CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The predictive models obtained by the data set for each oil type show great potential for practical application in the food processing industry. The models at this stage can be described as rudimentary models and still need refining for specific cases. The drastic effect of the pro-oxidant, copper at low concentrations on oxidation of palm-olein, emphasises the importance of insisting on copper levels < 0.01 mg/kg in commercial refined oils. The control of transport and storage conditions, such as the type of containers and pipes, to prevent copper from being picked up is thus imperative to ensure good quality refined oils. The effect copper had on the oils during long-term storage lead to greatly enhanced oxidation, as can be seen by the chemical reactions that occurred. This is evident in the elimination of primary oxidation products as possible predictors for the palm-olein model and the inclusion of secondary oxidation products. Although copper addition complicated the predictive modelling, it provided useful information on the chemical reactions that occur and the course of rancidity with a strong pro-oxidant such as copper, on long term storage. Refining the model on palm-olein oil would entail further shelf-life studies with no addition of copper and storage of different palm-olein oils, which will make provision for variation in oil quality, at two temperatures, e.g. 40°C and 50°C. This will supply information on repeatability and robustness of the prediction models and will enable the calculation of a Q_{10} value that will make it possible to estimate shelf-lives at different temperatures. Generally, only parameters highlighted by the models as predictors should be evaluated, although primary oxidation products will have to be included as well to ensure that the effect that copper had is taken into account. Sensory evaluation will be essential at the time the oil is taken out from storage, since sensory evaluation is the ultimate test for food quality and stability. The relationship between onset of rancidity as determined by sensory evaluation to the concentration of chemical quality parameters measured at that time is especially useful. This is particularly relevant for the interaction of volatile oxidation products and typical flavour descriptors.

The addition of the antioxidant, TBHQ to sunflower seed oil provided important information on the prolonged effect of antioxidants. Antioxidant content emerged as an important predictor of shelf-life as it has a clear effect on oil stability. For modelling

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purposes it has to be decided whether to determine the actual antioxidant content in the oil or to rely on values that had been added initially to the oil. However, the decision which antioxidant value to use in the model depends on the even dispersion of antioxidant in the oil and the magnitude of decrease in TBHQ content during storage and how the decrease during storage would effect prediction. Should the specified initial antioxidant level be known and where laboratories are unable to perform confirmation analyses, experience gained by this study suggest that the specified antioxidant level can be used in the predictive model. Since no analysis to determine the extent of decrease in TBHQ during storage was done in this study it is not possible to judge which value would be best to use for modelling purposes. As the sunflower seed oil models indicate, primary oxidation products, such as PV, are preferred as predictors to secondary oxidation products. For refining of the sunflower seed oil model, additional shelf-life studies are needed with different sunflower seed oil samples and storage at least two temperatures to eliminate the effect of variation between samples and determine shelf-life at specific temperatures. Storage at an ambient temperature such as 27°C in combination with storage at 37°C is needed, as 27°C would be a more representative storage temperature of sunflower seed oil for temperate local conditions. Sensory evaluation will be needed, as discussed. The important parameters to be studied have been highlighted by the modelling, thereby doing away with the need for an extended shelf-life study that included monitoring all 9 parameters determined.

Notably in the models for both oil types, it turned out that FFA and OSI were selected as predictors of shelf-life of oil. The importance of FFA as predictor was unexpected as FFA is normally associated with hydrolytic rancidity and not oxidative rancidity, but it appears that small changes in hydrolytic rancidity have an important effect on oil shelf-life. A contributing factor to the selection of FFA as predictor could be that only one oil sample was used for both oil types, which could have emphasised small increases in FFA. More oil samples would show greater variations in FFA and the emphases on small FFA changes might not be so noticeable.

The importance of OSI has been highlighted, as it was included in all the models. There has always been interest around in correlating accelerated oxidation tests such as OSI by itself with ambient shelf-life. This study showed that OSI predicated the actual shelf-life of the oils poorly. It appears that various factors are involved in long-term oil stability,

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such as FFA formation, that would not necessarily be measured by OSI. Although OSI is one of the most important variables selected for shelf-life prediction in a Practical model, it needs to be used in combination with other parameters such as FFA, PV and possibly conjugated triene value. The applicability of AV for modelling purposes will have to be verified by additional shelf-life studies where the pro-oxidant is excluded.

It was clear, as expected, that monounsaturated oils are more stable than polyunsaturated oils. The Control of both oil types obtained a shelf-life of 22 and 26 weeks, respectively bearing in mind that the monounsaturated oil was stored at 50°C and the polyunsaturated oil at 30°C. Sensory evaluation of the Control of both oil types clearly showed a greater stability in the monounsaturated oil with a shelf-life of 52 weeks when compared to polyunsaturated oil with a shelf-life of 26 weeks. However, with the storage conditions and additives used, oxidation in the monounsaturated oil was perceived in the secondary oxidation products, whereas in the polyunsaturated oil oxidation was encountered in the primary oxidation products. It must thus be noted that the selection of parameters for shelf-life prediction of monounsaturated oil could be altered from the ones selected for this study if the oil is stored without the addition of a strong pro-oxidant. This emphasises the need for further studies.

The Practical models developed (based on chemical as well as sensory detection of rancidity) will be applicable for implementation in the food industry to predict the shelf-life of mono- and polyunsaturated oils generally within an error of ± 4 weeks with 95 % confidence interval and within an error of ± 8 weeks in infrequent cases. Refining of the Practical models as suggested above will strengthen the agreement between the chemical and sensory models. The estimation of the shelf-life of oils will provide the food manufacturer the means to do proper planning of production and distribution lines. Less returns will lead to cost saving and reduction in food price inflation.