CONCLUSION

This study was investigated the potential of near-infrared (NIR) spectroscopy for quantitative and qualitative analysis of Thai commercial fish sauces. The chemical, physical and sensory properties and NIR spectra in the regions of 1100-1900 and 2000-2440 nm were measured. For quantitative analysis, the partial least squares (PLS) regression was used to develop the models for predicting the chemical, physical and sensory properties of Thai fish sauces. For qualitative analysis, the supervised pattern recognition techniques were used to develop the classification model for classifying Thai fish sauces into three groups based on their total nitrogen content.

For quantitative modeling, the chemical, physical and sensory properties were used as dependent variables (Y-data). The NIR spectra with the aids of two wavelength interval selection methods were used as independent variables (X-data) .These two methods were the moving window partial least squares regression (MWPLSR) and the searching combination moving window partial least squares (SCMWPLS). The MWPLSR method was applied for selecting the informative regions and subsequently the SCMWPLS method was used to combine and optimize the informative regions. The prediction results for the chemical, physical and sensory properties of Thai fish sauces were these followings:

The chemical and physical properties of fish sauce samples were measured by the standard methods. These properties were total nitrogen content, sodium chloride, pH, reducing sugar, density, baume, total soluble solid, refractive index, color CIE Lab (L*, a*, and b*). Results showed that the combination of MWPLSR and SCMWPLS was powerful to find out the suitable input wavelength variables, which could be used to develop a PLS models. The developed predictive models of each chemical and physical property provided the low root mean square error of prediction (RMSEP). The lowest RMSEP values of total nitrogen content, sodium chloride, pH, reducing sugar, density, baume, total soluble solid, refractive index, color L*, color a*, and color b* were 0.100%w/v, 0.647%w/v, 0.155, 0.407

mg/mL, 0.007 g/cm^3, 0.118 °Baume, 0.435 °Brix, 0.00079, 2.914, 1.023, and 4.803, respectively.

The PLS predictive models for the sensory properties of Thai fish sauces were also investigated. The independent wavelength variables were selected using the same techniques as the chemical and physical modeling. The sensory data used as dependent variables were evaluated by using the Generic descriptive analysis. The twelve trained panelists were used to determine and compare the sensory characteristics between the pure fish sauce (P) and the mixed fish sauce (M) samples. The results showed that there were fifteen sensory descriptors which were brown color, five aromatics (sweet, caramelized, fermented, fishy, and musty), four tastes (sweet, salty, bitter, and umami), three aftertaste (sweet aftertaste, salty aftertaste and bitter aftertaste) and two flavors (caramelized flavor and fishy flavor). The P samples had significant difference in all of sensory characteristics from the M samples ($p<0.05$). Subsequently, principal component analysis (PCA) was applied to investigate the relevant and interpretable structure in those sensory data. It could reduce those sensory attributes into two independent principal components, which accounted for 55.14% of the total variance, and could be explained the characteristics of each group classified by the cluster analysis. The first principal component (PC1) accounted for 30.44% of the variation and could be referenced as *fishy flavor component as* highly correlated fishy aromatic, sweet aftertaste, caramelized flavor and fishy flavor. PC1 could be interpreted as variation between P and M fish sauces. The P samples were characterized by higher degree of *fishy aromatic, sweet aftertaste, caramelized flavor and fishy flavor* then mixed fish sauce samples. PC2 could be explained an additional 24.70% of the variation and could be called *caramelized aromatic component*, as the caramelized aromatic attribute was highly correlated to this PC. The PC2 separated samples from PC1 in another two groups which high and low degree of *caramelized aromatic*.

The performance of PLS models for the sensory attributes was quantified by determining a specific sensory characteristic named the range error ratio (RER). The results showed that predictive information related to sensory properties

and NIR spectra was not clear. Most of the developed models yielded poor prediction results. While the models for fishy aromatic, salty flavor and fishy flavor provided good results. These sensory attributes might also have practical utility since the RER was higher than 5.0. The RER values for fishy aromatic, salty flavor and fishy flavor models were 7.96, 6.73 and 5.85, respectively.

For qualitative analysis, the classification models were developed to grade Thai fish sauce into three groups based on their total nitrogen content (TN). These groups were i) standard pure fish sauce (TN$\geq$0.9 %w/v), ii) standard mixed fish sauce (TN$\geq$0.4 %w/v) and iii) out of standard fish sauce (TN<0.4 %w/v). Five supervised pattern recognitions, Linear discriminant analysis (LDA), Factor analysis-Linear discriminant analysis (FALDA), Soft independent modeling of class analog (SIMCA), K nearest neighbors (KNN) and Artificial neural networks (ANNs) were applied to develop the models. The selected wavelength variables for total nitrogen content obtained by SCMWPLS were used as independent variables (X-data). The category memberships of samples were used as dependent variables (Y-data). Results showed that all of supervised pattern recognitions were able to classify fish sauces into three groups. They provided the corrective classification rate above 82%. The ANNs method had the highest correct classification rate (100%).

According to the quantitative and qualitative analysis results, NIR method with the aids of wavelength selection methods named MWPLSR and SCMWPLS is very useful techniques for Thai commercial fish sauces.