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## Consumer Juiciness Acceptability Supports the Beef Marbling Insurance Theory

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## Abstract

**Objective:** The objective of this study was to determine whether increased marbling reduces the negative impact that increased degree of doneness has on consumer palatability scores.

**Study Description:** Beef strip loins were collected to represent five quality treatments [Prime, Top choice, Low choice, Select, and Select enhanced; n = 12 pairs/quality grade] and fabricated to 1-in steaks. Steaks were cooked to one of six degrees of doneness: very-rare (130°F), rare (140°F), medium-rare (145°F), medium (160°F), well-done (170°F), or very well-done (180°F). Consumers (n = 360) rated each steak for juiciness, tenderness, flavor, and overall liking on 100

**The Bottom Line:** Marbling could play a role in compensating for the negative effects of advanced degrees of doneness on juiciness acceptability, providing insight into the quality grade needed for consumers to be satisfied with juiciness based on their preferred degree of doneness.

## Keywords

consumer, palatability, marbling, degree of doneness

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## Consumer Juiciness Acceptability Supports the Beef Marbling Insurance Theory

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### Introduction

Tenderness, juiciness, and flavor contribute to a consumer's overall experience of eating beef. These sensory traits can be detrimentally affected by increased cooking temperature (Lorenzen et al., 2003). As degree of doneness, or final internal temperature, increases consumer sensory scores for palatability traits decrease, leading to a decrease in overall eating satisfaction. However, an increase in the amount of marbling can lead to an increase in consumer sensory scores for tenderness, juiciness, and flavor—as well as overall eating satisfaction (O'Quinn et al., 2012; Lucherik et al., 2016). One theory proposes that increased marbling can counteract the negative effect of increased cooking temperatures. This theory is known as the insurance theory, as marbling acts as “insurance,” to maintain an acceptable eating experience as degree of doneness increases (Savell and Cross, 1988). To our knowledge there is limited research evaluating this theory, but potential verification could benefit the industry by better identifying products that will meet consumer eating expectations based on their preferred degree of doneness. Therefore, the objective of this study was to determine whether increased marbling reduces the negative impact that increased degree of doneness has on consumer palatability scores.

### Experimental Procedures

Paired beef strip loins (Institutional Meat Purchase Specifications #180) were collected from four U.S. Department of Agriculture quality grades [Prime, Top Choice (Modest and Moderate marbling), Low Choice, and Select; n = 12 pairs/quality grade]. An additional 12 pairs of USDA Select strip loins were collected for moisture enhancement. Subprimals were aged for 21 days in vacuum packages at 39.2°F. At the end of the aging period, strip loins designated for enhancement were enhanced at an 8% pump-level with a salt and alkaline phosphate solution using a multi-needle injector (Model N50; Schröder Maschinenbau GmbH, Werther, Germany). Strip loins were fabricated into 1-in steaks, with three consecutive steaks being grouped with a total of three groups per strip loin, and a total of six groups per strip loin pair. Within each strip loin pair, groups were randomly assigned one of six degrees of doneness: very-rare (130°F), rare (140°F), medium-rare (145°F), medium (160°F), well-done (170°F), or very well-done (180°F) so that each carcass had representation for each degree of doneness. Steaks were cooked to their designated degree of doneness on a clamshell grill (Cuisinart Griddler Deluxe,

Model GR-150, East Windsor, NJ) with temperatures monitored using a probe thermometer (Super-Fast Thermopen, ThermoWorks, American Fork, UT). Consumers ( $n = 360$ ) were served eight samples representing differences in quality grade and degree of doneness in a random order. Consumers in individual sensory booths under red incandescent lighting evaluated each sample for juiciness, tenderness, flavor, and overall liking on continuous 100-point line scales. Additionally, consumers rated each trait as either acceptable or unacceptable.

## Results and Discussion

Least squares means for consumer sensory scores are shown in Table 1. There was no interaction ( $P > 0.05$ ) between quality treatment and degree of doneness for all sensory traits evaluated. For the main effect of quality treatment, Select Enhanced had the highest consumer ratings ( $P < 0.05$ ) for juiciness, tenderness, flavor, and overall liking followed by Prime, which was higher ( $P < 0.05$ ) than all other lower grading samples. Top Choice and Low Choice had similar consumer ratings ( $P > 0.05$ ) for all sensory traits evaluated. Select steaks had the lowest ( $P < 0.05$ ) ratings for juiciness, flavor and overall liking and were lower ( $P < 0.05$ ) for tenderness than all grades other than Low Choice. When evaluating the impact of degree of doneness on consumer ratings, very well-done steaks had the lowest scores ( $P < 0.05$ ) for all traits evaluated except for overall liking, which were similar ( $P > 0.05$ ) to well-done. When evaluating steaks for juiciness, very rare steaks were rated higher ( $P < 0.05$ ) than all other treatments, except for rare, which were similar ( $P > 0.05$ ). Very-rare, rare, and medium-rare steaks had similar ( $P > 0.05$ ) consumer ratings for tenderness, flavor, and overall liking.

Figure 1 shows the interaction ( $P < 0.05$ ) between quality grade and degree of doneness for the percentage of steaks rated acceptable for juiciness. There were differences ( $P > 0.05$ ) among quality treatments within very-rare for juiciness acceptability. However, Select Enhanced had a higher ( $P < 0.05$ ) percentage of steaks rated acceptable than all other treatments at medium and above, being similar ( $P > 0.05$ ) to only Prime at very well-done. Select steaks had the lowest ( $P < 0.05$ ) percentage of steaks rated acceptable for juiciness at rare and medium, and were similar ( $P > 0.05$ ) to only Low Choice and Top Choice at well-done and very well-done. Prime had a similar ( $P > 0.05$ ) percentage of steaks rated acceptable for juiciness as Top Choice and Low Choice at all degrees of doneness, except when cooked to very well-done. Prime had a higher ( $P < 0.05$ ) percentage than all non-enhanced treatments, including Top Choice and Low Choice, when cooked to very well-done. Top Choice had a similar ( $P > 0.05$ ) percentage of steaks rated acceptable for juiciness as Low Choice across all degrees of doneness.

For consumer palatability scores, the negative impact of increasing final internal cooking temperature on juiciness, tenderness, flavor, and overall liking was the same across all quality treatments, as indicated by the lack of a significant quality grade  $\times$  degree of doneness interaction. The palatability scores generally increased as marbling increased, with the exception of Select Enhanced samples, which the consumers scored the highest for all sensory traits. These results would imply that the insurance theory is not valid, as an increase in marbling does not have any added benefit to reducing the negative impact of increasing degree of doneness in each individual palatability trait. However, when evaluating on an acceptability basis, an increase in marbling score does appear to modify the point at which a sample becomes unacceptable for juiciness. For

each quality treatment, there appears to be a degree of doneness point where there is a sharp reduction in the percentage of steaks rated acceptable for juiciness. For Select and Low Choice samples, the decrease appears to occur immediately after medium-rare. That drop is not observed in Top Choice until after the medium degree of doneness. Enhanced samples were able to maintain acceptable juiciness until being cooked to very well-done, most likely due to their added moisture. However, Prime steaks were able to maintain a steady, slight decline in the percentage of samples rated acceptable across all degrees of doneness, and did not appear to have the same dramatic drop off in acceptability due to increased degree of doneness observed in the other quality grades. Thus, the relationship between marbling and degree of doneness for juiciness acceptability does appear to be consistent with the “insurance theory.”

## Implication

These results indicate that marbling could play a role in compensating for the negative effects advanced degrees of doneness on juiciness acceptability, providing insight into the quality grade needed for consumers to be satisfied with juiciness based on their preferred degree of doneness.

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**Table 1. Least squares means for consumer (n = 360) ratings<sup>1</sup> of the palatability traits of five quality treatments cooked to six degrees of doneness**

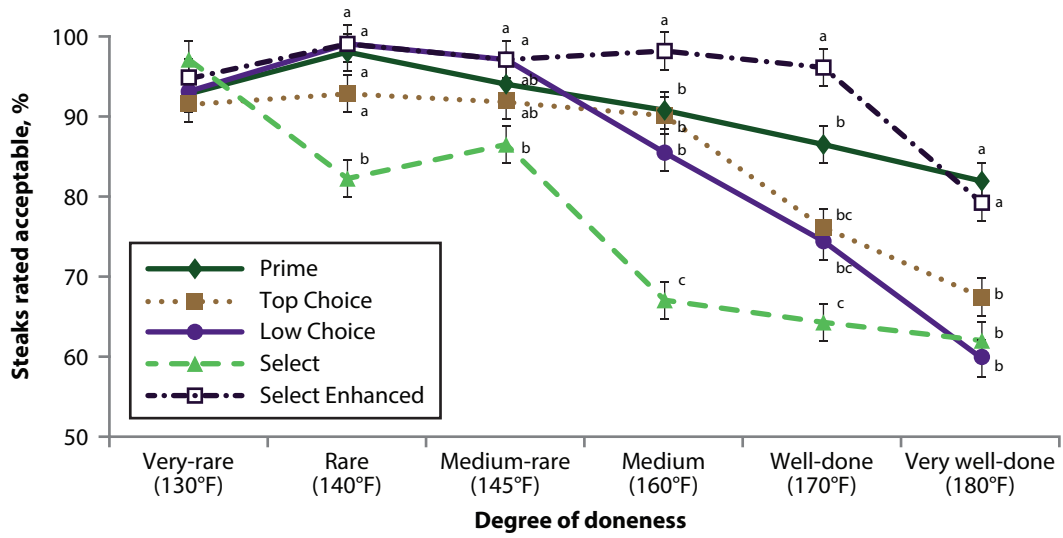
Treatment	Juiciness	Tenderness	Flavor	Overall like
<b>Quality grade</b>				
Prime	71.3 <sup>b</sup>	70.6 <sup>b</sup>	62.7 <sup>b</sup>	65.5 <sup>b</sup>
Top choice	64.4 <sup>c</sup>	60.0 <sup>c</sup>	56.7 <sup>c</sup>	58.2 <sup>c</sup>
Low choice	60.8 <sup>c</sup>	57.7 <sup>cd</sup>	55.4 <sup>c</sup>	56.9 <sup>c</sup>
Select	55.5 <sup>d</sup>	52.4 <sup>d</sup>	50.9 <sup>d</sup>	50.0 <sup>d</sup>
Select enhanced <sup>2</sup>	77.9 <sup>a</sup>	77.1 <sup>a</sup>	75.7 <sup>a</sup>	75.7 <sup>a</sup>
Standard error of the least squares means <sup>3</sup>	1.8	2.1	1.5	1.6
P-value	< 0.01	< 0.01	< 0.01	< 0.01
<b>Degree of doneness</b>				
Very rare (130°F)	77.4 <sup>a</sup>	69.4 <sup>a</sup>	62.0 <sup>a</sup>	63.2 <sup>a</sup>
Rare (140°F)	73.9 <sup>ab</sup>	68.0 <sup>a</sup>	64.4 <sup>a</sup>	65.9 <sup>a</sup>
Medium rare (145°F)	72.3 <sup>b</sup>	68.9 <sup>a</sup>	62.0 <sup>a</sup>	65.5 <sup>a</sup>
Medium (160°F)	65.6 <sup>c</sup>	64.1 <sup>b</sup>	61.0 <sup>ab</sup>	62.1 <sup>a</sup>
Well done (170°F)	58.1 <sup>d</sup>	58.6 <sup>c</sup>	58.2 <sup>b</sup>	57.1 <sup>b</sup>
Very well-done (180°F)	48.8 <sup>c</sup>	52.5 <sup>d</sup>	54.1 <sup>c</sup>	53.6 <sup>b</sup>
Standard error of the least squares means <sup>3</sup>	1.6	1.7	1.6	1.6
P-value	< 0.01	< 0.01	< 0.01	< 0.01
<b>Quality grade × degree of doneness</b>				
P-value	0.06	0.23	0.76	0.49

<sup>abc</sup>Least square means of treatment within column differ (P<0.05).

<sup>1</sup>Sensory scores: 0 = extremely dry/tough/dislike; 50 = neither dry nor juicy, neither tough nor tender, neither like nor dislike; 100 = extremely juicy/tender/like extremely.

<sup>2</sup>Enhanced to 108% of raw weight with a water, salt, and alkaline phosphate solution.

<sup>3</sup>Standard error (largest) of the least square means.



**Figure 1. Least squares means for the interaction ( $P < 0.05$ ) between quality treatment and degree of doneness for percentage of steaks rated acceptable for juiciness.**

<sup>abc</sup>Within degree of doneness, quality treatments lacking common superscripts differ ( $P < 0.05$ ).