The use of visible near infrared spectroscopy and nuclear magnetic
resonance spectroscopy to predict sensory evaluation of beef

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Objectives: Sensory characteristics are crucial factors that influence consumer preferences for fresh meat. Although Japanese consumers have preferred marbled beef in recent decades, the demand for other types of beef has gradually increased. Consequently, Japanese beef distributors and breeders are increasingly interested in evaluating beef sensory traits. However, measuring beef attributes using trained sensory panelists takes effort and requires a large number of samples. In contrast to analytical sensory techniques, visible nearinfrared (Vis-NIR) and nuclear magnetic resonance (NMR) spectroscopy are stable, with a high throughput and less labor-intensive techniques and with the potential for determining meat sensory characteristics at a low cost. This study evaluated the potential use of Vis-NIR and 1H-NMR spectroscopy in predicting sensory traits of beef products in the Japanese market.

Materials and Methods: A total of 140 ribeye samples (Longissimus dorsi, LD), were collected from various breed cattle as follows: Japanese Black (N=85), Japanese Black × Holstein crossbred (N=19), imported unknown breed (N=13), Japanese Brown (N=11), Japanese Shorthorn (N=7), Holstein (N=4) and Brown Swiss (N=1). Vis-NIR spectra were measured from the homogenized beef samples using a benchtop NIR instrument, model DS2500 (FOSS Electric, Denmark). The 1H-NMR spectra were analyzed from deuterium oxide (D_2O) extract which was performed modifying a previously reported method by kodani et al.[1], using a benchtop NMR instrument model Spinsolve 60 Ulra (Magritek, New Zealand). The D_2O extracts were concentrated by freeze-drying before spectra measurements. Beef samples for sensory evaluation were grilled. The cooking conditions and sensory analyses were per- formed as previously described [2]. Evaluated traits were as follows: tenderness (bite), chewiness, fibrous, juiciness, fattiness, sweet smell, Roasted Smell, odor desirability, flavor intensity, umami intensity (MSG) which taste like monosodium glutamate, umami intensity (IMP) which taste like disodium 5'inosinate, umami intensity (total). All statistical analyses were performed using R (version 4.0.2). Prior to partial least squares (PLS) regression analysis using the R package "pls," Vis-NIR and NMR data were pretreated using the Savitzky Golay algorithm (R package "prospectr"). Pretreatment methods, including smoothing, first derivative, and second derivative, were examined.

Results and Discussion: The capacity of Vis-NIRS to estimate texture-related sensory scores, fatty acid composition, moisture con- tent, crude protein, and crude fat has been reported [3][4]. In contrast, NMR can quantify endogenous water-soluble components of meat [1]. Thus, we hypothesized that NMR spectroscopy could be used to predict sensory evaluation scores for taste and odor in beef samples. Analysis of each pretreatment revealed that the best prediction could be obtained when the second-order spectral dif- ferentiation was used as the explanatory variable. As a result, the second-order spectral derivative detected R^2 prediction values of 0.72, 0.65, 0.64, 0.84, 0.85, 0.71, 0.6, 0.71, 0.72, 0.14, 0.43, and 0.4 for tenderness, chewiness, fibrous, juiciness, fattiness, sweet smell, roast smell, odor desirability, flavor intensity, umami intensity (IMP), umami intensity (Glu), and umami intensity (total), re- spectively. Texture- and odor-related traits had high R^2 coefficients, which suggested that the prediction was successful. In contrast, taste-related traits showed low R^2 coefficients, which indicated the limitation of the model in their prediction. These results indicated that the use of NIR and NMR techniques alone could be insufficient in predicting taste attributes in beef. In this study, a large number of explanatory variables were used from NIR and NMR, which suggest that caution should be taken to prevent overfitting when using PLS regression analysis. Future studies on different methods of performing regression analysis using as variable selec- tion method, such as genetic algorithms and Lasso regression, are needed.

Conclusions: Overall, our results indicated the potential reliability of Vis-NIRS and NMR in predicting sensory evaluation score for
beef samples. However, further refinement is required to improve its effectiveness in predicting taste-related scores.

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