Development and Consumer Acceptance of Pre-cooked Lamb Leg Roasts[1]

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Summary

The objective of this study was to develop a palatable pre-cooked lamb leg roast. Lamb legs (n = 60) were fabricated into 240 roasts. Roasts were assigned to one of four spice treatments: control (CON), Italian, Mexican, prime rib. After being injected with a 15 percent brine mixture, roasts were smoked to an internal temperature of 63°C, vacuum packaged, and frozen at -10°C. Roasts were thawed and reheated one of three ways (conventional oven, microwave oven, or boiling) and served to a trained sensory panel to determine differences in reheating method. No differences ($P > 0.05$) were found between reheating methods. The trained panel rated the prime rib spice the juiciest, the most tender, the most flavorful, and the best in overall acceptability. The control treatment (CON) was rated higher ($P < 0.05$) for lamb flavor, warmed-over flavor, and flavor intensity by trained panelists. Upon completion of trained sensory panel, a consumer panel (n = 199) was served samples of roasts to determine the preferred spice blend. Consumers rated the prime rib spice the highest ($P < 0.05$) for all palatability attributes and the CON the lowest ($P < 0.05$). This study indicated the prime rib spice treatment was preferred most often for tenderness, juiciness, flavor, and overall liking by both the trained sensory panel and consumer panel. Therefore, roasts seasoned with the prime rib rub appear to have the most market potential.

Key words: Lamb, Pre-cooked Roasts, Flavor, Reheating Method

Introduction

With the ever-increasing trend of both men and women working outside of the home, the demand for a convenient, fast, palatable meal has been on the rise (Salvage, 1999). The red-meat industry, especially the beef and pork industries, has taken steps to develop products that are not only low in fat, but also quick, easy, and convenient to prepare to accommodate the changing lifestyles of consumers (Nayga, 1993). Between 1970 and 1989 red-meat consumption, especially lamb, in the United States fell by nearly 50 percent (Nayga, 1993). It is obvious that the lamb industry needs to regain market share and needs to find a way to rebuild consumer confidence for flavor and rebuke any negative past experience in lamb products.

The biggest change in retail markets between 1988 and 1998 was toward convenience items (Nunes, 1998). The field of ready-to-eat products has been expanded greatly over the past few years in order to meet the convenience demands of consumers. Today, consumers tend to be more inclined to pay for the convenience of a pre-cooked, ready-to-eat meal (Nunes, 1998). Unfortunately, little effort has been focused on pre-cooking lamb. Most supermarkets have a variety of ready-to-eat foods and frozen prepared foods ready for heating (Nayga, 1993), a pre-cooked lamb product seems to be economically marketable and sustainable. Therefore, the lamb industry needs a product that can gain market share in home-meal replacement to increase the consumption of lamb and reverse the negative opinion that some consumers have about the overall eating satisfaction of lamb. The objective of this study was to determine the most acceptable reheating method, and the spices and flavorings most acceptable with lamb to develop a palatable, convenient, pre-cooked lamb leg roast.

Materials and Methods

Preparing the Roasts

Lamb legs (n = 60) were purchased from Pak Marketing in San Angelo, Texas. The legs were transported to the Texas Tech University Meat Laboratory for further processing. First, the patella was removed from the legs. The legs were cut into four 3.81 cm roasts with a bandsaw for a total of 240 uniform roasts. The most anterior roast from each leg was labeled roast number one, the next was labeled roast number two, the next most anterior was labeled roast number three, and the most posterior was labeled roast number four for all 60 legs. All roasts were then trimmed free of any external fat, and the seam fat containing the poplitenal lymph node was removed. All roasts were injected with a 15 percent brine mixture of water, 0.50 percent phosphate, and 1 percent salt using a Gunther Pickler Injector (model P1632, Koch Supplies, Inc., Kansas City, Mo.). After the roasts were injected, they were allowed to drain for 10 minutes at 36°F. Three spice blends (Table 1) were formulated (60 roasts/spice blend), and 60 roasts were used as a control group. The roasts were randomly assigned within location (1 to 4) to one of four spice treatments: control (CON), Italian, Mexican, and prime rib. This ensured an equal number of roasts from each anatomical location per treatment. Immediately after all roasts were rubbed, they were cooked and smoked in a smokehouse (model 1000, Alkar Corporation, Lodi, Wis.) to an internal temperature of approximately 63°C to achieve a medium-rare degree of doneness (AMSA, 1995). The smoke cycle consisted of two stages. Stage 1 lasted for 1.5 h, with the dry bulb set at 65°C and the wet bulb set at 38°C for a relative humidity of 18.5 percent. Stage 2 was set to cook to an internal core temperature of 63°C, with the dry bulb set at 74°C and the wet bulb set at 60°C to equal a 50 percent relative humidity. After cooking, the roasts were chilled to 2°C, vacuum packaged, and frozen at -10°C.

Trained Sensory Panel

Trained sensory panel analysis was conducted on 120 roasts (30 roasts/treatment) to determine the ideal reheating method and to detect differences between spices for differing palatability characteristics. The roasts were thawed and reheated one of three ways (10 roasts/treatment/reheat method): conventional oven, microwave, and boiling to an internal temperature of approximately 63°C for each reheating method. A conventional oven was preheated to 163°C, four roasts were placed in an aluminum pan, and 250 mL of distilled water was placed in the bottom of the pan. Two roasts were placed on paper plates, covered with wax paper, and reheated in a microwave at 1100 watts for 3.5 min (model JES1036PWH, General Electric, Louisville, Ky.). Boiling involved placing each individual roast into unsealed cryovac bags and placing them into pots containing two liters of distilled water. After reheating, roasts were cut into 1 cm x 1 cm x 3.81 cm pieces, placed into serving pans, and kept at 60°C. Samples were served warm to a seven-member panel, trained as recommended by Cross et al. (1978). Panelists evaluated the samples based on an 8-point hedonic scale involving initial and sustained juiciness, initial and sustained tenderness, flavor intensity, characteristic lamb flavor, and overall acceptability (8 = extremely juicy, tender, intense, characteristic lamb flavor, and like extremely; 1 = extremely dry, tough, bland, uncharacteristic lamb flavor, and dislike extremely). Panelists also evaluated the samples for warmed-over flavor (WOF) based on a 5-point hedonic scale (1 = no WOF; 5 = extreme WOF). Samples were served under red lights to mask color differences, and pan-

Table 1. Ingredient list of three different spice blends and the percentage of each spice for lamb roasts.

Italian	Mexican	Prime Rib
Italian spice (37.5%)	Coriander (10.7%)	Prime rib rub[a]
Rosemary (6.25%)	Paprika (21.4%)	
Oregano (12.5%)	Garlic powder (14.4%)	
Savory (6.25%)	Ground pepper (21.4%)	
Ground pepper (37.5%)	Cumin (10.7%)	

[a] AC Legg Blend RF-04-161-000 (Calera, AL).

elists were given apple juice and water to cleanse their palates between samples. Results from the trained panel were used to determine the most appropriate reheating method for the consumer panel.

Consumer Panel

The remaining 30 roasts per treatment were used for a consumer panel to determine which spice blend was preferred. Consumers (n = 199) at the San Angelo Livestock Show and Rodeo were asked to participate in the study. The trained panel detected no differences between reheating methods for palatability traits. Therefore, a microwave was used for ease of resources to serve consumers. Roasts were thawed and then reheated for 3.5 min using an 1100 watt microwave (model JES1036PWH, General Electric, Louisville, KY). Roasts were then cut into 1.5 cm x 1.5 cm x 3.81 cm pieces, placed into serving pans, and kept at 60°C. Each consumer tasted samples from each treatment. Panelists tasted each sample to determine juiciness, tenderness, flavor, and overall liking (6-point scale from 1=like extremely to 6=dislike extremely). Also, panelists were asked their likelihood to buy the roast (5-point scale from 1=definitely would buy to 5=definitely would not buy) if it was available in a grocery store. After tasting all four samples, consumers were asked which sample they preferred the least and the most. Additionally, consumers were asked to answer demographic questions including: marital status, gender, ethnicity, age, household income level, and how many times they have consumed lamb in the last month.

Statistical Analysis

Individual legs were blocked and data from the trained sensory panel were analyzed using the GLM procedure of SAS (2003), as a 3 x 4 factorial design (three cooking methods and four spice blends) with individual roast as the experimental unit. Least-square means were computed for each dependent variable and statistically separated by pairwise t-test (PDIFF option of SAS) with predetermined α = 0.05.

Data from the consumer panel were analyzed using the GLM procedure of SAS as a completely randomized design with spice blend as the treatment and individual roast sample as the experimental unit. Least-square means were computed for each dependent variable and statistically separated by pair-wise t-test with predetermined α = 0.05. Also, comparisons of frequencies from consumer panelists' responses were tested for significance (α ≤ 0.05) using Chi-Square tests.

Results and Discussion

Trained Sensory Panel

No differences (P > 0.05) were found between roasts from each anatomical location for tenderness, juiciness, flavor intensity, characteristic lamb flavor, overall acceptability, and WOF. Also, no differences (P > 0.05) were found between reheating methods for initial and sustained juiciness and tenderness, flavor intensity, characteristic lamb flavor, overall acceptability, and WOF. This result is similar to that reported by Boles and Parrish (1990), who found the flavor of pre-cooked pork roasts did not deteriorate when reheated with a microwave. In contrast with the results of the current study, Lyon and Ang (1990) found pre-cooked chicken patties to vary in their off-flavor development when reheated in either a microwave or a convection oven. Those reheated in a convection oven had higher off-flavor intensities. This could be because lamb contains fewer polyunsaturated fatty acids, and the chicken patties were refrigerated and the roasts for this study were vacuum packaged and frozen. No differences (P > 0.05) for a spice x reheating method interaction were found for initial and sustained juiciness and tenderness, flavor intensity, characteristic lamb flavor, overall acceptability, and WOF. A significant difference existed between spices for initial and sustained juiciness and tenderness, flavor intensity, characteristic lamb flavor, overall acceptability, and WOF (Table 2). For both initial and sustained juiciness, prime rib was the juiciest (P < 0.05), followed by Italian, Mexican, and the CON. According to Romans et al. (2001), the addition of phosphates helps to maintain juiciness of the product. Therefore, no differences should have been detected between spices for juiciness since all roasts were injected with the same brine solution. Certain spices used in the blends could have helped to increase the products overall juiciness, particularly the extra salt in

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Table 2. Least square means and standard errors of sensory panel ratings for different spice blends.

Trait	CON[k]	Italian[l]	Mexican[m]	Prime Rib[n]	SEM
			Treatment		
Initial juiciness[e]	4.68[d]	5.46[b]	4.96[c]	6.52[a]	0.10
Sustained juiciness[e]	4.84[d]	5.76[b]	5.13[c]	7.15[a]	0.10
Initial tenderness[f]	6.00[c]	6.90[ab]	6.62[b]	7.05[a]	0.12
Sustained tenderness[f]	6.27[c]	7.23[ab]	6.94[b]	7.35[a]	0.11
Flavor intensity[g]	5.88[a]	4.85[b]	4.91[b]	4.89[b]	0.09
Lamb flavor[h]	5.94[a]	4.26[b]	4.30[b]	4.35[b]	0.19
Overall acceptability[i]	4.01[d]	6.19[b]	5.37[c]	6.84[a]	0.10
Warmed-over flavor(WOF)[j]	1.39[a]	1.01[b]	1.05[b]	1.00[b]	0.03

[abcd] Means in a row with different superscripts differ (P < 0.05).
[e] 1 = extremely dry; 8 = extremely juicy.
[f] 1 = extremely tough; 8 = extremely tender.
[g] 1 = extremely bland; 8 = extremely intense.
[h] 1 = extremely uncharacteristic; 8 = extremely characteristic.
[i] 1 = dislike extremely; 8 = like extremely.
[j] 1 = no WOF; 5 = extreme WOF.
[k] CON = Control.
[l] Italian = Italian spice, rosemary, oregano, savory, ground pepper.
[m] Mexican = Coriander, paprika, garlic powder, ground pepper, cumin.
[n] Prime rib = AC Legg Blend RF-04-161-000 (Calera, AL).

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the prime rib pre-mix. Prime rib was more tender ($P < 0.05$) compared to the Mexican and the CON; and the CON was the toughest ($P < 0.05$) when compared to other treatments for both initial and sustained tenderness. The most intense flavor, characteristic lamb flavor, and WOF were associated with the CON group when compared to other treatments ($P < 0.05$). This indicates that the spices and seasonings used covered up the natural lamb flavor and helped to prevent WOF. Smith et al. (1984) reported adding phosphates to pre-cooked roasts decreases the occurrence of an off-flavor development, and Boles and Parrish (1990) discovered when phosphates were added to roasts, they were more palatable. Prime rib was rated the most acceptable overall, followed by Italian, Mexican, and the CON group ($P < 0.05$).

Consumer Panel

The 199 consumers who participated in the study varied in demographic characteristics (Table 3). The percentages and numbers are based on all data provided; however, not all of the participants provided complete demographics. The most common ethnic groups represented were Caucasian and Hispanic totaling 98 percent, with Caucasian totaling 91 percent of the total consumers surveyed. American-Indian and other ethnic groups comprised the other 2 percent. Because of the overwhelming percentage of Caucasians in the study and the lack of ethnic diversity, the effect of ethnicity on consumer ratings was omitted.

Results from the consumer panel are similar to the results from the trained sensory panel for tenderness, juiciness, flavor, and overall liking of the spice blend treatments. Consumers rated the roast with the prime rib spice the most tender, most juicy, most flavorful, and the highest for overall liking ($P < 0.05$) compared to all other treatment groups (Table 4.) The CON treatment was rated less desirable ($P < 0.05$) for tenderness, juiciness, flavor, and overall liking compared with other treatments. Roasts with the prime rib treatment were rated the most likely to be purchased ($P < 0.05$) and CON roasts were rated the least likely to be purchased compared to

other treatments.

No differences ($P > 0.05$) in tenderness, juiciness, flavor, overall liking, and likelihood to buy between the treatments were found based on differences in demographic data. Combined responses for the upper three tenderness categories of like extremely (LE), like very much (LVM), and like slightly (LS) for the CON, Italian, Mexican, and prime rib treatments were 87.9 percent, 89.9 percent, 91.5 percent, and 94.9 percent, respectively. Prime rib was rated LE a greater percentage of the time ($P < 0.05$) compared to other treatments. No differences ($P > 0.05$) existed between treatments for LVM, dislike slightly (DS), dislike very much

(DVM), and dislike extremely (DE). For the bottom three categories combined, prime rib had the lowest total percentage (5 percent), followed by Mexican, Italian, and the CON at 9 percent, 10.1 percent, and 12.2 percent respectively.

The juiciness category also heavily favored the prime rib spice. Ninety-five percent of the responses for prime rib fell into the LE, LVM, and LS categories, while responses from the other three treatments were comprised mainly in the LVM, LS, and DS categories. Consumers chose LE a higher ($P < 0.05$) percentage of the time and LS and DS a lower ($P < 0.05$) percentage of the time for prime rib compared to the other three treat-

Table 3. Demographic characteristics of consumer panel.

Trait	No.[a] of consumers	Percent
Gender		
Male	132	67.01
Female	65	32.99
Marital Status		
Married	132	68.39
Single	61	31.61
Ethnicity		
Caucasian	179	90.86
Hispanic	14	7.11
American-Indian	1	0.51
Other	2	1.52
Age, yr		
18 to 25	45	22.96
26 to 35	34	17.35
36 to 45	48	24.49
46 to 55	46	23.47
56 to 65	19	9.69
Over 65	4	2.04
Household Income Level		
<$10,000	19	10.11
$10,000 to 14,999	4	2.13
$15,000 to 24,999	6	3.19
$25,000 to 34,999	36	19.15
$35,000 to 49,999	29	15.43
$50,000 to 74,999	43	22.87
$75,000 to 99,999	34	18.09
>$99,999	17	9.04
Lamb Consumption[b]		
0	141	72.31
1	30	15.38
2	14	7.18
3	5	2.56
4	3	1.54

[a] Not all consumers who participated in the study provided complete data.
[b] Number of times consumers have consumed lamb in previous month.

Table 4. Least square means and standard errors of consumer panel ratings for different spice blends.

			Treatment		
Trait	CON[f]	Italian[g]	Mexican[h]	Prime Rib[i]	SEM
Tenderness[d]	2.31[c]	2.01[b]	2.09[b]	1.69[a]	0.08
Juiciness[d]	3.06[c]	2.67[b]	2.84[b]	1.86[a]	0.08
Flavor[d]	3.03[c]	2.77[b]	2.59[b]	1.91[a]	0.08
Overall liking[d]	2.95[c]	2.71[b]	2.64[b]	1.90[a]	0.08
Likelihood to buy[e]	2.95[c]	2.71[b]	2.64[b]	1.93[a]	0.08

[abc] Means in a row with different superscripts differ ($P < 0.05$).
[d] 1 = Like extremely; 6 = Dislike extremely.
[e] 1 = Definitely would buy; 5 = Definitely would not buy.
[f] CON = Control.
[g] Italian = Italian spice, rosemary, oregano, savory, ground pepper.
[h] Mexican = Coriander, paprika, garlic powder, ground pepper, cumin.
[i] Prime rib = AC Legg Blend RF-04-161-000 (Calera, AL).

ments. Consumers chose DVM a higher percentage ($P < 0.05$) of the time for the CON compared to other treatments for juiciness.

Consumer panelist ratings for flavor percentages followed the same trend as juiciness scores. The top four categories combined comprised 88.9 percent, 94 percent, 92.5 percent, and 96 percent of the CON, Italian, Mexican, and prime rib responses, respectively. Prime rib received a higher ($P < 0.05$) percentage of responses for the LE category compared to other treatments. The Mexican spice received a significantly higher percentage of responses than the CON for the same category. Prime rib was chosen significantly fewer times for LS compared to other treatments and a lower (P < 0.05) percentage of the time for DS and DVM compared to the CON. No differences (P > 0.05) were found for the LVM and DE categories between treatments.

The percentages of consumer ratings for overall liking of different spice blends are presented in Table 5. Of the responses, 82.3 percent, 82.7 percent, and 82.5 percent fell into the LVM, LS, and DS categories for the CON, Italian, and Mexican spices, respectively, whereas LE and LVM constituted 79.9 percent of the responses for the prime rib. Prime rib had a higher percentage ($P < 0.05$) for LE compared to other treatments. The CON had a higher percentage for DVM compared to prime rib, and the CON, Italian, and Mexican were chosen a higher percentage ($P < 0.05$)

for LS and DS compared to the prime rib spice.

Therefore, the roast seasoned with the prime rib spice would be the most likely to sell in a grocery store setting for pre-cooked lamb roast. This was evident by the consumers rating of likelihood to buy a roast seasoned by each treatment. Prime rib results showed that consumers chose "definitely would buy" or "probably would buy" 77.9 percent of the time, compared to 38.1 percent, 42.4 percent, and 45.8 percent for CON, Italian, and Mexican spices respectively. "Probably would buy," "may or may not buy," and "probably would not buy" were the most common ($P < 0.05$) answers for the CON and Mexican spice.

While demographics had no significant effect on ratings for tenderness, juiciness, flavor, overall liking, and likelihood to buy; significant effects were found between demographics and which spice blend was preferred the most and the least. Married and single consumers each preferred the prime rib spice the most and the CON the least ($P < 0.05$) compared to other treatments. Males and females also each preferred the prime rib spice the most ($P < 0.05$) compared with other treatments. Males ranked the CON as being preferred the least ($P < 0.05$), followed by Italian and Mexican, and then by prime rib. All age groups from 18 to 65 preferred the prime rib spice ($P < 0.05$) over the other treatments. The 18 to 25 age group chose the prime rib spice fewer ($P < 0.05$) times as the least favorite compared to other treatments. All income levels preferred the prime rib spice higher ($P < 0.05$) than the other treatments except for the $10,000 to $14,999 and $15,000 to $24,999 groups, where no significant differences were found. No income level rated one particular spice as the least ($P > 0.05$) favorite over the other treatments. As income level rose, the percentage of consumers that preferred the CON the least declined, and the percentage that preferred the prime rib the least increased. This could be explained by the fact that people with higher incomes tend to consume lamb more often (Nayga, 1993), and therefore, prefer the natural flavor of lamb over stronger spices that override its flavor.

Table 5. Percentages of each rating by consumer panelist for overall liking of samples from different spice blends.

		Treatment		
Rating Scale	CON[c]	Italian[d]	Mexican[e]	Prime Rib[f]
Like extremely	7.6[b]	10.7[b]	12.6[b]	42.7[a]
Like very much	30.5	29.6	33.2	37.2
Like slightly	30.0[a]	40.3[a]	34.2[a]	13.1[b]
Dislike slightly	21.8[b]	12.8[b]	15.1[b]	4.0[a]
Dislike very much	8.1[b]	4.1[ab]	3.5[ab]	2.5[a]
Dislike extremely	1.0	2.6	1.5	0.5

[ab] Percentages in a row with different superscripts differ ($P < 0.05$).
[c] CON = Control.
[d] Italian = Italian spice, rosemary, oregano, savory, ground pepper.
[e] Mexican = Coriander, paprika, garlic powder, ground pepper, cumin.
[f] Prime rib = AC Legg Blend RF-04-161-000 (Calera, AL).

Implications

The results of this study revealed roasts from lamb legs can be processed and retailed as a pre-cooked product to increase the value of these primal cuts. Certain spices have the ability to mask general lamb flavor and improve palatability characteristics held in high regard to consumers. An advantage exists to marketing a pre-cooked lamb product that is palatable and convenient, especially one with prime rib spice. Results from the current study are in agreement with previous research showing tenderness and flavor to be the two most important factors for determining overall eating satisfaction in lamb. Overall, these products should improve the overall eating quality of lamb and appeal to a large number of new consumers.

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