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Short communication: Guaranteeing Canadian lamb meat quality using near infrared spectroscopy on intact rack

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Abstract

Lamb racks from commercial carcasses were scanned using near infrared spectroscopy (NIRS). The predictions accuracies (R^2) for meat quality traits were assessed. Prediction accuracy ranged between 0.40 and 0.94. When predicted values were used to classify meat based on quality, 88.7-95.2% of samples were correctly classified as quality-guaranteed.

Keywords: classification; guaranteed; lamb; NIRS; quality

Current classification systems for lambs in Canada focus only on carcass traits. With further processing becoming more important for Canadian packers, rapid and non-destructive tools for guaranteeing minimum quality standards for lamb meat could be adopted. Near infrared spectroscopy (NIRS) has shown ability to predict lamb meat quality, especially chemical traits, such as moisture and intramuscular fat content (Kamruzzaman et al., 2012). For most meat quality attributes, NIRS predictability from whole carcasses or primal cuts is usually lower than those from ground meat (Prieto et al., 2017). However, NIRS technology could be used for on-line quality assurance purposes, even for those traits with limited prediction accuracy. The aim of the present study was to evaluate the classification potential of portable NIRS on intact lamb racks as a tool to guarantee the quality of lamb meat in the Canadian market. This technology would allow packers to offer buyers meat with minimum quality attributes guaranteed, what could be used to target niche markets with specific requirements and commercialized added-value meat and meat products.

MATERIAL AND METHODS

A total of 155 lamb carcasses, representative of the current variability in the Canadian lamb industry (17-30 kg weight; 5-23 mm backfat thickness; 90-115 cm length), were selected from a federally licensed plant (Innisfail, AB). At the Lacombe Research and Development Centre (Lacombe, AB), intact lean (*longissimus thoracis*, LT) and backfat from lamb racks were scanned at the level of the 13th rib using a portable LabSpec®4 Standard-Res spectrometer (Analytical Spectral Device-ASD Inc., Boulder, CO, USA) from 350 to 2,500 nm (Vis-NIR range) and a 20 mm ASD fibre-optic high intensity contact probe following 20 min bloom.

Spectral data were stored as the logarithm of the reciprocal of reflectance [log (1/*R*)] in 1 nm steps (2,151 data points).

Objective colour measurements from the posterior end of the LT were obtained in duplicate using a Minolta Spectrophotometer Model CM 700D with SpectraMagic™ NX Lite Color Data Software (CM-S100w Version 2; Minolta Canada Inc., Mississauga, ON, Canada) and averaged. A chop removed from the posterior of the LT was ground and the intramuscular fat content was analysed using NMR technology (SMART-Trac System, CEM Corporation Ltd., Matthews, NC, USA). The adjacent chop was grilled to a final internal temperature of 71°C and two 1.9 cm diameter cores were then used to determine peak shear force values (TA-XT Plus Texture Analyzer, Texture Technologies Corp., Scarsdale, NY, USA). Backfat free fatty acid methyl esters were prepared and analyzed as described by Dugan et al. (2007).

All statistical analyses were conducted with SAS (v 9.4). Several mathematical transformations were applied to NIR spectra prior to analysis, so the most accurate models could be developed. Partial least squares regressions (PLSR) were run using the transformed and untransformed spectra to determine their relationship with meat quality attributes and fatty acid groups. Internal full leave-one-out cross-validations were performed on the models in order to avoid over-fitting the PLSR equations. The coefficient of determination (R^2) from the resulting PLSR models was used to determine the NIRS prediction accuracy. In order to develop a guaranteed quality system, minimum quality thresholds were defined at the 20th percentile of the actual values for each quality trait and fatty acid group (i.e. the value where 80% of samples would meet the minimum quality threshold). For *L*,* shear force, saturated fatty acids (SFA), and n-6 lower values indicated higher quality, therefore thresholds were reversed so the 20th percentile was defined according to the value where 80% of samples had lower values. The percent of NIRS predicted

values correctly classified within (non-minimum quality guaranteed) and outside the 20th percentile (minimum quality guaranteed) were reported for all traits. Increasing the percentage of correctly classified samples meeting the minimum quality threshold can be achieved by using more stringent criteria to classify the predicted values. Therefore, NIRS predicted values were reclassified and retested using two additional thresholds (25th and 30th percentile of actual values).

RESULTS AND DISCUSSION

Average values for quality attributes from lamb meat (Table 1) are within those previously reported for commercial Canadian lamb (Pouliot et al., 2009). The NIRS prediction models for quality attributes on intact lamb rack ranged in accuracy (R^2) between 0.40 for shear force and 0.94 for hue. These results are in agreement with those from other studies shown in the review by Prieto et al. (2009), where high NIRS predictability was reported for meat chemical composition and colour, but lower for tenderness in several species.

In commercial settings, being able to classify primals based on minimum quality requirements might be more useful than predicting specific values. This approach may be especially useful for attributes with lower R^2, as it could allow accurate meat quality classifications based on any trait using specific market requirements. When samples were classified according to the predicted values using the 20th percentile quality threshold rank, 88.7-95.2% of samples were correctly classified outside the 20th percentile (minimum quality guaranteed). The percentage of samples correctly classified within the 20th percentile (non-minimum quality guaranteed) ranged between 54.8 and 80.6%. Although these thresholds were not based on industry standards, they allowed for assessment of the classification protocols in the present study. In the case of shear force, with

a low accuracy for predicting actual values, the percentage of correctly classified samples was still lower than for other quality traits (<90%). In order to successfully guarantee minimum quality, the proportion of correctly identified samples meeting the minimum quality standards needs to be high, with very few samples wrongly classified outside the 20th percentile. Increasing the threshold rank for predicted values up to the 25th and 30th percentiles increased the percentage of samples correctly classified outside the 20th percentile (91.8-98.1%). However, correct classification within the 20th percentile decreased (46.8-61.7%). Therefore, as expected, higher thresholds resulted in fewer samples wrongly classified outside the 20th percentile (high quality) and more samples wrongly classified as within the 20th percentile (low quality).

Average fatty acid groups (Table 2) were in the range of those reported for commercial lamb meat from different origins and countries (Juárez et al., 2008). NIRS prediction accuracies (R^2) ranged between 0.57 for total monounsaturated (MUFA), and 0.94 for total polyunsaturated (PUFA). In the review by Prieto et al. (2017), a wide range in R^2 for NIRS predictions of fatty acid composition in lamb meat was also reported. The percentages of samples correctly classified as meeting the guaranteed quality threshold (outside the 20th percentile) were 88.7% for n-6 and 95.2% for MUFA. The percentage of samples not meeting this threshold (within the 20th percentile) ranged between 54.8 for n-6, and 80.6% for MUFA. As observed for meat quality traits, higher thresholds (25th and 30th percentiles) resulted in higher percentages of samples correctly classified as meeting the guaranteed quality threshold (outside the 20th percentile) (90.7-95.2%) and lower percentages of samples correctly classified within the 20th percentile (44.7-61.7%). This suggests that, in order to develop a system that can guarantee minimum quality with a very high level of accuracy, a significant number of samples that do meet the minimum quality threshold would be misclassified. This approach would be acceptable in cases

where a specific market demands a minimum quality at a premium price. This approach has been used previously for meat quality assurance systems with other technologies, such as hyperspectral imaging (Naganathan et al. 2015). In the case of Canadian lamb, fatty acid composition is not a common trait for quality differentiation. However, the ability to classify lamb meat with a guaranteed minimum content in fatty acid groups of interest would allow added-value differentiation using current claim regulations (such as "source of n-3": 300 mg of n-3 per serving; CFIA and Health Canada, 2009).

In the current study, NIRS has shown potential to guarantee minimum quality in traits such as intramuscular fat, colour, tenderness and fatty acid composition. Results from the proposed NIRS-based classification system show the possibility of manipulating thresholds for meat quality traits and fat composition in Canadian lamb meat to achieve high levels of guaranteed quality required by the industry. However, the thresholds used to classify lamb racks must be balanced between client satisfaction and financial needs to maintain accuracy necessary to guarantee quality but limit high quality samples that are incorrectly classified as not meeting the threshold. Quality classification using NIRS could potentially be developed for other lamb carcass primals; however, further research is required to establish scanning areas and suitable quality traits.

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