The Measurement of Carcass Characteristics of Goats Using the Ultrasound Method

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ABSTRACT

The objective of this study was to determine if ante mortem carcass characteristics measured via the ultrasound method in live goats is associated with carcass characteristic measured postmortem. Forty crossbred Spanish goats were evaluated at five different time periods for a total of 80 days. Ante mortem measurements of fat thickness (FTU), longissimus muscle area (LMAU), longissimus muscle width (LMWU), longissimus muscle depth (LMDU), rib eye area, rump fat (RFU), and rump depth (RDU) were made using an Aloka 500V. Twenty-four hours postmortem, fat thickness (FTC), longissimus muscle width (LMWC), longissimus muscle depth (LMDC), rump fat (RFC), and rump depth (RDC) was measured. Correlation analysis performed on the data revealed a high significance between LMAU and LMAC ($r = 0.75$; $P < 0.01$), and LMDU and LMDC ($r = 0.71$; $P < 0.01$). Linear regression analysis performed on the data collected over the 80 day study period revealed significance for FTU and FTC ($r^2 = 0.24$; $P < 0.01$), LMAU and LMAC ($r^2 = 0.56$; $P < 0.01$), LMWU and LMWC ($r^2 = 0.27$; $P < 0.01$), LMDU and LMDC ($r^2 = 0.51$; $P < 0.01$), and RDU and RDC ($r^2 = 0.21$; $P < 0.01$). Data indicated that when ultrasonically estimating carcass characteristics, measurements tended to overestimate characteristics in smaller goats and underestimate characteristics in older goats taken 24-hours postmortem.

KEYWORDS: goat, ultrasound, carcass

Goat meat represents about 4% of the world's production of meat from ruminants. Its major impact in production and consumption is in Asia, Africa, and Latin America (Zapata et al. 1995). While goat meat is not widely consumed in the United States, the state of Texas has a goat population of 1.0 million (USDA Livestock Statistics 1995). Over the past thirty years, goat meat consumption in the United States has increased due in part to the growth of the ethnic populations (Harrelson et al. 1995) and their demand for goat meat in their diets (Esminger and Parker 1986). Another reason for the increase in goat meat consumption is the nutritional value of goat meat. Goat meat is 10% more lean than beef carcasses and 19% more lean than lamb carcasses, which makes it a more attractive product to the health conscious American consumer (Amoah and Gelaye 2003).

The ultimate goal of the livestock and meat industry is to have an accurate and objective measurement method for assessing the economically important traits of animals, and to determine the value and merit of the carcass while the animal is still alive (Boggs and Merkel 1993). In order to accomplish this, grading systems for swine, beef cattle, and sheep consider sex, age, quality, cutability, conformation, and is used to establish the price of the meat in the market place (National Live Stock and Meat Board 1977). They are also used to predict the range of cutability or the average amount of muscling from an animal (Smith et al. 1982).

Ultrasonic evaluation is an objective method of predicting the carcass components of live animals within reasonable accuracy levels (Boggs and Merkel 1993), and is also an accurate measurement tool of fat thickness over the ribeye area in lambs (Hopkins 1990), and rump fat and longissimus muscle area in beef cattle (Robinson et al. 1992). Currently, goats are subjectively classified on age (kid or cabrito, young goat, and old goats), carcass weight, meatiness, and fat cover (Haenlein 1984), but there is no objective method for predicting carcass components. Therefore, the objective of this project was to determine if the ultrasound method could be used to predict carcass traits in live goats.

MATERIALS AND METHODS

Animal Management. Forty crossbred Spanish goats (20 males and 20 females) of different ages were subject of this study. Animals were fed alfalfa hay and a commercial feed ration (Red Tag complete feed medicated, Godbold, Inc. Lubbock TX.); containing 16% crude protein, 2% crude fat, and 17% crude fiber during a total period of 80 d. Eight goats were selected randomly every 20 d for ante mortem and postmortem evaluation.

Ante mortem Measurements. On the left side of the animal, site of isonification was determined by physical palpation between the 12th and 13th ribs for ribeye area measurements, and on the pelvic bone for rump measurements. Selected goats were clipped in the designated isonification areas to provide optimum image registration. Using corn oil (Mazola, CPC Foodservice, Englewood, Cliffs, NJ.) as a couplant and an Aloka 500V (Colorimetric Medical System, Wallingford, CT.) equipped with a 125-mm scanning width probe, a 5.0 MHz linear array transducer, and a super-flab guide (Animal Ultrasonic Services, Ithaca, NY) ultrasonic measurement were taken ante mortem.

Ultrasound measurements for fat thickness (FTU), longissimus muscle area (LMAU), longissimus muscle width (LMWU), and longissimus muscle depth (LMDU) were made by placing the ultrasound probe parallel to the 12th and 13th rib bone of the animal. A video monitor, TR-930B (Matsuchita Electronic Industrial Co., LTD. Osaka, Japan), and a software package (PLUSMORF, Woods Hole Educational Associates, Woods Hole, MA.) were used to amplify and better interpret the image. Rump fat (RFU) and rump depth (RFU) were taken directly from the ultrasonic unit screen, without the aid of a video monitor or software package.

Postmortem Measurements. After ultrasound prediction of carcass characteristics, goats were transported to the Sul Ross State University abattoir and slaughtered using standard humane procedures. Immediately after slaughter hot carcass weight (HCW) was measured and the carcasses were cooled at 32°F for 24 h. After the cooling period, chilled carcass weight (CCW) was recorded and the carcass was split along the midline. The left side of the carcass was ribbed at the 12th and 13th rib interface to determine fat thickness (FTC), longissimus muscle area (LMAC), longissimus muscle width (LMWC), and longissimus muscle depth (LMDC). Rump fat (RFC) and rump depth (RDC) were evaluated in the midline section of the pelvic bone. A USDA preliminary cutability grade ruler was used to measure fat thickness (FTC), longissimus muscle width (LMWC), longissimus muscle depth (LMDC), rump fat (RFC), and rump depth (RDC). Longissimus muscle area (LMAC) was measured using a USDA loin eye dot grid for beef.

Statistical Analyses. Simple correlation analysis was used to determine the relationship between the different traits measured ante mortem and the carcass characteristics measured postmortem (SPSS 1993). Regression analysis was used to test the ability of the ultrasound measurement method to estimate the carcass traits (SPSS 1993). Differences between predicting methods among carcass characteristics were assessed using one-way analysis of variance (Zar 1984).

RESULTS AND DISCUSSION

The overall descriptive statistics taken from the 40 crossbred Spanish goats used in the study are displayed in Table 1.

Table 1. Overall descriptive statistics of the carcass traits from 40 crossbred Spanish goats during eighty days.

	Ultrasound			Carcass		
Trait	Mean	SD	Range	Mean	SD	Range
FT	0.09	0.04	0.07-0.29	0.05	0.07	0.00-0.25
LMA	6.65	1.60	3.46-10.29	9.98	2.17	5.81-14.84
LMW	4.50	0.52	3.26-5.35	4.44	0.68	2.67-5.33
LMD	2.44	0.48	1.41-2.69	1.96	0.31	1.52-3.30
RF	0.14	0.05	0.10-0.20	0.02	0.05	0.00-0.13
RD	2.01	0.39	1.00-2.50	2.75	0.63	1.78-4.95

$P < 0.05$

The differences of means using ultrasound and carcass methods of measurement reveal an overestimation of the fat thickness in goats. This trend was also found in beef (Perkins et al. 1992; Waldner et al. 1992) and pork (Moeller and Christian 1998). In contrast, Realini et al. (2001) found that ultrasound measurement means were lower than adjusted beef carcass fat thickness; indicating a tendency to underestimate carcass measurements in beef. Ozutsumi et al. (1996) also indicated that fat thickness in steers also tended to be slightly smaller than the actual thickness measured.

A possible reason for difficulty in measuring fat thickness in goats is due to the lower content of fat over the loin area in goats and has been identified as a problem in sheep. Houghton and Turlington (1992) concluded that ultrasound has limited utility for predicting carcass characteristics in sheep due to the lack of variation and small size in fat thickness and longissimus muscle area. Fernandez et al. (1998) suggested that it is difficult to obtain accurate identification of muscle fat boundaries with ultrasound in lambs due to the presence of muscle layers interspersed with fat. Finally, Ensminger and Parker (1986) stated that when compared to sheep, goat fat thickness is difficult to measure due to the lack of subcutaneous fat over the loins.

A possible advantage to measuring longissimus muscle area of goats when compared to beef cattle, is the fact that the area is so small on goats that the researcher does not have to split the image to capture the entire area, which must be done in cattle. With respect to the longissimus muscle area, the results indicate an overestimation for smaller ribeye areas associated with kids or small sized goats. As animals become larger and older in age, the opposite effect of underestimation of ribeye area occurs. The underestimation of longissimus muscle area is due to the relationship of the brightness of the image captured by the ultrasound, and the reflection of the sound waves, especially in the narrowness or end areas of the rib eye. Several studies have noticed that longissimus muscle area in beef was underestimated by ultrasound (Realini et al. 2001, Perkins et al. 1992). This was also noticed in swine when researchers concluded ultrasound tended to overestimate smaller carcasses and underestimate larger carcasses (Moeller and Christian 1998). In contrast, Waldner et al. (1992) noticed cattle with longissimus areas of less than 70 cm^2 were underestimated, and cattle with longissimus areas of more than 85 cm^2 were overestimated. The reason for the overestimation of smaller ribeye areas is due to the close space between ribs in relationship to the probe width. Stanford et al. (1995) also reported difficulty obtaining distortion-free ultrasound images due to the closeness of the 12th and 13th ribs in Alpine goats. Fernandez et al. (1998) also stated that small dimensions are difficult to measure with accuracy. Measurements that were taken at the first lumbar vertebrae in the study were distortion free, which could be a possible alternative site of measurement to remedy the overestimation problem in the current study.

Simple correlation coefficients for carcass traits measured at five different time periods during eighty days via ultrasound were calculated (Table 2) and were statistically significant for several carcass traits.

Table 2. Simple correlation between goat carcass traits with respect to the ultrasound method measured during eighty days at five different time periods.

	Correlation coefficients (r)				
Trait	0-Day	20-Day	40-Day	60-Day	80-Day
FTU vs FTC	0.00	-0.35	0.79*	0.49	0.26
LMAU vs LMAC	0.43	0.84**	0.62	0.42	0.57
LMWU vs LMWC	0.33	0.01	0.63	0.60	0.41
LMDU vs LMDC	0.87**	0.43	0.30	0.36	0.51
RFU vs RFC	0.38	0.71*	0.58	0.44	-0.22
RDU vs RDC	0.83**	-0.39	-0.30	0.25	0.76*

**P < 0.01
*P < 0.05
n = 8

Day 20 measurements revealed that RFU was significantly correlated with RFC ($r = 0.71$, $P < 0.05$). Measurements of RDU and RDC were significantly correlated on day 0 ($r = 0.83$, $P < 0.01$) and on day 80 ($r = 0.76$, $P < 0.05$). Pooled data of all goats collected over an 80-day period ($n = 40$) indicated a highly significant relationship between certain carcass traits, including LMWU and LMWC ($r = 0.52$, $P < 0.01$), and RDU and RDC ($r = 0.45$, $P < 0.01$) (Table 3).

Table 3. Pooled simple correlations between goat carcass traits with respect to the ultrasound method during the eighty-day trial period.

Trait	Correlation coefficient (r)
FTU vs FTC	0.49**
LMAU vs LMAC	0.75**
LMWU vs LMWC	0.52**
LMDU vs LMDC	0.71**
RFU vs RFC	0.26
RDU vs RDC	0.45*

** P < 0.01
*P < 0.05
n = 40

FTU was significantly correlated with FTC on day 40 only ($r = 0.79$, $P < 0.05$). The pooled correlation coefficient of all 40 animals measured for FTU and FTC ($r = 0.49$, $P < 0.01$) is much lower than the coefficient reported by Fernandez et al. (1997) in lambs ($r = 0.74$, $P < 0.001$), but 40-day measurements were similar indicating a high relationship between FTU and FTC. In another study by Fernandez et al. (1998), higher correlations were found for 25 kg ($r = 0.90$, $P < 0.05$) and 35 kg ($r = 0.92$, $P < 0.05$) Manchego lambs measured between the 12th and 13th rib. Ultrasound measurements of FTU and FTC in other species also yielded higher correlation coefficients. In swine, Moeller et al. (1998) reported a correlation of 0.87 for 10th rib backfat. In cattle, Perkins et al. (1992) reported a higher pooled correlation of 0.86 when comparing the accuracy of two technicians. Waldner et al. (1992) also had a higher reported correlation of 0.86, while May et al. (2000) reported a slightly higher correlation of 0.81 for 12th rib fat thickness. Finally, Crews et al. (2002) reported correlations ranging from 0.64 to 1 when measuring fat thickness. Therefore, fat measurements taken over an 80-day period may not be a good indicator of the relationship between ultrasound and carcass fat thickness.

Day 20 measurements revealed that LMAU was highly significantly correlated with LMAC ($r = 0.84$, $P < 0.01$), and the pooled data from all 40 goats also revealed that LMAU and LMAC were highly significantly correlated ($r = 0.75$, $P < 0.01$). Both these values are greater than the coefficient of 0.64 found for Alpine goats measured between the 12th and 13th ribs (Stanford et al. 1995), indicating an improvement in the study for measuring longissimus muscle area with ultrasound. These values were similar to the coefficients found in lambs ($r = 0.88$, $P < 0.001$) (Fernandez et al. 1997) and swine ($r = 0.74$) (Moeller et al. 1998). More recent studies involving beef, May et al. (2000) reported a smaller correlation of 0.61, while Crews et al. (2002) reported a similar correlation of 0.86. When measuring longissimus muscle area it is possible to measure the animals for an entire 80 days, but day 20 is the best indicator of the relationship between longissimus muscle area measured with ultrasound and actual carcass measurements.

Day 0 measurements of LMDU were highly positively correlated with LMDC postmortem measurements ($r = 0.87$, $P < 0.01$), and pooled LMDU and LMDC data ($r = 0.71$, $P < 0.01$) were also highly significantly correlated. Both values indicate a strong relationship between LMDU and LMDC, but measurements taken on day-0 are stronger than the pooled data. Both the day-0 correlation value and the pooled data value were higher than the value of 0.62 reported by Stanford et al. (1995) in Alpine goats, and the value of 0.56 reported by Fernandez et al. (1997) in lambs.

Simple linear regression equations and their determination coefficients for predicting carcass traits from crossbred goats pooled for the entire eighty-day trial period are shown in Table 4.

Table 4. Pooled simple linear regression equations predicting goat carcass traits from 40 crossbred goats using the ultrasound method during the eighty-day trial period.

Equation	Determination coefficient (r^2)
FTC = -0.25 + 0.85(FTU)	0.24*
LMAC = 3.21 + 1.02(LMAU)	0.56*
LMWC = 1.39 + 0.68(LMWU)	0.27*
LMDC = 0.27 + 1.10(LMDU)	0.51*
RFC = -0.01 + 0.23(RFU)	0.07
RDC = 1.27 + 0.73(RDU)	0.21*

*P < 0.01
n = 40

During day 0 measurements, the LMDC equation ($r^2 = 0.76$, $P < 0.05$) and the RDC equation ($r^2 = 0.69$, $P < 0.05$) were highly significant. On day 20 of the study, the LMAC equation was highly significant ($r^2 = 0.70$, $P < 0.01$). For the 40-day measurements, the FTC equation was significant ($r^2 = 0.63$, $P < 0.05$) with respect to FTU. For the 60-day measurement data there was not any significance for the regression equations calculated from the carcass measurements taken postmortem and the ultrasonic carcass measurements taken ante mortem. Finally, during day 80 of measurements, the RDC was the only equation that was significant ($r^2 = 0.58$, $P < 0.05$).

The equations for LMAC and FTC using ultrasound explained a moderate amount of the total variation. The LMAC equation was not as accurate as the single-trait prediction model for longissimus muscle area reported by Crews et al. (2002) in beef. The longissimus muscle area equation was found to have a much higher r^2 of 0.88. In the same study the r^2 value for FT of weaned cattle was 0.73, while the yearling r^2 value equaled 0.80. Both these values were improved when both weaning and yearling fat thickness were included in the equation ($r^2 = 0.83$).

The fact that measured fat thickness r^2 was increased by combining both weaning and yearling measurements indicates that possibly using other factors, such as body weight or body measurements, can improve the accuracy of equations using ultrasound in goats. This can been seen in a study conducted by Fernandez et al. (1998) that used ultrasound to predict fat thickness and longissimus area in Manchego lambs. When using live weight as a predictor of both carcass characteristics, r^2 values ranged from 0.54 to 0.64. When using ultrasound measurements combined with the live weight measurements, r^2 values ranged from 0.60 to 0.95. Therefore using other measurements in conjunction with ultrasound measurements can improve the accuracy of carcass characteristic prediction equations, which warrants further research.

One-way analysis of variance showed a low ability for ultrasonic measurements to predict postmortem carcass measurements (data not shown). This is especially true of fat thickness, longissimus muscle area, longissimus muscle depth, rump fat, and rump depth. The lone exception was for longissimus muscle width. Here the analysis indicated no difference between the ultrasound measurements and the measurements taken directly from the carcass ($P < 0.05$).

CONCLUSION

The use of ultrasound on crossbred Spanish goats tended to overestimate both fat thickness and longissimus muscle area. Correlations revealed strong relationships between ultrasound and carcass characteristics measured, in agreement with other studies conducted with beef, pork, and lamb. Regression equations indicated that not many carcass characteristics measured by ultrasound could be used to accurately make models for prediction. This research reveals the need for further studies with an increase in sample size at the different times of prediction, as well as, reducing the variability of the animals to be evaluated (the age and size of the animals).

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