The Use of Real-Time Ultrasound to Predict Live Feedlot Cattle Carcass Value

A.S. Leaflet R1731

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Introduction

Substantial structural changes have occurred and will continue to occur in the beef industry in the next ten years. Analysis of national beef production and marketing systems has indicated that to prevent further erosion of market basket share, the beef industry must make the improvement of quality and consistency for consumers its priority. Iowa has a future role to play in achieving this priority of quality, consistent beef for both domestic and foreign markets. Identification and utilization of superior genetics for end-products needs to be linked with Iowa-based production resources and branded beef marketing principles. By combining Iowa's resources--conscientious producers, feed, land, and cattle--with the new available technologies, Iowa's beef industry could be propelled into the leadership position in the production of high-quality and value-added branded beef products, sold on a value based system. For this system to be effective, a producer with a feedlot operation must know what they have for sale.

Real-time ultrasound technology has been developed at Iowa State University, (ISU) to determine ribeye area, subcutaneous fat cover, and percent intramuscular fat (marbling) on live beef cattle. ISU animal science researchers have tested this technology primarily on breeding cattle, yearling bulls, and replacement heifers. These measurements are collected by highly trained technicians across the U.S., processed centrally at ISU and used in the development of carcass EPD's by the breed associations. More recently, researchers have serially scanned feedlot cattle involved in research projects. Can this technology be transferred to the feedlot industry to help feedlot operators make marketing decisions? Three objectives must be evaluated to test the transfer of this technology:

1. Determine whether ultrasound measures, fat cover and percent intramuscular fat can be collected and processed accurately and expediently enough for chute-side application.
2. Determine if these measurements can be implemented into a marketing model for decision making at harvest time.
3. Determine whether ultrasound images collected and processed 100 days prior to harvest time (at the time of re-implanting) can be used to develop a marketing model to project specific cattle outcome groups and marketing dates.

Materials and Methods

Researchers at ISU have developed a chute-side feedlot ultrasound yield and quality grade predictor by utilizing an ultrasound scanner (Aloka500V® from Corometrics Medical Systems, Inc., Wallingford, CT, USA) with a 17-inch transducer, an external 9-inch video monitor, a powerful personal computer with Intel Pentium® 200 Mhz processor, and a 17-inch monitor. The system has the capacity to store more than 10,000 images.

The software for capturing and processing images is developed as an extension of ISU's USOFT® software (see 1997 A.S. Leaflet 1437). The USOFT Feedlot version has the following important features: 1) capturing longitudinal and cross-sectional images from the *longissimus dorsi* of an animal, 2) processing a 100-by-100-pixel region of interest from the longitudinal image for predicting percentage intramuscular fat, 3) averaging results of percentage intramuscular fat prediction for up to five longitudinal images, 4) predicting marbling score, 5) measuring fat thickness from the cross-sectional image, and 6) predicting yield grade. The image and all relevant information are continuously updated on the screen. This minimizes the number of steps required to process an image and to evaluate an animal. If the results need to be saved, the user is required to enter an animal ID. The result file can be printed or used with other databases and performance evaluation software for further analysis and reporting.

Shown on the following pages is a series of screens that demonstrates how the chute side hardware and software function (Screens 1-10). A percent intramuscular fat image can be collected and processed in 7-8 seconds; usually 3-4 images are collected to increase accuracy. The cross sectional image can be collected and a fat measurement taken in a total of 5 seconds. This combination of measurements can be collected and processed in less than 30 seconds. If the cattle are not clean and short haired, preparation time (including clipping, cleaning and oiling) may be the limiting factor in terms of the number sorted per hour.

Cattle used for the feedlot modeling project came from a number of sources including the Sioux Center Coop Feed Yard, the Rhodes research farm, the McNay research farm, the Armstrong research farm, the beef teaching center and a northwest Iowa cattle feeder's lot.

Results and Discussion

The first objective of this project, to collect and process images chute-side so that sorting and marketing decisions can be made immediately, has been accomplished as discussed in Materials and Methods. Currently the limiting factor that determines the number of animals that can be scanned per hour is animal preparation. The cattle must be clean, clipped and oiled before scanning.

The second objective relates to the accuracy of ultrasound measurements, percent intramuscular fat and 12th rib fat cover, taken within a weekly harvest, to predict carcass quality grade and yield grade.

Table 1 summarizes the results from scanning 307 grain-fed calves at three locations within one week of harvest. These calves were put on feed between 6 and 10 months of age and were fed a high concentrate corn based diet (85-90% concentrate) until harvest.

Cattle were scanned prior to slaughter with either an Aloka500V or both real-time ultrasound machines, (the Aloka and a PIE medical 200 scanner). These scan values were then compared with marbling scores (to the nearest 10th of a marbling degree) obtained in the grading line at the packing house and with an objective measurement of intramuscular fat level. This value was determined by facing the 12th rib, trimming subcutaneous fat, freeze grinding the sample and using a hexane extraction process to determine the level of fat within the ribeye muscle. These intramuscular fat values, the objective value from the hexane extraction and the predicted values from ultrasound were converted to marbling scores for direct comparison.

Figure 1 describes the relationship between marbling score and percent intramuscular fat. Table 2 compares the various methods of categorizing the amounts of marbling in young beef cattle. For example a steer that graded low choice would have a small amount of marbling, be given a marbling score between 1000-1090 and have a percent intramuscular fat percentage between 3.90 and 5.33%. These relationships have been developed from previous ultrasound validation projects, and the analysis and discussion is published in AS Leaflet R1529.

Mean marbling score comparisons are shown in Table 1. For example, the 87 Rhodes steers had a mean marbling score of 1061, converted from the chemical fat extraction. The USDA grader’s mean marbling score was 1024 (Low Choice), and the Aloka real time ultrasound machine predicted a marbling score of 1022 on the live cattle. The next line in Table 2 correlates the extracted fat derived marbling scores (the objective system) with the carcass marbling scores subjectively determined by the USDA grader (r = 0.78), and the derived marbling scores predicted on live cattle with ultrasound (r = 0.61). Looking at all four groups of cattle evaluated indicated these two relationships range from 0.70 - 0.78 and 0.61 - 0.85, respectively.

Table 1. Marbling Score Means, Correlations and Standard Errors of Prediction on four groups of cattle

	n	Hot carcass wt, lb.	CE[a] Marb	Carcass Marb	|------Ultrasound------| Aloka Marb	Classic Marb
Rhodes Steers	87	687	1061	1024	1022	---
Correlations with CE	87		---	.78	.61	---
SEP[b]	87		---	35	53	---
McNay Steers	76	759	1101	1073	1039	---
Correlations with CE	76		---	.74	.85	---
SEP[b]	76		---	58	49	---
Armstrong Steers	82	708	1044	995	960	1031
Correlations with CE	82		---	.71	.65	65
SEP[b]	82		---	45	41	60
Armstrong Steers	62	668	1053	1116	1000	1036
Correlations with CE	62		---	.70	.61	.66
SEP[b]	62		---	56	57	61

[a]Chemical extraction
[b]Standard error of prediction

Figure 1. Graph of the USDA Marbling Score linear-quadratic regression model.

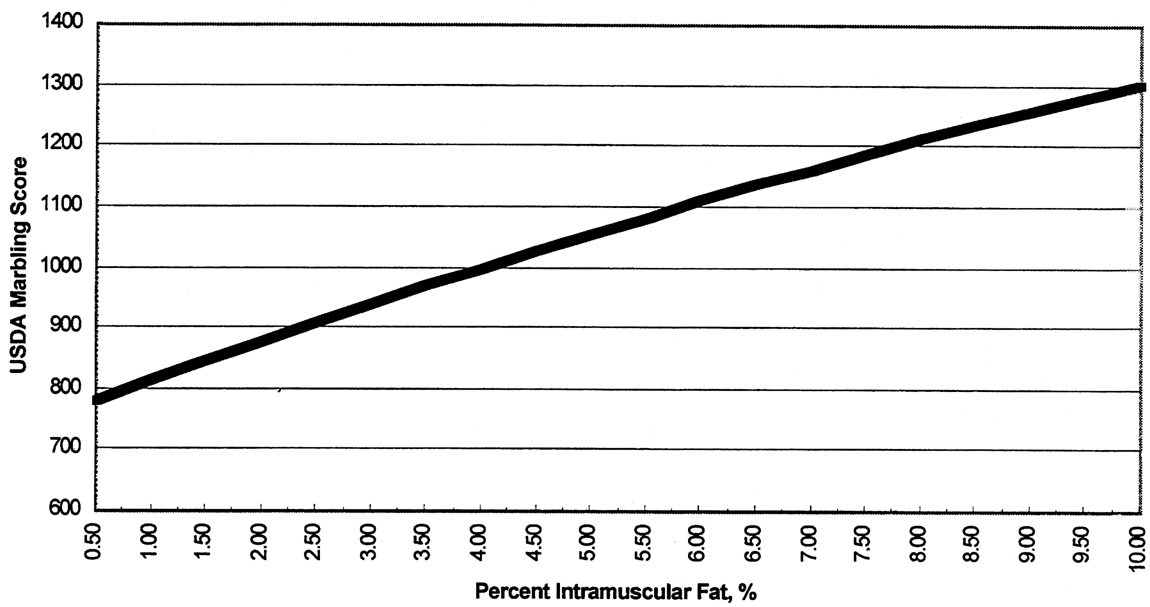

Table 2. Relationships among various methods of categorizing amounts of marbling in young beef cattle.

Marbling Score	Percentage Intramuscular Fat, %	USDA Quality Grade	Degree of Marbling
700 - 790 800 - 890	.28-1.37 1.37-2.58	Standard	Practically Devoid Traces
900 - 990	2.58-3.90	Select	Slight
1000 - 1090 1100 - 1190 1200 - 1290	3.90-5.33 5.33-6.88 6.88-8.55	$Choice^-$ $Choice^0$ $Choice^+$	Small Modest Moderate
1300 - 1390 1400 - 1490	8.55-10.32 10.32-12.21	Prime	Slightly Abundant Moderately Abundant

Standard errors of prediction for these groups of cattle indicate that ultrasound (SEP:41-57) is as accurate in predicting chemically extracted fat as the USDA graders marbling score (SEP:35-58). This statistic indicates that with ultrasound marbling score can be predicted 70 percent of the time within ± 50 of a marbling score.

These relationships between chemically extracted fat, the ultrasound predicted percent intramuscular fat, and marbling score indicate a major problem in increasing the accuracy of the ultrasound prediction. This ultrasound prediction algrithum is validated against the objectively determined chemically extracted percent intramuscular fat. The literature states that the correlation between chemically extracted fat and subjectively determined marketing scores is 0.75, which agrees with the values in Table 1. Therefore, predicting a subjective measure will likely be less than perfect. If hot carcasses were scanned with ultrasound or some other form of instrument grading to determine the amount of intramuscular fat, it would be much easier to develop an algrithum for ultrasound to use on live cattle.

Fat thickness was measured with ultrasound on 163 of the steers shown in Table 1 and compared with the carcass fat measurement at the 12th rib. The standard error of prediction (SEP) was 0.08 inches. Fat cover has been measured with ultrasound on thousands of live cattle and routinely the SEP will be less than 0.10, which indicates that 70% of the time the measurement will be within 0.10 inch. Since fat cover drives the yield grading equation, with average muscle, yield is predicted ± 0.25 yield grade.

The third objective of this project was to measure fat thickness at the 12th rib, and percent intramuscular fat on live feedlot cattle at reimplanting time (i.e. 90-100 days before slaughter) and then predict potential yield grade and quality grade at harvest time. The merit of this prediction would be to sort or identify groups of cattle at reimplanting time (while they are already in the chute) that could be managed and targeted for specific grid or branded product markets.

To initially test this concept models were developed for a group of 153 steers fed either an 86 or 93 percent concentrate diet at the Armstrong research farm in Southwest Iowa. The cattle were scanned 90, 46 and 6 days prior to slaughter. Means and standard deviations of an ultrasound scan and carcass measurements are shown in Table 3. As expected, fat cover, rib eye area, percent intramuscular fat and weight all increased as harvest approached.

Table 4 relates the correlations between each of the three live animal ultrasound scans for each trait--fat thickness and percent intramuscular fat--with the carcass measurements for these traits, measured fat thickness at the 12th rib and USDA marbling score recorded to the nearest 10th of a degree then converted to percent intramuscular fat. Correlations for both fat cover and percent intramuscular fat improved as scan date became closer to slaughter.

Table 3. Means and standard deviations of ultrasound scan and carcass measurements

	Scan Session (Real-Time Ultrasound)			Harvest Carcass Measurements
	1	2	3	
Days Prior to Harvest	90	46	6	0
UFAT Fat cover, in.	.17 (.07)	.24 (.08)	.38 (.10)	.33 (.09)
UREA Ribeye Area in.^{2}	9.60 (.89)	11.81 (1.12)	12.94 (1.21)	12.73 (1.31)
UPFAT % IM Fat	3.34 (.92)	3.09 (.59)	3.88 (.98)	3.97 (.97)
WT Weight, lb.	852.54 (53.71)	1051.36 (65.07)	1194.80 (75.93)	1194.80

Table 4. Correlations between live animal scans and carcass measures

	Scan Session	Ultrasound Fat Thickness	Ultrasound % IM Fat
Carcass fat thickness	1	0.53	---
	2	0.64	---
	3	0.72	---
Carcass % IM Fat[a]	1	---	0.56
	2	---	0.56
	3	---	0.66

[a]Marbling Scores converted to % IM fat

Models were developed for each scan date to predict carcass fat cover and percent intramuscular fat. The equations, r^2 values and residual mean squared error values are shown in Table 5 using pooled data. Scan 1, 90 days prior to slaughter, explained 35 percent of the variation in percent intramuscular fat and 29 percent of the variation in fat cover. As expected the accuracy of the equations improved as scan date approached harvest date. Six days prior to harvest, ultrasound scan measurements explained slightly more than 50 percent of the variation in each trait.

These models were validated on two groups of cattle, 276 crossbred steers fed in northwest Iowa and 74 grain fed bulls from the Rhodes beef breeding project.

The northwest Iowa crossbred steers were scanned 133 days before harvest with the feedlot program, and individual carcass data collected at the harvesting facility. The Rhodes grain fed bulls from the beef cattle breeding project were serially scanned; however, the scan used for this validation was 113 days before harvest. The results of the validation on these two groups of cattle are shown in Table 6. The equations developed did not predict the northwest steers very well. Both carcass data and ultrasound scan data were collected in strictly a "field data" situation. The validation using the Rhodes bulls looks much more promising (based on rank correlations and SEP) despite the fact that this group of cattle had lower means and less variation for both fat cover and percent intramuscular fat--which would be expected when comparing bulls with steers. The Rhodes carcass data and scan data were collected in a "research situation" by ISU personnel. This may be a partial explanation for the difference in how the developed equations predicted these two groups of cattle.

Implications

The increased interest in value based marketing, grid marketing or a branded beef product where carcasses are priced on an individual basis relative to their carcass merit makes it imperative that producers know what they have for sale. Real-time ultrasound scanning at sorting time just prior to harvest could greatly aid in the decision making process and reduce the risk at marketing time, particularly if the cattle are of unknown background. On an individual basis, yield grade can be predicted within ± 0.25 yield grade 70% of the time and quality grade within ± 0.5 marbling score. Individual predictions could be pooled to calculate the probability of a certain percentage of a load of cattle fitting into a particular quality and yield grade. However, as stated earlier this system can only be as accurate as the subjective grading system used by the USDA grader in the cooler. The scanning process will require extra time and effort during sorting. Provided the facilities are adequate, the cattle are cooperative and relatively clean, sixty head could be scanned in one hour. In many cases feedlot managers would need to change their philosophies regarding cattle sorting. Economics will dictate this philosophy change.

Predicting yield grade and quality grade 100 days (at re-implanting) before harvest is more difficult and requires a more detailed model. Work to date seems rather promising on some groups of cattle, although rather dismal on others. Additional factors describing the cattle, i.e., hip height, breed type as well as environmental factors such as implant strategy need to be added to the model. The model could also be "fine tuned" by scanning large sets of cattle serially over an extended period of their growth curve.

Acknowledgments

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Table 5. Models for prediction of fat thickness and percent intramuscular fat from ultrasound scans on live cattle.

Equation #	Equation	R2	RMSE
	Percent Intramuscular Fat		
Scan 1	Y = 1.79363 + 2.878570 UFAT + .5044720UPFAT	.35	.79-
Scan 2	Y = .60077 + 3.843499 UFAT + .7894168UPFAT	.41	.75
Scan 3	Y = 1.918743 + 2.275040 UFAT + .0742480UPFAT2	.51	.68
	Fat Thickness equations		
Scan 1	Y = .20251814 + .75036178 UFAT	.29	.08
Scan 2	Y = .14833687 + .75979450 UFAT	.52	.07
Scan 3	Y = .08300800 + .65262200 UFAT	.52	.07

Table 6. Validation of models using two groups of cattle, 276 northwest Iowa steers and 74 grain fed slaughter bulls.

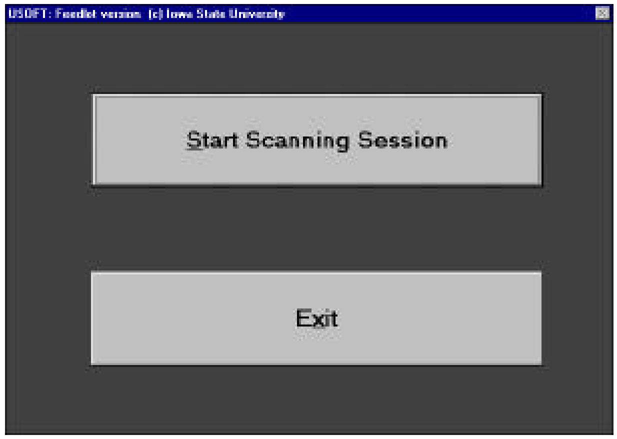
Mean Sd[a] SEP[b] Rank Correlation

	Mean	Sd	SEP	Rank Correlation
Percent Intramuscular Fat Models				
- Northwest Iowa Steers -				
Carcass Marbling (% Fat)	3.75	1.21		
Predicted Values (% Fat)				
Scan 1	4.33	.48	1.34	.21
Scan 2	4.42	.72	1.45	.20
Scan 3	3.52	.56	1.27	.17
-Rhodes Bulls -				
Carcass Marbling (% Fat)	2.93	1.01		
Predicted Values (% Fat)				
Scan 1	4.01	.41	1.38	.51
Scan 2	3.97	.63	1.35	.49
Scan 3	3.23	.44	0.91	.49
Fat Cover Models				
-Northwest Iowa Steers -				
Carcass Marbling (% Fat)	0.39	0.16		
Predicted Values (% Fat)				
Scan 1	0.36	0.05	0.16	.28
Scan 2	0.31	0.05	0.18	.28
Scan 3	0.22	0.05	0.23	.28
-Rhodes Bulls -				
Carcass Marbling (% Fat)	0.28	0.10		
Predicted Values (% Fat)				
Scan 1	0.31	0.04	0.09	.64
Scan 2	0.26	0.04	0.08	.64
Scan 3	0.18	0.03	0.13	.64

Sd[a] Standard deviation
SEP[b] Standard error of Prediction

USOFT/Feedlot Software

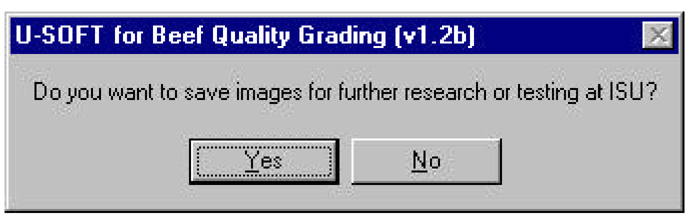
Startup screen



Screen 1

USOFT/Feedlot Software

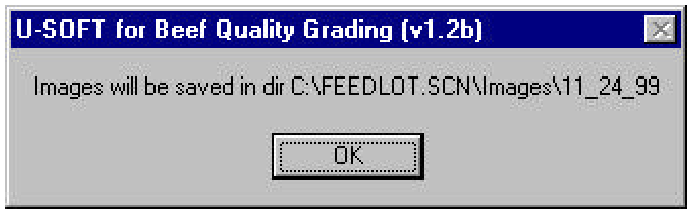
Option to save images for research



Screen 2

USOFT/Feedlot Software

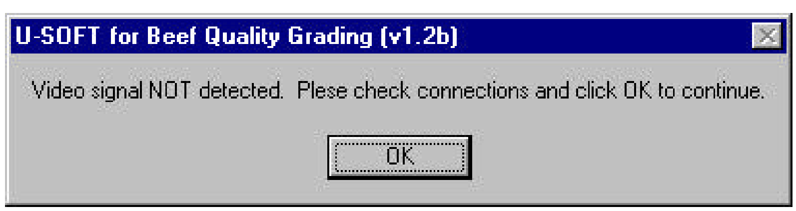
Directory name for saving images



Screen 3

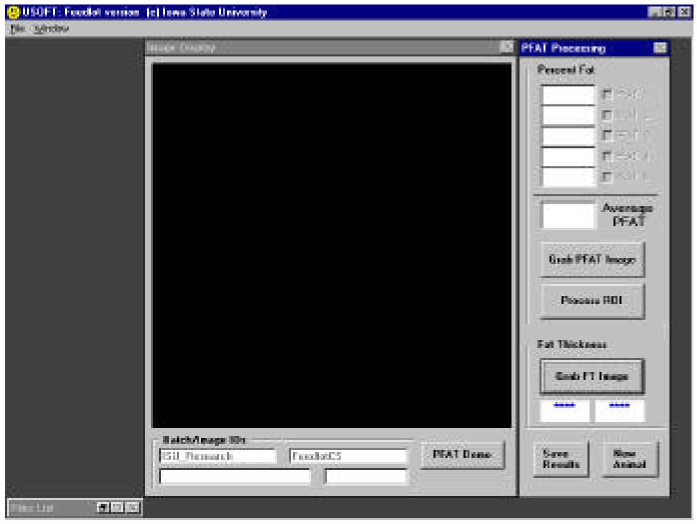
USOFT/Feedlot Software

Monitors video signal at frame grabber



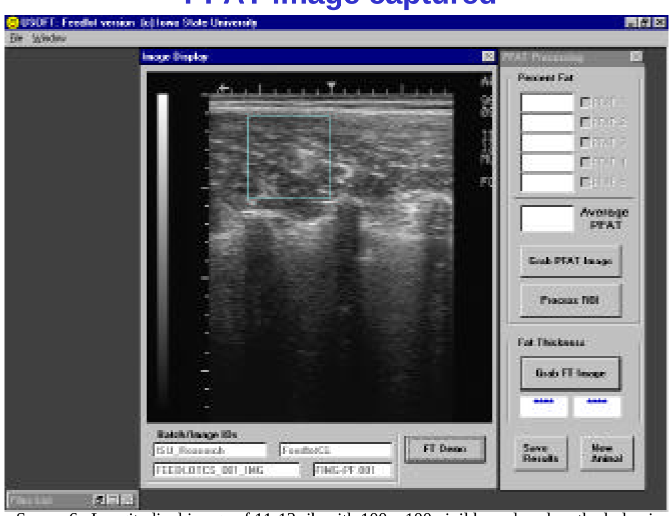
Screen 4

USOFT/Feedlot Software
Main screen



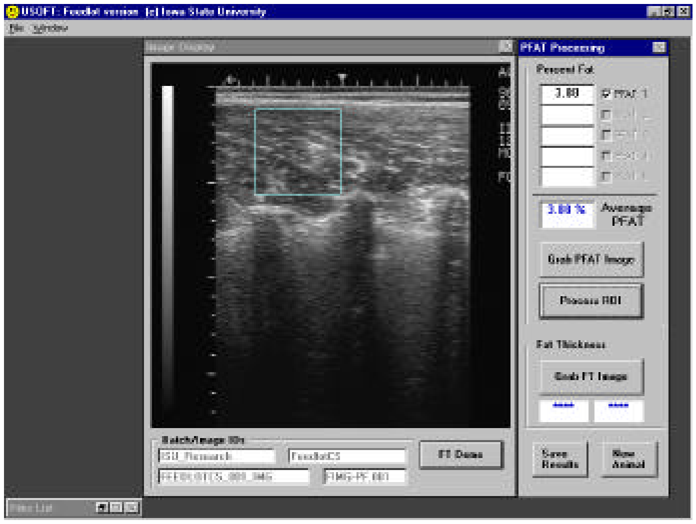
Screen 5. Screen format, % intramuscular fat (PFAT) and fat thickness (FT) shown on the right hand side of the screen.

USOFT/Feedlot Software
PFAT image captured



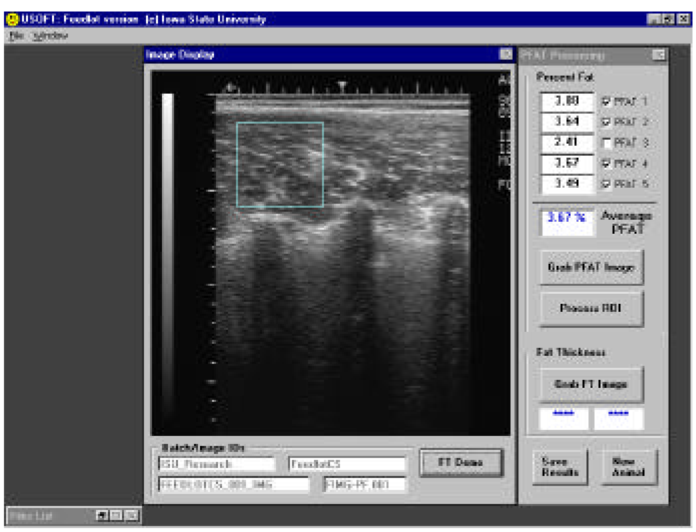
Screen 6. Longitudinal image of 11-13 rib with 100 x 100 pixil box placed on the l. dorsi muscle in the image.

USOFT/Feedlot Software
PFAT image processed



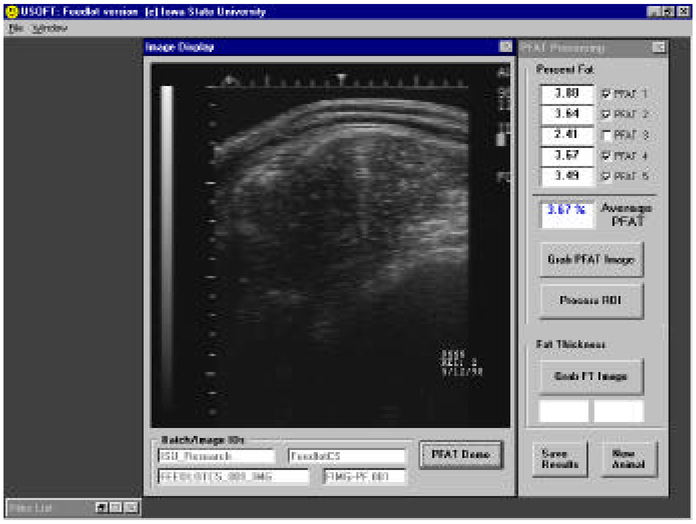
Screen 7. Longitudinal image processed, 3.88% fat.

USOFT/Feedlot Software
Results from Multiple PFAT images



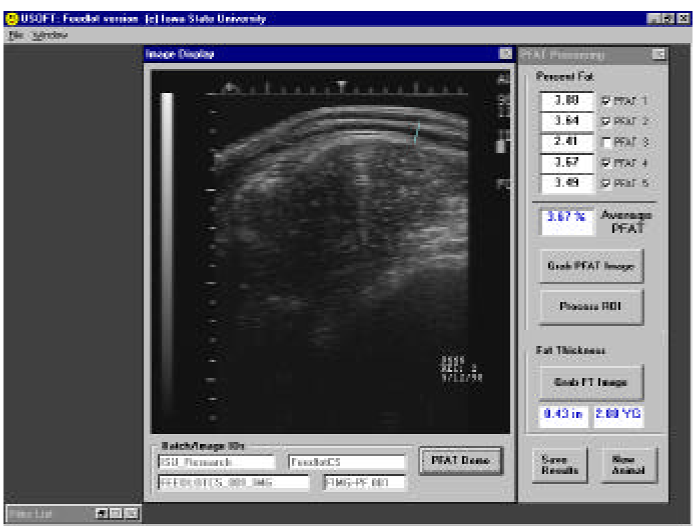
Screen 8. Average percent fat has been calculated after 5 images were processed and the 3rd image was rejected.

USOFT/Feedlot Software
FT image captured



Screen 9. Cross-sectional image

USOFT/Feedlot Software
FT measured



Screen 10. Cross-sectional image after fat thickness has been measured (0.43 in) at the 3/4 position on the l. dorsi muscle and converted to yield grade (2.88).