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1987

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Recommended Citation

Chen, C.M.; DeZeeuw, P.S.; and Costello, W.J., "Effects of Heating Rate and Endpoint Temperature on the Palatability and Storage Stability of Precooked Beef Roasts" (1987). *South Dakota Beef Report, 1987*. Paper 18.
http://openprairie.sdstate.edu/sd_beefreport_1987/18

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BEEF REPORT

EFFECTS OF HEATING RATE AND ENDPOINT TEMPERATURE ON THE PALATABILITY AND STORAGE STABILITY OF PRECOOKED BEEF ROASTS

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CATTLE 87-17

Summary

The primary objective of this study was to determine the optimal cooking rate and endpoint temperature of a precooking regime for beef roasts which maximizes consumer acceptability and storage stability. Percentage cooking loss and TBA values were minimized when roasts were precooked to the lowest endpoint temperature (45 C, 112 F). In addition, long-term cooking (heating rate = 16 min/C) improved TBA values (Thiobarbituric acid, a test for oxidative rancidity) for precooked beef roasts. Sensory qualities did not differ ($P>.05$) due to cooking rate or endpoint temperature. Findings suggest that a low-temperature long-term cooking method optimizes ($P<.05$) cooking characteristics while maintaining sensory qualities of precooked beef roasts.

(Key Words: Beef, Precooking Temperature, Precooking Rate, TBA, Sensory.)

Introduction

Demand for meat products that are easy and quick to prepare has increased due to changing consumer lifestyles and microwave cooking. The use of precooked meats offers these conveniences.

Longtime low-heat cookery methods are instrumental in breaking down the collagen cross-linking structure which is one of the major factors responsible for the toughness in less tender meat cuts. Laakkonen et al. (1970) concluded that the major decrease in Warner-Bratzler shear values occurred at 50 to 60 C (122-140 F) when beef muscles were heated at a slow rate. Draudt et al. (1964) observed that shear values changed little in samples cooked at temperatures up to 50 C (122 F), but decreased in samples cooked at 54 C (130 F), and reached a minimum in those cooked at 60 to 64 C (140-147 F).

The palatability of precooked beef which has been reheated is negatively influenced by warmed-over flavor. Laboratory analysis of the end-products of lipid oxidation indicate a high correlation ($R^2 = .89$) between Thiobarbituric acid (TBA) values and off-flavor formation in meats (Tarladigis et al., 1960). Therefore, TBA values can be used as an analytical measurement of warmed-over flavor.

This study was designed to explore the effects of heating rate and endpoint temperature on consumer acceptability of precooked beef roasts and to determine the optimum precooking conditions for beef roasts.

Materials and Methods

Two hundred chuck tender muscles (Supraspinatus) were trimmed of visible external fat, cut into rectangular mini-roasts (4 in x 4 in x 8 in) and individually put into cooking bags (Cryovac, W. R. Grace Co., Duncan, SC). Prior to the precooking treatments, all bags were evacuated and heat shrunk. Roasts were weighed and preheated to an internal temperature of 25 C (76 F).

Thermal processing was performed in a computerized smokehouse with a "Delta-T" program. Five heating rates and five endpoint temperatures were examined. Heating rates consisted of 4, 7, 10, 13 or 16 minutes of cooking

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time for each 1 C (1.8 F) increase in internal temperature (min/C). Endpoint internal temperatures were 45, 50, 55, 60 or 65 C (113, 122, 131, 140 or 149 F). All thermal processing was done at a relative humidity of 99%. Upon completion of the precooking regime, all roasts were weighed and stored at 4 C (39 F).

Percentage cooking loss was determined as (Raw weight - Cooked weight)/Raw weight X 100. After 1, 14 and 28 days of refrigerated storage, TBA analyses were performed on samples of the roasts (Tarladgis et al., 1960).

Sensory evaluation of the refrigerated precooked roasts was performed within 14 days of the precooking treatment and after the roasts were reheated in a microwave oven (Amana, Model RR-9TB) to an internal temperature of 70 C (158 F). Each member of a ten-member trained sensory panel rated a sample of each roast for juiciness, tenderness, connective tissue residue and flavor on an 8-point scale. In addition, objective tenderness measurements (Warner-Bratzler shear) of the beef roasts were performed on 12.5 mm (.5 in) cores.

Results and Discussion

No interaction (P>.05) between heating rate and endpoint temperature was observed in the percentage cooking loss data. Percentage cooking loss did not differ (P>.05) due to heating rate of the supraspinatus beef roasts (table 1). Although cooking period ranged from 2 to 11 hours, the cooking bags prevented differences in evaporation and drip losses during the cooking periods at all cooking temperatures. Percentage cooking loss of the precooked beef roasts increased linearly (R^2 = .93) with endpoint temperature (table 2). These data indicate that change in percentage cooking loss is a rate-temperature process having a very high endpoint temperature dependence.

Effects of heating rate on shear values were independent of endpoint temperature. Results obtained show that less (P<.05) shear force was required for product cooked at the slowest rate (16 min/C, table 1). These results agreed well with that of Bouton and Harris (1981) who indicated decrease in shear force values was dependent on animal age and cooking time. No difference (P>.05) in shear values was observed due to endpoint temperature at the heating rates studied (table 2).

TABLE 1. EFFECT OF HEATING RATE ON COOKING LOSS, SHEAR VALUE AND STORAGE STABILITY OF PRECOOKED BEEF ROASTS

	Heating rate (min/C)^{a}				
	4	7	10	13	16
Cooking loss, %	8.68	8.39	7.59	6.17	5.39
W-B shear, kg	4.17^{c}	5.03^{c}	5.45^{c}	4.64^{c}	3.79^{d}
TBA value^{b}	1.05^{e}	1.22^{ef}	1.98^{g}	1.93^{fg}	.97^{e}
1 day	.67	1.44	1.64	1.61	.60
14 days	1.08	1.04	2.56	2.38	1.64
28 days	1.39	1.17	1.74	1.79	.67

^{a} Heating rate = min/1 C (min/1.8 F) increase in internal temperature.
^{b} TBA value = mg malonaldehyde/kg sample.
^{c,d} Means in same row with a different superscript are different (P<.05).
^{e,f,g} Means in same row with a different superscript are different (P<.01).

Both heating rate and endpoint temperature affected (P<.01) TBA values of the beef roasts. Results indicated that the maximum rate of malonaldehyde formation was in roasts cooked at heating rates from 10 to 13 min/C (table 1). Although the intermediate precooking rates in the current study resulted in increased (P<.01) TBA values, sensory panel members did not indicate any incidences of warmed-over flavor. Endpoint temperature also had an effect (P<.01) on lipid oxidation in precooked roast beef. Each increase in endpoint temperature caused a quadratic increase (R^2 = .98) in TBA value (table 2). The lack of change (P>.05) in TBA values for beef roasts during 28 days of refrigerated storage indicated the precooked roasts maintained their shelf-stability for oxidative rancidity (tables 1 and 2).

TABLE 2. EFFECT OF ENDPOINT TEMPERATURE ON COOKING LOSS, SHEAR VALUE AND STORAGE STABILITY OF PRECOOKED BEEF ROASTS

	Endpoint temperature (C)				
	45 (113 F)	50 (122 F)	55 (131 F)	60 (140 F)	65 (149 F)
Cooking loss, %	2.49^{b}	3.39^{bc}	6.30^{cd}	9.22^{d}	14.81^{e}
W-B shear, kg	4.57	4.56	4.66	4.63	4.66
TBA value[a]	1.04^{b}	1.21^{b}	1.35^{cd}	1.52^{d}	2.03^{e}
1 day	.87	.95	1.05	1.36	1.73
14 days	1.17	1.43	1.77	1.73	2.61
28 days	1.06	1.24	1.24	1.48	1.74

[a] TBA value = mg malonaldehyde/kg sample.

[a,b,c,d] Means in same row with a different superscript are different (P<.01).

Analysis of the trained sensory panel results (table 3) indicated that heating rate, endpoint temperature and the interaction of the two had no effect (P>.05) on any of the individual sensory traits examined. Warmed-over flavor was not detected by panelists in any of the treatments.

TABLE 3. EFFECTS OF HEATING RATE AND ENDPOINT TEMPERATURE ON SENSORY EVALUATION OF PRECOOKED BEEF ROASTS[a]

	Heating rate (min/C)					Endpoint temperature (C)				
Sensory traits	4	7	10	13	16	45	50	55	60	65
Flavor	5.41	5.86	5.41	5.73	5.75	5.73	5.68	4.56	5.58	5.73
Tenderness	6.48	6.16	5.98	5.93	6.60	5.96	6.26	5.93	6.54	6.45
Juiciness	6.56	6.8	5.88	5.99	6.31	6.33	6.04	6.09	6.09	6.28
Connective tissue	5.88	5.80	5.43	5.44	6.38	5.63	5.95	5.43	6.11	5.81

[a] Flavor (8 = extremely desirable; 1 = extremely undesirable), tenderness (8 = extremely tender; 1 = extremely tough), juiciness (8 = extremely juicy; 1 = extremely dry) and connective tissue residue (8 = none; 1 = very abundant).

Panel tenderness scores were consistent with shear values observed ($R^2 = -.6$). Sensory panel responses for juiciness were consistent with cooking loss results and indicated higher endpoint temperatures tended to reduce juiciness scores.

Panel ratings for connective tissue residue were also similar to shear force values observed ($R^2 = -.67$). Longer cooking times seemed to increase collagen shrinkage reactions in these roasts.

The low temperature long-term precooking treatments optimized cooking losses while maintaining the sensory traits of the beef roasts which were precooked in cooking bags and reheated with the microwave.

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