Project Title: Cataloging Beef Muscles—A Review of Muscle Specific Research from Fed and Non-fed Cattle

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Background

To help fulfill goals outlined in the Beef Industry Long Range Plan (2001) to increase consumer demand for beef, the National Cattlemen's Beef Association (NCBA), a contractor to the Beef Checkoff, coordinated a research project that profiled the physical, chemical and organoleptic properties of individual beef muscles. That research is the most comprehensive of its kind to date and was designed to explore new ways of fabricating beef carcasses that might lead to increased value, especially for the round and the chuck.

The study identified several muscles that possessed sufficient tenderness and flavor attributes to be marketed as individual cuts, but there are still several individual muscles that remain underutilized in retail and foodservice markets. To continue to build on the initial success of the checkoff-funded muscle profiling study in introducing new cuts such as the Flat Iron to the marketplace, it is important to review other research that evaluated the attributes of individual muscles. To accomplish this task Colorado State University researchers compiled a literature review that represents a comprehensive summary of all muscle-specific research, including NCBA's muscle profiling work, for both fed and non-fed cattle.

Methodology

Fed Cattle
More than one hundred peer-reviewed research studies were included in this compilation. Characterizations of individual muscles, based on the research available, included the following:

Loin (IMPS/NAMP 172)

Wholesale Cut (IMPS/NAMP Number)	Muscle
Strip Loin (180)	*Longissimus lumborum*
	Gluteus medius
Top Sirloin Butt (184)	*Gluteus medius*
	Biceps femoris
Bottom Sirloin Butt (185)	*Tensor fasciae latae*
	Ball tip
	Rectus femoris
	Vastus medius
	Vastus intermedius
	Obliqus abdominis internus
Tenderloin (189A)	*Psoas major*
	Psoas minor

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Rib (IMPS/NAMP 103)

Wholesale Cut (IMPS/NAMP Number)	Muscle
Ribeye, Lip-on (112A)	*Longissimus thoracis*
	Spinalis dorsi
	Multifidus dorsi
	Complexus
	Serratus ventralis
	Latissimus dorsi
Blade Meat (109B)	*Subscapularis*
	Rhomboideus
	Latissimus dorsi
	Infraspinatus
	Trapezius

Brisket (IMPS/NAMP 120), Plate (IMPS/NAMP 121) and Flank (IMPS/NAMP 193)

Wholesale Cut (IMPS/NAMP Number)	Muscle
Brisket (120)	*Pectoralis profundus*
	Superficial pectoral
Plate, Short Plate (121)	*Diaphragm*
	Transversus abdominis
Beef Flank, Flank Steak (193)	*Rectus abdominis*

Round (IMPS/NAMP 158)

Wholesale Cut (IMPS/NAMP Number)	Muscle
Knuckle (167)	Quadriceps Complex
	Rectus femoris
	Vastus lateralis
	Vastus intermedius
	Vastus medius
	Tensor fasciae latae
Top, Inside (169)	*Semimembranosus*
	Adductor
	Gracilis
	Pectineus
	Sartorius
Bottom, Gooseneck (170)	*Biceps femoris*
	Semitendinosus

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Chuck, Square Cut (IMPS/NAMP 113)

Wholesale Cut (IMPS/NAMP Number)	Muscle
Shoulder Clod (114)	*Triceps brachii*
	Infraspinatus
	Brachiocephalicus omotransversarius
	Latissimus dorsi
	Teres major
	Deltoideus
	Brachialis
	Tensor fasciae antibrachii
Chuck Roll (116A)	*Serratus ventralis*
	Complexus
	Rhomboideus
	Multifidus/spinalis dorsi
	Splenius
	Longissimus capitus et atlantis
	Longissimus dorsi
	Levatores costarum
Chuck Tender (116B)	*Supraspinatus*

The *longissimus dorsi* was used as a reference point to compare across the various studies. From those comparisons, tenderness and juiciness indexes were developed to aid in identifying muscles that have been found to perform similarly to the *longissimus dorsi*.

Non-fed Cattle

A similar compilation of research associated with older animals, or non-fed cattle was also done. However, the literature is much more limited, so only the following muscles were described:

Longissimus dorsi
Biceps femoris
Gluteus medius
Psoas major
Rectus femoris
Semimembranosus
Semitendinosus

Findings

Fed Cattle

In all of the literature reviewed, researchers conducted all, or some of the following evaluations, to accurately assess individual muscles:

- Warner-Bratzler Shear Force (WBSF)
- Sensory panel evaluations, which typically assess palatability attributes such as tenderness, juiciness and flavor. Connective tissue amount was sometimes part of a panel evaluation.
- Chemical and physical attributes
- Consumer evaluation
- Optimum aging for individual muscles, however most of this work has only focused on the *longissimus dorsi*

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The individual muscle characterizations also compiled information regarding the origin and recommended cooking methods for each of the muscles, as well as physical and chemical properties and information regarding optimum aging periods for the individual muscles. Trying to compare results from the various studies that have evaluated individual muscles is somewhat challenging because even though many examined WBSF values, as well as sensory and chemical properties of the muscles, the materials and methods were seldom identical. The only common aspect among most of the published work is that the *longissimus dorsi* was included. As a result, that muscle was used as a reference point for this compilation.

To facilitate comparisons across studies, tenderness and juiciness indexes were developed. These indexes identify muscles that have been found to perform similarly to the *longissimus dorsi* for tenderness (both WBSF and sensory panel) and sensory panel juiciness. The indexes may also help identify muscles that could be expected to outperform the *longissimus dorsi*. The following table summarizes the indexes that were developed for tenderness and juiciness, using the *longissimus dorsi* as the base value.

Muscle (Primal)	WBSF Index	Sensory Panel Tenderness Index	Sensory Panel Juiciness Index
Psoas major (loin)	145.01 ± 29.49	127.05 ± 13.86	101.65 ± 10.23
Infraspinatus (chuck)	127.71 ± 19.42	109.11 ± 7.39	114.88 ± 10.83
Serratus ventralis (rib)	124.00 ± 25.29	94.20 ± -	130.77 ± -
Rectus femoris (round)	101.33 ± 19.21	109.79 ± 15.63	94.67 ± 3.34
Complexus (chuck)	100.58 ± 21.66	N/A	N/A
Gluteus medius	99.39 ± 6.04	N/A	86.69 ± 3.85
Biceps brachii (chuck)	92.86 ± 20.13	N/A	N/A
Triceps brachii (chuck)	91.66 ± 16.19	94.62 ± 8.13	97.84 ± 3.88
Biceps femoris (round)	91.32 ± 19.73	79.93 ± 19.78	96.23 ± 5.72
Adductor (round)	90.01	95.88 ± 11.37	88.96 ± -
Semimembranosus (round)	87.88 ± 13.54	77.18 ± 13.07	84.72 ± 5.65
Semitendinosus	86.99 ± 18.85	93.50 ± 16.49	81.87 ± 3.63
Supraspinatus (chuck)	85.49 ± 7.85	81.32 ± 6.48	98.69 ± 1.90
Pectoralis profundus (chuck)	73.99 ± 14.93	64.57 ± 13.43	92.45 ± 7.96
Rhomboideus (chuck)	73.15 ± 12.42	N/A	N/A
Longissimus dorsi	100	100	100

Non-fed Cattle

Almost 20 percent of the cattle slaughtered under federal inspection are cows and bulls. As a result, beef from non-fed market animals represents a substantial portion of U.S. beef production.

The Cow Muscle Profiling study conducted by NCBA in 2002 represents the most complete collection of muscle profiling research for older animals. The project profiled 21 individual muscles from beef and dairy cows, so that processors had more information to better utilize

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product from these animals. Beyond that study, there is limited information available about muscles from mature carcasses.

Most of the present knowledge pertaining to the age-related effects on beef and the palatability improvement processes applied to beef from mature cattle is based on studies that focused on the *longissimus dorsi.* Sensory panel scores for the juiciness and flavor of the *longissimus dorsi* vary widely, depending on the study and the range in carcass maturity being studied.

There are several limitations that do not allow for broad-based interpretations of the available research on individual muscles from non-fed cattle:

1. Available literature focuses on the *longissimus dorsi* (from the loin or rib) and minimal data is available for muscles from the chuck and round

2. The majority of the research has specified the use of muscles based on USDA quality grade (i.e. U.S. Commercial or Utility), which encompasses three maturity scores (C, D, or E). USDA quality grades, which are based on marbling and maturity, are almost never used by packers who process mature non-fed cattle. Most packers of market cows segregate carcasses into marketing groups based on evaluations of marbling, maturity, color of fat and lean, degree of fatness, and/or muscle thickness.

Implications

Fed Cattle

Individual muscle characterization has been shown to have significant potential to increase the value of certain underutilized cuts, especially from the chuck and round. The NCBA Muscle Profiling study represents the most comprehensive work to date, but there are still additional opportunities to more accurately describe the chemical and physical properties of individual beef muscles; characterize consumer evaluations; and determine aging recommendations for individual muscles.

Non-fed Cattle

Past research has suggested that 25 percent of the hot carcass weight of cull-cow carcasses is being fabricated into whole-muscle cuts. While the NCBA Cow Muscle Profiling study marked significant progress in summarizing the physical and chemical traits of muscles from non-fed, mature beef and dairy cattle, there is still a significant lack of scientific information on the subject. Such a gap in knowledge makes it difficult to make any recommendations for the appropriate uses of individual muscles.

Future research should reflect carcass type (beef or dairy), skeletal maturity (C,D, or E) and end use. This would allow for comparisons to existing information available about the *longissimus thoracis/lumbar*, reflect common industry practices for processing and marketing cull cow carcasses, and would complement checkoff-funded muscle profiling research.

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