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Color and Its Stability in Venison from *Cervus nippon yesoensis* (Japanese Yeso Deer)

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Cervus nippon yesoensis (Japanese Yeso Deer) 사슴육에서의 색소 및 색소 안정성

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Abstract

Color and its stability in venison, *longissumus dorsi* (LD) and *quadriceps femoris* (QF) muscles, from 8 wild *Cervus nippon yesoensis* (Japanese Yeso Deer) were investigated by means of the CIE L*a*b* measurement and autoxidation rate recorded using partially purified myoglobin. It was observed a common feature of the change of three mean values(L*, a* and b*) in both LD and QF that mean value increased at 1 or 2 day post-mortem and then decreased during storage. The differences between 1 and 7 days was the largest in a* value than those in L* and b* values. The mean differences among storage days were only significant in a* except for b* of LD. It was same tendency that the mean difference of CIE L*, a* and b* values during refrigerator storage was larger in a* than both in L* and b* reported in beef(Sekikawa et al., 1995) and venison(Stevenson et al., 1989) during storage. The smaller a* value was indicated that bright red of meat changed to dull red, brown red causing met-Mb formation. To compare of color stability with respects to the Mb autoxidation rate, we measured this rate of deer and horse muscles, because horse Mb was considered to have the fastest autoxidation rate among domestic animals, and we used crude Mb and pH 6.0, which might be reflected to the intact meat. Mean value of the autoxidation rate measured in this study in deer was 0.037 and that was 0.026 in horse(sigma). Although there was no significant mean difference and were different Mb purity between deer(A409/A 280 nm = 4.0) and horse(5.6), in generally Mb purity was the higher and the faster autoxidation rate, but this rate in deer was faster than in horse. These results might indicate that venison meat discolors at faster rate compared with beef.

Key words : Japanese Yeso Deer, color, myoglobin, autoxidation

Introduction

Yeso deer(*Cervus nippon yesoensis*) is natural protected animals that live in Hokkaido in Japan. Recently, the population of yeso deer increases rapidly and it is damage to the agriculture and forestry industry, and a threat to the citizen's life by the traffic accident and so on. For this, yeso deer

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is exterminated in premeditation as a harmful animal, and obtained venison is used for table meat. As for venison, the content of iron is basically high in low fat and a high protein (Ishida et al., 1991; Zomborszky et al., 1996). In addition, a fat from subcutaneous adipose tissue of Yeso deer reduced the concentration of the rat liver cholesterol in the presence of excess cholesterol in the diet(Fukushima et al., 1999). These features suggest that it is possible to become human food for which the deer meat is the best for those who suffered some disease due to ageing. Moreover, venison can become an important protein source for the world food crisis to which the future is forecast. It is thought that the deer is possible use by which the ecosystem is considered as a new domestic animal that does not compete with human's food.

Although the effect of handling, age, sex and species of domestic animals on the meat quality are well known(Lawrie, 1998), there are not much information of meat quality from wild animals(Onyango et al., 1998). Generally, it is considered that the quality of table meat and eating quality of cooked meat were dependent on tenderness, flavor and appearance color of meat. Because these characteristics are improved, the conditioning of meat is important. During this period, meat is tendered by the action of the Ca^{++} and proteases(Dransfields, 1994; Koohmaraie, 1992; Sekikawa et al., 2001; Takahashi et al., 1992) and the flavor is also improved with the accumulation of free amino acids(Mikami et al., 1994, Sekikawa et al., 1999). However, color appearance of meat surface is discolored in air atmosphere display. One of the most important quality characteristics of fresh and processed meat in the decision to purchase by the consumer is the appearance color of the meat and meat products(Van Oeckel et al., 1999). Meat color is primarily depended on concentrations and chemical states of myoglobin. The purpose in this study is to study the characteristics of color and color stability of the venison obtained from wild yeso deer.

Materials and Methods

A total of eight yeso deer, consisting of 6 males and 2 females, 3 years old of the average age estimated with teeth were used as materials, which were killed by shooting from autumn 1998 till spring 2000. Muscle samples were the left side *longissumus dorsi* and *quadriceps femoris* muscles taken at least within 6 hrs after shouting, and each sample was vacuum-packaged and stored at 4±1℃. Two steaks(2 cm thick) were cut from the middle part of each sample muscle. Proximate compositions of quadriceps femoris muscle, moisture, fat, protein and ash, were determined according to AOAC methods(1984).

The color was recorded using a tristimulus colorimeter(CM-1000, Minolta, Japan). All samples were wrapped with polyethylene film(KUREHA) and five measures were randomly taken from the different part of sample surface. The L*, a* and b*(CIELab, 1976) values were expressed the average value from the five measures.

Mb(myoglobin) content was determined by the methods described by Izumimoto(1976) and expressed to mg Mb g^{-1} meat. The deer Mb used in this study was partially purified according to the method of Nakanishi and Izumimoto(1972), briefly the lean meat sample of *quadriceps femoris* muscle from immediately after the slaughter, removed extra fat and connective tissue, ground and homogenized it with an equal volume of cold distilled water, added to 2 or 3 drops of saturated $K_3Fe(CN)_6$ in water and stored at 4±1℃ for overnight. The sample suspension adjusted pH 7.0 was centrifuged at 5,000 rpm(18PR-5, Hitachi, Japan). Mb was precipitated between 55 % and 95 % ammonium sulfate saturation. The final precipitated pellet was dissolved in small amount of distilled water, and dialysis against distilled water for 20 hr. The partially purified Mb was obtained to freeze dry the dialysate. The rate constant of Mb oxidation was determined by the method of Miura et al.(1979). Briefly, Mb was dissolved in 0.2 M phosphate buffer(pH 6.0) and the final concentration was Mb mg/ml containing 0.02 % sodium hydrosulfite(Kishida, Japan). This Mb solution was put into the plastic cell, which bottom was attached to the plastic tube connected to the peristaltic pump for air bubbling, it was inserted into the folder of spectrophotometer kept constant temperature(24±1℃) and absorbance of 582nm was measured by the intervals of 15 minutes.

At the autoxidation speed, MbO_2 showed the decrease rate of this absorbance, that is, the value when beginning by this inclination as 100% for the first the recurrence straight line of the decrease in a relative value(logarithm value). All analyses were carried out at least in duplicate.

Statistical analyses were done using SPBS(Statistical Package for the Bioscience, Ver. 8.77, Comworks, Tokyo), and used with the significant differences at the level of 5%.

Results and Discussion

Table 1. Proximate composition(%) of wild Yeso deer

	Moisture	Protein	Fat	Ash
Mean	76.40	21.79	0.93	1.00
SE	0.21	0.21	0.15	0.05

Sample used were *quadriceps femoris* muscle from 6 male wild Yeso deers.

Table 2. Change of pH in *quadriceps femoris* muscle during storage

Day	Mean	SE
0	6.61	0.10
1	5.65	0.02
2	5.68	0.02
5	5.73	0.02
7	5.73	0.02

Proximate compositions of wild Yeso deer meat(quadriceps femoris muscle) were showed in Table 1. In general, venison contains relatively high crude protein because of low fat. This tendency was observed even with Yeso deer meat in the present study, with Japanese deer(Ishida et al., 1991) and with Red deer meat(Zomborszky et al., 1996). The characteristics of fatty acids composition of venison in wild Yeso deer were already reported by Kasai et al.(1996).

The changes of pH during conditioning were showed in Table 2, the lowest pH was 5.65, recorded to one day post-mortem. This ultimate pH value was slightly higher than that of bovine skeletal muscle(5.5), and the rate of pH decline was faster than in bovine skeletal muscle(Boucque et al., 1999).

CIELab color values were showed in Table 3. CIE *Lab* color values were measured up to 7 days because the conditioning of deer meat was seemed to be finished 7 to 10 days with aspects of fragmentation of myofibrils, shear force vales and 30 kDa band appearance in our preliminary study which will be published elsewhere. Mean color values are similar to the value reported on venison from red deer using Minolta Chromo Meter CR200b(Stevenson et al., 1991). It was observed a common feature of the change of three mean values in both LD and QF that mean value increased at 1 or 2 day post-mortem and then decreased during storage. The differences between 1 and 7 days was the largest in a* value than those in L* and b* values. The mean differences among storage days were only significant in a* except for b* of LD.

The L*, a* and b* color space(CIELab) is presently one of the most popular color space measuring meat color. In this space L* indicates lightness and a* and b* are the chromaticity coordinate, axis of a* is the red direction and b* is the yellow direction in plus region. As b* rotates towards a*, there is an increase in the hue angle which results in more redness and higher a* and b* values, which mean an increase the distance between the origin and the measured point, is higher saturation of color, results the bright color with larger color purity. In current study, however, significant mean differences in L* and b* were not observed among storage days except for 0 day post-mortem. There were significant mean differences in a* among storage days. This tendency, difference during storage times in a* was larger than that in L* and b* were previously reported that in beef(Sekikawa et al., 1996) and venison(Stevenson et al., 1989) during refrigerator storage. Therefore, the smaller a* value were indicated that bright red of meat changed to dull red, brown red causing met-Mb formation.

To show and compare the present study and beef(Sekikawa et al., 1996), the decrease rate of a* from 1 day to 7days post-mortem, followings values were calculated, decrease(%) = a* in 7 day / a* in 1 day × 100, difference between means = a* in 7 day - a* in 1 day, results was showed in Table 4. A decrease of a* value of deer was larger than that of beef. This result is similar to the report previously published by Trout and Gutzke(1996) and might be related that venison meat discolors at faster rate to beef. Previous findings have established that a wide range of discoloration rates were observed between different muscles and between different species that are stored in various air containing atmospheres(Lawrie, 1998; Renerre and Bonhomme, 1991).

It was considered that Mb autoxidation rate is one of important factors affecting meat color stability. Therefore, numerous studies were carried out and recently Trout and Gutzke(1996) proposed that a simple, rapid preparative method for isolating and purifying oxymyoglobin and also reported that oxy-Mb purified in alkaline condition(pH 8.0) was very stable, no changing met form and the autoxidation rate was not differ in pork and beef. In this study, however, we used the old fashion method because we try to compare of color stability between the deer and horse, because horse

Table 3. Change of color values(CIE L*, a* and b*) during storage

	L*		a*		b*	
LD	MEAN	SD	MEAN	SD	MEAN	SD
0	37.25	3.26^{a}	11.63	1.34^{ab}	6.44	0.57^{b}
1	39.43	2.57^{a}	12.51	0.83^{a}	8.53	0.68^{a}
2	39.45	1.92^{a}	10.72	0.89^{abc}	7.89	0.83^{ab}
3	38.86	2.09^{a}	9.66	1.03^{abc}	7.60	0.93^{ab}
5	38.47	2.37^{a}	8.41	1.08^{bc}	7.25	1.07^{ab}
7	38.62	2.61^{a}	7.78	1.01^{c}	7.05	1.36^{ab}
QF	MEAN	SD	MEAN	SD	MEAN	SD
0	38.05	2.99^{a}	13.10	1.59^{a}	7.17	0.86^{a}
1	39.74	3.08^{a}	13.26	0.95^{a}	9.17	1.19^{a}
2	40.45	2.71^{a}	11.56	1.03^{ab}	8.53	1.23^{a}
3	39.17	3.25^{a}	10.90	1.14^{abc}	8.65	1.26^{a}
5	39.01	2.85^{a}	9.74	0.85^{bc}	8.06	0.98^{a}
7	38.62	2.83^{a}	9.03	0.83^{bc}	7.49	0.93^{a}

LD; *longissumus muscle*, QF; *quadriceps femoris* muscle.
Mean with different character(a~c) within column significantly differs at the level of 0.05%.

Table 4. Comparison of a* values change during storage between venison and beef

		a*			
		Day 1	Day 7	Diff.	Decrease (%)
Yeso deer	LD	12.51	7.78	4.73	62.2
	QF	13.26	9.03	4.23	68.1.
Beef	LD	15.79	13.39	2.40	84.8
	QF	15.07	11.50	3.57	76.3

Decrease(%)= a* in 7 day / a* in 1 day × 100.
Diff.(difference between means) = a* in 7 day - a* in 1 day.
LD, QF see Table 3.

Mb was considered to be the fastest autoxidation rate among domestic animals, and we used crude Mb and pH 6.0, which might be reflect to the in' ct meat. Although there were different Mb purity between deer and horse and there was not significant mean difference between them using student *t*-test at the level of 1 %, in generally Mb purity was the higher and the faster autoxidation rate, but this rate in deer was faster than in horse in this study(Table 5).

The reason for the differences in the display-life of muscles between different species is highly speculated amongst researchers, and between-species variability is probably less understood(Lawrie, 1998). The color stability of beef and

Table 5. Autoxidation rate and Mb purity of wild Yeso deer and horse meats

	a			b		Purity
	Mean[1)]	SD	Range	Mean	SD	Mean
Deer	0.037	0.005	0.032~0.046	1.994	0.003	4.0
Horse	0.026	0.003	0.023~0.029	1.994	0.006	5.6

y = a x + b(a: incline, b: intersection).
[1)] Mean Purity(A 409/A 280 nm) of Deer Mb obtained from 3 male deer was 4.0 and that in horse(sigma) was 5.6, and autoxidation rates were recorded at least in duplicate in each samples.

yeso deer venison has not been previously compared. The results of the present work revealed that the color stability of beef and venison muscles was highly variable. To account for the wide variation in the color stabilities between species, it has been suggested that the metabolic differences between muscles could also exist between species, and could account for the variation in the color stability between species. In general, one could, perhaps, speculate that the dynamic functions of venison muscles, compared to those of the other species, may be responsible for the differences observed in the color stabilities between similar muscles from different species.

In Japan, although there is reasonably demand for the venison of high-quality parts such as the loin, fillet and round, a low quality parts such as shoulder, chuck, shank and brisket, demand is a little and there are a lot of stocks. It is important to increase an additional value of the low quality part to improve the demand for venison, and to decrease the price of a high-quality part in Japan. Therefore, it is necessary to study suitable storage conditions and processing method for venison whose color stability is low.

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