The best estimate of maturity for predicting eating quality depends on the age range of the carcasses examined

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THE BEST ESTIMATE OF MATURITY FOR PREDICTING EATING QUALITY DEPENDS ON THE AGE RANGE OF THE CARCASSES EXAMINED

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Abstract – Ossification score and animal age are both used as proxies for maturity-related collagen crosslinking and consequently decreases in beef tenderness. Ossification score is strongly influenced by the hormonal status of the animal and may therefore better reflect physiological maturity and consequently eating quality. As part of a broader cross-European study, local consumers scored 18 different muscle types cooked in three ways from 482 carcasses with ages ranging from 590 to 6135 days and ossification scores ranging from 110 to 590. These scores were analysed with a linear mixed effects model using the full range of data and then again separately for carcasses with lesser and greater maturity. Across all the data, and for the carcasses with greater maturity, animal age had a greater magnitude of effect on eating quality than ossification score. In contrast, age had no relationship with eating quality for carcasses with lesser maturity leaving ossification score as the more appropriate measure. This is likely due to a loss of sensitivity in mature carcasses where ossification scores are approaching the maximum value. Therefore ossification score is more appropriate for most commercial beef carcasses however it is inadequate for carcasses with greater maturity such as cull cows.

Key Words – Beef quality, Consumer testing, Ossification score, animal age

I. INTRODUCTION

Variability in tenderness is seen as a major factor in the decline in beef consumption [1]. One of the most important determinants of beef tenderness is collagen crosslinking which increases with animal maturity resulting in tougher meat [2].

Ossification score, a visual assessment of calcification of the cartilage in the sacral and dorsal vertebrae, is used as a proxy for animal maturity in beef quality prediction for the Meat Standards Australia (MSA) system and the USDA (United States department of agriculture) system [3]. This measurement is strongly influenced by the hormonal status of an animal, particularly oestrogen. Factors such as stress, gender, castration, pregnancy and lactation all influence oestrogen levels and therefore ossification score. Alternatively animal age also reflects maturity. This measurement is readily available in Europe, yet in contrast to ossification is not influenced by physiological factors. Hence it is likely that ossification score will better reflect the physiological maturity of an animal than chronological age due to its sensitivity to physiological and environmental factors [4]. Therefore, we hypothesize that ossification score will be a better predictor of eating quality than chronological age.

II. MATERIALS AND METHODS

482 carcasses were selected at various commercial abattoirs for numerous individual experiments that have been collated for the purpose of this study. As such the carcasses reflect the different production practices of France, Poland, Ireland and Northern Ireland. All carcasses were graded by trained personnel using standard MSA (Meat

Standards Australia) and USDA grading protocols [5]. Ultimate pH was recorded at 24h post slaughter. All cattle were growth-promotant free. There was a wide range in age and ossification score, though the distribution was heavily weighted with carcasses of lesser maturity (Figure 1).

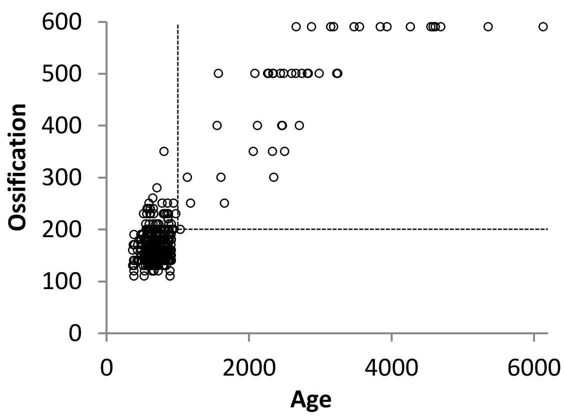

Figure 1 The age of each carcass against the ossification score

Age=animal age in days; Ossification score was recorded as standard MSA (Meat Standards Australia) measurements by trained graders. Carcasses above and right of the dotted lines had greater maturity; carcasses to the left and below the dotted lines had lesser maturity

There was an uneven distribution of the 6852 muscle samples amongst all the effects controlled for in this study which included post mortem ageing period, sex, carcass hang method, cooking method, source country and breed classification (Table 3). Animal breed was divided into four categories or classes. British beef breeds, European beef breeds, Dairy breeds and crosses between the beef and dairy breeds.

Consumer assessment of eating quality was performed according to protocols for MSA (Meat Standards Australia) testing described previously [6]. Samples were prepared using one of three cooking methods, grill, roast and slow cook. In total, there were 68520 consumer responses, with each individual consumer giving 6 separate responses. Consumers scored meat for tenderness, juiciness, flavour liking and overall liking [7]. Each muscle from each carcass was assessed by 10 individual untrained consumers. The highest and lowest two scores for each muscle were removed and the average was calculated for the remaining six scores. These clipped means were combined on the basis of a discriminant analysis [8] to create a single MQ4 score. There was a high correlation between all four sensory scores with a minimum partial correlation coefficient between any of the scores of 0.66 calculated on a subset of the data [9].

The impact of both ossification score and age on the composite MQ4 score was assessed in the full dataset and two subsets representing the greater or lesser maturity groups (Figure 1). The lesser maturity group, totaling 434 carcasses, contains carcasses with an ossification score of 200 or less or an age of 987 days or less. The greater maturity group, totaling 48 carcasses, was all carcasses not considered in the lesser maturity group.

A bivariate model accounting for the fixed effects of country, sex, class and kill group, and significant interactions between these terms, was used to determine the partial correlation coefficient between ossification and age.

The composite score MQ4 was analysed using a linear mixed effects model (SAS v9.1). Initially a base model was established, with the following fixed effects and all their significant interactions, carcass hang method, cooking method, muscle type, sex, country, and class. *Post mortem* ageing period in days was included as a covariate. Animal identification number, grader and kill group (animals slaughtered on the same day at the same abattoir) were included as random terms. The degrees of freedom were determined using the Kenward-Rodger technique. The consumers were expected to show minimal variation between countries on the basis of previous work [10] [11] [12]. Separately, ossification score and age were then incorporated into the base models, including all interactions, to assess their association with the MQ4. In all cases, non-significant terms (P>0.05) were removed in a step-wise fashion. This process was repeated for the three sets of data. Resulting models were compared using two different indicators, residual variance explained and magnitude of effect. Magnitude of effect was calculated as the difference between the lowest and highest predicted MQ4 values over the range of the covariate being examined, with larger values demonstrating a greater influence of the covariate on MQ4. A positive value would indicate an increase in MQ4 over the range of the covariate, and a positive relationship, while a negative value would indicate a decrease in MQ4 and a negative relationship. The covariates USA ossification score, USA marbling score, ultimate pH, animal age and carcass weight were tested in the models to evaluate their effects on the relationship between MQ4 and ossification score and age.

III. RESULTS AND DISCUSSION

The bivariate model for ossification and age within the greater maturity group had the greatest partial correlation coefficient, 0.80 ($p<0.01$). It was similar, 0.79 ($p<0.01$) when examining all the data, however was markedly reduced for the carcasses with lesser maturity, 0.35 ($p<0.01$). This shows that animal age and ossification score are closely related measures of maturity; however their relationship varies between different maturity levels. This is partly expected since the broader data range of the greater maturity group would be a contributing factor driving its higher correlation; however it also validates the exploration of the relationship between these maturity measurements and MQ4 over different ranges in maturity.

Across the full range of data, both ossification score and age were associated with decreasing MQ4, yet contrary to our hypothesis the magnitude of this effect was greater for age across all four cooking methods (Table 1). One explanation for this could be that MSA and USDA graders have less experience grading animals of greater maturity, which would therefore affect the consistency and accuracy of those scores. Alternatively, the sensitivity of the ossification scoring system may be the limitation. It has an upper limit of 590, when all cartilage has ossified, while age does not have this limitation. The plateau in ossification score in this dataset appeared at about 8 years (3000 days), and yet the age data extends well beyond this point, possibly explaining the smaller magnitude of effect of ossification score than age, particularly in data containing such old animals. For this reason, further analysis was undertaken after splitting the dataset, enabling the exploration of the maturity measurements with and without ossification score reaching its plateau.

Table 1 The magnitude of effect of age and ossification score on MQ4 for the full range, and for mature cattle only.

		All Data	
Cook Method	N	Age	Ossification
Grill	4333	-7.0	-6.8
Roast	2206	-1.9	0.5
Slow cook	180	-13.6	-13.0
		Greater maturity	
Cook Method	N	Age	Ossification
Grill	308	-6.1	-6.4
Roast	54	-15.0	-6.4
Slow cook	42	-8.7	-6.1

N= number of samples tested; Age=animal age in days; Ossification score was recorded as standard MSA (Meat Standards Australia) measurements by trained graders. All and greater refer to the sections of the data utilised for the calculation. All=all the carcasses; greater= ossification score >200 and age >987 days;

As would be expected, in the more mature animals age generally had the greatest magnitude of effect on MQ4. This was evident for both roast and slow cook methods, although the magnitude was slightly smaller for grill (Table 1). Overall, the model including age explained an extra 0.51% of the residual variance however the model including ossification score only explained an additional 0.01%. Hence age appears to be a better descriptor of eating quality than ossification score in animals with greater maturity, supporting the assertion that the plateau in ossification scores at about 3000 days diminishes its ability to predict MQ4.

In contrast, age had no relationship with MQ4 within the lesser mature carcasses. Ossification score however was significant and interacted with sex, cook method and country (data not shown). This result aligns well with the hypothesis that ossification score would more closely relate to physiological maturity [4] and therefore better reflect the impact of maturity on eating quality [2]. When the models were separately corrected for the covariates ultimate pH, carcass weight, marbling score, hump height and eye muscle area, there was no effect on the significance of ossification or age.

Overall the results have shown that the best maturity measurement depends on the expected maturity of the cattle to be evaluated. Animal age would be more useful for mature animals such as cull cows and bulls which are likely to have reached the maximum ossification score.

However, age would not be useful for steers and heifers produced in a more conventional beef production system with ossification score being more suitable.

IV. CONCLUSION

Eating quality is an important determinant of the repeat purchase of beef by consumers. Delivering a price signal on eating quality is a good incentive for producers to produce carcasses that have a better and more consistent eating quality. Maturity related decreases in eating quality are often estimated by either animal age or ossification score. The relationship of these measures with eating quality varies between groups of animals with different maturities. Ossification score is more appropriate within steer and heifer markets where animals tend to be younger. As animals mature, animal age becomes a more accurate predictor of eating quality, particularly for groups such as cull cows and mature bulls.

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