CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Profiling of Lard from Collected Pig Samples at Northern, Central, and Southern in Malaysia using FTIR combined with Principal Component Analysis (PCA)

This study has investigated spectra profiles of the lard from pig body parts collected from different Peninsular Malaysia regions. Returning to the research question at the beginning of this thesis, it is now possible to demonstrate FTIR with extended PCA, such as Hoteling T^2 approaches in lard profiling that was collected from various sources.

The following conclusion can be drawn from this study. First, prior knowledge based on past research is required to determine the frequencies of fats and oils and the importance of interferent peaks. This major study of lard of pig's body part based on different regions was unable to reveal differentiation of the spectra. Then the profiling similarity was determined using F-distribution derived by the Hotelling T^2 statistic of MSC-PCA models.

The results indicated that alternative evaluations corresponding to the trending of multivariate analysis, such as chemometrics approaches, can be re-apply to the new data on the proposed PCA model. This study has shown that the MSC-PCA model extended to Hotelling T^2 statistic provides a robust validation through re-sampling by PCA projection. However, this reference is best used with the same FTIR model. Calibration transfers are suggested to overcome the issues if new samples are measured from different FTIR

models. The other recommendation of the lard references is profiling using the NIR.

5.2 Discrimination of Pigs (Lard), Chicken, Beef, Mutton, and Plant Fats after Heating-Process using FTIR, ^{1}H-NMR, and ^{13}C-NMR with Chemometrics Techniques

This study recounted the reason for the chemometrics use of FTIR data on heating-process lard and edible fats. As mentioned in the earlier introduction, this study evaluated the lard samples and other edibles profiles after the heating-process using FTIR data combined with chemometrics.

The following conclusion can be drawn from the study; first, the finding in the chemometrics of the multivariate classification study showed MDA and QDA were more reliables output than LDA and SVMDA on FTIR data classification of edible fats after the heating-process. Secondly, OSC-PLSR most represents spectral bands related to lard and selected fats. Finally, the OSC-PLSR loadings plot has discovered that most secondary oxidation products are from the heating-process on FTIR data.

This study has also investigated the potential of ^{1}H-NMR to differentiate lard and other edible fats. As brought up in the earlier introduction, this research classified the lard against other edible fats after the heating-process using ^{1}H-NMR data combined with chemometric and regulates the chemical shift associated with lard and differs from the others.

The first finding is that pre-processing ^{1}H-NMR data has greatly impacted the PCA clustering results. The second finding is that the best multivariate classification of fats after the heating-process are MDA, QDA,

C-3-SVMDA, and *υ-0.5*-SVMDA. The third finding is multivariate calibration on ^{1}H-NMR acceptable results, given by OSC-PLSR, but could not be differentiated between lard and chicken groups at specific heat parameters. The results revealed that after proper pre-processing, there is a possibility to identify lard and other fat by multivariate classification. Nevertheless, to correlate the lard according to the chemical shift, the ^{1}H-NMR could not offer conclusive outcomes.

As mentioned in the earlier introduction, this study's purpose is to identify the TAG's carbon structure that can differentiate lard and chicken fats after the heating-process. The ^{13}C-NMR has successfully demonstrated by C-2 denoted by δ 34.21 and δ 62.10, tentatively as lard biomarkers.

The combination of the ^{13}C-NMR and chemometrics has proven to enhance the data mining interpretation in this study. A new expectation from this chemometrics technique might be to open an entirely new range of identification and novel development of ^{13}C-NMR applications leading from ^{1}H-NMR.

Further data analysis on FTIR and ^{1}H-NMR using Matlab software can provide many chemometrics techniques, and Unscrambler® X software has the advantage of being a friendly user.

5.3 Evaluation on Fatty Acids (FAs) of Lard and Selected Fats after Heating-Process using GC-FID and LC-MS/MS combined with Principal Component Analysis (PCA)

The use of GC-FID is well-known in animal fat profiling. As mentioned in the earlier introduction, the purpose of this study is to use the PCA approach to gain the possible FA degradation that discriminated lard against selected fats after the heating-process.

It can be concluded that FAs analysed by GC-FID could not differentiate heated lard from other fats. However, the heated animal fats could be grouped according to the sum of heat, from the lower to the higher level, which can be determined based on the *cis* and *trans* isomerization of FAs. On the other hand, only plant fats-based shortening could be discriminated from animal fats.

Lard and plant-based shortening have similar characteristics in bakery ingredients. Thus, the replacement of lard with shortening as an alternative has been used for decades ago. Furthermore, the similarity of features allows the adulteration of lard by commercial food providers. Hence, this GC-FID-PCA result could provide a database to authenticate between animal fats and plant-based shortening after the heating-process.

The limitation of the lard analysis using LC-MS/MS is due to the lipid complex. In this study, lipids' complexes can be reduced by selecting the targeted lipid class. As mentioned in the earlier introduction, this study aims to gain possible lipid classes of GL and GPPL existing in lard and selected fats after the heating-process.

In conclusion, GL of lard was found to be pronounced different at the temperature of 180 ºC (0.5, 1, & 2 hrs) that was contributed by DAG 32:0 and MAG 24:0. Meanwhile, from this study, GPPL lard has been found pronouncedly different at temperatures of 180 ºC (0.5, 1 & 2 hrs) which are contributed by PA 20:0, PA 21:0, PA 23:0, and PA 25:0.

The GL and GPPL lipid classes of outstanding lard could eventually lead to the identification of novel lard biomarkers at the range heating-process of parameters studied. Furthermore, the other solvents or sample preparation, such as solid phase extraction (SPE) on heated samples according to the interest lipid groups, could be recommended for different lipids using LC-MS/MS.