CHAPTER 1

Introduction

1.1 The Oil Palm

The oil palm was first introduced into Malaysia in 1875 and commercially planted in 1917. In the 1960's during the national agricultural diversification programme oil palm cultivation was intensified. Since then palm oil has become one of the major earners of the country, producing a record 7.8 million tonnes of palm oil in 1995 making Malaysia the largest producer and exporter of palm oil in the world.

The oil palm is a very highly productive crop per hectare. This, coupled with research on palm breeding and selection, resulted in a very impressive yield improvement compared to the original crosses. At present, the fruit yield of the commercial estates ranges from 22 to 30 tonne/ha/year, equivalent to about 5-7 tonne/ha of oil (1). As with other agricultural crops, the yield is very much dependent on the planting material, climatic influence, location and the agromanagement techniques. The oil palm, compared with other edible oil producing crops, has the advantage of being a perennial crop bearing fruits throughout the year with peak yield at the 5-7th years while the economical life spans over more than 18 years.

1.2 Extraction of Palm Oil

The mature fresh fruit bunches are harvested from the palm trees and transported to the palm oil mill for extraction of the palm oil (Fig. 1). On arrival at the mill, the fruits are sterilised to halt enzymic hydrolysis and to soften the fruits so that the fruitlets can be easily detached in the threshing stage. The mashed fruitlets are then screw- pressed to separate the oil/water liquor from the fibres. The pressed liquor is then kept in big clarification tanks where oil, being of lower density, will cream and separate from the aqueous phase. However due to time and space constraint, separation is further hastened by centrifuges or separators.

At various stages in the clarification process, water may be added to reduce the viscosity of the mixture. The final separated sludge liquor (mainly solid and water) still contains oil and is discharged as effluent. Other sources of effluent are the hydrocyclone water, steriliser condensate and floor wash. The sludge discharge constitutes the major portion of the effluent, amounting to 1.5 tonnes for every tonne of oil produced.

For every tonne of palm oil produced a combined volume of about 2.5 tonnes of effluent is discharged and it contains about 1% oil on a wet basis. (2). Although the oil content is small but considering that Malaysia will be producing at least 8 million tonnes of palm oil in 1996 the economic loss is enormous. This is more so if it should contain also other valuable minor components.

1.3 Palm Oil Effluent

Effluent discharged from the mill is viewed as the most undesirable but inevitable by-product in the industry. This waste usually entails much capital investment to treat before it can be discharged or recycled. The Malaysian palm oil industry faced the greatest technical challenge when the Department of Environment under the Ministry of Science, Technology and Environment in 1974 implemented the Environmental Quality Act sending the industry to a frantic search for a viable treatment system. By 1984 the private sector had, through intensive research and development, adapted and developed suitable technology which could meet the stringent 100 ppm BOD (Biological Oxygen Demand) enforcement limit. Meanwhile intensive research is being pursued to modify the milling process so as to reduce the volume of the effluent (3) correspondingly in view of the competitive nature of the industry. Research into the utilisation of the sludge, with possible incorporation of the dried effluent as animal food (4), partially treated effluent in land application as fertiliser (5) and generation of biogas was studied (6). Attempts to utilise effluent in fermentation and production of more value added products were also investigated (7). It is hoped that more value added products can be derived as by-products of the milling process.

The palm fruits are solely harvested for its oil and in the process only water is used for dilution. Thus much water soluble compounds from the fruit are present. Although Ho (8) had elucidated a wide range of natural products, it was never pursued further for commercial exploitation. As the industry gets more competitive,intensive resaearch is necessary to identify and possibly extract the more economically valuable minor components from the aqueous sludge.

Commercially, the total oil loss determined from the oil content of the sludge discharged serve as an indication of the efficiency of the milling process. It is debatable as what is the maximum amount of oil technically extractable from the fruits in terms of good milling practice using the present milling process. This is because although the total oil content of the fresh fruit bunches are determined by Soxhlet extraction which is a very exhaustive method. It can extract all solvent soluble substances that are present in the palm fruits.

Similar method is used in determining the oil content of sludge, thus it is misleading to consider the total organic extract as oil. The nature and type of the oil present in the sludge has been identified (9). The oil was established to be present in three categories according to the method of isolation ie. free oil droplets, oil present in unruptured cells and oil adhering to the fragmented plant cell debris.

Although much concern seems to be on the oil content of the effluents, the exact amount of discharge is seldom actually quantified, even in the more quality-conscious mills. The discharge is a natural reservoir of valuable products which at present are untapped. The sludge being colloidal in nature with a high suspended solids will be beneficially studied from the view point of colloid chemistry.

1.4 Uses of Palm Oil

Crude palm oil is refined and fractionated into various fractions with different physical properties for different uses. As a food product they are usually presented in various physical forms obtained by blending fractions of other vegetable oils so as to achieve the desired physical characteristics and stability (10). For certain functional purpose, it is possible for vegetable oils to assume the role of a dispersing medium and in others as the dispersed phase. An example is the water-in-oil emulsions of margarine and conventional spread. With the trend towards lower fat intake, various palm oil based low fat spreads have been patented (11). Other common edible emulsified oils are mayonnaise, ice-creams, whipping cream, chocolate and some confectioneries. Certain vegetable oil emulsions have also being found suitable to be used as vehicle in the formulation of certain parenteral drugs.

1.5 Emulsions

The history of food emulsions may probably date back to approximately 2.4 x 10^7 BC when mammalian milk was produced (12). Later, milk was obtained from domestic animals from which butter and cheese were subsequently prepared. It is of interest to know that homogenised milk made with Gaulin's first high-pressure valve homogeniser was drunk at the World's fair in Paris in 1900. In modern times, it has now become common manufacturing practice to formulate mixtures of food ingredients into emulsions for improvements of "mouth feel", texture, palatability, shelf life and product appearances. With the latest discovery of numerous food additives and stabilisers, more novel foods are being formulated in keeping with the modern life and "new" way of cooking. There is a greater demand to formulate novel food which will essentially contain the basic ingredients but in a more palatable and convenient forms, one of which is in emulsified form.

An emulsion is conventionally defined as a colloidal dispersion of liquid droplets in a liquid continuous medium. However in the broader sense, emulsions may fall into the category of colloids where the dispersed or continous phase may be a semi solid or even solid phase. This may be through crystallisation as in ice cream or gelation in meat paste or dairy products. The importance of emulsions in relation to food formulations (there being many other technical products in emulsified forms too) and the necessity and quest to understand them more scientifically can be seen by the numerous recent texts (13-17) dedicated to the field, besides the more general reviews on emulsions (18-20). In the Annual Index of Food Science and Technology Abstracts for 1995 a total of 75 publications were listed under the subject heading of "Emulsions" (21).

The mechanisms involved in the formation, stabilization and destabilisation of emulsions are complex and any emulsion is potentially unstable (22). The primary process of instability is creaming, flocculation and coalescence. A set of at least 12 factors of relative importance in relation to the 3 processes involved have been identified (Table 1) while rheology, besides affecting stability plays a key role in texture modification and food palatability.

1.6 Objectives of Study

The Palm Oil Research Institute of Malaysia, commonly known as PORIM (where the candidate is financially supported in this study) was established under the Palm Oil Research and Development Act 1979 with the following objectives:

- o expand and improve current uses of palm oil products
- o find new uses, improve production efficiency and quality of products
- o promote the use, consumption and marketability of palm oil products.

This study has basically been carried out in compliance with the objectives of PORIM as briefly outlined:

a. Most of the analysis on palm oil has been related to the product specification requirements: relating to oxidative stability or refining suitability. The possible effects of some natural components of the fruits on the milling or refining process is often speculated. Much agitation and intensive pumping occurs during processing; in the milling process undesirable emulsification could take place where oil droplets may be formed. This will slow down clarification and if the oil or water droplets should further be stabilised at the interface, separation of the oil as a homogenous phase would be difficult as the present milling process is mainly mechanical. In Chapter 2 an analysis of the lipid constituents present together with the oil droplets separated from the sludge discharge will be made with the objective of understanding the role and nature of these lipids in relation to the oil droplets stability.

b. Palm oil has a wide potential of applications. However, there seems to be a lack of information on the fundamental physical surface activity. Interfacial tension is an important property of the palm oil/water interface. To gain a better understanding of the various processes such as milling, refining and emulsification of palm oil, the effect of various compounds (extracted from the oil in the milling process) on the interfacial adsorption behaviour will be essential. This is the objective of Chapter 3 where various lipids are added to refined palm oil and the surface coverage and orientation of these surface active materials are discussed in relation to the palm oil/water system.

c. Palm oil is a relatively "new oil" compared to the more traditional vegetable oils such as soyabean, corn or coconut oil. The possible application of palm oil in the diverse field of food and non food uses bears great potential. Palm oil may be used in the form of an emulsion. This has the advantage of a much wider range of flow characteristics, consistencies and functionability not possible in the from of pure oil if used as such. In Chapters 4 and 5, attempts are made to emulsify palm oil with some emulsifiers. Its physical properties and stability with respect to rheology, creaming and particle size are monitored. Chapter 4 describes the systematic determination of the optimum HLB of surfactants for emulsification of palm oil while Chapter 5 reports the use of monoglycerides in the stabilisation and rheological modification of emulsion/liquid crystal formation. It is hoped that by making available these fundamental data on the emulsification of palm oil will provide the manufacturers a wider choice of oil types in potential formulations of palm oil products. This is more urgent now as the world acknowledges that palm oil is a renewable resource and when used without chemical derivitisation is highly biodegradable.

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Table 1. Twelve key physical factors affecting the stability and rheology of emulsions (0=not important, 1=sometimes important, 2=often important, 3=generally important)

Factor	Creaming	Flocculation	Coalescence	Rheology
Droplet size	3	2	1	1
Droplet size distribution	3	2	0	2
Droplet volume fraction	3	3	3	3
Density difference between phases	3	0	0	0
Rheology of continuous phase	3	3	2	3
Rheology of dispersed phase	0	0	0	1
Rheology of adsorbed layer	0	0	3	2
Thickness of adsorbed layer	1	2	3	2
Electrostatic interactions	1	3	2	1
Steric (polymeric) interactions	0	3	2	2
Fat crystallization	0	0	3	3
Liquid crystalline phases	1	1	2	2

Source: E. Dickinson (1992). Emulsions. *"An Introduction to Food Colloids"*, Oxford University Press, New York, 80.

Fig. 1. Flow Diagram of Palm Oil Extraction in a Palm Oil Mill