# Palm-based *Trans*-free Roll-in Margarine

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## INTRODUCTION

Fats used for formulating shortening and margarine require a certain amount of solids. These solids are mainly obtained by the catalytic hydrogenation of liquid oils. However, hydrogenated fats are undesirable in food formulations as they contain *trans* fatty acids. *Trans* fatty acids (TFA) were reported to be a cholesterol-elevating agent, raising the low density lipoprotein (bad cholesterol) and lowering the high density lipoproteins (good cholesterol) in humans (Mensick and Katan, 1990; Judd *et al*., 1994). Epidemiological studies have suggested a link between the consumption of TFA and coronary heart disease risk (Hennekens and Willett, 1997). Palm-based oils and fats are considered to be a potential replacement for hydrogenated fats as they have natural solid components easily obtained by fractionation, and they do not contain TFA (Berger and Idris, 2005; List and King, 2006).

Fats are used in food preparations to provide structure, flavour and nutritive value. The structural and crystalline properties of fats determine their functionality in food; hence, fats with certain desirable properties are required by the manufacturers to produce specific products such as short pastry, cake and puffed flaky pastry. This article focuses on fats used in puffed flaky pastry dough lamination. Dough laminated with roll-in fats has the ability to rise up to eight times its original thickness when baked, forming a flaky structure. This rising is enabled by the unique and intricate lamination of alternate layers of dough and roll-in fats.

Lamination is a method applied in bakery products to obtain a layered structure during the baking process. Wheat flour and water are conditioned in order to develop the flour protein to provide a certain degree of elasticity in the dough for lamination. The lamination of dough is done by sandwiching a layer of fat between two layers of dough, which is subsequently evenly rolled out into a thin sheet of 3 mm to 4 mm and folded. The sheeting and folding are repeated till the required number of layers is achieved. During the baking process, the water in the dough turns into steam, which forces the dough to expand due to the pressure developed between each impervious layer of the laminating fat. The expansion induced by steam causes the dough to puff-up. The puffed-up dough forms the flaky and crispy structure in the post-baking phase. The ability to form a thin, even and continuous layer between the layers of dough is the most crucial factor that determines the performance of the laminating media. This unique ability of the laminating media is known as the plasticity of the product (Cochran and Baeuerlen, 1981; Kazier and Dyer, 1995).

Crystal form and product consistency have a profound influence on the performance of the fat in foods. The blend for roll-in fat must have a firm and plastic texture, as it is required to stretch and to sheet out into a very thin and continuous layer. The roll-in fat must not soften when mechanical stress is applied during the sheeting. The softening may cause the fat layer to leak out and discontinue the fat layer. If the fat used is hard and not flexible, the brittleness of its texture may cause it to penetrate into the dough during the lamination process (Wayne, 2001; Podmore, 2002). Laminating fat is used for preparing a wide variety of products such as Danish pastry, croissant, fruit tarts, Napoleon, strudels, pinwheels, pretzels, palmiers and papilonsas (William, 1983) as shown in *Figure 1*.

Laminating fats or roll-in fats can either be shortenings or margarines. The roll-in fats are commercially produced from blends of hydrogenated fats. Hydrogenated

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*Figure 1. Pastries made from roll-in margarine or shortening.*

fats are the manufacturer's preferred choice as they exhibit fast crystallization rates to form a firm and plastic texture in the resting tube as soon as the blends are subjected to a super chilling process. To the roll-in fats manufacturer, a fast crystallization rate also translates to a higher production capacity. However, the challenge faced by the manufacturer is the restriction on the usage of hydrogenated fats which contain TFA. Palm oil, with its naturally occurring solid portion, has a great potential for replacing hydrogenated fats in the production of roll-in fats.

## MATERIALS AND METHODS

### Materials

Commercial roll-in margarine was obtained from the European market for analysis. Palm-based oils and fats were evaluated to formulate suitable blends that match the commercial roll-in fat sample. The oils and fats evaluated were RBD palm oil, RBD palm stearin (iodine value ranging from 44 to 14), RBD palm olein (iodine value ranging from 56 to 62), palm kernel oil, palm kernel stearin, palm kernel olein and interesterified fats (palm oil and palm kernel). Non-palm based-oils such as soyabean oil, sunflower oil and canola oil were also considered. In the margarine blend, the following additives were used: distilled monoglycerides, standard grade soya lecithin and vacuum-dried salt. (All products were obtained from local trading houses).

### Preparation of Blend

A margarine emulsion of 82% oil phase, 16% water, 0.3% distilled monoglyceride (DMG), 0.2% of soya lecithin and 2.5% salt was prepared. A 60-kg batch of margarine was prepared in the blending tank. The temperature of the oil blend was set at 65°C. The DMG and lecithin were dissolved into the blended oil at a ratio of 1:4, and added into the blending tank. The salt was dissolved in the water phase and gradually incorporated into the oil phase.

### Processing Method

The roll-in margarine was produced in a perfector pilot plant from Gerstenberg and Agger, Denmark at MPOB. The emulsion was processed through three chilling tubes and a resting tube as recommended by the manufacturer. The product demanded high cooling rates to ensure complete crystallization of the blend in the chilling tubes. Three chilling tubes were used to ensure sufficient chilling of the blend to produce block formation in the resting tube. The usual practice in margarine and shortening is to use two chilling tubes. An additional chilling tube was introduced to the processing unit to manage the heat release of the blends, and to facilitate the formation of a firm and plastic structure in the resting tube. The working unit was not used in this study (Pernille, 2006). The final input temperature into the resting tube was set at 25°C below the slip melting point of the reformulated blend. The process set-up and flow chart are shown in *Figures 2* and *3*, respectively. The products were tempered at 20°C for four days.

### Methods of Analysis

***Solid fat content.*** The solid fat content (SFC) profile was measured by a Bruker Minispec Pulse Nuclear Magnetic Resonance (pNMR) spectrometer (Karsruhe, Germany). The analysis was carried out according to the MPOB test method p. 4.8: 2004. The parallel method of measurement was used. The samples in the pNMR tubes were melted at 70°C for 30 min, followed by chilling at 0°C for 90 min, and then held at each measuring temperature for 30 min prior to measurement. SFC was

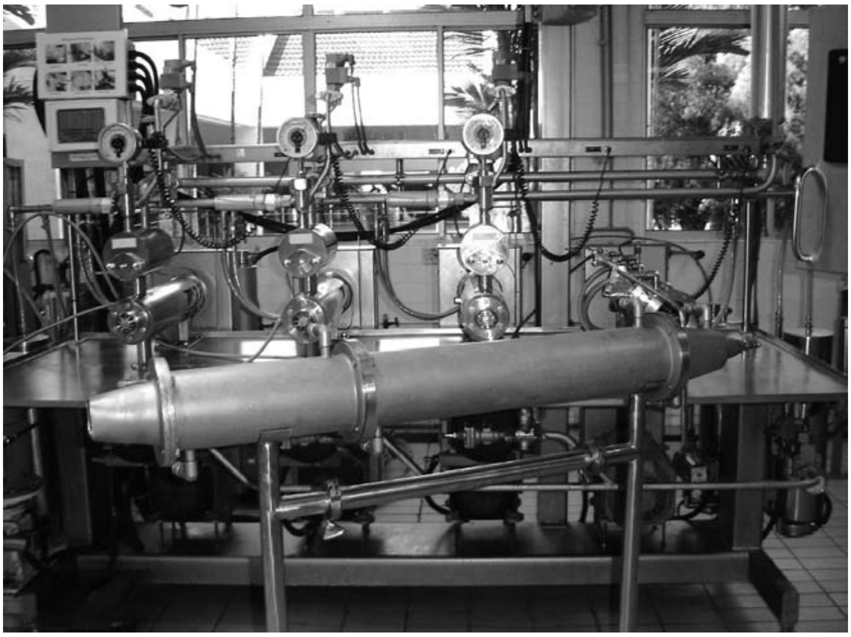

*Figure 2. Pilot plant set-up for the trial runs on palm-based roll-in margarine.*

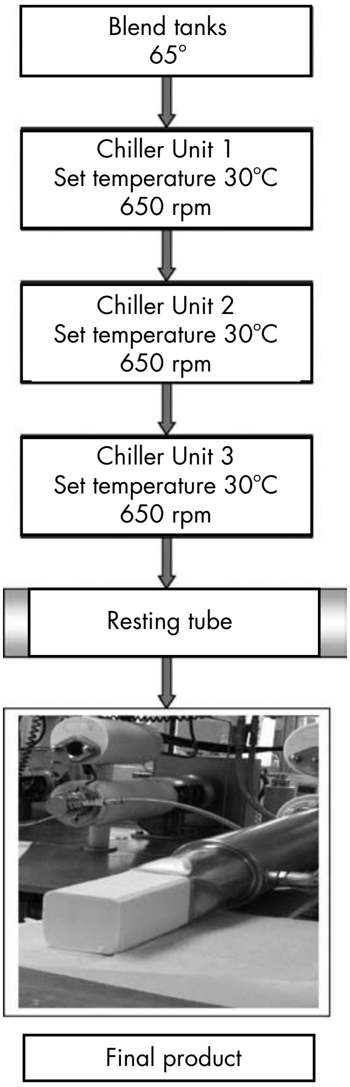


*Figure 3. Flow chart of the processing conditions for the production of palm-based roll-in margarine.*

measured in the temperature range of 5°C to 45°C at 5°C intervals (MPOB, 2005).

***Slip melting point.*** The slip melting point (SMP) analysis was carried out in accordance with the MPOB test method p. 4.2: 2004. It was carried out by dipping three open-ended capillary tubes (with internal diameters of 1.1-1.3 mm and external diameters 1.4-1.7 mm) in a filtered liquid oil, so that a column of fat of 10 mm rose into each tube. The tubes were then chilled immediately against ice, placed in a test tube and tempered in a 10°C water bath for 16 hr. After tempering, each tube was tied against a mercury thermometer, dipped in cold distilled water and the temperature of the water was raised at 1°C $min^{-1}$ until the fat column in the capillary began to rise. The temperature at the point of rising is reported as the SMP (MPOB, 2005).

***Texture analysis.*** In texture analysis, the block of roll-in margarine was first kept at 25°C for 24 hr. The plasticity of the margarine was then determined by using a TA-XT2 Model texture analyser (Stable Micro System USA) as shown in *Figure 4*. The mode of operation was through measuring the force in compression with the option of start to return. A 5-mm cylinder (P/5) with a 5-kg load cell was used. A 5-g surface trigger was attached to the probe. During the test, the probe was released to penetrate the sample to a depth of 12 mm.

*Figure 4. TA-XT2 model texture analyser (Stable Micro System USA).*

## RESULTS AND DISCUSSION

### Oil Blends

Roll-in margarine is usually produced from fully or partially hydrogenated fats, as this product requires a high SFC at a working temperature of between 20°C and 25°C. Partial hydrogenated fats may contain up to 60% total TFA (Gerrit, 2005). The challenge faced in reformulating the roll-in margarine is to obtain a blend formulation with sufficient levels of solids that is free of TFA. The SFC profiles of three commercial roll-in margarine products that were derived from hydrogenated fats are given in *Figure 5*, which shows that the SFC ranged from 30% to 50% at a working temperature between 20°C and 25°C. This is the typical temperature at which roll-in fats are sandwiched between the dough and when the lamination process is carried out in bakery units. The high percentage of solids at this crucial temperature is necessary to withstand the extensive stretching process which the roll-in fats will undergo during the sheeting and folding of the dough to form layers. The roll-in fat should neither soften nor oil out during the sheeting and folding stage, and should also able to provide an even, consistent and continuous film of fat within the dough. The other temperature of interest is 35°C, as at this temperature, the solid content decreases to 15%-22%. This steep drop in SFC helps to minimize the waxy or greasy mouth-feel of the final products. The SMP of the commercial products are shown in *Table 1*.

Possible palm products that can replace hydrogenation fats are given in *Table 2*. This selection of the oils and fats was based on three crucial functions played by the oils and fats in the structure formation of roll-in margarine. The palm-based *trans*-free roll-in margarine, *MPOB PPM 1*, was formulated taking into consideration all of these three basic requirements, namely, high melting fraction, medium melting fraction and low melting fraction. High melting fats, such as premium palm stearin with high melting triaclyglycerols (TAGs), especially tripalmitoylycerol (PPP, as high as 60%), can act as the backbone structure that contributes to the firmness of the product during the lamination process (Siew, 2002). The recommended usage ranges from 15% to 25%. On the other hand, the medium melting point fats, such as palm oil, palm stearin (iodine value above 35), palm kernel stearin and interesterified fats (palm oil and palm kernel), can facilitate the formation of a firm and plastic structure in the resting tube immediately after the blend leaves the super chilling process. The recommended percentage is 30% to 50%. Finally, liquid oils, when used at a recommended range of 25% to 40%, can lower the high SFC profile that is contributed by the high and medium melting TAGs. The addition of liquid oils will not cause an oil out problem in the final products. When the liquid oils are supercooled and crystallized, they are trapped within the crystal network (Juriaanse and Heert,1988; Firouz *et al.,* 2002).

*MPOB PPM1* was formulated based on the three categories of fats and oils as discussed earlier. The palm-based fractions were carefully selected to yield the desirable composition suitable for formulating the roll-in margarine and also having SMP comparable to the commercial products (*Table 2*). The fractions were combined with soyabean oil to obtain the required SFC. The blend was able to deliver a natural and *trans*-free formulation. The usage of these fractions also reduced the product cost, as no hydrogenation of the fats was needed, which otherwise would incur additional expenses. *MPOB PPM 1* was able to match the solid fat profile of the commercial sample from Europe as shown in *Figure 5*.

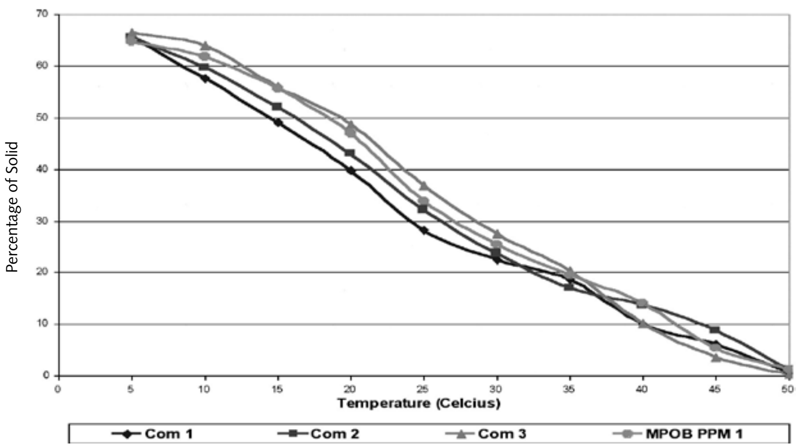


*Figure 5. Solid fat contents of commercial and* MPOB PPM 1 *roll-in margarines.*

**Texture Analysis**

The texture of roll-in fat is similar to that displayed by clay (play dough), which has the unique ability to be formed and reformed according to the stress or force applied. This flexibility in texture enables the roll-in fats to facilitate the formation of even, consistent and continuous layers of fats during the sheeting and lamination process. This special ability of the roll-in fats depends very much on the oil blends and the processing condition. *MPOB PPM1* was passed through three chilling units to facilitate rapid cooling of the blend to form it into a firm and plastic block in the resting tube. The product was tempered and the texture was analysed.

*Figure 6* shows the graph obtained from the texture analyser for *MPOB PPM 1* roll-in margarine stored at 25°C. Based on the graph,

**TABLE 1. SLIP MELTING POINTS OF COMMERCIAL AND *MPOB PPM 1* ROLL-IN MARGARINES**

| Roll in margarine | Slip melting point (°C) |
|---|---|
| Com 1 | 45 |
| Com 2 | 43 |
| Com 3 | 42 |
| *MPOB PPM 1* | 43 |

**TABLE 2. SELECTION CRITERIA OF OILS AND FATS SUITABLE FOR THE PRODUCTION OF ROLL-IN MARGARINE**

| | High melting point fraction | Medium melting point fraction | Moderator or modifier |
|---|---|---|---|
| Function | Promotes fast crystallization at temperatures below 30°C. Acts as the backbone structure at temperatures above 30°C. | Promotes block formation at temperatures below 30°C. Should melt down at temperatures above 35°C to avoid greasy or waxy aftertaste. | Used for obtaining the desirable solid fat content profile to suit user requirements. |
| Suitable palm products | Premium palm stearin (IV below 20). | Palm oil, palm stearin (IV above 35), palm kernel stearin interesterified fats (palm oil- and palm kernel oil-based). | Palm olein (IV 56 to 62), palm kernel oil, palm kernel olein, soyabean oil, sunflower oil, canola oil. |
| Suitable level in blend | 15% to 25% | 30% to 50% | 25% to 40% |

the release reading was calculated to be 1556 g with smooth penetration, a broad band and single-stage release pattern. The graph pattern denotes flexibility of the roll-in margarine. A similar penetration pattern was obtained from commercial product as shown in *Figure 7*. The flexibility is crucial in ensuring the performance of the roll-in fats in forming evenly layered and continuous films of fat. The ability to form a consistent film of fat will ensure even puffing-up of the pastry during baking. Firm but hard and brittle roll-in fats will not be suitable as they are not flexible enough to facilitate the sheeting process, but will resist sheeting by either lumping up or puncturing the dough. In the case of soft fats, they will not be able to withstand the stress of sheeting. These fats form patches or slip out from the dough during sheeting. Hence, *MPOB PPM 1*, the specially formulated fat, is suitable as a roll-in fat as it displays a flexible clay-like texture.

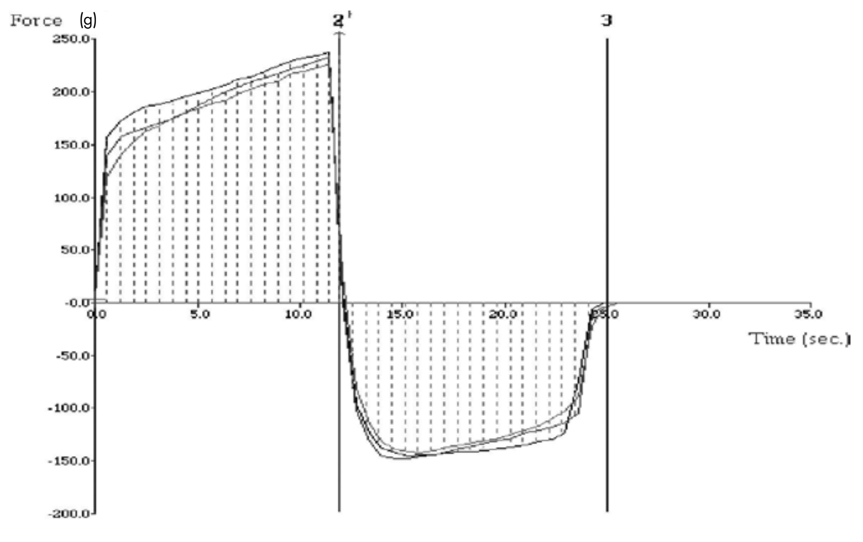


*Figure 6. Texture analysis graph of palm-based* trans-*free roll-in margarine* (MPOB PPM 1*) stored at 25°C.*

## CONCLUSION

The selection of the oils and fats is crucial as the balance between the high melting fats, medium

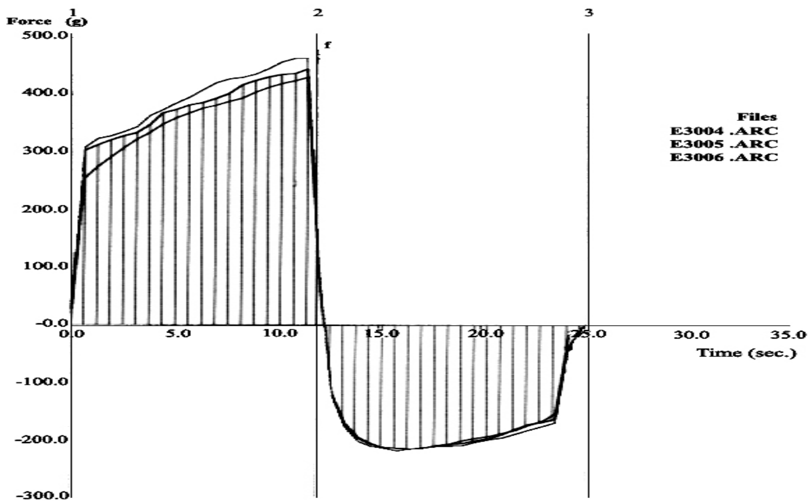


*Figure 7. Texture analysis graph of commercial roll-in fats stored at 25°C.*

melting fats and liquid oil is critical in order to form a firm and clay-like texture during processing. Processing conditions were enhanced with three chilling tubes to facilitate the formation of these blocks. *MPOB PPM 1*, formulated with palm-based fractions, was able to match the function and application of commercial roll-in margarine products (that contain hydrogenated fats) in terms of texture flexibility. Hence, palm-based fractions are excellent replacements for hydrogenated fats in the formulation of roll-in margarine.

**ACKNOWLEDGEMENT**

The authors thank the Director-General of MPOB, for permission to publish this article. The technical assistance provided by Radzuan Hussin, Zakaria Md Yusof, Nasoikhieddinah Md Purdi, Abd Aziz Abd Rahman, Che Maimon Che Ha, Hanirah Hassan, Jamaliah Hassan, Ramlah Ahmad, Suid Abd Aziz, Ahmad Hisham Md Zahari, Rosli Nordin and Mohd Adrina Malek is very much appreciated.

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