A COMPARATIVE STUDY ON THE PHYSICO-CHEMICAL AND FUNCTIONAL PROPERTIES OF OSTRICH MEAT AND BEEF DURING AGING

S. Alasvand Zarasvand[1]., M. Kadivar[2], M. Aminlari[3*], and S. S. Shekarforoush[4]

[1]Department of food Science and Technology, School of Agriculture, Shiraz University, Shiraz 71345, Iran
[2]Department of Food Science and Technology, Isfahan University of Technology, Isfahan, Iran
[3]Department of Biochemistry, School of Veterinary Medicine, Shiraz University, Shiraz 71345, Iran
[4]Department of Food Hygiene, School of Veterinary Medicine, Shiraz University, Shiraz 71345, Iran
[*]Corresponding author (phone: +98-711-2286950; fax: +98-711-2286940; e-mail aminlari@shirazu.ac.ir

Abstract*-- The objective of this search was to evaluate chemical, physical parameters and functional properties of ostrich meat (M. iliofibularis) and beef (M. longissimus dorsi) during storages at 4 °C for 4.5, 24, 72 and 168 h post-mortem. Results indicated significant decrease in shear force values (p<0.05) in both meat types during storage. Lightness (L*) of the two muscles decreased while redness (a*) and yellowness (b*) increased in both meat types. pH values significantly decreased (p<0.05) while buffering capacity, emulsifying capacity, emulsifying stability, foaming capacity, water holding capacity, and myofibrilar fragmentation index were increased during 7 days postmortem (p<0.05). Aging showed no effect on cooking loss either in ostrich or in beef. Within the parameters of the present study, it is concluded that ostrich meat has superior functional attributes compared to beef initially and during aging time (p<0.05). Results indicated that meat functional properties improved upon aging in two species.

***Index Terms*—Aging, beef, meat, ostrich.**

I. INTRODUCTION

Meat from ostrich (*Struthio camelus*) is perceived and marketed as healthy alternative to other types of red meats. Ostriches have excellent feed conversion rates, which makes the cost of producing ostrich meat favorable. Ostrich meat products are being marketed as steaks, sausage links, summer sausage, fillets, hamburger, pastrami and jerky. Ostriches produce red meat that is similar in taste and texture to veal and beef. ostrich meat is characterized by a high pH (>6.2), dark visual coloring because of a high pigment content, similar sensory tenderness to beef, low collagen and high polyunsaturated fatty acid and low saturated fatty acid contents, similar cooking loss to beef, low sodium and high iron content. It is well known that ageing produces changes in meat characteristics.

The aim of this research was to determine some fundamental parameters (physico-chemical, functional, of ostrich meat during storage at 4 ºC. These properties were compared with those of beef. The muscles tested were *M. longissimus dorsi* in cattle and *M. iliofibularis* in ostrich.

II. MATERIALS AND METHODS

Ostrich meat was obtained from 12 to 14 months old Blue Neck male birds slaughtered at a local Shiraz abattoir (Fars, Iran). Muscles were separated after removing feather and skin. Fan fillets (*M. iliofibularis*) were obtained from 3 carcasses of ostrich and L*ongissimus dorsi* muscles obtained from 3 carcasses of 3-5 years old male Holstein cattle. Meats were kept at 4°C and at 4.5, 24, 72 and 168 h post-mortem, samples were separated, visible fat and connective tissue removed and samples were used for subsequent studies.

Chemical parameters (protein, ash, fat, moisture, and collagen, hydroxy-proline, myofibrillar and sarcoplasmic proteins), physical parameter (cooking loss, color, pH, tenderness, myofibrilar fragmentation index (MFI)) and functional properties (water holding capacity (WHC), nitrogen solubility index (NSI), foaming capacity (FC), buffering capacity (BC), emulsifying capacity (EC) and emulsifying stability (ES)) were determined.

III. RESULTS AND DISCUSSION

Table 1 shows the results of chemical analysis of ostrich meat and beef. Ostrich meat appears to have higher moisture but lower ash, and collagen than beef. Other parameters were not significantly different. The fat content of meat is of particular importance from the nutritional point of view. Ostrich meat contains lower fat and higher moisture than beef. Ostrich meat has an exceptionally low intramuscular fat content relative to other species (Sales, 1995). Ostrich meat is characterized by a low connective tissue content associated with its low mean collagen content Hydroxyproline and collagen contents of ostrich meat were higher than beef ($p<0.05$) in comparison with beef . No significant differences were observed between ostrich meat and beef in myofibrillar and sarcoplasmic proteins contents.

The results of changes in physical characteristics are given in Table 2. There was a significant decrease in pH in *M .iliofibularis* of ostrich meat during 7 day of post mortem ($p<0.05$). pH of *M. longissimus dors*i of cattle did not significantly change during 7 day postmortem. pH of ostrich meat is significantly higher than beef at all storage time studied. Difficulties in pre-slaughter handing cause's animals to experience stress which results in glycogen depletion and a high post mortem pH of meat (Lawrie, 1998). During the post-mortem period the pH drop causes the concentration of ca^{+2} ions in the muscle fibers to increase (Dransfield, 1993). Berge, Lepotit, Renerre, and Tiuraille (1997) reported that depletion of glycogen reserves following ante-mortem stress in ratites might be the major reason for relative high pH values compared to other meats. Meat pH can be affected by many factors; however, growth of lactic acid bacteria resulting in lactic acid production is the major factor in pH decrease in packaged meats (Gill, 1996).

During storage cooking loss values slightly decreased from 35.45 at 4.5h postmortem to 33.07 at 168h in ostrich and from 34.68 to 33.21 in beef ($p<0.05$). There was no significant difference between ostrich meat and beef at each of the four ageing times. Cooking losses are negatively correlated with pH value (Purchas, 1990). A higher final pH results in a higher WHC and a lower moisture loss. Therefore pH will also influence the percentage cooking loss of meat. The lower percentage cooking loss of ostrich is due to the higher pH of this meat.

Analysis of shear force values for post-mortem ageing (Table 2) showed that the integrity of the tissues significantly decreased. Aging improved tenderness in both types of meats. Muscles held for 7 days were more tender than muscles held for 1 day post-slaughter. As a general rule, increasing the aging time will increase tenderness. Longer than 6 days do not significantly decrease the shear force (Silva et al., 1999). Tenderization is primarily due to postmortem proteolysis mediated by proteolytic enzymes such as calpains and lysosomal proteases (Koohmaraie, 1994). Lightness (L*) of the two muscles decreased while redness (a*) and yellowness (b*) increased in both meat types. Fernandez-Lopez and other (2000) reported that the meat with high content of connective tissue showed high values of b*. Mellet and Salles (1997) reported a negative correlation between yellowness (b*) and tenderness. The dark color of meat in general is result of the high final pH whereas the dark color of ostrich meat is partially a result of the high pigment content of the meat (Sales, 1996). At higher pH values, mitochondrial enzyme system do not shut down and have the ability to utilize available oxygen (Lawrie, 1998). In a high oxygen atmosphere, oxymyoglobin is rapidly formed providing the typical cherry-red visual color of ostrich meat. These results indicate that ostrich meat is very dark in appearance, both initially and over time, in comparison to cattle meats.

The results of functional parameters variation in ostrich meat and beef during storage time at 4ºC is shown in Table 3.

MFI increased significantly ($p<0.05$) in both meat types during 7 days postmortem at 4 ºC. However, the changes were significantly different in two species ($P<0.05$). One possible cause of this variability could be the difference in the enzyme content and more likely the enzyme/inhibitor ratio, a parameter reflecting the efficiency of the proteolytic process among species (Caballero et al., 2007). MFI (the extent of fragmentation of myofibrils caused by homogenization) has been shown to be highly correlated with indices (shear force and sensory panel tenderness) of meat tenderness (Olson *et al.*, 1976).

Emulsifying properties of ostrich meat were significantly higher than beef during the 7 days postmortem storage. The emulsion capacity (EC) of ostrich meat did not significantly change during storage. Unlike beef, ostrich meat showed significant increase in emulsion stability during ageing period. ES in ostrich was higher than beef. Usually two factors affect the emulsifying capacity of muscle. These are the amount of soluble protein available and the efficiency of the protein to emulsify fat (Saffle *et al.*, 1967).

Water holding capacity (WHC) is a major functional property of meat and meat products. WHC increased significantly during the ageing in both meat types ($P<0.05$). WHC of ostrich was significantly higher than beef. Ostrich meat, which has an ultimate pH of 6.0, should by implication, have a high water-holding capacity (Lawrie, 1991). WHC of muscle has been reported to be positively related to pH (Bouton et al., 1972) and negatively related to rate and extent of postmortem glycolysis (Briskey, 1964).

A significant increase in buffering capacity (BC) of ostrich meat and beef is observed during ageing period. The BC of ostrich meat was higher compared to that of beef over the whole period.. Acidic buffering was 5.39 at 4.5h postmortem and with upward trend to 6.68 in 168h postmortem. The compounds that affect the buffering capacity in the pH range 5.5-7.0 are: (1) phosphate compounds having pk_a values between 6.1- 7.1; (2) imidazole group of histidine residues of myofibrillar protein; and (3) the dipeptides carnosine and anserine.

There was as remarkable increase in foam stability (FS) of both ostrich meat and beef after 10 min during 7 days post-mortem. FC values in ostrich meat were higher than beef. There was significant differences between two types of meat after 10, 30 and 60 min in each of the four times of ageing ($p<0.05$), but after 30 min and 60 min, the foaming of each meats had not increased significantly ($p>0.05$). Foaming is a techno-functional property of proteins that plays an ambiguous role even though foamed foods are of high interest for food processors (Campbell & Mougeot, 1999).

IV. CONCLUSION

Taken together, this study showed that ostrich meat has superior functional attributes compared to beef initially and during aging time. Results indicated that meat functional properties improved upon aging in two species.

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Table 1. Chemical composition of ostrich meat (*M. iliofibularis*) compared with cattle meat (*M. longissimus dorsi*)*

Component	Meat type	
	Ostrich	Cattle
Moisture (%)	77.23 ±0.30[a]	74.40± 0.10 [b]
Total protein (%)	22.40± 0.55 [a]	21.73± 0.25 [a]
Fat (%)	1.1± 0.10 [a]	4.2± 0.10 [b]
Ash (%)	1.08± 0.01 [a]	1.11± 0.01 [b]
Collagen (%)	0.44± 0.03 [a]	1.23± 0.11 [b]
Hydroxy proline(µg/g)	513.80± 55.12 [a]	1646.40± 145.25 [b]
Myofibrillar protein (%)	11.38± 0.68 [a]	11.20± 0.64 [a]
Sarcoplasmic proteins (%)	7.40± 0.55 [a]	6.53± 0.55 [a]

[*]Results are mean (± SD) of triplicate samples
a,b values in rows with different superscripts differ significantly ($p<0.05$).

Table 2. Physical parameters variation in ostrich meat (*M. iliofibularis*) and cattle meat (*M. logissimus dorsi*) during storage time at 4ºC.

parameter	Meat type	Aging time (h)				P values
		4.5	24	72	168	
Color a*	Ostrich	14.36±0.15[a]	14.70±0.10 [a]	15.30±0.10 [a]	17.50±0.10 [a]	0.000
	Beef	12.33±0.15 [b]	12.60±0.10 [b]	12.80±0.10 [b]	13.20±0.10 [b]	0.009
Color b*	Ostrich	6.57±0.02 [a]	6.60±0.10 [a]	7.60±0.10 [a]	8.30±0.10 [a]	0.001
	Beef	8.37±0.15 [b]	9.20±0.10 [b]	10.40±0.10 [b]	11.33±0.15 [b]	0.000
Color L*	Ostrich	31.47±0.15 [a]	28.33±0.15 [a]	29.36±0.15 [a]	33.50±0.10 [a]	0.001
	Beef	32.50±0.10 [b]	29.40±0.10 [b]	31.60±0.10 [b]	32.40±0.10 [b]	0.012
pH	Ostrich	6.21±0.02 [a]	6.03±0.02 [a]	5.92±0.02 [a]	5.85±0.03 [a]	0.002
	Beef	5.88±0.01 [b]	5.57±0.02 [b]	5.52±0.02 [b]	5.48±0.01 [b]	0.000
Shear force	Ostrich	6.65±0.08 [a]	5.35±0.09 [a]	5.15±0.08 [a]	4.18±0.16 [a]	0.004
	Beef	7.46±0.12 [b]	6..85±0.10 [b]	6.25±0.08 [b]	4.74±0.07 [b]	0.000
Cooking loss	Ostrich	35.45±0.75 [a]	34.45±0.60 [a]	33.25±0.91 [a]	33.07±0.93 [a]	0.004
	Beef	34.68±0.96 [a]	33.67±1.01 [a]	33.41±1.00 [a]	33.21±1.21 [a]	0.009
Myofibrilar fragmentation index	ostrich	51.14±0.15 [a]	72.19±0.19 [a]	72.35±0.13 [a]	98.40±0.20 [a]	0.000
	Beef	47.10±0.21 [b]	65.51±0.17 [b]	75.35±0.15 [b]	84.30±0.17 [b]	0.000

a,b values in column with different superscripts differ significantly ($p<0.05$).

Table 3. Functional parameters variation in ostrich meat (*M. iliofibularis*) and cattle meat (*M. logissimus dorsi*) during storage time at 4ºC.

Parameter	Meat type	Aging time (h) 4.5	24	72	168	P(value)
Foaming capacity (%) (after 10mine)	Ostrich	69.20±0.82 [a]	70.40±0.87 [a]	70.60±0.36 [a]	72.20±0.46 [a]	.044
	Cattle	56.40±0.79 [b]	57.77±0.25 [b]	60.60±0.56 [b]	62.27±0.47[b]	.009
Emulsifying capacity (ml/gmeat)	Ostrich	56.07±1.16 [a]	56.33±0.85 [a]	56.10±0.36 [a]	57.20±0.30 [a]	0.31
	Cattle	39.23±0.75[b]	41.87±0.40[b]	42.50±0.62[b]	41.27±0.97[b]	0.076
Emulsifying stability (%)	ostrich	64.30±0.95 [a]	64.27±0.75 [a]	65.27±0.75 [a]	66.30±0.70 [a]	0.048
	Cattle	55.30±0.95[b]	56.37±0.75[b]	55.63±0.49 [b]	55.93±0.45 [b]	0.55
Buffering (phu~4.7) (mmol/pH*100gmeat)	Ostrich	5.40± 0.06 [a]	5.49 ± 0.04 [a]	5.62 ± 0.02 [a]	5.68 ± 0.01 [a]	0.009
	Cattle	4.70 ± 0.03 [a]	4.80 ± 0.03 [b]	4.93 ± 0.04 [b]	5.16 ± 0.05 [b]	0.008
Buffering (ph~7) (mmol/pH*100gmeat)	Ostrich	5.53 ± 0.03 [a]	5.67 ± 0.01 [a]	5.82± 0.02 [a]	5.81 ± 0.01 [a]	0.002
	Cattle	4.56 ± 0.05 [b]	4.86 ± 0.03 [b]	5.16 ± 0.05 [b]	5.10 ± 0.10 [b]	0.000
Nitrogen solubility index (%)	Ostrich	38.38±1.13 [a]	40.51±1.08 [a]	41.75±0.98 [a]	42.63±0.91 [a]	0.009
	Cattle	36.43±1.08 [a]	37.59±0.91 [b]	38.57±1.18 [b]	40.53±1.07 [a]	0.002
Water holding capacity (%)	Ostrich	40.34±0.14 [a]	41.34±0.14a [a]	43.40±0.10 [a]	43.66±0.21 [a]	0.002
	Cattle	37.30±0.10 [b]	38.33±0.15b [b]	40.59±0.10 [b]	41.30±0.03 [b]	0.000

a,b values in column with different superscripts differ significantly ($p<0.05$).