La revue scientifique
Viandes & Produits Carnés
Référence de l'article : VPC-2023-3923
Date de publication : 29 novembre 2023
www.viandesetproduitscarnes.com

Classement des carcasses pour la durabilité de la filière viande bovine et ovine. Partie II.

Classement des carcasses pour la qualité et l'efficacité afin de garantir la durabilité des filières viandes bovine et ovine dans le futur. Partie II.

Mots-clés : carcasse, bovins, qualité, ovins.

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Cet article est un compte-rendu des posters inclus dans la session 18 du 74ème congrès européen des sciences animales (European Federation of Animal Sciences (EAAP)) qui a eu lieu à Lyon du 28 août au 1er septembre 2023 conjointement avec le congrès de l'association mondiale de la production animale (WAAP).

Résumé :

Les posters associés à cette session ont été affichés les deux premiers jours du congrès joint EAAP/WAAP. Ils ont présenté les dernières recherches scientifiques relatives aux méthodes de classements de carcasses de bœuf, agneau et porc. Les études conduites sur trois continents montrent un engouement de la filière viande pour l'utilisation de méthodes innovantes de prédictions de la qualité des carcasses. Les résultats de ces études démontrent un grand potentiel de détermination des caractéristiques des carcasses pour aider la filière viande à répondre à différents enjeux tels que les prédictions du rendement, de la composition et de la qualité des carcasses. L'utilisation de ces outils de prédiction pourra guider la création de filières de qualité garantie et permettra à la filière de répondre aux besoins des consommateurs qui sont au centre de l'attention.

Abstract: Carcase grading for quality and efficiency – underpinning future sustainability of beef and lamb. Part II.

The posters associated with this session displayed on the first two days of the joint EAAP/WAAP congress presented the latest scientific research on grading methods of beef, lamb and pork carcasses. Studies conducted on three continents show a craze in the meat industry for the use of innovative methods for predicting carcass quality. The results of these studies demonstrate a high potential for determining carcass characteristics to help the meat industry address issues such as predictions of carcass yield, composition and quality. The use of these prediction tools can guide the creation of quality assured supply chains and allow the industry to meet the needs of consumers at the center of attention.

INTRODUCTION

The meat products are an essential source of nutrients for human diet (Leroy *et al.*, 2023) and its consumption will increase globally over the next decade due to growing population (OECD and FAO, 2023). The meat industry challenges such as improving the productivity and quality are the most urgent. The use of data for production improvement is an important decision-making factor and leads to the development of predictive models using strong scientific and statistical approach. This session presented at the recent combined EAAP/WAAP in Lyon addressed these issues with presenters from Europe, Brazil and Australia. This research focuses on various meat sector objectives including the use of data to predict carcass yield with conformation and fat cover to optimise fabrication. The use of technologies to define the composition of the carcass with computed tomography or to measure marbling were also studied. Finally, the prediction of the carcass traits is leading to pathways to improve meat eating quality.

I. PREDICTION OF CARCASE CONFORMATION AND FATNESS AND USING DATA TO OPTIMISE FABRICATION

Potential of deep learning video image analysis for automated SEUROP-classification

In cattle slaughterhouses in Europe, video image analysis (VIA) combined with linear regression (LR) modelling is widely used to assist or replace human SEUROP-classifiers. During the authorization procedure of the VBS 2000 (E+V) in Belgium in 2022, a deep learning (DL) algorithm was evaluated as an alternative for LR in terms of correct classification as well as other potential advantages. In Belgium, carcasses are classified into 18 different subclasses for conformation (SEUROP with subclasses +, = and -), 15 subclasses for fat cover (12345 with subclasses +, = and -) and 7 animal categories (ABCDEZV). For the authorization test, a sample grid of 650 carcasses was made according to the distribution of category, conformation and fat cover in the Belgian carcass population. A jury of 5 assigned classification experts (2 from Belgium and 3 from other EU member states) were positioned next to the VBS 2000 and independently graded 1123 bovine carcasses, of which 650 were finally used to fill in the grid on a first come, first served basis. The carcass classification was predicted by a previously developed VBS 2000 DL algorithm as well as a LR model, and these scores were compared with the median score of the jury. Correct classification was defined as having the same subclass or one subclass difference compared with the median expert score. For conformation, DL and LR resulted in high and comparable correct classification (90.9% and 92.0% respectively). Differences of 2 and 3 subclasses were observed for 8.9% and 0.2% respectively of the carcasses for DL, and 7.4% and 0.6% for LR. For fat cover, the correct classification was meaningfully larger for DL than for LR (95.7% versus 86.6%). A difference of 2 subclasses was found for 1.3% and 12.0% of the cases respectively, whereas DL had no scores with 3 subclasses difference and LR had 1.4%. Unlike LR, DL does not need the animal category nor the hot carcass weight as input, meaning it can operate separately from other software. In addition, DL was able to grade carcasses as S+, which LR couldn't, and produced less errors due to damage of carcasses. In conclusion, DL offers advantages compared to LR for bovine carcass classification.

In-abattoir 3D image parameters of beef carcasses for predicting carcass classification and weight

Imaging technology can extract measurements from beef carcasses, allowing for objective grading. However, many abattoirs still rely on manual grading due to the infrastructure and cost required, making the technology unsuitable. This study explores 3-Dimensional (3D) imaging technology, requiring limited infrastructure and its ability to extract automated measurements from beef carcasses to predict cold carcass weight (CCW), and EUROP conformation and fat class on the 15-point scale. Time-of-flight cameras captured 3D images of beef carcasses in a commercial abattoir in Scotland over 6-months. Up to 35 frames were captured per carcass, with 74 measurements (lengths, widths, and volumes) extracted from each image using machine vison software. Values were averaged across frames giving one data row per carcass (9,577 steers, 8,323 heifers). The data were randomly split into training and validation datasets (70:30). The training dataset was used to build multiple linear regression and stepwise selection models, using fixed effects1 (sex, breed type, kill date (and CCW for conformation and fat class predictions)) or a combination of fixed effects and 3D measurements2. Including 3D measurements substantially improved the fit of models for conformation (R^2Adj = 0.251, 0.542, RMSE = 1.181, 0.932), fat class (R^2Adj = 0.201, 0.302, RMSE = 1.551, 1.382) and CCW (R^2Adj = 0.21, 0.742, RMSE = 31.141, 21.022). Validation of the best fitting models had low, moderate, and high accuracy, respectively, for fat (R^2 = 0.32, RMSE = 1.362), conformation (R^2 = 0.542, RMSE = 0.932), and CCW (R^2 = 0.742, RMSE = 21.282). Mapping predictions on to the traditional EUROP grid used in the UK showed that 95% of fat classes and 81% of conformation classes were classified within the correct or one neighbouring grade. The 3D measurements were found to add value to the models, improving accuracy, indicating the potential for technology requiring limited infrastructure to predict carcass traits.

Prediction of liveweight from linear conformation traits in beef cattle

In the present study, live weight in beef cattle was modelled using linear conformation traits. For this purpose, Mutterkuh Schweiz provided data from a total of 26,374 beef cattle (♀: 17920; ♂: 8454) of 19 different breeds from years 2015-2023. For each animal, the first linear description was used in each case. In the linear description, the live weight of the animal was also determined with a scale in each case. The relationship between live weight and linear conformation traits was investigated using a linear mixed model. The model included the fixed effects sex, breed, age and month at the measurement, height at withers (cm), top line (score:1-9), body length (cm), length of rump (cm), rump angle (score:1-9), chest depth (cm), width at hips (cm), muscularity (score:60-99), BCS (score:1-9), muscularity shoulder side view (score:1-9), thickness of loin (score:1-9), thigh rounding side view (score:1-9), thigh length (score:1-9) and final score (score:60-99), as well as expert as random effects and residual effect. This model resulted in a coefficient of determination of 87.7% and a root mean squared error of 38.26kg. The largest fixed effects were observed for sex ((♀-♂: 37.97±1.17kg) and the breeds Grauvieh-Charolais (36.51±2.00kg), Grauvieh-Aubrac (33.55±1.97kg), Grauvieh-Dexter (24.51±3.64kg), Grauvieh-Galloway (16.80±4.00kg) and Grauvieh-Simmental (16.08±1.85kg). The main estimated fixed effects for linear conformation traits were 8.51±0.49 kg/score, 7.92±0.49 kg/score, 6.26±0.12kg/cm, 6.17±0.12kg/cm, 5.80±0.43kg/score and 5.55±0.67kg/score for thigh rounding side view, muscularity shoulder side view, width at hips, chest depth, BCS and rump angle, respectively. In conclusion, linear conformation traits can be used to estimate live weight of beef cattle.

Predicting P8 Fat Depth in Hot Beef Carcasses using a Handheld Microwave System

Non-destructive and non-invasive methods of measuring live animal and carcase fatness on genotypically and phenotypically diverse cattle are crucial as they enable optimised carcase boning, producer feedback, and value-based trading. However, the suitability of the technology that takes these measurements depends upon numerous factors including accuracy, reliability, cost, portability, durability, speed, ease of use, safety, and for in vivo measurements the need for fixation or sedation. Working within these constraints a portable Microwave System has been developed at Murdoch University to measure fat depth. This study details the accuracy of this system to predict P8 fat depth of hot beef carcases at commercial abattoir chain speeds. Beef carcases (n=1304) were scanned hot using the Microwave System at the P8-site 30min post-mortem and simultaneously measured for P8 fat depth by the in-house grader. The average carcase weight of these cattle was 476kg (+/-30kg Stdev) and ranged between 156 and 548kg, while the average P8 fat depth was 16mm (+/- 5mm Stdev) and ranged between 2 and 35mm. The Microwave System operated at frequencies of 100MHz to 5.4GHz with output power of -10dBm coupled with a prototype broadband Vivaldi patch antenna. The reflected microwave signals were recorded at 10MHz intervals across 531 frequencies. The magnitude of the frequency domain signals was used to predict the P8 fat depth, with the model trained using an ensemble stacking technique in WEKA and tested using 5-fold cross validation. The average precision was high with average R^2 of 0.81, with root-mean-square-error of the prediction of 2.78. The average bias (difference between the predicted and actual values at the mean of the dataset) was 0.12, while the average slope between predicted and actual values deviated from 1 by 0.02. This study demonstrates that the Microwave System can precisely and accurately predict hot P8 fat depth across divergent phenotypes. Given that these measures were captured at commercial chain speed, these results suggest that the hand-held device has the potential for commercial deployment as a simple cost-effect technology for measuring carcase fatness.

An optimisation model for operational planning in lamb supply chains

A Carcase Optimisation Tool was developed for use by the lamb processing industry to sort carcases into boning groups by optimally allocating them to cutting plans using lean meat yield and weight, and to maximise profit. Processors are challenged to design cutting plans and sort carcases into groups to fabricate the most efficient and profitable combination of cuts from each carcase whilst satisfying market specifications. Currently, carcases are grouped using hot weight as the primary sortation criteria. As technologies that precisely and accurately measure carcase yield have become available, such as dual-energy X-ray absorptiometry (DXA) (Gardner *et al.,* 2021), carcase lean meat yield percentage (LMY%) may be used with carcase weight to predict individual cut weights to allocate 'the right carcase' to 'the right cutting plan'. This task is well suited to be solved using mathematical optimisation models (Wang *et al.,* 2023). The tool uses an Integer Linear Programming model to allocate carcases of varying weight and LMY% to cut plans to maximise profit. The tool does this by; (i) specifying multiple cut plans; (ii) using cut weight ranges (min and max) and piece counts to constrain and shape the allocation of carcases to plans to meet market orders; (iii) accounting for the differential cost of labour to process individual carcases based on their weight and LMY%. The potential for the tool to improve profit was tested in a case study in an Australian domestic lamb supply chain. An optimised scenario using carcase weight and LMY% was compared to i) carcases randomly allocated to cut plans, and ii) carcases allocated to cut plans by weight; as is the current industry standard practice. Using cut weight alone, profit was 4.1% greater than when carcases were randomly allocated to cutting plans. Optimisation yielded an additional 1% profit when compared to the carcase weight scenario. This work provides a pathway whereby DXA technology, combined with cut weight prediction and optimisation algorithms, and carcase sortation may improve the profitability of lamb supply chains.

II. PREDICTION OF MARBLING OR INTRAMUSCULAR FAT

Meat@ppli, a smartphone application to predict fat content of beef

Fat has a major economic importance in the beef sector. It affects all the meat food chain steps: from the farmer to the consumer. However, nowadays, the monitoring of fat, and especially marbling, in beef is difficult, due to the lack of a suitable assessment tool, i.e., reliable, simple, fast, non-destructive and inexpensive. The exponential growth of smartphones equipped with high quality imagers and high computing power has provided tremendous opportunities for measuring fat on bovine carcasses. The Meat@ppli project aimed 1) to predict intramuscular and total fat content of 6th rib from its image captured under non-standardized and uncontrolled conditions, using image analysis methods and deep learning, 2) to embed the algorithms in a smartphone application. For this purpose, cross section images of the 6th rib of 164 carcasses chosen to be representative of the beef marbling variability, were captured with a smartphone Samsung® Galaxy S8 fitted with polarizing filters (Meunier *et al.*, 2021). The ribs were then removed to determined gold standard measures: total fat content by dissection and weighing, and intramuscular fat content (IMF) by the Soxhlet method. From more than 3500 images of 6th ribs and gold standard measures, several artificial neural networks were trained to segment the rib, the ribeye, IMF in the ribeye and total fat in the rib (Normand *et al.*, 2022). The correlations between the gold standards and the parameters from the image analysis were strong, with correlation coefficients of 0.91 and 0.79 for IMF and total fat content, respectively. The prediction models were then embedded in the Meat@ppli application. The application starts by taking a picture of the cross section of the 6th rib. The captured image is then displayed and submitted for validation. In less than 10 seconds, the application calculates IMF and total fat content. The Meat@ppli application remains a proof-of-concept that, in the future, could be used by the beef industry to route carcasses to the most suitable distribution channels and to perform massive phenotyping for the selection of bovines with appropriate marbling.

Hand-held NIR device predicting chemical intramuscular fat% in pork

The use of fast growing, muscular genotypes of pigs in Australia has been shown to result in some genotypes having intramuscular fat (IMF) as low as 1% (D'Souza *et al.*, 2003). The SOMA S-7090 NIR is an AUS-MEAT accredited device for measuring chemical IMF% in sheepmeat. This study tested the SOMA using a lamb algorithm to predict pork chemical IMF%. Chemical IMF% and SOMA measures were taken from the same location on the exposed loin eye surface (M. longissimus lumborum). Pork carcasses were collected from 3 sites; site 1 in New South Wales (n = 120), site 2 in Queensland (n = 115) and site 3 in Western Australia (n = 104). The SOMA predicted pork IMF% with low precision (R^2 = 0.10, RMSEP = 0.63) and accuracy (bias = -0.15). This work demonstrated the sheepmeat IMF% algorithm currently installed in the device was not transferable to predicting pork IMF%. However, nearly 70% of the chemical IMF data was below 1.5%. This aligns with the national pork IMF% levels which are inherently low due to the muscular, fast growing genotypes utilised. Further work could involve training a pork specific IMF% algorithm which would likely see additional improvements in precision and accuracy.

Assessing dual-energy X-ray absorptiometry prediction of intramuscular fat content in beef

The dual-energy X-ray absorptiometry (DEXA) application to assess physical and chemical composition from the 9th-to-11th rib section of beef cattle has been described (Ribeiro *et al.*, 2011; Prados *et al.*, 2016), but the potential use of this method for prediction of intramuscular fat content in beef, as a grading method, should be evaluated. This study assessed the capability of DEXA to predict intramuscular fat (IMF) content of beef longissimus steaks against chemical IMF as the gold standard. DEXA performance of fat prediction was assessed using a leave-one-out cross validation method among Angus and Nellore steaks, which generated a chemical fat range of 14.05–36.82% and 2.46–7.84%, respectively. There was a positive association between DEXA predicted fat and chemical fat content. However, higher precision was found for pooled data (R^2 = 0.95, RMSECV = 1.95) than within breed group (Angus: R^2 = 0.75, RMSECV = 2.39; Nellore: R^2 = 0.15, RMSECV = 1.22). Accuracy also had the same response with average slope values close to one for pooled data and Angus and a lower value (0.42) for Nellore group. DEXA precisely predicts IMF content across a wide range of fat content. However, its precision and accuracy of prediction within low-fat beef samples are lower than in high-fat beef steaks.

Beef marbling assessment by accredited graders and a hand-held camera device

Marbling is one of the most important traits of beef related to eating quality. According to the MSA (Meat Standards Australia) methodology, marbling should be evaluated visually in the chiller by accredited graders although various technologies have been developed. The aim of this study was to evaluate the performance of a hand-held camera (Q-FOM Beef) to predict MSA marbling scores (MSA-MS) between the 5th and the 6th rib. The MSA-MS ranged from 100 to 1190. Two MSA trained graders were used for this study, one being an expert grader. A total of 285 carcasses were assessed in the chiller by these 2 graders. The R^2 of prediction between scores from the expert grader and the second grader was 0.78 with a RMSE of 47.9 MSA marbling points. Then, 779 images from the same carcasses were acquired with the Q-FOM Beef camera (i.e. between 2 and 3 images per carcass). In a first analysis with the 285 carcasses, a Q-FOM Beef calibration model using expert grader MSA-MS as reference was developed. This calibration model was applied to one image per 285 carcasses resulting in a R^2 of prediction 0.75 and the RMSEP was 44.9 MSA marbling score points. To be accredited in Australia, the requirements are that ≥49% of the samples must be within 50 MSA-MS from the expert grader, ≥79% of the samples must be within 100 MSA-MS and ≥97% must be within 200 MSA-MS. The grader-to-grader comparison showed 75.9% were within 50 MSA-MS, 97.1% were within 100 MSA-MS and 100% were within 200 MSA-MS. This indicates that the graders performed well when comparing their scores. In a second analysis, a subset (N = 124) of the 285 carcasses were also assessed on-screen by the expert grader. The R^2 of prediction between in chiller and on-screen MSA-MS was 0.78 with a RMSE of 48.7. The in-chiller and on-screen comparison showed that 79.8% were within 50 MSA-MS, 96.8% were within 100 MSA-MS and 100% were within 200 MSA-MS. This suggests that on-screen assessment would be an acceptable method to develop a marbling calibration model, although more investigations would be required.

Beef on dairy - meat quality and prediction of intramuscular fat on the slaughter line

Increased use of beef semen on dairy cows in Denmark is the consequence of focus on sustainable beef production, where beef on dairy has less CO2 emission than beef from purebred beef breeds. However, this also leads to a larger variation in the carcasses at the slaughterhouse and an interest in optimizing the meat quality from these cross-bred calves. No tools have previously been implemented on the slaughter line to quantify meat quality in Denmark. However, Q-FOM™ (Frontmatec Smoerum A/S, Denmark), a handheld camera solution, designed to predict intramuscular fat (IMF) could be a solution to quantify IMF in the carcasses, and a way to generate a large number of meat quality data, which could be used in genomic selection of breeding stock. The aim of the study was to characterize the meat quality of cross-bred calves from Holstein cows sired with Danish Blue (DB), Charolais (CHA) or Angus (ANG) bulls and to evaluate the Q-FOM™ to predict IMF in the loin on carcasses split between 5th and 6th thoracic vertebra. 335 cross-bred calves were included in the study, representing 126 DB, 100 CHA and 109 ANG including both heifers and bulls. They were slaughtered at the age of approximately 9.5 months. One day postmortem, the carcass was split between the 5th and 6th thoracic vertebra and a Q-FOM™ image was captured of the loin at 5th thoracic vertebra side. At the same time, 7 cm of the loin was removed and aged for additional 2 days before analysis. The Q-FOM™ prediction model was developed based on the chemical IMF analysis of 261 samples of these cross-bred calves and in addition 111 samples representing loins from cattle with IMF between 6 and 23%. The carcasses from the DB cross-bred calves were the heaviest (221 kg) followed by CHA (216 kg) and ANG (210 kg), and the bulls were on average 15 kg heavier than heifers, although the heifers were 21 days older at slaughter. The amount of IMF measured chemically was highest in ANG (3.5%) versus CHA (3.0%) and DB (2.5%), and with a clear difference between heifers (3.7%) and bulls (2.3%). The Q-FOM™ model had a RMSEC of 1.5% (R^2 = 0.89), however if the model was used only on cross-bred calves below 6% IMF, the RMSEC was 1.4%.

III. USING COMPUTED TOMOGRAPHY (CT) AS THE GOLD STANDARD FOR CARCASE COMPOSITION

Computed tomography vs chemical composition for determination of Australian Lamb carcase composition

Computed Tomography (CT) is commonly used as the gold standard measure of carcase composition in Australian lamb. For industry acceptance, experimentation against its predecessor, chemical composition was undertaken to demonstrate its comparability. A group of 30 lambs with a wide phenotypic range were sectioned into fore, saddle and hind and CT scanned at 36 hrs post-mortem. The 3 sections including bones were minced post scan through a 5mm grinding plate until a uniform and homogenous mix was produced. Five samples were obtained in each of the fore(F), saddle(S), and hind(H) sections of the carcase and tested for their chemical composition of protein, lipid, and ash. These values expressed as percentages were then compared to the CT estimates of fat %, lean % and bone %. There was a strong association between chemical protein % and CT lean % with the R^2 and RMSE values for each section 0.86 and 2.82% (F), 0.92 and 2.82% (S) and 0.91 and 2.20% (H). A similar association was found with chemical lipid % and CT fat % across all carcase sections showing R^2 and RMSE values of 0.93 and 2.11% (F), 0.93 and 3% (S), and 0.89 and 2.05% (H). These strong associations demonstrate the relative equivalence between these two values as indicators of carcase composition. There was a weaker association found with chemical ash % and CT bone % showing R^2 values of < 0.67 across all three sections and highlighting the well documented difficulty in homogenizing bone in a multi-tissue sample. Chemical analysis for protein, lipid and ash all showed marked sub-sample variation. Despite extensive mixing, the average deviation of each rep from the sample mean was 1.15 protein % units, an amount which represents 3.42% of the average protein value. Comparatively, for CT, the average deviation from the mean for each rep was 0.01 CT lean % units, which represents 0.02 % of the average CT lean value. Similar findings were found for lipid and CT fat %, and ash and CT bone %. This variation in chemical sampling makes calibration of objective measurement tools against chemical analysis an unreliable method when compared to CT.

Pig carcass and cuts lean meat content determined by X-ray computed tomography

Currently, the value of the pig carcass is determined by its lean meat content (LMP). At slaughterhouse, LMP is determined objectively by means of manual, automatic or semi-automatic devices. These devices need to be previously calibrated and calibration is carried out by performing a cut-test, using as a reference the manual dissection of the carcass or the virtual dissection by means of a computed tomography (CT) equipment (Font i Furnols and Gispert, 2009). In Spain an old fixed CTf (GE HiSpeed Zx/I) was calibrated to determine carcass LMP (Font i Furnols *et al.*, 2009). However, a new mobile CTm unit (Philips Brilliance 16) has recently become available, and it is necessary to validate this new equipment to be used as a reference. Therefore, two different tests have been carried out, (1) adapting the old CTf formula to the new CTm and, (2) calculating a new formula for the CTm. For both approaches, a total of 20 carcasses and its 4 main cuts (ham, belly, shoulder and loin) had been scanned with the new CTm and, after that, they have been fully dissected to determine the LMP. In the first test, when the equation of the old CTf was applied to the images of the new one (CTm) and regressed against the LMP obtained by full dissection, R^2 was 0.97. As a second test, a preliminary and simple new formula for LMP determination with the new CTm has been obtained calculating the volume associated to Hounsfield values between 0 and 120 and divided it by the carcass (or cuts) weight. A correction factor of 1.072 has been found to be applied to adjust the LMP to the dissection with an accuracy of $R^2 = 0.99$. This formula has also been applied to the images obtained from the cuts (n=20 x 4) scanned with the CTm and the relation between LMP obtained by CTm and by dissection is $R^2 = 0.99$. Thus, it can be concluded that with these preliminary results, it is possible to have a good determination of pig carcass LMP with the new CTm either by applying the calibration formula of old CTf with a correction factor or by determining the LMP considering the volume associated to lean and the carcass weight, also with a correction factor.

IV. PATHWAYS FOR IMPROVED BEEF QUALITY

Relationships between ultimate pH, weight, conformation and fatness of carcasses

We hypothesized that the transportation of cattle prior to slaughter causes stress that results in lower quality carcasses due a higher final ultimate pH (Prache *et al.*, 2021). Therefore, the objective of this study was to investigate the effects of stress during transport to slaughter from farms located in different geographical areas in France, specifically the effects on ultimate pH for Limousin cattle. Cold carcass weight, age, and the EUROP conformation and fatness scores were recorded from 3,809 Limousine carcasses from a private slaughterhouse in Limoges, France, which were evaluated 24h post-mortem, from May 2021 to November 2021. We performed statistical analyses of the relationships between ultimate pH, geographical areas (< 50 km; between 50 and 150 km; and between 150 and 250 km from the slaughterhouse), cold carcass weight, conformation and fatness of carcasses. European conformation score was correlated with cold carcass weight ($r = 0.76$, $P<0.001$) and fat score ($r = 0.57$, $P<0.001$). Similarly, fat score was correlated with cold carcass weight ($r = 0.57$, $P <0.001$). As expected, the variability in cold carcass weight can be explained in part by the variables studied (mainly age, European conformation, and fat score), explaining approximately 60% of the variability in carcass data. The variables studied (area, age, European conformation, and fat scores) explained only 2.45% of the total variability in pH data. Values of ultimate pH were lower in the geographical area farthest from the slaughterhouse (5.74 versus 5.78, $P < 0.05$) because cattle were transported the day before slaughter in contrast to the first two areas. In conclusion, long distances slightly affect beef pH, with consequences on beef eating quality that remain to be studied but are likely to be small.

Elite Dairy Beef – A pathway for male dairy calves into the premium beef market

The Elite Dairy Beef program is based on consumer eating experience from dairy beef raised under a unique tightly controlled nutritional program. The program is aimed at changing industry perception of “dairy beef” from the traditional lower quality manufacturing image to a high value premium product that justifies the raising of male dairy calves. A requirement for cattle marketed under this brand requires animals to be antibiotic, hormone and ionophore free. The nutritional program was initially developed in Spain and is widely used in Europe and the UK in the premium beef programs. A locally adapted program utilising key ingredients from Spain in conjunction with local sourcing has since been tested and proven in Australia. The milk replacer and rations are of extremely high quality and specifically targeted at superior early life nutrition to rapidly develop the calf immune system and rumen function, thereby maximising health and avoiding the use of antibiotics. Contrary to conventional rearing systems, this system is based on a low milk replacer intake and immediate concentrate consumption from birth. The critical and interlinked aims are to avoid negative energy balance, optimise gut health, and fast-track rumen development. Calves are purchased at 5 days of age and transported to a rearer. They have ad lib access to concentrate Quickstart, plus specialised milk powder InzarMilk, fed at 2L twice a day for 3-4 weeks. After 2 weeks, calves transition onto a grower ration Papincalf enabling early weaning of the calf. This ration is fed until 14 weeks after which cattle are transitioned onto the final ration Econbeef until slaughter. Cattle are finished at 12-13 months of age with a liveweight of 500-550kgs and a carcass weight of 280-300kgs. Optimal fat cover on these animals is observed for minimal trimming and little waste, with straight Holsteins yielding similar to their beef cross counterparts. Cattle also carry a positive carbon story, with the calf primarily offset by the cow coupled with a highly efficient animal capable of good conversion and fast finishing times.

CONCLUSION

Estimating carcase composition is an important component of modern grading systems. In Europe beef conformation, especially the EUROP score, is one approach. The prediction of EUROP score can be improved with a combination of new statistical approaches and 3-dimensional imaging technologies. New technology based on microwave also shows promise for estimating fat depth at the P8 site, an alternative measure which related to the total fatness level of the carcase and so lean meat yield. An important aspect of grading for carcase composition is using the data to improve fabrication at the processing plant. Results have showed that a highly accurate estimation of lean meat yield in lamb using whole carcase DEXA scanning can improve carcase sortation into defined cutting plans for different end markets and so improve profitability across the supply chain.

Prediction of marbling in beef and pork was also addressed. Camera systems have been tested including a promising smartphone application (Meat@ppli) which predicts intramuscular fat and the total fat content at the 6th rib set which is at proof of concept phase. In addition, the Q-FOMTM Beef (Frontmatec Smoerum A/S) camera system was tested by European researchers for estimating IMF and visual marbling score in beef and dairy cross breeds of cattle. This system has now received official AUSMEAT accreditation (part I) for the estimation of visual marbling and also looks very promising for use in Europe. Other technologies included the use of laboratory DEXA imaging of beef steaks and a hand help NIR device for estimation of IMF in pork. It was concluded that DEXA imaging DEXA precisely predicts IMF content across a wide range of fat content. However, its precision and accuracy of prediction within low-fat content samples are lower than in high-fat content beef steaks. The NIR system, previously calibrated to predict the intramuscular fat content of lamb performed poorly to predict pork IMF almost certainly due to the very low levels of IMF in Australian pork samples (mostly less than 1.5%).

A critical aspect of using technologies to measure meat science traits is the agreed use of a 'gold standard' which ideally is highly quantitative and accurate. For the estimation of lean meat yield, computed tomography (CT) is an accepted gold standard to replace chemical proximate composition as determined by protein, fat and ash determination of ground carcases. Moreover, CT estimated lean meat percentage is also equivalent to the traditional dissection system, the latter being prone to errors associated mainly to butchers. The robustness of CT was shown when used in pig carcases to measure lean meat yield. Thus, older CT machines can be compared to newer CT technologies by use of a relatively simple correction factor.

Finally, aspects of the beef production system were discussed in terms of underpinning high quality beef for consumers. Transport and lairage time were highlighted as important determinants of ultimate pH in beef ultimate. An elite dairy beef program in Australia was presented whereby castrate male calves (5 days old) enter a controlled nutrition program developed in Europe. Final carcase weights of 280-300kgs can be achieved at 12-13 months of age resulting in high quality cuts as determined using the Meat Standards Australia system. These young male castrate dairy cattle also carry a positive carbon story, with the calf primarily offset by the dairy cow coupled with a highly efficient animal capable of good conversion and fast finishing times.

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