Meat quality from the cattle raised with organic and conventional diet.

Imanari M. [1], Yonai M. [1], Muramoto T. [2], Higuchi M. [3], Shiba N. [1] and Watanabe A. [1]

[1] Grazing and Meat Production Research Team, Tohoku National Agricultural Research Center, Morioka, Japan
[2] Iwate University, department of Animal Science, Morioka, Japan
[3] Functional Food Research Team, National Institute of Livestock and Grassland Science, Nasushiobara, Japan

Abstract—**This study was conducted to show the advantages of organic production on meat quality. Three groups of feeding systems were prepared as follows: conventional feeding of 55% concentrate in the dry matter of the diet (CON), grazing on organic pasture and organic corn silage feeding (ORG1), and same as ORG1 but mixed with 0.5kg/head/day brown rice feeding (ORG2). Cattle were slaughtered at 24 to 40 months old, and the meat from each group was evaluated on proximal and fatty acid composition, alpha-tocopherol (alpha-Toc) content and meat color stability. The fat contents were significantly lower in ORG1 (2.8%) and ORG2 (2.7%) compared with CON (4.3%), and a lower n-6/n-3 fatty acid ratio (<4.0) in the organic groups was also observed because of an increase in n-3 PUFA in these groups. Alpha-Toc content of ORG1 (1.5mg/kg) was significantly lower compared with the other two groups, resulting in rapid metmyoglobin formation during storage. This defect was, however, improved by feeding brown rice in ORG2. The meat from cattle fed organic diets had a lower fat content and healthier fatty acid composition for humans compared with the concentrate feeding system, which is conventional in Japan. Though the loss of color stability was observed in organic feeding, an alpha-Toc rich diet, such as brown rice, could overcome this defect.**

Keywords—**organic beef, fatty acid composition, brown rice**

I. INTRODUCTION

Considerations for food safety and environmental protection have led to a rise in consumer's interest in organic farming systems. Japanese agricultural standards for organic animal production were established in 2005, but production of organic beef is sparse. Organic beef production is an attractive option to stimulate organic farming on the mountain side. The advantages of organic meat have been reported in calves of 6 months old [1], but young meat consumption is low in Japan. The conventional Japanese system is to feed until 20 months of age or more, therefore a comparison between organic and conventional beef is best studied using this age of animals. The aim of the present study is to show the advantages of organic production on meat quality compared to beef from the Japanese conventional system.

II. MATERIALS ANS METHODS

Animals and muscle samples

Three groups of feeding systems were prepared as follows: conventional feeding of 55% concentrate in the dry matter of the diet (CON, n=3), grazing on organic pasture and organic corn silage feeding (ORG1, n=3), and same as ORG1 but mixed with 0.5kg/head/day of brown rice feeding (ORG2, n=6). Cattle were slaughtered at 24 to 40 months old. The *semitendinous* muscles were removed from each carcass, and aged at 0-2°C for 10 days. The samples were divided for the measurements listed below.

Proximal analysis and fatty acid composition

Moisture, crude fat (as ether extract) and protein (Kjeldahl method) were analyzed according to the method of the Association of Official Analytical Chemists [2]. Extraction, and methylation of free fatty acids with trimethylsilyldiazomethane were carried out using the method of Aldai *et al*. [3]. Gas chromatography analysis was performed using a

Shimadzu gas chromatograph (GC-17A) equipped with a CP-Sil88 (60m × 0.25mm i.d., 0.2 μm film thickness, Varian INC., Mississauga, Canada). The carrier gas was helium at a pressure of 225kPa. The GLC conditions were as follows: temperature programmable (100°C, at 1.2°C/min to 226°C); a split of 100:1; injector temperature, 250°C; detector temperature, 300°C.

Meat color, metmyoglobin formation and alpha-tocopherol content

Muscle samples were sliced into 1.5cm thick stakes, and 3×3cm square samples were prepared. Samples were placed on a disposable tray, over-wrapped with oxygen-permeable PVC film, and stored for one hour as day 0, and for 2, 5, 8 and 10 days at 4°C. Meat color of the Commission International del'Dclairage (CIE) L^*, a^* and b^* values were measured from day 0 samples only, and surface metmyoglobin percentages were obtained during storage using a Minolta CM-2500d spectrophotometer (Konica Minolta Holdings, INC., Tokyo, Japan) [4]. Alpha-tocopherol (Alpha-Toc) content in muscle was measured using the day 0 sample and the method of Ueda and Igarashi [5].

Statistical analysis

Data were analyzed using the General Linear Model procedure and the differences between the groups were evaluated by Tukey's test using SAS (software release 9.2; SAS Institute Inc., Cary, NC, USA).

III. RESULTS AND DISCUSSION

Proximal analysis

Results of the proximate composition analysis are shown in Table 1. ORG2 meat had significantly lower fat and higher moisture content compared to CON meat (*P*<0.05). Protein content was significantly higher in ORG1 meat when compared with CON and ORG2 meat (*P*<0.05). The ORG meat was considered low fat in this study, however, Miotello *et al*. [1] reported the content of lipid in conventional calf meat as 1.31%, even in rib muscle, which is markedly lower than in the ORGs in the present study. Although the production of meat as low in fat as the calf meat was not achievable in this study, the fat percentage was much lower in the ORG meat compared with the conventional system.

Table1 Proximate analysis of muscle from organic and conventional read cattle

	CON	ORG1	ORG2
Moisture, %	72.8 ± 0.7[b]	74.3 ± 0.8[a]	74.4 ± 0.7[a]
Fat, %	4.3 ± 0.7[a]	2.8 ± 0.7[ab]	2.7 ± 1.1[b]
Protein, %	21.1 ± 0.3[b]	22.1±0.7[a]	21.2 ± 0.3[b]

Values in rows with different superscripts differ significantly (*P*<0.05).

Fatty acids

The ratio of n-6/n-3 fatty acid and conjugated linoleic acid (CLA) percentage were calculated from the fatty acid compositions (Table 2). The n-6/n-3 ratio is an important nutritional index, and is recommended to be less than 4.0. The lowest ratio was observed in ORG2, and the highest was in CON meat. Inversely, CLA was lowest in CON and highest in ORG2 meat. Significant differences were observed between CON and ORG meat for the ratio and CLA percentage. The low ratio in ORG meat resulted from an increase in n-3 PUFAs, such as C20:4n3, C22:5n3 and C22:6n3. The ratio in ORG1 and ORG2 was 3.22 and 2.32, respectively, and significant higher CLA was observed in ORG meat, suggesting they can be recommended for human health. Unlike the fat content, the measured ratio was similar to that measured in meat from organic calves [1]. French *et al*. [6] demonstrated that pasture feeding of cattle increased the concentration of CLA and n-3 PUFA in muscle compared with cereal based concentrate feeding, suggesting the differences in fatty acid composition observed in this study are caused by the differences in diets.

Table 2 Fatty acid composition of muscle from organic and conventional reared cattle

	CON	ORG1	ORG2
C10:0	0.03[ab]	0.04[a]	0.02[b]
C12:0	0.05[a]	0.04[ab]	0.03[b]
C14:0	2.65[a]	2.31[a]	1.32[b]
C14:1	0.60[ab]	1.05[a]	0.49[b]
C15:0	0.22b	0.39[a]	0.33[a]
C16:0	31.84[a]	28.35[b]	23.97[c]
C16:1	3.84	5.38	3.94
C17:0	0.52[b]	0.76[ab]	0.75[a]
C18:0	11.43	10.96	11.93
C18:1n9t	0.27[b]	0.31[b]	0.36[a]
C18:1n9c	42.10	41.39	45.23
C18:1n7	1.76[a]	0.23[b]	0.24[b]
C18:2n6t	0.04[b]	0.09[a]	0.11[a]
C18:2n6c	2.01	3.40	3.76
C20:0	0.05	0.07	0.07
C18:3n6	0.02	0.04	0.03
C20:1	0.17[b]	0.70[ab]	1.21[a]
C18:3n3	0.14[ab]	0.08[b]	0.16[a]
CLA c9,t11	0.26[b]	0.53[ab]	0.72[a]
C20:2n6	0.03	0.06	0.04
C20:3n6	0.23	0.42	0.57
C20:4n6	0.77	1.59	1.95
C20:4n3	0.02[b]	0.10[ab]	0.22[a]
C20:5n3	0.10	0.44	0.81
C22:4n6	0.16	0.11	0.13
C22:5n3	0.21[b]	0.91[ab]	1.25[a]
C22:6n3	ND	0.12	0.13
n-6 PUFA	3.22	5.66	6.55
n-3 PUFA	0.51[b]	1.77[ab]	2.80[a]
n-6/n-3	6.57[a]	3.22[b]	2.32[b]

Values in rows with different superscripts differ significantly ($P<0.05$).

Meat color

The effects of diet on meat color were determined using the day 0 sample. CIE *L** and *a** values in ORG1 (38.6 and 24.2, respectively) were slightly lower than those in ORG2 (41.7 and 26.2, respectively) and CON (42.4 and 25.7, respectively), although there was no significant differences in these values between the groups. In addition, no significant differences in CIE b^* values were observed (data not shown). Nuernberg *et al*. [7] reported that grass based feeding resulted in darker meat color than concentrate feeding, which is probably due to the higher proportion of oxidative fibers [8]. Muscle fiber type was not determined here, but the slight darker color in ORG1 might be due to this fiber type difference.

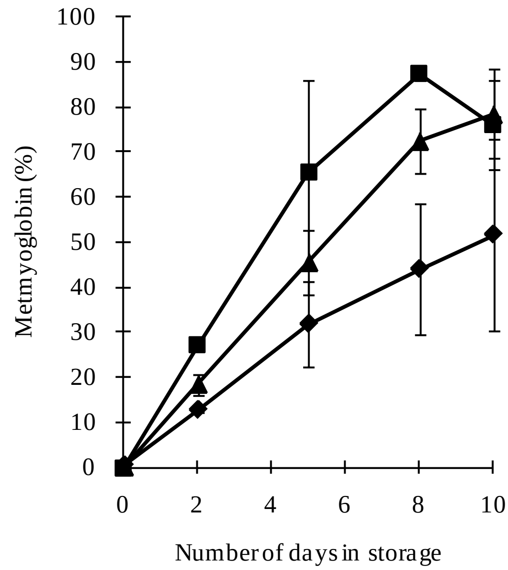

Fig.1. Surface metmyoglobin percentages of muscle stored under display conditions at 4°C for 10days. ORG1(■), ORG2(▲) and CON(◆).

Alpha-Toc content and discoloration

ORG1 meat had a significantly lower alpha-Toc content compared with CON and ORG2; there was no significant difference between CON and ORG2 (Table 3). Morrissey *et al*. [9] have reported that alpha-Toc concentration in excess of 3mg/kg beef is necessary to delay metmyoglobin formation. This report and our result indicate the lower alpha-Toc content in ORG1 would induce rapid metmyoglobin formation. As expected, the metmyoglobin formation was surely more rapid in ORG1 than in other groups. Alpha-Toc content in muscle depends on levels of vitamin E in the diet [10]. It has been shown that alpha-Toc content was increased in muscle from cattle kept on pasture [7], and, in contrast, decreased in muscle from cattle fed maize silage [11]. These reports suggest the alpha-Toc content in ORG1 would be strongly influenced by corn silage feeding but differences in alpha-Toc

Table 3 Alpha-tocopherol content of muscle from organic and conventional reared cattle

	CON	ORG1	ORG2
Alpha-Toc, mg/kg meat	4.97 ± 1.79[a]	1.50 ± 1.05[b]	3.55 ± 0.80[a]

Values in rows with different superscripts differ significantly (P<0.05).

content between ORG1 and ORG2 were observed, even though both cattle were fed corn silage. This is because ORG2 cattle were fed brown rice, which contained rich alpha-Toc [12], resulting in the higher alpha-Toc content and slower metmyoglobin formation compared with ORG1.

IV. CONCLUTIONS

Meat from cattle fed organic diets had a lower fat content and healthier fatty acid composition compared with the concentrate feeding system, which is conventional in Japan. Though a loss of color stability was observed with organic feeding, an alpha-Toc rich diet**,** such as brown rice**,** could overcome this defect.

REFERENCES

1. Miotello S, Bondesan V, Tagliapietra F, Schiavon S and Bailoni L (2009). Meat quality of valves obtained from organic and conventional farming. Italian Journal of Animal Science 8(3):213-215.
2. Williams S (1984) Official Methods of Analysis of the Association of Official Analytical Chemists, 14thedn:431-434. Association of Official Analytical Chemists, Varginia.
3. Aldai N, Osoro K, Barron LJR, Najera AI (2006) Gas-liquid chromatographic method for analyzing complex mixtures of fatty acids including conjugated linoleic acids (cis9trans11 and trans10cis12 isomers) and long-chain (n-6 or n-3) polyunsaturated fatty acids. Application to the intramuscular fat of beef meat. J Chromatogr A 1110:133-139
4. Stewart MR, Zipser MW, Watts BW (1965) The use of reflectance spectrophotometry for the assay of raw meat pigments. J Food Sci 30:464-469
5. Ueda T, Igarashi O (1987) New solvent system for extraction of tocopherols from biological specimens for HPLC determination and the evaluation of 2,2,5,7,8-pentamethyl-6-chromanol as an internal standard. J Micronutr Anal 3:185-198
6. French P, Stanton C, Lawless F, O'Riordan EG, Monahan FJ, Caffrey PJ, Moloney AP (2000) Fatty acid composition, including conjugated linoleic acid, of intramuscular fat from steers offered grazed grass, grass silage, or concentrate-based diets. J AnimSci 78:2849-2855
7. Nuernberg K, Dannenberger D, Nuernberg G, Ender K, Voigt J, Scollan ND, Wood JD, Nute GR, Richardson RI (2005) Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds. Livestock Production Science 94:137-147
8. Vestergaard M, Oksberg N, Henckel P (2000) Influence of feeding intensity, grazing and finishing feeding on muscle fiber characteristics and meat colour of semitendinousus, longissimusdorsi and supraspinatus muscle of young bulls. Meat Sci 54:177-185
9. Morrissey PA, Buckley DJ, Sheehy PJA (1994) Vitamin E and meat quality. Proceedings of the Nutrition Society 53:289-295
10. Jensen C, Lauridsen C, Bertelsen G (1998) Dietary vitamin E: quality and storage stability of pork and poultry. Trends in Food Science and Technology 9:62-72
11. O'Sullivan A, O'Sullivan K, Galvin K, Moloney AP, Troy DJ, Kerry JP (2002) Grass silage versus maize silage effects on retail packaged beef quality, J AnimSci 80:1556-1563
12. Britz SJ, Prasad PV, Moreau RA, Allen LH Jr, Kremer DF, Boote KJ (2007) Influence of growth temperature on the amounts of tocopherols, tocotrienols, and gamma-oryzanol in brown rice. J Agric Food Chem 55:7559-7565