APPLYING A NOVEL METHOD FOR THE ANALYSIS OF BEEF ULTIMATE pH IN THE DETECTION OF QUANTITATIVE TRAIT LOCI

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ABSTRACT

Beef ultimate pH (pH_U) is an economically important trait related to meat quality. Values of pH_U higher than the normal 5.5 have a detrimental effect on tenderness, colour and keeping quality. The amount of lactic acid that is produced by the conversion of the glycogen stored in the muscle at time of slaughter (G_0) determines pH_U.

A novel biochemically-based approach for pH_U analysis was evaluated in the detection of quantitative trait loci (QTL) affecting this characteristic. The procedure proposed by Pleasants *et al.* (1999) transforms pH_U to the underlying glycogen generating a new variable, named predicted glycogen (PG_0). This model may overcome the limitations in pH_U investigations derived from its typical skewed distribution, characterised by a peaked primary mode at 5.5 and a long tail that comprise high pH_U values. In addition to PG_0, G_0, pH_U and the logarithmic transformation of pH_U (LpH_U) were analysed in: a simulated back-cross involving two inbred lines based on a model including a QTL and polygenic effects influencing G_0 and thus pH_U; and in experimental data from a reciprocal back-cross between Jersey and Limousin implemented by AgResearch.

The significance levels achieved by LpH_U did not differ from pH_U, indicating that there was no advantage of using this transformation. Evidence of QTL was clearer for PG_0 than pH_U in the simulation. A better performance of PG_0 compared to pH_U was observed when there were more elevated pH_U values. Results from the experimental data did not confirm the superiority of PG_0 in QTL detection. With the exception of one value of 6.2, pH_U data obtained in the experiment were close to 5.5.

It is concluded that PG_0 may improve the significance in QTL searching compared to pH_U when pH_U include high values that lead to the typical skewed distribution. The new procedure can also be exploited in other investigations utilising pH_U. Additional research work involving the characterisation of G_0 and pH_U is recommended to re-evaluate the parameters assumed in the implementation of this innovative approach.

Key words: beef, ultimate pH, muscle glycogen, quantitative trait loci

Dedicated to Mariano Navajas
and Afranio Velosa-Guzman,
two precious souls

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CHAPTER ONE

INTRODUCTION

The quality of product, in addition to the quantity produced per unit input, affects the economic efficiency of any meat-producing system. In an ideal marketplace, the value of beef presented in a similar way is determined by aspects of meat quality differences, which will impact returns from the production systems (Purchas *et al.*, 1989). Although "taste", price and healthfulness were identified as the three primary motivators related to meat purchase and consumption, if beef fails to meet quality expectations, price and healthfulness were irrelevant (Chambers and Bowers, 1993).

Ultimate pH is a meat characteristic that is not directly evaluated by consumers but has a strong influence on some of the most relevant quality attributes: colour and tenderness. Meat colour is the first criterion used by consumers to judge meat quality and acceptability. High pH values (>6.0) lead to dark cutting or dark, firm and dry meat which is rejected by consumers because of its unacceptable colour (Abril *et al.*, 2001). On the other hand, intermediate pH beef (5.7-6.2) has been associated with reduced tenderness, which has been rated by consumers as the most important aspect of eating quality (Tarrant, 1998). High pH values also reduce the shelf life due to altered bacterial growth (Gill and Newton, 1981).

Meat pH is often used as a means of monitoring meat quality and a pH below a threshold of pH 5.8 is usually demanded for chilled beef markets (Wright *et al.*, 1994). The percentage of carcasses that fail this specification in New Zealand has been estimated to be about 10 to 30% (Graafhuis and Devine, 1994; Smith *et al.,* 1996). These percentages indicate that too many carcasses have variable and sub-optimal meat quality parameters. An evaluation of the economic impact of this problem in New Zealand suggests that a lower incidence of high pH leads to financial benefits by reducing costs and increasing the potential price of the product (Wright *et al.*, 1994).

Several studies have been carried out to understand factors contributing to high pH beef. However, the distorted distribution of ultimate pH has hindered this task. The frequency distribution of ultimate pH in slaughtered animals typically presents a peak around pH of 5.5 and a long upper tail with a variable proportion of values up to 7.0-7.2.

Recently a biochemically-based approach to analyse beef pH has been developed. The gradual fall in muscle pH following slaughter, from approximately neutral values (7.0) to around 5.5, results from the post-mortem accumulation of lactic acid in the muscle that is produced by the conversion of glycogen. If muscle glycogen levels at slaughter are low, the supply of substrate for glycolysis is limited resulting in a lower concentration of lactic acid and a higher ultimate pH. Pleasants *et al.* (1999) proposed a mathematical model that includes knowledge of the biochemical pathways from glycogen to lactic acid in a manner suitable for statistical analysis. In this study, the new approach is applied in the detection of quantitative trait loci (QTL) for ultimate pH.

It is now known that a proportion of the variation in some economically important traits can be attributed to one or few major genes, known as QTL. Knowledge of the existence and chromosomal location of QTL can be exploited through breeding programs utilizing strategies that include molecular information (MAS, marker-assisted selection). MAS is especially appealing in the genetic improvement of meat quality traits as it would allow the evaluation of live breeding animals of both sexes at a young age and this may increase the genetic response compared to traditional methods of selection.

Different methods have been developed to identify QTL using linked markers (Haley and Knott, 1992; Knott *et al.*, 1996). However, the standard techniques have not specifically incorporated the information about the biological processes involved in the expression of a specific trait. The objective of this study is to evaluate the effect of applying the new approach in QTL detection in two situations: a simulated back-cross involving two inbred lines; and in experimental data that was collected in a project carried out by AgResearch and the University of Adelaide, using a double-back-cross between Jersey and Limousin. The variables to be analysed include muscle glycogen in the live animals, actual ultimate pH, logarithmic transformation of pH and glycogen predicted from the pH information based on the new methodology.