APPROXIMATE GLYCOLYTIC POTENTIAL IN A LARGE POPULATION OF NEW ZEALAND CATTLE AT SLAUGHTER

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Background

A method of rapidly determining the ultimate pH from the approximate glycolytic potential of muscles of slaughtered animals has been devised. It is protected in many countries by patent (WO 00112844). Values for approximate glycolytic potential and – by calibration ultimate pH – can be obtained on prerigor muscle within five minutes of muscle sampling. The method is currently in commercial use in four New Zealand abattoirs, where it is used to select normal from dark-cutting beef carcasses before carcass weight is recorded. This paper describes calibration of the method in an industrial environment and the results obtained from the first six months of operation.

Objectives

There were three objectives:

- To calibrate the approximate glycolytic potential against ultimate pH.
- To gain an overall profile of glycolytic potential from a large number of animals.
- To relate glycolytic potential to climatic and preslaughter conditions.

Methods

The hot-boning abattoir was in a pastorally-based dairying district supplying two main animal classes, dairy breed bulls and so-called 'prime'. Prime comprises virgin females (heifers) and steers from cross breeds.

After a head-only electrical stun, cattle are ejected for throat cut and thoracic stick. An immobilising current and low voltage stimulation are applied. After hide removal, 20 min postslaughter, the *longissimus* muscle is sampled (between 1 and 2 g) and the method is applied. In outline, the muscle glycogen is hydrolysed to glucose which is measured by clinical blood glucose equipment. Values are normalised to 1 g.

For calibration, 500 g pieces of *longissimus lumborum* were dissected from 51 prerigor bull carcasses before the glycolytic samples were taken. The pieces were held at 18°C for 24 hours before the pH was measured at their anaerobic cores with a conventional meter probe. Lactate was also measured in calibration work, again with clinical equipment.

After calibration the method was applied to 9255 prime cattle and 4463 bulls processed over 113 days in between November (late spring) to May. Meteorological data were drawn from two stations, 30 km west and 20 km north of the abattoir. The data from each site were averaged on a daily basis.

The glucose values obtained have not been converted to glycogen concentration. Rather, the calibration trials (Fig. 1) established a (proprietary) glucose value below which carcasses were graded manufacturing because of high pH.

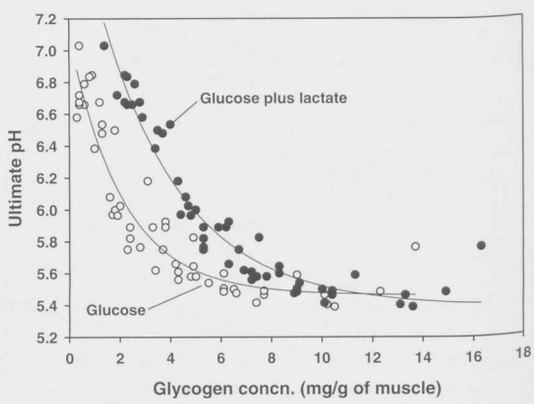

Fig. 1. Calibration of ultimate pH to glycogen concentration in bulls. R^2 values for exponential equations were 0.89 (glucose), 0.94 (glucose and lactate)

Results and discussion

Calibration

Using bovine *semimembranosus* muscle, Fischer & Hamm (1981) showed that within 30 min of slaughter most of the glycolytic carbon is in the form of glycogen and lactate. The glycolytic intermediates represent a significant but constant pool, irrespective of ultimate pH. Thus glycogen concentration should be a good indicator of ultimate pH. Fig. 1 confirms this with 51 bulls, where glycogen concentration was as determined from glucose alone and from glucose plus lactate (as glucose equivalents). Lactate had accumulated in the 20 minutes from slaughter, as expected. However, high ultimate pH animals could be identified on the basis of approximate glycogen concentration from glucose measurement alone, without the need to measure lactate.

Large industrial trial

The concentration of glucose among prime cattle showed a roughly normal distribution, whereas that for bulls was strongly skewed toward lower values (Fig. 2).

Daily averages of normalised glucose values were calculated on a daily basis between November to May. Fig. 3 plots these values against date. Glucose values were generally higher for prime cattle on all dates. For both classes glucose values appeared to be lower in January through April, and this was confirmed by regression analysis (not shown).

Whereas being prime or bull is the best indicator of glycogen status at slaughter, the data in Fig. 3 suggest that climatic factors might also be involved directly on the live animal or indirectly through diet. All these animals were raised in a pastoral system where feed supply is somewhat dependent on climate. January to March are often hot dry months in New Zealand.

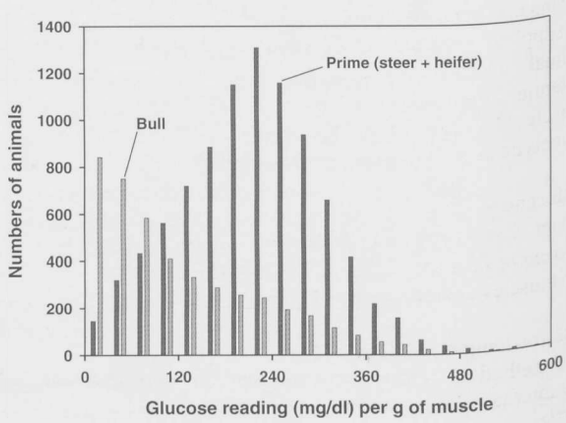

Fig. 2. Glycogen distribution (as glucose) in 13,700 cattle

Linear correlation coefficients were calculated for prime cattle and for bulls between: daily means of normalised glucose values, their percent variance, numbers of animals slaughtered per day, and a number of climatic variables. The numbers of animals slaughtered per day is an indicator of the livestock traffic through the abattoir and hence the potential for stressful interactions. Climatic variables were maximum and minimum temperature on the day (and days) before slaughter, and rainfall in the days before slaughter. The day of slaughter refers to the 24 hours before 0900 on the day of slaughter.

Many of the correlations were significant. For example, correlation between mean glucose and percent variance was (negatively) high for prime and bulls (Fig. 4). On days when the mean was high, for whatever reason, percent variance was low. Mean bull muscle glycogen (as glucose) was lower on days when many bulls were slaughtered (r = -0.25, Fig. 5).

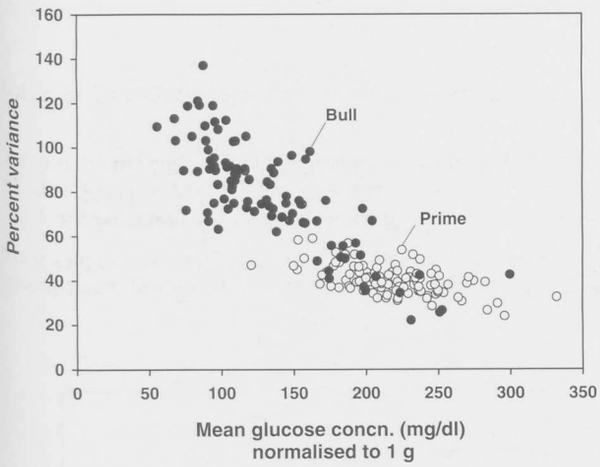

Fig. 4 Correlation between mean normalised glucose and percent variance for prime (r = -0.56) and bulls (r = -0.81).

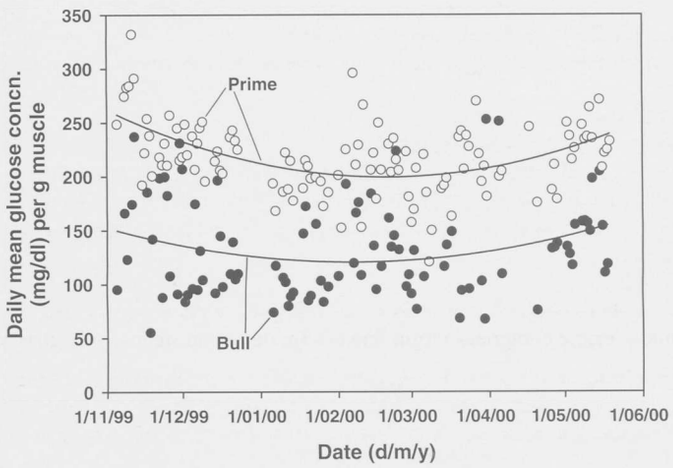

Fig. 3 Mean glucose concentration normalised to 1 g, from data collected for prime cattle and bulls between 5 November 1999 and 22 May 2000. Quadratic equations are both $P < 0.01$.

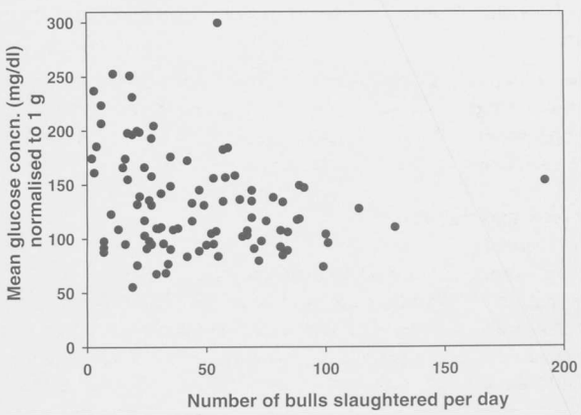

Fig. 5 Correlation between mean normalised glucose and number of bulls slaughtered per day (r = -0.25).

High temperatures on and preceding the slaughter day appeared to adversely affect glycogen, with correlation coefficients ranging from -0.32 to -0.19 ($P \leq 0.05$) (graphs not shown). Lower temperatures were conducive to high glycogen. The survey was conducted from late spring to late autumn, and severely cold conditions, which have been implicated in the dark-cutting condition (Tarrant and Sherington, 1980), were not encountered.

Conclusion

This patented method of rapidly determining glycolytic potential in slaughtered cattle has immediate application in determination of ultimate pH before carcasses are graded. However, its role in supply chain management may be more important. For example, glycogen data fed back to suppliers and animal handlers should result in an improved quality of animal presented for slaughter, should price signals be sufficient. Its potential in animal welfare may be important too because animals low in muscle glycogen have been subjected to some stress. Knowing the glycolytic potential may highlight stressful practices.

References

Fisher, C.& Hamm, R. (1981). Post-*mortem* muscle biochemistry and beef quality. In D.E. Hood & P.V. Tarrant, *The Problem of Dark-Cutting in Beef* (pp. 387-394). The Hague: Martinus Nijhoff. • Tarrant, P.V. and Sherington, J. (1980). An investigation of ultimate pH in the muscles of commercial beef carcasses. *Meat Science* 4, 287-297.

Acknowledgement and statement

The method to rapidly predict ultimate pH was developed under contract to Meat New Zealand who is co-owner, with Celentis Limited, of the international patent (WO 00112844) that protects the technology. Written permission from the owners must be obtained before other parties can use the method in commercial or non-commercial applications. Semi-automated equipment to apply the method is currently being developed at MIRINZ Centre, AgResearch Ltd., for international sale.