Monitoring physicochemical changes during the ageing of ostrich meat

Pavol Roba, Beáta Koréneková, Ján Mačanga, Pavlína Jevinová, Peter Popelka

Institute of Meat Hygiene and Technology
Department of Food Hygiene and Technology
University of Veterinary Medicine and Pharmacy
Košice, Slovak Republic

Abstract

This work reports physicochemical changes during the ageing of ostrich meat at different temperatures. Thigh meat from the common ostrich (*Struthio camelus*) was bought from an ostrich farm in Staré (Slovak Republic). The meat was stored in fridges at two different temperatures (2 °C and 4 °C). Lactic acid concentrations were analyzed by an EA 102 electrophoresis analyzer and pH values were measured on Day 1, (24 hours after slaughter - experiment day zero), and on Days 7 and 14. In meat stored at 2 °C, a statistically significant decrease ($p \leq 0.01$) in lactic acid levels and an increase in pH values ($p \leq 0.01$) were found on Day 7 of the experiment. A significant decrease ($p \leq 0.05$) in lactic acid levels and an increase in pH values ($p \leq 0.05$) were found on Day 14 as compared to Day 1 of the experiment. At 4 °C, a decrease in lactic acid was observed on Days 7 and 14 of the experiment, and a significant increase in pH on Days 7 ($p \leq 0.05$) and 14 of the experiment were recorded which was also accompanied by sensory changes. It follows from the above that the ostrich meat showed the best physicochemical properties on Day 7 after slaughter if it was stored at 2 °C, and that the shelf life of the meat at that temperature was extended to 14 days.

Lactic acid, meat, ostrich, pH value

Introduction

Various foods, sometimes with dubious quality are currently finding their way onto the market. For this reason, consumers are looking for ways to eat healthily by adding new food items to their menus. Such non-traditional types of foods include ostrich meat, which looks exotic at first glance and excels in quality and nutritional value.

From the nutritional point of view, ostrich meat is characterized by low fat content and its consumption is therefore suitable for weight-loss diets, during convalescence and cardiovascular diseases (Girolami et al. 2003). Ostrich meat has a low energy density and an extremely low cholesterol level. Ostrich thigh meat contains on average 20.95% protein and 2.29% fat. The collagen content is very low, which results in easier digestibility of the meat and makes it an extremely valuable food from the point of view of health. The fat content of ostrich meat is three times lower than that of pork (Majewska et al. 2009). The fat in ostrich meat contains up to 27 – 33% polyunsaturated fatty acids. The ratio of individual polyunsaturated, saturated and monounsaturated fatty acids is unique at 1: 1: 1 (Girolami et al. 2003). From a sensory point of view, ostrich meat is distinctly red; its structure and colour is similar to beef. Taste is relatively variable, depending on culinary preparation (Hoffman and Mellet 2003).

Animal meat is a complex dynamic and biological system, in which a number of post-mortem biochemical processes take place. We call the entire process meat ageing, during which the meat acquires the required sensory, technological and culinary characteristics (Lagin 2006).

Meat quality characteristics depend on pH values. When meat is stored, its pH and lactic acid concentrations increase and decrease in dependence on the length and temperature of meat storage. These parameters provide information on the course of post-mortem changes and the quality of ostrich meat. The pH value of ostrich meat in the range 5.4 to 5.6 is considered most desirable for the culinary use. The pH value will fall if there is sufficient

Address for correspondence:

MVDr. Pavol Roba
Institute of Meat Hygiene and Technology
Department of Food Hygiene and Technology
University of Veterinary Medicine and Pharmacy
Komenského 73, 041 81 Košice, Slovak Republic

Email: pavol.roba@student.uvlf.sk

substrate, which is glycogen in the case of meat. Glycogen is broken down into lactate by the biochemical process of glycogenolysis. Acting through hydrogen ions, the generated lactic acid causes acidification and a decrease in pH values. If there is little glycogen, little lactic acid is produced, which (in cattle, for example) leads to the undesirable phenomenon known as dark, firm and dry (DFD) beef (Young et al. 2004). Lactic acid is a guarantee of food safety and improves shelf life. Its low toxicity for macro-organisms opens the door to many new uses for this organic acid. The antibacterial action of lactic acid is based on its lipophilic nature. Undissociated lactic acid molecules pass through the bacterial cell membrane. It reacts with alkalis in the cytoplasm of the bacterial cell and interrupts the proton motive force and prevents energy release (Hall and Adams 1988).

The aim of this work was to determine the course of physicochemical changes during the ageing of ostrich meat at different storage temperatures.

Materials and Methods

Ostrich (*Struthio camelus*) meat was obtained from animals reared on the ostrich farm in Staré in Slovak Republic. Ostriches aged 9 months were slaughtered and bled on the farm. Following slaughter procedures, thigh muscle samples were collected, placed in a refrigerated box at 4 °C and transported to the Institute of Meat Hygiene and Technology at the University of Veterinary Medicine and Pharmacy in Košice.

Sample collection and preparation

Thigh muscle samples were divided and stored in two refrigerators set to different temperatures (2 °C and 4 °C). Twelve muscle samples (6 samples stored at 2 °C and 6 samples stored at 4 °C) were taken the following day (Day 1 of the experiment). The same procedure was followed on Days 7 and 14 of the experiment. The ostrich meat samples were then thoroughly homogenized.

Physicochemical analysis of samples

The values of pH were analyzed in an aqueous ostrich meat extract using a WTW inoLab-720 digital pH meter with a glass electrode. Aqueous extracts of ostrich meat samples were made and their analysis performed using an EA 102 electrophoretic analyser (Villa Labeco, Slovak Republic), with a conductivity detector using a leading electrolyte 10 mM HCl, β-alanine, 0.1 % mHEC, pH 3.2 and terminating electrolyte 5 mM caproic acid and 5 mM TRIS. The direct current was 250 µA in the upper column and 50 µA in the lower column. The analysis took about 20 minutes. The results were evaluated using the analytical computer program ITPPpro 32 and are reported in $g.100g^{-1}$ of sample.

Statistical evaluation of results

From the data obtained, we calculated the arithmetic mean and standard deviation, and determined the maximum and minimum values. The data were statistically evaluated using a Student's T-test at 3 levels of significance, i.e. $p \leq 0.05$; $p \leq 0.01$; $p \leq 0.001$.

Results

The evaluation of lactic acid dynamics in the thigh meat stored at 2 °C (Table 1) showed a statistically significant ($p \leq 0.01$) decrease (0.919 ± 0.251) on Day 7 of the experiment as compared to Day 1 (1.504 ± 0.143). On Day 14 of the experiment (1.179 ± 0.301), another statistically significant ($p \leq 0.05$) decrease in lactic acid levels was observed as compared to Day 1 of the experiment (Table 1). The maximum value of lactic acid was attained on Day 1 of the experiment.

Table 1. Changes in lactic acid levels during meat ageing at 2 °C

Lactic acid	day 1	day 7	day 14
X	1.504	0.919**	1.179*
Sd	0.143	0.251	0.301
X max	1.668	1.344	1.545
X min	1.236	0.587	0.803

*statistical significance recorded at $p \leq 0.05$; **statistical significance recorded at $p \leq 0.01$, Sd – standard deviation

The pH values in ostrich thigh meat samples on Day 7 (6.168 ± 0.027) showed that the levels increased significantly ($p \leq 0.01$) during meat ageing as compared to Day 1 of the experiment (6.157 ± 0.060) (Table 2). On Day 14 of the experiment, a statistically significant decrease ($p \leq 0.05$) in pH values (6.120 ± 0.024) as compared to Day 7 of the experiment was found (Table 2).

Table 2. Changes in pH values during meat ageing at 2 °C

pH	day 1	day 7	day 14
X	6.157	6.168**	6.120*
Sd	0.060	0.027	0.024
X max	6.220	6.210	6.160
X min	6.060	6.140	6.090

*statistical significance recorded at $p \leq 0.05$; **statistical significance recorded at $p \leq 0.01$, Sd – standard deviation

In ostrich thigh meat stored at 4 °C (Table 3), a significant decrease in lactic acid levels (1.102 ± 0.531) on Day 7 as compared to Day 1 of the meat ageing experiment (1.416 ± 0.108) was found. On Day 14 of the experiment (1.272 ± 0.276), a significant decrease in lactic acid levels as compared to Day 1 of the experiment was observed (Table 3).

Table 3. Changes in lactic acid levels during ostrich meat ageing at 4 °C

Lactic acid	day 1	day 7	day 14
X	1.416	1.102	1.272
Sd	0.108	0.531	0.276
X max	1.607	1.1916	1.498
X min	1.282	0.463	0.911

Sd – standard deviation

In thigh muscle samples stored at 4 °C (Table 4), a significant increase ($p \leq 0.05$) in pH values on Day 7 (6.230 ± 0.023) as compared to Day 1 of the meat ageing experiment (6.100 ± 0.067) was found. On Day 14 of the experiment, a similar pattern of changes in the form of an increase in pH values (6.324 ± 0.477) as compared to Day 7 of the experiment was recorded.

Table 4. Changes in pH values during ostrich meat ageing at 4 °C

pH	day 1	day 7	day 14
X	6.100	6.230*	6.324
Sd	0.067	0.023	0.477
X max	6.220	6.250	6.530
X min	6.040	6.200	5.200

*statistical significance recorded at $p \leq 0.05$; Sd – standard deviation

When comparing lactic acid levels in ostrich thigh meat stored at different temperatures in the experiment, a higher lactic acid levels on Days 7 and 14 of the experiment in meat stored at 4 °C than in meat stored at 2 °C was recorded (Table 5).

Table 5. Comparison of lactic acid levels at 2 °C and 4 °C

Lactic acid	day 1	day 7	day 14
2 °C	1.504	0.919	1.179
4 °C	1.416	1.102	1.272

At the same time, a higher pH values ($p \leq 0.05$) in ostrich meat stored at 2 °C on Day 1 of the experiment than in meat stored at 4 °C was found. However, on Day 7 of the experiment, statistically significant ($p \leq 0.001$) values were observed in thigh meat stored at 4 °C. Similarly higher values were also recorded in meat stored at 4 °C on Day 14 of the experiment (Table 6).

Table 6. Comparison of pH values at 2 °C and 4 °C

pH	day 1	day 7	day 14
2 °C	6.157*	6.168	6.120
4 °C	6.100	6.230**	6.324

* statistical significance recorded at $p \leq 0.05$; ** statistical significance recorded at $p \leq 0.001$

Changes in physicochemical parameters during the post-mortem ageing of ostrich meat, which were influenced by different storage temperatures, also manifested themselves in significant sensory changes.

Meat stored at 4 °C was pale red to grey-red in colour on Day 7 of the experiment. The meat had a distinctly animal smell, its consistency looked watery.

The colour of the meat stored at 2 °C, on the other hand, was a clear red to cherry-red on Day 7 of the experiment; its aroma was good, protein flavour noticeable, i.e. the flavour of good high-quality meat. The consistency was firm, with clearly delineated edges.

On Day 14 of the experiment, the meat stored at 2 °C had a typical cherry-red colour without any signs of spoilage. The smell was pleasant, with a typical meaty flavour.

Meat at 4 °C showed signs of spoilage. The meat was slimy and sticky on the outside, and had an unpleasant and rather sour smell.

Discussion

The pH value is one of the parameters that influences the quality of ostrich meat; 24 hours post-mortem it falls within a range of between 5.8 and 6.2 (Polawska et al. 2011). In our experiment, the average pH of meat stored at 2 °C and 4 °C was 6.157 and 6.100, respectively. The same range was also reported by Majewska et al. (2009). According to Fisher et al. (2000), meat at this pH value has ideal characteristics for culinary processing. The decrease in pH values during meat ageing depends on the amount of time that has elapsed since the ostriches were slaughtered (Botha et al. 2006). As noted in the study by Hoffman et al. (2008), the highest pH values were recorded in the darkest portions of ostrich meat with the lowest drip loss and cooking loss. Meat and its pH values are influenced by many factors, with the most important being the method of killing, stunning, bleeding, packing and, in particular, storage conditions (Hoffman et al. 2009). Glycogenolysis, i.e. the process in which lactic acid is produced, significantly affects the post-mortem decline in pH values. Some muscles, such as the *musculus ambiens*, *musculus iliofibularis* and *musculus obturatorius medialis*, do not exhibit the typical decrease in pH values. Their pH drops suddenly after two hours, then increases again and remains level (Balog et al. 2006).

The most important qualitative characteristics of meat associated with post-mortem decrease in values are the meat's colour, water-binding capacity and shelf life (Balog and Almeida Paz 2007). In their study, Van Schalwyk et al. (2005) reported a shorter shelf life and dark meat colour at a high pH value. The temperature, time and the influence of the ambient atmosphere and oxygen content affect the pH values of ostrich meat and its shelf life in general (Capita et al. 2006). Chilling also impacts the quality of taste, appearance and meat texture parameters (James et al. 2014).

In this work, it was found that a temperature of 2 °C extended the shelf life of meat and preserved its final quality. A higher temperature (4 °C) had a negative impact on the quality and shelf life of ostrich meat as early as on Day 7 of the experiment. For this reason, careful meat quality control is required if ostrich meat is stored for more than 7 days at 4 °C.

Brenesselová et al. (2015) stated that the lactic acid values in meat not protected by a modified atmosphere, i.e. unpackaged meat, remained constant at 4 °C until Day 7 and were increased on Day 14. A statistically significant decrease in lactic acid levels ($p \leq 0.01$) was recorded on Day 7, though an increase was observed on Day 14 of the experiment at both temperatures.

Conclusions

As reported in the literature, the optimum temperatures for storing fresh meat fall within a range of 2 – 4 °C. It is imperative that this range is observed during sale, distribution and household storage. Maintaining the desired conditions influencing the quality of the meat is achieved by temperature monitoring. Ideal sensory properties such as taste, colour and aroma are attained in the temperature range from 2 °C to 4 °C. We found that the temperature of 2 °C extended the shelf life of the meat and preserved its final quality. The higher temperature of 4 °C had a negative effect on the quality and shelf life of the meat. At 2 °C, the best values were obtained on Day 7 of the experiment.

References

Adams MR and Hall CJ 1988: Growth inhibition of food-borne pathogens by lactic and acetic acids and their mixtures. Int J Food Sci Tech **23**(3): 287-292

Balog A and Almeida Paz ICL 2007: Ostrich (Struthio camellus) carcass yield and meat quality parameters. Revista Brasileira de Ciência Avícola **9**(4): 215-220

Balog A, Mendes AA, Almeida P, Silva MC, Takahashi SE, Komiyama CM 2006: Rendimento de carcaça e avaliação da qualidade da carne de avestruzes. 43[a] Anais da Reunião Anual da Sociedade Brasileira de Zootecnia. João Pessoa, PB. Brasil. 100-107 (In Spanish)

Botha SSC, Hoffman LC, Britz T J 2006: Effect of hot-deboning on the physical quality characteristics of ostrich meat. South African J Anim Sci **36**(3): 197-208

Brenesselová M, Koréneková B, Mačanga J, Marcinčák S, Jevinová P, Pipová M, Turek P 2015: Effects of vacuum packaging conditions on the quality, biochemical changes and the durability of ostrich meat. Meat Sci **101**: 42-47

Capita R, Díaz-Rodríguez N, Prieto M, Alonso-Calleja C 2006: Effects of temperature, oxygen exclusion, and storage on the microbial loads and pH of packed ostrich steaks. Meat Sci **73**(3): 498-502

Fisher P, Hoffman LC, Mellett FD 2000: Processing and nutritional characteristics of value added ostrich products. Meat Sci **55**(2): 251-254

Girolami A, Marsico I, D'andrea G, Braghieri A, Napolitano F, Cifuni G F 2003: Fatty acid profile, cholesterol content and tenderness of ostrich meat as influenced by age at slaughter and muscle type. Meat Sci **64**(3): 309-315

Hoffman LC, Cloete SWP, Van Schalkwyk SJ, Botha SSC 2009: Effect of bleeding method and low voltage electrical stimulation on meat quality of ostriches. South African J Anim Sci **39**(3): 206-213

Hoffman LC and Mellett FD 2003: Quality characteristics of low fat ostrich meat patties formulated with either pork lard or modified corn starch, soya isolate and water. Meat Sci **65**(2): 869-875

Hoffman LC, Muller M, Cloete SWP, Brand M 2008: Physical and sensory meat quality of South African Black ostriches (Struthio camelus var. domesticus), Zimbabwean Blue ostriches (*Struthio camelus australis*) and their hybrid. Meat Sci **79**(2): 365-374

James SJ and James Ch 2014: Chilling and freezing. In: J. Motarjemi and H. Lelieveld (eds.) Food safety management. Elsevier, Amsterdam, The Netherlands, 481-510

Lagin L 2006: Technológia mäsa II: Spracovanie mäsa. 1[st] Ed. Nitra: SPU v Nitre, 150 p, ISBN 80-8069-671-3 (In Slovak)

Majewska D, Jakubowska M, Ligocki M, Tarasewicz Z, Szczerbińska D, Karamucki T, Sales J 2009: Physicochemical characteristics, proximate analysis and mineral composition of ostrich meat as influenced by muscle. Food Chem **117**(2): 207-211

Poławska E, Marchewka J, Cooper RG, Sartowska K, Pomianowski J, Jóźwik A, Strzałkowska N, Horbańczuk JO 2011: The ostrich meat–an updated review. Ani Sci Papers and Reports **29**(2): 89-97

Van Schalkwyk SJ, Hoffman LC, Cloete SWP, Mellett FD 2005: The effect of feed withdrawal during lairage on meat quality characteristics in ostriches. Meat Sci **69**(4): 647-651

Young OA, West J, Hart AL, Van Otterdijk F F H 2004: A method for early determination of meat ultimate pH. Meat Sci **66**(2): 493-498