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Techniques to Identify Palatable Beef Carcasses: Marc Tenderness Classification, SDSU Colorimeter and Near-Infrared Spectrophotometry (NIR) Systems

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TECHNIQUES TO IDENTIFY PALATABLE BEEF CARCASSES: MARC TENDERNESS CLASSIFICATION, SDSU COLORIMETER AND NEAR-INFRARED SPECTROPHOTOMETRY (NIR) SYSTEMS

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The value of any product is determined by a customer's willingness to pay for that product, which is determined by that customer's wants and needs. The value of beef is therefore ultimately determined according to beef customers' desires. There are three basic beef carcass characteristics that affect value. These are shown in Table 1.

Table 1. Beef carcass characteristics affecting carcass value and the ease at which they are assessed.

Beef carcass characteristic	Ease of assessment
Product size	Easy to assess
Product cutability	χ
Product quality (appearance and eating quality)	Difficult to assess

Beef is offered for sale to the consumer at generally higher prices than other protein sources. The relatively higher retail price of beef is mainly a result of inherent disadvantages in cattle production efficiency, such as longer gestation periods, lower prolificacy, and reduced feed conversion as compared to pigs and poultry. Although beef producers should strive to reduce production costs and retail beef prices, the industry must rely on superior quality to increase demand for its product because beef will, inevitably, always be priced higher than pork and poultry. According to the Beef Customer Satisfaction Study, consumers perceive beef to be better tasting than either chicken or pork (NLSMB, 1995). However, several studies have documented wide variation in the quality of beef currently produced in the United States (Morgan et al., 1991; Savell et al., 1991).

The United States Department of Agriculture (USDA) Grading Service attempts to sort through this diversity in the cattle population and assign carcasses into grades of expected eating quality. These USDA quality grades are based primarily on evaluations of carcass maturity and the amount of intramuscular fat (marbling) present in the longissimus muscle (USDA, 1989). Both of these factors, maturity and marbling, have been shown by numerous researchers to significantly impact beef palatability. Increased maturity has been associated with decreased palatability (Romans et al., 1965; Breidenstein et al., 1968; Prost et al., 1975; Smith et al., 1982; Smith et al., 1988). The largest study of maturity effects on palatability was conducted by Smith

et al. (1982) and utilized beef from 1,005 carcasses of all maturity groups (A through E). Substantial decreases in palatability and tenderness were found with increased maturity. However, the vast majority of carcasses within the fed steer and heifer population are classified into the "A-maturity" group (Lorenzen et al., 1993), and Smith et al. (1982) found little association between maturity and palatability within the "A-maturity" group ($r^2 = 0$ for longissimus muscle, $r^2 = .18$ for semimembranosus). Furthermore, USDA grades are assigned independent of differences in carcass maturity within the "A-maturity" group (USDA, 1989). Therefore, we can assume that, for most of the fed steer and heifer population, maturity is a constant and marbling is the sole determinant of USDA quality grade.

The impact of marbling level on beef palatability has also been extensively examined (Blumer, 1963; Romans et al., 1965; McBee and Wiles, 1967; Smith et al., 1984; Savell et al., 1987). Similar to the research on beef maturity, the effects of marbling on palatability have been studied across the extreme range of marbling scores. Smith et al. (1984) utilized 1,005 carcasses with marbling scores from "practically devoid" to "moderately abundant" and found a moderate relationship between marbling and palatability ($r^2 = .34$ for longissimus muscle, $r^2 = .07$ for semimembranosus) within the "A-maturity" group. However, The National Beef Quality Audit (Smith et al., 1995) reported that 84% of all carcasses from the fed steer and heifer population had marbling scores of "small" or "slight". Smith et al. (1984) reported no significant differences between means for "small" and "slight" for all 14 palatability attributes examined. With the majority of the fed steer and heifer slaughter being in a narrow maturity range (A-maturity) and in a narrow marbling range (slight and small), the USDA quality grades do not effectively segregate these carcasses into uniform palatability groups. However, substantial palatability differences do exist within this narrow maturity:marbling window. Therefore, the beef industry must seek other methods of distinguishing carcasses with palatable beef from carcasses with unpalatable beef, and continue to strive towards improving palatability.

Two ready-to-use on-line methods of assessing the palatability of beef carcasses appear promising. For the purpose of this paper, these two methods will be referred to as: 1) the Tenderness Classification System and 2) the Colorimeter System.

The Tenderness Classification System was developed by USDA researchers at the U.S. Meat Animal Research Center (MARC) in Clay Center, Nebraska (Shackelford et al., 1999). The shear force of cooked meat has long been used by researchers in the laboratory to assess meat tenderness. The Tenderness Classification System uses this shear force technology, but in an accelerated manner which therefore makes it adaptable to on-line use in a packing plant. In this system, a one-inch-thick rib steak is removed from each carcass and trimmed of all fat and bone. This steak is then cooked on a belt grill, which cooks both sides simultaneously, for a period of 7 minutes. Following cooking, a 0.4 inch by 2.0 inch slice is removed from the steak and the force required to shear this slice is measured on an electronic testing machine. The entire process, from cutting the steak to shearing the steak can be accomplished in 10 minutes. This system could be utilized at chain speeds of 400 head per hour (Goering, 1999). The Tenderness Classification System has been shown to explain 46 to 56% of the variation in aged beef tenderness (Shackelford et al., 1997).

The Colorimeter System was first tested at Colorado State University (Wulf et al., 1997),

later at The Ohio State University (Wulf et al., 1998), and currently at South Dakota State University. The Colorimeter System, as defined by the Ohio State research uses three factors to predict eating quality: marbling, hump height, and colorimeter readings. Hump height is a measure of the neck hump on beef carcasses and can be used to sort out those tenderness problems associated with *Bos indicus* genetics. If those carcasses with humps of greater than 3.5 inches are excluded, eating quality can be improved. Colorimeter readings are very simple to measure. It requires only 3 seconds to obtain a colorimeter reading on the surface of the rib eye muscle. The one critical factor that must be taken into account is bloom time, because bloom time will dramatically affect muscle color. Carcasses with a darker shade of muscle color (not necessarily dark cutters) have been shown to have less tender beef than carcasses with a brighter muscle color. In the Ohio State research, marbling explained 12% of the variation in eating quality, hump height explained 8% of the variation in eating quality, and colorimeter readings explained 24% of the variation in eating quality. Putting these three factors together in a single grading system explained 39% of the variation in eating quality (Wulf et al., 1998).

Table 2 shows a comparison of systems at predicting eating quality. The Tenderness Classification System is the most accurate system and will probably always be the most accurate system because it is a direct measure of tenderness, whereas the other systems are indirect measures of tenderness and/or eating quality. However, the Tenderness Classification System is an evasive system (it uses one steak from each carcass) and is also quite expensive to operate in its present form. Other systems are not evasive and are relatively simple to operate. Therefore, one must weigh accuracy versus expense when deciding which system to use.

Table 2. Accuracy of various methods at predicting eating quality within the young beef (fed steers and heifers) population.

Method	r^2 for prediction of eating quality
USDA quality grades	.05 to .15
Tenderness Classification (Shackelford et al., 1997b, 1999)	.46 to .61
Colorimeter System (Wulf et al, 1998)	.36 to .42

Another promising technology is near-infrared spectroscopy (NIR). NIR is a measure of reflectance, and in that regard it is similar to the colorimeter. The difference is that the colorimeter measures reflectance in the wavelength spectrum associated with visible light, whereas NIR measures reflectance in the wavelength spectrum corresponding to that region between visible light and infrared. NIR has been shown to be quite accurate at predicting beef tenderness in preliminary studies. Park et al. (1998) reported that NIR was able to explain 67% of the variation in beef tenderness among 119 beef carcasses under laboratory conditions. In its current form, NIR instruments are not engineered for on-line, noninvasive measurement; however, NIR technology is currently being investigated further to validate it as a predictor of beef tenderness and NIR certainly holds promise as future tool to predict beef palatability on-line.

As the beef industry moves towards a more consumer-oriented approach to decision making, beef producers must increase product quality and consistency. Currently, however, it is very difficult for beef producers to improve product eating quality because a rapid, accurate method of measuring palatability is not being used. How can we improve quality when we can't measure it? The beef industry cannot hit a target that it can't see. These new systems reviewed here may or may not be implemented into the USDA grading system. However, at a minimum, they hold much potential for a branded beef program to differentiate its products. And if used, these systems would allow a more true value assessment of beef.

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