EFFECTS OF DIETS AND BEEF BREEDS ON COLOR AND IRON CONTENT OF MUSCLES

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Background

Japanese consumers prefer to taste not only well marbled but light colored beef. To increase the consumption of beef , an improvement of meat color is one of the important issues in Japan irrespective of a domestic or an imported beef. Color of beef produced in Japan is lighter compared with those produced in USA and Australia. Among these countries, there are differences in beef production styles, especially in diets fed to cattle and length of fattening periods. In Japan, high bran containing concentrate rations and small amount of roughage (mainly rice straw only) are fed to cattle for more than 1.5 years (from 8 to 26 months). In contrast with Japanese style, in USA or Australia, cattle are fed rations higher in roughage and shorter periods. Diets fed to American finishing cattle are relatively high in iron and also usually include iron supplements[3] . Phytates which are rich in wheat bran are very effective in reducing the absorption of non-hem iron in rats[2]. Also it has been demonstrated that the addition of tea to human diets dramatically reduces absorption of non-hem iron[5]. Thus, feeding green tea or catechin to cattle may be an effective way for Japanese and/or American cattle producers to reduce the hem iron content of beef, thereby changing its color favorably.

Objective

Two experiments were done to investigate the possibility of beef color improvement by reducing an iron content of muscles. In Experiment 1, as a environmental factor, the effect of feeds on meat color was investigated using wheat bran and green tea. The two substrates are rich in the concentration of phytates and catechins[4], respectively. In Experiment 2, the effect of breeds, as a genetic factor, was investigated on meat color using several breeds fattened under a same nutritional plane.

Methods

Experiment 1: Effect of feed stuffs on meat color and iron content was investigated by an ad libitum feeding of a basal concentrate ration (flaked corn 40 %, steam rolled barley 55% ,soybean oil meal 5%, NaCl 1%, $CaCO_3$ 1%). For the bran and tea treatment groups , bran and green tea were fed, 2.0 and 0.5 kg/day, respectively, with 1.5kg of rice straw.
Two Japanese Black heifers were allotted to each treatment group and fed for 174 days. After the feeding experiment, muscles of *longissimus thoracis, semimembranosus and gluteus medius* were sampled for the analyses of lipids content and meat color measurements. Lipids and meat color were measured by an ether-extraction method and by using Minolta-B200, respectively.

Table 1. LSM[1] of intramascular lipid(IML)%, and the LSMs[2] of Fe content and meat color aspects of Experiment 1 and 2

Experiment/ Treatment groups/muscle/breed		n	IML (%)	Fe (mg/100g)	Color aspects L*	a*	b*	θ [3]	$\sqrt{a^{*2}+b^{*2}}$
Experiment 1									
Control	*longissimus thoracis*	2	23.1a	1.52bc	40.7ab	25.2ac	13.4ab	0.49ab	28.6abc
	semimembranosus	2	16.9ab	2.01ab	39.5ab	29.0a.	14.7a	0.47ab	32.6a
	gluteus medius	2	7.9b	2.58a	38.5b	27.5ab	12.9ab	0.44b	30.4ab
	pooled muscle data	6	15.9y	2.05x	39.6y	27.3x	13.7	0.47y	30.6x
Bran	*longissimus thoracis*	2	21.4ac	1.85bde	39.0ab	23.0c	11.5b	0.47ab	25.7bc
	semimembranosus	2	18.4ab	1.99abde	28.9ab	22.8c	11.5b	0.47ab	25.6c
	gluteus medius	2	8.9b	2.33ad	40.4ab	27.5ac	13.7ab	0.46ab	30.7ad
	pooled muscle data	6	16.2y	2.07x	39.4y	24.5y	12.3	0.46y	27.4y
Tea	*longissimus thoracis*	2	26.3a	1.32e	43.0ab	24.6bcd	12.2b	0.46ab	27.bcd
	semimembranosus	2	24.8a	1.45be	41.0ab	23.5bc	12.4ab	0.49ab	26.6bcd
	gluteus medius	2	10.6bc	2.13ab	41.1ab	28.1ad	14.3a	0.47ab	31.5ae
	pooled muscle data	6	20.5x	1.69xy	41.6xy	25.7xy	13.0	0.47xy	28.8xy
Other (Experiment 2) cattle		97	13.6ybc	1.62ye	42.2xa	24.5ybc	13.2ab	0.47xa	27.9ybc
Experiment 2	B[4]	29	16.9bd	1.48c	43.0a	24.7b	13.7a	0.51a	28.2b
	BHo	16	12.3c	1.81b	41.6ab	24.5b	13.3ab	0.50ab	27.9b
	BBHo	18	16.2bf	1.75b	42.1ab	24.0b	12.6b	0.49bd	27.1b
	RBHo	11	8.4e	1.53c	41.7ab	24.1b	13.3ab	0.51ab	27.5b
	CBHo	11	6.5e	1.68bc	42.4ab	25.3b	13.1ab	0.49cd	28.5ab
	NBHo	12	14.9cdf	1.61bc	41.7ab	25.0b	12.7b	0.47cd	28.1b
Other (Experiment 1) cattle									
	longisimus thoracis	6	23.6a	1.55bc	41.0ab	24.2b	12.4b	0.47bc	27.2b
	semimembranosus	6	20.0ab	1.81b	39.9b	25.1ab	12.9ab	0.48bc	28.2b
	gluteus medius	6	9.1c	2.47a	39.9b	27.7a	13.6ab	0.46c	30.9a

Means with different letters(a-f) are different significantly within Experiment 1 and 2 ($P<0.05$). Pooled muscle means with different letters(x-y) are different($P<0.05$). 1): Least squares means 2):Adjusted by IML % 3): $\theta=\tan^{-1}(b^*/a^*)$
4): B: Japanese Black, BHo:F1 between B bulls and Holstein cows, BBHo: Backcross between B bulls and BHo cows, RBHo and CBHo: Three way crosses between Japanese Brown(R) and Charolais(C) bulls and BHo cows, respectively.

Total iron was measured in wet ash digests using a colorimetric procedure(AOAC,1990)[6]. This procedure involves ashig the samples at 550C, suspending the ash in HCl, and producing a color reaction(at 510nm) in a NaOAc buffer solution containing NH_2OH-HCl and dipyridyl.

Experiment 2: Effect of breeds on meat color and iron content of *m. of longissimus thoracis* were investigated using stocked samples from the other fattening experiment done using many breeds fed under a same high nutritional plane. Composition of the concentrate ration used were: flaked corn 25%, steam rolled barley 20%, wheat bran 10%, powder enriched wheat bran 15%, gluten feed 10% barley bran 10% and rice bran 8% and mineral additives 2%.

Results and Discussion

Least squares means (LSM) of intramuscular lipid (IMF) in muscles, and iron content and color aspects which were adjusted by IMF as a covariate, were compared among each and pooled muscle, and among breeds. These results were shown in Table 1. IMF% of pooled muscle data differed significantly among treatment groups in Experiment 1 and that of the tea group was greater than those of the other groups. Difference of IMF % of pooled by each muscle were also significant and that of *m. of gluteus medius* was lower than those of the other two muscles. Difference of Fe content of *m. of longissimus thoracis* was only significant among treatment groups, however the LSMs of Fe of pooled muscle data and each muscle of the tea group were inclined to be lower than those of the other groups and muscles. There are several species differences that may influence the ability of tea to reduce iron absorption. Addition of tea or catechin to the diets of rats has very little effect on iron absorption[7]. It subsequently was demonstrated that rats do not respond to tea or catechin because they can synthesize vitamin C[2], which increase non-heme iron absorption[8]. Vitamin C apparently has no effect on the ability of wheat bran to lower iron absorption in rats[2], but strongly reduces the ability of phytates to reduce iron absorption in man[1]. Because it is thought that cattle are supplied enough levels of vitamin C for normal growth and function, a reduction of iron absorption by tea or bran intake will not necessarily be expected. From the present results, it was not possible to confirm the effect of vitamin C on the reduction of iron absorption by the bran (phytates) feeding, but the possibility of its reduction by the tea (catechin) feeding is expected as the iron level of *m. of longissimus thoracis* in tea group was lower ($P<0.05$) and the other two muscles had smaller values than those of control groups. It was not found any significant difference about L* values among muscles or pooled muscle data, but those values of the tea group were inclined to be larger than those of the other two groups. There was a relatively good quadratic relationship ($R^2=0.79$) between Fe and L* values as shown in Figure 1. This result indicates that the iron content and luminosity of meat is highly related and feeding of tea will be effective to increase the luminosity of meat by reducing the content of iron in muscles. The pooled muscle values of a*(redness) and saturation of chromaticity ($\sqrt{a^{*2}+b^{*2}}$) of the bran group were significantly lower than those of the control group and those values of the tea group were not significantly different from but intermediate of the values of the other two groups. These results indicate that the bran and tea feeding possibly change the redness and saturation of chromaticity of meat.

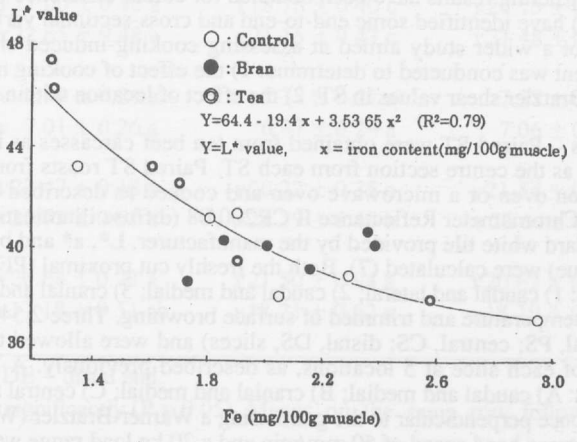

Figure 1. Relationship between L* values and iron contents of muscles in Experiment 1

Differences of the IML % and Fe content of *m. of longissimus thoracis* were found among breeds. Breed differences with color aspects were found only about b* and Hue angle values. Relationships between the iron content and color aspects were not clear.

Conclusion

The reduction of Fe content of meat by tea (catechin) feeding was significant in *m. of longissimus thoracis*, and an increment of luminosity of meat highly related to the reduction of Fe content of meat. This result suggested that the tea (catechin) feeding has the possibility to improve the color aspects of meat.

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