PE4.105 Visible and near infrared spectroscopy for meat tenderness evaluation of nellore (Bos indicus) cattle 383.00

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***Abstract*—the aim of this study was to evaluate the use of visible (VIS) and near infrared (NIR) spectroscopy to predict meat tenderness of *Bos indicus* (Nellore) cattle. Ninety-two Longissimus samples (5th rib level), from 23 Nellore steers (four samples per animal) were taken, vacuum packaged and aged for either 0, 7, 14 or 21 days, for posterior Warner Bratzler shear force (WBSF) and spectrometry analyses. WBSF decreased linearly with ageing period. Non-aged samples (0 day) were less reflective at all wavelengths than aged samples and showed the higher WBSF values. Samples aged for 7 days were more reflective than those aged for 14 days (all wavelengths) and from those aged for 21 days in the visible region (400 to 560nm). Coefficient of correlation and percentage of correct classification of samples in tenderness groups decreased as ageing period increased. The coefficient of correlation between observed (WBSF) and predicted (VIS/NIR) shear force was 0.75 (R^2=0.5655) suggesting that the VIS/NIR spectroscopy has a good potential to predict tenderness and then classify meat in tenderness classes.**

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***Index Terms*—Beef cattle, meat quality, reflectance spectroscopy**

I. INTRODUCTION

TENDERNESS has long been considered the most important beef palatability attribute. There has been considerable effort to develop an objective measure of beef palatability, and this measure could then be used to classify carcasses into groups with steaks of similar tenderness or palatability characteristics [10].

Several methods have been employed to predict tenderness, like Warner-Bratzler shear force (WBSF), mechanical probes and video image analysis (VIA). The WBSF requires sample preparation which is time consuming and not suitable for on-line applications. VIA systems provide a non-invasive and fast method but they cannot classify on the basis of meat quality and need therefore to be augmented with other suitable systems to measure meat eating quality traits [2].

Recently the near infrared (NIR) spectroscopy has been reported as an analytical technique for estimating quality attributes of meat. NIR technologies provides complete information about molecular bonds and chemical compositions of a sample scanned, so it is a convenient tool not only for characterizing foods, but also for quality measurements and process control [2]. Because quality attributes of meat are a result of interactions between chemical and physical factors, NIR can be a useful tool to detect these differences.

Cattle with *Bos indicus* influence have been reported to produce meat less tender than meat from *Bos taurus* breeds and are often discriminated against due to negative perceptions of their carcass merit and palatability compared to *Bos taurus* cattle [11,5]. However, some studies have demonstrated to have a great variation in meat quality attributes, among individuals within breed [5,4].

Brazil is an important player in the international market of beef meat and the production system is based on *Bos indicus* breeds (mainly Nellore breed), which accounts for 80% of its herd. In order to improve beef tenderness and overall quality, identification of tough carcasses must be a top priority for the beef industry. A system that could predict beef tenderness on-line can be of great importance to industry that can sort carcasses in tenderness groups increasing consumer satisfaction. This information also can be of great utility for producers that can retrieve this information and incorporate these data into genetic evaluations programs to improve the meat quality of *Bos indicus* breeds.

Therefore, the objective of this work was to evaluate the ability of NIR spectroscopy to determine meat tenderness in *Bos indicus* (Nellore) cattle.

II. MATERIALS AND METHODS

All procedures involving animals described in this work were conducted according to the Institutional Animal Care and Use Committee Guidelines of

Faculdade de Zootecnia e Engenharia de Alimentos of Universidade de São Paulo.

A. Experimental animals and sample collection

Twenty four Nellore steers (435±35.0 kg of mean body weight and 24 months age) were feedlot finished with a diet containing 21% of roughage and 79% of concentrate. After 74 days of feeding animals were slaughtered at Experimental Abattoir of *Faculdade de Zootecnia e Engenharia de Alimentos of Universidade de São Paulo*, in accordance to Humanitarian Slaughter Guidelines as required by Brazilian laws and carcass processing followed the common industry practices adopted in Brazil. The mean shrunk body weight was 434±35 kg and mean backfat thickness at 12th rib level was 3.6±1.1 mm.

After twenty four hours of chilling at 2°C carcasses were ribbed between 5th and 6th ribs and four samples of 2.5 cm thick of the Longissimus muscle (LM) were taken, from cranial to caudal direction. In order to achieve more variation in tenderness, samples were vacuum packaged and aged for 0, 7, 14 or 21 days. After each period of ageing samples were frozen at −18°C for further WBSF analysis.

B. Spectroscopy analysis

Before performing analysis, samples were thawed in refrigerator (2 to 5°C) for twenty four hours. After removal from the vacuum package samples were bloomed by 20min for posterior NIR scanning.

NIR analyses were performed using a spectrophotometer model EPP2000-CXR-Srs and EPP2000-InGaAs (Stellarnet Inc., Tampa, FL). The equipment was capable of collecting light in the visible (VIS) and NIR regions (220 to 1.700 nm). A fiber optic reflectance probe was used to transmit light reflected from the beef surface to an internal detector. A white reflectance standard was used to create a reference for the measurements. Light was supplied by a 20-W halogen light source and a diffuse reflection. Detectors consisted of a photodiode array, a thermoelectrically cooled Indium Galium Arsenide (InGaAs) detector. Spectral resolution was set to 1nm and a total of 5 scans were averaged for every spectrum. Data was collected with SpectraWiz software (Stellarnet Inc., Tampa, FL). Each sample was scanned three times at different locations throughout the LM sample.

C. Warner Bratzler Shear Force Analysis

WBSF determinations were performed according to AMSA [1] recommendations. Each sample was cooked in electric broiler cookery to an internal temperature of 40°C, flipped, and cooked to a final internal temperature of 71°C. Steaks were stored overnight at 2 to 5°C before removing six to eight 1.27-cm-diameter cores from each steak, parallel to the fiber direction. Each core was sheared once perpendicular to the muscle fibers using the WBSF equipment with a crosshead speed of 250 mm/min. Due to a small size of LM at 5th rib level the WBSF values are represented as the average of six cores of each sample.

D. Statistical analyses

Due to the high level of spectral noise data lesser than 400nm and greater than 1100nm were discarded. To reduce spectral noise and avoid model overfitting a multivariate, dimensionality reduction technique was employed. Partial least square regression (PLS) was used for predicting tenderness using VIS/NIR spectra between 400 and 1100nm with a 20nm interval, using PLS procedure of SAS® system (SAS Institute Inc., Cary, NC). Internal full cross validation was performed in order to avoid overfitting PLS equations. The optimal number of factors in each equation was determined as the number of factors after which the standard error of cross validation no longer decreases substantially.

Predicted (by PLS) and observed WBSF values were used to categorize meat samples in "tender" (WBSF ≤ 4.5kg) or "tough" (WBSF > 4.5kg). The frequency procedure of SAS was used to compare the frequency of "tender" and "tough" classes of observed and predicted WBSF. Analyses were performed within and between (overall) ageing periods.

III. RESULTS AND DISCUSSION

The WBSF decreased linearly with ageing period (P<0.0001; Figure 1) as expected. The WBSF of samples without ageing (day 0) ranged from 4.6 to 8.8kg and were all classified as "tough" samples. As ageing period increased the percentage of tender samples also increased from 8.7; 30.4 and 78.3% for 7, 14 and 21 days of ageing, respectively. These high values of WBSF are in agreement with results reported by literature [11,4] for Nellore cattle.

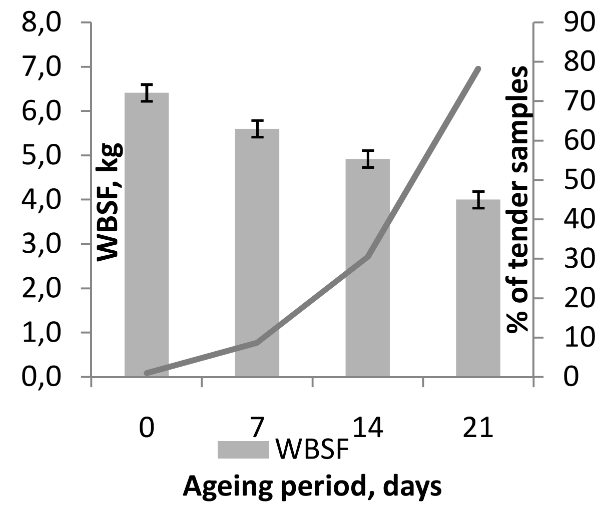

Figure 1–Warner Bratzler shear force (WBSF) of Longissimus samples and percentage of observed tender samples (WBSF≤4,5kg) according to ageing period.

The mean spectra for samples aged for 0, 7, 14 or 21 days from 400 to 1100nm are presented in Figure 2. Spectra of non-aged samples (0 day) were less reflective along all wavelengths when compared to aged samples. These differences were less noticeable at 400nm and from 500 to 540nm but kept fairly constant from 420 to 460nm and from 560 to 1100nm. However, differences among aged samples were not consistent along all wavelengths. Samples aged for seven days were more reflective when compared to those aged for 14 days along all wavelengths, and than those aged for 21 days from 400 to 560nm but were similar for all the other wavelengths. The pattern of reflectance for samples aged for 14 or 21 days were similar from 400 to 560nm and after that samples aged for 14 days were less reflective along all wavelengths.

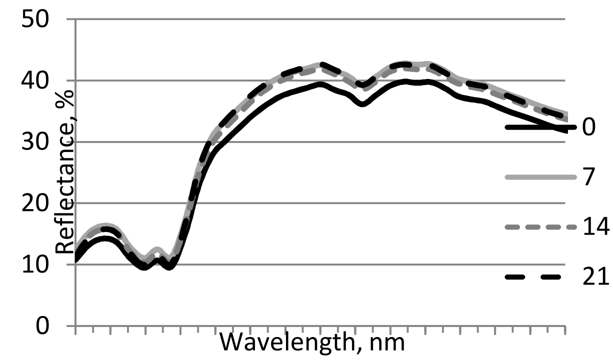

Figure 2– Mean spectral values of samples aged for different periods.

Results observed for reflectance values for different ageing period were not consistent to observed linear decrease of WBSF values. Data from literature have demonstrated that tough samples show smaller reflectance (or higher absorbance) than tender samples [8, 7].

With this in mind, it would be expected that non-aged samples (100% tough) were less reflective than aged samples as happened in fact. However, this pattern was not observed among aged samples. Those samples aged for seven days (8.7% tender samples) were more reflective (for all wavelengths) than those aged for 14 days (30.4% of tender samples) and than those aged for 21 days (from 400 to 560nm; 78.3% of tender samples). These results suggest that ageing treatment altered some physical-chemical properties of meat detected by VIS/NIR that were not related to WBSF. Different from observed in this work, Andrés et al. [3] analyzed the spectra of beef samples and observed no differences between samples aged for 1, 3, 7 or 14 days, suggesting that no differences due to ageing process could be observed by NIR, despite of differences observed by analytical methods.

Prediction of WBSF using VIS/NIR spectra as independent variables was explored within each ageing period and using the pool of all samples, as well (Table 1). The higher coefficient of correlation (0.83) and percentage of correct classification (95.7%) was observed for non-aged (0 day) samples.

Table 1 – Prediction of Warner-Bratzler shear force (WBSF) by VIS/NIR spectroscopy

Ageing period	n	Number of optimal factors[a]	r^b	% correct classification[c]
0	23	5	0.83	95.7
7	23	4	0.75	91.3
14	23	5	0.78	91.3
21	23	2	0.59	82.6
Overall	92	6	0.75	88.0

[a] number of optimal factors used to perform the calibration equation model; [b] coefficient of correlation between observed and predicted WBSF; [c] percentage of correct classification of observed and predicted WBSF in tender or tough classes.

As the ageing period increased the coefficient of correlation decreased (from 0.83 to 0.59) as well as the percentage of correct classification (from 95.7 to 82.6%). The higher percentage of correct classification observed for day 0 could be due to the high level (95.7%) of tough samples (WBSF ranging from 4.6 to 8.8kg). As ageing process increased and WBSF decreased, the number of samples that were close to the cut point (4.5kg) for tender/tough classes was greater and the error in prediction classes tended to increase.

The overall equation showed a correlation of 0.75 between observed *vs* predicted WBSF and classified correctly 88% of samples, according to tenderness class. The plot of observed and predicted WBSF is presented in Figure 3.

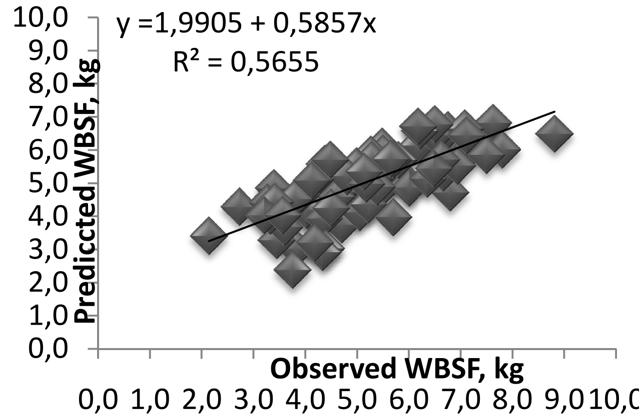

Figure 3– Correlation plot of observed *vs* predicted (VIS/NIR) Warner-Bratzler shear force (WBSF).

Due to the high variation of equipments and treatments used in different studies is difficult to establish a direct comparison to others studies. However, in a general way the results of WBSF prediction from VIS/NIR data observed in this work are in accordance with reported by the literature. Liu et al. [6] found that a model using VIS/NIR data classified correctly 83 to 96% of samples in tenderness classes with a coefficient of determination (R^2) between predicted *vs* observed WBSF varying from 0.20 to 0.49, according to statistical model used. Similar to observed in this work Rosenvolt et al. [9] found a R^2=0.58 between observed and predicted WBSF and concluded that NIR perform as well as – or better than – the reference method for tenderness determinations. Higher association (R^2=0.65) between observed and predicted WBSF was reported by Andrés et al. [3] suggesting that VIS/NIR have a good potential to predict WBSF of intact muscles.

CONCLUSION

The VIS/NIR spectroscopy has a good potential to predict tenderness and to classify meat of *Bos indicus* cattle in tenderness classes. Further studies using a great number of animals and evaluating other complementary traits like pH, water holding capacity and color parameters could be useful to improve the accuracy of models.

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