Rapid processing systems for pork

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Introduction

The excision of muscles prior to chilling is of growing interest to the meat industry as a result of the concern for energy conservation. As the current trend toward high priced energy is likely to continue, economical processing systems will continue in their importance to the meat industry.

During the past three years, a series of studies have been conducted by researchers at the University of Georgia to develop and evaluate systems for the rapid processing of whole muscle pork cuts. Of specific interest was the development of systems which would reduce in-plant holding times while minimizing variations in quality and palatability.

Materials and Methods

Study I: Evaluation of conditioning systems for the production of hot processed pork

Freshly slaughtered pork carcasses were conditioned at 17°C for 4, 6 or 8 h prior to fabricating into primal cuts to determine the effects of conditioning time on the physical and sensory traits of boneless, vacuum packaged pork. The loins and shoulders were removed from each side and uniformly trimmed to a fat thickness of 0.64 cm and then completely deboned. Each loin was divided into two equal segments which were randomly assigned to either a 14 or 21 d storage period. All of the shoulders were deboned and stored for a 21 days. Prior to storage, all cuts were vacuum packaged in shrinkable barrier bags using a Multivac type AG500 machine with a setting of 5.5. The cuts from the left side of each carcass were chilled in a conventional cooler (0°C) while cuts from the right side were brine chilled (-8°C) for approximately 45 minutes. After chilling, all cuts were held in a 0°C cooler for the duration of the storage period.

Study II: Comparison of hot processing systems for pork

Twenty-four market weight hogs (100 kg) were slaughtered and randomly assigned to postmortem treatments of 1, 2, 3 or 4 h at 17°C to determine if an acceptable fresh pork product could be produced from carcasses conditioned 4 h or less. Immediately after slaughter, the subcutaneous fat covering the left loin of each carcass was trimmed to 0.64 cm in order to determine the effects of fat cover during conditioning on the physical and sensory characteristics of the products. At the end of each conditioning period, the sides were fabricated into boneless loins and shoulders. The boneless loins were cut in half, vacuum packaged and randomly assigned to either a 7 or 14 d storage period. The shoulders were vacuum packaged and stored for 21 d at 0°C. All cuts after vacuum packaging were held in a -1°C cooler for 18 h prior to being placed in the 0°C storage cooler.

Study III: Physical and sensory attributes of stimulated (ES) and non-stimulated (NS) pork whole muscle cuts.

Boneless loins and shoulders were obtained from 12 ES and 12 NS carcasses to determine the effects of electrical stimulation on the physical and sensory traits of vacuum packaged pork. ES carcasses were pulse stimulated (1.9 s on, 1.5 s off) with 550V, 5.5A for 105 s. The ES left sides (ESHP) were deboned 1 h postmortem, vacuum packaged and brine chilled to 3°C while these right sides (ESCP) were conventionally chilled (2°C) for 24 h then deboned and vacuum packaged. For the nonstimulated (NS) carcasses, the left sides (NSHP) were conditioned at 17°C for 3 h, deboned, vacuum packaged and brine chilled to 3°C. The right sides (NSCP) were chilled (2°C) for 24 h then deboned and vacuum packaged. All cuts were stored at 0°C for 21 d.

Study IV: Evaluation of whole muscle cuts from stimulated (ES) and non-stimulated (NS) carcasses.

The primary objectives of this study were to determine the effects of ES and conditioning treatments on the physical and sensory characteristics of whole muscle cuts. Fifty-four market weight hogs (100 kg) were slaughtered using conventional methods and randomly assigned to one of the following treatments: (a) debone 30 m postmortem, vacuum package; condition (17°C) for 3 h, debone, vacuum package; (c) ES (550V, 5.5A, 30 s) within 10 min postmortem, debone 1 h postmortem or 24 h postmortem, vacuum package; (d) conventionally chilled (2°C) for 18 h, debone, vacuum package. Following vacuum packaging, all cuts were chilled in a glycol chiller (-2°C) to an internal temperature of 3°C. The boneless loins, top and bottom hams were then boxed and held for a 21 d storage period (°C).

In each of these studies, samples were evaluated for percentage purge, thaw loss and cook loss and cumulative loss upon completion of each storage period. In addition, loin chops were obtained for sensory evaluation by 5 member trained panel. For sensory evaluation, all chops were cooked on open face broilers units to an internal temperature of 70°C. Samples were evaluated for flavor, juiciness, tenderness and overall desirability using 8 point rating scales (1 = extremely dry, tough, undesirable; 8 = extremely juicy, tender, desirable).

Results and Discussion

Study I

Mean values for percentage purge in boneless loins and shoulders were not significantly affected by conditioning time or length of storage (Table 1). However, significant differences in percentage purge were noted between cooler and brine chilled loins. Brine chilled loins exhibited significantly higher levels of purge than the cooler chilled loins. These differences may be the result of freezing and thawing which occurred in the brine chilled loins. During brine chilling, the external surface of the loins were crust frozen and stabbed as the internal temperature of the loins equilibrated to 0°C during storage.

Percentage thaw loss (Table 1) was not significantly influenced by conditioning or storage time. However, thaw losses were greater ($p < .05$) for chops from cooler chilled loins than brine chilled loins. No differences were noted for cooking losses when stratified by conditioning time, chill method or length of vacuum storage. Similarly, no differences were noted in cumulative losses which indicated that total losses when measured from the point of fabrication to the point of consumption were not affected by the variables observed in this study.

Sensory traits of flavor, juiciness, tenderness and overall desirability were not significantly influenced by conditioning time, chilling method or length of storage. These findings indicate that conditioning beyond 4 h postmortem does not improve the acceptability of these traits.

Study II

Boneless loins and shoulders from carcasses conditioned at 17°C for 3 h exhibited lesser amounts of purge than those from carcasses conditioned either 1 or 4 h (Table 2). The highest numerical values for purge were associated with these cuts from carcasses of the latter two conditioning periods. These findings suggest that high levels of purge may be expected when cuts are removed from carcasses conditioned at 17°C at less than 2 h or beyond 3 h postmortem. Sarcomere lengths were the shortest (1.6 u) for loins from carcasses conditioned for 1 h which indicated that the adverse affects of cold shortening were present after 1 h of conditioning at 17°C. The 4 h conditioning period may create a condition similar to that noted in the development of PSE which may explain the higher levels of purge. It was also observed in this study that percentage purge increased with time in storage (7 d x = .9, 14 d x = 1.4; data not reported in tabular form).

Values for percentage thaw loss were significantly affected by length of conditioning time (Table 2). Chops obtained from carcasses conditioned either 1 or 4 h exhibited the highest levels of thaw loss. Chops from the 3 h conditioning period exhibited the lowest levels of cook loss and cumulative weight loss.

It was also noted in this study (data not presented in tabular form) that the removal of subcutaneous fat did not significantly influence any of the observed traits. In addition, sensory ratings for all of the chops were rated very desirable.

Study III

Mean values for percentage purge of the boneless loins were significantly affected by processing treatment (Table 3). Loins from the ESCP carcasses exhibited significantly greater purge levels than loins from the other processing treatments. The high purge levels may have been due to the low pH and high muscle temperature observed for these carcasses. At 1 h postmortem, the average pH for these carcasses was 5.5. while the muscle temperature was 40.2°C. This may have created a PSE type condition in the muscle. No differences due to processing treatment were noted for the boneless shoulder cuts. No significant differences were noted for either percentage thaw loss or cook loss, however, values for cumulative weight loss were much lower ($p < .05$) for loins from the NSCP carcasses.

Sensory panel traits were influenced ($p < .05$) by processing treatment in this study. Chops from the ESCP carcasses exhibited the least desirable ratings for flavor, juiciness, tenderness and overall desirability. In general, chops from nonstimulated carcass were considered more tender than those from stimulated carcasses. These findings indicate that processing systems employing electrical stimulation and cold boning may result in meat with an undesirable quality.

Study IV

Mean values for percentage purge for the four primal cuts evaluated are reported in Table 4. Purge values for knuckle cuts were not significantly influenced by processing treatment, which suggests that this cut may not be useful in studies designed to evaluate factors affecting purge levels. Values for percentage purge were significantly affected by processing treatment in the other three cuts evaluated. In general, loins and bottom and top ham cuts from carcasses that were electrically stimulated and cold processed (ESCB) exhibited the highest levels of purge. While hot processing systems utilizing the 11°C and 17°C conditioning treatments (HB-11°C, HB-17°C) did not consistently produce the lowest purge values for every cut, in general, lower purge values were observed when compared to the other treatments.

Values for percentage thaw loss and cook loss were also affected by processing treatment; however, none of the processing treatments evaluated consistently produced the highest or lowest values. It is important to note that even though differences in thaw and cooking losses existed, no significant differences in cumulative weight loss were noted.

Processing treatment did not significantly influence any of the observed sensory traits with the exception of juiciness. Chops from ESCB carcasses exhibited the lowest values for this trait. Otherwise, chops from the other processing treatments were rated highly acceptable for all observed sensory traits.

Conclusions

1. The use of brine chilling systems which induce crust freezing may result in higher levels of purge in vacuum packaged pork.
2. Processing systems employing electrical stimulation and cold boning appear to be undesirable for the processing of pork.
3. The use of electrical stimulation coupled with hot boning resulted in products similar to those from conventionally processed pork.
4. Of the systems evaluated, hot processing systems employing a 11°C or 17°C conditioning period were rated as the best systems for the accelerated processing of pork.
5. Hot processing appears to be a feasible method of producing very palatable, high quality pork cuts.

Bibliography

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Table 2. Study II - Mean values for percentage purge, thaw loss, cook loss and cumulative loss for loin chops produced by different conditioning times at 17°C.

Conditioning time (h)	Purge loss	Thaw loss	Cook loss	Cumulative loss[a]
1	1.3[b]	4.3[b]	24.9[b]	30.8[b]
2	1.1[bc]	2.8[c]	24.2[b]	28.2[bc]
3	0.9[c]	3.1[bc]	20.8[c]	25.1[c]
4	1.4[b]	4.4[b]	24.4[b]	30.2[b]

Miller et al., 1984.

[a] Cumulative loss = purge (%) + thaw loss (%) + cook loss (%)

[b] Mean values within the same column bearing unlike superscripts differ $p < .05$

Table 1. Study I -- Mean values for percentage purge, thaw loss, cook loss and cumulative loss of hot processed, vacuum packaged pork primals stratified by conditioning time, chill method and length of storage.

Treatment variable	Purge %		Loin		
	Loins	Shoulders	Thaw loss	Cook loss	Cumulative loss
Conditioning Time (h)					
4	1.4	1.1	5.7	34.5	41.7
6	1.8	0.8	4.8	35.3	41.9
8	1.5	1.0	5.6	34.0	41.1
Chill Method					
Cooler	1.3[a]	0.9	6.1[a]	34.6	41.9
Brine	1.8[b]	1.1	4.8[b]	34.6	41.2
Storage Time (d)					
14	1.4	-	5.6	35.0	42.0
21	1.7	0.9	5.2	34.2	41.1

Wynne, 1980.

[a,b] Means in the same column within the same treatment variable bearing unlike superscripts differ significantly.

Table 4. Study IV -- Mean values for percentage purge, thaw loss, cook loss and cumulative loss of certain boneless, vacuum packaged pork primals stratified by processing treatments.

Processing[a] treatment	Purge (%)				Thaw loss (%)	Cook loss (%)	Cumulative loss (%)
	Loin	Ham			Loin	Loin	Loin
		Knuckle	Top	Bottom			
HB - 11°C	2.1[b]	1.6[b]	2.3[bcd]	1.2[d]	11.5[b]	27.7[bc]	39.2[b]
HB - 17°C	2.1[b]	2.3[b]	2.1[d]	1.7[cd]	10.5[bc]	25.2[c]	35.8[b]
NS-CB	2.6[bc]	2.0[b]	3.1[b]	2.8[c]	10.0[bc]	26.5[c]	36.4[b]
ES-HB	2.7[bc]	1.6[b]	2.2[cd]	2.1[c]	8.7[cd]	30.9[b]	39.6[b]
ES-CB	3.0[c]	2.0[b]	3.0[bc]	3.1[b]	7.6[d]	29.3[bc]	35.9[b]

Reagan and Honikel, 1984.

[a] HB-11°C = debone 30 m PM, condition at 11°C for 5 h; HB-17°C = condition carcass at 17°C for 3 h, debone; CB-NS = chill carcass at 0°C for 18 h, debone; ES-HB = pulse stimulate 550V (on 2 s, off 1 s), 5.5A for 30 S at 10 m PM, debone 1 h PM; ES-CB = same stimulation as ES-HB, debone after 18 h chilling at 0°C.

[b,c,d] Mean values in the same column bearing unlike superscripts differ significantly ($p < .05$).

Table 3. Mean values for percentage purge, thaw loss, cook loss and cumulative weight loss of boneless loins and shoulders from stimulated (ES) and nonstimulated (NS) carcasses.

Processing treatment[c]	Purge %		Loin		
	Loins	Shoulders	Thaw loss	Cook loss	Cumulative loss
NSHP	4.3[a]	1.7[a]	3.9[a]	27.2[a]	35.4[ab]
NSCP	3.7[a]	1.7[a]	3.9[a]	25.6[a]	33.3[a]
ESHP	3.6[a]	1.2[a]	3.7[a]	28.0[a]	35.6[ab]
ESCP	5.9[b]	1.9[a]	3.5[a]	28.4[a]	37.8[b]

Wiley et al., 1984.

[a,b] Means in the same column bearing unlike superscripts differ significantly ($p < .05$).

[c] NSHP = nonstimulated, conditioned 3 h at 17°C deboned; NSCP = nonstimulated, chilled 24 h at 0°C deboned; ESHP = electrically stimulated (pulsed, 550V, 104 s), deboned 1 h postmortem; ESCP = electrically stimulated (pulsed, 550V, 105 s), chilled 24 h at 0°C, deboned. Hot processed (HP) were chilled to 3°C in a -4°C brine chiller.