DEFINING CARCASS AND MEAT QUALITY STANDARDS FOR CANADIAN PORK: MEAT COLOUR

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Abstract – The development of Canadian standards for the measurement of pork meat and carcass quality is required to provide the Canadian pork industry with a mechanism to establish quantifiable points of differentiation. The Canadian Carcass and Meat Quality Standards Project aims at developing standard methods for evaluation of various carcass and meat quality characteristics, using a science-based approach to develop two-tier evaluation systems involving both objective and subjective methods. As part of the project, a photo bank was constructed in 2010 based on standardized loin chop pictures collected 24hr after slaughter on 631 purebred pigs. Specific computer vision algorithms were developed in order to extract pork colour information from each image, using mean shift to estimate the most representative colour (MRC) within each chop. Based on the information collected on this first data set, a pork colour curve was fitted in the L,a,b colour space. This curve was used to derive a preliminary colour chart made up of 7 colour chips, which was suggested as a potential new pork colour chart for subjective assessment.

Key Words – computer vision, pork colour, scoring charts

I. INTRODUCTION

In recent years, export and domestic markets have shown a strong interest for differentiated pork. Proper and recognized methods are required for the production of differentiated pork products to assess carcass and meat quality. Carcass and meat quality standards need to be customized in order to better reflect Canadian pork. Specifications in terms of which traits to measure and how to measure them are an essential first step towards developing Canadian standards. The need for Canadian standards is important. It is required for marketing purposes in both domestic and export markets but also to build a strong national database with carcass and meat quality data recorded in a harmonized way. Such a database will be useful for benchmarking studies, research projects requiring harmonized measurements, genetic improvement programs and objective grading systems.

The overall project objective is to develop standard methods for evaluating various carcass and meat quality characteristics, using a science-based approach for the development of a two-tier evaluation system involving both objective and subjective methods. The scoring methods and charts developed as 'Canadian standards' will be made available to the Canadian swine industry for various purposes such as benchmarking, marketing, carcass grading and genetic improvement [1].

This paper focuses on the development of new visual charts for pork colour, as an example of standards development. Currently, the most popular visual standards for colour assessment in plants and laboratories are the Japanese pork colour standards [2] and the NPPC pork colour standards [3]. Both were developed several decades ago and have some limitations. In addition, pork meat has changed over time, due to factors such as genetic selection and changes in feeding programs, which has resulted in a need to develop Canadian standards that are better adapted to reflect the quality of pork produced in Canada.

II. MATERIALS AND METHODS

Picture collection - A digital photo bank was constituted for the development of computer vision tools for colour and marbling. This photo bank was initially created by collecting high quality digital pictures of chops from 639 purebred pigs slaughtered in 2010 (Deschambault station tests #27 and 28). The pigs were raised and slaughtered under similar conditions, and were individually tracked at the slaughter plant and measured for various subjective and objective carcass and meat quality measurements, approximately 24 hours after slaughter. After a 20-minute bloom time, digital pictures of both sides of the 4th last chop were collected using a Nikon D5000 camera equipped with a 35mm fixed focal lens and a specific tripod adjusted at a standard distance from the table (70.5 cm) as shown in Figure 1.

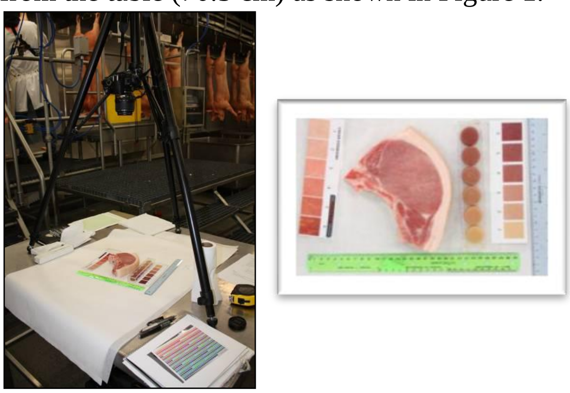

Figure 1. Setup in the slaughter plant cutting floor for collecting chop pictures and example picture

The camera was connected to a laptop and the photo capture was controlled using commercial photo capture software, allowing for colour pre-calibration (using a Colour Checker Passport prior to each session) and all settings to be saved. Next to the chop, a set of both commonly used standards (NPPC and Japanese pork colour charts) were placed, along with a ruler prior to collecting an image.

Computer vision analyses - The pictures were saved and analyzed by Polyrix inc (Quebec City, Quebec). In order to ensure proper colour accuracy and reproducibility, a specific colour management protocol was used, at each step of the process, from picture collection to chart printing.

As shown in Figure 1, colour varies within a single chop. This variation can be caused by marbling, lack of uniformity in meat colour and, in some cases, specular reflections due to moisture on the surface of the chop. These factors make the otherwise simple work of classification challenging since a single representative colour is generally sought to match (using human vision or computer vision) to a specific standard colour. It is therefore essential to compute a single colour per chop, called the Most Representative Color (MRC). For each chop, the pixel colours contained within the pre-segmented loin eye was determined by computer vision using the Lab colour space. The MRC of each chop was determined using a specific algorithm to determine the mean shift (or mode) of the distribution of colour values of each pixel contained in the loin eye (Figure 2) [4].

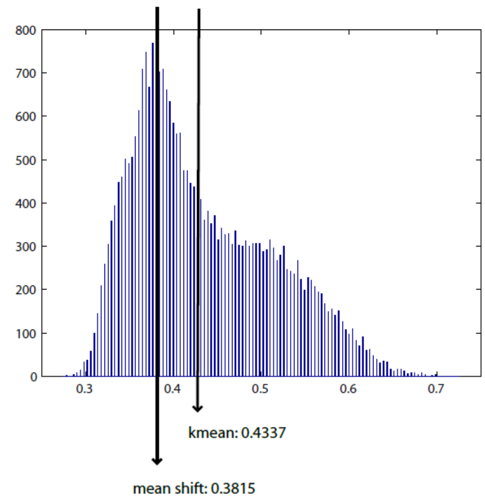

Figure 2. Determination of MRC (mean shift)

An algorithm was developed to define a representative colour curve in the Lab colour space using the MRC of each chop from the 639 pigs in the data set, using standard nonlinear least-square optimization routine (Levenberg-Marquadt) [5].. The resulting model is a good compromise between complexity and accuracy of fit. The general mathematical expression for the chosen curve in Lab colour space was the following:

$s(t) = [x_0 + x_1 t + x_2 t^2, y_0 + y_1 t + y_2 t^2, z_0 + z_1 t + z_2 t^2]$,

where x_i, y_i and z_i , i = 0,1,2, are the optimization parameters to fit the chop colours. The expression for this optimization is thus:

$s^*(t) = arg\min_{x_i,y_i,z_i} \sum_j (min_t \|s(t) - c_j\|^2)$

where the c_j are the Lab MRC of each chop and s* is the curve sought.

Building a colour chart based on the colour curve - Using the colour curve fitted in previous steps, a group of 25 equally spaced colour levels was selected, among which 7 levels were kept for the subjective pork colour chart.

Validation and refinement of colour charts - The first version of the colour chart was tested in plant conditions by a group of meat quality experts. Their feedback on the chart was used to refine the colour chips. In addition, a set of new pictures collected on 251 carcasses (from crossbred hogs slaughtered in 2011) was processed with computer vision and used to validate and improve the colour curve.

III. RESULTS AND DISCUSSION

Fitting the pork colour curve

The MRC of the chops from the first set of 631 pigs were used to fit the colour curve in Lab colour space. It was later improved and included the pictures from the 251 hogs slaughtered in 2011. Figure 3 shows the curve developed with all pictures included.

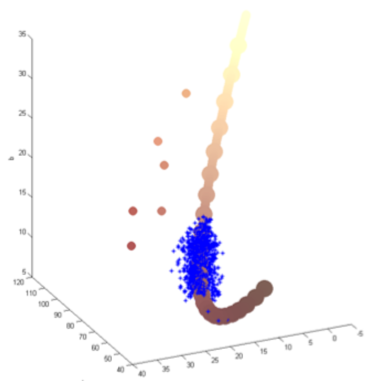

Figure 3. Colour curve fitted in Lab space (the 6 dots on the left of the curve represent the location of the Japanese colour chips)

Figure 4. Twenty-five colour chips extracted from the fitted colour curve

Selection of colour levels along the colour curve to create a scoring chart

Assuming that the fitted curve is representative of current pork colour, colours on the curve could then be used to build a colour chart. Figure 4 shows 25 equally spaced colour levels selected from the colour curve to design a proposed visual chart.

Each dot on the colour curve is assigned a standardized parameter (t) ranging from -32.8 to 44, which defines its relative position on the curve. Using the 25 chips and based on the colour range in chops and colour levels that are visually distinguishable, a visual scoring chart made of 7 colour chips was produced. Several versions were created and tested, before reaching a consensus on a specific range. Figure 5 shows the proposed colour chart derived from the different tests and validations. The new chart, compared to other standards in use, seems to address most of the issues raised by meat quality experts. There is consistency with real meat colour range, and the number of levels especially in the middle of the chart (scores 2, 3 and 4) covers the range where most pork meat would fall. These scores should avoid the use of half-points which can be an issue with subjective scoring. Table 1 shows the main characteristics of the 7 selected chips, in terms of coordinates in the Lab and RGB colour spaces, as well as their t parameter in the new classification system based on the most accurate colour curve.

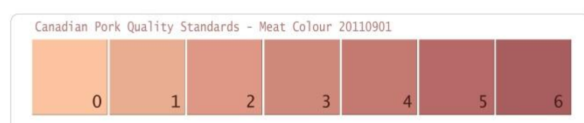

Figure 5. Proposed pork colour chart

Table 1. Summary of the colour chips selected for the new pork colour chart

Chip	t parameter	L/a/b values	R/G/B values
0	-20	83/17/26	236/193/159
1	-15.2	76/21/23	218/171/145
2	-10.4	70/25/21	204/151/133
3	-5.6	64/26/20	189/136/122
4	-0.8	59/29/17	177/120/113
5	5.6	53/31/15	163/105/103
6	12	49/31/13	150/94/95

Comparison of the new proposed chart with the Japanese and the American pork colour charts

The new proposed colour chart was compared to the other colour standards currently in use. Table 2 shows the t parameter in the new classification for the 6 Japanese colour chips and the 6 colour levels in the NPPC pork colour standards. The t values for these standards were computed by projecting each of their colour levels onto the most recent version of the colour curve. This analysis is also interesting because it provides a comparison between the Japanese and NPPC pork colour standards, which are rarely compared or used at the same time. The t parameters of both the American and Japanese colour charts, and when compared to the proposed Canadian chart, show that the lightest colour chip in the Canadian colour chart is lighter than the two other charts and that the darkest chip is also lighter than the darkest standard (level 6) in both charts (Table 2). The Canadian chart has more levels in the middle of the chart (scores 2, 3, 4), which makes it more accurate in the colour region where pork chops from this study are most likely to fall.

Table 2. Characteristics of the Japanese and American colour charts when projected on the colour curve

Chip (1=lighter, 6=darker)	t parameter for Japanese color chip	t parameter for NPPC colour chip
1	-14.7	-16.1
2	-10	-14
3	-1.3	-8.2
4	7.6	-1.5
5	14.2	3.1
6	21.8	13.2

Other traits

Similar visual charts were also developed for fat colour, as well as for marbling, using chemical IMF results and hyperspectral analysis as references to develop the marbling scoring chart. These charts will also be provided to the industry and refined over time using computer vision algorithms.

IV. CONCLUSION

This work, although preliminary, provided very valuable, objective information in terms of pork colour attributes. The proposed colour chart developed during the project will be provided to the Canadian pork industry in different formats in terms of content (uniform colour chips *vs.* charts derived from real pictures) and form (rulers, color discs, factsheets). More chop pictures will also be collected and processed in order to check for any potential improvement of the colour curve derived from 2010 and 2011 data sets. Consequently, further refinement and improvement of the charts is likely to occur before the final versions of the standards are made available to the industry.

ACKNOWLEDGEMENTS

This project is supported by Canada Pork International, through the International Pork Marketing Fund from Agriculture and Agri-Food Canada.

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