Le persillé : biologie et importance pour la qualité des viandes Le rôle du persillé dans la qualité des viandes ovine et bovine : développement, importance, mesure et harmonisation des méthodes d'évaluation

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Le rôle du persillé dans la qualité des viandes ovine et bovine : développement, importance, mesure et harmonisation des méthodes d'évaluation

Mots clés : persillé, méthode, évaluation, MSA, gras intramusculaire, qualité sensorielle

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Cet article évoque le rôle du persillé dans la qualité des viandes de bœuf et d'agneau, son développement, son importance actuelle, son évaluation et l'harmonisation des méthodes d'évaluation à travaux des travaux de recherche présentés au congrès annuel de la fédération européenne des sciences animales (EAAP) à Florence du 1er au 4 septembre 2024.

Résumé

Cet article est une synthèse d'une session consacrée à la recherche sur le persillé ou le gras intramusculaire chez le bœuf et l'agneau présentée lors du congrès annuel de la fédération européenne des sciences animales (EAAP) à Florence du 1er au 4 septembre 2024. Une vue d'ensemble du développement du persillé a été présentée insistant sur les rôles de la génétique en termes de prolifération et de localisation des adipocytes intramusculaires et de croissance musculaire, ainsi que sur le rôle de la nutrition et de l'âge de l'animal durant la finition. L'avènement de nouveaux outils de mesure en ligne du taux de gras intramusculaire a conduit au développement d'un nouveau modèle australien des normes de la viande pour prédire la qualité sensorielle de la viande d'agneau sur la base de l'équilibre entre le rendement en viande maigre et le taux de gras intramusculaire. D'autres technologies basées sur la chimie des lipides du tissu musculaire, telles que la spectrométrie de masse à ionisation par évaporation rapide (REIMS), sont très prometteuses pour classer les pièces de viande cuites selon leur flaveur et leur qualité globale attribuée par les consommateurs. Enfin, la détermination chimique du taux de gras intramusculaire est proposée comme la meilleure méthode pour étayer les futurs systèmes de classement des carcasses qui est actuellement basé sur l'évaluation visuelle du persillé.

Abstract: The role of marbling in beef and lamb quality - development, importance, measurement, harmonisation

This session, presented at the EAAP meeting in Florence on September 2nd, 2024, described research on marbling or intramuscular fat in beef and lamb. An overview of marbling development was presented with the important roles of genetics in terms of intramuscular adipocytes proliferation and location and muscle growth, along with the role of nutrition and animal age during finishing. The advent of new tools to measure intramuscular fat on-line has led to the development of a new Meat Standards Australian model to predict the eating quality of lamb based on balancing lean meat yield and intramuscular fat. Other technologies based on general lipid chemistry of muscle tissue such as Rapid Evaporative Ionisation Mass Spectrometry (REIMS) shows great promise to classify both flavour liking and the overall quality grade given by consumers to cook beef cuts. Finally, chemical intramuscular fat is proposed as the best method for underpinning future carcass grading schemes that currently use visual appraisal of marbling.

INTRODUCTION

Intramuscular fat (also known as visual marbling) is an important depot in meat producing animals. It is well characterised scientifically that this depot plays an important role in the sensory quality of red meats such as beef and lamb, enhancing flavour, juiciness and even tenderness outcomes for the consumer (Dikeman 1987; Pannier *et al.*, 2014; Thompson, 2004). Key topics discussed include understanding the biological development of fat at the intramuscular site, its role in predicting eating quality outcomes as determined by consumer sensory panels and finally the merits of using chemical intramuscular fat as the gold standard in to the future for all carcass grading systems that currently use visual marbling assessment. This session was presented at the European Association of Animal Production annual conference, Florence, Italy with speakers from France, Australia, Ireland and Italy, addressing these issues.

I. INTRAMUSCULAR FAT – DEVELOPMENT AND OVERWIEW

Jean-François Hocquette introduced the session on intramuscular fat (IMF), also known as marbling which results from adipocyte proliferation and expansion within connective tissue and vascular seams of muscle (Hocquette *et al.*, 2010). The stored triacylglycerol has a positive influence, even at moderate levels, on the sensory properties of beef. The expression is heavily influenced by the extent of muscle growth given that IMF is the ratio of [fat]/[fat + muscle]. So, younger animals, more muscular breeds and entire males have lower IMF levels due to muscle development diluting fat accretion. In addition, muscle groups with more aerobic muscle fibres have generally an increased level of IMF. A key enabler of IMF expression is genetic selection for this trait specifically, rather than for fat deposition at other sites such as subcutaneous fat. There is consistent evidence that IMF adipocytes are different to those found at other depots with the cells being smaller, metabolically less active and typically showing a preference for glucose and lactate as a fat precursor rather than acetate. Consistent with this, is the role of feeding high energy diets (typically containing starch from cereal grains) to improve the expression of IMF. However, nutritional manipulation of IMF independently from other fat depots has proved more problematic with typically total carcase fatness also increasing along with IMF; although manipulating the Vitamin A axis has shown some promise. There is an increased expression of IMF in older cows at a given total body fatness and muscularity which may relate to fat turnover favouring IMF over many calving cycles. The higher IMF in cows is an opportunity to value-add selected cuts to meet consumer expectations. A French premium beef brand has been launched to better value IMF.

II. PREDICTING THE CONSUMER RATING OF COOKED BEEF OR LAMB

II.1. An evaluation of muscle cut, maturation and meat quality of beef using Rapid Evaporative Ionisation Mass Spectrometry (REIMS) analysis

Lynda Perkins discussed Rapid Evaporative Ionisation Mass Spectrometry (REIMS) which is a rapid ambient analytical technique. Applications of REIMS include determination of biological tissue, food fraud and more recently sensory quality parameters of meat, in particular beef (Hernandez-Sintharakao *et al.*, 2023; Liu *et al.*, 2024). Determination of beef muscles, maturation period as well as the sensory quality using consumer taste panels and the Meat Standards Australia (MSA) grading system is currently unknown. Therefore, the aim of this study was to use REIMS and advanced chemometric modelling to uniquely connect REIMS data from four raw beef muscles, season, maturation, consumer sensory scores and MSA grading. Beef samples (N=149) from four muscles, were collected from 31 carcasses from two seasons (summer and winter) after 7- and 21-day maturation post-slaughter. Carcasses were MSA graded, and consumer taste panels were conducted at 18 different locations in Wales. Beef samples were burned using a monopolar electrosurgical “iKnife” attached to the REIMS system; a Xevo G2-XS QTof Mass spectrometer (Waters Corporation, Wilmslow, UK). Data acquisitions were performed in sensitivity mode with continuum data acquisition in negative ionisation mode. REIMS data was extracted using the Abstract Model Builder software and analysed using Simca software. REIMS analysis successfully identified four beef muscles, in addition to summer and winter seasons and 7- and 21-day maturation. Consumer taste panel results and MSA grading scores were also positively discriminative using REIMS. This study has demonstrated that REIMS can detect and categorise unique chemical fingerprints related to muscle, season, maturation, and sensory quality of beef.

II.2. REIMS (Rapid Evaporative Ionisation Mass Spectrometry) prediction of beef sensory quality and its relationships to fat level

Jingjing Liu further described an experiment using the REIMS technology. To characterize beef eating quality and its relationship to marbling and lipids, 31 young grass-fed crossbred Angus x Salers were used in this study. Three muscles (*longissimus dorsi*, *triceps brachii*, and internal abdominal obliques) were used for sensory evaluation and REIMS analysis. Results indicated that grass-fed crossbred Angus x Salers produced lean meat of ”better than average” palatability. Although no significant correlation was observed between beef sensory quality and

marbling/lipid levels, however, lipid molecules were the primary component detected by REIMS. REIMS showed great potential to classify beef sensory quality and grades (i.e., higher flavor liking vs. lower flavor liking; satisfactory vs. unsatisfactory) with accuracies up to 99% (Liu *et al.*, 2024). Moreover, REIMS has the potential to predict visual-measured marbling and gas chromatography measured lipid and/or FA levels, with varying efficacy due to distinct REIMS fingerprinting. In addition, in very lean beef, fatty acid species can be better indicators of sensory attributes rather than total fat content. Overall, REIMS classification results may be more robust with larger sample sizes and wider variances.

II.3. Flavour drives consumer eating quality acceptability as intramuscular fat increases in Australian lamb

Sonya Moyes then discussed the role of intramuscular fat in lamb in determining flavour liking by consumers. Untrained consumer-determined scores for overall liking, flavour, tenderness and juiciness are highly correlated due to consumers' inability to discriminate between these traits. Overall liking is an indicator of a consumer's overall product acceptability; hence, overall liking is considered to reflect flavour, tenderness and juiciness attributes (Liu *et al.*, 2020). Increasing IMF improves all eating quality traits, principally juiciness and flavour (Pannier *et al.*, 2014). Carcasses with a higher loin IMF% content result in meat which are juicier and more flavoursome; therefore, these traits could be expected to contribute more to a consumer's overall acceptability. The knuckle, loin, outside, rump, topside, leg, rack and shoulder were collected 24 hours post-slaughter from 3119 lambs. Each cut was assessed for overall liking, flavour, tenderness and juiciness on 100-point scale lines (100=best) by untrained consumers. Chemical IMF% was determined for the loin. Consumer responses (n=108,410) were arbitrarily split based on IMF ranges between 2.0-4.0, 4.1-6.0, 6.1-8.0 and >8.0%. Within each IMF category, data was divided into five subgroups balanced for IMF%. Within each subgroup, a linear model was used to predict overall liking, with flavour, tenderness, and juiciness simultaneously included as independent variables. Relative weight analysis then determined the contribution of each variable to the prediction of overall liking. The mean of the relative weights for each of the five subgroups was calculated and compared between IMF categories via a one-way analysis of variance. Flavour was the highest contributor to overall liking within each IMF category, improving ($P<0.05$) from 43.4 to 47.3% across the 10.8% IMF range. This was associated with a decline ($P<0.05$) in the contribution of tenderness (29.1-26.5%). The contribution of juiciness to overall liking was not affected ($P>0.05$) by IMF. The increasing importance of flavour between IMF categories has occurred over a relatively small IMF range of as little as 4%. This implies that the contribution of flavour to eating quality may become more important as future genetic selection broadens the range of IMF in lamb.

II.4. A cuts-based Meat Standards Australia grading system for sheepmeat

Liselotte Pannier then described how a new cuts-based Meat Standards Australia (MSA) eating quality grading system is being developed for lamb and sheepmeats. This system requires objective measurements of carcass traits acquired at processing that describe eating quality variation. Previous studies have identified these carcass traits to be intramuscular fat % (IMF%), lean meat yield (LMY), and hot carcass weight (HCWT) (Pannier *et al.*, 2018). To develop the model, data was collected from 3,106 lambs of which 11,040 cuts were sampled. Consumer tasting sessions (n=312) were carried out with 18,720 untrained consumers who scored samples for tenderness, juiciness, flavour liking and overall liking on a scale from 0 (worst) to 100 (best). Loin, topside, outside, rump and knuckle cuts were grilled, whereas the rack, leg, shoulder, and knuckle cuts were roasted. A discriminant analysis of the 4 eating quality traits defined their combined weightings within a single meat quality score. A linear model was then fitted to predict this score, using IMF%, LMY, and HCWT as covariates and cut as a fixed effect. Results indicated that eating quality was predicted with an accuracy of 75% (grill) and 72% (roast), though great individual consumer variation exists. The model will allow allocation of cuts according to eating quality grades.

II.5. Characterisation of Meat Quality Attributes in Different Cattle Breeds: Implications for Labelling and Consumer Choice

Luca Grispoldi explained how consumer preferences for beef are increasingly driven by the desire for high hygienic, nutritional, and organoleptic quality. This paper investigated the impact of cattle breed on key quality attributes—colour, marbling, and tenderness—central to consumer choice. Six different bovine breeds were taken into consideration: German Red Pied (n = 63), Piemontese (n=117), Chianina (n=63), Angus (n=63), Friesian (n=18) and a Polish cross breed (n=63). The cut of meat analysed was the entrecôte, or boneless rib, obtained from the muscles located between the fifth and eighth rib of the loin. Colorimetric assessments, marbling evaluations, fatty acid profiling, and tenderness measurements, were conducted on meat cuts from each breed. Results revealed significant variations in colour, marbling, and tenderness among breeds. Statistical analysis of the data was carried out using StatView 5.0.1 software (SAS Institute, Cary, NC, USA) for the analysis of variance (ANOVA) with Fisher PLSD (protected least significant differences). Chianina, Friesian, and the Polish crossbreed exhibited distinct colour characteristics, with Chianina displaying notably brighter meat. Angus emerged as the most marbled breed, while Chianina and Piemontese showed lower marbling. Total lipids content correlated with visible marbling. Fatty acid composition varied, with Angus having higher omega-3 percentages. Tenderness assessments identified Angus and Friesian as the most tender breeds. The study's findings contribute to a proposed grading scale for colour, marbling, and tenderness, offering potential labelling infographics to assist consumers in making informed

choices based on individual preferences and needs. These insights underscore the importance of breed-specific information on labels to enhance consumer understanding and facilitate more informed purchasing decisions.

III. CHEMICAL INTRAMUSCULAR FAT – THE NEW GOLD STANDART TO GRADE MARBLING

III.1. Transforming chemical intramuscular fat% into MSA and AUS-MEAT marbling scores and potential application in the Australian beef industry

Sarah Stewart discussed how the Meat Standards Australia (MSA) and AUS-MEAT visual marbling scoring systems are key determinants of carcass value in the Australian beef industry and are well recognised traits in national and international markets. With the more recent the emergence of objective measurement technologies there are opportunities to grade beef carcasses using objective traits such as chemical IMF%. However, abrupt change to MSA model inputs and AUS-MEAT grading practices would cause significant disruption to the beef industry. Therefore, a solution was proposed to develop an industry approved equation to convert IMF% into MSA marbling and AUS-MEAT marbling scores. These converted marbling values would then seamlessly integrate into existing grading and marketing systems, whilst being underpinned by an objective, gold standard trait (Stewart *et al.*, 2021). Carcasses (n = 5,513) from industry experiments across 7 years (2017 – 2023) were graded for MSA marbling and AUS-MEAT marbling and sampled for chemical intramuscular fat (IMF%). Using this data, equations were derived to convert IMF% to MSA marbling (IMF%-MSAMB) and AUS-MEAT marbling (IMF%-AUMB). When validated the IMF-MSAMB model described 91% of the variation in MSA marbling (Residual Standard Error (RSEV) = 57.9), with a slope of 0.90 and negligible bias of -0.54. Similarly, IMF-AUMB described 88% of the variation in grader AUS-MEAT marbling scores (RSEV = 0.68) with a slope very close to 1 (0.94) and little bias (0.06) (Stewart *et al.*, 2024a). Industry-wide implementation of this equation is currently being considering in Australia. This would enable grading technologies to be calibrated and validated against chemical IMF% whilst minimising industry disruption.

III.2. Prediction of consumer palatability in beef using visual marbling scores and chemical intramuscular fat percentage

Finally, Garth Tarr described that with development of objective technologies which can predict chemical intramuscular fat percentage (IMF%), there is a need to understand the relationships between existing marbling traits, IMF% and eating quality. This presentation initially demonstrated the strong correlation between chemical IMF% in the striploin and chemical IMF% in other muscles, particularly the eye round, outside and the oyster blade (Stewart *et al.*, 2021). This is an important finding because of the way that measurements taken at a single site, e.g. the striploin, are used in cut by cook eating models to predict eating quality in other muscles. A related analysis of historical carcass data (n = 9,641 observations) from the Meat Standards Australia (MSA) industry research dataset and included MSA grading data, chemical IMF% data and weighted composite eating quality scores (MQ4). Several analyses were performed to assess the prediction of eating quality by MSA marbling, M. longissimus thoracis et lumborum (striploin) IMF% and cut specific IMF%. Results demonstrated that there was similar precision between chemical IMF% (R2 = 0.32, RSE = 11.8) and MSA marbling (R2 = 0.28, RSE = 11.9) in the prediction of grilled 14-day aged striploin MQ4. These results, published in Stewart *et al.*, (2021), support the continued development of objective technologies that predict chemical IMF%, like that described in Stewart *et al.*, (2024b), in parallel with MSA marbling for carcass grading and the prediction of eating quality.

IV. CONCLUSION

Intramuscular fat is a complex trait being a combination of adipocytes between muscle fibres. Its development is heavily influenced by the ability of animals (i) to have adipocytes located within muscle tissue and (ii) the rate of muscle tissue development. Genetic predisposition for adipocytes within muscle is important along with the provision of high energy diets (via high quality pasture or concentrate feeding). Animal age is therefore a factor and indeed the development of IMF is higher in cows which represents a value-adding opportunity for cuts from this class of animal. New techniques are being developed that either can measure intramuscular fat on-line (cameras, near infrared spectroscopy and microwave for example) or more generally lipids within muscle such as REIMS. The on-line technologies have made it possible to develop an MSA model for predicting the eating quality of cut by cook options for lamb and sheepmeats which is based on balancing lean meat yield and IMF. The REIMS technology is showing great promise for being able to accurately classify the quality grades (unsatisfactory, good every day, better than every day, premium) given by consumers to cooked beef cuts. In addition, the REIMS technology can also classify high/low flavour scores which is driven substantially by the level of IMF. Finally, it is clear that chemical intramuscular fat is the best trait for underpinning future carcass grading schemes that currently use visual appraisal of marbling. Importantly IMF explains the same variance in eating quality as visual marbling and is repeatable, meaning new technologies can be more precisely calibrated. Subsequently resulting data streams will enhance on-farm decision making including genetic programs aimed at increasing IMF.

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