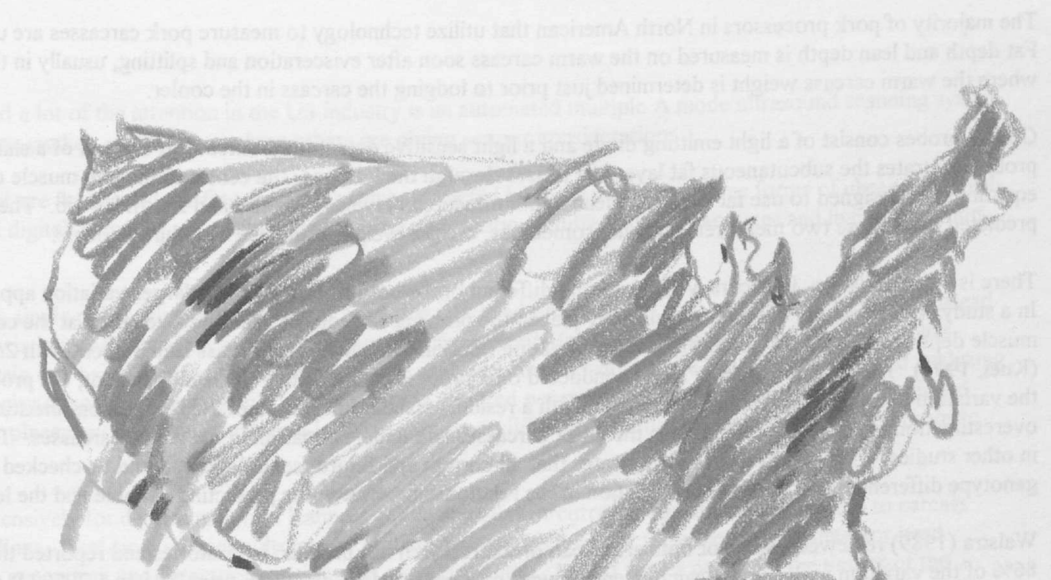
SECTION B

Value Based Meat Marketing Systems

*B-5: see page 676.



B1

VALUE BASED MARKETING SYSTEMS: TECHNOLOGY IMPLEMENTATION

JOHN C. FORREST
Animal Sciences Department
Purdue University
West Lafayette, IN 47906

INTRODUCTION

Value based marketing of live animals has lead to the development of price discovery systems that base the price paid for an animal on the utilitarian value of the carcass and its parts. The determination of utilitarian value is usually based upon the composition of the carcass and, where applicable, those factors that may influence the palatability of the final consumer product whether fresh or processed. Many grading programs around the world are based upon subjective appraisal of value determining factors by trained personnel. Although subjective grades have played a major role in marketing and price discovery , there is a continual desire on the part of both buyers and sellers to improve the objectivity and consistency of the price discovery process. This desire has driven the development of technology with the goal of improving the precision of the evaluation process and give more consistent information upon which to base prices as well as to provide better information feedback to producers of livestock who must make important decisions regarding the selection of breeding stock and designing of production systems that will provide consumers with meat products that meet their desires for leanness and palatability.

Europe leads the world in the establishment of value based marketing systems and the implementation of technology to support objective evaluation that is so critical to a truly effective and fair system. The swine industries in most countries seem to lead the way in the development and adoption of technology by providing the necessary research support.

IMPLEMENTATION OF TECHNOLOGY IN NORTH AMERICA

Implementation of technology is an evolutionary process. Several technologies have the potential for implementation but are in various stages of development. This report summarizes the current status in North American. An updated status report will be made available to symposium participants at the time of presentation.

Technologies that are in use currently include optical fat-lean probes, electromagnetic scanning, ultrasound, and various forms of machine vision or video imaging.

Optical fat/lean probes

The majority of pork processors in North American that utilize technology to measure pork carcasses are using the optical fat lean probe. Fat depth and lean depth is measured on the warm carcass soon after evisceration and splitting, usually in the area on the slaughter line where the warm carcass weight is determined just prior to lodging the carcass in the cooler.

Optical probes consist of a light emitting diode and a light sensitive detector mounted near the end of a sharpened arrow-like tip. The probe penetrates the subcutaneous fat layer and passes through the lean near the center of the loin muscle cross-section. Most prediction equations are designed to use fat depth and lean depth measured between the third and fourth last rib. The lean content of the carcass is predicted from those two measurements and, sometimes, carcass weight is utilized as a third variable.

There is some variation in accuracy (CD) among different probe brands; however, the larger variation appears to be due to operator error. In a study where a single operator consistently placed the probe at the correct anatomical location at the correct probe angle, fat depth and muscle depth accounted for about 82% of the variation (CD) in total dissected carcass lean percent with 2.15% residual standard deviation (Kuei, 1991). However, in another study conducted on a processing line with a different operator, the probe accounted for only 52% of the variation in total dissected lean percentage with a residual standard deviation of 3.5%. This on-line study also revealed a tendency for overestimation of the lean percentage in the fatter carcasses and underestimation in the leaner carcasses. This tendency has been observed in other studies. This observation demonstrates that all current and future technologies should be checked for biases that may be caused by genotype differences within the pig population in the relationship between the predicting variable and the lean endpoint being evaluated.

Walstra (1989) reviewed results of optical fat/lean probe research in European laboratories and reported that they accounted for from 68 to 86% of the variation in dissected lean percentage with residual standard deviation from 2.45 to 1.79%. It appears that optical fat/lean probes are acceptable for commercial operation provided a high level of quality control and supervision is associated with probing technique and that operators are regularly checked for consistent probe placement. Development of a robot for accurate placement of the sensors should improve the consistency of this technology. The Danish Classification Center which is a robotized multiple optical probe device provides a good example where proper automation of technology improves accuracy and precision of measurements (Klinth-Jensen 1991).

In addition to giving an evaluation of the lean percent, the optical probes provide pork producers with an indication of fatness in their animals. Many producers use the fat thickness measure alone as an evaluation of their breeding and selection programs. This information is especially helpful in the transition to leaner genetics.

The optical fat/lean probes have played a major role in the movement toward value based marketing in North American. With the establishment of value based programs for purchase of livestock many pork processors are looking for greater precision and the ability to gain more information on the composition of various parts of the carcass.

Electromagnetic scanning

Electromagnetic scanning has been in continuous operation in one plant for 2 years. Electromagnetic scanning uses the conductivity differential between fat and lean tissue to measure total body electrical conductivity (TOBEC). A low level magnetic field is generated by a coil of copper wire around a plexiglass tube large enough to accommodate the sample to be measured. A carcass can be passed through the magnetic field on a conveyor belt. Any muscle present in the field will absorb energy because of its conductivity while fat and bone absorb little energy. Since a carcass is moving through the field, the energy absorption curve generated gives an indication of the amount of lean in the field at any given position. This allows quantification of lean in the various parts of the carcass as well as the total lean mass. Several studies at Purdue University and the University of Nebraska have shown that TOBEC can account for 90% or more of the variation in lean mass in pork, beef and lamb carcasses (Forrest et al., 1991, Gwartney et al., 1994, Berg et al., 1994). A technology transfer study sponsored by the National Pork Producers Council and conducted by Purdue University demonstrated that a similar level of accuracy is achievable in an on-line installation in a pork plant, processing 350 warm carcasses per hour. The on-line electromagnetic scanner accounted for 90% of the variation in total carcass lean weight, and 86% for total carcass lean percentage and could predict lean mass in the ham, loin and shoulder with accuracy levels of 83, 86 and 85% respectively (Berg et al., 1993). If this technology is used to determine carcass value, greater precision is achieved when lean is detected accurately in the individual parts of the carcass compared to basing value on total lean. One advantage of an electromagnetic system is that it is totally non-invasive and it could be engineered to be completely automatic, thus eliminating or reducing chance for human error. However, the system requires extensive engineering to return warm carcasses to the rail after scanning and before entering the chill cooler.

Carcasses must be removed from the rail and placed horizontally to pass through the scanning chamber. Lack of automation of this process has been a major deterrent to the adoption of this technology. Carcasses are automatically dropped form the rail and positioned for scanning, however, the carcasses must be manually regambreled and returned to the rail after scanning. One installation was attempted where chilled carcasses were scanned just prior to fabrication into primal cuts. That installation was unsuccessful because carcass temperature variation was too great for accurate results. Research is currently underway to design a fully automated conveyor system that will operate accurately at 1000 scans per hour. Only if this technology is successfully automated will there be widespread adoption by the industry.

Ultrasound

The second system that has attracted a lot of the attention in the US industry is an automated multiple A mode ultrasound scanning system. This instrument is being tested by one packer, while two or three others are giving serious consideration.

Ultrasound utilizes sound waves that are far beyond the frequency that can be detected by the human ear. Three forms of ultrasound (real-time imaging, velocity of sound and digital-A-mode) are available for sensing compositional differences in carcasses and live animals non-invasively.

Digital A-mode ultrasound utilizes a single pulse echo detector sensor head that is moved on a track to scan an area of the carcass instead of a multiple array. This technology is in an advanced developmental stage, but is not ready for commercial testing. The concept has several potential advantages, the main one being that the digital signal can be analyzed directly without the need for creating and analyzing an image. The advantage over velocity of sound is that a single contact point is required per measurement versus two precisely aligned points. The potential also exists for placement of two or three non-invasive sensors at different locations on the carcass using a robot to enhance prediction accuracy.

Real-time imaging is being used extensively for determination of leanness in live animals but currently has limited application to carcass evaluation on high speed slaughter lines. Real-time imaging ultrasound utilizes pulse-echo detector technology. The detector head consists of a multiple array of pulse generators and detectors positioned in close proximity. Sound waves penetrate the tissues of the carcass and some are reflected back as an echo when they encounter various tissue boundaries or changes in density and tissue type. The reflected signals are converted to digital information that is used to create an image of the tissues under the detector head. Since pulse signal generation and echo detection occur continuously, the image generated changes with movement of the detector head. This permits the operator to determine when the tissues are in the proper orientation and position for consistent measurement. In most real-time instruments, the selected image can be paused and recorded in digital format either on video tape or printed with a laser printer. Images can then be analyzed for fat depth and/or muscle area. Image analysis software is being developed to measure images directly on the computer screen. Also, analysis can be accomplished manually on a computer screen or with a compensating polar planimeter directly from laser prints.

Two different image sections have been used on carcasses in experimental trials. The most common has been a cross-section of the longissimus muscle at the space between the 10th and 11th ribs in pork and the 12th and 13th ribs in beef. This permits measurement of the loin muscle area and the fat depth at a point 3/4 the distance along the longitudinal axis of the muscle cross section lateral to the chine bone as accomplished on ribbed carcasses. Ultrasound detection of fat depth, and loin muscle area, combined with warm carcass weight accounted for 78% of the variation in dissected carcass lean with a residual standard deviation of 4.6 lb. in pork carcasses (Kuei, 1991). Newer ultrasound systems may provide greater resolution and sharper images that will improve the ability to predict lean.

Some investigators place the detector head parallel to the long axis of the longissimus muscle approximately 3 in. lateral to the midline of the carcass. Since the detector head is about 5 in. long, this permits measurement and averaging of lean and fat depth at three or more points under the head. A study by Gresham et al. (1992) reported that a regression equation including sex, warm carcass weight, ultrasound fat depth and muscle depth accounted for 91% of the variation in weight of boneless lean cuts with a residual standard deviation of 3.0 lb. However, the same variables accounted for only 53% of the variation in boneless lean cut percentage. The main advantage to this system is that the muscle depth may be easier to measure in an automated computer image analysis system than loin muscle area. Further testing and validation of this procedure seems warranted.

The most advanced form of ultrasound that may have future application to carcass evaluation is velocity of sound (VOS). This technology operates on the principle that ultrasound waves pass through muscle at a higher velocity than through fat (Ferguson, 1991). By generating ultrasound waves, transmitting them through a sample and receiving them on the other side, one can determine the rate of travel of the wave. The path of the ultrasound wave must not be obstructed by bones or intestines. Such measurements can be made across the back of the animal in the thoracic region by passing the wave between the spinous processes of the thoracic vertebrae. A major advantage of the VOS technique is the elimination of images and image analysis. The velocity will determine accurately the composition of the combined tissues in the path of the ultrasound wave. Specific anatomical locations must be identified that can be scanned and provide consistently good predictions of the composition of the entire carcass. Some laboratory studies suggest that VOS would be more precise in predicting carcass lean and fat than real-time imaging ultrasound.

Machine Vision Systems

One machine vision system is know to be in operation in a US beef slaughter plant. This instrument reportedly estimates lean composition and evaluates marbling from an image of the loin cross-section.

The advent of sophisticated digital imaging techniques creates the potential for computerized image analysis from a wide range of imaging sources. Analysis of video images based on color and/or grey scale offers the potential for objective evaluation of traits that have been evaluated traditionally by visual means on the basis of fatness and conformation.

Work at Kansas State University and at the U.S. Meat Animal Research Center, Clay Center, Nebraska, several years ago demonstrated that a video image of the cross-section of the beef rib-eye and the subcutaneous fat covering the muscle could be used to determine beef yield grades with accuracy (Cross et al., 1983). Other systems have been developed in Australia, Great Britain and Denmark in which video images of the carcass side were analyzed for thickness of fat to predict lean yield. Some of these methods appear promising for lean yield evaluation but the greatest power that advanced video image technology may have to offer in the future may be in the area of color and marbling evaluation.

Currently the only technology being utilized for evaluation of quality palatability factors appears to be machine vision. Several investigations are being supported by the National Livestock and Meat Board and the National Pork Producers Council to further develop technology that will allow the early post mortem detection of problems that might be associated with color or water holding capacity, and tenderness. Studies are also being conducted that would allow the on-line sorting of individual retail fresh meat cuts prior to packaging when done by central distributor.

SUMMARY

The utilization of technology to support value based marketing in North American is most advanced in the swine industry. The beef industry has supported extensive research over the past decade. That research will ultimately lead to viable technology. The lamb industry is also supporting technology research that will lead to a technology based system of price discovery for carcasses. Research is being conducted in the poultry meat industry, however the marketing goals are different in a vertically integrated industry therefore the technology will likely be utilized for sorting and grading.

Very little technology is being used for the objective measurement of quality attributes in meat products. Considerable research and development activity is underway to find practical objective measures of meat quality

For a more comprehensive review of potential technologies and technologies under development see Forrest and Judge (1994) and Forrest (1995).

References

Berg, E.P., Forrest, J.C., Fisher, J.E. and Judge, M.D. (1993). Electromagnetic scanning of warm pre-rigor carcasses in an on-line industrial configuration. Proceedings 39th International Congress of Meat Science and Technology, Calgary, Alberta, Canada. p. 182, File:S4Po4.wp.

Berg, E.P., Forrest, J.C., Thomas, D.L., Nusbaum, N., and Kauffman, R.G. (1994) Electromagnetic scanning to predict lamb carcass composition. J. Anim. Sci. (In Press).

Cross, H.R., Gilliland, D.A., Durland, P.R., and Seideman, S. (1983) Beef Carcass evaluation by use of a video image analysis system. J. Anim. Sci. 57:908-917.

Ferguson, D.M. (1991). Ultrasonic evaluation: Ultrasound measurements and their relation to composition, Proceedings of the Symposium Electronic Evaluation of Meat in Support of Value-Based Marketing, Purdue University, West Lafayette, Indiana. pp. 49-71.

Forrest, J.C., Kuei, C.H., Chen, W., Lin, R.S., Schinckel, A.P., Walstra, P., Kooper, H., and Judge, M.D. (1991). Electromagnetic scanning: Carcass evaluation, Proceedings of the Symposium Electronic Evaluation of Meat in Support of Value-Based Marketing, Purdue University, West Lafayette, Indiana. pp. 85-111.

Forrest, John C. and Judge, Max D. (1994) Technology to assess carcass and product composition. In "Low-Fat Meats" (H.D.HAFS and R.G. Zimbelman, eds.) Academic Press, Inc. San Diego, CA, 922101. pp 113-129.

Forrest, John C. (1995) New techniques for estimation of carcass composition. In "Quality and Grading of Carcasses of Meat Animals" (S.D. Morgan Jones, ed) CRC Press, Inc. BocaRaton, FL 33431, pp 157-171.

Gresham, J.D., McPeake, S.R., Bernard, J.K. and Henderson, H.H. (1992). Commercial adaptation of ultrasonography to predict pork carcass composition from live animal and carcass measurements. J. Anim. Sci. 70:631-639.

Gwartney, B., Calkins, C., Lin, R., and Forrest, J. (1994) Validation of electromagnetic scanning for composition using two different beef carcass populations. Nebraska Beef Cattle Report, The Agricultural Research Division, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, Nebraska. pp. 61-67.

Klinth-Jensen, Werner. (1991) Optical Probes: Single probes and classification system. Proceedings of the Symposium Electronic Evaluation of Meat in Support of Value Based Marketing, Purdue University, West Lafayette, Indiana. pp. 11-23.

Kuei, C.H. (1991). Evaluation of electronic methods for estimation of pork carcass composition. Ph.D. Thesis, Purdue University, West Lafayette, IN, 242 pages.

Walstra, P. (1989). Automated grading probe for pigs currently in use in Europe, their accuracy, cost and ease of use. In Proceedings of the EAAP Symposium: New Techniques in Pig Carcass Evaluation. Helsinki, Finland. EAAP Publication No. 41. pp. 16-27.