DEVELOPMENT AND VALIDATION OF A VALUE- ADDED LAMB SHOULDER PRODUCT

Vander Wal L., Udomvarapont P., Thippareddi H., Kropf D., Kastner C., Boyle E., Phebus R., Danler R., Hunt M.
Food Science Institute, Department of Animal Sciences and Industry, Kansas State University, Manhattan, KS, 66502 USA

Background

Consumers and food service providers increasingly demand high-quality, convenient meal solutions, yet the food industry must meet these demands with a microbially safe product (Kuntz, 2000). Pasteurizing food products under vacuum conditions, followed by rapid chilling and storage in the same bag increases product yields, improves product flavor and nutrition, reduces aerobic spoilage bacteria, and reduces the risk of post-cooking contamination (Creed, 1998).

Vacuum-cooked refrigerated foods are inherently susceptible to microbial concerns due to formulation with few preservatives, non-sterilizing thermal processing, anaerobic environment to select for *Clostridium botulinum*, and the necessity of adequate refrigeration to prevent *C. botulinum* outgrowth (Creed, 1998). Despite these risks, many chilled pre-cooked beef and pork products are currently available in retail stores and continue to gain in popularity. However, lamb products have not experienced this same growth in retail or food service. In 2000, only 2- 3% of U.S. households purchased lamb, with average per capita consumption declining from 0.45 kg in 1980 to 0.32 kg in 2000 (Garrison, 2000). Negative flavor and texture experiences, lack of preparation knowledge, limited product availability, and high cost all contribute to the low consumption rates of lamb products (Young and Braggins, 1998).

Objectives

This study was designed to develop a sous vide-like processed lamb and sauce product and assess its quality and microbial safety.

Methods

Lamb shoulders were deboned, visible fat and connective tissue removed, and cut into pieces approximately 2.54 cm^3. Raw lamb (227 g) was combined with a commercial sauce (227 g) (Creative Seasonings) in cook-in bags, then vacuum packaged, and steam cooked at 85°C for 2 h or at 90°C for 1, 2, 3, 4, or 5 h. The cooked product was chilled from 54.4 to 4.4°C in < 5 h. Twelve trained sensory panelists assessed fork tenderness, initial tenderness, fiber breakdown, sheep meat aroma and flavor, and fat-like mouth coating of each lamb product and a commercial beef tips in gravy product as a comparison. Tenderness also was measured using Lee-Kramer Shear force.

A microbial validation study of the cooking, chilling, and refrigerated storage life of this product was conducted utilizing the time/temperature processing combination (90°C for 2 h) considered to produce the optimum sensory characteristics as well as a lower temperature process (85°C) for the same time period (2 h). The raw product was inoculated with *Clostridium sporogenes* PA 3679, a more heat-resistant surrogate organism than *C. botulinum* as an index of the thermal destruction of proteolytic *C. botulinum.* Each bag (raw, cooked at 85°C, or cooked at 90°C) was stomached (2 min), 25 g homogenized sample removed, and serially diluted with 0.1% peptone water (Difco). *Clostridia*-like organisms (CLO) in both inoculated and non-inoculated product were enumerated using Fung Double Tubes (FDT) (Ali et al., 1991) containing Tryptose Sulfite Cycloserine (TSC; Difco) agar. In the non-inoculated product, lactic acid-producing bacteria (LAB) were enumerated using Bacto™ Lactobacilli MRS agar (Difco) in FDT, aerobic plate counts (APC) were determined on APC Petrifilm™ (3M), and anaerobic plate counts (ANA) were enumerated utilizing APC Petrifilm™ plates incubated in a Brewer anaerobic jar.

Homogenized cooked product was inoculated with *Clostridium perfringens* and vacuum packaged into 5.1 x 7.6 cm cook-in bags. The product was heat shocked, then chilled logarithmically utilizing the USDA recommended chilling schedule (1.5 h from 54.4 to 26.7°C and 5 h from 26.7 to 4.4°C) or a slightly longer customized chill schedule. *C. perfringens* populations were enumerated using TSC in FDT as previously described (incubated 37°C for 8-12 h) both immediately after heat shock and after the two chilling cycles. Non-inoculated samples cooked at 90°C for 2 h were stored at 4 or 10°C for up to 150 days. CLO, LAB, APC, and ANA were enumerated every 30 days for each storage temperature utilizing the previously described methods. Pairwise differences were compared using Proc GLM of SAS (SAS, 1999).

Results and Discussion

Panelists were able to differentiate products cooked at varying times and temperatures (Table 1). Product cooked at 85°C for 2 h and a commercial beef product were described as "slightly tender". The products cooked at 90°C for 3, 4, or 5 h were considered "moderately" to "very tender", with those cooked at 90°C for 1 or 2 h being statistically intermediate in tenderness. Tenderness assessment using Lee-Kramer shear force followed a trend similar to panelist assessments. In addition to decreased product tenderness, products cooked at 85°C for 2 h and 90°C for 1 h had a "slightly perceptible" sheep meat aroma and taste. Products cooked at a higher temperature or for longer times had less perceptible sheep meat aroma and taste. Panelists detected a "just perceptible" fat-like mouth coating from the commercial beef product and a "slightly perceptible" mouth coating in all lamb products. Cooking at 90°C for 2 h was considered to produce the optimum product, both minimizing sheep meat flavor and providing product tenderness similar to the commercially available beef product.

Cooking the non-inoculated product at 85 and 90°C for 2 h reduced all microbial counts (CLO, LAB, APC, and ANA) to < 1.6 and <1.0 log CFU/g, respectively (Table 2). Cooking the *C. sporogenes* inoculated product at 85 and 90°C for 2 h reduced CLO by 0.51 and 1.37 log CFU/g, respectively. Grischy et al. (1983) reported that a 5 log reduction in *C. sporogenes* was equivalent to a 12 log reduction of the most heat resistant strain of *C. botulinum* (Type A- proteolytic). Using this rationale, the heating processes (85 and 90°C for 2 h) used would provide a 1.22 and 3.29 log CFU/g reduction of *C. botulinum*, respectively. Both chilling schedules met USDA performance standards of < 1 log growth of *C. perfringens* during chilling (Table 3). Antimicrobial ingredients (spices) present in the lamb and sauce product may have contributed to the 1 log CFU/g *C. perfringens* reduction in the shorter USDA recommended chilling schedule. Even under abusive storage conditions of 10°C, CLO remained below the detection limit (< 0.30 log CFU/g) and APC, ANA, and LAB remained below 1.1 log CFU/g throughout the 150 days of storage (Table 4).

Conclusions

The described process produced a "moderately tender" product with "just perceptible" sheep meat flavor, which favorably compared to a commercial beef product. The cooked product appears to be microbially safe at ≤ 10°C storage for up to 150 days.

Pertinent Literature

Ali, M. S., D. Y. C. Fung, and C. L. Kastner. 1991. Comparison of rapid methods for isolation and enumeration of *Clostridium perfringens* in meat. J. Food Sci. 56:367-370.

Creed, P. A. 1998. Sensory and nutritional aspects of sous vide processed foods, p. 57-88. *In*: S. Ghazala (ed.), Sous vide and cook-chill processing for the food industry, Aspen Publishers Inc., Gaithersburg, MD.

Garrison, B. 2000. Veal, lamb sales make producers say bah. Food Bev. Rep. (12):52.

Grischy, R. O., R. V. Speck, and D. M. Adams. 1983. New media for enumeration and detection of *Clostridium sporogenes* (PA3679) spores. J. Food Sci. 48:1466-1469.

Kuntz, L. A. 2000. New cuts on meat. Food Product Design. (6):113.

SAS. 1999. Statistical Analysis System User's Guide. SAS Institute Inc, Cary, NC.

USDA-FSIS. 1999. Performance standards for the production of certain meat and poultry products. FSIS Directive 7111.1. United States Department of Agriculture- Food Safety and Inspection Service, Washington, DC.

Young, O. A. and T. J. Braggins. 1998. Sheep meat odour and flavour, p. 101-130. *In* F. Shahidi (ed.), Flavor of meat, meat products and seafoods, 2nd ed. Blackie Academic and Professional, London, UK.

Table 1. Effect of cooking time and temperature on sensory and shear qualities (mean ± standard deviation) of lamb and sauce product[a].

Product	Lee-Kramer Shear[b]	Initial tenderness[c]	Sheep-meat taste[d]	Fat-mouth coating[e]
Commercial beef	$4.99^{x} \pm 0.41$	$4.02^{z} \pm 0.53$	$5.67^{w} \pm 0.25$	$4.93^{x} \pm 0.30$
85°C- 2 h	$4.53^{x} \pm 0.69$	$3.68^{z} \pm 0.69$	$4.03^{z} \pm 0.82$	$4.42^{y} \pm 0.47$
90°C- 1 h	$4.44^{x} \pm 0.96$	$4.72^{y} \pm 0.77$	$4.17^{yz} \pm 0.63$	$4.32^{y} \pm 0.41$
90°C- 2 h	$2.98^{y} \pm 0.32$	$4.98^{xy} \pm 0.58$	$4.41^{xy} \pm 0.51$	$4.39^{y} \pm 0.49$
90°C- 3 h	$3.13^{y} \pm 0.29$	$5.34^{wx} \pm 0.24$	$4.67^{x} \pm 0.57$	$4.45^{y} \pm 0.37$
90°C- 4 h	$2.50^{y} \pm 0.84$	$5.40^{w} \pm 0.33$	$4.68^{x} \pm 0.61$	$4.48^{y} \pm 0.39$
90°C- 5 h	$2.75^{y} \pm 0.38$	$5.50^{w} \pm 0.42$	$4.58^{x} \pm 0.59$	$4.35^{y} \pm 0.38$

[a] Means within a column with same superscripts are not different ($P > 0.05$).
[b] Energy (kg force/ g product). Meat pieces were randomly placed in the shear box.
[c] Trained sensory panel assessment. 1= least tender, 6= most tender
[d] Trained sensory panel assessment. 1= very strong taste, 6= no detection
[e] Trained sensory panel assessment. 1= very much, 6= no detection

Table 2. Effect of cooking temperature on microbial levels (mean ± standard deviation) in log CFU/g.[a,b]

		Internal product temperature	
Analysis (incubation conditions)	Raw	85°C	90°C
CLO- inoc (42°C for 30 h)	$5.48^{x} \pm 0.17$	$4.96^{y} \pm 0.16$	$4.10^{z} \pm 0.08$
CLO non-inoc (42°C for 30 h)	$1.60^{x} \pm 0.46$	$0.49^{y} \pm 0.20$	$< 0.30^{y}$
LAB (35°C for 48 h)	$5.54^{x} \pm 0.35$	$0.98^{y} \pm 0.33$	$0.47^{y} \pm 0.40$
APC (35°C for 48 h)	$5.92^{x} \pm 0.24$	$1.61^{y} \pm 0.15$	$0.79^{z} \pm 0.25$
ANA (35°C for 48 h)	$5.94^{x} \pm 0.46$	$1.53^{y} \pm 0.07$	$0.76^{z} \pm 0.15$

[a] Means within a row with same superscripts are not different ($P > 0.05$).
[b] Detection limit = 0.30 log CFU/g

Table 3. Mean *C. perfringens* (log CFU/g) before and after controlled chilling of thermally processed lamb and curry sauce from 54.5 to 26.6°C in 1.5 or 2 h and from 26.6 to 4.4°C in 5 h[a].

Chilling Time	After heat shock	After chilling
1.5/ 5 h	$2.94^{x} \pm 0.17$	$1.99^{y} \pm 0.11$
2/ 5 h	$2.80^{x} \pm 0.11$	$2.80^{x} \pm 0.17$

[a] Means within a row with same superscript are not different ($P > 0.05$).

Table 4. Effect of storage time and temperature on microbial levels in log CFU/g[a].

	Days post cooking					
	0	30	60	90	120	150
CLO-4°C	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
CLO-10°C	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
LAB-4°C	0.47	<0.30	<0.30	<0.30	<0.30	<0.30
LAB-10°C	0.47	0.43	<0.30	0.55	<0.30	<0.30
APC-4°C	0.79	0.7	1.06	0.73	0.99	0.88
APC-10°C	0.79	1.1	1.11	0.77	1.01	0.77
ANA-4°C	0.76	<0.30	0.4	<0.30	<0.30	<0.30
ANA-10°C	0.76	0.88	<0.30	0.33	0.52	<0.30

[a] Detection limit = 0.30 log CFU/g