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FLAVOR AND TEXTURE PROFILING OF ENHANCED BEEF LONGISSIMUS

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Introduction

Enhanced beef (ie. with added water, salt, phosphate and other ingredients) has become more popular in the marketplace (Robbins and others 2003). Currently, there are a number of enhanced raw beef steaks available at retail, and a few roasts are available as fully cooked products. Historically, meat scientists have limited sensory evaluation of fresh meats to 6-8 product attributes. However, using only a few descriptors such as "tenderness" or "overall flavor" may not fully describe the sensory experience for enhanced products.

Objectives

The objective of this research was to characterize the flavor and texture of enhanced beef *longissimus* muscle using a highly-trained descriptive panel.

Methodology

Twelve beef loin samples were selected that represented different quality, processes and packaging (Table 1). Three were fully cooked (prime rib) while three represented various quality grades (USDA Prime, Certified Angus Beef [CAB], USDA Select) of intact loin. There were four commercially "enhanced" steaks. Two additional treatments were included (CAB dry-aged steaks and a USDA Select loin roast). Three replications of the experiment were performed. Steaks packaged in high oxygen were generally evaluated 3 to 4 days before the "sell by" date.

Steaks were grilled (14 to 22 min) to a final internal temperature of 71°C (removed from the electric grill at 69°C). The USDA Select loin roast was heated in a conventional oven at 177ºC to an internal temperature of 63°C and held for three minutes. The precooked prime rib roasts were cut into 2.5 cm-thick slices and reheated in a microwave oven to 60°C. Steaks (and roast slices) were weighed before and after cooking (reheating), and the percentage of cooking (reheating) loss was calculated.

Descriptive profiling was conducted by a 5-member professional panel in the Sensory Analysis Center (SAC), Kansas State University. The panelists evaluated six treatments during each 90 min session. These panelists had completed 120 h of training in all aspects of sensory techniques, had a minimum of 1000 h of general sensory testing, and had

experience evaluating meat products. Selection and refinement of terms was carried out during four preliminary sessions. Cooked samples were trimmed of fat and connective tissue so that only the center portion of the *longissimus lumborum* was served to the sensory panel. Panelists rated flavor and textural properties on 15-point scales.

Six to 8 cores (1.27 cm in dia) were removed parallel to muscle fibers from each sample and were sheared once perpendicular to the fiber direction using a Warner Bratzler shear (WBS) attachment on an Instron (Model 4201, Canton, MA) with a 25 kg load cell and a crosshead speed of 250 mm/min. Expressible moisture (EM) was determined by measuring moisture loss following centrifugation (750 x g; Shand 2000). A sample of the *longissimus* muscle of each cooked steak was analyzed for pH, moisture, protein, crude fat, ash and sodium chloride using standard methods.

Analysis of variance (ANOVA), principal component analysis (PCA) and cluster analysis (CA) were conducted using the Statistical Analysis System (SAS Institute Inc., Cary, NC, USA).

Results & Discussion

Proximate composition: Proximate composition of cooked non-enhanced steaks was as expected, with the USDA Prime steak containing the most fat (12.9%) and the USDA Select steak the least (3.7%). The E1 steaks with 8.9% fat were from USDA Choice beef, while E2 to E4 were from USDA Select beef (fat content 3.8 to 4.2%). Precooked roasts had similar and higher sodium chloride content, moisture content and pH, and lower protein and fat content than intact and enhanced steaks.

Cook yield and doneness: Cook yields of enhanced steaks were similar at 77-78% and slightly higher than that of the intact USDA Prime steaks at 72%. All steaks were cooked to 71°C (160°F) with most appearing to be of medium to medium-well doneness. Two products, E2 and E3, were distributed in high oxygen packaging and may have undergone premature browning resulting from oxidation of the myoglobin during storage (Seyfert and others 2004). Reheating yields in the microwave for precooked roast slices were 83-86%.

Textural properties: The non-enhanced USDA Select steak was noticeably tougher with higher Warner-Bratzler shear values than other intact and enhanced steaks (Table 2). It also had low juiciness and high chewiness, fiber awareness and residual connective tissue scores. There was some variability in textural properties of the four enhanced steaks. The E3 steaks were generally tougher than the others and were similar to the non-enhanced Select steaks. E1, E2 and E3 had similar textural properties to the non-enhanced CAB and USDA Prime steaks. While E1 might be expected to be similar to CAB (as E1 was from USDA Choice beef), the enhancement of E2 and E4 clearly improved eating properties above that expected for USDA Select beef. Since we only replicated each treatment three times, E3 steaks may not be typical of that supplier. However, these results may indicate that enhancement cannot overcome the inherent toughness of some USDA Select beef. No atypical ham-like textures were noted. In general, the precooked roasts were more tender and juicy than the non-enhanced USDA Select roasts, but were considered to be more “mealy” in texture than the grilled steaks.

Flavor properties: Non-enhanced steaks and some of the enhanced steaks (E1 and E4) had high beef flavor ID and brown roasted notes with some “bloody serumy” flavor

(Table 3). Both enhanced steaks previously stored in high oxygen (E2 and E3) had slight warmed-over flavor with less beef flavor ID and less bloody serumy flavor, while E1 (stored in carbon monoxide/carbon dioxide) and E4 (under vacuum) did not. The E2 steaks had an atypical brothy note. Other flavor notes, such as metallic and rancid, were of low intensity. While all steaks had similar sour and bitter flavors, enhanced steaks (especially E2) were slightly more salty than the intact steaks.

All precooked prime rib products had brothy/boullion-like notes and were somewhat salty. These also tended to have some organ meat notes. As expected, the prime rib samples (cooked in a bag) did not have browned roasted notes. Even though P1 to P3 were precooked and were stored under vacuum for several weeks, "warmed-over" flavor was almost undetectable. The USDA Select roast and P1 to P3 roasts had more metallic flavor that the steaks. Since the roasts appeared rare in doneness, the presence of a metallic note was not unexpected.

Principal component (PCA) and cluster analysis (CA): PCA was used to investigate underlying similarities and differences among products and degree of correlation among descriptive terms. The first two principal components (PCs) accounted for 90% of the total variability (Figure 1). In plots of PCs, terms that are correlated with each other group together (if positive) or move in the opposite direction (if negative) and objects close together have similar characteristics. PC1 accounted for 74% of the variation. Terms such as brown roasted and beef flavor identity had high positive loadings for PC1, while brothy and salty had moderately negative loadings. PC2 accounted for much less of the variability (14%) and seemed to be driven by textural properties. PC2 had high positive loadings for initial firmness, fiber awareness and residual connective tissue and a high negative loading for tenderness.

Beef *longissimus* samples were further categorized into 3 clusters by CA (Figure 1). Products in Cluster 1 were high in beef flavor ID and browned roasted notes, but varied in tenderness, with CAB, Prime and E1 and E4 showing a negative loading for PC2 and CABdry, E4 and the Select loin steak a positive loading for PC2. All of the precooked roasts grouped together in Cluster 2. In general, they lacked browned flavor notes and were higher in brothiness and saltiness. The Select Roast and Enhanced steak 2 formed cluster 3. This group was intermediate in some properties. The Select Roast lacked the browned notes of the steaks, but had more fiber awareness than the precooked roasts. The E2 enhanced steak was very different than its enhanced counterparts for PC1 and PC2. It was much more salty and brothy, which cannot be explained from the ingredient listing. Both E2 and E3 also had slight warmed-over flavor, which differentiated these products from the others when PC3 was plotted (data not shown). E4 (from Select beef) clustered in the same region as products from higher grades (E1, Prime, CAB), while the non-enhanced USDA select steak and roast were much tougher.

Conclusions

Overall, enhancement of beef loin steaks resulted in greater changes in flavor properties than textural properties. Generally, enhanced steaks were very lean but more tender and juicy than the non-enhanced USDA Select steaks, showing the importance of enhancement to improving quality of USDA Select beef in particular. However, some enhanced steaks were still relatively tough. No atypical textural properties were reported.

The flavor differences between intact and enhanced steaks ranged from “slight” to “major”, depending on the composition of the enhancement solution and packaging method. Enhancement generally increased the perception of saltiness. Some enhanced steaks also had atypical brothy flavors and were quite salty. Furthermore, packaging of enhanced steaks in a high oxygen environment, unlike those in the carbon monoxide masterpack, likely caused oxidation and led to several flavor changes after cooking, including increases in warmed over flavor and decreases in bloody serumy and beef flavor ID. Premature browning during cooking also was evident for steaks packaged in high oxygen.

Precooked roasts were distinctly different in textural and flavor properties from steaks. In addition, these three products varied widely in composition, ingredients, pH and fat level. Even though the P1 roasts were not injected, the marination and/or cooking method resulted in a similar flavor profile to the other two products. As ready-to-eat products represent a potential growth area, it is also important to better understand drivers for consumer acceptability of this type of product.

References

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Table 1. Steak and roast samples selected for this study.

Sample	Grade	Added Ingredients	Packaging
Prime strip steak, aged for 22-29 days	USDA Prime	None	Vacuum packaged
Certified Angus Beef strip steak, aged for 22-29 days	USDA Choice	None	Vacuum packaged
Dry Aged CAB strip steak, dry aged 17-22 days, total of 22-29 days	USDA Choice	None	Mostly aerobic storage
Select strip steak, aged 23-30 days	USDA Select	None	Vacuum packaged
E1 - Enhanced strip steak #1, supplier 1	USDA Choice	Contains up to 12% of a patented solution of beef broth, potassium lactate, sodium phosphate, salt, sodium diacetate, flavoring	Tray with O_2-permeable over-wrap. Previously in CO / CO_2 master pack
E2 - Enhanced strip steak #2, supplier 2	USDA Select	Contains up to a 10% solution of water, sodium phosphate, salt and natural flavor	Rigid tray with high oxygen
E3 – Enhanced strip steak #3, supplier 3	USDA Select	Same as E2	Rigid tray with high oxygen
E4 – Enhanced strip steak #4, supplier 3	USDA Select	Same as E3	Vacuum packaged
Select strip loin roast (freshly cooked)	USDA Select	None	Vacuum packaged
P1 – Fully cooked prime rib roast, not enhanced (foodservice)	USDA Choice	Rubbed with salt, dextrose, hydrolyzed soy protein, corn syrup solids, onion powder, caramel color, garlic powder, spice, soybean oil, natural flavor	Vacuum packaged
P2 – Fully cooked prime rib roast, enhanced (retail)	USDA Select	Marinated up to 10% with a solution of water, sodium phosphate, salt, hydrolyzed corn protein, flavoring. Coated with salt, dextrose, hydrolyzed corn protein, caramel color, dried beef stock, spices	Vacuum packaged
P3 – Fully cooked prime rib roast, enhanced (retail)	Not known	Contains up to 10% of water, sodium phosphate, salt, hydrolyzed corn protein, spice extractives and onion extractives. Coated with salt, dextrose, hydrolyzed corn protein, dried beef stock, black pepper, flavorings	Vacuum packaged

Table 2. Sensory properties[1] (texture) and Warner-Bratzler shear values of control and enhanced beef loin steaks and precooked prime rib roast samples[2].

Product	Initial Firmness	Tender-ness	Juiciness	Chewi-ness	Rubberi-ness	Mealy	Fiber Awareness	Residual Connect-ive Tissue	WB shear, kg
USDA Prime Steak	5.3	8.4	8.5	6.7	0.1	0.8	4.2	2.5	2.6
CAB Steak	5.6	8.6	7.4	7.8	0.0	1.2	3.9	2.7	3.2
CAB dry-aged Steak	7.1	7.4	7.4	8.4	0.2	0.4	4.8	3.4	3.6
USDA Select Steak	8.9	6.0	5.8	9.6	0.2	0.6	6.7	4.8	5.1
E1 Steak	4.6	8.7	7.4	7.4	0.1	1.2	4.4	2.4	2.7
E2 Steak	5.8	8.9	7.7	7.5	1.3	0.9	3.7	3.0	2.5
E3 Steak	8.1	6.5	6.2	8.9	0.1	1.4	5.9	3.1	4.0
E4 Steak	4.2	9.6	7.9	7.9	0.1	1.8	3.5	2.0	2.8
USDA Select Roast	5.6	7.1	6.8	8.2	0.5	1.4	5.6	3.2	4.6
P1 Roast	4.1	9.8	7.7	7.0	0.1	3.5	3.2	1.5	2.4
P2 Roast	3.2	11.3	9.4	6.5	0.4	3.6	3.3	1.4	1.8
P3 Roast	6.3	8.6	9.0	7.7	0.2	2.4	4.9	3.4	2.6
LSD[3]	*2.6*	*2.7*	*1.3*	*1.5*	*0.7*	*1.4*	*1.7*	*1.4*	*1.4*

[1] Highest possible score = 15; 15= extremely firm, tender, juicy, chewy, rubbery, mealy, increased fiber awareness and high amount of perceptible connective tissue.

[2] Based on analysis of three steaks or roasts per product by five expert panelists. E=enhanced steaks P=precooked roasts

[3] LSD= Least significant difference.

Table 3. Sensory properties[1] (flavor) of control and enhanced beef loin steaks and precooked prime rib roast samples[2].

Product	Beef Flavor ID	Brown Roasted	Organ Meat	Bloody Serumy	Brothy	WOF	Metallic	Rancid	Sour	Salty	Bitter
USDA Prime Steak	11.5	12.1	0.6	1.3	0.0	0.7	1.7	0.9	2.0	3.0	2.5
CAB Steak	11.5	11.9	0.6	1.1	0.0	0.1	1.6	0.4	1.9	3.2	2.7
CAB dry-aged Steak	11.5	11.7	0.2	1.3	0.0	0.4	1.8	0.8	2.4	3.3	2.6
USDA Select Steak	10.4	11.5	0.1	0.5	0.0	0.5	1.7	1.2	2.2	3.3	3.1
E1 Steak	11.7	12.7	0.4	0.5	0.0	0.4	1.6	0.2	2.4	4.4	2.7
E2 Steak	7.8	9.8	0.1	0.1	2.8	2.3	1.7	0.8	2.5	6.4	2.8
E3 Steak	9.9	10.8	0.0	0.1	0.1	3.2	1.4	0.6	2.5	4.0	2.7
E4 Steak	11.1	11.7	0.1	1.3	0.2	0.4	1.7	0.9	2.3	3.7	2.8
USDA Select Roast	5.5	3.0	1.0	2.8	1.0	1.3	2.6	1.6	2.6	3.3	2.9
P1 Roast	3.7	3.4	2.3	0.5	5.3	0.7	2.6	1.1	2.8	6.8	3.3
P2 Roast	3.6	2.8	1.5	1.7	3.7	0.6	2.4	0.2	2.8	6.7	2.9
P3 Roast	3.1	2.4	0.4	1.0	6.6	0.1	2.8	0.3	2.7	7.1	3.3
LSD[3]	*1.5*	*1.2*	*1.0*	*1.5*	*0.7*	*1.0*	*0.9*	*ns*	*0.5*	*0.7*	*0.5*

[1] Highest possible score = 15; 15= extremely intense, 0= not detectable.

[2] Based on analysis of three steaks or roasts per product by five expert panelists. E= Enhanced steaks, P= precooked roasts

[3] LSD= Least significant difference.

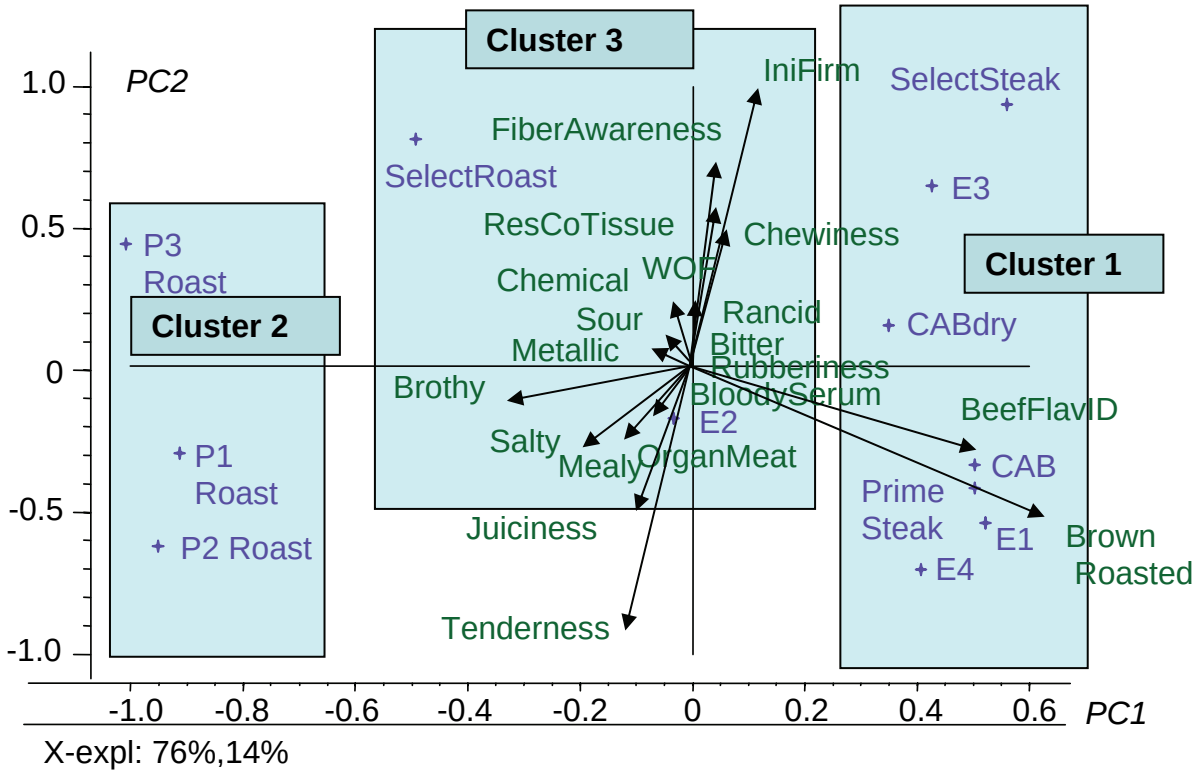

Figure 1: Sensory map of the first two principal components for describing the flavor and texture characteristics of enhanced beef *longissimus* steaks and roasts.