Incidence of low post-slaughter pH in beef and its influence on post-mortem tenderization

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Introduction

Anti-mortem as well as rapid post-mortem glycolysis and utilization of high energy phosphates have been shown to cause rapid onset of rigor mortis and to have deleterious effect on the quality of beef (Khan and Lentz, 1972; Marsh, 1964 and Webb et al, 1967), pork (Bendall and Wismer-Pedersen, 1962; Briskey, 1964; Tarrent et al, 1972) and poultry (DeFremery and Pool, 1960; Khan and Nakamura, 1970). A drop in pH to 6.2 or lower within 1 hr after slaughter caused rapid onset of rigor mortis, slow tenderization and larger variation in ultimate tenderness of beef (Khan and Lentz, 1972). Beef with a post-slaughter pH value of 6.7 or higher, on the other hand, tenderized faster and was generally more tender than low post-slaughter pH beef. Since these findings indicated that post-slaughter pH could be used to segregate beef carcasses on the processing line with respect to required aging time and tenderness, information on the distribution of post-slaughter pH in commercial plants was desirable.

This paper reports results of a study of post-slaughter pH (1 hr post-slaughter) of beef in two commercial plants in Canada. Information on the source of beef animals, their age and sex and the type of feed during holding before slaughtering was also collected where feasible, to determine their effects on post-slaughter pH. Shear force changes in low (5.8-6.2) and high (6.7-7.1) post-slaughter pH muscles during 16 days of aging are also included to demonstrate the effect of post-slaughter pH on shear force. These results have been reported in detail elsewhere (Khan and Lentz, 1972).

Experimental

Tests were made in two meat packing plants in central Canada. At plant A measurements were made on different days during one week of operation on many different lots of animals. At plant B measurements were made during two weeks, three months apart. Information on the age and sex of the animal, duration of the period for which the animal was held before slaughtering, type of feed used during the holding period and if possible the source of procurement of the animal was also collected.

The pH measurements were made (1 hr post-slaughter) after the carcasses were split into halves and moved off the killing floor. These measurements were made by inserting a combination Calomel-glass electrode probe directly into the Semimembranosus and Adductor muscles. During normal splitting of the carcass, these muscles are exposed near the aitch (ISCHIUM) and pelvic (Tuber ISCHII) bones. The electrode was washed with distilled water after each measurement and standardized after every tenth measurement.

For shear force measurements during aging, samples were obtained from twenty half carcasses (S-1 grade, carcass weight 225-275 kg) selected on the basis of post-slaughter pH. One half of the selected carcasses had post-slaughter pH values between 6.7-7.1, and the remaining ten between 5.8-6.2. This selection was made to compare tenderness changes in muscle that undergoes the largest proportion of glycolysis ante-mortem (low pH) with muscle that undergoes the largest proportion of glycolysis post-mortem (high pH). The half carcasses were aged in the laboratory at 2°C in still air at a high relative humidity. Shear force measurements were made on cooked meat samples using the Ottawa texture measuring system equipped with the Kramer meat shear cell as described earlier (Khan and Voisey, 1972). Measurements were made on Gluteus medius, Longissimus dorsi, Semimembranosus and Triceps brachii muscles during 2-16 days aging period (at 24 hr intervals).

Results and Discussion

The frequency distribution of post-slaughter pH varied between the two packing plants and to a lesser extent between weeks of measurement (Table 1). The number of carcasses having post-slaughter pH values of 6.2 or lower, a pH range which appears to have deleterious effects on tenderness, varied by 2-22% between plants. The largest number of carcasses, however,

had post-slaughter pH values between 6.6-6.8 in plant A and 6.4-6.6 in plant B.

Carcasses having low post-slaughter pH occurred in all groups of animals, irrespective of the source of procurement, sex, age and duration of holding time at the plant and the nature of feed during holding time (Table 2). Although cows appeared to have lower incidence than steers or heifers, no clear pattern as to the effect of age could be established. The results in Table 2 also emphasize the effect of the processing plant on the incidence of low post-slaughter pH.

High post-slaughter pH muscles were more tender in a shorter aging time than low post-slaughter pH muscles (Table 3). In high post-slaughter pH muscles aging longer than 5-7 days had no beneficial effects on shear force. In contrast, the shear force value of low post-slaughter pH muscles continued to decrease for upto 16 days of aging.

The biochemical changes occurring as a result of ante-mortem glycolysis and rapid onset of rigor mortis as they affect beef tenderness are not understood at present. It appears, however, that the phenomenon of ante-mortem glycolysis and rapid onset of rigor mortis is common to porcine, poultry and beef muscles. Ante-mortem glycolysis and rapid onset of rigor mortis have been shown to cause pale, soft and exudative pork and have been studied extensively (Briskey, 1964; Tarrent et al, 1972). In porcine muscle, rapid glycolysis to pH 6.0 while the temperature of the carcass is still high, a condition similar to that occurring in low post-slaughter pH beef, has been shown to bring about changes in the properties of sarcoplasmic and myofibrillar proteins. These changes have been shown to cause the loss of solubility of myofibrillar proteins (Bendall and Wismer-Pedersen, 1962). Since the loss of solutility of myofibrillar proteins in beef has been directly correlated to toughness (Hegarty et al, 1963), it is plausible to conclude that similar changes may affect tenderness in low post-slaughter pH beef.

Table 1. Frequency distribution of post-slaughter pH of carcasses in two packing plants. (Plant A, measurements were made on 946 carcasses during one week. Plant B measurements were made on 165 carcasses during the first week and on 120 carcasses during the second week.)

Post-slaughter pH	Plant A %	Plant B %	Plant B %
5.95 or below	–	1.8	2.5
5.96–6.05	–	4.2	5.0
6.06–6.15	0.5	3.6	5.8
6.16–6.25	1.4	10.3	9.2
6.26–6.35	1.5	8.5	10.0
6.36–6.45	5.2	8.5	15.8
6.46–6.55	12.0	17.6	19.2
6.56–6.65	18.0	19.4	17.5
6.66–6.75	22.8	18.2	8.3
6.76–6.85	22.6	6.7	5.0
6.86–6.95	10.9	1.2	0.8
6.96–7.05	4.9	–	0.8
7.06–7.15	0.4	–	–

Table 2. Effects of source of procurement, sex and age of the animal and nature of feed during holding on the incidence of low post-slaughter pH in beef. (Number of animals tested is given in brackets.)

Factors		Carcasses having post-slaughter pH 6.25 or lower (%)	
		Plant A	Plant B
Source	Non-specific	2(946)	19(165)
Sex or age	Steers	6(297)	28(121)
	Heifers	9(191)	35(20)
	Cows	3(140)	16(19)
Feed during holding	None	5(54)	–
	High energy ration	3(376)	–
	Hay	7(169)	–
Not held	–	9(33)	–

Table 3. Correlation coefficients for post-slaughter pH (1 hr post-mortem) vs. shear force value and aging time. (n = 20. One half of the samples had post-slaughter pH between 6.7-7.1 and the remaining ten between 5.8-6.2.)

Primal cut	Muscle	Correlation coefficient 5-7 days post mortem[a]	16 days post mortem
Chuck	Triceps brachii	-0.81[b]	-0.77[b]
Round and Rump	Semimembranosus	-0.79[b]	-0.46[c]
Short loin	Longissimus dorsi	-0.75[b]	-0.03
Sirloin	Gluteus medius	-0.89[b]	-0.61[b]

[a]Aging period after which no further shear force changes occured in high post-slaughter pH muscles.

[b]$P<0.01$. [c]$P<0.05$.

References

Bendall, J.R. and Wismer-Pedersen. 1962. Some properties of the myofibrillar proteins of normal and watery pork muscle. J. Food Sci. 27:144.

Briskey, E.J. 1964. Etiological status and associated studies on pale, soft, exudative porcine musculature. Adv. Food Res. 13:89.

DeFremery, D. and Pool, M.F. 1960. Biochemistry of chicken muscle as related to rigor mortis and tenderization. Food Res. 25:73.

Hegarty, G.R., Bratzler, L.J. and Pearson, A.M. 1963. The relationship of some intracellular protein characteristics of beef tenderness. J. Food Sci. 28:525.

Khan, A.W. and Lentz, C.P. 1972. Influence of ante-mortem glycolysis and dephosphorylation of high energy phosphates on beef aging and tenderness. In press.

Khan, A.W. and Nakamura, R. 1970. Effects of pre- and post-mortem glycolysis on poultry tenderness. J. Food Sci. 35:266.

Khan, A.W. and Voisey, P.W. 1972. Determination of shear force value of major beef muscles using the Ottawa texture test system. In press.

Marsh, B.B. 1964. Meat quality and rigor mortis. In carcass composition and appraisal of meat animals C.S.I.R.O. Paper no. 12.

Tarrent, P.J.V., McLoughlin, J.V. and Harrington, M.G. 1972. Anaerobic glycolysis in biopsy and post-mortem porcine Longissimus dorsi muscle. Proc. Roy. Irish Acad. 72:55.

Webb, N.B.,Kahlenberg, D.J., Nauman, H.D. and Hedrick, H.B. 1967. Biochemical factors influencing beef tenderness. J. Food Sci. 32:1.