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High Temperature Processing of Pork: A Review

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Meat processing procedures have traditionally incorporated the post-mortem chilling of carcasses prior to disassembly and the processing of cuts and products. Under these procedures, marketable products require processing times of 2 to 14 days before shipment. Only in the past few years has concern been accorded the possibility of processing carcasses and products prior to initial chilling.

Recent advances in processing techniques have suggested the feasibility of processing pork carcasses, cuts and products prior to initial chilling. Provided that yields and quality can be maintained, considerable reduction of overhead costs through reduced refrigerator storage space, smaller inventories, reduced handling and shorter processing times could result from the application of this processing technique.

Historical

Preliminary reports from Oklahoma State University (Henrickson, 1965) indicated that hams processed by three rapid methods (15, 95, 119 h) were equal in quality to conventionally processed hams. Results of moisture and shear press tests showed that the hams also were as juicy and tender as hams from the same carcasses processed conventionally.

Cozart (1965) indicated that eye appeal of hot processed pork equalled that of the conventionally processed pork. While the loins of the carcasses cut hot were not quite as smooth as those cut cold, differences were not as evident in the retail cuts. Hot processed hams had virtually the same shape as conventionally processed hams and could be shaped more easily for consumer appeal. Preliminary opinion of the Oklahoma researchers was that hot processed pork could compare favorably with the normally processed product.

Virgil and Paul Vogel (Anon., 1965) patented a processing and packaging technique which provides for hot boning, processing and freezer storage of pork sausage in less than 1½ h after slaughter. Hot carcasses are transferred directly from the kill floor and boned within 45 min (internal temperature 38°C). Grinding, batching, seasoning, mixing and stuffing are accomplished within a ½ h interval with product temperature at not less than 32°C. Stuffing of the product in a warm and fluid state tends to consume any oxygen which might be entrapped within the casing. Evaluation of oxidative rancidity by determination of the peroxide and thiabarbituric acid (TBA) values suggest maintenance of quality over extended storage periods. Microbiological analyses of samples indicated the predominant organisms to be lactic acid bacteria, organisms associated with souring rather than putrefactive or rancid spoilage.

Accelerated Pork Processing

Accelerated pork processing, as referred to by Mandigo (1967), refers to the completion of all in-plant processing steps prior to the initial chilling of the pork product. This system was designed to accelerate in-plant processing and to eliminate unneeded processing steps.

The schematics of the system for fresh pork cuts are presented in Figure 1. Procedures for the slaughter and preparation of carcasses for the cooler remain unchanged. Accelerated processing commences at the point where carcasses would normally be placed in the cooler for chilling. Using this time as a base, comparison of the two procedures can be made. With the conventional system, one hour is allowed for effective chilling to start and 24 h for carcass chilling. Thus, under the conventional system, carcasses may be cut and prepared for shipment after 25 h. With accelerated processing, the initial chilling is omitted and carcasses are cut and ready for subsequent chilling within two hours. Chilling of fresh pork cuts requires up to two hours; consequently, the product is ready for shipment within four hours from slaughter. Hence, under the accelerated system there is a considerable saving in processing time and in addition, the product is immediately available.

Comparison in preparation of cured meat products by the two methods is shown in Figure 2. Procedures are identical to those observed in the fresh meat scheme through the disassembly operations. Pumping of the cure takes place after 26 h post-mortem in the conventional system and two hours post-mortem in the accelerated system. Although considerable variation may be observed in the industry, a three

Figure 1. Flow Diagram for Fresh Cuts

FRESH CUTS

CONVENTIONAL	Time Lapse (Hour)		ACCELERATED
SLAUGHTER	0	0	SLAUGHTER
CHILLING	1	0	
CUTTING	25	1	CUTTING
		2	CHILLING
SHIPMENT	25	4	SHIPMENT

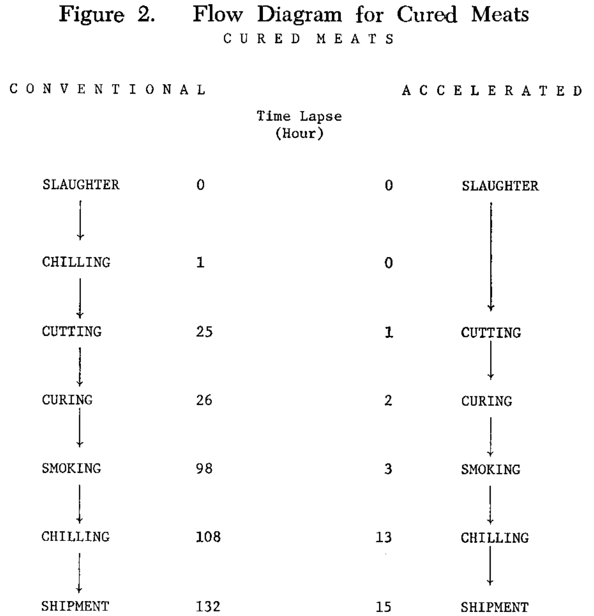
Mandigo, R. W. (1967)

day curing time is used here as an example of a conventional processing time. For the accelerated processing system, one hour curing time is allowed prior to placing the hams into the smoke house. An identical cooking and smoking time of 10 h was allowed for both systems. Chilling times of 24 h and two hours were designated for the conventional and accelerated systems, respectively. Thus, under the Nebraska system (Mandigo, 1967), the total processing time in the conventional system is 132 h as compared to 15 h for the accelerated system.

Cured Products

Preliminary studies on the effect of processing method on the yield and quality of ham have been reported from various stations. Weiner *et al.* (1966) reported that conventionally processed hams had significantly higher cooking and drip losses than hams processed within one hour post-mortem. Mandigo and

Figure 2. Flow Diagram for Cured Meats



Mandigo, R. W. (1967)

Henrickson (1966) reported no significant differences in yield, moisture content or juiciness of ham processed hot or conventionally. Studies at Minnesota (Davidson *et al.*, 1968) failed to detect any significant differences in processing weights, processing shrinkage weights, and percent processing shrink of the cured and smoked hams from hot or conventionally processed carcasses (Table 1).

Analysis of variance data (Davidson *et al.*, 1968) for proximate chemical composition comparisons of the cured and smoked semimembranosus and biceps femoris muscles (Table 2) failed to demonstrate any significant differences in percentages of moisture, protein, ash or salt attributable to the post-mortem treatment of the carcasses. Similarly, Warner-Bratzler shear values and expressible moisture ratio values

Table 1. Mean weights and processing yields of cured and smoked hams from hot and chilled pork carcasses.

	Chilled	Hot	Difference[a]
Green weight, kg.	8.55	8.65	—.10 ns
Final weight, kg.	8.41	8.52	—.09 ns
Processing[b] shrink, kg.	1.08	1.08	.00 ns
Processing[c] shrink, %	11.31	11.21	.10 ns

[a] Chilled value minus hot value.
[b] Pumped weight minus final weight.
[c] Percent of pumped weight.
Davidson, et al. (1968)

of these muscles did not suggest a significant advantage for either processing method. These findings largely agree with those of Mandigo and Henrickson (1966) who reported nonsignificant differences in Warner-Bratzler shear values between hot and conventionally processed hams.

Pulliam and Kelly (1965) made bacteriological comparisons of hot processed and normally processed hams. Prior to smoking, total bacterial counts were found to be significantly greater in the hot processed hams. Smoked ham counts were low regardless of the processing method employed. Coliform counts were less than one per g of tissue in unsmoked and smoked product by both processing methods. Barbe *et al* (1967) noted that while the incidence of aerobic bacteria in rapid processed hams was comparable to that of the conventionally processed product, greater reduction in total bacterial numbers was obtained with the rapid processing techniques. Generally, counts at mesophilic temperatures obtained from hot processed ham samples were similar to those obtained from the conventionally processed. Incubation of plates at psychrophilic temperatures generally resulted in erratic and low counts. Incidence of coliform bacteria in both treatments was extremely low in the fresh samples

Table 2. Comparison of some chemical and physical properties of cured and smoked **semimembranosus** and **biceps femoris** muscles from hot and conventionally processed hams.

	Chilled	Hot	Difference[a]
Moisture, %			
Semimem.	69.65	69.50	0.15 ns
B. femoris	70.48	70.15	0.33 ns
Protein, %			
Semimem.	23.15	22.97	0.18 ns
B. femoris	22.71	22.77	—0.06 ns
Expressible moisture ratio			
Semimem.	3.32	3.28	0.04 ns
B. femoris	3.22	3.14	0.08 ns
Warner-Bratzler shear value, 1b.			
Semimem.	9.00	8.80	0.20 ns
B. femoris	15.68	15.08	0.60 ns

[a] Chilled value minus hot value.
ns = Not significant at ($P < .05$).
Davidson, et al (1968).

Table 3. Peroxide numbers of fresh pork sausage from hot and chilled pork carcasses.

	Chilled	Hot	Difference[a]
Peroxide No.			
0-Day	0.79	0.88	−0.09 ns
10-Day	1.81	1.35	0.46 **
20-Day	6.25	2.45	3.80 **

[a] Chilled value minus hot value.
** Difference significant ($P<.01$).
Davidson, et al (1968).

and was subsequently reduced to less than one coliform per g by both processing methods.

Studies by Mandigo and Henrickson (1967) indicated that shorter but wider bacon slabs were characteristic of accelerated processed bellies. Shape differences between conventionally and accelerated processed bacon were not reflected in yield comparisons from the two methods. Essentially no differences were found between the pumped weight, cold smoked weight, number of full slices, or weight of sliced bacon from the hot or cold processed bellies.

Fresh Pork

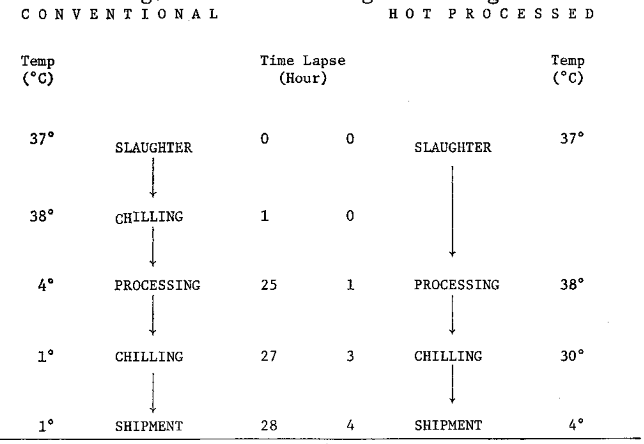
The influence of method of cutting on the quality of fresh pork loins has been investigated by Moore *et al* (1966). Using four-inch loin samples from each side of 40 barrows, they did not detect any significant differences in thaw loss, cooking loss, residual moisture or shear force values attributable to the particular method of cutting (hot vs. cold processing). Weiner *et al* (1966) reported that muscles from loins removed within one hour post-mortem and chilled had significantly lower shear values than controls. Processing loins within one hour post-mortem had no significant effect on cooking losses, ether extract or total moisture of the loins. However, loins removed within one hour post-mortem and subsequently frozen had significantly higher shear values and expressible moisture values than control loins chilled 48 h at 0-2°C before freezing. It was postulated that results obtained for frozen loins may parallel the phenomenon of "thaw rigor" described by Perry (1950). While freezing temperatures were employed by Moore *et al* (1966), the time the loins were subjected to −62°C was only sufficient to permit surface refrigeration to carry the internal temperature below 5°C by tempering.

Previously reported differences in appearances of conventionally and accelerated processed pork loins (Cozart, 1965) have been partially compensated for by specially designed loin molds which facilitate shaping of the loin and improve the appearance of the fat covering.

Pork Sausage

An evaluation of fresh pork sausage prepared by the hot processing method was reported by Davidson *et al* (1968). Subsequent to slaughter, the left sides of hog carcasses were disassembled and processed. Right sides of carcasses were held intact and chilled for 24 h at 2°C prior to identical disassembly and processing (Figure 3). Boston butts, picnics, jowls and bellies were removed from their respective side at the appropriate times (0 and 24 h, post-slaughter) for use

Figure 3. Pork Sausage Processing



in fresh pork sausage. Cuts were skinned, boned, ground seasoned and stuffed in 1 lb bags within 1½ h after after slaughter or chilling. Product temperature of sausage designated as "hot processed" was always 30°C or more during the stuffing process. Packages were chilled 1 h at −23°C in an air-circulated freezer to an internal temperature of approximately 4-7°C. In the conventionally processed sausage, internal product temperature following the 1 h chilling period at −23°C approximated −2 to 1°C.

Statistical comparisons of proximate chemical composition data for fresh pork sausage did not reveal any significant differences in moisture, protein, ether extract, ash and salt contents due to processing the hot or chilled carcasses into pork sausage.

Possible effects of post-mortem processing treatments of pork carcasses on formation of peroxides during storage of fresh pork sausage may be reflected in a comparison of their peroxide values (Table 3). Significantly greater peroxide values ($P<.01$) were observed in the conventionally processed pork sausage after 10 and 20 days of storage. These findings are in agreement with reported advantages of hot processing of pork carcasses for sausage production and might be attributed to the physical state of the respective product when stuffed (Anon., 1965).

Comparisons of mean mesophilic and psychrophilic counts of hot and conventionally processed pork sausage are presented in Table 4. Generally, average mesophilic counts from hot processed sausage samples

Table 4. Comparison of mean bacterial counts of fresh pork sausage from hot and chilled pork carcasses[a].

Period	Mesophilic[b]		Psychrophilic[c]	
	Chilled	Hot	Chilled	Hot
0-Day	3.58**	3.78**	2.12	2.46
5-Day	3.47**	3.63**	2.30	2.63
10-Day	3.57*	3.85*	3.02	3.14
15-Day	3.79	4.10	4.05**	4.80**
20-Day	4.19*	4.59*	4.67*	5.30*

[a] Values expressed as log of number per g fresh sausage.
[b] Plates incubated at 32°C for 48 h in Bacto APT agar.
[c] Plates incubated at 2°C for 14 days in Bacto APT agar.
* Differences significant ($P<.05$).
** Differences significant ($P<.01$).
Davidson, et al (1968).

were significantly greater than those obtained from conventionally processed samples. Similarly, average psychrophilic counts of hot processed sausage at 15 and 20 days of storage were significantly greater than counts of conventionally processed sausage at equivalent storage times. These findings tend to be in agreement with those of Pulliam and Kelly (1965) who reported that prior to smoking, bacterial counts of hot processed hams were significantly greater than counts from normally processed hams. In agreement with the findings of Barbe *et al* (1966), coliform counts of all samples were somewhat erratic but generally low.

Conclusions

While the concept of hot processing of carcasses is not new its adaptation to fresh and processed pork products on a commercial scale is essentially an innovation of the past few years. Past and current research in the area clearly indicates that under experimental conditions, the yields and quality of pork products can be maintained. However, only through actual packing plant testing and application can the true merits and economic feasibility of the technique be accurately assessed.

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