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—Research Note—

Prediction of the Crude Fat Contents in Rib-Eye Muscle of Beef Using the Fat Area Ratio Calculated by Computer Image Analysis

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Abstract The purpose of this study was to examine the accuracy of estimation of crude fat contents in rib-eye muscle determined by chemical analysis from the fat area ratio calculated by computer image analysis (CIA). The materials used were 64 rib-eye images of 35 Japanese Black, 6 Angus and 23 F_1 breed cattle. The fat area ratio was calculated using a software developed by the authors. The regression equation of the crude fat contents (Y) on the fat area ratio (X) calculated by CIA was $Y=0.741X-2.22$ ($r^2=0.91$, $P<0.01$). The difference between the estimated crude fat percentage using the regression equation and the actual one was −2.54～2.80%. No significant effect of the breed on the regression coefficient was found ($P>0.10$).

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Key words : Image analysis, Fat area ratio, Crude fat, Beef cattle

Marbling is one of the most important property of "Wagyu" production in Japan. Generally, marbling is evaluated macroscopically by a qualified examiner at the time of grading. The crude fat contents in beef is often measured in order to evaluate marbling more objectively during feeding trial, progeny testing, etc. However, the sampling of meat for chemical analysis reduces the carcass value and requires a great deal of labor for processing.

There are some reports on the prediction of crude fat in beef using non-destructive methods such as near-infrared reflectance spectroscopy and computer image analysis. A high accuracy of predicted crude fat contents by near-infrared reflectance spectroscopy was reported for minced meat and cut meat by Roberts *et al.*[9)] and Mitsumoto *et al.*[8)], respectively. Konishi *et al.*[4)] reported that it was possible to accurately predict crude fat contents by computer image analysis (CIA). Anada *et al.*[1)] and Karnuah *et al.*[3)] indicated the possibility of estimating carcass composition from CIA of carcass cross-sections.

画像解析による牛ロース芯内脂肪面積割合からの粗脂肪含量推定法：口田圭吾・小西一之[1)]・鈴木三義・三好俊三
（帯広畜産大学，帯広市 080-8555，[1)]農林水産省家畜改良センター奥羽牧場，青森県七戸町 039-2567）

As a result of the development of information processing equipment in recent years, high-resolution digital images can now be handled by computer. The authors[6] reported an image analysis technique that accurately calculate the fat area ratio in rib-eye area using multiple threshold values. The purpose of this study was to examine the possibility of estimation of chemically determined crude fat contents from the fat area ratio calculated by CIA.

Materials and Methods

Sixty-four cross-sections of the 6-7th rib were obtained from 35 Japanese Black, 6 Angus and 23 F_1 breeds of Japanese Black sires and foreign breed dams. After slaughtering, the materials were formed, vacuum packaged and transported under low-temperature storage. A CCD camera (SONY : DXC 930) was used to photograph the cross-sections of the 6 7th rib after they had been kept in a refrigerator for at least 12 hours. The materials were taken out from the refrigerator just before the photographing to ensure that the temperature of the meat surface did not increase during this process. The CCD camera was fixed perpendicular to the meat surface. A zoom lens (SONY : VCL 712 BXEA) was used to take as large an image as possible of the rib-eye area. The image resolution from this equipment was 512 $\times$480 pixels (about 740 K bytes). The fat area ratio was calculated using software developed by the authors[6] for the objective evaluation of beef marbling. This software automatically draws contours of marbling on a true color image displayed on the computer screen. If the contours are judged to be wrong, it is possible to adjust for the minimal area until the contours agree with that of the marbling in the true color image.

The rib-eye muscle was trimmed from the intermusclar fat, sliced to about 1 cm in thickness from the cross-section, and minced. Chemical measurement of the crude fat contents in the muscle was performed by the method of AOAC[2]. Crude fat was extracted by ether. SAS[10] was used for the statistical analysis.

Results and Discussion

Chemical measurements of the crude fat and CIA calculations of the fat area ratio for each breed of cattle are shown in Table 1. The crude fat contents and the fat area ratio in Japanese Black cattle were significantly lower than those in the other breeds. The fattening periods were 581 days for Angus cattle and 581 and 350 for 12 and 11 F_1 breed cattle, respectively. In contrast, the fattening period of Japanese Black cattle, except for two steers, was 308 days. This relatively short fattening period may be the cause of the low crude fat contents and fat area ratio in Japanese Black cattle.

The relationship between the chemically measured crude fat and the fat area ratio calculated by CIA is plotted in Fig. 1. The following equation for the prediction of crude fat

Table 1. Crude fat contents and fat area ratio of the rib-eye area for each breed

Breed	n	Crude fat (%)			Fat area ratio (%)		
		Mean±S.D.	Min	Max	Mean±S.D.	Min	Max
Japanese Black	35	9.6±3.5[a]	2.1	16.8	16.0±4.8[a]	6.1	25.7
Angus	6	16.0±6.6[b]	7.4	27.1	23.6±6.8[b]	16.1	36.1
F_1	23	14.1±3.1[b]	8.6	21.6	22.2±4.0[b]	14.1	31.7

F_1 : Japanese Black ♂ × Foreign breed ♀

[a,b] : Means within the same row with a different superscript significantly differ ($P<0.01$).

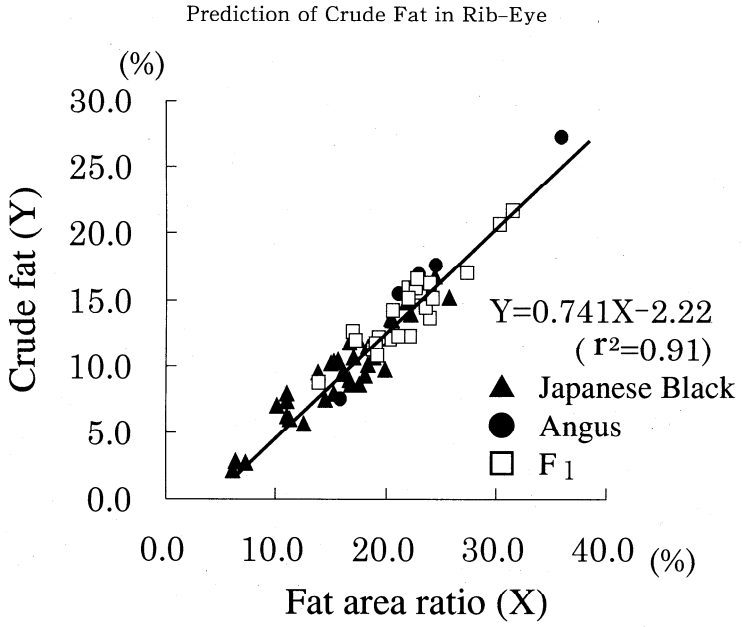

Fig. 1. The Relationship between crude fat contents measured by ehter extraction method and fat area ratio calculated by computer image analysis of the rib-eye area in cattle (n=64).

percentage from the fat area ratio was obtained :

$$Y = 0.741\,X - 2.22,\ (r^2 = 0.91 : P < 0.01)$$

where Y is the chemically measured crude fat percentage and X is the fat area ratio calculated by CIA. The difference (prediction error) between the predicted crude fat using the above regression equation and the measured crude fat percentage was −2.54～2.80%. Five samples were overestimated by more than + 2%, and one sample was underestimated by more than −2%. For the remaining 58 samples, the prediction error was within ±2%. Thus, it was possible to accurately estimate the crude fat contents by the CIA method. Analysis of variance was performed to examine the influence of breed on the prediction, and revealed no significant breed effect on the regression coefficient ($P > 0.10$).

For chemical analysis of the crude fat, samples were sliced to about 1 cm in thickness from a cross-section of the rib-eye area and minced. For prediction of the crude fat from the fat area ratio calculated by CIA, it was assumed that the ratio of fat area on the surface of the sample was the same through the 1 cm of thickness, although in real meat samples, the ratio is not constant. This might be one of the causes of the prediction error.

Mitsumoto *et al.*[8] reported that it is possible to predict the crude fat contents of a rib-eye area using near-infrared spectrum analysis with high accuracy ($r^2 = 0.79$～0.93). However, the near-infrared spectrum analysis meter is easily affected by a low temperature such as that in a refrigerator. Konishi *et al.*[4] reported that the determination coefficient of multiple regression in which the dependent variable is the crude fat contents and the independent variables are the fat area ratio calculated by CIA and the averages of the brightness of the outside and inside of the rib-eye was, 0.79. In their method, minute adjustment of the illumination is necessary to obtain an image of the rib-eye area because brightness data were contained in the independent variable. Therefore, it is difficult to take a photograph noting the irradiation of light without cutting the

carcass, and their method has a problem from the viewpoint of non-destructive prediction for the crude fat. In our method, the carcass cross-section must be photographed in a perpendicular direction, but this drawback could be solved by improvement in the input devices and by the use of a rectangular scale[5] when photographing the rib-eye. The advantages of our method are that no special device are needed and a photograph taken at the rib-eye area in a past examination can be used.

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