THE MEASUREMENT OF FAT THICKNESS IN LIVE CATTLE WITH AN ULTRASONIC DEVICE AS A PREDICTOR OF CARCASS COMPOSITION

T. Mitsuhashi[1], M. Mitsumoto, Y. Yamashita[2]
and S. Ozawa

Department of Animal Production, Chugoku National Agricultural
Experiment Station, Kawai-Cho Oda-Shi Shimane-Ken 694, Japan

Summary

The fat thicknesses of twenty-eight Japanese Black beef steers were measured with an ultrasonic device at eleven points on the cattle prior to slaughter and side dissection. The relation between live fat thickness and both weight and percentage of fat and lean in the carcass was examined. Fat thickness obtained from nine points of the chest, flank and rump regions was found to relate significantly ($P < 0.01$) to both weight and percentage of fat. However, shoulder fat thickness measurements were not significantly related to the weight or percentage of fat or lean in the carcass.

Addition of live fat thickness to animal age or live weight as an independent variable markedly improved the precision of multiple regression equations for predicting weight of fat and lean, and percentage of fat. In predicting the percentage of lean, both animal age and body weight were not employed in the multiple regression equation. The residual standard deviation for predicting percentage of fat and lean were 1.93 and 1.87, respectively. The ultrasonic measurement of fat thickness is supposed to be useful to the prediction of carcass composition of beef cattle.

(Key Words: Beef Cattle, Ultrasonic, Carcass Composition)

Introduction

Ultrasonic scanners have been used recently on live cattle to visualize tissue outlines. Rib-eye area measurements, in ultrasonic and actual tracing on the corresponding cross section of carcass, have been significantly related (Stouffer et al., 1961; Hedrick et al., 1962; Harada et al., 1985; Watanabe et al., 1986; Ozutsumi et al., 1988), although the muscle-fat boundaries parallel to the sonic beam path has been slightly marked in the projected image (Stouffer et al., 1961; Miles et al., 1972). A highly significant relationship between live estimated fat thickness and actual fat thickness in the carcass has been achieved (Hedrick et al., 1962; Bennett et al., 1982). Among these, ultrasonic techniques have appeared to provide reliable discrimination of tissue boundaries perpendicular to the beam path.

When considering practical application, a numerical value should be easily interpreted from the image. In addition, ultrasonic technique must be evaluated on how well the measurements contribute to effective animal production. The objective of this research was to evaluate the accuracy of the prediction of carcass composition with ultrasonic point measurement of fat thickness obtained from various positions of live cattle.

Materials and Methods

Twenty-eight Japanese Black steers between 19.1 and 29 months of age were used. Body weight ranged from 545 kg to 665 kg. Fat thickness at eleven points on the left side of the steers (figure 1) were measured with a real-time ultrasonic device equipped with 5 MHz probe (Aloka Co., Ltd., Japan) during an eleven day period prior to slaughtering. The hair was clipped around the point and gel was applied to obtain good acoustic contact. The transducer was pressed to the point firmly so as to obtain a clear video image on the screen. Excessive pressure distorts fat tissue and underestimates the thickness. Fat thickness was measured by a vertically opened caliper on the

[1]Address reprint requests to Mr. T. Mitsuhashi, Department of Animal Production, Chugoku National Agricultural Experiment Station, Kawai-Cho Oda-Shi Shimane-Ken 694, Japan.

[2]Hokuriku National Agricultural Experiment Station, Jouetsu-Shi Niigata-Ken 943-01, Japan.

Received August 5, 1989
Accepted June 20, 1990

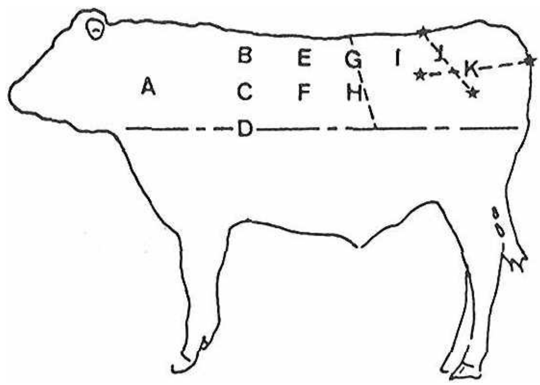

Figure 1. Points of measurement taken. A: Intersecting point of line from mandible to shoulcer and line between vertical sides of neck. B: One-sixth of curvilinear distance from dorsal to abdominal midline perpendicular to the spine at 8th vertebra. C: Twice the curvilinear distance of position B (again from dorsal to abdominal midline) of 8th vertebra. D: Threefold distance of position B of 8th vertebra. E: Equal level to position B of 10th vertebra. F: Equal level to position C of 10th vertebra. G: Equal level to position B of 13th vertebra. H: Equal leve to position C of 13th vertebra. I: Equal level of position B on perpendicular midline between front articulation of 13th vertebrae and Tuber sacrale (hooks). J: Middle point on curvilinear line from hooks to Articulatio sacroiliaca. K: Middle point on linear line from protrudent point of Tuber coxae to behind edge of Ossa coxae.

video image. The readings were taken from the second layer in the cross-section video profile to exclude hide depth (figure 2).

After slaughter, all carcasses were split and kept refrigerated at 4°C for two days. The left side of each carcass was dissected into lean, fat and bone.

Correlations were calculated with live fat thickness and both absolute and relative weight of fat and lean. Prediction equations for carcass composition, taking into account the slaughter age and live weight, were developed using commercial

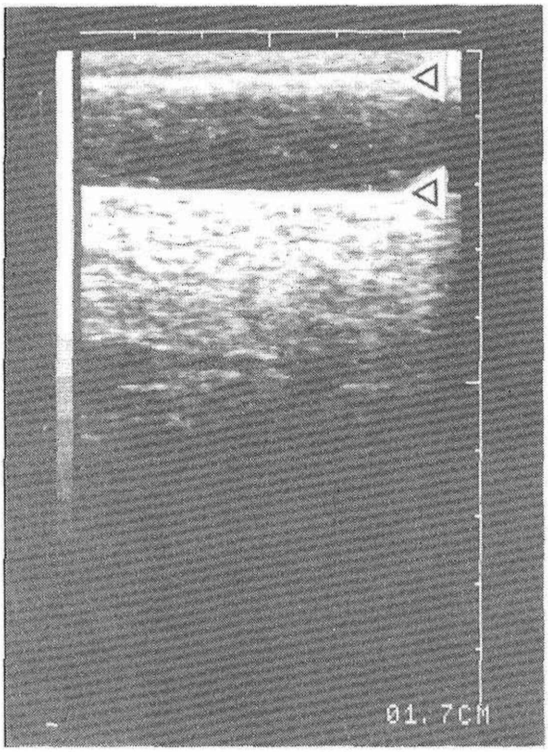

Figure 2. Ultrasonic image of tissue outline near the surface of live steer. The distance between triangles shows fat thickness of measured point.

software (multivariate analysis library I, IBC).

Results and Discussion

Description of carcass component and ultrasonic measurement are shown in table 1. Simple correlations between ultrasonic measurements of fat thickness and carcass measurements are shown in table 2. Fat thickness at nine positions significantly related to carcass fat weight. However, fat thickness of the neck (point A in figure 1) and the first point from the midline at the 8th vertebra (point B) did not significantly correlate to the fat weight. The low correlation obtained from point A is believed to be due to a difficulty in reliable discrimination of the border of fat from other boundaries. The video image obtained from point A displayed some boundaries of a shallow depth under the hide. The lowest correlation obtained from point B is believed to be

TABLE 1. DESCRIPTION OF EXPERIMENTAL ANIMAL AND CARCASS COMPOSITION[1]

	Minimum	Maximum	Average	S.D.
Age(month)	19.3	29.1	24.7	2.54
Live weight(kg)	545	665	622	37.90
Fat(kg)	29.5	74.3	49.3	9.38
Fat(%)	20.0	37.8	28.1	4.07
Lean(kg)	85.8	119.1	101.7	8.47
Lean(%)	50.6	64.7	58.4	3.26

[1]Carcass components were weighed in left side of carcass except kidney fat.

TABLE 2. CORRELATION COEFFICIENTS BETWEEN LIVE ANIMAL MEASUREMENTS AND ULTRASONIC FAT THICKNESS AND CARCASS COMPOSITION

	Carcass component			
	Fat(kg)	Fat(%)	Lean(kg)	Lean(%)
Age	.67**	.71**	.01	−.63**
Live weight	.70**	.42*	.77**	−.36
Points of measurement taken				
A	.30	.22	.26	.21
B	.01	.08	−.21	.04
C	.77**	.77**	−.01	.75**
D	.81**	.80**	.02	−.73**
E	.71**	.73**	−.06	−.72**
F	.82**	.76**	.16	.70**
G	.81**	.75**	.15	−.69**
H	.76**	.74**	.08	−.67**
I	.77**	.76**	.06	−.71**
J	.76**	.81**	−.12	.76**
K	.56**	.61**	−.12	−.57**

*: $P < 0.05$; **: $P < 0.01$

due to a low reproducibility of the measurements per animal. Many times, the boundary between fat and muscle was not parallel (usually greatly so) to the skin-fat boundery and would occasionally become disconnected in the video image. This is caused by the measurement being held near the ventral boundary of trapezius muscle. Wallace et al. (1977) reported that the shoulder fat thickness (at the ventral tip of the trapezius muscle, between the 5th rib and 6th rib) was measured with the least precision among four positions they measured and was the most difficult position to standardize in the live animal.

The highest correlation between fat thickness and total fat weight was 0.82, obtained from the second point from the midline at 10th vertebra (point F). The highest correlation between fat thickness and carcass fat percentage was 0.81, obtained from the rump region (point J). Allison (1982) obtained a correlation of 0.75 between a single fat thickness 125 mm from the midline at the 13th rib and total fat concentration. With regard to this point, a correlation coefficient of 0.75 was obtained from the corresponding point G in our trial. Except in the case of point B, every fat thickness obtained from ultrasonic measurement on the chest and flank regions significantly related to both absolute and relative weight of fat. Even in the case of two points on the rump (points J and K), the relationships were highly significant. Kempster et al. (1981) assumed that no particular position in the rib region was of outstanding value for predicting carcass composition because the position giving the most precise prediction depended on the samples of cattle in the different trials. The similar correlations obtained from different points in the chest and flank region in present study confirms that ultrasonic measurements of fat thickness of different positions are similar in their ability to predict carcass fat weight and percentages, when the reproducibility of the measurements is previously certified by anatomical knowledge.

Kempster et al. (1981) employed live animal weight together with ultrasonic measurements of fat depth from different positions for predicting carcass subcutaneous fat percentage. Allison(1982) reported that a combination of ultrasonic measurements from different positions improved the accuracy of prediction of carcass composition. In the present study live weight and age were accounted as proposed independent variables in the computation of multiple regression equations predicting carcass composition. The prediction equations are shown in table 3. Ultrasonic measurements gave extra precision when added as independent variables to animal age or live weight in the prediction equations. In the case of predicting lean percentage, neither age nor live weight were adopted in the prediction equation.

TABLE 3. PARTIAL REGRESSION COEFFICIENTS IN THE EQUATIONS TO PREDICT CARCASS COMPOSITION WITH LIVE ANIMAL MEASUREMENTS AND ULTRASONIC FAT THICKNESS[1]

	Partial regression coefficients						Intercept	R^{2**2}	R.S.D.[3]
	Age	Live weight	Fat thickness (mm)						
			C	F	I	J			
Fat(kg)									
	–	0.182**	–	–	–	–	−63.65	0.45	7.23
	1.823**	0.135**	–	–	–	–	−79.53	0.65	5.88
	–	0.088	–	0.732**		0.961**	−25.97	0.84	3.97
Fat(%)									
	1.134**	–	–	–	–	–	0.08	0.48	2.94
	1.025**	0.019		–		–	−9.03	0.49	2.92
	0.367		0.247**	–	–	0.438**	9.06	0.78	1.93
Lean(kg)									
	–	0.172**	–	–	–	–	−5.51	0.58	5.49
	−1.182**	0.203**	–	–	–	–	4.79	0.68	4.80
	–	0.237**	–		−0.791*	−0.705*	−30.61	0.82	3.62
Lean(%)									
	−0.813**	–	–	–	–	–	78.43	0.38	2.58
	−0.745**	−0.01	–	–	–	–	84.11	0.37	2.60
	–		−0.217**	–	–	0.420**	67.50	0.67	1.87

[1]Fat thicknesses not used are not presented.
[2]Coefficient of determination adjusted by degrees of freedom.
[3]Residual standard deviation; *: $p < 0.05$; **: $p < 0.01$

Live weight was an important independent variable in the equation predicting absolute weight of carcass fat. However in predicting carcass fat percentage live weight was discarded and animal age was used in the equation. Significant single and partial correlations between age and carcass fat percentage in table 4 confirms the advantage of using of age for predicting carcass fat percentage of Japanese Black steers in the latter period of fattening. Residual standard deviation (s.d.) for the prediction of fat percentage was 1.93 with a base s.d. of 4.07. This residual s.d. compares with a residual s.d. of 2.05 with a base s.d. of 4.01 for prediction of carcass fat percentage with Dan-scanner ultrasonic machine (Allison, 1982) and a residual s.d. of 1.58 with a base s.d. of 2.62 for prediction of carcass subcutaneous fat percentage with Sonatest (Kempster et al., 1981).

Present fat thickness measurement contributed to a prediction of lean weight in the carcass (table 3), although every correlation coefficient between fat thickness and lean weight was not significant (table 2). The reason for this contribution is due to reciprocal effect of fat weight on lean weight in the carcasses. The significant partial correlation coefficient of a negative number between fat and lean weight (table 5) suggests that the steer with less fat in the carcass has more lean than those with more fat and the variation

TABLE 4. SINGLE AND PARTIAL CORRELATION COEFFICIENTS BETWEEN LIVE ANIMAL MEASUREMENTS AND CARCASS FAT PERCENTAGE

	Age	Live weight	Carcass fat(%)
Age	–	.384*	.706**
Live weight	.134	–	.422*
Carcass fat(%)	.650**	.231	–

Partial correlation coefficients are presented under the oblique line; *: $p < 0.05$; **: $p < 0.01$

TABLE 5. SINGLE AND PARTIAL CORRELATION COEFFICIENTS BETWEEN LIVE WEIGHT AND WEIGHT OF CARCASS COMPONENTS

	Live weight	Lean	Fat
Live weight	–	.771**	.697**
Lean	.895**	–	.205
Fat	.865**	.729**	

Partial correlation coefficients are presented under the oblique line; **: $p < 0.01$

in bone weight has little effect on the relationship, when comparing steers of equal live weight. Therefore, fat thickness measurements, which assess the fat weight, account for lean weight in the carcass when the live weight is previously added in the equation.

Kempster et al.(1981) employed live weight in a prediction of carcass lean percentage. Wallace et al.(1977) reported that the live weight of cattle did not contribute significantly to the prediction of retail yield on a percentage basis. In the present study, live weight or age was of little value for improving accuracy in the prediction and these two items were automatically discarded from the prediction equation (table 3). However, the residual s.d. of 1.87 with a base s.d. of 3.26 compared with a residual s.d. of 2.60 with basal s.d. of 3.77 by Sonatest (Kempster et al., 1981).

Therefore, it is hypothesised that the present point measurement of fat thickness effectively contributes to the prediction of carcass composition and to the precise judgment of the degree of fatness of beef cattle.

Literature Cited

Allison, J.C. 1982. The use of a danscanner ultrasonic machine to predict the body composition of Hereford bulls. Anim. Prod. 35:361.

Bennett, G.L., L.A. Swiger, R.L. Preston and V.R. Cahill. 1982. Evaluation of urea space and ultrasonic measurement as selection criteria for beef animal composition. J. Anim. Sci. 54:553.

Harada, H., K. Moriya and R. Fukuhara. 1985. Early prediction on carcass trait of beef bulls. Jpn. J. Zootech. Sci. 56:250.

Hedrick, H.B., W.E. Mayer, M.A. Alexander, S.E. Zobrisky and H.D. Naumann. 1962. Estimation of rib-eye area and fat thickness of beef cattle with ultrasonics. J. Anim. Sci. 21:362.

Kempster, A.J., A. Cuthberton, D.W. Jones and M.G. Owen. 1981. Prediction of body composition of live cattle using two ultrasonic machines of differing complexity: a report of four separate trials. J. Agric. Sci. Camb. 96:301.

Miles, C.A., R.W. Pomeroy and J.M. Harries. 1972. Some factors affecting reproducibility in ultrasonic scanning of animals. Anim. Prod. 15:239.

Ozutsumi, K., K. Chikuni, T. Koishikawa, S. Kato, K. Ito, M. Kobayashi, T. Ebata, Y. Tamada and M. Yoshitake. 1988. Improved method for estimating M. longissimus thoracis fat and area on live cattle with a color scanning scope. Jpn. J. Zootech. Sci. 59:916.

Stouffer, J.R., M.V. Wallentine, G.H. Wellington and A. Diekman. 1961. Development and application of ultrasonic methods for measuring fat thickness and rib-eye area in cattle and hogs. J. Anim. Sci. 20:759.

Wallace, M.A., J.R. Stouffer and R.G. Westervelt. 1977. Relationship of ultrasonic and carcass measurements with retail yield in beef cattle. Livestock Production Science 4:153.

Watanabe, A., Y. Takimoto, E. Tsuneishi and K. Nishimura. 1986. Estimation of the M. longissimus scanning scope using a mechanical scan. Jpn. J. Zootech. Sci. 57:813.