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FLAVOR RELATIONSHIPS AMONG MUSCLES OF THE BEEF CHUCK AND ROUND

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Introduction

New cuts from the beef round and chuck have gained popularity. There have been anecdotal reports of off-flavors, especially a liver-like flavor, in some of these beef value cuts. The incidence and intensity of liver-like flavor in various muscles is unknown. Flavor is highly correlated with overall-like ratings in beef (Neely et al., 1998; Goodson et al., 2002). Goodson et al. (2002) concluded that flavor was the overwhelming trait of importance in clod steaks. With the importance of flavor to the consumer, it is likely that they will not try the same cut again if they have a bad experience. The objective of this research was to compare different beef muscles for off-flavor notes and to determine the relationship of pH and heme-iron content to off-flavor.

Methods and Materials

After grading, knuckles and shoulder clods were removed from 16 Choice and 14 Select-grade beef carcasses. Hot carcass weight, fat thickness, marbling, rib-eye area, and percentage kidney, pelvic, and heart (KPH) fat were recorded and yield grade was calculated. The knuckles and shoulder clods were stored in a 1˚C dark cooler until 7 d postmortem. The *m. rectus femoris* (REC), *m. vastus lateralis* (VAL), *m. vastus medalis* (VAM), *m. infraspinatus* (INF), *m. teres major* (TER), and *m. triceps brachii* capat longam (TRI) were fabricated from each carcass. The INF was filleted, and the connective tissue running laterally through the middle of the muscle was removed. Each half of the INF was then cut into three steaks. A small sample was cut from the dorsal, anterior end of each muscle, minced, and placed in a plastic bag for chemical analysis. All muscles except for the INF were cut into 2.54 cm steaks, wrapped, and frozen at -20˚C.

Samples were prepared by cubing, freezing in liquid nitrogen, powdering the frozen sample with a blender, and storing at -80°C. The powdered samples were used for moisture analysis, pH, and heme-iron concentration.

Powdered sample was used to measure moisture content using a LECO Thermogravimetric Analyzer-601 (Model 604-100-400, LECO Corp., St. Joseph, MI). The pH of the samples was determined by combing 10 g of meat with 90 mL of distilled water. Total heme-iron concentration was determined using the method described by Hornsey (1956) as modified by Lee, B.J., Hendricks, D.G., and Cornforth, D.P. (1998). Two grams of powdered sample were weighed into tubes and concentration was determined in triplicate. Samples were homogenized with 8.1 mL of acetone and 0.2 mL of hydrochloric acid. This mixture was filtered and tubes were stored for approximately

15 minutes in a dark cabinet to limit light exposure. The filtrate was then read with a spectrophotometer at 640 nm. The absorbance value was then multiplied by 680 to give the amount total pigment. Total pigment was converted to heme-iron content using the following formula: (total pigment (ppm) x 8.82/100).

Frozen steaks were tempered for 1 day in a 1˚C cooler before cooking. The steaks were weighed and trimmed of external fat before cooking. Each steak was grilled to an internal temperature of 65˚C. Thermocouples were inserted in the approximate center of each steak. An Omega handheld digital thermometer model 450-ATT (Omega Engineering Inc., Stamford, CT) was also used to confirm the internal temperature. Steaks were turned for the first time after two minutes and then flipped as needed to minimize charring.

When the steak reached the desired internal temperature, the steak was removed from the grill and weighed. The steak was then covered in foil for no more than 10 minutes. The steaks were cut into 1.27 cm x 1.27 cm x 2.54 cm steak cubes and placed in double broilers until served (<15 min).

Taste panelists were trained using the guidelines and procedures of Meilgaard, M., Civille, G.V., and Carr, B.T. (1991). Taste panels were held mid-morning or mid-afternoon and panelists were asked to avoid soft drinks, coffee, and food one hour prior to the sampling session. The panelists received between six and eight samples per session. All eight samples were either from the same muscle type or they were in groups of four from two different muscles. On days that samples from two muscles types (such as steaks from both the INF and TER) were served, a five minute break was given to separate the two muscles. All steaks were from a uniform location on the muscle. The steaks were from the second to fourth steaks counted from the anterior end of the muscle for the REC, VAL, INF, and TRI. Because of the small size of the TER and VAM, they were cooked as whole muscles. The order of the day that each muscle was served was random and steaks for each muscle were served in random order. Panelists were not aware of which type of steak they were eating.

Panelists were isolated in individual booths to reduce collaboration and samples were served under red incandescent light to eliminate visual differences. Distilled water and unsalted crackers were provided for panelists between samples to cleanse their palate. The steak cubes were served on ceramic plates to the panelists. Charred edges were removed to allow for consistent sampling.

Panelists used an 8-point hedonic rating scale with 8=extremely juicy, extremely tender, no connective tissue and no off-flavor, and 1=extremely dry, extremely tough, abundant amount of connective tissue, and extreme off-flavor. They also identified off-flavor notes including charred, liver-like, metallic, musty/oxidized, acidic, rancid, and sour flavors. Oxidized was described as a “warmed-over” flavor while rancid was the flavor associated with lipid oxidation.

Statistics

Muscle carcass traits were analyzed by analysis of variance using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Muscle and grade were included in the model. Least square means were separated at a predetermined significance level of $P<0.05$ using the PDIFF function of SAS. Muscle off-flavor notes were analyzed by analysis of variance

using the MIXED procedure of SAS. Fixed effects included muscle and group. Animal within group was a blocking factor and considered a random effect. Least square means were obtained and separated using the PDIFF function. Muscle off-flavor notes were analyzed by analysis of variance using the GLM procedure of SAS. The model included muscle and grade. The linear and quadratic functions, as well as the interaction of, heme-iron and pH were analyzed to obtain the coefficients of determination.

Results

Only percent KPH fat and marbling differed between Choice and Select cattle, with Choice-grade cattle having a greater amount of both. This result is expected because carcasses are sorted into quality grades based primarily on marbling.

Off-flavor intensity differed among muscles. The INF had the lowest off-flavor intensity rating and juiciness rating and was among the most tender and juicy of the muscles tested while the VAL had the most intense off-flavor ratings and was the least tender, had the most connective tissue, and had the lowest amount of juiciness ($P<0.05$) (Table 1). This could be due to a "halo effect" where a sample that has a good flavor is rated more tender or juicy than one with bad flavor. The INF, TER, and VAM had the highest pH values of the muscles tested. There were no differences ($P<0.05$) among muscles for heme-iron concentration.

Liver-like, bloody, and rancid flavors were not affected by muscle type (Table 2). The INF, which had the lowest amount of off-flavor, was among the lowest in percentage of panelists detecting sour, metallic, and oxidized flavors, although it received a higher rating of fatty flavor than the other muscles ($P<0.05$). The VAL, which had the most intense off-flavor, was among the highest in percentage of panelists detecting sour, charred, and oxidized flavors ($P<0.05$). Most of the other muscles were rated as being intermediate in the percentage of panelists detecting specific off-flavor notes.

Table 1. The effect of muscle on sensory characteristics, heme-iron concentration, and pH

Muscle	Tenderness	Connective tissue	Juiciness	Off-flavor intensity	Heme-Iron Concentration	pH
Infraspinatus	6.50^{ab}	5.77^{ab}	6.22^{a}	6.03^{a}	44.42	5.70^{a}
Rectus femoris	6.11^{b}	5.44^{b}	5.69^{b}	5.68^{b}	46.25	5.59^{b}
Teres major	6.58^{a}	5.85^{a}	6.15^{a}	5.41^{bc}	42.99	5.71^{a}
Triceps brachii	5.45^{c}	4.32^{c}	5.68^{b}	5.54^{b}	45.43	5.47^{c}
Vastus lateralis	4.66^{d}	3.63^{d}	5.07^{c}	5.10^{c}	45.60	5.54^{bc}
Vastus medialis	5.45^{c}	4.18^{c}	6.04^{a}	5.58^{b}	47.47	5.66^{a}

^{a,b,c,d} Means within a column (for sensory traits) with different superscripts are significantly (P<0.05) different

Taste panel scale: 8=extremely juicy, extremely tender, no connective tissue and no off-flavor, and 1=extremely dry, extremely tough, abundant amount of connective tissue, and extreme off-flavor

Table 2. The effect of muscle on percentage of panelists detecting each off-flavor note

Muscle	Liver-like	Sour	Metallic	Charred	Bloody	Oxidized	Fatty	Rancid
Infraspinatus	0.09	0.23^{a}	0.09^{a}	0.30^{b}	0.02	0.09^{ab}	0.14^{b}	0.09
Rectus femoris	0.10	0.44^{b}	0.13^{a}	0.20^{ab}	0.03	0.07^{a}	0.03^{a}	0.05
Teres major	0.09	0.49^{b}	0.15^{ab}	0.22^{ab}	0.02	0.08^{ab}	0.03^{a}	0.06
Triceps brachii	0.08	0.49^{b}	0.20^{b}	0.22^{ab}	0.01	0.13^{abc}	0.02^{a}	0.06
Vastus lateralis	0.09	0.48^{b}	0.15^{ab}	0.31^{b}	0.01	0.17^{c}	0.01^{a}	0.07
Vastus medialis	0.11	0.49^{b}	0.17^{ab}	0.15^{a}	0.03	0.15^{bc}	0.02^{a}	0.07

^{a,b,c} Means within a column (for off-flavor notes) with different superscripts are significantly (P<0.05) different

When the off-flavor intensity scores were assessed, it became obvious that when one muscle of a given carcass was off-flavored, all muscles were off-flavor (Table 3). Sixteen of the 18 muscles from animals six, seven, and nine had off-flavor intensity scores below five.

Table 3. Off-flavor intensity scores among muscles

Animal	Grade	INF	TER	TRI	REC	VAL	VAM
1	Choice	6.36	4.20	6.06	6.44	5.58	5.25
2	Choice	6.25	6.17	6.00	5.75	5.14	5.65
3	Choice	6.75	6.45	6.31	6.78	5.44	6.05
4	Choice	7.19	5.44	6.11	6.75	5.86	6.33
5	Choice	6.61	5.00	5.56	6.75	5.72	5.65
6	Select	4.17	2.55	3.56	3.83	3.36	3.10
7	Select	4.38	3.39	4.39	3.31	4.14	4.90
8	Select	6.07	6.05	4.89	6.38	4.86	5.50
9	Select	4.56	5.35	5.06	4.94	4.60	4.00
10	Select	6.55	5.33	4.88	6.31	4.56	6.22

Taste panel scale: 8= no off-flavor, and 1= extreme off-flavor

In an attempt to explore the off-flavor intensity ratings among these muscles, the muscles were grouped. All muscles that were rated a five or below in off-flavor intensity, where at least 30% of the panelists recognized the off-flavor as liver-like, were placed together in an “off-flavor” grouping while the other muscles were left in a “normal” group. There were no group by muscle interactions for sour, metallic, fatty, bloody, or oxidized off-flavor notes (Table 4). When grouped this way, the percentage of panelists detecting liver-like scores was very high, which is to be expected as this is how they were grouped ($P<0.05$). Charred flavors were lower for the off-flavor group than for the normal group ($P<0.05$). This could be because the intense liver-like flavor overwhelms the charred flavor. There was also an interaction among rancid samples which was only significant for the VAM, where off-flavor samples were less rancid than normal samples ($P<0.05$). This suggests that liver-like flavor does not contain a significant amount of other flavor notes.

Table 4. The effect of normal vs. off-flavor group[a] and muscle on percentage of panelists detecting each off-flavor note

	Liver-like				Charred					Ran
Muscle	Normal	Off-flavor	Sour	Metallic	Normal	Off-flavor	Bloody	Oxidized	Fatty	Normal
Infraspinatus	0.83^{y}	0.04^{x}	0.14^{b}	0.05^{b}	0.06	0.32	0.01	0.05^{b}	0.10	0.00
Rectus femoris	0.48^{y}	0.05^{x}	0.28^{b}	0.18^{cd}	0.23	0.21	0.02	0.04^{b}	0.02	0.08
Teres major	0.49^{y}	0.04^{x}	0.37^{c}	0.13^{bc}	0.69^{y}	0.17^{x}	0.01	0.11^{bc}	0.03	0.07
Triceps brachii	0.41^{y}	0.05^{x}	0.34^{c}	0.24^{d}	0.52^{y}	0.20^{x}	0.00	0.18^{c}	0.01	0.05
Vastus lateralis	0.48^{y}	0.04^{x}	0.38^{c}	0.14^{bcd}	0.65^{y}	0.27^{x}	0.01	0.19^{c}	0.01	0.13
Vastus medialis	0.60^{y}	0.05^{x}	0.48^{c}	0.14^{bcd}	0.20	0.15	0.02	0.17^{c}	0.03	0.23^{x}

[a]Off-flavor group includes all muscles with a off-flavor intensity score of five or less, when the flavor note indicated was livery. Normal is all other muscles

[b,c,d] Means within a column (for sour, metallic, bloody, oxidized, and fatty) with different superscripts are significantly (P<0.05) different

[x,y] Means within a row (for liver-like, charred, and rancid) with different superscripts are significantly (P<0.05) different

Regression equations containing the linear and quadratic functions of heme-iron concentration, muscle pH, and their interaction were established for the frequency of off-flavor notes within each muscle for each quality grade. Within Choice, only the VAL and INF showed a relationship between pH, heme, and bloody flavor ($P<0.05$). There were no significant relationships between pH, heme-iron concentration, and metallic flavors or oxidized flavors for either Choice or Select-grade muscles. Select-grade stronger relationships between off-flavor notes and pH and heme-iron, possibly because the three carcasses with strong, liver-like off-flavor were Select. Heme-iron and pH explained some of the off-flavor intensity of the TER, VAL, and VAM ($P<0.05$).

Bloody flavor notes in the TRI showed a relationship ($P=0.003$) for heme-iron concentration and pH. Heme-iron concentration and pH influenced liver flavor ($P=0.0003$) and sour flavor ($P=0.042$) in the REC. Liver-like flavor in the VAM was also influenced ($P=0.042$). Heme-iron concentration and pH influenced charred flavor ($P=0.032$) and rancid flavor ($P=0.042$) in the TER.

Conclusion

These data suggest that when one muscle from a carcass contains liver-like off-flavor, all muscles contain that flavor. Muscles from the chuck and round have different off-flavor amounts as well as different sensory characteristics. Heme-iron concentration and pH influenced off-flavor in some select grade muscles, although there appears to be only a slight relationship. More research is needed to explain this relationship.

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