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Muscle Profiling

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INTRODUCTION

In the mid >90's, Cattle Fax released some alarming data. They showed that over the previous 5-year period the value of the beef rib and loin had increased by just 3-4% while the value of the chuck and round had dropped by 24-25%. Given that these later two primals make up the more than 56% of the carcass, it was clear that dramatic action was needed to reverse the trend. Increasing the value of the chuck and round meant knowing more about the muscles which comprise these cuts. Therefore, the University of Nebraska and the University of Florida joined together and embarked upon the most comprehensive study ever conducted of the muscles in the beef chuck and round. The project was funded by the Cattlemen=s Beef Board through the National Cattlemen=s Beef Association.

The American Heritage Dictionary defines profiling as Aa biographical essay presenting the subjects most noteworthy characteristics and achievements.@ This is a good description of what the project was intended to do - determine the most noteworthy characteristics of the muscles in the chuck and round. The ultimate goal was to add value to the product.

There are several reasons to study these muscles. Some of them have inadequate tenderness. Others may be too variable in tenderness to be of much use in value-added products. In many cases, they may contain excessive amounts of connective tissue. Excessive seam might be addressed by altering the manner in which cuts are fabricated. Ultimately, knowledge of muscle properties will allow greater opportunity for value enhancement.

To ensure we were on track and providing information that the industry wanted and needed, we established a task force to provide guidance and input into the project. We also met with packers, processors, and retailers to determine their questions and needs. This group provided input as to the project design and well as suggestions about the format of the finished report.

We began the project with several guiding principles. First, we wanted to know as much about each muscle as possible. Second, we began with the intent to separate muscles that had traditionally been kept together during merchandising. It was our hypothesis that muscles in close proximity to each other do not necessarily have the same biological function and thus do not have the same physical and chemical properties. One of our packer partners told us to look at muscles as small as a quarter of a pound. We did so. Third, we attempted to determine the effect of carcass weight, quality grade, and yield grade on the muscle characteristics - a process that allowed us to examine 39 different muscles from 142 different beef carcasses.

Not surprisingly, this type of study generates a tremendous amount of data. We examined over 5,500 muscles and determined composition, sensory panel ratings, Warner-Bratzler shear force, collagen content, color, pH, water holding capacity, myoglobin content, and fat binding ability (emulsion capacity). We also determined the fiber type profile of most of the muscles. During fabrication, we obtained muscle dimensions, weights, and yields at a commodity trim level, 2-inch trim, and completely denuded of fat. As a result, we were able to build a data set with well over 30,000 different pieces of information - literally the encyclopedia of information about the muscles in the chuck and round.

THE PROJECT DESIGN

A selection grid was created to sample the diversity of carcasses in the meat cooler. Samples were obtained over a 5 month period from one mid-west packing plant. We sought to obtain four carcasses in every possible combination of three carcass weight categories (550-650, 650-750, 750-850 lbs), three quality grades (upper 2/3 Choice, low Choice, Select) and four yield grade categories (1, 2, 3, and 4/5).

To accomplish this volume of work we divided the labor. My colleague at the University of Florida (Dwain Johnson) managed the yield and dimensional data. He determined Warner-Bratzler shear and sensory panel ratings on muscles cooked by both dry and moist heat cookery methods. The mid-weight carcasses were used for this purpose. In our laboratory, we conducted all of the biochemical characterizations listed above on the heavy and light weight carcasses.

THE RESULTS

We found an astounding amount of variation among muscles for nearly every trait we studied. The results for each of the muscles are summarized in the following tables (1 and 2). Of quality grade, yield grade, and weight, quality grade was the effect that was most frequently significant ($P < .05$) for having an impact on the physical and chemical properties. For muscles with a significant quality grade effect, moisture content and ash content decreased while fat content and pH most often increased with an increase in quality grade.

Significant ($P < .05$) yield grade effects were seldom linear, reflecting inconsistent trends as yield grade increased or decreased.

Where carcass weight was significant ($P < .05$), moisture, color (L8, a* and b* values), and expressible moisture increased with heavier carcass weight while pH, fat content, and fat binding (emulsion) capacity decreased with increasing carcass weight. Collagen content was unaffected by carcass weight for any of the 39 muscles.

These data indicate opportunities exist to identify optimal uses for each individual muscle. The ideal use for one muscle might be quite different than the optimal use for another. For example, the *Teres major* in the chuck is ideally suited for grilling and then slicing into medallions. The infraspinatus, sometimes called the top blade or flat iron, is among the most tender muscles in the beef carcass. Some processors, overlooking the potential for the infraspinatus, were grinding the muscle because there is a seam of connective tissue that runs through it. The marketplace has since demonstrated that it will reward processors for taking the time to cut the muscle properly. In Nebraska, the flat iron steak has become something of a phenomenon. When one of the state=s major newspapers ran a front page story on it, restaurants offering the cut ran out and could not keep up with subsequent demand. We fielded enough calls that we offered a special workshop to show retailers, processors, and packers how to cut and merchandise it. In the first quarter of 2001, the value of the beef chuck and round both rose faster than those of the middle meats (ribs and loins), attributed in part to increased demand for those muscles in development of value-added products.

IMPACTS

Molly Meade McAdams, a retail product development specialist, identifies the benefits of the research this way. Knowing more about each muscle allows us to capture the greatest value for each and every muscle. Finding alternative uses for the muscles allows for targeted enhancement, thereby increasing the demand and value of the lesser utilized cuts. These impacts are of considerable interest to packers, processors and producers.

Perhaps the best outcome is the improvement in product quality in value-added meats. Consumers, then, are the ultimate benefactor of such research. The increase in product desirability translates directly into greater demand for the product and thus for improved prices to the producer.

ADDITIONAL RESEARCH

One consequence of this project has been the dramatic increase in research effort directed at optimizing use of each muscle. Several land-grant institutions are heavily involved in projects that target a specific muscle and seek to identify ways to enhance its value to consumers. The project also spawned additional research at Florida and Nebraska. Dr. Johnson helped characterize the yield of individual muscles from various sup-primals and we have characterized other beef raw materials used for value-added products.

Perhaps one of the more visible outcomes has been development of the Muscle Profiling Manual, which can be purchased from the National Cattlemen=s Beef Association for $40 (Calkins and Johnson, 2000). The manual was recently translated into 5 different languages. I worded with a colleague, Dr. Steven Jones, and others at Nebraska who developed a Bovine Myology CD-ROM - the companion to the manual (Jones et al., 2000). To date, about 1,000 of the $15 CD=s have been distributed world-wide. We also have a web site (http://deal.unl.edu/bovine/) that provides the same information as the CD. Contacts identified from the web site indicate users exist within out government, meat industry, academia (both high school and university), and throughout the world.

Naturally, a project of this dimension and impact leads to additional questions. The recent National Market Cow and Bull Beef Quality Audit revealed about 44% of the beef from cull cows is directed into the boxed beef market, with specific customers (Roeber et al., 2000). The potential may exist for upgrading more of the meat from cows. Our universities are currently involved with the cow muscle profiling project. We have sampled both beef and dairy cows across a range of carcass weights, fat thicknesses, degrees of muscling and carcass maturity. We will be studying 21 different muscles and muscle groups from throughout the carcass. The protocol calls for samples from several regions of the U.S. over several months. Samples have been obtained and are currently being analyzed. Results are expected in 2002.

An additional initiative might include an assessment of the best way to disassemble a carcass. Muscles are deposited in layers, yet we persist in cutting the chuck and round across multiple muscles with fibers going in many different directions. This violates one of the basic principles of meat fabrication - cut across the grain of the meat. Clearly the opportunity exists for innovative fabrication strategies.

Decades ago, the industry experienced a revolution as beef merchandising went from carcass form to boxed beef. Further disassembly into boneless and semi-boneless sub-primals has become predominant, and the advent of closely trimmed cuts has helped to drive this approach. More recently, the commercial implementation of case-ready beef has rapidly expanded. There is no doubt the industry is moving in the direction of single-muscle merchandising. The USDA is currently developing a nomenclature and numbering system for individual cuts. It appears that attention to individual muscles over multi-muscle cuts is more than a passing fad. It just might be the wave of the future.

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Table 1. Classification of beef chuck muscles by trait.

	Fat %	pH	WHC	Bind, mL	Myoglobin mg/g	Collagen mg/g	Moist, WBS	Dry, WBS
Biceps brachii	striped	striped	striped	black	striped	striped	white	white
Brachiocephalicus omot.	striped	striped	striped	striped	black	striped	black	black
Brachialis	white	striped	striped	white	striped	striped	striped	striped
Cutaneous omo brachialis	black	striped	white	white	black	striped	-----	-----
Complexus	striped	striped	striped	white	striped	striped	striped	striped
Deep pectoral	striped	striped	striped	white	black	striped	black	black
Deltoideus	striped	striped	black	striped	black	striped	striped	black
Dorsalis oblique	striped	white	striped	white	black	striped	striped	black
Infraspinatus	striped	striped	striped	striped	striped	white	white	white
Intertransversales	striped	striped	white	striped	striped	striped	white	black
Latissmus dorsi	striped	striped	striped	white	black	striped	black	black
Longissimus capitus et Atlantis	striped	striped	striped	white	striped	striped	white	striped
Longissimus costarum	black	white	white	striped	striped	striped	striped	black
Longissimus dorsi	striped	striped	striped	striped	striped	striped	striped	black
Levatores costarum	striped	white	striped	striped	striped	white	white	white
Multifidus & spinalis dorsi	black	white	striped	black	striped	black	white	white
Rhomboidus	striped	white	striped	striped	striped	striped	black	black
Scalenius dorsalis	striped	striped	striped	striped	black	striped	striped	black
Serratus ventralis	black	white	striped	white	striped	white	striped	white
Splenius	white	striped	striped	white	black	striped	striped	striped
Superficial pectoral	black	striped	white	striped	striped	white	striped	striped
Subscapularis	white	white	striped	striped	striped	black	striped	white
Supraspinatus	white	white	black	white	striped	black	white	black
Tensor fascia antibrachii	white	striped	striped	striped	striped	white	striped	black
Teres major	striped	striped	striped	striped	black	striped	white	white
Trapezius	striped	white	white	white	black	white	-----	-----
Triceps brachii	striped	striped	striped	black	striped	white	striped	striped

The white cells represent fat <5%, pH >5.8, WHC (expressible moisture) <36%, bind >175 mL, heme-iron >25 ppm, collagen <01 mg/g, while the black cells represent fat >10%, pH <5.7, WHC >38%, bind <170 mL, heme-iron <20 ppm, collagen >15 mg/g. The values represented by the striped cells are intermediate.

Table 2. Classification of beef round muscles by trait.

	Fat %	pH	WHC	Bind, mL	Myoglobin mg/g	Collagen mg/g	Moist, WBS	Dry, WBS
Adductor	white	striped	black	striped	striped	striped	striped	striped
Biceps femoris	striped	black	black	striped	striped	striped	striped	striped
Gluteus medius	striped	striped	striped	white	black	striped	black	black
Gracilus	white	striped	black	white	striped	black	white	striped
Pectineus	white	white	black	white	striped	striped	striped	white
Rectus femoris	striped	striped	black	striped	black	striped	white	white
Sartorius	white	striped	black	striped	black	striped	striped	striped
Semimembranosus	white	striped	black	white	striped	striped	striped	striped
Semitendinosus	white	striped	striped	white	black	striped	black	striped
Vastus intermedius	striped	white	striped	striped	white	white	white	striped
Vastus lateralis	white	striped	black	striped	striped	striped	striped	black
Vastus medialis	white	striped	black	black	white	striped	striped	white

The white cells represent fat <5%, pH >5.8, WHC (expressible moisture) <36%, bind >175 mL, heme-iron >25 ppm, collagen <01 mg/g, while the black cells represent fat >10%, pH <5.7, WHC >38%, bind <170 mL, heme-iron <20 ppm, collagen >15 mg/g. The values represented by striped cells are intermediate.