Meat Composition Measurement:

Status of Applied Research on Instrument Assessment of Composition Since Completion of the 1994 National Beef Instrument Assessment Planning Symposium

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Introduction

In 1991, the beef industry initiated efforts to improve beef quality. But after four years, a 1995 National Beef Quality Audit (Smith et al., 1995) demonstrated that vast sums of money are still sacrificed due to quality shortfall. Almost everyone agrees that instrument technology would assist in developing a "quality-based" marketing system—permitting consumers to transmit preferences to producers and thereby allow correction of quality defects. Instrument assessment research was initiated in the 1970's in the U.S. (Cross and Whittaker, 1992), but progress has been slow. In 1994, the Beef Product Technology Subcommittee of the National Live Stock and Meat Board (NLSMB) convened a National Beef Instrument Assessment Planning (NBIAP) Symposium to assess instrument technology and to recommend industry research focus. Research since the 1994 NBIAP Symposium will be explored here.

NBIAP Follow-up Research

Cross and Belk (1992) reviewed available instrument technologies at the 1992 International Congress of Meat Science and Technology. Available technology included: Ultrasound, X-ray, nuclear magnetic resonance, electrical conductivity, near-infrared reflectance, video image analysis (VIA), optical fat/lean and connective-tissue probes, bioelectrical impedance, velocity of sound and elastography. The NBIAP (1994) Symposium identified video image analysis (VIA) and electromagnetic scanning (ToBEC) as among the most promising technologies to create a true value-based marketing system. VIA was identified as the most promising, ranked first for applied research funding and considered to be ready for commercial testing.

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Yield Grades, ToBEC and VIA.

In 1995, Colorado State University, Oklahoma State University and the University of Nebraska, in conjunction with USDA-Agricultural Marketing Service, contrasted some currently available instruments for accuracy and precision relative to predicting beef carcass composition (Dolezal et al., 1996). USDA yield grades, ToBEC (via Dr. Chris Calkins, University of Nebraska) and VIA (via Dr. Dell Allen, Excel Corp.) were included in congruity with the 1994 NBIAP Symposium. USDA yield grade and instrument measures were compared with averages of a three-member expert panel of carcass evaluators (N = 265) across the full spectrum of USDA Yield grades (1, 2a, 2b, 3a, 3b, 4/5's).

Expert yield grades explained the most variance in carcass composition when percent boxed beef yields was used as the independent variate (R^2 = .75; Table 1). This implied that yield grades—applied correctly—are very effective in segregating carcasses into classes reflecting real value differences. Expert yield grades also accounted for differences in mean trimmable fat yields at 1.0 or .25 inches external fat trim remaining on cuts (R^2 = .61 and .66, respectively).

Simple correlations between carcass/instrument measures and yield traits (trimmed to .25 inches; Table 2) indicated that line-grader yield grades effectively segregated carcasses into groups based on yields of trimmed fat and boxed lean (r-values of .76 and -.77, respectively). They were only exceeded in precision by expert estimates of fat thickness and final yield grade (r-values of .86 and -.74 for fat

TABLE 1. Amount (R^2) of Variation in Cutability Endpoints Explained by Expert Yield Grades.

Trait	R^2	Root MSE	Mean	N
Bone (%)	.19	1.41	14.1	265
Fat, trimmed to leave 1.0 in (%)	.61	1.81	14.3	265
Fat, trimmed to leave .25 in (%)	.66	2.19	18.0	265
Boxed beef (%)	.75	1.40	50.2	265
80% Lean trimmings (%)	.23	0.51	11.4	265
50% Lean trimmings (%)	.19	0.45	6.3	265

(Source: Dolezal et al., 1996)

TABLE 2. Simple Correlations Between Carcass/Instrument Measures and Cutting Yield Traits. (Cuts were trimmed to leave .25 inches of external fat).

Trait	Fat trim (%)	Bone (%)	Boxed lean (%)
Line graders yield grade	.76	- .40	- .77
Expert graders:			
Fat thickness	.86	- .69	- .74
Ribeye area	- .37	- .20	.57
Actual % KPH	.43	- .06	- .46
Hot carcass weight	.13	- .12	- .11
Final yield grade	.83	- .34	- .89
VIA (at chain speed):			
Fat area	.70	- .55	- .61
Fat thickness	.67	- .49	- .61
Ribeye area	- .18	- .04	.24
ToBEC (peak value):			
Beef band	- .06	.04	.04
Cross-cut chuck	- .42	.12	.43
Hindquarter, KP-removed	- .51	.12	.58

(Source: Dolezal et al., 1996)

TABLE 3. Instrument Measures Substituted for Yield Grade Factors to Predict Boxed Lean Carcass Yields. (Cuts were trimmed to leave .25 inches of external fat).

	Factors in Model			
Fatness	Muscling	% KPH	HCW	R^2
Expert AFT[a]	Expert REA[d]	Actual	Actual	.838
Expert AFT	Expert REA	Expert	Actual	.825
Expert AFT	Expert REA	None	Actual	.755
Expert AFT	VIA[e]	Expert	Actual	.716
Expert AFT	VIA	None	Actual	.590
VIA-Thickness[b]	VIA	Expert	Actual	.548
VIA-Area[c]	VIA	Expert	Actual	.552
Expert AFT	ToBEC[f]	Expert	Actual	.844

[a] *Adjusted fat thickness.*
[b] *Video image analysis estimate of fat thickness at the twelfth rib interface.*
[c] *Video image analysis estimate of fat area at the twelfth rib interface.*
[d] *Ribeye area (in^2).*
[e] *Video image analysis estimate of ribeye area at moving chain speeds.*
[f] *Electromagnetic scanning peak values for hind-quarters, with kidney and pelvic fat removed.*
(Source: Dolezal et al., 1996)

thickness and .83 and -.89 for final yield grade, respectively). No instrument measures performed better than yield grades assigned by experts or USDA graders.

A series of regression equations were developed to ascertain if substitution of instrument measures for expert yield grade factors could improve accuracy and precision of USDA line-graders at chain speeds (Table 3). If expert yield grades currently are the most accurate and precise estimate of carcass composition, but USDA line-grader accuracy and precision suffers because of the rate at which factors and final grades must be applied, then it may be possible to augment information available to line-graders and thus improve effectiveness of USDA grades.

When VIA ribeye area was substituted for expert ribeye area (at leisure), augmentation reduced explained variability (R^2) by 12%. This reduction, from expert assessment at leisure to VIA assessment at rapid chain speeds, would partially be offset by improved consistency and repeatability in application. Use of VIA to determine combined carcass fatness and ribeye area resulted in dramatic losses in predictive capability (reductions in R^2 of almost 30% from that achieved with expert yield grades) and further supported the concept that augmentation may be the best method for incorporating instrument assessment into commercial grading.

Substitution of a ToBEC measure (peak value; internal fat removed) for expert ribeye area was very precise (R^2 = .84). However, ToBEC is not ready for incorporation into carcass grading and assessment systems operating at chain speeds at this time. Because of its accuracy and precision though, ToBEC may be best suited for use with fabricated beef.

Newly-initiated Research

Colorado State University has continued work on VIA—initiating work with HunterLab Associates Laboratory, Inc. (Reston, Virginia) in 1996 to investigate their Color Visions System. This system captures pixelated video (250,000 pixels per measure) and evaluates color reflectance differences within the image. Different colors are separated from irregular shapes and used to calculate the relative areas, as well as L*, a* and b* parameters. This is similar to what would be expected of a grading instrument and also provides color assessment—known to be associated with beef tenderness (Unpublished CSU Data).

Although data are not yet available, a current assessment of those attributes in beef that may be measured with the HunterLab Color Visions System are presented in Table 4. HunterLab engineers feel that it is fully possible to assess accurately those factors identified in the 1994 NBIAP Symposium relative to measures of both carcass composition and palatability; but it may also be possible to add additional by incorporating L*, a* and b* values of fat and lean.

TABLE 4. Beef Attributes That Can, Possibly or Actually, Be Measured Using The HunterLab Color Vision System.

Attribute	Effects	Priority	Status
Marbling, amount	Palatability	1	Testing
L*, a*, b* of muscle	Palatability	2	Testing
Marbling, texture	Palatability	3	Unknown
L*, a*, b* of fat	Palatability	4	Testing
Range of lean L*, a*, b*	Palatability	5	Unknown
Range of fat L*, a*, b*	Palatability	6	Unknown
Percentage of fat	Composition	1	Testing
Ribeye (*longissimus M.),* area	Composition	2	Promising
Fat thickness measurement	Composition	3	Promising

(Source: Christopher D. Bunting, HunterLab Associates Laboratory, Inc.—May 7, 1996)

Conclusions

USDA yield grades, when perfectly assigned, are very reliable for segregating carcasses based on composition. However, it is difficult for on-line USDA graders, at chain speeds, to perform at the same level of accuracy and precision as perfectly assigned yield grades. Thus, the need for instrumentation is clear. It appears that grading could be improved if augmented such that all measurable factors, accept adjusted preliminary yield grades, were provided to on-line graders by instruments. VIA technology (HunterLab System), while somewhat less accurate than ToBEC for predictions of composition, has the potential advantage of quantitatively assessing quality grade factors as well. Research with HunterLab Color Vision Systems continues.

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Bovine Spongiform Encephalopathy

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The Bovine Spongiform Encephalopathy (BSE) problem is of enormous importance as a food safety issue. It is most difficult to summarize because there are several unknown scientific factors which are needed in order to make sound judgments. Intense research effort is being focused on the problem with the result that considerable new information is forthcoming rapidly; publications are rapidly outdated. Therefore, only a brief and general statement follows and it is suggested that the Internet be consulted for the most recent conclusions (see for example — http://www.aphis.usda.gov/oa/bse.html).

BSE is also known as "mad-cow disease" since affected animals lose their coordination, develop abnormal posture and experience changes in behavior. The incubation period for the disease is 2 to 8 years, and when clinical symptoms appear, the disease course is from weeks to months and results in death.

BSE was observed in Great Britain in 1985, and the epidemic peaked in 1993 at nearly 1,000 new cases per week. The disease has been identified in several other countries. Most evidence points to the disease-causing agents as being unique proteins that do not contain genetic material, as do other infectious agents. These proteins are called prions, a shortened form for proteinaceous infectious particles. BSE is one of a number of neurodegenerative diseases known as transmissible spongiform encephalopathies (TSE). The most common form is scrapie, which has been known for some time as a disease of sheep and goats. One theory regarding the cause of BSE in Great Britain is the use of protein feed supplements made from meat and bonemeal of carcasses of scrapie-infected sheep. In 1988, Great Britain banned the use of protein supplements derived from ruminants for use in ruminant feeds.

Of great concern is the question of whether humans can become infected with a disease by consuming meat from BSE-infected cattle. The most common spongiform encephalopathy in humans is termed Creutzfeldt-Jakob disease (CJD). It is rare and occurs world-wide at a rate of about 1 person per 1,000,000. It usually affects older adults of about 60 years of age. Of concern, however, was a variant discovered in Great Britain and which affects victims ranging in age from late teens to early 40's. The human disease is fatal.

No cases of CJD have been linked directly to consumption of beef. In March 1996, the British Government reported however that 10 recent cases of the variant CJD may have been associated with BSE.

The USA is following a strict program to avoid introduction of BSE into the country. Since 1985, no beef has been imported from Great Britain. In 1989, the USDA banned the importation of live sheep, cattle and goats from countries where BSE exists. In 1994, the FDA proposed to prohibit the use in ruminant feed of specified offal from adult sheep and goats. A strong surveillance program continues. Field investigations are regularly conducted of suspicious disease conditions. The brains from cattle more than two years of age and which show signs of neurological disease are examined by trained pathologists. More than 2,660 specimens from 43 states have been examined and none have tested positive for BSE. Surveillance of CJD in the USA reveals that the disease rate remains consistent with the worldwide incidence.

BSE has not been identified in cattle in the USA and no cases of CJD have been linked directly to BSE.

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