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Palm Stearin as Low Trans Hard Stock for Margarine
(Stearin Sawit Sebagai Stok Keras Marjerin Rendah Trans)

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ABSTRACT

Formulation models of brick margarine prepared from the interesterified of a fully hydrogenated palm stearin (POS) and palm kernel oil (PKO), POS of low iodine values and sunflower oil (SFO) were characterised, physically and chemically. Formulations with low trans fatty acid content were used in the margarine preparation and the products were evaluated for 25 days at storage temperatures of 5,10 and 15°C. The study had shown that formulations of POS in the form of simple blend with PKO and SFO (sample 900), blend of interesterified fully hydrogenated POS with PKO and SFO (sample 905) and simple blend of fully hydrogenated POS with PKO and SFO (sample 904) could achieve similar fatty acid composition, but not SFC profile. The results showed that POS was not only a suitable hard stock in trans-free brick margarine formulations but provided functional property in product texture. The formulations, with saturated fatty acid content <36% and <1% trans fatty acid had produced brick margarine with the desired spreadability at refrigerator temperature (5-15°C).

Keywords: Hyrdrgenated palm stearin; palm oil kernel

ABSTRAK

Model formulasi untuk marjerin berbentuk bata telah disediakan daripada stearin sawit (POS) yang telah dihidrogenankan sepenuhnya dan dinteresterifikasikan dengan minyak isirong sawit (PKO), POS yang rendah nilai iodinnya (IV) dan minyak bunga matahari (SFO). Minyak dan lemak ini telah perincikan daripada segi sifat kimia dan fizikalnya. Formulasi yang rendah asid lemak transnya telah digunakan dalam penyediaan dan pembuatan marjerin ini dan hasilnya telah dinilai selama 25 hari pada suhu penyimpanan 5, 10 dan 15°C. Kajian telah menunjukkan bahawa formulasi adunan mudah POS dengan PKO dan SFO (sampel 900), adunan POS terhidrogenat sepenuhnya dan PKO yang diinterestrifikasi dan SFO (sampel 905) dan adunan mudah POS terhidrogenat sepenuhnya dengan PKO dan SFO (sampel 904) boleh menghasilkan masing-masing komposisi asid lemak (FAC) yang serupa, tetapi tidak serupa daripada segi profil kandungan lemak pepejal (SFC). Keputusan ujian produk menunjukkan bahawa POS bukan sahaja sesuai sebagai asas minyak keras dalam formulasi marjerin berbentuk bata yang bebas trans, tetapi boleh menghasilkan sifat kefungsian yang diperlukan untuk tekstur marjerin yang baik. Formulasi yang mengandungi jumlah asid lemak tepu <36% dan <1% asid lemak trans telah berjaya digunakan dalam penghasilan marjerin bentuk bata yang mempunyai keupayaan sapuan yang baik pada suhu peti sejuk (5-15°C).

Kata kunci: Minyak isi rong sawit; stearin sawit dihidrogenankan

INTRODUCTION

Palm oil products and their fractions have become important raw materials in food products as such or after modifications. The fatty acid and triacylglycerol (TAG) composition of palm oil is unique. It could be physically modified by fractionation while hydrogenation and interesterification will modify its chemical characteristics.

Margarine is food product in plastic or liquid form (Haighton 1976). It is a water-in-fat emulsion in which water droplets are kept separated by the fat crystal (Haighton 1976). Weiss (1983) had categorised margarine with regard to demand by different consumers, based on hardness and melting point. Hard and medium plastic is for bakery margarine and medium plastic and soft is for table margarine. Table margarine is divided into the distinct categories of tub and brick margarine (Weiss 1983). Tub margarine has fairly low solids at low temperature, thus enabling it to be spreadable direct from the refrigerator (deMan et al. 1989). In addition the fat blends should be completely melted below 37°C for good oral melt down. Brick margarine should have the properties similar to tub margarine, but with SFC of 28% at 15°C to facilitate wrapping and between 12-15% at 20°C to avoid oil out. To meet the melting profile of this margarine, hydrogenated oil is the common oil used in the formulation. Thus, such margarine becomes the main contributor of *trans* fatty acid in food.

To address the current demand for zero *trans* fatty acids in food formulations and further for no hydrogenated oil, and to some extend an all palm oil formulation, careful study need to be conducted. The challenges for the oils and fats producers are mainly on reduction of production capacities. This is mainly due to the slow crystallisation properties of palm oil (Duns 1985; Chong 2001), that leads to chains of quality problems such as post crystallisation in soft margarines, softening of product in puff pastry margarine and shortening, no good lift in pastry products, collapsed creaming and inferior cake volume. However, hydrogenation and having *trans* fatty acid in the fat formulation lead to good quality and desired product such as beta prime margarine (Yap et al. 1989), rapid crystallization (Moziar et al. 1989) and stable consistency (deMan et al. 1989).

The aim of the study was to determine suitability of palm stearin in the formulations of *trans*-free, in brick margarine low in saturated fat and spreadable at refrigerator temperature (5-10°C).

Materials and Methods

Material: Commercial table margarine samples (brick type). Fully hydrogenated palm stearin (POS) of iodine value equal to zero (IV 0) was purchased from Premium vegetable oil, Johor, POS with IV 14 was purchased from IOI, Johor, sunflower oil and palm kernel oil from Mewah Oleo, Selangor. Other ingredients were emulsifier (distilled monoglycerides 90% monoester, SMP 69°C from Danisco Ingredients (M) Sdn. Bhd. Prai Industrial Estate, Penang, Malaysia), water (filtered municipal supply) and vacuum-dried salt.

Margarine preparation; 80% fat phase, 0.3% emulsifier, 16% water and 2.0% salt was used in the margarine preparation. Oils and fats were melted in a Memmert drying oven (854 UL 80, Schwabach, Germany) at 65°C then weighed accordingly for 50-kg production batches. The emulsifier was added to the fat phase at a ratio of 1: 4. The water phase at room temperature (28°C) was then added slowly to the oil phase with agitation to form a good emulsion. The emulsion temperature was maintained at 55°C and held for 10 min in the mixing tank prior to processing in a perfector pilot plant (Gerstenberg and Agger, Copenhagen, Denmark) at the Malaysian Palm Oil Board (MPOB). The tube cooler (A-unit) has a volume of 900 mL and scraped cooling surface of 0.063 m^2 area. Three tube coolers were set at different temperatures suitable to the end product consistency, based on individual formulation. The pin worker (B-unit) had a volume of 3 L was set before the third A unit. The emulsion was pumped into the A-unit (at throughput rate of 45 kg/hr) where it was rapidly cooled. The scraper was rotated at 1000 RPM, whereas pin worker stirrer speed was 275 RPM. The margarine was allowed to form into brick shaped margarine in a 3L resting tube before it was collected at the end of the processing line after the pin worker and stored at 5, 10 and 15°C for evaluation.

Chemical and physical analysis: Fatty acid composition (FAC), slip melting point (SMP) and solid fat content (SFC) were determined according to MPOB Test Methods (2005).

Quality assessment: The samples for analysis were placed in 5, 10 and 15°C incubators for 25 days. The consistency was determined by the penetration (Haighton 1965, deMan et al. 1989) using a cone penetrometer (Stanhope-Seta, Surrey, England) with 40° cone, of weight 79.03g with penetration time of 5 sec. The calculation was according to Haighton (1965), $KW/P^{1.6}$, Where K=5840, W=79.03+ added weight, and P is the mean of penetration readings. Six readings were taken from each sample every day, with different sub-samples. Microscopic examination for crystal distribution was measured as described by Miskandar et al. (2004).

Results and Discussion

Hydrogenation had been long known process of tailor-making the soft oils and fats meeting the desired properties of various types of margarines. However, the adverse health effect due to *trans* fatty acid developed during partial hydrogenation has driven off food formulators from using these oils and fats. Alternatively, the combination of arts and science in formulation activities had resulted in suitable margarine profile without hydrogenation. SFC profile is one of the physical properties important in margarine formulation (Goli et al. 2009). It provides the physical data that reflects the overall feature of the product and is important for processing.

CHARACTERISATION OF VARIOUS MARGARINES IN RELATION TO POS

In formulation work involving direct blending, the melting profile of the final blend, which is shown by the shape of the curve of SFC to the function of temperature, will determine the overall performance of the margarine such as packaging, storage and eating quality (Miskandar et al. 2005). Thus, the individual melting properties of selected oils and fats will contribute significantly to the behaviour of the final blend. Figure 1 shows that SFO, which is liquid at 5°C, has flat SFC profile even at its initial temperature, at 5°C. The SFC of POO sharply declines from its initial SFC of 52% at 5°C to 0% at 22°C. PKO has an almost flat SFC at 5°C to 15°C (75-65%) and sharply declining to 0% at 33°C, indicating that PKO is able to effectively modify the SFC profile of blend of few oils and fats. Such an SFCprofile could be achieved easily by partially hydrogenating soft oil.

The SFC profile of POS with various IVs shows that each IV produces SFC profile of distinct properties. Figure 1 shows that POS with IV 40 has the lowest range of SFC profile, POS with IV 30 being distinctly positioned between IV 40 and 20. POS of IV20 produced flat shaped SFC profile at 5-20°C, while generally the other two fats produced flat shaped SFC profile at 35°C-45°C. Since margarine will experience wide ranges of temperature fluctuations as it leaves the factory, such as temperature differences in the warehouse, transport chains, dealer and retail's storehouse and household, such a shape of POS with IV 20 is beneficial as it assists in stabilising the product during the temperature fluctuations (Miskandar et al. 2005). When PKO is added

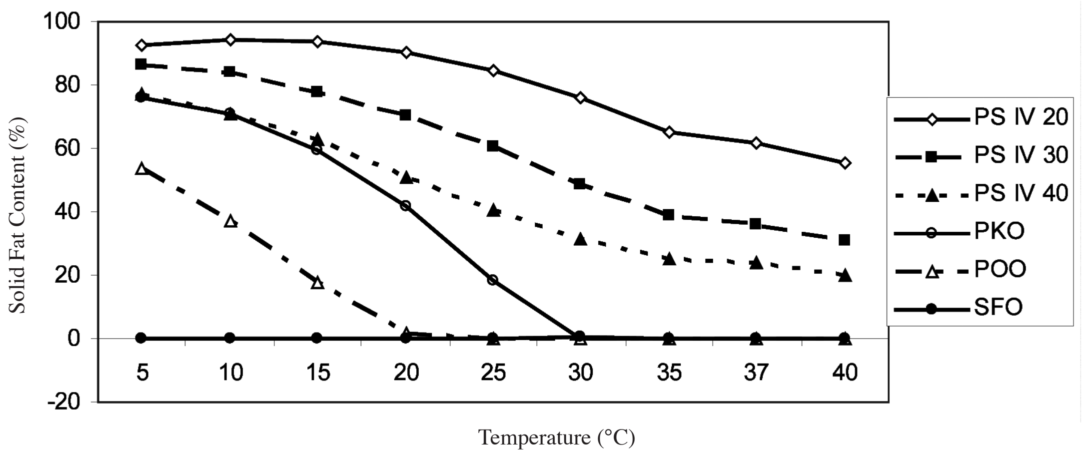


FIGURE 1. Solid fat content (SFC) profile of palm stearin of various iodine values for hard stock, where PS= palm stearin, PKO=palm kernel oil, POO=palm olein, SFO=sunflower oil, SFC=solid fat content and IV=iodine value

to the POS IV20, the high SFC profile at 30-40°C will be tremendously reduced while maintaining the profile at <30°C.

Figure 2 shows the SFC profiles of selected margarines in comparison to PO and POS of IV 30. The soft margarine evaluated showed that the SFC was low (25-30%) at 5°C indicating that the product would be suitable for temperate country and require refrigerated condition (Haighton 1976). The low SFC ensures that hardening would not occur at low storage temperature. The brick type margarine evaluated had higher SFC range of 47-60% at 5°C, 38-50% at 10°C and 19-26% at 20°C. Such a profile ensures that the product is spreadable at refrigeration temperature with no significant softening at 20°C (Haighton 1976). SFCs of shelf stable and pastry margarines are not critical at 5°C and 10°C. As shown in Figure 2, the sample contained high SFC (>50% SFC) at 5-15°C as the margarines are normally kept and handled at room temperature of above 28°C. However, shelf stable margarine had 20-25% SFC at 20°C and a complete melt at 37°C for ease of spreading and working at room temperature and melt cleanly on consuming it. Pastry margarine sample had flatter SFC profile at temperature range of 20-40°C with 65-70% and 30-40% SFCs, respectively. According to Faur (1996), such a profile is desired as it will provide the long plasticity range to the margarine and the ability of the margarine to be worked by folding and rolling the dough and finally the formation of flaky end product texture.

PERFORMANCE OF EXPERIMENTAL MARGARINES

In our brick margarine formulation, as shown in Figure 2, optimum amount of POS was used as hard stock that provided sufficient solid at 5-30°C and that the product had formed the brick shape at the least time during the production and maximum amount of solid at >30°C to 40°C that melted readily in mouth, but did not soften at serving time. Since the melting behaviour of the formulated fat, as indicated by the shape of SFC profile, was produced by the least amount of POS and PKO, adding liquid oil, SFO, had served as the filler to meet the final requirement of the product. As more liquid oil was added to the blend, the SFC

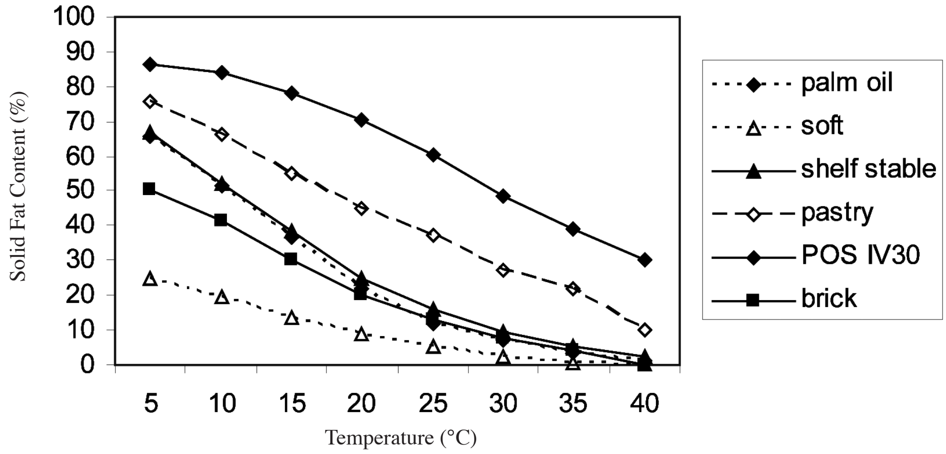


FIGURE 2. Solid fat content (SFC) profiles of selected types of margarines in comparison to palm oil and palm stearin of iodine value 30, where soft, shelf stable, pastry and brick are the selected types of margarine

was further reduced (Goli 2009). Optimum amount of POS was able to maintain the desired shape of the SFC profile and producing formulation with lower saturated fats and *trans* free as shown in Table 1.That was an improvement from the commercial sample (com) that contained 6.3% *trans* fatty acid (maximum *trans* fat allowed in Denmark is 2%) and total saturated fats acid < 40%.

POS as Hard Stock Sample 900 was formulated by direct blending of low IV POS (IV<20) with PKO and SFO. It was formulated to contain total saturated fatty acid < 36% and with low SFC at 5°C to avoid hardening at storage temperature (5-10°C). The SFC range of 47-60% (5°C), 38-50% (10°C) and 19-26% (20°C) produced brick margarine that was spreadable with no significant softening at the desirable yield value of < 800 g/cm^2 at 5°C. Figures 3-5 show that POS IV< 20 directly blended with PKO and SFO had reached its equilibrium during storage on the second week of storage with no significant post-hardening. Consistency of the margarine at 5, 10 and 15°C for a storage period of 30 days showed that the product had experienced hardening phenomenon on the first week of storage, very similar to other margarines (Faur 1996; Miskandar et al. 2002). Thus, POS IV < 20 had excellently served as hard stock in direct blended of brick margarine formulation, low in saturated fatty acid.

Fully Hydrogenated POS as Hard Stock Sample 904 consisted of a direct blend of fully hydrogenated POS (IV=0) with PKO and SFO. Sample 904 had good consistency profile during the storage at 5, 10 and 15°C for 30 days (Figures 3-5). Following the normal hardening at the second week of storage, the product stabilized promptly and maintained its consistency for the rest of the storage period. Although, the average consistency at all storage temperatures was higher than sample 900, sample 904 had produced smoother curve at 5 and 10°C as shown in Figures 3 and 4. Smooth yield value curve during storage indicate that the margarine did not experience significant post-crystallization that led to serious crystal agglomeration, softening and oiling-out (Goli 2009). The results indicated that the hydrogenated POS had better performance in minimizing post-crystallization than a normal POS. However, the performance of hydrogenated POS at 15°C was not significantly different than the other POS for hard stock of low saturates brick margarine.

Interesterified POS and PKO as Hard Stock Sample 905 contained palm-based hard stock from an interesterified product of fully hydrogenated POS and PKO blended with SFO. Storage study at 5, 10 and 15°C for 30 days showed that the consistencies of sample 905 had reached its equilibrium as early as the first week of storage (Figures 3-5). The

TABLE 1. Fatty acid composition of brick margarine samples

Sample code	C8:0	10:0	12:0	14:0	16:0	18:0	18:1t	18:1c	18:1i	18:2 ct	18:2cc	18:3	20:00
Com	0.1	0.1	0.6	1	33	5.7	5.8	32.6	1.9	0.5	16.4	1.9	0.4
900	1.5	1.2	15.6	5	8.3	3.1	nd	22.7	nd	nd	41.8	0.5	0.3
904	0.9	0.8	9.8	3.4	13.5	7.4	nd	19.3	nd	nd	44	0.6	0.3
905	1	0.8	9.9	3.3	13	7.2	nd	19.5	nd	nd	44.4	0.6	0.3

Key: nd= non detectable

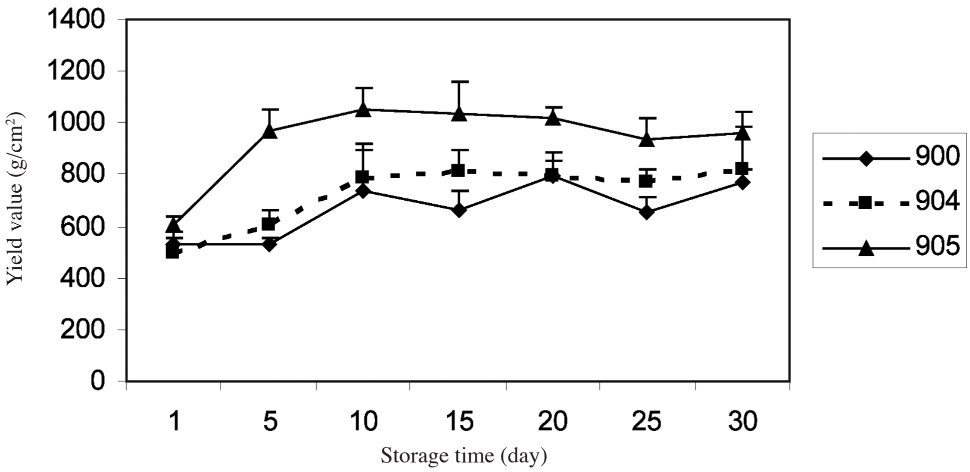


FIGURE 3. Yield values of table margarines 900 (direct blend), 904 (fully hydrogenated) and 905 (interesterified) at 5°C

products were stable with no significant (P>0.05) changes in texture and appearance at these temperatures indicating that interesterified blend had produced homogeneous crystal with no significant post-crystallization during storage. Sample 905 was the most stable product at 5°C as compared to other formulations, indicating that transformation of crystal type and crystal development in an interesterified hard stock was minimized at 5-15°C.

To support the consistency results above, microscopic examination on crystal and water droplets development in all samples during storage at all temperatures had shown that they were insignificant. Crystals and water droplets were homogeneously distributed at sizes <2μm, as shown in Figure 6. This could be due to the efficient crystallization process during the production of these margarine samples that had created good crystal matrices. Crystal matrices could minimise the movements of crystals. This created the condition of stillness that caused the slow growth of crystals. In most cases such a condition could create hardening to margarine. However, since the formulations contained optimum amount of solid from the selected oils and fats used, crystals seemed not to form strong packing that could create serious hardening.

The results indicated that POS had acted as the backbone of the margarine and the total saturated fatty acid contributed by POS was optimized. POS had provided the required solids at 20-30°C, thus prevented rapid softening of the product at serving time. The sharp melting properties of PKO as demonstrated by its SFC profile influenced in the melting in the mouth properties of the product. PKO, due to its rapid crystallizing properties, assisted in processing by increasing the rate of crystallization especially during brick shape formation and to facilitate the wrapping process. SFO is liquid in nature and had contributed to the softness of the product. The amount was optimized as to avoid oiliness or deformation of the product at serving time. The study had also showed the suitability of processing condition arrangements (AABA with short resting tube (3Litre size)) to produce good brick margarine for bread spread with total saturated fatty acid content <36%.

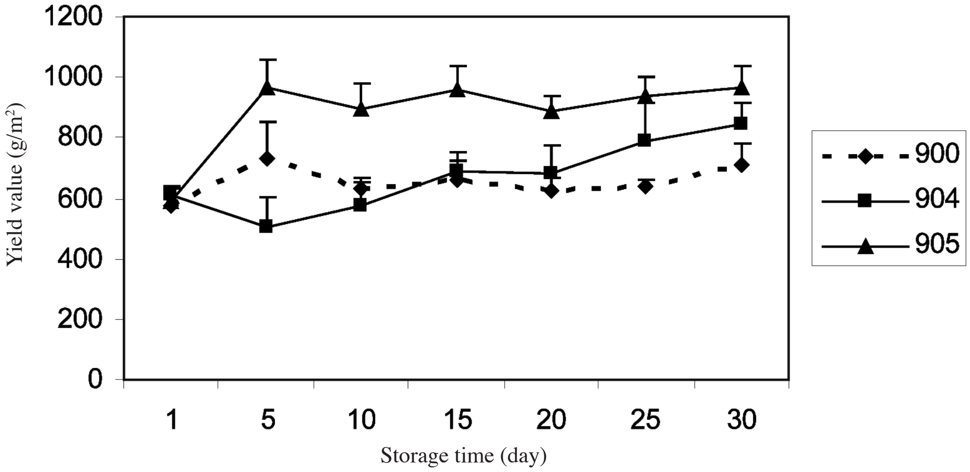


FIGURE 4. Yield values of table margarines 900 (direct blend), 904 (fully hydrogenated) and 905 (interesterified) at 10°C

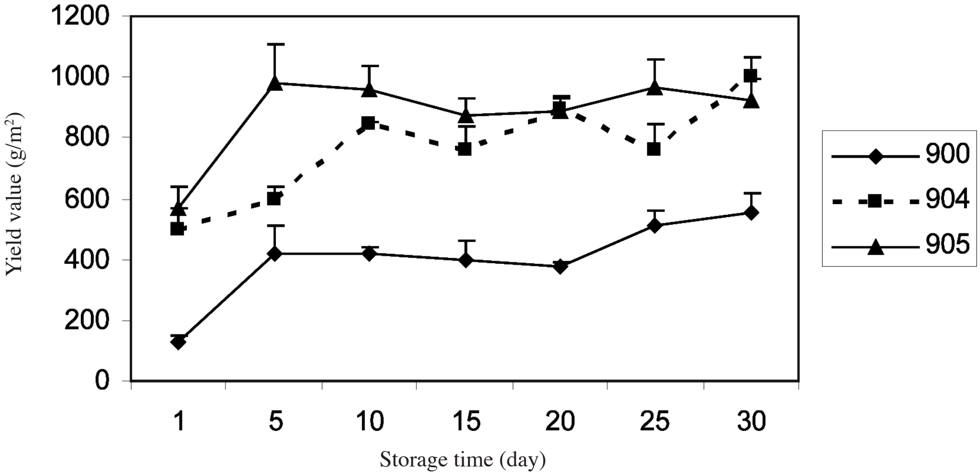
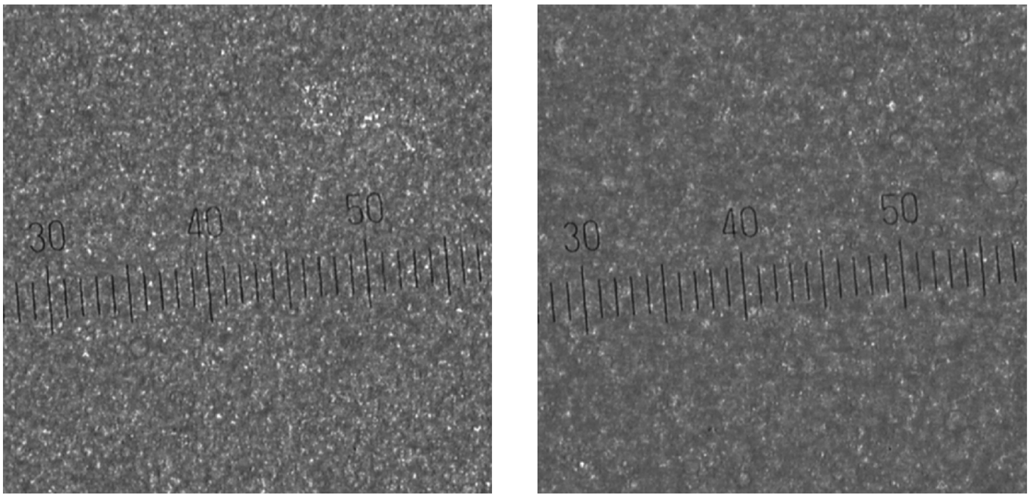


FIGURE 5. Yield values of table margarines 900 (direct blend), 904 (fully hydrogenated) and 905 (interesterified) at 15°C



(a) (b)

FIGURE 6. Microscopic study of table margarine during storage. Crystals of Sizes <4 µm are homogeneously distributed in samples (a) 900 and (b) 905 after 30 days storage at 5°C. (Other samples stored at 5, 10 and 15°C for the same period had shown no differences in the crystal size and distribution)

CONCLUSION

The study had shown that formulation works with POS in the form of simple blend (sample 900), blend of interesterified fully hydrogenated POS with PKO (sample 905) and simple blend of fully hydrogenated POS (sample 904) could be used in the preparation of brick margarine with the desired spreadable at refrigerator temperature (5-15°C). Palm stearin in these formulations was suitable for hard stock in trans-free brick margarine formulation with saturated fatty acid content <36%.

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