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Evaluation of Diet and Frozen Storage on Protein Functionalities of Ostrich Muscle

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급이사료의 종류와 냉동저장이 타조육단백질의 기능성에 미치는 영향에 관한 연구

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요 약

본 연구에서는 급이한 사료의 종류(농후사료 대 조사료)와 냉동저장이 타조육단백질의 기능성에 미치는 영향을 조사하기 위하여 도살 후 냉장온도에서 5~6시간이 경과한 타조육 (*M. flexor cruris lateralis*, outside strip)을 진공포장한 후 -20℃에서 4개월간 동결저장 중, pH, 일반성분, 감량, 보수력, 단백질 용해성 등을 검사하였다. 냉동전 타조육의 pH는 농후사료와 조사료 처리구가 각각 6.14, 6.24이었고, 동결시간이 지남에 따라 감소하는 경향을 보였으나 급이사료의 종류에 따라서는 차이를 보이지 않았다 ($P>0.05$). 농후사료를 급이한 타조육이 조사료를 급이한 처리구보다 수분함량이 1% 적었고, 지방함량은 오히려 약간 높은 결과를 보였으며, 2개월 동안 동결저장 중 감량이 많았으나, 그 이후로는 두 처리구간의 감량의 차이는 없었다. 보수력은 급이한 사료에 영향을 받지 않았으며, 단지 저장기간이 길어질수록 감소하는 경향을 보였다. 근장단백질의 용해성은 급이한 사료의 종류나 냉동저장에 따른 차이를 보이지 않았으나($P>0.05$), 근원섬유단백질의 용해성은 냉동저장 2개월 이후부터 급격한 감소($P<0.05$)를 보여주었다. 이상의 결과로 볼 때 냉동저장은 타조육의 저장성을 증가시킬 수 있으나, 2개월 이상의 장기간 냉동저장은 타조육의 기능성을 감소시키는 결과를 나타낼 수 있다.

Key words: ostrich muscle, diet, frozen storage, protein functionalities.

Introduction

Since ostrich meats have a shorter shelf-life during refrigerated storage than other red meats due to their higher pH and moisture content(%), they should be stored with vacuum-packaged and frozen condition for the longer shelf-life[1,2]. Pollok et al.[1] reported that ostrich steaks were stored in vacuum packages for no more than 2 weeks, which was shorter shelf-life than other meat sources. Thus, freezing may be the best choice when considering long-term storage of ostrich meat.

Functional property defined as a muscle tissue's ability to hold water and binding capacity with meat pieces in formulated meat products during processing and storage. These traits are influenced by pH and moisture content of the muscle tissue and storage conditions. However, frozen storage of meats may cause to reduce the protein functionality, such as increased expressible moisture (%) and reduced protein solubility($\mu g/\mu l$). These characteristics, in turn, may affect detrimentally product yields, color and palatability of ostrich meat. The objective of this

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study was to determine the influence of diet and frozen storage conditions on protein functionalities of ostrich meat.

Materials and Methods

Experimental design

Thirty male ostriches between the ages of 4 and 6 months were divided into six pens by age and weight. These pens were then assigned to either a concentrate or forage diet group. The diet management used for this experiment was followed by Chin and Keeton[2]. In the concentrate diet, the ostriches were fed a nutritionally complete grower diet from the start of the study until the average pen weight reached about 90kg. At this time, the diet was switched to a nutritionally complete finisher diet. The composition of the grower and finisher diets consisted mainly of wheat middlings, ground corn, soybean meal and alfalfa meal, as shown in Chin and Keeton[2]. All feed was fed *ad libitum*. However, in the forage diet, the ostriches were given 1kg of supplement, mainly consisted of soybean meal and ground corn, per bird per day. Ostriches on the forage diet treatment were fed 75% alfalfa and 25% bermuda grass hay at the start of the study. Then, they were switched to a 50/50 mixture. Toward the end of the study, the birds were switched to 80% bermuda grass and 20% alfalfa hay. Alfalfa pellets were also supplemented at 0.9 kg per bird per day starting the 20th week of the study. The alfalfa pellets were fed at the same time as the supplement, twice a day.

The left sides of *M. flexor cruris lateralis* (FCL, outside strip) from 13 ostriches from the 30, 6 of which were fed concentrate diet and 7 forage based diet were excised at 1 hr postexsanguination. Upon receipt to the analysis laboratory, each muscle was cut into 4 equal sections, vacuum packaged, stored at refrigerated temperature for 5~6 hrs and stored at frozen temperature(−20°C) for 4 months.

Physico-chemical analyses

During frozen storage, each sample at 1, 2 and 4 months was thawed in walk-in-cooler (4°C) overnight. pH, moisture and fat contents, drip loss(%), water holding capacity (free and bound water, %) and protein solubility(sarcoplasmic and myofibrillar, $\mu g/\mu l$) were determined to investigate the effect of diets on protein functionalities of ostrich meat, as described in Chin and Keeton[2].

Statistical analyses

Statistical model used in this study was split-plot design. The whole plot was represented by diet treatments(concentrate and forage) and the subplot was represented by 4 different frozen storage time(months). Data were analyzed using analysis of variance(ANOVA) by the general linear model(GLM) procedures of Statistical Analysis System(SAS)[3]. When treatment effects were significant($P<0.05$), mean separation was accomplished using Student-Newman-Kuels procedure.

Results and Discussion

pH and proximate analysis

Since there was interaction($P<0.05$) between diet and storage time, the pH data were separated out and listed in Table 1. pH values of ostrich *M. flexor cruris lateralis*(FCL) fed with two diets(concentrate vs forage) ranged from 6.14 to 6.24 at the initial storage time, tended to be decreased and reached at the pH range of 6.02~6.05 after 4-month storage at −20°C. The reduced pH during frozen storage may be partially due to the further glycolysis during thawing procedure in the refrigerator. The pH range of frozen storage was lower than that of refrigerated storage for 2 weeks in the previous report[2]. During frozen storage, FCL muscles from forage diet fed ostriches

Table 1. Changes of pH values of an ostrich muscle(*M. flexor cruris lateralis*) as affected by diet and frozen storage at −20℃

Diet		Storage time (months)			
		0	1	2	4
Concentrate (n=6)	Mean	6.14[a]	6.12[a]	6.13[a]	6.05[b]
	SD	0.11	0.08	0.07	0.05
Forage (n=7)	Mean	6.24[a]	6.18[b]	6.12[c]	6.02[d]
	SD	0.07	0.04	0.06	0.03

[a,b,c,d]Means in the same row having the same superscript are not different(P>0.05).
SD: Standard deviation

Table 2. Changes of moisture and fat contents(%) of an ostrich muscle(*M. flexor cruris lateralis*) as affected by diet and frozen storage at −20℃

Parameters	Diet		Storage time (months)			
			0	1	2	4
Moisture	Concentrate (n=6)	Mean	76.20[ya]	74.67[yb]	74.74[yb]	74.81[yb]
		SD	0.60	0.68	0.49	0.34
	Forage (n=7)	Mean	77.26[xa]	75.80[xb]	75.35[xb]	75.86[xb]
		SD	1.00	0.78	0.96	0.78
Fat	Concentrate (n=6)	Mean	1.65[xa]	1.89[xa]	1.20[ya]	1.48[xa]
		SD	0.34	0.50	0.34	0.47
	Forage (n=7)	Mean	0.74[yab]	0.75[yab]	0.96[ya]	0.64[yb]
		SD	0.21	0.34	0.29	0.14

[x,y]Means between two diets within same storage time having the same superscript are not different(P>0.05).
[a,b]Means among storage time within same diet having the same superscript are not different(P>0.05).
SD: Standard deviation

contained −1% more moisture and −1% less fat content than those from concentrate diet fed counterpart(Table 2). Frozen storage caused a slight amount of moisture loss(~1.5%) in FCL muscles from both diets fed animals, resulting in a slightly higher protein content. Thus, moisture and fat contents(%) of ostrich meat were affected (P<0.05) by the diet and storage time in this study.

Water holding capacity and drip loss(%)

Water holding capacity(WHC) has been known as the ability of meat retain its own water or added water during the application of some external force or treatment[(5)]. There are several methods to determine WHC, such as drip loss (DL, %), press method, centrifugation method[(6)]. Laack and Solomon[(7)] suggested that DL(%) was highly related to WHC in fresh uncooked meat. In this study, FCL muscles from concentrate diet fed animals had higher(P<0.05) DL than those from forage fed ostriches up to 2 months of frozen storage and reached similar DL(8~9%) after 4 months of frozen storage(Fig. 1). Although the reason for the marked DL difference between two diets at the first month of frozen storage was not fully

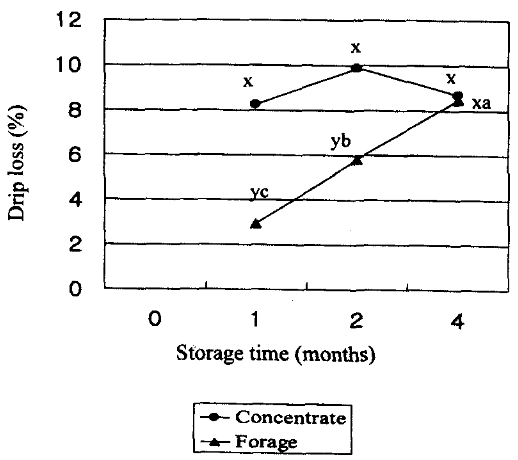

Fig. 1. Changes of drip loss of an ostrich muscle (*M. flexor cruris lateralis*) as affected by diet and frozen storage at −20℃. ^{x,y}Means between two diets within each storage time having the same superscript are not different (P>0.05). ^{a,b,c}Means among storage time(month) within same diet having the same superscript are not different (P>0.05).

understood, the higher DL in FCL muscles from concentrate diet fed animals may partially due to lower pH-values than forage diet. This result indicated that the ostrich FCL muscles from forage fed ostriches may have advantages for frozen storage within 2 months as compared to those from concentrate diet. This DL was an important factor to determine meat quality during storage because it was related to the product yield, retention of nutrients and meat palatability, such as juiciness, appearance and texture[4,6]. Andrew et al.[8] reported that drip was mainly consisted of sarcoplasmic proteins in origin. They also suggested that it might be from intracellular fluid from outside the myofibrils, then diluted with fluid from within the myofibrils and that there is some denaturation of specific proteins. Therefore, increased amount of drip during frozen storage was observed due to increases in denatured proteins, resulting in reduced functionality of the muscle proteins. This finding was supported by Laack and Solomon[7] who reported that a large amount of water (20~60% per 100g of protein) was located in a less organized fashion between protein molecules and this bound water might be lost due to the protein denaturation. However, the raw meat result for drip loss may not be used for predicting water holding capacity(WHC) of cooked product until we obtained the rela tionship between the raw and cooked product has been determined with same conditions[4].

As the frozen storage time increased, ostrich muscles from concentrate diet fed animals were increased(P<0.05) the amount of free water(%), resulting in lower WHC, whereas those from forage diet was not changed(Fig. 2). Protein denaturation may affect the structure and charge of the protein, which cause to decrease the binding of the water and solu-

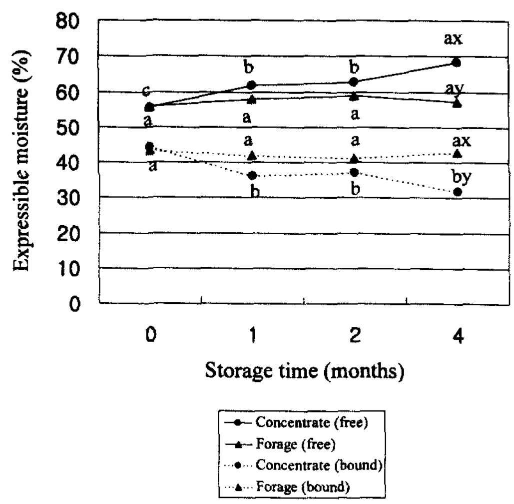

Fig. 2. Changes of water holding capacity (free, bound water, %) of an ostrich muscle (*M. flexor cruris lateralis*) as affected by diet and frozen storage. ^{x,y}Means between two diets within same storage time having the same superscript are not different(P>0.05). ^{a,b,c}Means among storage time within same diet having same superscript are not significantly different(P>0.05).

bility of the protein[7] in our study. The free water(%) of ostrich meat seemed to be higher than those of other red meats, which had a range of mostly 30~50% EM in previous study[9]. However, it could not be directly compared to the previous study because it had a variation of samples within muscles and species[10].

Solubility for sarcoplasmic and myofibrillar proteins

The solubility of muscle protein is the major factor affecting functional property which is related to the water and fat binding so that it affect the final quality in processed meats[11]. Sarcoplasmic protein solubility($\mu g/\mu l$) of ostrich muscle from concentrated diet fed animals was higher($P<0.05$) than that of forage diet fed counterpart at the initial storage, decreased after a month of frozen storage and tended to be plateau thereafter(Table 3). It didn't change the solubility of sarcoplasmic protein during frozen storage, even though it might be possibly denatured. This result might be partially due to the increases in DL(Fig. 1). The initial concentration of myofibrillar protein ranged from 17.04~17.24 $\mu g/\mu l$, tended to be plateau during frozen storage up to 2 month and decreased($P<0.05$) markedly thereafter(Table 3). This result indicated that the solubility of myofibrillar protein started to denatured significantly($P<0.05$) after 2 month of frozen storage.

Saffle and Galbreath[12] reported that the freezing of beef muscle reduced the salt soluble protein by 9% compared to unfrozen beef at 48 hr postmortem due to the increases in protein denaturation. Miller et al.[13] found that the extractability of total protein was reduced in beef and pork, as the storage time increased. However, Lan et al.[11] studied that they frozen rapidly or slowly with beef and pork muscles, stored for a week and found that no effect of freezing on salt soluble protein found in *M. longissimus dorsi*(LD) for beef and pork. This discrepancy with those studies might be partially due to the differences in freezing conditions. Thus, protein solubility may be affected by not only the freezing conditions, such as freezing rate (rapid or slow), time and temperature, but also thawing conditions.

Table 3. Changes of protein solubilities ($\mu g/\mu l$) of an ostrich muscle(*M. flexor cruris lateralis*) as affected by diet and frozen storage at −20℃

Parameters	Diet		Storage time (months)			
			0	1	2	4
Sarcoplasmic protein	Concentrate (n=6)	Mean	12.91^{xa}	9.25^{b}	9.03^{b}	8.21^{b}
		SD	2.54	0.98	0.95	0.80
	Forage (n=7)	Mean	9.21^{y}	9.19	8.94	9.03
		SD	1.39	0.73	0.90	0.73
Myofibrillar protein	Concentarte (n=6)	Mean	17.04^{a}	17.48^{a}	17.73^{a}	14.95^{b}
		SD	1.64	3.40	3.01	2.67
	Forage (n=7)	Mean	17.24^{a}	17.86^{a}	18.76^{a}	14.51^{b}
		SD	2.53	2.34	2.91	2.63

^{x,y}Means between two diets within same storage time(month) having the same superscript are not different($P>0.05$).

^{a,b}Means among storage time within same diet having the same superscript are not different($P>0.05$).

SD: Standard deviation

Summary

The diet had an effect($P<0.05$) on the nutritional contents of ostrich meat during 4 month of frozen storage. As frozen storage increased up to 4 months, pH, water holding capacity(WHC) and myofibrillar protein solubility($\mu g/\mu l$) were reduced ($P<0.05$), however, increased drip loss(DL, %) was found in ostrich muscle from forage fed ostriches. This study suggests that frozen storage(-20℃) up to 4 months in ostrich FCL muscle(outside strip) could be reduced protein functionality, due to increase in DL, decrease in WHC, and markedly decrease in myofibrillar protein solubility($\mu g/\mu l$).

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