International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Chemical and bacteriological quality of newly Trade Ostrich's Meat Cuts

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International Journal of Science and Research Archive, 2024, 13(02), 2734–2742

Publication history: Received on 28 October 2024; revised on 10 December 2024; accepted on 12 December 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.13.2.2468

Abstract

In Egypt, ostrich meat as a production animal is relatively under-researched compared to other farmed animals, especially regarding its meat quality. Despite ostrich farming being prominent for feather production in the early 20th century, its meat is gaining popularity among Egyptian consumers. Ostriches provide multiple products, including feathers, leather, and low-fat red meat. However, there is a lack of comprehensive data on ostrich meat's chemical and microbial quality, which is essential for ensuring food safety and quality. This study aims to analyze the proximate chemical and bacteriological properties of ostrich meat cuts sold in Egyptian markets. Thirty frozen ostrich meat samples (inside leg, outside leg, wings, and trim) were randomly collected from an ostrich abattoir and analyzed for moisture, protein, fat, ash content, and microbial load. The results showed that ostrich's meat had favorable nutritional characteristics, as high protein and low-fat content, with moisture levels ranging from 73.86% to 76.39%. The protein content in ostrich's meat ranged from 17.22 % to 21%, while the fat content varied from 1.82% to 5.11%. Microbiological analysis revealed that the total bacterial counts ranging in ostrich's meat from $4.1x10^3$ to $3.2x10^4$ CFU/g. *Escherichia coli* and *Staphylococcus aureus* were detected in some in ostrich's meat samples under the potential food safety concerns. The findings suggested the need for stricter hygiene practices during processing and storage to maintain meat quality and ensure consumer safety. This research underscores the importance of improving the scientific knowledge surrounding ostrich's meat in Egypt, particularly regarding its chemical and microbiological quality to enhance consumer confidence and promote its broader use.

Keywords: Ostrich's meat; Chemical; Microbiological; Quality and safety

1. Introduction

In reality, there is relatively little literatures about any aspect of the ostrich as a production meat animal in Egypt compared to other farmed animals, especially in concern to meat quality. Worldwide until 2019, there are lack of information and published literatures for ostrich's meat compared to any other red meat [1]. Ostrich meat is a newly product start to gain popularity among Egyptian consumer In the early 20th century, ostrich farming was very important for production of ostrich feathers, Egypt has numerous strengths and opportunities to develop its ostrich sector [2].

Nowadays, Egypt was mentioned as one of many countries involved in ostrich production. Ostrich reared for different purpose, it gives 1.4-1.8kg of feathers, 34-41kg of low-fat red meat, and 1.1-1.3m^2 of leather [3]. More scientific data about actual chemical and microbial quality of the ostrich meat is necessary so as to determine the actual sanitary status of ostrich meat during slaughtering, processing, distribution and storage.

Ostrich meat production is a relatively new industry in Egypt and is expanding quickly globally, making ostriches a valuable source of meat for humans. The underutilization of ostrich meat is caused by public awareness of its nutritional worth and the paucity of scientific data regarding its nutritious composition [3]. The optimal age for slaughtering

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ostriches is 12 to 14 months for the African Black subspecies, and 10 to 12 months for the subspecies Red Neck, Blue Neck, and crossbred ostriches. This is when these birds present the best meat, leather, and feather quality [4].

Consumers are all over the world are becoming progressively aware of the nutritional quality and functional properties of the foods that they consume. Poultry meat remained a great part of human diet with high quality nutrients such as, protein, vitamins and minerals. Mostly of poultry meat products are highly desirable, palatable, digestible and more importantly nutritious for all times [5]. The biggest world market for ostrich meat is Europe, which import ostrich' meat mainly from South Africa and Australia [6-7]. Actually, ostrich meat is not a regular meat type found on the Egyptian market, so it is considered special type of meat has a high price and special consumer's target. Over the recent years growing interest in ostrich farming and breeding, including ostriches, emu, and rhea, has been observed worldwide [8].

Ostrich's meat is an ideal solution for whom seeking of healthy food, consuming meat with good biological value, high quality protein, and fat. Ostrich's meat is usually sold in many restaurant and special meat shops with very high prices [9]. Ostrich meat has a high nutritive and dietetic value in which most food scientists considered it as valuable component of human diet, it has a low intramuscular fat content, a favorable fatty acid, a high content of iron and vitamin E and low of Sodium [8].

Prolong shelf life and meat safety features are very significant both for meat industry and consumers. Ostriches are especially reared for their high-quality meat, however, until few years ago, scientific projects worldwide on bacteriological quality of ostrich meat is still restricted [10, 11, 12]. Particularly in Europe, only limited data are existing regarding the bacterial quality and safety ostrich's meat, and obvious bacteriological criteria for ostrich's meat have not been established yet [13]. Food-borne pathogens included *Salmonella species and E. coli* on ostrich's meat may pretense a food poisoning threat and following of high promotional mainly consumer concerns regarding the meat safety.

Little literatures published in concern to the chemical and bacteriological quality of ostrich meat particularly in Egypt and generally worldwide, therefore, this study has been carried out to find the chemical and bacteriological quality of ostrich's meat cuts trade in the meat markets.

2. Material and methods

2.1. Samples collection

A total of 30 frozen ostrich meat samples (from Inside leg, Outside leg, Wings and trim, Inside strip) were randomly collected from ostrich abattoir. All samples were packed in an ice-box and transferred without delay to the Laboratory of the Department of Hygiene and Control, Faculty of Veterinary Medicine, Suez Canal University for evaluation.

2.2. Samples Preparation

- **Thawing:** The samples were kept in a frozen state till the performance of analysis. Samples thawing were completed overnight in a refrigerator at 4ºC for 8- 10 hours.

2.3. Proximate chemical analysis

2.3.1. Determination of Moisture Content

Moisture analysis was performed using rapid method **[14]**. Samples (approximately 2.0 g) were weighted out into aluminum tins and allowed to dry for 2h at 120°C in an air-oven. After drying in the oven, the samples were allowed to cool in desiccators and then were weighted. Loss in weight was reported as percent moisture as follow:

$$\text{Moisture \%} = \frac{\text{Weight loss (g)}}{\text{Sample weight (g)}} \text{ X } 100$$

2.3.2. Determination of Ash Content

Ash was determined using the **AOAC [15]** as follow: Approximately 5.0g of sample was placed into a dried pre-weighted crucible. The samples were allowed to ignition in muffle furnace at 550°C for 12 hours. Samples were allowed to cool (to about 110°C) then placed in a desiccators for cooling to the room temperature and then were weighted. Ash was calculated by loss in weight as percent ash as follow:

$$\text{Ash \%} = \frac{\text{Ash weight (g)}}{\text{Sample weight (g)}} \text{ X } 100$$

2.3.3. Determination of Protein Content

Protein was determined using the **AOAC [15]** as follow: **Digestion:** One gram of the homogenized sample was placed in kjeldahl's flask with 8g catalyst mixture (96% anhydrous Sodium Sulfate, 3.5% Copper Sulfate and 0.5% Selenium Dioxide). Then, 20ml of conc. H_2S0_4 were poured on the sample and vigorous shaking was applied. The flask with its contents was heated in an incline position below the boiling point of the acid until frothing ceased. Vigorous boiling was carried out till the mixture become clear and transparent then allowed to cool. This is called "digestion mixture".

- **Distillation:** The digested mixture was transferred into another kjeldahl's flask then 400ml of distilled water and 75ml of 50% NaOH were added. The flask related to condenser then, heating was applied and receiving of the liberated ammonia in a conical flask contains 50ml of 2% boric acid with indicator (20g boric acid with 200ml Alcohol plus 700ml distilled water plus 10ml mixed indicator). Approximately, 300 ml of the distillate was gained.
- **Titration:** The boric acid containing ammonia was titrated against N/10 NAOH and determines the amount of sodium hydroxide used (R).
- **Calculation:** Each 1ml of boric acid N/10 was equivalent to 0.0014 g nitrogen. The total nitrogen in the sample was estimated by the following equation:

$$\text{Protein \%} = \frac{\text{(50-R) x 0.0014}}{\text{Sample weight (g)}} \text{ X } 100$$

Using N x 6.25 to convert nitrogen to protein from the following equation:

Protein% = Nitrogen% x 6.25

2.3.4. Determination Fat Content

Fat was determined using the **AOAC[15]**. A clean Soxhelt's flask was placed in a hot air oven at 105°C for 30 minutes, and then it was placed in desiccator and weighted just after cooling. The flask was fitted with a soxhelt's extractor and secured in a stand on the bench. Mould a filter paper on a large test-tube and the homogenized samples were transferred into the paper and then plug the top of the paper with de-fattened cotton wool and pushed it down into the lower part of the extractor, then added light petroleum ether through the top of the extractor, making sure to wash round the rime to which the paper had previously adhered. A suitable condenser was attached and heating was applied to the flask in the apparatus on special water bath. The extraction was begun and continued for about 16 hours. After fat was completely extracted, the flask was removed from the bath and the paper was taken out. The ordinary extractor was replaced with one that is suitable for removing solvent and placed on the apparatus and tap of the condensed solvent.

When the solvent was nearly removed, the flask was detached and wiped off any water from the outside. The flask was placed in a hot air oven at 105°C for 3-5 hours. Hence, the flask was removed from time to time during the heating and blow air onto the fat by using a hand bellows. Finally, the flask was transferred to desiccator, cooled and weighted to determine the weight of fat by difference. The fat as a percentage of the original sample was calculated as follow:

$$\text{Fat \%} = \frac{\text{Fat weight (g)}}{\text{Sample weight (g)}} \text{ X } 100$$

2.4. Bacteriological evaluation

2.4.1. Preparation of Sample Dilution.

All samples were prepared according to the technique recommended by **ICMSF [16].** A mass of 25g from each prepared minced ostrich meat samples were aseptically cut and transferred into a sterile stomacher bag and blended with 225ml sterile normal saline. The mixture was then homogenized using a stomacher homogenizer (Stomacher 400, Seaward medicals, UK.) at 230 rpm for 60 seconds to obtain the original homogenate fluid of dilution rate of 1:10 (10^1). Then,

one ml of the previous homogenate was aseptically transferred into 9ml normal saline in test tube. Similarly, further dilutions required for inoculation were prepared by this decimal serial dilution process of up to 10^{-5}.

2.4.2. Determination of Total bacterial counts for ostrich meat samples

Three of 3M Petrifilm Rapid aerobic Count Plate **[17]** were placed on level surface. The top films were lifted and with the pipette perpendicular 1mL of ostrich meat samples suspension of each group (group A, group B and group C) was dispensed onto the center of the bottom of each three films, respectively. The top films were dropped down onto the sample. With ridge side down, 3M™ Petrifilm™ Spreader was placed on top films over inoculum. Gently pressure was applied on 3M petrifilm spreader to distribute inoculum over circular area before gel is formed. 3M petrifilm spreader was lifted. Plate was left undisturbed for at least one minute to permit the gel to form. Plates were incubated with clear side up in stacks of up to (24hrs ± 2hrs at 35°C ±1).

2.4.3. Determination of Enterobacteriaceae plate count

The 3M petrifilm Enterobacteriacea count plate **[18]** is a sample ready culture medium system which contains modified Violet Red Bile Glucose (VRBG) nutrients, a cold-water soluble agent and a tetrazolium indicated that facilitate colony enumeration. On 3M petrifilm EB plates, Enterobacteriaceae, appear as red colonies with yellow zones, red colonies associated with gas bubbles or red colonies with yellow zones and gas bubbles associated. The 3M food safety is certified to ISO 9001 for design and manufacturing.

2.4.4. Determination of E. coli/Coliform plate count

The 3M™ Petrifilm™ *E. coli*/Coliform Count Plate **[19]** is a sample-ready-culture medium system which contains modified Violet Red Bile (VRB) nutrients, a cold water-soluble gelling agent, an indicator of glucuronidase activity, 5-bromo-4-chloro3-indolyl-D-glucuronide (BCIG), and a tetrazolium indicator that facilitates colony enumeration. The 3M Petrifilm *E. coli*/Coliform Count Plates are used for the enumeration of *Escherichia coli* (*E. coli*) and coliforms in the food and beverage industries. As Aerobic Count Plate as figure No. 7. Most *E. coli* (about 97%) produce beta glucuronidase which produces a blue precipitate associated with the colony indicated by the blue to red-blue colonies. The top film traps gas produced by the lactose fermenting coliforms and *E. coli*. About 95% of *E. coli* produce gas, as indicated by colonies associated with entrapped gas (within approximately one colony diameter)

3. Results and Discussion

Ostrich meat offers valuable nutritional characteristics due to its minimal intramuscular fat, optimal fatty acid composition, and high levels of iron and vitamin E, making it an appealing alternative for those seeking nutrient-dense protein sources with low sodium content **[8].**

3.1. Proximate chemical analysis of ostrich's meat

3.1.1. Moisture Content of Ostrich Meat

Meat quality is one of the important crucial factor that effect meat suitability and rejects aptitude in which moisture content is one important factor. The mean moisture values of ostrich's meat from different ostrich cuts were shown in table 1. The mean moisture values for 1st, 2nd and commercial ostrich's meat cuts were 76.39, 75.30 and 73.86 g respectively. The moisture content, which contributes to the meat's tenderness and juiciness, varies across grades, affecting market appeal **[20].** Ostrich meat has a higher moisture level than beef, chicken, and turkey, with values ranging between 65.8% and 77.7%**.** Ostrich's meat is reported higher moisture content values (65.8 to 77.7%) compared to beef, chicken and turkey **[21-22].** Ostrich meat cuts fit within the Egyptian standard for 1st, 2nd and commercial cuts were 20 (100%), 19(95%) and 14(70%) respectively. Meanwhile, Ostrich meat cuts un fit within the Egyptian standard for 1st, 2nd and commercial cuts were 0 (0%), 1 (5%) and 6 (30%) respectively as shown in Table 2.

Table 1 Mean ± S.E. of proximate chemical analysis of trade ostrich's meat cuts

Meat cuts	Moistures	Protein	Fat	Ash
1st grade	76.39 ±0.83	21.34 ±0.36	1.82 ± 0.18	1.26 ±0.32
2nd grade	75.30 ± 0.45	19.221 ±0.30	3.50 ±0.17	1.83 ± 0.41
Commercial	73.86 ± 1.08	17.22 ±0.95	5.11 ± 1.59	2.94 ±0.82

Table 2 Proximate chemical analysis results of ostrich meat in compared to Egyptian standard

Meat cuts	Exceed EOS (%)	Within EOS (%)
1st grade	0 (0%)	20 (100%)
2nd grade	1 (5%)	19 (95%)
Commercial	6 (30%)	14 (17%)

EOS (2008): Moisture content in ostrich's meat range between 73 to 77%

3.1.2. Protein Content of Ostrich Meat

As general, poultry meat has a protein component of high quality compared to plant-derived foods, which have a less favorable protein profile [23]. The mean protein values of ostrich's meat from different ostrich cuts were shown in table1. The mean protein values for 1st, 2nd and commercial ostrich's meat cuts were 21.34, 19.221 and 17.22g respectively. The obtained results came to agree with recent studies done by Henry et al., [24] recorded that ostrich, *Struthio Camelus*, meat had a considerable level of protein ranged from 16.54 to 20.80%, iron and zinc, in concern to fat, more than half of fatty acids in ostrich meat are unsaturated fatty acids. Protein levels are high in ostrich meat, of about 28% in average, and the most frequent amino acid is creatinine [25]. Tenderness is the most appreciated ostrich meat characteristic. This is due to its low levels of saturated fat and its collagen to protein ratio, which are part of the connective tissue, and are responsible for meat texture. In addition to the arrangement of the muscle fibers, which are transversally oriented, may also explain its tenderness [26].

3.1.3. Fat Content of Ostrich Meat

The mean fat values of ostrich's meat from different ostrich cuts are shown in Table1. The mean fat values for 1st, 2nd and commercial ostrich's meat cuts were 1.82, 3.50 and 5.11 g respectively. Ostrich meat is considered a healthy food due to their higher in essential fatty acids than beef, broilers or turkey [21]. All food scientists confirmed the role of intramuscular fat in enhancing meat's flavor and texture. Ostrich meat offers health benefits due to its essential fatty acids. However, its low-fat content can reduce tenderness and juiciness, making it a key point in assessing consumer preferences and nutritional value [27].

3.1.4. Ash Content of Ostrich Meat

The mean ash values of ostrich's meat from different ostrich cuts are shown in Table1. The mean ash values for 1st, 2nd, and commercial ostrich's meat cuts were1.26, 1.83 and 5.11g respectively. The ash content of ostrich meat, edible offal, and fat tissue ranged from 0.97 to 1.17% [24]. The ash content of ostrich meat is conservable higher than beef and other poultry [21].

Majewska *et al.* [28] recoded ostrich muscles had similar content ash ranging from 1.07 to 1.17%. However, a higher content of ash were recorded ostrich meat by Horbańczuk et al., [22] and Akram et al., [29] respectively.

3.2. Bacteriological quality of ostrich meat

3.2.1. Total bacterial count content of ostrich meat

The mean total bacterial count values of ostrich's meat from different ostrich cuts are shown in Table 3. The mean total bacterial count values for 1st, 2nd, and commercial ostrich's meat cuts were $4.1x10^3$, $5.3x10^3$ and $3.2x10^4$ g respectively. The total bacterial count (TBC) in ostrich meat indicates the significance of stringent hygiene practices and proper storage conditions for maintaining quality. Woyda et al. [30] identified that critical storage factors, such as optimized temperature and pH management, directly influence bacterial load, with lower TBC values typically found under cooler, controlled conditions. Moreover, research by Xedzro et al. [31] emphasizes the variability in contamination levels across different processing steps, especially during skinning and evisceration, which pose higher microbial risks. These studies underline the need for rigorous microbial assessments and stringent handling practices to ensure microbial safety and longevity of ostrich meat in commercial markets. The total bacterial counts content of ostrich meat cut in compared to Egyptian standard shown in table 4. Ostrich meat cuts fit within the Egyptian standard for 1st, 2nd and commercial cuts were (100%), 20(100%) and 16(80%) respectively. Meanwhile, Ostrich meat cuts unfit within the Egyptian standard for 1st, 2nd and commercial cuts were 0 (0%), 0 (0%) and 4 (20%) respectively.

3.2.2. Enterobacteriaceae counts content of ostrich meat

The mean Enterobacteriaceae count values of ostrich's meat from different ostrich cuts are shown in Table 3. The mean total bacterial count values for 1st, 2nd, and commercial ostrich meat cuts were $3.4x10^2$, $8.5x10^2$and $6.5x10^4$ g respectively. The Enterobacteriaceae plays a significant role in the microbiological assessment of meat quality and safety, as it includes several pathogenic species such as *Escherichia coli*, *Salmonella spp.*, and *Klebsiella spp.*, which are commonly associated with foodborne illnesses [32].

Table 3 Mean ± S.E. of spoilage microorganism for trade ostrich's meat cuts

Meat cuts	Total bacterial counts	Enterobacteriaceae counts
1st grade	$4.1x10^3 \pm 2.4x10^2$	$3.4x10^2 \pm 0.4 \times 10^2$
2nd grade	$5.3x10^3 \pm 3.9x10^2$	$8.5x10^2 \pm 1.4 \times 10^2$
Commercial	$3.2x10^4 \pm 4.8x10^4$	$6.5x10^4 \pm 5.3x10^3$

Table 4 Spoilage microorganism results of ostrich meat in compared to Egyptian standard

Meat cuts	Exceed EOS (%)	Within EOS (%)
1st grade	0 (0%)	20 (100%)
2nd grade	0 (0%)	20 (100%)
Commercial	4 (20%)	16 (80%)

EOS (2008): Total bacterial count in ostrich's meat not exceed 10^5

3.2.3. Escherichia coli content of ostrich meat

The mean Escherichia coli count values of ostrich's meat from different ostrich cuts are shown in Table 5. The mean Escherichia coli count values for 1st, 2nd, and commercial ostrich meat cuts were $1.3x10^2$, $5.3x10^2$ and $2.4x10^3$g respectively. Meat contamination by *Escherichia coli* is a leading cause of foodborne illness, hospitalizations, and humans deaths [30]. The most pathogens commonly involved in ostriches enteritis are *Escherichia coli* and *Salmonella spp.* [33]. *Escherichia coli* is a gram-negative bacterium, facultative anaerobic and a member of the Enterobacteriaceae family [31]. *Escherichia coli* is a commensal pathogens of the poultry gastroenteritis included ostriches. Food-borne diseases are highly associated with the consumption of undercooked and contaminated meat. Poultry including ostrich usually colonized by *Escherichia coli* on their gastrointestinal tracts which associated with the high public health hazards for meat consumers [34].

3.2.4. Staphylococcus aureus content of ostrich meat

The mean *Staphylococcus aureus* content values of ostrich's meat from different ostrich cuts are shown in Table 5. The mean *Staphylococcus aureus* count values for 1st, 2nd, and commercial ostrich meat cuts were 0.9×10^2, $1.2x10^2$ and $1.5x10^3$ g respectively. The explored of *Staphylococcus aureus* prevalence, antimicrobial susceptibility, virulence genes in meat-processing industry is recommended to optimize interventions and to improve the meat safety [35]. Nearly recent study done by Pérez-Boto *et al.,* [36] concluded that the occurrence of *S. aureus* with virulence genes and antimicrobials resistance might represent a potential health hazard for meat consumers. *Staphylococcus aureus* produces classical enterotoxins SEA, SEB, SEC, SED, and SEE [37]. Newly staphylococcal enterotoxin-like proteins have been recovered [35]. A high number of *Staphylococcus aureus* harbor the enterotoxin gene cluster (egc) [38], containing newer enterotoxin genes (seg, sei, sem, sen, seo, and seu), which widely distributed in *S. aureus* isolated from meat and food handlers [39]. *S. aureus* enterotoxin are heat-stable which considered the main cause of Staphylococcal food poisoning, meanwhile, toxic shock syndrome toxin 1, Panton-Valentine leukocidin and hemolysin are common virulence factors of *S. aureus*, which can cause diverse types and degrees of consumer hazards [40].

Table 5 Mean ± S.E. of Food-borne pathogens for trade ostrich's meat cuts

Meat cuts	Total *E. coli* counts	Total *Staphylococcus aureus*
1st grade	$1.3x10^2 \pm 0.3 x10^2$	$0.9 x10^2 \pm 0.1x10^2$
2nd grade	$5.3x10^2 \pm 1.1 x10^2$	$1.2x10^2 \pm 0.2x10^2$
Commercial	$2.4x10^3 \pm 5.1x10^2$	$1.5x10^3 \pm 2x10^2$

4. Conclusion

The findings of this study underscore significant variations in the nutritional and microbiological properties of ostrich meat across different grades (1st grade, 2nd grade, and Commercial), with important implications for both quality control and consumer health. Ostrich's meat from 1st grade cuts demonstrated superior nutritional quality higher protein content, optimal fat distribution, and balanced moisture levels along with better microbiological safety in compared to 2nd grade and commercial grade cuts. On the other hand, commercial grade ostrich's meat exhibited higher fat content, bacterial contamination, and lower protein levels, making it less desirable for health-conscious consumers.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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