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The quality of the meat of ostriches transported over various distances*

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The aim of the study was to determine the effects of different transport distances from the farm to the slaughterhouse in summer on the quality of ostrich meat. The experimental materials were 110 ostriches aged 10-12 months, raised on four Polish farms. The study showed that increasing the transport distance varied the quality parameters examined in the meat. As transport distance increased slightly lower water content was observed in the meat, with a higher content of protein, fat and ash and an upward trend in acidity (both pH_{45min} and pH_{24h}), increased water holding capacity and a lighter colour 45 minutes meat after slaughter. The results may indicate an increasing burden of stress factors on the ostriches during transport, which then affect the quality of ostrich meat.

KEY WORDS: ostrich / transport / quality of meat

Recent years have witnessed a growing interest in ratites, primarily ostriches, which are commercially raised on farms for their meat, leather, feathers and eggs [11, 26, 27]. Ostrich meat is recognized as a high quality product characterized by low fat levels and relatively high amounts of n-3 fatty acids [10, 21]. However, meat quality (nutritive and technological value) is influenced by various factors, including genetic factors, diet, the housing system and the entire pre-slaughter handling process, including transport. During pre-slaughter treatment the birds are exposed to a variety of noxious and stressful stimuli, including food and water deprivation, loading, transport, unloading, restriction of natural behaviour, and pain and discomfort [16]. The accumulation of so many stressors within a short time leads to increased mortality rates, weight loss, injuries, and stress-induced dete-

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rioration of meat quality or defective meat [6, 13, 16, 25]. Since ostriches have not yet been fully domesticated, they are more susceptible to stress and their meat is characterized by relatively high ultimate pH levels in comparison with the meat of other livestock species [4, 17, 26]. The rate of postmortem glycolysis and ultimate pH affect the sensory attributes of meat, such as colour, water-holding capacity, consistency, texture, and storage life [3, 5]. The stress response of ostriches to pre-slaughter handling (particularly transport) remains poorly researched [6, 8, 15, 28, 31, 32]. The losses resulting from pre-slaughter stress can be minimized by improving transport conditions and boosting the birds' resistance to adverse stimuli through the administration of vitamin or mineral preparations or multivitamin and mineral dietary supplements [16, 33, 34].

The aim of the study was to determine the effects of different transport distances from the farm to the slaughterhouse in summer on the quality of ostrich meat.

Materials and methods

The experimental material comprised 110 ostriches aged 10-12 months, with body weight of about 92 kg (±3 kg), raised on four Polish farms.

In June 2011 the ostriches were transported from farms to an abattoir in vehicles adapted for ostrich transport, in accordance with Council Regulation (EC) 1/2005 of 22 December 2004 on the protection of animals during transport and related operations [24].

The ostriches came from farms located within 50 km (T-50, 27 birds), 100 km (T-100, 28 birds), 200 km (T-200, 28 birds) and 300 km (T-300, 27 birds) of the abattoir. All ostriches arrived at the slaughterhouse between 4.00 p.m. and 6.00 p.m. The birds were fasted for two hours before transport, with free access to water (they were deprived of water only during transport). On arrival, the ostriches were weighed and then they stayed in the lairage until slaughter the next day (12-15 hours). The birds were sacrificed at an EU-approved cattle and pig slaughterhouse in Wolbrom, according to the procedure described by Majewska *et al*. [14] and national regulations [23].

Physical and chemical analyses of the meat were performed 45 min post mortem and after the carcasses had been chilled for 24 hours at 4°C. Samples were collected from the *m. gastrocnemius pars interna*. Meat acidity, including pH_{45min} (45 min post mortem) and pH_{24h} (24 h post mortem), was measured using an HI 99163 portable meat pH-meter (Hanna Instruments, Germany) with an FC 232D electrode.

Colour brightness (45 min post mortem and 24 h post mortem) was determined with a Minolta CR-400 Chroma Meter (Japan) on the basis of light reflectance values in the CIELAB system, as follows: lightness L* (0 – black, 100 – white), redness a* (magenta – positive values, green – negative values) and yellowness b* (yellow – positive values, blue – negative values). The measurement was repeated three times along the long axis of the muscle [18]. Water-holding capacity (24 h post mortem) was determined as drip loss by the method proposed by Grau and Hamm, as modified by Pohja and Niinivaara [19]. A ground meat sample weighing 0.3 g was placed on Whatman grade 1 filter paper, between two glass plates, and a load of 2.0 kg was applied for 5 min. The surface area of two spots, representing extruded meat juice and meat, was measured using a HAFF 317E planimeter (Gebrueder HAFF GmbH, Germany). The infiltrate area (cm^2) was expressed as the difference between these two surface areas.

Before determining the proximate chemical composition of the meat, samples were thoroughly homogenized with a Buchi B-400 mixer (BUCHI, Switzerland) and assayed for moisture, crude fat, total protein and ash [1].

A sensory evaluation of the meat was performed on samples cooked in a convection steam oven (Beck FCV 4 EDS, GmbH, Jagsthausen, Germany) for 30 minutes until an internal temperature of 75°C was reached, according to the method proposed by Baryłko-Pikielna and Matuszewska [2], with our own modification. The sensory properties of the meat were assessed on a five-point scale (5 – highest, 1 – lowest). The following attributes were evaluated: aroma – intensity and desirability, palatability – intensity and desirability, juiciness, tenderness, and colour.

The data were verified statistically by one-way ANOVA. Arithmetic means ($\overline{x}$) and standard deviations (SD) were calculated, and significance of differences between means was determined by Duncan's test. Computations were performed using Statistica software ver. 10.0 PL [30].

The experiment was approved by the Local Ethics Committee (Resolution no. 77/2008).

Results and discussion

The experimental pre-slaughter handling was carried out in June 2011. Bioclimatic conditions during transport were as follows: ambient temperature 18-20°C and relative humidity 60-65%. Inside the vehicles, these parameters were higher by 3-5°C and 10-15%, respectively.

The impact of transport distance on the chemical composition of the *m. gastrocnemius pars interna* was not confirmed statistically (Table 1). Analysis of the proximate chemical composition of the meat of ostriches transported to the abattoir in the summer revealed a minor decrease in the water content of the meat and an increase in the concentrations of protein, fat and ash as the transport distance increased. Similar relationships have been observed in chickens by Pomianowski et al. [22] and Sowińska et al. [29]. The chemical composition of ostrich meat in the present study remained within reference ranges given by other authors [14, 21].

The different transport distances used in the experiment were associated with changes in the physicochemical parameters of the ostrich meat (Table 2) and its sensory properties (Table 3). The results of the analysis of variance for the physicochemical properties of the ostrich meat (Table 2) showed statistically significant differences between transport distances in meat colour 45 minutes after slaughter, for the values of L^*_{45min} and b^*_{45min}. Analysis of variance of the sensory evaluation of the ostrich meat (Table 3) showed statistically significant differences between transport distances only for desirability of flavour. Therefore Duncan's Multiple Range Test was also performed for these characteristics, and the results are shown in Tables 2 and 3.

Table 1
Chemical composition of ostrich meat (*m. gastrocnemius pars interna)*

Specification		Transport			
		T-50	T-100	T-200	T-300
Moisture (%)	$\overline{x}$	76.71	76.68	76.39	76.15
	SD	1.15	0.82	1.00	0.65
Crude fat (%)	$\overline{x}$	1.03	1.15	1.17	1.31
	SD	0.62	0.64	0.59	0.45
Total protein (%)	$\overline{x}$	21.14	21.17	21.27	21.26
	SD	0.63	0.54	0.58	0.57
Ash (%)	$\overline{x}$	1.13	1.14	1.14	1.16
	SD	0.10	0.05	0.08	0.12

Transport: T-50 – 50 km, T-100 – 100 km, T-200 – 200 km, T-300 – 300 km

The increase in ostrich meat acidity with transport distance, from 6.10 to 6.26 for pH_{45min} and from 6.01 to 6.19 for pH_{24h}, was not confirmed statistically. High pH of the *m. gastrocnemius* was also noted in stress-exposed ostriches by Hoffman et al. [9] and Lambooij et al. [12]. In the study by Hoffman et al. [9], the pH of meat from ostriches transported over a distance of 60 km reached 6.30 and 5.93 within 60 min and 24 h post mortem, respectively. The respective values in meat from ostriches transported 600 km were 6.37 and 6.11.

Ostrich meat is dark-red in colour, and the values of the CIELAB coordinates are as follows: L* 27-39, a* 12-23, and b* 0-13 [7, 12, 14, 20, 21]. In the present study the colour of the *m. gastrocnemius* (Table 2) was significantly lighter (L^*_{45min}) in ostriches transported greater distances: 35.35 in group T-100 and 34.90 in group T-300, as compared with 32.32 in group T-50. The darker meat from the control (T-50) was characterized by a lower contribution of the yellow component (b^*_{45min}=1.12) as compared with groups T-100 (2.49, P≤0.01) and T-300 (2.36, P≤0.05), while redness values were similar (a^*_{45min} 19.04-21.06). Meat colour was darker 24 hours post mortem (L^*_{24h}) and remained at a stable level of 27.45 to 28.73. In all groups, the values for redness (a^*_{24h}) and yellowness (b^*_{24h}) were lower than those noted 45 min post mortem, at 18.58–19.27 and 0.29–0.61, respectively.

The water-holding capacity of meat, i.e. the ability to retain and bind water during the technological process, is an important attribute. Water is bound to the muscle proteins and water-binding capacity is affected by acidity levels [3, 5], decreasing with a drop in pH and increasing with a rise in pH. The findings of Lambooij et al. [12] and Van Schalkwyk et al. [31], as well as the results of the present study (Table 2), confirm a correlation between the pH and water-holding capacity of meat. A slight reduction in drip loss was noted in our study, as the surface area of extruded meat juice decreased from 3.86 cm^2 in the control to 2.88 cm^2 in group T-300, thus suggesting that the wa-

Table 2
Physicochemical properties ostrich meat (*m. gastrocnemius pars interna)*

Specification		Transport			
		T-50	T-100	T-200	T-300
pH_{45min}	$\overline{x}$	6.10	6.22	6.26	6.26
	SD	0.26	0.29	0.27	0.22
L^*_{45min}	$\overline{x}$	32.32^{a}	35.36^{b}	34.47	34.90^{b}
	SD	4.74	3.97	4.40	3.54
a^*_{45min}	$\overline{x}$	19.04	20.53	19.98	21.06
	SD	2.31	4.06	3.56	3.37
b^*_{45min}	$\overline{x}$	1.12^{Aa}	2.49^{B}	2.02	2.36^{b}
	SD	1.17	2.10	2.04	1.77
pH_{24h}	$\overline{x}$	6.01	6.14	6.18	6.19
	SD	0.19	0.33	0.30	0.32
L^*_{24h}	$\overline{x}$	27.66	28.73	27.62	27.45
	SD	2.00	1.83	1.97	2.14
a^*_{24h}	$\overline{x}$	18.71	18.86	18.58	19.27
	SD	1.23	2.45	1.91	1.78
b^*_{24h}	$\overline{x}$	0.29	0.61	0.46	0.54
	SD	0.47	1.01	0.75	0.77
WHC (cm^2)	$\overline{x}$	3.86	3.64	3.19	2.88
	SD	1.36	1.64	1.64	1.43

Transport: T-50 – 50 km, T-100 – 100 km, T-200 – 200 km, T-300 – 300 km
Values marked with different letters differ significantly: A, B – $P \leq 0.01$; a, b – $P \leq 0.05$

ter-holding capacity of meat was higher in the groups transported greater distances. A similar trend was observed in broiler chickens by Wójcik et al. [33]. Hoffman et al. [9] studied the physicochemical properties of meat from ostriches transported 60 and 600 km and from birds that were not transported prior to slaughter. The author found that despite a higher ultimate pH, the meat of the transported ostriches had a brighter colour (L*) and lower water-holding capacity than the group of birds that were not transported to the abattoir.

The high pH levels, dark colour and high water-holding capacity of the meat in the present study, as compared with results reported by other authors for ostrich meat [7, 28] and other red meats [4, 17], indicate that the *m. gastrocnemius* could have the DFD quality defect. Similarly, Hoffman et al. [9] found meat with a pH above 6.2 after 24 hours post mortem in 37.5% of ostriches transported a distance of 600 km.

The scores for the sensory attributes of the meat (Table 3) were similar: 3.13-4.48 points. However, meat from ostriches transported a distance of 300 km received slightly

Table 3
Sensory evaluation of ostrich meat (*m. gastrocnemius pars interna*) on a five-point scale

Specification		Transport			
		T-50	T-100	T-200	T-300
Aroma: intensity	$\overline{x}$	3.89	3.95	3.92	3.82
	SD	0.68	0.64	0.67	0.67
Aroma: desirability	$\overline{x}$	3.97	3.99	3.97	3.92
	SD	0.57	0.57	0.62	0.58
Juiciness	$\overline{x}$	3.29	3.26	3.22	3.13
	SD	1.02	1.00	1.04	1.07
Tenderness	$\overline{x}$	3.44	3.47	3.46	3.32
	SD	0.79	0.85	0.82	0.88
Palatability: intensity	$\overline{x}$	3.84	3.82	3.77	3.67
	SD	0.58	0.63	0.67	0.66
Palatability: desirability	$\overline{x}$	3.99^{b}	4.04^{B}	3.97^{b}	3.82^{Aa}
	SD	0.51	0.45	0.52	0.57
Colour	$\overline{x}$	4.48	4.44	4.42	4.35
	SD	0.47	0.50	0.49	0.52

Transport: T-50 – 50 km, T-100 – 100 km, T-200 – 200 km, T-300 – 300 km
Values marked with different letters differ significantly: A, B – P≤0.01; a, b – P≤0.05

lower scores in comparison with the other groups. The scores for juiciness and tenderness were lower (3.13-3.48 points) than those for other sensory attributes (3.67-4.48).

The study showed that increasing transport distance varied the quality parameters examined in the ostrich meat. With increased transport distance slightly lower water content was observed in the meat, with a higher content of protein, fat and ash and an upward trend in acidity (both $pH_{45\ min}$ and $pH_{24\ h}$), as well as increased water holding capacity and a lighter colour 45 minutes meat after slaughter. The results may indicate a growing burden of stress factors on the ostrich organism during transport, which then affect the quality of ostrich meat.

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