represents the number of ostriches utilized to derive the information presented in the table.

b - The live weight was calculated by summing the carcass weight with the weight of the by-products removed during slaughter.

c - Full Gizzard & Crop wt. represents the weight of the crop and gizzard plus the weight of the ingesta within the crop and gizzard. Empty Gizzard and Crop wt. is the weight of the crop and gizzard only.

Table 2: The mean percent, standard deviation, minimum percent, and maximum percent of carcass and of by-products on a live weight basis.

Item, %	n ^a	Mean (%)	Standard Deviation (%)	Minimum (%)	Maximum (%)
Dressing Percent ^b	14	58.59	2.48	54.54	63.74
Feather	14	1.85	.61	1.03	3.42
Blood	14	3.11	1.32	0.95	5.15
Wing	14	0.78	0.23	0.51	1.12
Feet	14	2.64	.61	1.09	3.27
Tail	14	0.38	0.11	0.22	0.59
Head	14	0.82	0.14	0.65	1.11
Hide	14	7.04	0.84	5.43	7.94
Heart	14	0.99	0.20	0.76	1.49
Lung and Trachea	14	1.36	0.19	1.04	1.73
Full Gizzard & Crop ^c	14	6.05	1.88	4.19	10.35
Empty Gizzard & Crop ^c	14	2.26	0.38	1.70	3.15
Caul Fat	14	0.90	0.55	0.41	1.43
Liver	14	1.49	0.28	1.00	2.10
Viscera	14	8.68	1.58	6.07	11.06
Abdominal fat	14	4.28	1.46	1.47	6.30
Kidney	14	0.41	0.06	0.29	0.54
Testis	7	0.09	0.07	0.02	0.19
Ovary	7	0.18	0.15	0.01	0.47
Sternum Plate	14	1.29	0.41	0.76	2.11

a - n is an abbreviation for *number of observations* and represents the number of ostriches utilized to derive the information presented in the table

b - Dressing Percent is calculated by dividing carcass weight by live weight and then multiplying by 100.

c - Full Gizzard & Crop wt. represents the weight of the crop and gizzard plus the weight of the ingesta within the crop and gizzard. Empty Gizzard and Crop wt. is the weight of the crop and gizzard only.

Carcass Yields

The cold carcass weight and the weight and percentage of side components after the carcasses were split down the backbone and then fabricated into major wholesale cuts are shown in Tables 3 and 4. The neck made up 4.33% of the carcass weight. Each single tenderloin cut (*M. obturatorius medialis*) which is found along the back bone represented 1.72% of the total weight of the carcass. The largest portion (34.86%) of the carcass is each semi-boneless leg and thigh portion on the carcass. The leg and thigh is were the majority of the muscle mass is located on ostrich carcasses.

Table 3: The mean weight, standard deviation, minimum weight and maximum weight of carcass and carcass side components^a.

Item, lbs.	n ^b	Mean (lbs.)	SD (lbs.)	Minimum (lbs.)	Maximum (lbs.)
Cold carcass	14	120.28	12.77	96.00	138.00
Neck	14	5.17	0.54	4.18	6.25
Semi-boneless leg and thigh	28	41.96	5.31	32.80	54.40
Leg Bone	28	2.31	0.36	1.72	3.15
Bone ^c	28	5.76	0.79	4.60	8.05
Lean Trim ^c	28	4.72	0.71	3.20	6.10
Fat ^c	28	2.97	1.76	0.70	6.45
<i>M. obturatorius medialis</i>	28	2.07	0.37	1.20	2.65

a - With the exception of cold carcass weight and neck weight the remainder of the weight are of components excised from a single side.

b - n is an abbreviation for *number of observations* and represents the number of ostriches utilized to derive the information presented in the table.

c - The bone, lean and fat weight presented in this table is the weight of these components that were removed from one side as carcasses were fabricated into major wholesale cuts.

Table 4: The mean percentage, standard deviation, minimum percentage and maximum percentage of the carcass side components^a, calculated on a total carcass weight basis.

Item, %	n ^b	Mean (%)	SD (%)	Minimum (%)	Maximum (%)
Neck	14	4.33	0.48	3.71	5.63
Semi-boneless leg and thigh wt	28	34.86	1.91	30.94	39.42
Leg Bone	28	1.93	0.25	1.56	2.48
Bone	28	4.82	0.67	3.59	6.20
Lean Trim	28	3.94	0.51	3.13	5.23
Fat	28	2.45	1.42	0.52	5.20
<i>M. obturatorius medialis</i>	28	1.72	0.23	1.19	2.10

a - Percentage of side components were calculated on a carcass weight basis. Each carcass was divided into two halves down the backbone. Each half is referred to as a *side*.

b - n is an abbreviation for *number of observations* and represents the number of ostriches utilized to derive the information presented in the table.

c - The bone, lean and fat percentages presented in this table is the % of these components that were removed from one side as carcasses were fabricated into major wholesale cuts.

Carcass Composition

From the 120.3 pound mean carcass weight, the carcass composition consisted of 64.5 % knife separable lean, 9.2% knife separable fat, and 26.9% bone on a carcass weight basis (Table 5 and 6). These figures are lower in percent fat and higher in percent bone than is found normally among other muscle food sources. On a live weight basis, 35.7% of the live animal is in the form of lean.

Of the lean separated from the ostrich carcass approximately two-thirds represented the ten major muscle and one-third lean trimmings. The majority of the ten major muscles can be utilized for whole muscle applications (i.e. steaks, roasts, cubes, and stir fry). Within the 10 major muscles the *M. gastrocnemius*, *M. iliofibularis*, and *M. iliotibialis lateralis* were the largest muscles from the ostrich carcass with each making up over 6% of the carcass weight (Table 7). The *M. obturatorius medialis* muscle, which has been merchandised in the ostrich meat industry as the tenderloin, made up 3.7% of the carcass weight.

Table 5: The mean weight, standard deviation, minimum weight and maximum weight of knife separable fat, lean and bone and of the 10 major muscles as well as the lean trimmings fabricated from the entire ostrich carcass.

Item, lbs.	n ^b	Mean (lbs.)	Standard Deviation (lbs.)	Minimum (lbs.)	Maximum (lbs.)
Cold Carcass	14	120.3	3.48	96	138
Total Carcass	14	75.2	2.62	57.11	92.79
Lean ^a					
Total Carcass Fat	14	11.1	1.42	11.55	18.72
Total Carcass Bone	14	32.2	.78	26.31	36.26
10 Major Muscles ^a	14	49.8	1.87	38.39	62.52
Lean Trimming ^a	14	25.4	.87	18.72	30.27

a - Total Lean has been further divided into the 10 major muscle weight and the lean trimming weight.

b - n is an abbreviation for *number of observations* and represents the number of ostriches utilized to derive the information presented in the table.

Table 6: The mean percentage and standard deviation on a carcass weight and live weight basis of knife separable fat, lean and bone and of the 10 major muscles as well as lean trimmings fabricated from the entire ostrich carcass.

Item, %	n ^b	Mean % Carcass wt. Basis	Standard Deviation %	Mean % Live wt. Basis	Standard Deviation %
Total Carcass	14	62.5	.96	35.7	.78
Lean ^a					
Total Carcass Fat	14	9.2	1.18	5.2	.66
Total Carcass Bone	14	26.9	.53	15.3	.28
10 Major Muscles ^a	14	41.3	.72	23.6	.54
Lean Trimmings ^a	14	21.1	.45	12.1	.34

a - Total Lean has been further divided into the 10 major muscle percent and the lean trimming percent.

b - n is an abbreviation for *number of observations* and represents the number of ostriches utilized to derive the information presented in the table.

Table 7: The mean weight and standard deviation and the mean percentage on a carcass and live weight basis of the ten major muscles excised from the ostrich carcass.

Muscle	Muscle No.	n ^a	Mean Muscle wt., lbs.	Standard Deviation Muscle wt., lbs.	Mean % Carcass wt. Basis	Mean % Live wt. Basis
<i>Fexor cruris lateralis</i>	1	14	2.3	.38	1.92	1.10
<i>Iliofemoralis</i>	2	14	2.1	.36	1.71	.98
<i>Iliofibularis</i>	3	14	7.7	.95	6.38	3.65
<i>Iliotibialis cranialis</i>	4	14	3.1	.42	2.56	1.46
<i>Iliofemoralis externus</i>	5	14	3.2	.46	2.69	1.53
<i>Iliotibialis lateralis</i>	6	14	7.7	1.29	6.43	3.67
<i>Femorotibialis</i>	7	14	4.6	.60	3.84	2.19
<i>Obturatorius medialis</i>	8	14	3.7	.65	3.12	1.78
<i>Gastrocnemius</i>	9	14	9.6	1.79	7.99	4.57
<i>Fibularis longus</i>	10	14	5.7	1.62	4.71	2.69

a - n is an abbreviation for *number of observations* and represents the number of ostriches utilized to derive the information presented in the table.

Microbiology

Aerobic plate counts (APC), *Listeria*, *Salmonella* and *Campylobacter* isolation results are shown in Table 8. APCs (\log_{10}/cm^2) of the carcasses for each of the three sample days averaged 4.0, 3.2 and 3.6, respectively. This is within an acceptable range, especially considering that some of the carcasses were handled a great deal by plant and USDA personnel as slaughter and inspection procedures were being developed. The bacterial types that predominated on these carcasses (Table 9) consisted of organisms common to the environment as well as some native to the skin of animals and humans. *Micrococcus* spp. predominated on all of the carcasses. Coryneform bacteria, *Staphylococcus* spp., *Bacillus* spp., *Lactobacillus* sp., *Flavobacterium* sp., *Moraxella* sp., and *Trichosporan*, a yeast of environmental origin, were also present.

Listeria innocua was recovered from the three carcasses slaughtered during the first sampling trip. *L. innocua* is non-pathogenic, and is considered by some to be a non-pathogenic strain of *L. monocytogenes*. Its presence indicates the potential for the presence of pathogenic *Listeria* species. Given the wide distribution of *Listeria* spp. throughout the environment, however some level of the organisms would be expected on the ostrich carcasses or any other foods that have not undergone a heat treatment.

Salmonella spp. was recovered from a surface sample taken from one bird and a fecal sample taken from another. Since *Salmonella* is found in the gastrointestinal tracts of many animals and birds, recovery of these organisms from ostrich carcasses is not surprising. *Campylobacter* spp. are also present in the gastrointestinal tracts of many animals and birds, however, none was recovered from the surface or cecal samples taken in this study. Given the sensitive nature of *Campylobacter*, it is possible that the organisms, if present, did not survive the storage period required before laboratory analysis could be undertaken.

The recovery of foodborne pathogens from the ostrich carcasses indicates that the same considerations must be taken as with other raw foods of animal origin. Temperature abuse, underprocessing and cross-contamination from raw to cooked products can make such foods vehicles for foodborne illness. Proper precautions must be taken in the food processing and food service environment as well as in the home.

Table 8: Aerobic plate counts (APC) and the presence of *Listeria* spp., *Salmonella* spp., and *Campylobacter* spp. on surface and fecal and cecal samples of eighteen ostrich carcass sampled immediately post evisceration during three sampling trips.

Bird #	<i>Listeria</i> ^a	<i>Salmonella</i>	<i>Campylobacter</i>	APC(Log ₁₀ /cm ²)
1	+	-	-	4.0
2	+	-	-	3.9
3	+	-	-	4.0
Sample trip #1 average				4.0
4	-	-	-	3.2
5	-	-	-	3.0
6	-	+	-	2.9
7	-	-	-	2.6
8	-	-	-	3.7
9	-	-	-	3.0
10	-	-	-	2.8
11	-	-	-	4.5
12	-	-	-	3.0
Sample trip #2 average				3.2
13	-	-	-	4.6
14	-	-	-	4.1
15	-	-	-	2.8
16	-	-	-	2.8
17	-	-	-	2.7
18	-	-	-	4.3
Sample trip #3 average				3.6
Fecal/Cecal swabs (Trip #2)				
4	-	-	-	
5	-	-	-	
6	-	-	-	
7	-	-	-	
8	-	+	-	

^aIsolates were identified as *L. innocua*.

Table 9: Microflora and aerobic plate counts (APC) of five ostrich carcasses sampled immediately post evisceration.

Bird #	APC (log ₁₀ /cm ²)	Percentage distribution of microbial types ^a							
		Bac	Cor	Fla	Lac	Micr	Mx	Staph	Trich
2	3.9	7.0	19.8	4.7	10.5	58.1			
3	4.0	3.3	1.1			82.4		12.1	1.1
14	4.1		12.4			68.6	7.4	11.6	
15	2.8	1.8	22.8			75.4			
16	2.8	1.1	18.9			72.6		4.2	3.2

^aBac = *Bacillus* spp., Cor = coryneform bacteria, Fla = *Flavobacterium* sp., Lac = *Lactobacillus* sp (homofermentative), Mic = *Micrococcus* spp., Mx = *Moraxella* sp., Staph = *Staphylococcus* spp., Trich = *Trichosporon* sp. (yeast).

Subjective Color Evaluation

The color of the fresh meat products offered to the consumer is an important merchandising consideration. The mean subjective color scores given for each of the ten ostrich muscles ranged from 4.5 to 5.5 on an 8-point scale (Table 10). These scores indicate that uncooked ostrich muscle is slightly dark red to slightly cherry red in color. Beef is generally described as being slightly cherry red to moderately cherry red in color. Therefore, ostrich meat is darker in color than beef. The *M. iliotibialis cranialis* was the lightest colored muscle and it was lighter than the other muscles, except for the *M. iliofibularis*. The *M. flexor cruris lateralis* or Inside Thigh was the darkest colored muscle in the ostrich carcass. The other ostrich muscles did not differ in lean color. These results indicate that the *M. flexor cruris lateralis*, *M. iliofibularis* and *M. iliotibialis cranialis* muscles differ in color from other ostrich muscles. These muscles may need to be merchandised as separate muscles as they appear slightly different (either lighter or darker) than other ostrich muscles. Additionally, these muscles may need to be segmentation from other muscles in further processed products to reduce variation in visual appearance of the final product.

Table 10: Subjective color evaluation^d of the ten major muscle from the ostrich carcass.

Muscle	Mean Color Score	Standard Deviation
<i>Flexor cruris lateralis</i>	4.71 ^{ab}	0.46
<i>Iliofemoralis</i>	4.44 ^a	0.70
<i>Iliofibularis</i>	5.29 ^{cd}	0.62
<i>Iliotibialis cranialis</i>	5.59 ^d	0.61
<i>Iliofemoralis externus</i>	5.21 ^c	0.77
<i>Iliotibialis lateralis</i>	4.94 ^{bc}	0.49
<i>Femorotibialis</i>	5.06 ^c	0.49
<i>Obturatorius medialis</i>	4.59 ^c	0.56
<i>Gastrocnemius</i>	5.11 ^c	0.54
<i>Fibularis longus</i>	5.09 ^c	0.51

d - Subjective color evaluations were made using a scale from 1 to 8 with 8 representing bright cherry red colored lean and 1 representing a very dark colored lean
Numbers with the same superscript are not significantly different

Sensory Analyses

Objective Tenderness Evaluation

Shear force values, a mechanical measurement of tenderness, are presented in Table 11. The *M. obturatorius medialis* had the lowest shear force value and was more tender than the *M. gastrocnemius* muscle. The *M. iliofibularis* and *M. iliotibialis lateralis* had similar shear force values to the *M. obturatorius medialis* and *M. gastrocnemius* muscles. The *M. gastrocnemius* muscle varied greatly in shear value as indicated by the high standard deviation. Therefore, the *M. gastrocnemius* can be tender or tough. A shear force value of less than 8 is considered very tender, with values between 8 and 10 being acceptable, and shear force values greater than 10 indicating tougher meat. These results indicate that ostrich meat from the *M. iliofibularis*, *M. iliotibialis lateralis* and *M. obturatorius medialis* are tender. The variability in tenderness of the *M. gastrocnemius* could present problems. Mechanical tenderation may be required to minimize the inconsistency in tenderness in the *M. gastrocnemius*.

Table 11: Mean and standard deviation Warner-Bratzler shear values^a for the cooked *M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius* from the ostrich carcass.

Muscle	Mean Shear Force (lbs. per square inch)	Standard Deviation
<i>Ilioibularis</i>	6.65 ^{ab}	2.49
<i>Iliotibialis lateralis</i>	7.08 ^{ab}	2.06
<i>Obturatorius medialis</i>	5.64 ^a	1.93
<i>Gastrocnemius</i>	9.95 ^b	5.23

a - The Warner-Bratzler Shear machine is an objective tenderness test. As the shear value increases the more pounds of force required to cut a 1/2" diameter core of meat in half.

Consumer Taste Panel Ratings

Consumers' perceptions of ostrich meat palatability from three muscles are reported in Table 12. A Choice beef top loin steak was evaluated by consumers at the same time that the three ostrich muscles were evaluated to provide a basis for comparison to commonly marketed meat from another species. Additionally, interpreters of the results should bare in mind that consumers did not know the source of the meat that they were consuming. Red lights were used to mask any visual appearance differences between samples. Consumers also were placed in individual booths which limited communication between consumers. This type of consumer test helps to control any outside influences that may affect consumers' perceptions or acceptability. However, when a meat product is consumed in the home or in a foodservice establishment, the visual appearance of the product, the positive and/or negative perception of knowing the meat source, and the influence of other people seated at the table influence their perceptions. In our research, we decided to remove the aforementioned influences to determine consumers' acceptability where outside influences did not affect consumer sensory perception. Interpreters of these results should always keep in mind the testing environment.

Consumers rated ostrich *M. iliofibularis*, *M. obturatorius medialis*, *M. iliotibialis lateralis*, and *M. gastrocnemius* steaks similarly to a Choice beef top loin steak for overall like and texture like. These results indicate that overall, consumers had the same perception of overall acceptability and tenderness acceptability for the four ostrich muscles and Choice beef top loin steak. Consumers rated the ostrich *M. obturatorius medialis* steaks as tougher than the ostrich *M. iliofibularis* steaks; however, the ostrich steaks were similar in consumer tenderness rating to the Choice beef top loin steak.

Table 12: The average and standard deviation for the consumer taste panel ratings of the *M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius* from the ostrich carcass and a top loin steak from a beef carcass.

Muscle	Overall Like/ Dislike ^c		Flavor Like/ Dislike ^c		Flavor Intensity ^c		Texture Like/ Dislike ^c	
	AVG ^d	STD ^d	AVG	STD	AVG	STD	AVG	STD
<i>Ilio fibularis</i>	4.04 ^a	2.07	4.34 ^{ab}	2.23	4.64 ^{ab}	2.10	3.68 ^a	1.89
<i>Iliotibialis lateralis</i>	4.19 ^a	1.96	4.49 ^{ab}	2.08	4.65 ^{ab}	2.11	3.99 ^a	2.11
<i>Obturatorius medialis</i>	4.30 ^a	1.96	4.51 ^{ab}	2.19	4.69 ^{ab}	2.24	4.24 ^a	2.11
<i>Gastrocnemius</i>	4.63 ^a	1.95	4.84 ^b	2.05	5.05 ^b	2.03	4.21 ^a	2.00
Choice beef top loin	3.95 ^a	2.06	3.89 ^a	2.11	4.14 ^a	2.11	3.90 ^a	1.98

c - The consumer taste panel ratings are from a scale of 1 to 9 with 1 representing an extremely desirable attribute (1=like extremely; extremely tender) and 9 representing an extremely undesirable attribute (9=dislike extremely; extremely tough) for like/dislike scales and tenderness rating, and 1 = none and 9 = extremely intense for flavor intensity scale.

d - AVG is the abbreviation for Average, STD is the abbreviation for Standard Deviation. Numbers with the same superscripts are not significantly different.

Consumers preferred the flavor of the Choice beef top loin steak when compared to the *M. gastrocnemius* muscle. The *M. iliofibularis*, *M. iliotibialis lateralis*, and *M. obturatorius medialis* had similar rating for flavor acceptability to the Choice beef top loin steak. The Choice beef top loin steak had less intense flavor than the *M. gastrocnemius* steaks.

Consumer Panel Comments on Flavor

When asked what they liked or disliked about the flavor of the sample, consumers tended to identify an after-taste in ostrich steaks more frequently than in the Choice beef top loin steak (Table 13). Consumers tended to indicate that ostrich steaks were bland more frequently than the Choice beef top loin steak. Consumers commented that the Choice beef top loin steak was beefier more frequently than the ostrich steaks. The *M. gastrocnemius* steaks were identified as bland more frequently by consumers than other steaks in the study. Consumers commented that the *M. obturatorius medialis* steaks were strong or intense in flavor more frequently than the other steaks in the study. The Choice beef top loin steak was identified as having more fatty flavors and being more flavorful than ostrich steaks.

Table 13: Consumer response, by muscle, to the question: What did you like/dislike about the flavor of the sample?

Consumer	<i>Ilio</i> <i>fibularis</i>	<i>Ilio</i> <i>tibialis</i> <i>lateralis</i>	<i>Obturatorius</i> <i>medialis</i>	<i>Gastroc-</i> <i>nemius</i>	Beef Top Loin steak
After Taste	15	19	22	14	7
Beefy	9	9	12	6	18
Bitter	2	1	1	1	2
Bland	20	18	18	31	10
Bloody/Serum	4	6	6	6	0
Fatty	1	3	1	7	17
Flavorful	3	5	1	3	12
Lamby	1	2	0	0	0
Liver	9	2	6	5	1
Meaty	3	2	3	1	4
Metallic	2	3	2	2	2
Mild	4	3	4	7	6
Off-Flavor	2	4	7	8	2
Smoky	3	1	0	2	0
Sour	2	1	1	0	5
Strong/Intense	8	11	16	5	8
Sweet	3	1	2	1	1
Wild/Venison	6	5	7	4	1

a - The number of consumer panelists out of the 122 members that commented in a similar manner on that point. For example, 15 panelist thought the ostrich *M. iliofibularis* steak had an aftertaste.

Consumer Panel Comments on Texture

Consumers were asked what they liked or disliked about the texture of the steaks (Table 14). While some consumers commented on why they liked or disliked the texture of the steaks, consumer responded less frequently than when asked about the flavor of the steaks.

Table 14: Consumer response by muscle to the question: What did you like/dislike about the texture of the sample?

Comment	<i>Iliofibularis</i>	<i>Iliotibialis lateralis</i>	<i>Obturatorius medialis</i>	<i>Gastrocnemius</i>	Beef Top Loin steak
Coarse	3 ^a	6	7	6	1
Fine-Textured	6	3	2	2	4
Firm	2	3	2	1	3
Grainy	1	2	7	3	3
Rubbery	1	0	1	1	0
Smooth	9	12	13	11	13
Stringy	3	4	4	3	1

a - The number of consumer panelists out of the 122 members that commented in a similar manner on that point. For example, 2 panelist thought the ostrich *M. iliofibularis* steak was firm.

Consumer Panel General Comments

Consumers were given the opportunity to respond in an open-ended question where they were asked to make any additional comments about the steaks that were evaluated. These results are summarized in Table 15. Consumers' indicated that ostrich steaks tended to be drier and the Choice beef top loin steak was juicier. While a high percentage of consumers indicated that the ostrich steaks were tender, a higher percentage of consumers reported that the Choice beef top loin steak was tender. Additionally, 21 consumers indicated that the ostrich steak from the *M. obturatorius medialis* was tough.

Table 15: Miscellaneous responses, by muscle, made by the consumer taste panelists.

Comment	<i>Iliofibularis</i>	<i>Iliotibialis lateralis</i>	<i>Obturatorius medialis</i>	<i>Gastrocnemius</i>	Beef Top Loin Steak
Dry	17 ^a	10	15	7	1
Juicy	16	6	13	12	24
Tender	43	30	31	39	53
Tough	7	17	21	15	7
Under-cooked	6	5	5	10	6

a - The number of consumer panelists out of the 122 members that commented in a similar manner on that point. For example, 17 panelist thought the ostrich Semitendinous steak was dry.

Consumer Taste Panel Conclusions

These results indicated that consumers overall liked ostrich steaks similarly to Choice beef top loin steak and that they perceived the tenderness of ostrich steaks to be similar to the tenderness of Choice beef top loin steak, even though there is a slight trend for ostrich steaks, especially the *M. obturatorius medialis*, to be slightly tougher than the Choice beef top loin steak. Additionally, ostrich meat was perceived to be slightly different in flavor than Choice beef top loin steak. Ostrich steaks were more bland, especially the *M. gastrocnemius* muscle, had a more intense flavor, and tended to lack the fatty and beefy flavors associated with a Choice beef top loin steak. Ostrich steaks tended to be drier than a Choice beef top loin steak. In summary, consumers found slight differences in the palatability attributes of ostrich steaks compared to Choice beef top loin steaks, however, these slight differences in palatability did not significantly affect overall acceptability of ostrich steaks versus a Choice beef top loin steak.

Nutritional Analyses

Proximate Analyses

The percentage of moisture, lipid, protein, and ash from four muscles (all nutritional information is on an as consumed basis—cooked lean) from the ostrich carcass are reported in Table 16. These ostrich muscles ranged in moisture percentage from 65.75 to 68.46%. The *M. iliofibularis*, *M. iliotibialis lateralis*, and *M. gastrocnemius* muscles were similar in moisture content with approximately 68% moisture; however, the *M. obturatorius medialis* muscle had a lower percentage of moisture. As moisture and lipid percentage are inversely related in muscle (as percentage of lipid increases, the percentage of moisture decreases), the percentage of lipid in the *M. obturatorius medialis* muscle was higher than the percentage of lipid in the other three ostrich muscles, as would be expected. Figure 1 shows that the meat cuts from ostrich were lower in total lipid (chemical fat) than selected meat cuts from beef and chicken. Protein percent did not differ between the four muscles and ranged in value from 23.34 to 26.25%. High standard deviations for percentage of protein most likely contributed to the lack of statistical difference between muscles, as from the practical basis, the *M. obturatorius medialis* muscle had a lower percentage of protein from the *M. gastrocnemius* muscle. The large standard deviation in percentage of protein could be due to experimental error in conducting the analysis or inherent variation between the same muscle of different ostrich carcasses. Ash did not vary between the four different muscles of the ostrich carcass. These results indicate that these four ostrich muscles are high in protein and low in lipid content.

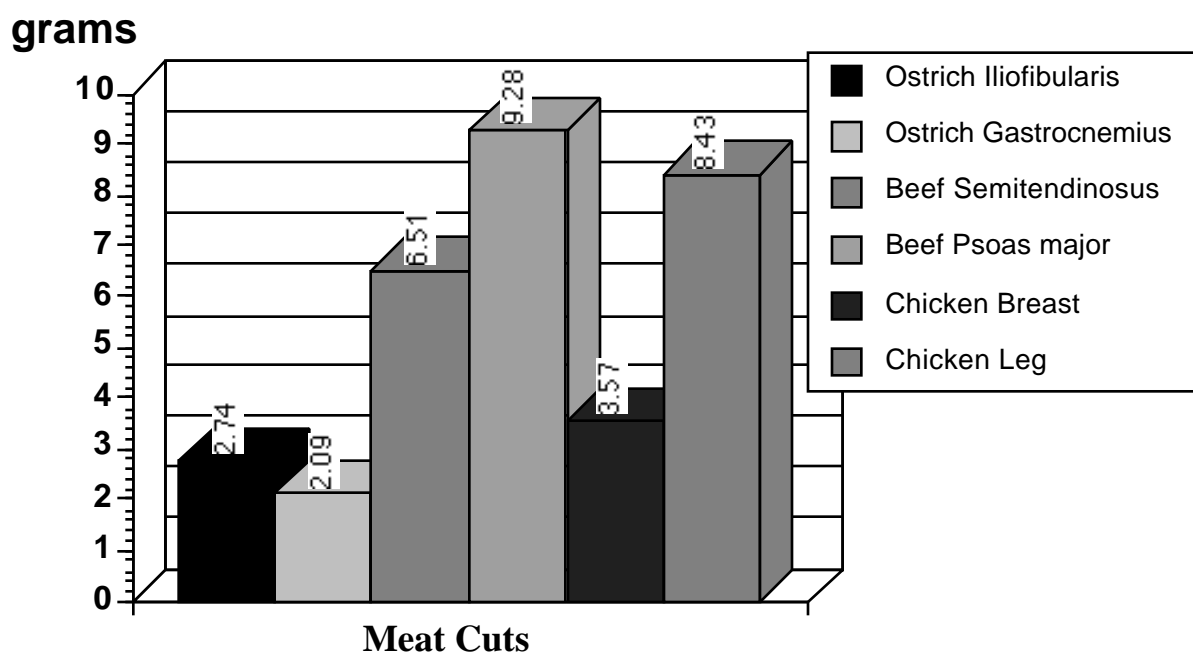
Table 16: The mean and standard deviation for the percentage chemical lipid, moisture, protein, and ash for the cooked *M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius* from the Ostrich carcass.

Muscle	Moisture, %		Lipid, %		Protein, %		Ash, %	
	MEAN ^a	STD ^b	MEAN	STD	MEAN	STD	MEAN	STD
<i>Ilioibularis</i>	68.42 ^a	1.90	2.74 ^a	0.33	25.52 ^a	4.40	1.21 ^a	0.07
<i>Iliotibialis lateralis</i>	68.46 ^a	1.99	2.66 ^a	0.37	24.16 ^a	4.50	1.24 ^a	0.10
<i>Obturatorius medialis</i>	65.75 ^b	0.54	3.75 ^b	1.07	23.34 ^a	3.22	1.28 ^a	0.09
<i>Gastrocnemius</i>	68.31 ^a	1.36	2.09 ^a	0.22	26.25 ^a	2.99	1.22 ^a	0.11

a - Mean is another word for average

b - STD is an abbreviation for Standard Deviation

Figure 1: A comparison of the grams of fat found in 100 grams of cooked lean from selected ostrich, beef^a and chicken^b meat cuts.



a- Beef figures calculated from information found in USDA Nutrition Handout 8-13
The *M. iliofibularis* was roasted and the *M. obturatorius medialis* was broiled.

b- Chicken figures calculated from information found in USDA Nutrition Handbook 8-5
Both the breast and leg were roasted.

Cholesterol and Other Nutrients

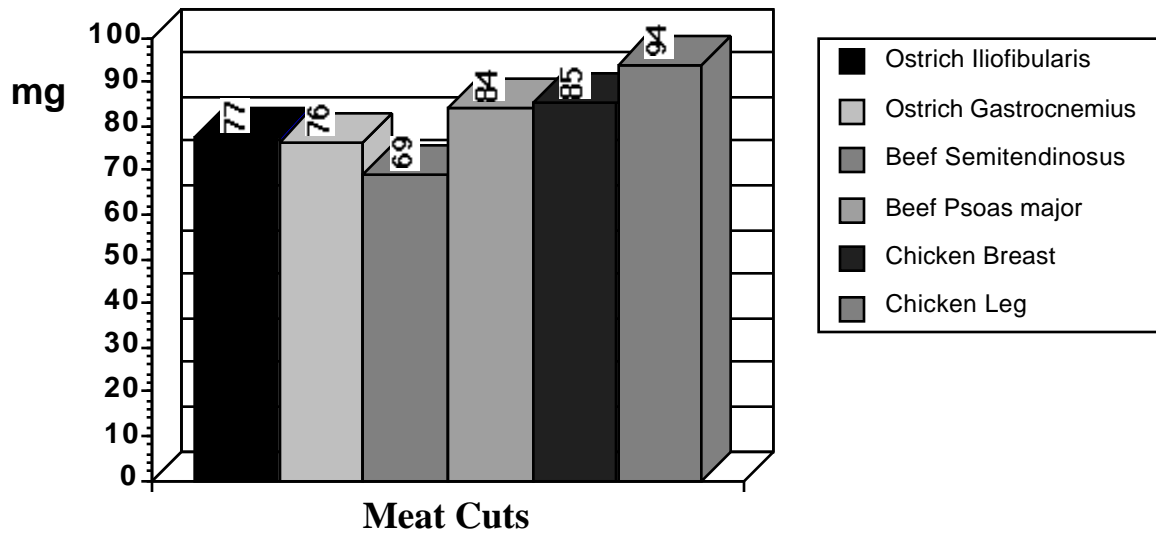
The percentage of cholesterol, calcium, sodium, and iron content of the four major muscles from the ostrich carcass are reported in Table 17. Ostrich muscle varied in cholesterol content from 76.07 to 94.68 mg/100g of cooked lean. The *M. obturatorius medialis* muscle was higher in cholesterol than the other three muscles evaluated. Calcium and iron content did not vary across the four different ostrich muscles and calcium and iron ranged from 1.47 to 2.02 and 2.79 to 3.00 mg/100g of cooked lean, respectively. The iron content found in cooked lean from ostrich carcasses is higher than is typically found in poultry (Figure 2). Sodium content was highest in the *M. gastrocnemius* muscle and lowest in the *M. iliofibularis* and *M. iliotibialis lateralis* muscles. The cholesterol level in cooked lean from ostrich carcasses in this study was found to be similar to the USDA figures reported for beef and chicken cholesterol levels (Figure 3). These levels are expected as the cell membranes in all muscles, regardless of species, have cholesterol inside the membrane.

Table 17: The mean and standard deviation for level of cholesterol, calcium, sodium, and iron (mg/100g of cooked lean) for the *M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius* from the ostrich carcass.

Muscle	milligrams/100 grams of cooked lean							
	Cholesterol		Calcium		Sodium		Iron	
	<u>MEAN</u> ^a	<u>STD</u> ^b	<u>MEAN</u> ^a	<u>STD</u> ^b	<u>MEAN</u> ^a	<u>STD</u> ^b	<u>MEAN</u> ^a	<u>STD</u> ^b
<i>Ilio</i> fibularis	76.71 ^a	13.82	1.47 ^a	0.39	62.39 ^a	5.24	2.87 ^a	0.88
<i>Ilio</i> tibialis <i>lateralis</i>	81.17 ^a	10.12	1.55 ^a	0.44	62.65 ^a	10.81	2.83 ^a	1.05
<i>Obturatorius</i> <i>medialis</i>	94.68 ^b	10.03	1.85 ^a	0.50	72.07 ^b	9.08	2.79 ^a	1.28
<i>Gastroc-</i> <i>nemius</i>	76.07 ^a	10.15	2.02 ^a	0.76	85.10 ^c	12.22	3.00 ^a	1.02

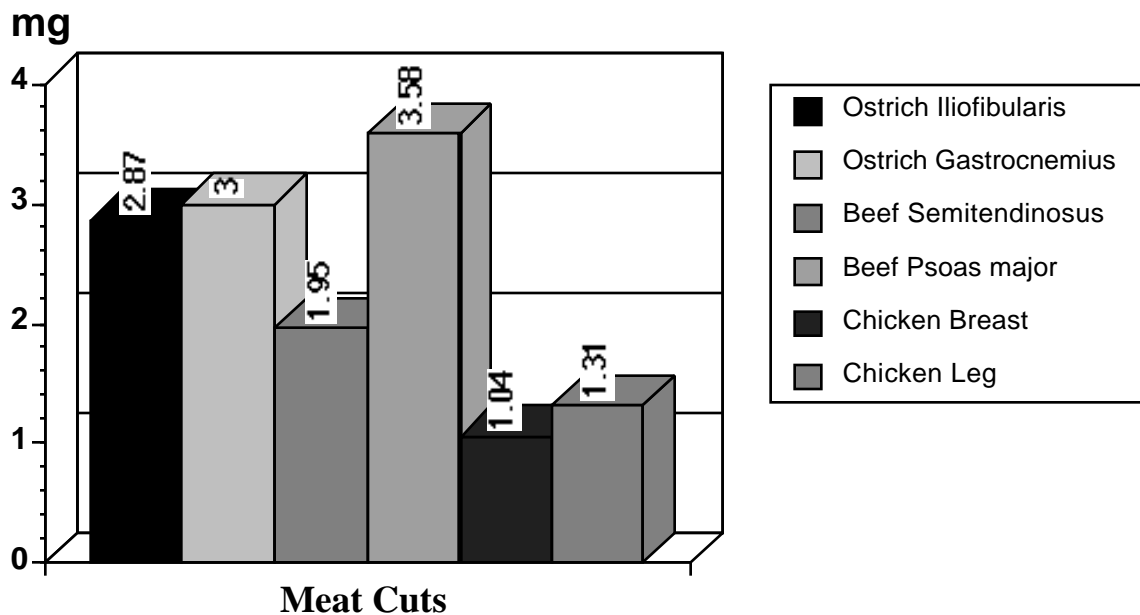
a - Mean is another word for average and STD is the abbreviation for Standard Deviation.

Figure 2: A comparison of the milligrams of cholesterol found in 100 grams of cooked lean from selected ostrich, beef^a and chicken^b meat cuts.



- a- Beef figures calculated from information found in USDA Nutrition Handout 8-13
The *M. iliofibularis* was roasted and the *M. obturatorius medialis* was broiled.
- b- Chicken figures calculated from information found in USDA Nutrition Handbook 8-5
Both the breast and leg were roasted.

Figure 3: A comparison of the milligrams of iron found in 100 grams of cooked lean from selected ostrich, beef^a and chicken^b meat cuts.



- a- Beef figures calculated from information found in USDA Nutrition Handout 8-13
The *M. iliofibularis* was roasted and the *M. obturatorius medialis* was broiled.
- b- Chicken figures calculated from information found in USDA Nutrition Handbook 8-5
Both the breast and leg were roasted.

Fatty Acid Profile

The fatty acid profile of cooked lean from ostrich showed monounsaturated fatty acids to be the most prevalent followed by saturated fatty acids and then polyunsaturated fatty acids (Table 18). Monounsaturated fatty acids levels within the four ostrich muscles were similar, while the range in polyunsaturated fatty acids and saturated fatty acids was larger.

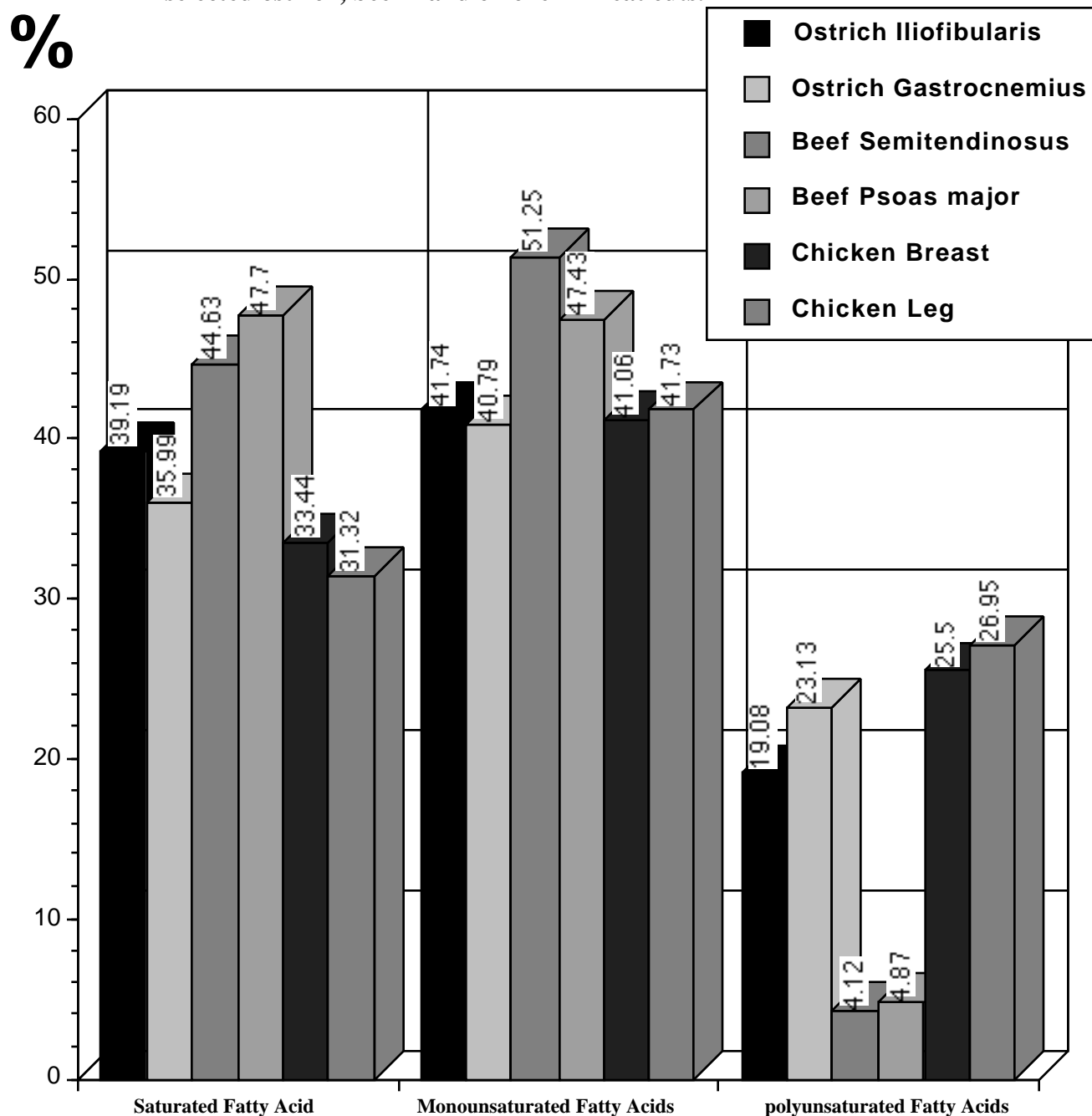
Cooked lean from ostrich tended to be higher in polyunsaturated fatty acids and lower in saturated fatty acids than beef. When compared to the USDA Handbook 8-5 figures for poultry, the cooked lean from ostrich was higher in saturated fatty acids and lower in polyunsaturated fatty acids than chicken breast and chicken leg (Figure 4). The individual fatty acids most often discussed, because of research showing their impact on blood level cholesterol, are palmitic acid (16:00), stearic acid (18:00), and oleic acid (18:01). Some researchers have reported that stearic acid (18:00) and oleic acid (18:01) lower blood level cholesterol in diet responsive patients, while palmitic (16:00) acid were shown to elevated blood level cholesterol in diet responsive patients. The cooked lean from ostrich examined in this study was similar to chicken in the percentage of palmitic acid and oleic acid (% calculated as a percentage of total fatty acids) and similar to beef in the amount of stearic acid (% calculated as a percentage of total fatty acids). Without performing human diet studies the significance of the fatty acid profile found in cooked lean from ostrich is unknown. However, some consumers may appreciate the low level of total fat and the distribution of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids found in ostrich meat when placed on a nutritional label.

Table 18: The mean and standard deviation for the percentage of saturated, monounsaturated, and polyunsaturated fatty acids in the cooked *M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius* from the ostrich carcass.

Muscle	Statistic ^a	Saturated Fatty Acids %	Monounsaturated Fatty Acids %	Polyunsaturated Fatty Acids %
<i>Ilioibuaris</i>	MEAN	39.19	41.74	19.08
	STD	3.36	3.32	5.23
<i>Iliotibialis lateralis</i>	MEAN	37.43	40.35	22.33
	STD	2.03	4.60	5.41
<i>Obturatorius medialis</i>	MEAN	38.65	40.5	20.85
	STD	3.49	4.04	5.33
<i>Gastrocnemius</i>	MEAN	35.99	40.79	23.13
	STD	2.56	4.22	5.83

a - Mean is another word for average and STD is the abbreviation for Standard Deviation.

Figure 4: A comparison of the percentage saturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids found in 100 grams of cooked lean from selected ostrich, beef^a, and chicken^b meat cuts.



a- Beef figures calculated from information found in USDA Nutrition Handout 8-13
The *M. iliofibularis* was roasted and the *M. obturatorius medialis* was broiled.

b- Chicken figures calculated from information found in USDA Nutrition Handbook 8-5
Both the breast and leg were roasted.

Table 19: The mean and standard deviation for the percentage of common individual fatty acids in the cooked *M. iliofibularis*, *M. iliotibialis lateralis*, *M. obturatorius medialis*, and *M. gastrocnemius* from the ostrich carcass.

Muscle	Stat. a	14:00 ^b	16:00	17:00	18:00	16:01 ^b	18:01	20:01	18:02
<i>iliofibularis</i>	MEAN	0.77	25.71	0.45	12.40	6.67	34.98	0.50	12.94
	STD	0.11	3.26	0.23	1.42	1.22	2.88	0.00	3.15
<i>iliotibialis lateralis</i>	MEAN	0.70	23.05	0.52	13.43	8.81	33.68	0.75	13.77
	STD	0.14	2.43	0.32	1.62	7.64	4.17	0.07	2.77
<i>Obturatorius medialis</i>	MEAN	0.68	24.54	0.28	13.22	6.13	34.15	0.36	14.14
	STD	0.14	4.00	0.08	2.31	1.32	2.93	0.06	2.73
<i>Gastrocnemius</i>	MEAN	0.67	21.10	0.33	14.14	6.47	34.19	0.53	13.93
	STD	0.11	2.48	0.15	2.21	1.23	3.53	0.15	3.64

a - Stat. is and abbreviation for Statistic, Mean is another word for average, STD is the abbreviation for Standard Deviation

b - Fatty acids are described by the number of carbons in the compound and by the number of double bonds in the compound. For example 14:00 is an abbreviation for 14 carbon atoms and zero double bonds, while 16:1 is an abbreviation for 16 carbon atoms and one double bond.

Value-Added Products

General Observations

The three value-added products produced (Uncured Ostrich Roast, Cured Ostrich Ham-Type Product, and Ostrich/Pork Polish Sausage) in this study differed with respect to consumer acceptability as perceived by the meat technologists. First, it should be pointed out that a substantial amount of labor intensive work was required to remove connective tissue from the ostrich meat. This connective tissue, if allowed to remain, would lower the acceptance of these products from an appearance standpoint and from a taste standpoint. Most meat cuts from ostrich carcasses have a thin layer of connective tissue located on the outside of the muscle. Whether the ostrich meat is destined for a steak or roast or for the production of a value-added meat item, this connective tissue should be removed.

Of the three products, only the Cured Ostrich Ham-Type Product and the Ostrich/Pork Polish Sausage showed promise for future marketing. The Uncured Ostrich Roast was undesirable in appearance and taste. Also, within the Uncured Ostrich Roast numerous gelatin pockets were found, further detracting from its appearance.

The cured ostrich products had excellent color and appeared to have good binding properties. They also had an acceptable flavor and texture.