OFTEC Pilot Plant and Laboratory Facilities

Miskandar Mat Sahri*; Noor Lida Habi Mat Dian*; Wan Rosnani Awg Isa*; Salmi Yati Samsudin*; Nor Aini Idris* and Karimah Ahmad*

INTRODUCTION

The Oils and Fats Technology Centre (OFTEC) is a research centre under the Product Development and Advisory Services (PDAS) division. Its research and development activities focus on the application of palm oil in food products. It is equipped with adequate laboratory facilities for oils and fats analyses, and pilot plant facilities to support the role of the division as a front liner in the palm oil industry. OFTEC is currently involved in research programmes on *trans*-free formulations, frying, structured fat products, non-dairy milk, cheese analogue, palm-based chocolate and processing. Beside these, the group also actively provides services to researchers from other units in MPOB, universities and the oil palm industry. OFTEC has the following facilities that are available for use by the researchers and industry:

- margarine and shortening pilot plant;
- batch fryers;
- batch-scale bread-making machine;
- colloid mill for producing emulsion products;
- laboratory-scale spray-drying unit for producing coconut milk (*santan*) powder and coffee whitener;
- laboratory-scale production machine for chocolate and chocolate products;
- laboratory-scale ice cream machine;
- refining pilot plant;
- chemical interesterification pilot plant; and
- enzymatic interesterification reactors.

* Malaysian Palm Oil Board,
P. O. Box 10620,
50720 Kuala Lumpur,
Malaysia.
E-mail: miskand@mpob.gov.my

MARGARINE AND SHORTENING PILOT PLANT

The margarine pilot plant facilities (*Figure 1*) were set up to service the research and development programmes in MPOB and for the development of fat-based products for both local and foreign users of Malaysian palm oil products. The facility comprises two 70-litre mixing tanks, a high pressure pump, three tube-chillers (0.06 m^2, swept-surface heat exchanger), a 3-litre pin rotor, resting tubes for pastry and brick margarines and a 2-litre high pressure pin rotor. The average production capacity is 50 kg hr^{-1} for margarine, 25 kg hr^{-1} for pastry margarine and 75 kg hr^{-1} for soft shortening.

Margarines and shortenings are formulated to suit the end product requirements. The ingredients, both aqueous and oil phases, are mixed thoroughly and emulsified before being chilled. The emulsion is chilled rapidly and the crystals formed are homogenized making it into smooth and uniform product. The

Figure 1. Margarine pilot plant.

consistency of the product depends on the formulation and process conditions. Products coming out of the machine need to be tempered before delivery to the consumers. The crystals formed will take some time to find their equilibrium, and this depends on the formulation and process conditions. A good margarine will have the desired spreadability with yield values of 200-1000 g cm^{-2}.

The facilities in the pilot plant are very useful to the local manufacturers of margarines, shortenings and vegetable ghee as well as Malaysian palm oil users overseas for process optimization and market sample preparation. Local margarine manufacturers such as Lam Soon, Sime Darby, Jomalina Food Industry, Kempas Edible Oil, MMVita Oils, Mewah Oleo and Intercontinental Specialty Fats have been using the services of the OFTEC pilot plant facilities. A practical course on making margarine is held every year for overseas users of palm oil to provide hands-on experience in trying out palm oil formulations for various fat products. Post-graduate students also use the margarine pilot plant facilities for their Ph.D or M.Sc programmes. Results from the studies using this pilot plant have been published in many peer-reviewed journals such as *J. Amer. Oil Chem. Soc.*, *J. Food Lipids*, *J. Food Processing and Preservation* and also in in-house publications of MPOB.

BATCH FRYERS

The open and pressure batch fryers available at OFTEC are similar to those used by fast-food restaurants such as KFC, McDonalds and A & W. Open fryers (*Figure 2*) are normally used for frying products such as French fries, nuggets and onion rings, whilst the pressure fryer (*Figure 3*) is used for frying battered and breaded chicken. The pressure fryer in OFTEC has a capacity of handling 17 kg oil, while the open fryer handles 11.5 kg. To obtain comparable results in frying tests, the amount of materials to be fried in each batch should be standardized in order to have consistent results. For most frying tests, the optimum amount of materials to be fried is about 500 g.

Frying experiments are normally conducted for a period of 40 hr, similar to the conditions used in fast-food restaurants, or until a desired point is achieved. The facility can be used to determine the performance of various frying oils. Based on requests, frying studies have been conducted on blended oils, interesterified single and blended oils. The effects of additives in the oil, or of frying different foods were also evaluated. Analyses conducted to monitor the quality of oils during frying include determining peroxide value (PV), anisidine value (AV), iodine value (IV), free fatty acid (FFA) content, oxidative stability index (OSI)/Rancimat, colour (of both oil and fried products), polar, polymer, smoke point and triacylglycerol (TAG) content. To ensure accuracy of the test results, these analyses are carried out as soon as the experiment is completed. Sensory evaluation to assess the acceptance of the fried products is also carried out using MPOB's in-house trained panel.

Figure 2. Open fryer.

Figure 3. Pressure fryer.

The results and information obtained from these studies serve as useful references for industry, for example, for establishing guidelines for industrial-scale frying operations to ensure the safety of food handlers and to maintain the product quality. Results of frying tests will also help to establish discard markers for used frying oils.

BATCH-SCALE BREAD-MAKING MACHINE

The performance of a cake or industrial margarine can be tested and quantified in bread or cake baking. The OFTEC bakery has a batch-scale bread-making machine (Model: Mendoza from Spain) suitable for making buns and sandwich loaves for this purpose (*Figure 4*). For performance testing, the bread dough is fed into the hopper of the bread machine and cut into portions of the desired size. The dough portions are then passed through a channel where they are formed into spherical pieces. Each of these spherical dough portion is then dropped into the rotating bag bucket where fermentation is initiated. Finally, the semi-proven dough passes through rollers where it is kneaded again followed by a second proving stage. The whole set of the batch-scale bread-making

Figure 4. The bread-making machine.

machine consists of the following equipment:

- dough mixer: this machine mixes ingredients such as flour, water, yeast and other minor ingredients into a dough;
- dough divider and kneader: the divider is able to apportion the dough according to the desired size, which can range from 30-650 g each;
- intermediate prover: this is where the dough portions enter the bag bucket to rest and to initiate the process of fermentation. It has a pre-proving time of 4 to 22 min; and
- roller and moulder: this machine rolls the partially proved dough into the desired forms prior to transferring them onto baking trays.

COLLOID MILL FOR PRODUCING EMULSION PRODUCTS

Emulsion food products such as mayonnaise, chocolate spread and sauces require efficient mixing and shearing of the ingredients into emulsions of the desired stability. A good emulsion should have a desirable taste and good stability. The facilities at OFTEC are able to produce these emulsion products. The colloid mill (*Figure* 5) has a capacity of 5 kg, and it consists of a vacuum mixer with a pedal-type agitator fixed to a homogenizer. During the preparation of the emulsion, various ingredients are mixed and homogenized under vacuum. The production sequence starts with emulsifying the liquid ingredients (such as oil and water) in the mixer under vacuum. This is followed by mixing the dry ingredients such as sugar, spices and salt into the emulsified liquid ingredients by opening a valve in the mixer leading to a hopper. The mixing and homogenizing actions increase the viscosity of the emulsion, which is dependent on the rate of homogenizing. The final products,mayonnaise or chocolate spreads, are viscous in texture but 'spoonable'.

LABORATORY-SCALE SPRAY-DRYING UNIT

A spray dryer is used for producing powdered products. When a liquid stream is fed in, the spray dryer will separate the solute or the suspension as a solid, and the solvent into a vapour. The solid is usually collected in a drum or a cyclone. The input liquid stream is sprayed through a nozzle as droplets into a hot vapour stream and vaporized. Solids are formed as the moisture quickly leaves the droplets. The nozzle can be set to make the droplets as small as possible, while the vacuum inside the spray dryer ensures efficient

Figure 5. Colloid mill unit.

heat transfer and vaporization. Droplets obtained can range from 20 µm to 180 µm, depending on the size of the nozzle.

The spray dryer has the ability to dry a wet product very quickly compared to other methods. It can convert a solution or slurry into a dried powder in a single step. Recent studies suggest that the spray-drying technique can be used as an alternative method for crystallizing amorphous powders.

OFTEC has a laboratory-scale spray dryer (Lab Plant, UK) capable of producing 100 g of powder per batch (*Figure 6*). This equipment is very useful for research and development in the formulation of coffee whitener, milk powder, ice cream mixes, imitation coconut milk (*santan*) and instant drink mixes. A number of companies have used the dryer for experimenting with products such as coffee creamer. It can also be used in the micro-encapsulation of various active ingredients.

LABORATORY-SCALE MACHINE FOR CHOCOLATE AND ITS PRODUCTS

There is a high demand for specialty fats, and extensive research in this area is still being conducted. The production of specialty fats for confectionery applications in Malaysia has increased from 25 984 t in 2006 to 26 968 t in 2007. Research is geared towards developing *trans*-free and low saturated fats. Currently, most of the specialty fats in the market are produced mainly from partially hydrogenated fats (lauric or non-lauric) that contain *trans* fatty acids and are high in saturated fatty acids. As consumers demand safe and healthy food, companies are looking for healthier alternatives that are *trans*-free and lower in saturated fats without compromising the organoleptic properties of the final products.

The laboratory-scale facility at OFTEC is capable of producing chocolate and chocolate products (*Figure 7*), as well as specialty fats from palm oil. It comprises a pre-mixer, a three-roll refiner, a 2-kg concher, a 2-kg chocolate tempering machine, accessories, moulds and cabinets for stabilizing and also for cool storage. This small-scale pilot facility is suitable for research and development, and for producing trial samples. It is important to note that three days' processing time is required for one batch (2 kg) of chocolate.

Besides research and development activities, OFTEC also provides services to industry in preparing and analysing new fats for chocolate formulations and in training.

Future areas of research in specialty fats are focused on healthy chocolate products, low saturates chocolate filling and truffle filling. Currently, research is conducted on non-hydrogenated coating fats and non-hydrogenated cream fillings and targeting them

Figure 6. Spray dryer.

Figure 7. Refining unit in the chocolate production.

for commercialization. Inquiries on the application of palm mid fraction (PMF) in confectionery and other food products have been received from industry.

LABORATORY-SCALE ICE CREAM MACHINE

The filled dairy products laboratory at OFTEC is capable of producing 40 litres ice cream mix per batchs. For this purpose, several unit operations in series are involved which require the use of a multi-purpose processing vessel, a double-stage homogenizer, a pasteurizer and a paddle-freezer unit. As ice cream is a delicate food containing milk solids and sugar, it is very susceptible to deterioration due to bacteria and environmental contamination. Thus, it is important to ensure that the equipment and containers used for the entire process are made of food-grade stainless steel (*Figure 8*), and good hygienic practices must be adopted during processing.

The set-up of the facilities is flexible; thus, it can be used in the research and development of filled dairy products such as ice creams, whipping creams and filled milk. Other products such as yoghurt, beverages and mayonnaise can also be produced with the same facilities. In our research activities, milk fat can be substituted with palm products such as palm oil, palm olein, palm stearin and palm kernel oil. The capacities of the equipment are suitable for R&D as well as for preparing trial samples.

REFINING PILOT PLANT

The purpose of refining of a vegetable oil is to ensure the removal of gums, waxes, phosphatides and free fatty acids to produce a light-coloured, bland and odourless quality oil fit for consumption. Refining is carried out either in batches or as a continuous operation, and can be either via a physical or chemical process.

OFTEC is equipped with a batch refining pilot plant with a capacity of 40-80 kg batch^{-1} (*Figure 9*). Since the 1980s, MPOB has assisted several companies in their R&D work on the refining process.

CHEMICAL INTERESTERIFICATION PILOT PLANT

Interesterification (IE) is one of the important processes currently utilized for modifying the physico-chemical characteristics of oils and fats. The purpose of the IE process is to change the melting profile and improve the compatibility amongst TAGs in the solid state. It can also improve the plasticity of the resulting solid by changing the crystallization behaviour and functionality of the oils and fats required for a finished product.

In chemical IE, sodium methoxide is commonly used as a catalyst. The process is typically carried out at temperatures between 100°C and 120°C. The reaction rate is relatively rapid and complete randomization is usually achieved in only 30-60 min. The properties of the chemically interesterified product are determined by the composition of the fat blends. No *trans* fatty acids are formed during chemical IE. Although the reaction time is short, the IE product has to be washed, bleached and deodorized before it can be used in food formulations.

Figure 8. Soft-serve ice cream machine.

Figure 9. Multi-purpose vessel for refining and interesterification.

OFTEC is also equipped with a 40-80 kg batch^{-1} chemical IE batch pilot plant. Since early 1980s, it has been used by MPOB and also many private companies for the extensive research and development efforts in chemical IE of blends of palm products with other vegetable oils.

ENZYMATIC INTERESTERIFICATION REACTORS

Enzymatic interesterification (EIE) is an excellent way for modifying the melting characteristics of edible oils and fats. EIE carried out in a column has been practised for more than 20 years. The high price of the enzyme has limited its usage in the market penetration of specialty products. The development of the granulation technology has resulted in a quantum leap in lipase immobilization technology. This granulated lipase developed by Novozymes enables these enzymes to be used for production enzymatically interesterified fats used in the production of margarines, shortenings and vanaspati.

EIE is carried out at relatively a low temperature of approximately 60°C. The reaction rate is slow and, thus, reaction time is long (18-24 hr or even longer). IE catalyzed by lipase can be very specific, *e.g.*, it can be positional or fatty acid-specific, depending on the type of lipase used. For example, with a 1,3-specific lipase, only the fatty acids at the 1,3-positions are shifted around, while the fatty acid at the 2-position of the TAG molecule is left untouched. Thus, with this technology it is possible to produce structured TAGs with the desired fatty acids remaining at the 2-position.

OFTEC has several batch EIE reactors of different capacities. They can be used for performing several cycles of reaction daily, depending on the reaction time (*Figure 9*). Extensive research on EIE of palm products using different kinds of lipases have been carried out with these facilities by MPOB's researchers as well as those from private companies.

CONCLUSION

The extensive pilot-scale production facilities at OFTEC, coupled with the availability of the necessary expertise and skills, will provide the much needed support to industry in their R&D efforts, and they are most welcomed to make full use of these facilities.

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