INDUSTRIAL HOT BONING OF BEEF CARCASSES IN CUBA

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SUMMARY: The hot boning of beef on industrial scale is studied. Results show that in the present conditions the alternative of large commercial cuts packed in plastic trays (i), with any of two polyethylene coated cuban papers can be introduced in industrial practice. Under these conditions energy consumption in chilling can be cut down by 38% and refrigerated space by 50%, as compared to the traditional boning system. Total weight losses average around 2% for the proposed operation. In our conditions strict hygiene has to be applied.

INTRODUCTION: Nowadays hot boning, packaging and refrigeration of beef is an item of special interest from scientific and commercial point of view. Reductions in meat evaporative losses and savings in refrigeration capacity and energy are the main advantages of this procedure (Ferguson, R. 1982). Hygiene and temperature of the process must be specially controlled.

In Cuba the refrigeration of beef carcass is carried out rather slowly in most industrial slaughterhouses. These traditional systems only can guarantee temperatures of 2 - 4 ^{0}C; relative humidity of 85 - 90 % and 0.3 - 0.5 m/s of air speed. Under these conditions the carcasses reach 10 - 12 ^{0}C in the thickest part in 18 - 20 hr during chilling process. Total weight losses are around 3% including boning operation.

In this work different alternatives considered feasible without large investments were tried for hot boning on industrial scale under conditions similar to those existing in Cuban cattle slaughterhouses.

MATERIALS AND METHODS: The procedure was developed in two stages: laboratory and pilot plant experiments (1) and industrial experiment (2). In the first stage the effect of different films on microbiological and organoleptic quality of hot boned beef was evaluated.

The main characteristics of the 5 films employed in the first experiments are presented in table 1.

The half of L. dorsi muscle from a hot boned side of carcass was obtained 45 min after slaughter and then cut in five pieces of 0.5 kg each. Immediately each piece was covered with one type of the films described.

Hot boning was carried out with strict hygiene. The attachment of films to the meat was made by hands in order to avoid air between both surfaces. Samples were put in a chilling room at 0 - 2 ^{0}C

during 48 hr. The other half of L. dorsi was kept in the side and refrigerated at 0 - 2 °C during 24 hr. After that the side was boned and L. dorsi muscle was hanged in a stainless steel gambrel and stored 24 hours in refrigeration, then a piece of 0.5 kg was cut and used as control in the organoleptic test.

Table 1 Characteristics of packaging films

Films	Weight g/m	Thickness micron	Water vapor permeabil. (g/m/day)	Ripping resist. mili-Newt
A	92.0	110.0	3.75	744.0
B	87.0	98.0	3.6	654.4
C	52.0	60.0	1.60	1100.0
D	22.0	25.0	0.97	1200.0
E	35.0	30.0	52.4	84.0

A: White cuban paper with a polyethylene layer (20 g/m each side)
B: Beige cuban paper with a polyethylene layer (41 g/m each side)
C: Low density polyethylene (60 microns)
D: Co-extruded and bioriented polypropylene
E: Cellophane

For sensory analysis (color, odor and aspect) the samples were served in trays to be evaluated by nine experienced judges. The results were processed by Tukey test.

Samples for microbiological analysis were taken by swabbing technique (Kitchell et al 1973) before packaging, 24 and 48 hr after refrigeration. Plate counts were made of mesophilic aerobes (plate count agar, 35 ± 1 °C, 48 h).

According to the results the white cuban paper was selected to be used in following experiments.

In order to know the behavior of hot boned meat in different storage ways, a Pilot Plant experiment was developed.

Hot boned beef (45 min after slaughter) was chilled in three different fashions: large commercial cuts (according to cuban standards) packed in plastic trays (600 X 400 X 522 mm) with exposed surface covered with the selected film (i); fully butchered retail cuts in small plastic trays each of them completely wrapped with perforated film (ii). The small trays were also put in plastic trays (the same size of the experiment i); large commercial cuts hanged on stainless steel gambrel without any cover (iii) and a control (conventional chilled boned beef). In all cases chilling was carried out in air at 2 - 4 °C and 85 - 90 % RH. The cooling rate for each treatment was recorded.

For hot boning the weight of carcass, meat after boning and

chilled meat (after 24 hr) was measureded. For cool boning the weight of carcass (after 24 hrs) and chilled meat (after 36 hrs) was measured.

Microbiological analysis were made. Samples were taken by swabbing on carcass surfaces, boned meats and chilled meats (after 24 hr refrigeration). For small trays shelf life of them was obtained. Sensory and microbiological analysis were made daily. A group of 8 - 10 experienced judges made the acceptance rejection test for off odor detection. For this purpose, the meats were overturned on other trays.

The same microbiological analysis were applied. Shelf lives were obtained using the maximum likelihood techniques for incomplete failure data developed by Weibull distribution law (Nelson 1982).

In no case was vacuum packed applied.

In the second stage Pilot Plant results were scaled-up in industrial facilities.

Hot boning of carcasses (45 min after slaughter) was made as common in a selected slaughterhouse and it was the control of the experiment; the meats were hanged on stainless steel gambrels. The test samples were hot boned (45 min after slaughter), put in plastic trays (600 x 400 x 255 mm) and covered with cellophane. The height of meat in trays was 130 mm. Hygienic rules during slaughter and boning were strictly applied.

The meats from gambrels and plastic trays were conducted to the cold-storage plant (at 3 Km distance) in non refrigerated transport. The trays were placed in pallets (4 columns of 5 trays in each pallet). The gambrels were put in the same chamber.

Measurements of temperature to the chamber and cooling rate of meats were made (Comark electronic thermometer). Air velocity was measured (Wallac electronic Anemometer).

The weight of carcasses and meats before and after 24 hr refrigeration was controlled.

Microbiological analysis of the process were carried out.

A comparison in energy consumption and refrigerated between the two boning methods considering a theoretical slaughterhouses plant of 200 carcass working capacity was made.

RESULTS AND DISCUSSION: Results of Tukey test applied to color evaluation are presented in table 2. Polypropylene film (D) lightly affected the meat surface color. It could be because of his lower oxygen permeability. No significant differences in color among control and other materials were observed.

Satisfactory results in odor and general appearance for all the

samples were obtained and there was not indication of any significant difference between each sample and the control.

Table 3 represents the effect of the films on microbial counts. It can be noticed that meats covered with polypropylene films presented higher counts than these covered with cellophane and cuban paper. The lower oxygen permeability of polypropylene and polyethylene produces a selective effect on present microflora Lactobacilli sp. could grow and spoilage m.o. can be inhibited (Taylor et al, 1972).

Table 2 Tukey test for color evaluation of samples covered with different films.

Treatments	The sum difference	Significant level	Level of difference
Control- A	4 < 8.64	n.s.	no
Control- B	1 < 8.64	n.s.	no
Control- C	2 < 8.64	n.s.	no
Control- D	14 > 8.64	*	slight
Control- E	4 < 8.64	n.s.	no
A - B	3 < 8.64	n.s.	no
A - C	6 < 8.64	n.s.	no
A - D	0 < 8.64	n.s.	no
A - E	18 > 8.64	*	light
B - C	3 < 8.64	n.s.	no
B - D	3 < 8.64	n.s.	no
B - E	15 > 8.64	*	light
C - D	6 < 8.64	n.s.	no
C - E	12 > 8.64	*	light
D - E	18 > 8.64	*	no

Table 3 Total mesophilic counts of meat surface covered with five different films $\log_{10}$ c.f.u.g^{-1}.

Sample	Initial count	after 24 h	after 48 h
A	3.38	3.43	3.00
B	3.38	3.26	3.58
C	3.38	3.69	6.90
D	3.38	3.70	5.90
E	3.38	3.49	3.58

Weight losses of meats belonging to the second experiment (first stage) are showed in table 4. As expected coated meats had a lower weight loss than non-coated ones. Taking into account the 3 measured parameters jointed (weight loss, trimmings and yields) the best treatment is the cold storage of meats in large trays. Although in general hot boning and packaging procedure involve a higher percentage of fat and meat trimmings (Taylor, 1981).

Table 4 Weight losses of meats (Pilot Plant experiment).

	Control	Large trays	Gambrels	Small trays	S.E
Carcasses	7	7	7	4	
Chilling losses %	0.91c	0.19b	2.26d	0.00a	0.24
Total evaporative losses %	2.69a	1.8 b	2.50a	1.5b	0.25
Meat and fat trimmings %	5.98c	7.69b	7.25b	16.20a	0.44
Yields %	65.40a	66.40a	65.20a	58.40b	0.54

mean values with different letter significant difference P<0.01

Figure 1 shows the cooling rate of the 4 treatments. It can be observed that all treatments reached 10 °C before the control. Thus suggesting the advantageous effects of hot boning on energy consumption.

Table 5 shows microbiological results of the experiment. Microbiological quality of carcass is acceptable for both, the cold and the hot boned types. After 24 hr for meat in gambrels and plastic trays, comparable results were obtained. This suggests that changes in boning procedures when strict hygiene practices are applied do not diminish bacteriological quality of meat.

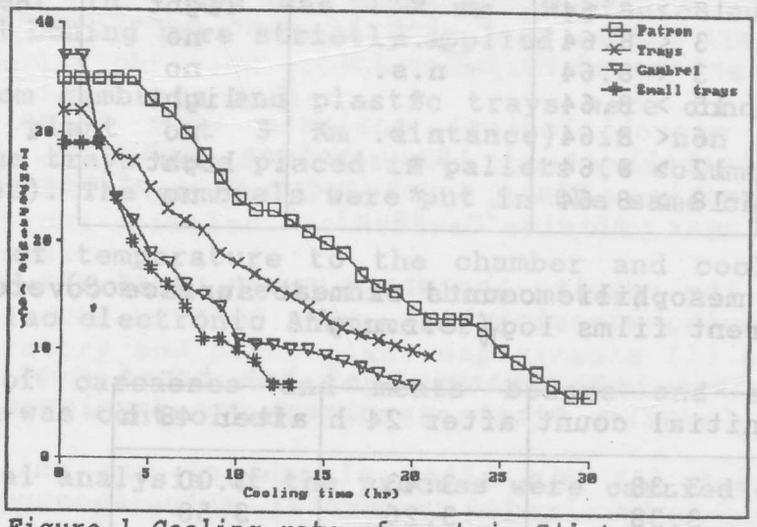

Figure 1 Cooling rate of meat in Pilot Plant experiment.

In table 6 can be seen that behavior of the two boning procedures employing small trays was similar; taking into account the application of strict hygienic rules for the hot boning process, as suggested by Valladares et. at. (1985) for similar conditions.

The resulting shelf lives were in both cases similar when hazard plot were applied.

Scale parameters ( ) Weibull distribution law.

Control	Value	lower limit	upper limit
scale	5.5584	4.7000	6.5735
	S.D. = 0.1592 days		
	$*D_{max}$ = 0.113	$D_{(10, 0.05)}$ = 0.251	
Sample			
scale	5.5649	4.6592	6.6467
	S.D. = 0.1908 days		
	$*D_{max}$ = 0.125	$D_{(11, 0.05)}$ = 0.232	

* D_{max} = Maximum difference from Kolmogorov Smirnov test.
$D_{( )}$ = Limit difference of Kolmogorov distribution

Table 5 Total mesophilic counts of meats (Pilot Plant experiment) Log_{10} c.f.u.g^{-1}

	Initial count	After 24 h
Carcasses	3.38	—
Hot boned meat before packaging	4.15	—
Hot boned meat in gambrels	4.41	5.65
Hot boned meat in plastic trays	4.34	5.45

Note: For carcasses, 7 samples were analyzed (3 points each).

Table 6 Total mesophilic counts of hot and cold boned beef in small trays (without any vacuum packaging). Log_{10} c.f.u.g^{-1}

	Total mesophilic counts				
Sample	1	2	3	4	5
hot-boned beef	4.59	5.58	5.79	6.67	7.75
cold-boned beef	4.45	5.66	6.46	6.95	7.99

The main results of the industrial experiments are shown in table 7.

Studies on weight losses showed a large difference between hot boned beef in plastic trays and gambrels. The value achieved by plastic trays procedure is perfectly comparable with the weight loss obtained in modern refrigeration systems.

Table 7 Results of industrial experiment.

	Hot boned beef in plastic trays	Hot boned beef in gambrels
Number of animals	25	—
Total carcasses weight (kg)	3826.7	—
Total hot-boned beef weight (kg)	2348.6	1375
Total hot-boned beef weight after refrigeration (kg)	2319.0	1264.5
Weight loss (kg)	29.6	110.5
Weight loss (%)	1.3	8.0

Table 8 Cooling rate of the meat (^{0}C).

	Hot boned beef in plastic trays	Hot boned beef in gambrels
Average initial temp.	36.7	37.4
Average final temp.	12.7	6.2
Minimum air temp.	5.1	
Maximum air temp.	11.3	
Air velocity (m/s)	0.0	

It can be noticed in table 8 that cooling rate of the meat was very slow, it only achieved 12 ^{0}C as average. However the meat hanged in gambrels reached around 7,5 ^{0}C. It is explained by the behavior of the cooling parameters which were not as suitable as expected.

Table 9 represents microbiological results to industrial scale. At the beginning the microbial counts of the meat were comparable with the results obtained in the pilot test (first stage of this work) where good hygiene practices were applied. However higher counts of hot boned meats in plastic trays illustrate how differences in time, temperature and humidity during cooling may lead to different end results (Ingram et at, 1976).

Considering a slaughterhouse of 200 beef carcasses capacity hot boning system could produce a reduction of 50 % in refrigerated space requirement and 38 % in energy consumption in comparison with the traditional system.

CONCLUSIONS: The introduction of hot boned beef in the present conditions of cuban slaughterhouses, is feasible if specific hygienic cautions during cutting and processing are taken, as well as to guarantee better refrigeration conditions.

In the system studied, it was estimated that a reduction of approx 50 % in refrigerated space requirement is possible. The energy requirements might be reduced by approx. 38 %.

Table 9 Microbiological results to industrial scale $\log_{10}$ c.f.u.g.$^{-1}$.

Sample	Initial count	After (24 hr)
Hot carcasses	3.67	——
Hot boned meat	4.56	——
Meats in plastic trays	5.72	6.93
Meats in gambrels	5.41	5.73

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