Feasibility of Detecting Palm Oil Adulteration with Chicken Fat using NIR spectroscopy and Chemometrics Analysis

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Abstract — Detection of adulteration is among major issues in the food industry. We report our result in investigating the feasibility of classifying the palm oil samples from the one adulterated with chicken fat using the NIR spectroscopy and chemometrics analysis. The chemometric analysis result using an open source R software has shown that adulterated oil samples with above 31.8% adulteration were correctly classified.

Keywords — Near Infrared spectroscopy, NIR, Chemometrics, R.

I. INTRODUCTION

DETECTION of adulteration is among major issues in the food industry [1]. In certain countries such as Malaysia with many Muslim consumers, such situation causes problems when the adulterant is from prohibited sources. For vegetarians, adulteration with animal source is very much undesired. One possible technique of detecting such adulteration is by using Near Infrared (NIR) spectroscopy combined with its natural partner, the chemometrics analysis. The NIR spectroscopy has been recognized as an appropriate and useful tool for non-invasive analysis of chemical and physical properties, and it has been widely applied to analyze the quality characteristic in food and agricultural commodities [2,3]. For example, characteristics such as fatty acid composition, its length and unsaturated degree which are known to be different for every oil/fat is known to form a fingerprint unique to every fat/oil [4,5].

This fact was used by Yang et al (2005) to discriminate the edible oils and fats in their experiment [6]. Through the use of discriminant analysis methods they managed to get around 90% of correct discrimination. Their work was however only based on pure samples and did not cover the adulterated samples. In this work, we conduct an experiment to acquire NIR spectral data of pure palm oil, pure chicken fat and of the palm oil adulterated with chicken oil. The spectral data were analyzed with chemometrics analysis using the open source R software for classification [7]. With the objective of investigating the feasibility of classifying palm oil adulteration with chicken fat, this article is organized as follows. The next section describes the experimental setup. The result is discussed in section three. Section four conclude and suggests future works.

II. MATERIALS AND EXPERIMENTAL SETUP

A. Materials

The palm oil and the adipose tissues of chicken were obtained from local market. The chicken fat was cleaned with water to remove blood and skins and was boiled until the water was completely evaporated. For adulterated samples, a set of standards for calibration consists of chicken fat in palm oil was constructed by blending the chicken fat and the palm oil at concentration ranges of 28.57% ~ 48.28 % (v/v) of chicken fat in palm oil. For prediction, two sets of adulterated samples were constructed. The first consists of adulterated samples with concentration range above 30% and the second consists of samples at concentration ranges of 6.25 ~ 48.28 % (v/v). The prepared samples were labeled according to the percentage of the chicken fat in palm oil and were kept in refrigerator. When used for calibration, they were first heated by putting the container bottle in a warm water to be liquidized.

B. Experimental Setup

The NIR spectral was scanned using a FT-NIR spectrometer from Arcoptix [8]. It is a spectrometer with a resolution of nearly 6 nm. Each measurement gives intensity for 909 wavelengths between 900 nm ~ 2600 nm. The sample were placed in a cuvette at ambient temperature (20 °C). A background of air and cuvette spectrum was set as the baseline for all spectral measurements. After every scan, a new reference baseline was taken. These spectral were recorded as absorbance values at each data point in average of 10 rounds. The mixed sample is heated at around 50 °C and stirred using magnetic stirrer before each measurement to ensure its homogeneity. A simple schematic of the experimental setup is depicted in Figure 1.
III. RESULTS AND DISCUSSIONS

As previously mentioned, the R software has been chosen for use as the chemometrics tool [7]. Using the absorption spectral data, the “lda” function from the “MASS” package was used to build the linear discriminant calibration model that classifies the palm oil, chicken oil and the adulterated oil spectrum. The predictive ability of the linear discriminant model was further used to predict the prediction samples. The spectrum of all samples is depicted in Figure 2.

As can be seen from Figure 2, similar to Yang et al. (2005), the obtain spectrals displayed high peaks at 1666 nm ~ 1818 nm and 2083 nm ~ 2222 nm regions. As described by Yang et al [6], the former comes from the first overtones of the C-H stretching from -CH2, -CH and -CH=CH- functional groups while the later comes from the combination of C-H stretching related to cis double bonds and increases with the degree of unsaturation. Instead of using specific regions, we opted to use the whole spectral for our chemometric analysis as this has been reported to give better results. In this analysis, as it was meant to show the feasibility of classifying the samples from the adulterated one and also the feasibility of using an open source software R for such analysis, sample pre-treatment was not used although there exist user contributed packages in R that can easily be used for treating the spectrum at the pre-processing stage. The resulted scatter plot is depicted in Figure 3.

From Figure 3, we can see that the chicken samples (Ch) and palm oil samples (P) were clearly separated. The adulterated samples (A) rest in between and looks a little closer to chicken sample (Ch). This is easily understood as the quantity of chicken fat in the adulterated samples were less than 50%. Interestingly, we can see that the first discriminant function alone looks almost enough to discriminate all samples to their group. The recorded proportion of trace is at 0.9681 and 0.0319 for the first and the second discriminant function respectively. With a careful inspection on Figure 3, one would realized that one sample from adulterated group has fell into the palm group.

It is always convenient to view the classification result by displaying the confusion table. Telling R to display the confusion table by comparing the train data frame against prediction from calibrated model gives:

```
> table(oil$class, oil.pred$class)

   A  Ch  P
A  9  0  1
Ch 0 10  0
P  0  0 10
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We can see that one of the adulterated samples was misclassified as palm oil group and the rest were correctly classified to their group. Obviously, the probability of correctly discriminating the adulterated samples is 90%.

Now against the first test samples which consists of four pure palm oil (P), five pure chicken fat (Ch) and ten adulterated samples (A) with more than 30% adulteration, the correct classification rate was 100%. Against the second test samples set which consists of fifteen adulterated samples (A) with several concentrations in the range of 6.25 ~ 48.28 % (v/v), the correct classification rate was 73.33%. Since all samples with 31.8% adulteration and above was correctly classified, we can say that the obtained calibration model can
be used to safely classify the palm oil samples with 31.8% adulteration and above. This percentage can surely be improved if better calibration is performed for example with higher number of samples and by applying some preprocessing techniques before the chemometrics analysis. This result has to a certain extend shown that it is feasible to use the NIR spectroscopy combined with an open source software, namely R to classify palm oil samples adulterated with chicken fat

IV. CONCLUSION AND FUTURE WORKS

It has been shown in this work that the NIR spectroscopy combined with chemometrics analysis using an open source R project is feasible in detecting palm oil adulteration in corn oil with above 31.8% adulteration. The fact that an open source R software was used for the chemometric analysis increases the practicality aspect in terms of cost. It is believed that with a better sample data and chemometrics analysis, a better calibration model can be obtained and further improves the classification result. This is left as our future works.

ACKNOWLEDGMENT

The authors would like to thank Noor Nazurah Mohd Yatim and Abdur Rehman Laili for fruitful discussion in conducting the experiment.

REFERENCES


