ACCELERATED PROCESSING: ECONOMICAL CONSIDERATIONS

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INTRODUCTION

The positive trade balance in The Netherlands in 1988 was approximately 3 billion Dfl, whilst a positive balance of 18 billion was secured through agricultural activity. The Dutch meat industry is a major element of the national agricultural infrastructure. This is illustrated by the volume of meat produced in The Netherlands, i.e. about 2.6 million tons of primarily pork, beef and veal, marketed either as carcasses or bone-in primals. This would never have been possible without a technologically advanced meat industry, relying on sophisticated slaughter and processing procedures and a rapid product flow.

The industries' traditional way of processing meat (chilling of carcasses and sides, boning of beef primals after a certain holding period and the reheating and re-chilling of meat for the manufacturing of meat products) is not very economical from an energy point of view. Hot boning, which implies processing of the carcass before the body temperature has been substantially reduced, has been considered to provide a more economical alternative and to allow a higher turnover.

In the early 1970's hot boning of carcasses gained considerable interest as a potential means for slaughterhouses to reduce space and energy requirements. Furthermore weight losses during chilling (which may amount to 2% of the dressed carcass weight) would be reduced. In 1979 a research project aiming at rationalising meat production through accelerated processing, was initiated in The Netherlands. Initially, research focussed on the effects of electrical stimulation on sensory quality of beef and veal. Although it affected processing time only marginally the use of electrical stimulation would allow rapid chilling. Currently at least 50% of the Dutch beef and veal slaughter-plants use electrical stimulation. Rather than being the ultimate aim of the project, the implementation of electrical stimulation enabled the introduction of farther adaptation of the processing system, i.e. the hot boning and processing of meat.

The potential of a new processing technique is usually judged by its effect on the sensory, microbiological and technological quality. However, whether a novel technique should be adopted by the meat industry is ultimately dictated by the return on investments.

In an attempt to analyse the costs and benefits of accelerated processing those economic factors were considered that would determine the feasibility of introduction of accelerated processing in The Netherlands. Within the framework of this presentation major emphasis is placed on meat yield data.

MATERIALS AND METHODS

Experiment 1 (beef)

Eight cows (280-330 kg hot carcass weight) were stimulated electrically within 5 min post mortem (Mitab[R], 85V, 14 Hz, 30s). Within 1½ h post mortem a randomly chosen side from each carcass was hot boned on the rail; the remaining sides were subjected to blast chilling (-1 to -4°C, air velocity of 3 m/s). Immediately after boning, hot or cold boned loins were vacuum packaged and stored at 1±1°C. After 12 days of storage at 1±1°C the loins were unpacked and drip losses were measured.

Experiment 2 (veal)

On 5 separate days a total of 40 Friesian Holstein veal calves were electrically stimulated (3000 V, 0.83 Hz, 1.5 ms pulsewidth, 14 Hz) within 5 min post mortem. At 45 min post mortem one side of each carcass was hot boned 'on the rail'. The other sides were subjected to blast chilling (-14, -8 and -4°C during 30 min each, air velocity 8 m/s) whereafter these were stored at 3±1°C (air velocity .5 m/s). At 24 h post mortem the chilled carcass sides were cold boned (on the table). Hot and cold boned loins of 8 of these carcasses were vacuum packaged and stored at 1±1°C for 11 days. After storage packs were opened and drip losses were measured.

Experiment 3 (pork)

Ten halothane-negative Large White/Dutch Landrace cross-bred pigs with an approximate weight of 110 kg were slaughtered. At the end of the slaughterline, ca. 40 min post mortem, those carcasses were selected that had pH values > 6.2 in the loin. Immediately after selection the right side of each carcass was hot boned. Control sides were chilled overnight at 2±2°C before being cold boned. The loins of these carcasses were vacuum packaged and chilled immediately after boning. After 12 days of refrigerated storage at 2±2°C the meat was unpacked and drip losses were assessed.

Experiment 4 (restructured beef steaks)

A total of 24 cows were electrically stimulated as described for experiment 1. Hot flank muscles were excised from the right sides at approximately 45 min post mortem. The cold flank muscles were excised from the remaining sides after these had been chilled as described in experiment 1. After excision muscles were defatted, desinewed, cut into pieces and flaked in a Comitrol^R 1700 processor (Urschell Dutch Office, Wijk bij Duurstede, The Netherlands). The flaked meat was mixed 2 min in a Hobart^R blendor, 1% salt was added and the meat was mixed for another 3 min. The hot meat was restructured immediately after blending. The cold meat was packed in plastic bags, quickly frozen and stored at -40°C for approximately 1 month. One day before restructuring these meat packs were tempered at 4±1°C, to -2°C. The restructuring was carried out with VM 400 HD equipment (Koppens Machinefabriek, BV Bakel, The Netherlands). After restructuring, the steaks were frozen at -40°C and stored at -20°C. Before cooking 18 steaks of each treatment group were removed from the freezer and allowed to temper for 24 h at 4±1°C, Steaks were heated on a contact grill (Neumaerker, type 60500) to a core temperature of 70-75°C.

Experiment 5 (hamburgers)

Hamburgers were prepared as described by Smulders and van Laack (1989).

Experiment 6 (cooked hams and shoulders)

Cooked hams and shoulders were prepared as described by Van Laack et al. (1989).

RESULTS AND DISCUSSION

Yield data

A higher yield of saleable meat is claimed as a potential advantage of hot boning. Reportedly this is largely due to the lower evaporative weight losses resulting from packaging soon after slaughter.

Table 1 includes yield data from hot boning experiments on beef, veal and pork.

Although hot boning limited evaporation losses considerably, it did not result in higher meat yield. Meat yield is greatly influenced by the degree of fat trimming and the extent to which the meat is removed from the bones. Reportedly fat trimming is easier to perform when hot boning (Mandigo et al., 1979; Dupit, 1986). However, in practice only part of the fat is removed. Moreover, in our experience it is more difficult to conform to current specifications when trimming off hot than cold fat. Another aspect which may have influenced our results is the fact that in our experiments beef and veal carcasses were hot boned on the rail to limit cross contamination; the chilled carcasses were cold boned on the table. Lack of

Table 1: Chilling losses (% of hot carcass weight) and meat yields (% of hot carcass weight) as affected by hot and cold boning of cow, calf and pig carcasses (experiments 1, 2, 3, respectively).

Species	n	Chilling losses cold boned sides	Saleable meat (%) Hot boning	Cold boning	p-level
Cow	8	2.1	70.8	70.5	NS
Calf	40	1.8	67.6	67.1	NS
Pig	10	1.7	66.0	66.2	NS

experience with boning on the rail technique may have resulted in less careful boning.

Besides through reduced carcass shrinkage weight losses during refrigerated storage may be smaller when meat is hot boned. Waterholding capacity decreases post mortem. The rate of post mortem pH fall is an important determinant of the ultimate waterholding capacity. A fast rate of pH fall at a high temperature promotes denaturation of sarcoplasmic proteins and increases drip losses during storage (Penny, 1977). In hot boned primals the chilling rate may be faster and more even than in muscles on the carcass (Tarrant, 1977). Therefore the pH fall takes place at a lower temperature and denaturation may be limited. Theoretically this would result in lower drip losses during storage.

Table 2: Drip loss (%) of beef, veal and pork loins assessed after 12 days of vacuum storage, as affected by hot and cold boning (experiments 1, 2, 3, respectively).

	Hot boned	Cold boned
Beef	0.44	0.38
Veal	0.99^{a*}	1.20^{b}
Pork	1.03^{b}	0.89^{a}

* Means with different superscript differ significantly ($p<0.05$); paired Student t-test

Table 2 includes results on drip losses after 11 days of vacuum storage. Surprisingly, time of boning only marginally affected drip losses of both beef and pork. This is explained by the fact that the Dutch meat industry currently relies mainly on rapid refrigeration systems. Under these circumstances the chilling rate of hot vs. carcass-attached muscles might be quite similar.

It is a well-established fact that the water-binding capacity of meat decreases post mortem (Hamm, 1972). The superior processing properties of pre-rigor meat can be largely retained by the addition of salt. We investigated the effect of hot processing on the cooking yields of several beef and pork products. Results are included in Table 3. Cooking yields of hot processed beef products were significantly higher than cooking yields of cold processed controls. However, for cooked hams and shoulders the advantage of hot processing over the conventional methods was negligible.

Table 3: The effect of hot and cold processing on cooking yields (%) of restructured beef steaks, hamburgers and cooked hams and shoulders (experiments 4, 5, and 6).

Product	Hot processed	Cold processed
Restructured beef steaks	87.4[a*]	76.1[b]
Hamburgers	75.7[a]	81.2[b]
Cooked shoulders	77.2	77.1
Cooked hams	83.8	84.3

* Means with different superscript differ significantly ($p<0.05$); paired Student t-test

Other economical considerations

Other important economic considerations in feasibility studies are quality aspects, costs for chilling, internal transport, storage and labour as well as factors pertaining to plant logistics and marketing.

Our studies, as well as those of other research groups have indicated that accelerated processing can be implemented without adversely affecting sensory quality of beef and pork. However, an important drawback of hot boning is that the shape of some hot boned primals may be severely distorted. In our trials this led to rejection of hot boned pork bellies by some wholesalers. For other primals such as beef loins the flexibility of warm meat helped to give the primal a more attractive shape.

From a bacteriological standpoint accelerated processing poses little problems provided strict measures of Good Manufacturing Practices (GMP) are adopted by the meat industry (van Laack, 1989).

Higher standards for hygiene would increase the costs irrespective of the system of boning. Currently the meat industry is already under severe pressure to place more emphasis on sanitation. This markedly impacts the costing of quality surveillance programs in traditional processing procedures. Consequently, it is anticipated that additional costs for hot boning are negligible.

To prevent excessive evaporation during chilling hot boned meat must be packaged in one way or another. The Dutch meat industry only recently introduced packaged primals and those have almost exclusively been beef. In the pig meat industry primals are generally distributed unpackaged. Since the Dutch retail market is not eager to pay extra for vacuum packaged primals the return on extra costs for packaging films and machines and for personnel is not guaranteed. On the other hand more and more retail organisations consider to close down their boning departments and to rely on the supply of bone-less packaged primals by the slaughterhouses. Therefore the incentives for packaging meat will become stronger in the near future.

Considerable savings may be expected from reduced refrigeration energy, cooler space and -time. Henrickson (1981) estimated that energy savings would be as high as 65%. Calculations from Dutch data indicate similar savings (Dortmond et al., 1988). It must be stressed, however, that these calculations were made for a situation in which all carcasses were either hot or cold boned. Should only part of the daily production be hot boned, the savings would be negligible. Finally, the actual benefit of energy savings is determined completely by energy prices and these may be subject to considerable fluctuations.

Labour time-savings may result from hot boning because carcasses need no longer be transported to chilling and boning rooms. In addition, hot boning appears to be easier to perform and consequently would require less labour. Obtaining reliable data is hindered by the fact that experiments have to be performed with boners which are trained for the conventional cold boning techniques. For them to gain similar skills in hot boning takes considerable time. It has been suggested that labour conditions in a hot boning operation would be more favourable than for traditional processing (van Logtestijn, 1979). For instance, the carcass heat would prevent the boner's hands from becoming cold. Apart from reducing the inclination of workers to interrupt boning to warm their hands, sick-leave percentages might be lowered. The economic impact of the latter is hard to quantify. Danish and Swedish experience would seem to indicate, however, that such might be of practical importance (Anonymus, 1984).

Introduction of accelerated processing seriously affects the logistics of slaughtering and boning. Synchronising the slaughter- and boning operations requires a strict (re-)organisation and adaptation of the working schedules. Presently the Dutch meat industry is highly segmented. Whereas 15 years ago many operations included both slaughtering and processing facilities, today many of these have concentrated either on slaughtering, boning or meat product manufacture. However, with large retail organisations closing their boning operations, incentives for the slaughterhouses to capitalize on their boning services are getting stronger.

The introduction of semi-hot boning of pig carcasses has less impact on both costs and benefits. As it implies the use of a chiller, energy-savings are minimal. Furthermore boning techniques are similar and special hygiene arrangements are not required, nor will shape be affected significantly. Finally, synchronising the slaughtering and boning procedures poses no specific problems while a higher turnover rate can be achieved.

CONCLUSIONS

A cost-benefit analysis of accelerated processing is markedly affected by plant lay-out. Consequently it would be unjust to emphasize the quantitive aspects of this Dutch case study too much. Furthermore, energy prices and local marketing situation may differ significantly. Their impact on logistics, the investments involved in retrofitting existing facilities to a hot processing operation, and possible problems in marketing hot boned meat may vary considerably from country to country.

It is conceivable that semi-hot boning of pig carcasses will be introduced in The Netherlands in the near future. Adoption of other accelerated processing options are currently discouraged by some of the afore-mentioned considerations.

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