Meat quality responses to feeding distiller's grains to finishing Holstein steers[1,2]

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ABSTRACT: Strip loins from two experiments were used to evaluate effects of feeding dry (DDG) or wet (WDG) distiller's grains on beef color, tenderness, and sensory traits of Holstein steers. In Exp. 1, conducted at the University of Illinois at Champaign–Urbana, dietary treatments consisted of a control whole corn–corn silage diet with soybean meal (SBM) or diets formulated with 12.5% DDG plus urea, 25% DDG, 25% WDG, 50% DDG, or 50% WDG (DM basis). In Exp. 2, conducted at Iowa State University, dietary treatments consisted of cracked corn–corn silage–hay diets with either SBM or urea (Urea) as the control diets, or diets formulated with 10, 20, or 40% DDG or WDG (DM basis). Within each study, strip loins from each of four steers (representing 45.7 and 66.6% of steers in Exp. 1 and 2, respectively) in four replicate pens per treatment were aged for 13 d at 4°C for subsequent color, tenderness, and palatability evaluation. Color of steaks was measured objectively using a HunterLab Miniscan XE spectrophotometer and was subjectively evaluated by a trained panel. Tenderness was measured using the Warner-Bratzler shear force (WBSF) instrument on steaks cooked to 70°C. For sensory evaluation, 95 consumers were recruited to evaluate tenderness, juiciness, and flavor of cooked steaks. In Exp. 1, steaks from steers fed 25% WDG had higher ($P < 0.05$) a* values after 138 h of simulated retail display than all other treatments, except for those from steers fed 12.5% DDG. In Exp. 2, a greater ($P < 0.05$) percentage of steaks from steers fed 40% DDG or 40% WDG were considered moderately undesirable during retail display (steaks that received a consumer acceptability score of 3 or less). There were no ($P = 0.20$ in Exp. 1, and $P = 0.33$ in Exp. 2) differences among treatments in Exp. 1 and Exp. 2 for WBSF (1.47 ± 0.66 kg and 1.58 ± 0.72 kg, respectively) or taste panel tenderness (5.7 ± 0.30 and 6.2 ± 0.22, respectively), beef flavor (6.0 ± 0.23 and 6.2 ± 0.22, respectively), and juiciness (5.6 ± 0.31 and 5.8 ± 0.23). Feeding distiller's grains at up to 50% of the dietary DM did not affect tenderness or sensory traits, and seems to be a viable feed alternative without negatively impacting sensory attributes.

Key Words: Beef, Carcass, Distiller's Grains, Holstein, Sensory Traits

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Introduction

The prevalence of distiller's grains (**DG**) from dry milling of corn is increasing in the upper Midwest due to growing interest in processing corn for ethanol production. Increased production of DG is leading cattle feeders and others in the beef industry to consider DG as a feed source. Ojowi et al. (1997) observed that steers fed a diet consisting of wheat-based DG had more ($P < 0.05$) intermuscular fat and less ($P < 0.05$) s.c. fat than those fed wet brewer's grains or barley. Reports from Canada indicated that steaks from steers fed wheat-based DG were similar in sensory traits and shear force values to those from steers fed brewer's grains or barley (Shand et al., 1998).

Distiller's grains have significant concentrations of vitamins, including B complex, A, D, and E; however, it is not known whether these characteristics of DG contribute to enhancing the value of beef. Dahlen et al. (2001) reported that steaks from steers fed a combination of condensed distiller's solubles (a component of DG with solubles) and barley by-product were redder than steaks from steers fed corn gluten feed. These studies have evaluated beef cattle fed DG, but limited information exists on the effects of DG on beef tenderness and sensory traits.

Because consumer preference for wholesome, high-quality beef is the focal point of the beef industry, it is imperative that we gain knowledge on the effect of feed-

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Table 1. Composition of diets in Exp. 1 (%, DM basis)

	Dietary treatments[a]			
Ingredient	Control	12.5 DDG	25% DDG or WDG	50% DDG or WDG
Whole corn	70	57.5	45	20
Corn silage	15	15	15	15
Whole corn:corn silage	4.7	3.8	3.0	1.3
Distiller's grains	—	12.5	25	50
Soybean meal	12.22	—	—	—
Urea	0.82	0.92	0.46	0.46
Dicalcium phosphate	0.10	—	—	—
Limestone	1.29	1.56	1.57	1.57
Trace mineral premix[b]	0.25	0.27	0.28	0.28
Liquid fat	0.25	0.27	0.28	0.28
Vitamin premix[c]	0.014	0.015	0.015	0.015
Copper sulfate	0.0068	0.0075	0.0075	0.0075
Zinc methionine	0.0200	0.0225	0.0225	0.0225
Rumensin[d]	0.017	0.019	0.019	0.019
Tylan[e]	0.0120	0.0126	0.0127	0.0127

[a]DDG = dry distiller's grains; WDG = wet distiller's grains.
[b]Trace mineral premix ingredients are described by Rinker and Berger (2003).
[c]Vitamin premix ingredients are described by Rinker and Berger (2003).
[d]178 g/kg of Rumensin (Elanco Animal Health, Indianapolis, IN).
[e]89 g/kg of Tylan 300 (Elanco Animal Health).

ing DG on beef quality and sensory traits. Therefore, the objective of this study was to determine the effects of feeding dry or wet DG on beef quality traits and sensory attributes from Holstein steers.

Materials and Methods

Strip Loin Collection

Carcasses were selected randomly using a random number generator before carcass data collection, and subsequently, fabricated according to North American Meat Processors guidelines (NAMP, 1997). Strip loins (NAMP #180) were collected from carcasses of steers fed DG for 270 and 299 d at University of Illinois at Champaign–Urbana (Exp. 1) and Iowa State University (Exp. 2), respectively. In Exp. 1, Holstein steers were fed a control diet that consisted of whole corn-corn silage diet with soybean meal (**SBM**), or diets containing 12.5% dry distiller's grains (**DDG**) plus urea, 25% DDG, 25% wet distiller's grains (**WDG**), 50% DDG, or 50% WDG (Table 1). In Exp. 2, Holstein steers were fed control diets of cracked corn–corn silage–hay diets supplemented with either urea or SBM, or dietary treatments that included 10% DDG, 10% WDG, 20% DDG, 20% WDG, 40% DDG, or 40% WDG (Table 2). Detailed descriptions of treatment allotment and cattle management in Exp. 1 and 2 are reported by Rinker and Berger (2003) and Trenkle (2004), respectively.

Strip loins from four steers in each of four replicate pens per treatment were tagged, collected postfabrication, and aged for 13 d at 4°C for subsequent retail display/color evaluation, tenderness, and palatability evaluation. Following aging, the anterior end of the strip loin was faced, and one 2.54-cm-thick steak was cut, placed on a Styrofoam tray, and over-wrapped for simulated retail display. The remaining portion of the strip loin was vacuum-packaged and frozen at –20°C for subsequent shear force and taste panel analysis. Three 2.54-cm-thick steaks were cut on a band-saw from frozen strip loins, and the most anterior steak was used for Warner-Bratzler shear force (**WBSF**) determinations, whereas the remaining two steaks were used for consumer sensory panel evaluation.

Simulated Retail Display

After each steak was over-wrapped with a polyvinyl chloride film, steaks were placed on a table in a cooler maintained at 2 ± 1°C. In accordance with the guidelines of Hunt et al. (1991), steaks were exposed to continuous 807 to 1,614 lx of deluxe warm-white, fluorescent lighting (bulb type = F32T8/TL741; Phillips Inc., Somerset, NJ). Beginning at 6 h under display conditions, each steak was objectively and subjectively evaluated for color attributes at 12-h intervals during retail display for 6 d.

Objective Color Evaluation

The color of each steak was measured with a HunterLab Miniscan spectrophotometer equipped with a 6-mm aperture (Hunter Laboratory Associates, Inc., Reston, VA) and using illuminant D65 to determine CIE (1976) L* (measure of darkness to lightness), a* (measure of redness), and b* (measure of yellowness) values. The mean of three random readings on each steak at the beginning of simulated retail display, after 6 h of display, and at 12-h intervals were used for statistical analyses.

Table 2. Composition of diets in Exp. 2 (%, DM basis)

	Dietary treatments[a]				
Ingredient	Urea control	SBM control	10% DDG or WDG	20% DDG or WDG	40% DDG or WDG
Cracked corn	83.4	81.8	74.3	64.6	44.7
Corn silage	10.00	10.00	10.00	10.00	10.00
Cracked corn:corn silage	8.3:1	8.2:1	7.4:1	6.5:1	4.5:1
Distiller's grain	—	—	10.00	20.00	40.00
Chopped grass hay	3.00	3.00	3.00	3.00	3.00
Molasses	0.75	0.75	0.75	0.75	0.75
Soybean meal	—	2.00	—	—	—
Urea	1.16	0.83	0.38	—	—
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.30	0.30	0.30	0.30	0.30
Potassium chloride	0.23	0.16	0.16	0.17	0.12
Trace mineral premix[b]	0.024	0.024	0.024	0.024	0.024
Vitamin premix[c]	0.08	0.08	0.08	0.08	0.08
Rumensin[d]	0.0195	0.0195	0.0195	0.0195	0.0195
Elemental S	0.037	0.027	0.012	—	—

[a]SBM = soybean meal; DDG = dry distiller's grains; WDG = wet distiller's grains.
[b]Trace mineral premix ingredients are described by Trenkle (2004).
[c]Vitamin premix ingredients are described by Trenkle (2004).
[d]178 g/kg of Rumensin (Elanco Animal Health, Indianapolis, IN).

Subjective Color Evaluation

A three-person, trained panel of the University of Minnesota personnel subjectively evaluated color. Panelists were trained using a system of open discussion and the procedure outlined by Lavelle et al. (1995). Panelists assigned scores to each steak for muscle color, overall appearance, and surface discoloration at each evaluation time as prescribed by Hunt et al. (1991). Panelists characterized meat color (8 = extremely bright cherry red, to 1 = extremely dark red), overall appearance (8 = extremely desirable, to 1 = extremely undesirable), and surface discoloration (8 = no [0%] discoloration, to 1 = complete [76 to 100%] discoloration). Steaks were evaluated until at least 80% of the steaks were assigned a mean overall appearance score of 3 (moderately undesirable) or lower.

Tenderness Determination

Steaks were removed from the freezer, thawed for 24 h at 4°C, and then cooked in electric clam shell type grills (model GGR88DK, Salton, Inc., Lake Forest, IL) to a final internal temperature of 70°C. Internal temperature was monitored with a thermocouple (Type T, Omega Engineering, Stamford, CT) inserted into the geometric center of each steak. Each steak was cooled to room temperature, and six to ten 1.27-cm-diameter cores were removed from each steak parallel to the muscle fiber orientation using a hand-coring device. A single, peak shear force measurement was obtained for each core using the WBSF instrument (G-R Elec. Mfg. Co., Manhattan, KS). Peak WBSF values from each steak were averaged for statistical purposes.

Palatability Determination

Ninety-five consumers were recruited from the Minneapolis/St. Paul metropolitan area using the University of Minnesota's Food Sensory Center's consumer database. Panelists evaluated tenderness, juiciness, and flavor of cooked steaks, and were given verbal instructions on how to evaluate each sample. Panelists evaluated the palatability attributes of the steaks cooked to 70°C (medium degree of doneness). Steaks were thawed and cooked in the same manner for palatability determination as for the WBSF determinations. When steaks were removed from the grill, $1.27 \times 1.27 \times 2.54$ cm cubes were cut and served to the panelists for evaluation. Each consumer evaluated 14 steak samples in their assigned session, with a break after the seventh sample. Consumers were provided distilled water and unsalted saltine crackers to cleanse their palates between samples. Consumers evaluated samples for like/dislike of tenderness, juiciness, and flavor (1 = dislike extremely, to 9 = like extremely), and were asked whether they were satisfied with the overall eating quality of the steak sample. Demographic information was collected from each consumer during the study.

Statistical Analyses

Data from each experiment were analyzed separately because treatment groups were confounded within study location. Each experiment was analyzed individually, with pen as the experimental unit. Simple descriptive statistics for the carcasses from which strip loins were collected were computed for each treatment group in each experiment. All data were analyzed using the mixed model procedure of SAS (SAS Inst., Inc., Cary, NC), and

Table 3. Effect of distiller's grains on objective color and subjective appearance scores of strip steaks after 138 h of simulated retail display (Exp. 1 and 2)

Dietary treatments[a]	No. of pens	L*[b]	a*[b]	b*[b]	% of "moderately unacceptable" steaks[c]
Exp. 1					
Soybean meal	4	31.41	5.24[z]	10.39[c]	75.0[x]
12.5% DDG	4	31.35	6.33[xy]	11.36[x]	64.6[x]
25% DDG	4	32.48	5.70[yz]	10.96[yc]	72.7[x]
50% DDG	4	32.68	5.69[yz]	11.12[xyc]	72.9[x]
25% WDG	4	32.36	7.30[x]	11.94[x]	45.8[y]
50% WDG	4	32.73	6.09[yz]	11.49[xy]	70.8[x]
SEM		0.833	0.452	0.309	0.50
P-value		0.733	<0.05	<0.05	<0.05
Exp. 2					
Urea	4	29.79[y]	7.70[x]	11.54	40.6[y]
Soybean meal	4	31.31[x]	7.18[x]	11.64	40.6[y]
10% DDG	4	29.77[y]	7.17[x]	11.60	46.7[y]
20% DDG	4	31.92[x]	5.84[yz]	11.24	59.4[xy]
40% DDG	4	32.34[x]	5.32[z]	10.93	71.9[x]
10% WDG	4	30.16[y]	7.55[x]	11.43	43.8[y]
20% WDG	4	31.28[xy]	6.84[xy]	11.53	46.9[y]
40% WDG	4	32.38[x]	5.17[z]	11.19	75.0[x]
SEM		0.593	0.414	0.281	0.45
P-value		<0.05	<0.05	0.579	<0.05

[a]DDG = dry distiller's grain; WDG = wet distiller's grain. See Tables 1 and 2 for diet descriptions.

[b]L* values measure darkness to lightness (higher L* value indicates a lighter color); a* values measure redness (higher a* value indicates a redder color); and b* values measure yellowness (higher b* value indicates a more yellow color).

[c]A mean visual panel score of 3 or less ("moderately unacceptable") was considered the point at which strip loin steaks would be discounted for quick sale at retail.

[x,y,z]Within experiment and column, least squares means that do not have a common superscript letter differ, $P < 0.05$.

pairwise *t*-tests were used to separate least squares means with $\alpha \leq 0.05$. The ANOVA model for simulated retail display included dietary treatment and dietary treatment × duration of simulated retail display as the fixed effects, with duration of simulated retail display as a repeated measure. Additionally, χ^2 analysis was used to ascertain differences between treatments for the percentage of steaks that were "moderately unacceptable" during simulated retail display. The model for WBSF data included dietary treatment as a fixed effect and marbling score as a covariate, whereas the model for consumer taste panel data included dietary treatment as the lone fixed effect and consumer within session as the random effect. Additionally, an orthogonal contrast was used to ascertain a difference in simulated retail display, WBSF, and consumer taste panel data between DDG and WDG in cattle finishing diets.

Results and Discussion

Performance and carcass characteristics of steers in Exp. 1 and 2 were presented by Rinker and Berger (2003) and Trenkle (2004), respectively. Strip loins obtained from Exp. 1 and 2 were from carcasses with an average carcass weight of 333 and 364 kg, s.c. fat thickness of 0.57 and 0.70 cm, LM area of 73.7 and 78.9 cm^2, yield grade of 2.6 and 3.4, and marbling score of $Small^{48}$ and $Modest^{05}$, respectively.

Retail Display

There were no ($P = 0.42$) duration of simulated retail display × dietary treatment interactions for any color trait. Therefore, only the main effect of dietary treatments on beef appearance, and L*, a*, and b* values at 138 h of simulated retail display (time at which >50% of the steaks evaluated were classified as "moderately unacceptable" by trained panelists) are presented in Table 3.

A visual appearance score of 3 (moderately unacceptable) is when steaks were assumed to be discounted for quick sale in retail display. Zerby et al. (1999) documented that visual appearance scores were moderately to highly correlated to CIE a* values. In Exp. 1, steaks from steers fed 25% WDG had a lesser ($P < 0.05$) percentage of steaks receiving an appearance score of 3 or less compared with steaks from the other dietary treatments. Conversely, in Exp. 2, there was a greater ($P < 0.05$) percentage of steaks from steers fed 40% DDG and 40% WDG considered at least moderately unacceptable than steaks from steers fed the control diets supplemented with either SBM or urea, 10% DDG, 10% WDG, and 20% WDG. Because Zerby et al. (1999) demonstrated that visual appearance scores were moderately to highly correlated to a* values, it is not surprising that steaks from steers fed 25% WDG had greater ($P < 0.05$) a* values than steaks from the other dietary treatments, except

12.5% DDG (Exp. 1). Additionally, in Exp. 2, steaks from steers fed control diets supplemented with SBM and urea, as well as those from steers fed 10% DDG and 10% WDG, were redder (higher a* values; $P < 0.05$) than steaks from steers fed 20% DDG, 40% DDG, and 40% WDG. The greater a* values reported for beef from steers fed DG in Exp. 1 and 2 may be due to the presence of xanthophylls, any of several neutral yellow to orange carotenoid pigments that are oxygen derivatives of carotenes. Roberson (2004) documented that corn dried DG contained 30 mg/kg of xanthophylls and attributed increasing a* values in egg yolk color (as the percentage of DDG with solubles increased in the diet) to the presence of these xanthophylls.

Although there was no ($P = 0.73$) effect of diet on L* values in Exp. 1, steaks from steers fed the control diet supplemented with SBM, 20% DDG, 40% DDG, and 40% WDG were lighter (higher L* values; $P < 0.05$) than steaks from steers fed 10% of either DDG or WDG in Exp. 2 (Table 3). On the other hand, in Exp. 1, steaks from steers fed 12.5 and 25% WDG were more yellow (higher b* values; $P < 0.05$) than those from steers fed the control diet (with SBM) or 25% DDG; however, b* values were not ($P = 0.58$) affected by dietary treatment.

Table 4. Effect of distiller's grains on Warner-Bratzler shear force (Exp.1 and 2)

Dietary treatment[a]	No. of pens	Warner-Bratzler shear force, kg
Exp. 1		
Soybean meal	4	1.47
12.5% DDG	4	1.33
25% DDG	4	1.42
50% DDG	4	1.65
25% WDG	4	1.45
50% WDG	4	1.47
SEM		0.066
P-value		0.200
Exp. 2		
Urea	4	2.47
Soybean meal	4	1.48
10% DDG	4	1.45
20% DDG	4	1.46
40% DDG	4	1.38
10% WDG	4	1.50
20% WDG	4	1.40
40% WDG	4	1.48
SEM		0.072
P-value		0.325

[a]DDG = dry distiller's grain; WDG = wet distiller's grain. See Tables 1 and 2 for diet descriptions.

Shear Force

To ensure that differences being evaluated were due to dietary treatments, WBSF data were adjusted to a common marbling score. In Exp. 1, marbling score was not significant ($P > 0.23$) and therefore was removed from the model; however, in Exp. 2, the marbling score covariate was significant ($P < 0.05$). No differences in WBSF values were observed among treatments (Table 4) in either Exp. 1 ($P > 0.20$) or Exp. 2 ($P > 0.32$); however, WBSF values were below the consumer acceptability threshold reported by Shackelford et al. (1991). Results of this study are in agreement with those of Kroger et al. (2004), who failed to find a difference in WBSF values among cattle fed a control finishing diet or diets containing 20 and 40% WDG or DDG.

Consumer Taste Panel

The age distribution was slightly skewed to the younger categories, but is likely related to the 40% of the consumers indicating that they were students. The remaining consumers were evenly distributed among the age groups of 30 to 39, 40 to 49, and 50 to 59 yr. Again, income distribution was slightly skewed to the lower (under $20,000) and the upper (over $60,000) income brackets. Consumers were primarily white (92.6%) and may not have represented the demographics of the St. Paul, MN, area; however, the high percentage of Caucasian consumers is more likely related to their willingness to participate in the study.

Consumer panel results for Exp. 1 and 2 are presented in Table 5. Steaks from steers fed 25% WDG received the highest, and those from steers fed 50% WDG the lowest numerical tenderness ($P = 0.081$) and juiciness ($P = 0.083$) like/dislike scores; however, flavor like/dislike ratings did not ($P = 0.224$) differ among dietary treatments in Exp. 1. Across all dietary treatments in Exp. 1, almost half (49%) the consumers were pleased with the overall quality of the samples in the treatment group. Nonetheless, when consumers were displeased with quality of a sample, they were more often dissatisfied with the tenderness of the sample than with the juiciness or the flavor.

In Exp. 2, consumer-evaluated tenderness, juiciness, and flavor like/dislike scores did not differ ($P = 0.487$) among dietary treatments. At least 50% of the consumers were pleased with the samples in each treatment group. As in Exp. 1, when consumers were unpleased with the quality of the sample, they were more often dissatisfied with the tenderness of the sample than with the juiciness or the flavor.

Consumer panel results in Exp. 1 and Exp. 2 were similar to those of Shand et al. (1998), who documented that there was no effect of feeding brewer's grains or wheat-based DG on sensory characteristics of steaks. Given WBSF values obtained in Exp. 1 and 2, high levels of consumer acceptance for tenderness were expected; however, even though consumers tended to "rank" the dietary treatments in accordance to WBSF in both experiments, the percentages of displeased consumers did not differ and these percents were higher than expected given shear force values. The percentage of unpleased consumers that were dissatisfied with tenderness also was surprisingly high, which is perhaps due to some consumers' generalization of a trait (tenderness, juiciness, flavor) because of an unfavorable evaluation of the

Table 5. Effect of distiller's grains on sensory attributes (Exp. 1 and 2)

Dietary treatment[a]	No. of pens	Tenderness like/dislike[b]	Juiciness like/dislike[b]	Flavor like/dislike[b]	% (No.) of panelists unpleased with the sample[c]	Percentage of unpleased panelists that were not satisfied with		
						Tenderness	Juiciness	Flavor
Exp. 1								
Soybean meal	4	5.51	5.49	5.74	47.4 (45)	60.0	40.0	53.3
12.5% DDG	4	6.07	5.81	6.31	38.9 (37)	45.9	37.8	40.5
25% DDG	4	5.62	5.50	5.99	45.3 (43)	62.8	44.2	39.5
50% DDG	4	5.56	5.44	5.75	49.5 (47)	68.1	51.1	46.8
25% WDG	4	6.15	6.05	6.12	34.7 (32)	56.3	50.0	50.0
50% WDG	4	5.47	5.22	5.86	50.5 (48)	52.1	47.9	58.3
SEM		0.30	0.31	0.23	0.60			
P-value		0.081	0.083	0.224	0.165			
Exp. 2								
Urea	4	6.25	5.79	6.38	34.7 (33)	51.5	33.3	45.5
Soybean meal	4	6.15	5.85	6.29	33.7 (31)	77.4	38.7	58.1
10% DDG	4	6.31	5.81	5.98	37.9 (36)	50.0	61.1	50.0
20% DDG	4	6.04	5.75	6.16	36.8 (35)	54.3	34.3	57.1
40% DDG	4	6.39	5.86	6.14	38.9 (37)	51.4	51.4	48.6
10% WDG	4	6.35	6.13	6.39	29.5 (27)	48.1	25.9	48.1
20% WDG	4	6.00	5.68	5.95	41.1 (38)	50.0	55.3	39.5
40% WDG	4	6.13	5.85	6.05	34.7 (33)	48.5	45.5	42.4
SEM		0.22	0.23	0.22	0.50			
P-value		0.852	0.885	0.487	0.785			

[a]DDG = dry distiller's grain; WDG = wet distiller's grain. . See Tables 1 and 2 for diet descriptions.
[b]Tenderness, juiciness and flavor like/dislike: 1 = dislike extremely; 9 = like extremely.
[c]Percentage of panelists that indicated that the sample was, overall, not acceptable (unpleased with the sample).

flavor or juiciness of the sample (also known as the halo effect and their inability to completely separate tenderness, juiciness, and flavor), similar in principle to the halo effect documented by Roeber et al. (2000).

Implications

Results of this study indicate that including distiller's grains in cattle finishing diets at high (40 to 50% of dietary dry matter) inclusion rates may have a negative effect on color stability of strip loins during retail display. Conversely, distiller's grains could be included in the finishing diets of steers at a low to moderate inclusion level (10 to 25% of dietary dry matter) to maintain, or even enhance, shelf life of steaks in a retail outlet, without affecting cooked beef palatability.

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