Using Total Body Electrical Conductivity (TOBEC) and Optical Fat Probes for Estimating Carcass Composition

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Current methods of pricing live animals do not adequately recognize differences in carcass composition and therefore do not adequately relate consumer demands to producers. Pricing systems based on carcass merit will be necessary before this relationship can exist. In order for carcass merit pricing systems to be accepted, methods to estimate carcass composition must be both accurate and objective. This session was designed to demonstrate total body electrical conductivity (TOBEC) and optical fat probes as potential methods to obtain objective measurements of carcass composition under commercial applications.

Total Body Electrical Conductivity (TOBEC)

This procedure has been shown to be a very rapid indicator of lean mass in both carcasses and primal cuts. The basic unit is comprised of a cylindrical copper coil sealed in a heavy-gauged steel cabinet with a polyvinylchloride liner through the coil. When energized, the coil produces an electromagnetic field having a frequency of 2.5 MHz, similar in strength to a citizen band (CB) radio. As a sample enters the electromagnetic field, the amount of energy absorbed by the sample is proportional to the conductivity of the material and increases as the mass of the conductive material increases.

The basis of operation for the TOBEC method relies on differences in electrical impedance of the carcass components. The unit measures the amount of energy absorbed by a sample exposed to the electromagnetic field. To be measured by this technique, the conductive properties of the sample must be in mid-range. Materials having very high conductive properties, such as metals, have very little impedance of the electromagnetic field and therefore very little energy absorption. For materials with very low conductivity, such as fat, impedance is very high, inhibiting conductance of the electromagnetic field and therefore little energy absorption. Meat has conductive properties in mid-range, making it ideally suited for measurement using this technology.

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Prior to the start of the scanning process, the TOBEC unit is standardized using a "phantom" sample that absorbs energy at a pre-measured quantity. Various "phantom" samples can be used based on the range in which actual measurements will be taken. As the "phantom" sample is passed through the electromagnetic field, the energy absorbed is compared to the predetermined value and adjustments are made as needed.

A conveyor belt is supplied with the TOBEC unit to assist in passage of the sample through the magnetic field at a constant rate. The speed of the conveyor belt should be kept constant as it will affect the area and width of the response curve obtained. As the rate of passage increases, the area under the curve becomes more narrow. Additionally, samples under study should be positioned on the conveyor belt so that each will pass through the same part of the electromagnetic field. The coil produces an electromagnetic field that imparts a weaker signal at each end of the tunnel. Passing different samples through different parts of the signal will result in inconsistent predictive values. Materials which project beyond the ends of the coil can contribute to conductivity. For this reason, technicians should wear rubber gloves to avoid any interference in data acquisition during the positioning of the carcass.

Each sample is placed on the center of the conveyor belt, oriented so that the hind shank enters the chamber first. The unit is equipped with an electric eye that signals when the hind shank first enters the tunnel and initiates data capture. Some of the newer commercial units are equipped with automatic detection software that detects samples invading the electromagnetic field and signals the initiation of data collection. As the samples pass through the tunnel, conductivity is measured up to 80 times per second. By interfacing with a computer and appropriate software, the data points can be plotted for the entire scan.

The data obtained from a scanning session is typically bell-shaped when plotted, signifying the low lean content as the hindshank first enters the tunnel, and at the opposite end of the carcass showing a reduction in lean as the sample leaves the tunnel (Figure 1). The peak of this curve occurs when the entire carcass is inside the tunnel, and the complete carcass is exposed to the electromagnetic field.

Temperature of the sample is extremely important due to changes in impedance as temperature changes. Scanning can be successfully done on both hot and chilled carcasses. However, differences in measurements will be realized due to tem-

Carcass characteristic:	*HQ #1*	*HQ #2*	*HQ #3*	*HQ #4*
Live weight, kg	549	554	549	554
Hindquarter weight, kg	81.5	83.7	76.1	82.4
Hindquarter lean weight:				
Actual, kg	52.8	46.3	44.2	38.7
Predicted, kg	51.0	44.6	42.7	38.7
Scan peak	611	457	402	337
3/4 fat thickness, cm	0.31	1.41	0.56	2.11

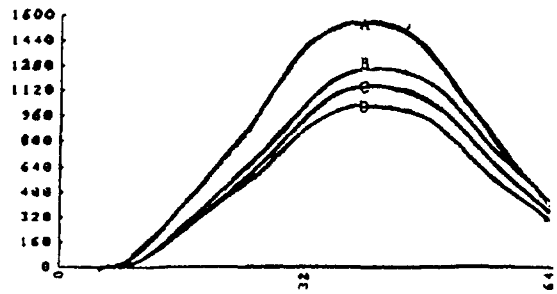

Figure 1. Examples of the phase/angle distance curves from 4 beef carcass quarters scanned for total body electrical conductivity through the Meat Quality Inc. MQ27 electromagnetic scanner. Data characterizing each carcass are presented above the curves.

Table 1. Coefficient of Determination (CD) and Residual Standard Deviations (RSD) for Individual Quarters and Primal Scans (n=59).

Variable		*CD*	*RSD*
Hindquarter	(kg)	94.79	1.00
	(%)	78.53	1.48
Round	(kg)	96.49	0.51
	(%)	54.81	1.50
Loin	(kg)	89.39	0.51
	(%)	68.45	2.21
Forequarter	(kg)	93.16	1.33
	(%)	64.19	1.63
Chuck	(kg)	93.43	0.81
	(%)	55.64	2.03
Rib	(kg)	92.13	0.24
	(%)	67.90	1.87

The prediction equations for either weight (kg) or percentage (%) included scan peak, (length or temperature), weight, and 3/4 fat thickness.

perature effects. Higher predictive values have been obtained on hot carcasses when compared to chilled counterparts. This technology cannot be used to test frozen samples due to the low conductivity of frozen meat.

The peak height obtained by the TOBEC scan can be used as one variable in a regression equation to determine lean yield. Among the more common variables otherwise included in the regression equation are carcass length, carcass temperature and carcass weight. In commercial applications, the slaughter sequence is steady enough that carcass temperature will not be highly variable and therefore, may not be required in the equation. The operator should realize, however, that any slow-down in the slaughter process that will cause a change in temperature of the carcass at the time of scanning should be accounted for in the final prediction equation. Table 1 contains coefficients of determination (CD) and residual standard deviations (RSD) for regression equations used for the prediction of lean content in beef quarters and primal cuts. The prediction equations used scan peak, length or temperature, weight and 3/4 fat thickness. As indicated from the data, TOBEC has a higher CD when predicting lean weight than when predicting percentage lean. The loin had the lowest CD associated with the prediction equation while the round had the highest.

The scanning of raw materials destined for further processing is also possible with this technique. Australia has successfully implemented the use of this system for the scanning of boxed beef trimmings. Consistent orientation of the container is important. Changes in the orientation of the container can change the readings obtained. The effect of meat piece size on the performance of the instrument determined correlation coefficients of 0.75, 0.88 and 0.88 for cartons containing large, intermediate and small meat pieces, respectively. Cartons can pass through the instrument at rates up to 1000 per hour.

Domestic commercial application of this technology is located in a pork slaughtering facility in Sioux City, Iowa. The scanning of the sides is located just subsequent to splitting the carcasses on the slaughter floor. Approximately 300 carcasses per hour are scanned at this facility with very promising results.

Optical Fat Probes

Optical fat probes are used throughout the U.S. and Europe for the purpose of pricing carcasses on the basis of lean yield. As our industry moves closer to value-based marketing, interest is increasing in the utilization of this technique. Although this method is relatively simple to use, there are potential ways in which predictive capabilities are decreased. Inconsistencies can arise if the orientation of the needle as it enters the carcass is angled so that the cross section of the fat or muscle at that point is elongated.

The carcass is probed at a predetermined point with a pistol-like optical fat-lean probe that measures the depth of the loin muscle and backfat. As the probe is withdrawn, an electric eye records the difference in reflectance between the lean and fat areas of the loin. These measurements of loin fat depth and loin muscle depth are combined with hot carcass weight in a regression equation to estimate carcass lean content. Optical fat probes of lean and fat, in conjunction with carcass weight, can account for approximately 80% of the variation in total lean weight in pork carcasses.

Summary

Value-based marketing of livestock will depend on the accurate and practical method of determining carcass composition. With this ability, producers can provide processors with the type of livestock they are seeking through targeted breeding and management practices. Emerging technologies, such as the TOBEC and optical probes, bring the industry much closer to having the capability of objectively identifying carcasses that yield higher amounts of lean.

Optical fat-lean probes are currently being utilized extensively across Europe, Canada and in several pork plants in the United States. The TOBEC is currently operating successfully on-line in one pork slaughter plant in the United States.