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USING PH-ENHANCEMENT OF BEEF STEAKS TO IMPROVE CUSTOMER SATISFACTION.

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Introduction

The palatability of beef is one of the most important attributes in determining customer satisfaction. Beef consumers are willing to pay higher prices for more palatable beef than for less palatable beef (Platter et al., 2005). Therefore, methods of improving beef palatability would likely increase customer satisfaction.

Numerous researchers have shown that the pH of beef is related to tenderness and overall palatability (Purchas, 1990; Watanabe et al., 1995; Wulf et al., 2002). Meat pH can affect palatability by affecting postmortem protein degradation as well as water-holding capacity. Dransfield (1981) reported that beef with an abnormally high ultimate pH (dark, firm and dry beef) was considerably more tender than normal beef. Consequently, increasing meat pH has the potential to improve beef palatability and customer satisfaction.

Freezing Machines, Inc. (FMI) of Dakota Dunes, SD has developed and patented the use of ammonium hydroxide as a processing aid in the production of foodstuffs, including beef products (the technology is the subject of various issued and pending patents, and is validated to reduce or eliminate potential pathogens in meat products processed using the technology; other patent pending technology also includes dissolved carbon oxide in the injection process). Ammonium hydroxide has the potential to increase the pH of meat and meat products and may therefore also be useful in improving beef palatability. Ammonium hydroxide is a GRAS ("Generally recognized as safe" according to U.S. Food and Drug Administration) food additive commonly used as a leavening and/or pH control agent.

Objectives

Hypothesis: Increasing pH of fresh beef with FMI technology improves cooked beef palatability and customer satisfaction.

Objective: Determine the effect of pH enhancement with FMI technology on consumer acceptability of beef steaks.

Methodology

A 2 x 2 x 2 factorial design was used with two beef sources: Limousin cattle (LIMO) and Certified Angus Beef (CAB), two muscles: longissimus lumborum (LL) and semitendinosus (ST), and two treatments: control (CON) and pH-enhanced (PHE). The LIMO beef was obtained from cattle from a purebred Limousin breeder, and the CAB beef was obtained as boxed beef. Twelve subprimals were used for each source by muscle by treatment combination. Muscles designated for PHE were injected with a patent pending solution containing water, ammonium hydroxide, carbon oxide, and salt.

pH was measured on raw steaks by homogenizing 10 g of muscle tissue with 90 g of water. Steaks from each subprimal and treatment combination were cooked on electric broilers to a target internal temperature of 71 degrees C. After cooling cooked steaks to room temperature, six 1.3-cm-diameter cores were removed from each steak, parallel to the muscle fiber orientation. Each core was sheared once, perpendicular to the muscle fiber orientation, on a Warner-Bratzler shear machine. The average peak force of six cores was calculated for each steak as Warner-Bratzler shear force (WBS). Dividing the cooked weight by the raw weight and multiplying by 100 determined cooking loss.

Consumer panels were conducted 1 to 5 days after enhancement. Panelists were recruited from the Brookings, SD area using fliers and newspaper advertising. Two hundred eighty-eight consumers participated in the study over 12 different panel times. Steaks were cooked on gas grills, turning every 2.5 minutes, to a target internal temperature of 71 degrees C. Immediately following cooking, steaks were cut into uniform 1.3 by 2.5 cm samples using a sample sizing guide, placed into styrofoam bowls with holes punched in the bottom to allow juices to drain, covered with aluminum foil, and held in a 60 degree C warming oven until served. Panels were conducted in booths preventing panelist interaction. Prior to the start of the panel, panelists were given brief instructions about panel procedure and were asked to sign a notice of informed consent. All samples were served under red lights to limit differences in visual appearance. One sample of each treatment combination was served in a random order to the panel. The first sample was always a longissimus steak obtained from the SDSU Meat Lab and was used as a warm-up sample to prevent first-sample bias; this data was not included in the analysis of data nor were any conclusions drawn from that sample. Samples were coded with a random code to blind consumers to treatment combinations.

Results & Discussion

Carcass trait means for the 12 LIMO carcasses were 385 kg hot weight, 0.7 cm fat thickness, 107 sq. cm ribeye area, 1.54 USDA yield grade, and Slight 23 marbling score (data not presented in tabular form). These carcass traits indicated that the LIMO carcasses were lean, muscular, and high cutability with low marbling scores.

A wide range of consumer demographics were represented in the consumer panel (Table 1). A higher-than-normal proportion of young (18 to 29) consumers were sampled.

Steaks from LIMO had a higher pH (5.87 vs. 5.68) than steaks from CAB (Table 2). Meat pH was raised from 5.39 for CON to 6.16 for PHE. Steaks from LL had less cooking loss (25.2 vs. 34.6%) than ST steaks. Control steaks had less cooking loss (28.3 vs. 31.4%) than PHE steaks. A significant source by muscle interaction for WBS

indicated that the tenderness difference between LL and ST was greater for CAB (LL = 2.41 kg, ST = 4.17 kg) than for LIMO (LL = 3.29 kg, ST = 3.31 kg). A significant source by treatment interaction for WBS indicated that pH enhancement had greater effects on LIMO (CON = 4.13 kg, PHE = 2.47 kg) than on CAB (CON = 3.68 kg, PHE = 2.90 kg). A significant muscle by treatment interaction for WBS indicated that pH enhancement had a greater effect on LL (CON = 3.69 kg, PHE = 2.01 kg) than on ST (CON = 4.12 kg, PHE = 3.36 kg).

A significant source by muscle interaction for consumer "overall like", consumer "like of tenderness", consumer "like of juiciness", consumer "like of flavor", and consumer intent-to-purchase indicated that the differences between LL and ST were greater for CAB (LL vs. ST = 7.25 vs. 5.78 for "overall like", 7.59 vs. 5.30 for "like of tenderness", 7.18 vs. 5.52 for "like of juiciness", 6.88 vs. 5.81 for "like of flavor", 71 vs. 42% for intent-to-purchase) than for LIMO (LL vs. ST = 6.70 vs. 6.24 for "overall like", 6.97 vs. 6.55 for "like of tenderness", 6.53 vs. 6.32 for "like of juiciness", 6.49 vs. 5.82 for "like of flavor", 62 vs. 52% for intent-to-purchase). A significant source by treatment interaction for "overall like", "like of tenderness", and "like of juiciness" indicated that pH enhancement had greater effects on LIMO (CON vs. PHE = 5.56 vs. 7.27 for "overall like", 5.61 vs. 7.90 for "like of tenderness", 5.41 vs. 7.43 for "like of juiciness") than on CAB (CON vs. PHE = 5.83 vs. 7.19 for "overall like", 5.62 vs. 7.27 for "like of tenderness", 5.62 vs. 7.07 for "like of juiciness"). pH enhancement resulted in higher "like of flavor" ratings (CON = 5.51, PHE = 7.00) and more "Yes" responses to the question, "Would you be likely to purchase this steak?" (CON = 43%, PHE = 71%).

Overall, treatment explained 68%, muscle explained 28%, and source explained 4% of total explained variation in "overall like" ratings (data not presented in tabular form). The effect of pH enhancement on palatability traits was very large. pH enhancement lowered WBS by 46% in LL steaks and by 18% in ST steaks. Overall, pH enhancement increased "overall like" ratings by 1.58 units. This 1.58 unit increase in "overall like" from pH enhancement was much greater than the muscle effect (CON LL – CON ST = 0.86 units) and the source effect (CON CAB – CON LIMO = 0.27 units). Consumers rated PHE beef higher than CON beef for all three palatability traits – tenderness, juiciness, and flavor. Based on these observations, it appears that pH enhancement offers great potential for enhancing beef steak palatability and improving beef customer satisfaction.

Conclusions

pH enhancement using the FMI technology was very effective at improving palatability of beef steaks. pH enhancement lowered Warner-Bratzler shear force and increased consumer ratings for "overall like", "like of tenderness", "like of juiciness", and "like of flavor". pH enhancement increased consumer intent-to-purchase from 43% to 71%. pH enhancement offers great potential for enhancing beef steak palatability and improving beef customer satisfaction, in addition to it's other favorable attributes as a processing aid.

References

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Tables and Figures

Table 1. Demographic profile of 288 consumer panelists.

	Number of consumers	% of consumers
Age		
18 to 29	174	60
30 to 39	29	10
40 to 49	41	14
50 to 59	27	9
60 and older	17	6
Household Annual Income		
Under $20,000	159	56
$20,000 to $39,000	58	20
$40,000 to $59,000	35	12
$60,000 and higher	33	12
Working Status		
Not employed	29	10
Part-time	39	14
Full-time	125	44
Student	93	33
Gender		
Male	136	47
Female	151	53
Times per week beef is consumed		
0	8	3
1 to 2	94	33
3 to 5	110	38
6 to 8	53	18
9 or more	22	8
Times per month steak is consumed		
0	29	10
1	66	23
2	65	23
3 to 5	95	33
6 or more	32	11

Table 2. Least-squares means for meat pH, cooking loss, and Warner-Bratzler shear force (WBS) by source (LIMO = Limousin cattle, CAB = Certified Angus Beef), muscle (LL = longissimus lumborum, ST = semitendinosus), and treatment (CON = control, PHE = pH-enhanced).

Source	Muscle	Treat-ment	Meat pH	Cooking Loss, %	WBS, kg
LIMO	LL	CON	5.41	24.0	4.47
LIMO	LL	PHE	6.30	25.9	2.11
LIMO	ST	CON	5.47	33.4	3.80
LIMO	ST	PHE	6.28	35.4	2.82
CAB	LL	CON	5.36	23.0	2.90
CAB	LL	PHE	6.13	28.0	1.91
CAB	ST	CON	5.32	33.0	4.45
CAB	ST	PHE	5.91	36.5	3.89
Pooled SEM			0.08	1.9	0.22
Probability of no effect					
Source (S)			0.002	0.728	0.952
Muscle (M)			0.336	<0.001	<0.001
Treatment (T)			<0.001	0.022	<0.001
S X M			0.185	0.953	<0.001
S X T			0.135	0.404	0.005
M X T			0.243	0.794	0.005
S X M X T			0.671	0.773	0.128

Table 3. Least-squares means for consumer ratings (10 = like extremely, 1 = dislike extremely) by source (LIMO = Limousin cattle, CAB = Certified Angus Beef), muscle (LL = longissimus lumborum, ST = semitendinosus), and treatment (CON = control, PHE = pH-enhanced).

Source	Muscle	Treat-ment	Overall Like	Like of Tender-ess	Like of Juiciness	Like of Flavor	Would Purchase, %
LIMO	LL	CON	5.74	5.63	5.47	5.62	46
LIMO	LL	PHE	7.66	8.30	7.59	7.36	78
LIMO	ST	CON	5.39	5.60	5.35	5.02	36
LIMO	ST	PHE	7.08	7.51	7.28	6.63	67
CAB	LL	CON	6.52	6.79	6.45	6.17	59
CAB	LL	PHE	7.98	8.38	7.91	7.58	82
CAB	ST	CON	5.15	4.45	4.79	5.21	29
CAB	ST	PHE	6.40	6.15	6.24	6.42	55
Pooled SEM			0.13	0.17	0.13	0.14	3
Probability of no effect							
Source (S)			0.630	0.007	0.424	0.059	0.822
Muscle (M)			<0.001	<0.001	<0.001	<0.001	<0.001
Treatment (T)			<0.001	<0.001	<0.001	<0.001	<0.001
S X M			<0.001	<0.001	<0.001	0.047	<0.001
S X T			0.017	0.006	0.003	0.066	0.102
M X T			0.258	0.172	0.614	0.422	0.698
S X M X T			0.951	0.062	0.626	0.850	0.675