Crossbred dams with three-line cross litters were superior to the average of the three purebred lines for 10 of the 13 traits studied. Significant differences were obtained for 8 of the 10 traits. These traits were live pigs farrowed per litter (0.8 pig), birth weight (0.10 lb.), litter birth weight (4.0 lb.), pigs weaned per litter (1.0 pig), survival rate (6.2 percent), litter 56-day weight (47.1 lb.), carcass length (0.5 in.) and carcass backfat thickness (-.02). Purebred pigs were superior for average daily gain (0.05 lb./day), feed efficiency (0.05 lb. feed/lb. gain) and loin eye area (0.15 sq. in.).

Crossbred dams with crossbred pigs were definitely superior to purebred dams with crossbred pigs for 5 of the 12 traits studied. These traits were number of live pigs farrowed per litter (1.0 pig), pig birth weight (0.13 lb.), litter birth weight (3.8 lb.), litter 56-day weight (41.1 lb.) and carcass backfat thickness (—.06 in.). Crossbred pigs from purebred dams were significantly superior to crossbred pigs from crossbred dams only for average daily gain.

Pork Can Be Processed Before Chilling

R. L. Henrickson

It is well to have meat animal production efficiency but unless slaughtering and processing are also efficiently accomplished, the whole industry is placed in jeopardy. The actual reversal of physical movement of product in its trip through a plant is wasteful. These plant inefficiencies could be called "thermal backtracking", since many cuts are chilled and reheated.

When it is considered that more than 70 percent (ham, picnic, belly, butt, and fat) of the carcass will be heated to a temperature in excess of 137°F (58.3°C), it seems desirable to critically examine the existing processing method. Particularly when the original body temperature of the hot carcass is approximately 102°F (38.8°C) and is chilled down to a temperature of 35°F (1.7°C) for cutting. Chilling, reheating, and rechilling tons of pork (10,736,000,000 lbs. Federally Inspected) annually is not only costly, but adds time and opportunity for fat oxidation and microbial contamination to occur. Under present processing procedures it takes 12 to 18 hours of refrigeration to reduce the carcass temperature below a harmful bacteria level. The carcass is then cut and moved back through the bacterial incubation zone for smoking and cooking.

It is well established that hot muscle has excellent binding properties and is desirable in sausage manufacture. In addition, there appears little reason to chill fat before it is rendered for lard.

Cutting "hot pork carcasses" could help the processor by reducing inventory costs. Part of the inventory would remain in the pen and reduce the need for expensive refrigerated storage. The amount of chilling space would be reduced since fat, bone and skin would not be refrigerated. Therefore, plant operation would become more efficient and output increased. However, before continuous processing of warm carcasses can be termed commercially feasible, it will be necessary to provide an end product of desired quality. New equipment must be designed, constructed, and developed. Existing equipment and plant facilities will need modification. Labor requirements and large volume testing of the new concept will be necessary before the process will be adopted by the food industry.

This work was initiated to compare the quality of pork products processed to a finished form prior to initial chill with products processed after an initial chill.

Materials and Methods

Eighty barrows of similar breeding, age, and weight (91 Kg) when slaughtered were used in these studies. The animals were slaughtered according to the methods and practices currently used in the industry. Following bleeding, scalding, dehairing and eviscerating, the carcasses were split and washed prior to assignment to the alternate processing treatments. Pre-chill processing involved removal of the wholesale parts and processing the cuts within 30 minutes after slaughter. The warm cuts were trimmed free of excess fat and chilled in a blast freezer at —62°C until the center temperature reached 10°C, then tempered in a room at 1.7°C. Post-chill processing involved a 24 hour chill period at 1.7°C prior to any cutting or processing. Processing of the chilled cuts was the same as for the pre-chill pieces.

The hams were removed from the hot carcass (internal temperature 1.7°C), defatted, injected with brine to 110% of green weight, boned, and inserted into fibrous casing, placed directly into forming molds, heated, and smoked. Chilling the hot ham was accomplished at —62°C, until the internal temperature reached 10°C, followed by tempering to a temperature of 1.7°C. Samples for detailed physical, chemical, histological, and microbiological studies were taken at appropriate points in the processing.

Results and Discussion

The processing of pork products to a finished form prior to initial chilling appears to have many feasible applications to present fabrication techniques. Adaptation of all or part of the process by industry will, however, likely be slow since some change in equipment and plant layout will be needed. While the pliable nature of the warm meat will facilitate processing at some points in the fabrication process, it will likely require equipment modifications at other areas of the line.

Cutting the warm carcass seems to be easier than for a chilled carcass. The ease of fat and bone removal are facilitated. Preliminary evidence indicated that brine will penetrate warm muscle more rapidly than chilled muscle.

The yield of conventional wholesale cuts as a result of pre-chill processing was not significantly affected by the new method. Slight difference in the size or shape of the piece was noted primarily due to the position of the carcass as it was cut. The effect of pre-chill processing on the yield and loss of ham is presented in Table 1. The differences in yield were not significant. In every case the variation could be accounted for by the way in which the ham was removed from the carcass. In some hams more flank muscle was left while in others more fat was removed. The greater total loss in the post-chill ham was also reflected in the amount of total moisture remaining in the ham after complete processing, Table 1.

The Warner-Bratzler shear value as a measure for tenderness was made using ¾ inch diameter cores of the semimembraneous and longissimus dorsi muscles. The difference in tenderness between the processing methods was non-significant. Weiner 1964 found rapid processed ham more tender than the controls. However, the methods of processing the ham were different.

Pre-chilled cured ham contained more salt than the post-chill cured ham although the difference was found to be non-significant. The nitrate content of the muscle was the same in both type hams. Ether extract was not influenced by the processing treatment.

Bacon

The hot processed belly was heavier for the pre-chill method. This difference was attributed to the failure of the operator to cut at cor-

Table 1.—The Effect of Processing Method on the Properties of Ham

Ham	Unit	Mean		Std. error of mean
		Pre	Post[1]	
Unprocessed	Kg	7.73	7.48	.08
Boneless	Kg	4.37	4.42	.08
Lean Trim	Kg	0.48	0.53	.03
Fat Trim	Kg	2.40	2.19	.07
Bone Trim	Kg	0.84	0.78	.02
Fini-hed	Kg	3.57	3.58	.07
Loss	%	17.19	18.83	1.10
Shear value	Kg	3.09	3.28	0.16
Moisture	%	67.73	68.14	0.57

[1] Pre-chill or post-chill processing.

responding points in each carcass side. A difference in the length and width of the fresh belly and the subsequent cured and smoked bacon was readily evident. The freshly cut belly was always shorter and wider for the pre-chill method. Most of the difference was removed as the bellies cured, and smoked, Table 2. When the cured bacon was pressed and formed, the difference in length and width was further reduced. The post-chilled bellies when measured before processing were influenced by stretching as a result of chilling 24 hours in the carcass. Bellies from the pre-chill method contracted unless mechanical stretching force was applied during the heating and smoking period.

Since the ultimate measure of bacon yield depends upon the final pressed measurement, more knowledge can be obtained through a study of yield, Table 2. Post-chill bellies yielded smaller slices, but a few more slices than was true of the pre-chill bacon. The quantity of trim was no different for the two methods. A significant ($P<.05$) difference in the percent shrink was found between the pre- and post-chill processed bacons. The reason for this difference was in part due to the weight loss of the post-chill belly during the initial chill period. A slight day to day difference in the heating and smoking cycle may have caused a portion of the difference.

Several methods of measuring the influence of the pre- and post-chill processing method were used to account for the difference seen in the bacon slice. The bacon slice weight and a total weight of six slices from each slab indicated that the slices from the pre-chill method were heavier. This difference was also reflected by the greater slice depth, Table 3. Acetate tracings of six slices from each bacon were used to determine the total area and the area of fat and lean. The total slice area was significantly greater for bacon from the pre-chill method. Both the lean and fat areas were greater for the pre-chilled bacon. This difference was attributed to the fact that contraction occurred in the pre-chill belly. When the data were calculated on a percentage basis, the percent fat was greater while the percent lean was slightly less. Since the pre-chill bacon is both wider and deeper, one would expect the slice length and depth

Table 2.—The Effect of Processing Method on the Yield of Bacon.

Bacon	Unit	Mean Pre	Mean Post[1]	Std. error of mean
Unprocessed length	cm	51.95	60.11	0.67
Unprocessed width	cm	33.14	27.63	0.39
Smoked length	cm	52.68	54.99	1.63
Smoked width	cm	25.65	24.40	0.05
Pressed length	cm	52.30	53.44	0.75
Pressed width	cm	24.13	23.45	0.20
Slices	No.	173.97	177.45	4.04
Slice wt.	Kg.	4.27	4.13	0.08
Trim wt.	Kg.	0.48	0.48	0.05
Shrink	%	23.71	21.66	1.21

[1] Pre-chill or post-chill processing.

to agree, Table 3. When the weight of the bacon slice is used as a unit of measure, those from the pre-chill bacon were heavier, Table 4. This difference was reflected by a greater total amount of fat and lean. The percent lean in the slices from formed bacon slabs was essentially the same for bacon processed by both methods. The greater percentage of lean in the bacon slice was favored by the post-chill method. One would expect this to be the case since fat would contract along with the lean in the pre-chill belly.

Loin

The weight of the full loin, while non-significant was found to be slightly less for the pre-chill method. This same trend was reflected in the weight of the fat trimmed from the loins. Removal of excess fat from the pre-chill loin was found easier. In order to provide a smooth white surface to the fat, it was necessary to chill the loin in a special mold to produce a smooth fat surface.

Essentially no difference was found between the pre- and post-chill processed loins in the amount of total moisture remaining in the longissimus dorsi muscle after being cooked, Table 5. Warner-Bratzler shear value of the oven roasted loin muscle was not significantly different. Shrinkage as reflected by the thaw loss was larger for the pre-chill processed loins, but the difference was non-significant. Cooking loss was consistantly greater for the post-chill treatment, however, the difference was not significant.

Table 3.—The Effect of Processing Method on the Bacon Slice

Bacon	Unit	Mean Pre	Mean Post[1]	Std. error of mean
Slice area	sq. cm.	91.28	81.88	1.38
Lean area	sq. cm.	25.64	24.47	0.83
Fat area	sq. cm.	65.64	57.48	1.39
Lean	%	28.22	29.94	0.73
Fat	%	72.78	70.06	0.73
Slice length	cm.	24.70	23.22	0.30
Slice depth	cm.	4.00	3.83	0.06

[1] Pre-chill or post-chill processing.

Table 4.—The Effect of Processing on the Quantity of Lean and Fat in Bacon

Bacon	Unit	Mean Pre	Mean Post[1]	Std. error of mean
Slice weight	g	135.47	124.37	3.32
Lean	g	45.17	43.28	1.51
Fat	g	90.29	80.75	3.46
Lean	%	33.36	34.19	1.02
Fat	%	66.43	65.94	1.02

[1] Pre-chill or post-chill processing.

A detailed study of the muscle indicated a consistently larger fiber and one which possessed a greater degree of rigor as a result of the post-chill treatment, Table 5. The higher percentage of twisted fibers for the post-chill treatment would indicate that pork muscle had not undergone complete resolution of rigor during the 24 hour chill period.

Consumer eye appeal for cured meat makes brine diffusion through pork muscle and color fixation two factors of considerable importance in manufactured pork products. The quantity of nitroso-pigments extracted before and after exposure to light provided a measure of color fixation and stability. The data are presented graphically in figure 1. Prior to light exposure, there was no difference between treatments for the amount of cured ham nitroso-pigments. Significantly more pigment remained in the pre-chilled processed ham, exposed to 200 ft. C of light for 30 minutes, than in the post-chilled ham. Ham exposed to light for one through 24 hours showed that the pre-chill ham contained more nitroso-pigments although the difference was not significant. Pigment variation within treatment was greater for the pre-chill ham indicating the need for further work.

The zero time exposure was assumed to be 100 percent of the nitroso-pigments that could be extracted. This was then used to calculate the remaining amount of pigment at varied light exposure time. After 30 minutes exposure to light, the pre-chill processed ham contained 80.5 percent of the zero time pigment as compared to 65.9 percent for the post-chill samples. The greatest reduction in cured meat color would be expected during the first four of the exposure period. The difference in extractable pigments between one and six hours was significant. The pre-chill cured ham retained more nitroso-pigments than the post-chill processed ham. However, the color variation was greater. Commercially processed ham would be expected to have wide color variation due to the animal to animal and muscle to muscle variation.

Table 5.—The Effect of Processing Method on the Quality Attributes of Pork

Loin[1]	Unit	Mean Pre	Mean Post[2]	Std. error of mean	
Moisture	%	60.3	60.1	0.57	
Shear value	Kg	10.2	10.2	0.31	
Thaw loss	%	3.9	3.7	0.41	
Cooking loss	%	24.4	25.4	0.60	
		Longissimus dorsi Mean		Semimembranosus Mean	
		Pre	Post	Pre	Post
Fiber size	μ	76.8	79.5	70.1	74.2
Rigor fibers	%	58.0	59.0	29.5	30.0

[1] Longissimus dorsi muscle.
[2] Pre-chill or post-chill processing.

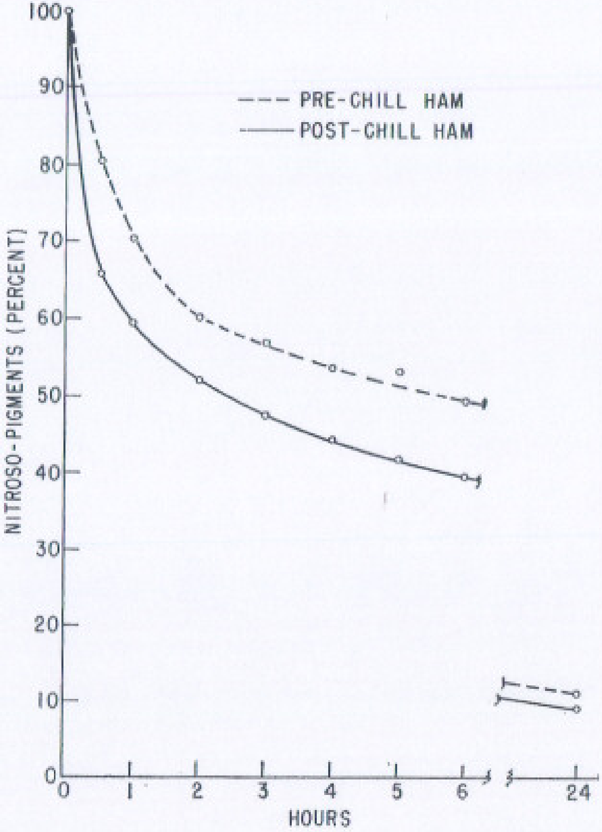

Figure 1. Relative nitroso-pigments remaining following exposure to light (200 ft.-C).

Bacterial numbers were based upon the quantitation of 19 pairs of ham. No pre-chill processed cured ham samples exceeded 109 bacteria per gram. Whereas, two cured post-chill hams yielded high count samples. Categorially, 68 percent of the cured pre-chill processed hams yielded samples from which no colonies could be plated or the count was less than 10 per gram. In the cured post-chill ham, only 53 percent of the samples had less than 10 colonies per gram when incubated at 37°C. Incubation of the tissues at the psychrophilic range (15°C) yielded low count samples. In most cases, the count was less than one psychrophile per gram. Explanation of the greater number of mesophilic to the psychrophilic count can be attributed to the method and manner of processing.

The reduction in total aerobic population due to the cured-cooked treatment effect is shown in Table 6. Ham injected with curing brine immediately after physical separation from the carcass had fewer bac-

Table 6.—Aerobic Bacterial Colonies in Pre- and Post Chill Processed Ham

	Treatment			
	Pre-chill		Post-chill	
	Uncured	Cured	Uncured	Cured
Colonies/gram[1] (N=19)	203.1	15.4	217.5	107.8
Std. dev.	502.0	27.4	337.0	303.5

[1] Plated on TGEA and incubated at 37°C.

teria per gram than ham chilled 24 hours before curing. The results of this work indicated no significant microbial problem in the concept of complete processing prior to chilling.

Summary

The cutting and fabrication of pork to a retail form prior to initial chilling provides products which have quality equal to the conventional processed products. The pork carcass may be cut immediately following the dressing operation and prior to chilling. Attractive conventional cuts can be made from the warm meat; however, the cuts must be formed during chilling. Excess fat removal is more easily accomplished prior to chilling. This is particularly true when it is necessary to remove intermuscular fat as in the ham. Yield of trimmed cuts were equal to those of the post-chill method. In some cases, more fat is removed from the pre-chill cuts, but more shrink loss is noted in the post-chill method. This loss has been attributed to moisture evaporation which occurs when the carcass is chilled.

The only difference in the size and shape of the wholesale cuts is that of the bacon. Pre-chill bacons were always shorter but wider than those from the post-chill method. The post-chill bacon slabs yielded smaller, but always a few more slices than was true of the pre-chill bacon. The post-chill method provided a greater percentage of lean in the bacon slice than did the pre-chill method. This would be expected since the fat must contract with the lean in the pre-chill method.

The weight of full loin was less for the pre-chill method. This was caused by the closer fat trim and ease of removing the belly at a point closer to the loin. Fat on the loin was smooth and white when chilled on a smooth surface.

Shear value for the longissimus dorsi and semimembranosus muscles indicated no significant difference in tenderness of pork when processed to a finished form prior to chilling. Water holding capacity of the fresh muscle was favored by the pre-chill method, as well as cure diffusion and color fixation. Muscle fiber size and degree of rigor were slightly greater in the post-chill pork.

The incidence of aerobic bacterial flora in the rapid processed ham is comparable to that of the post-chill processed ham. Greater reduction in total bacterial numbers were obtained with rapid processing. Knowledge obtained from the bacterial population studied revealed no significant bacteriological problems in the new concept of complete processing prior to chilling.

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