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PHYSICO-CHEMICAL PROPERTIES AND COMPATIBILITY STUDY ON PALM OIL PRODUCTS WITH COCOA BUTTER

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ABSTRACT

The physico-chemical properties of binary blends of palm oil products with deodorised cocoa butter (DCB, IV 32.7) at levels ranging from 10% to 90% (w/w) were evaluated. Cocoa butter equivalent (CBE, IV 32.4) showed full compatibility with DCB at all concentrations and crystallised to form a strong β in a mixture of β + β′ polymorphic forms. Results of solid fat content (SFC) show that the addition of 10% to 20% palm-mid fraction (PMF, IV 41) and cocoa butter substitute (CBS, IV 0.3) with DCB gave rise to eutectic effects and that the mixture crystallised to form a strong β′ in a mixture of β + β′ polymorphic forms. The differential scanning calorimetry (DSC) melting thermograms of the CBE and DCB blends showed a single melting peak at ± 19.5°C. There were two prominent melting peaks observed in the blends containing more than 10% to 20% of CBS and PMF.

Keywords: deodorised cocoa butter, cocoa butter equivalent, cocoa butter substitute, palm-mid fraction, palm oil products.

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INTRODUCTION

Cocoa butter fat has a complex polymorphism which is manifested in six polymorphs called forms I to VI (Timms, 1996). Cocoa butter is a fat-phase material used in products like chocolate. It accounts for about 28% to 38% of the ingredients used in chocolate production (Jefery, 1990). This fat is important for the successful production of chocolate as well as in obtaining a high quality product to suit consumer expectations (Petersson, 1988). The crystallisation and melting properties of cocoa butter are of major importance in the production of chocolate and other confectionery. A steep melting profile with a high solid fat content at 30°C, capable of being fully melted at mouth temperature, will result in a glossy chocolate with good mouth feel, flavour release and easy remolding (Petersson, 1988).

Vegetable fats that have very similar chemical and physical properties to cocoa butter, and able to replace certain amounts of cocoa butter in chocolate and confectionery products without any effects on processing or product quality, are known as cocoa butter equivalents (CBE) and cocoa butter substitutes (CBS). They help to reduce the raw material cost as these fats are much cheaper than cocoa butter (Wong, 1996). The prices of CBE can be approximately 30% cheaper than cocoa butter (Anon, 1996). However, the addition of different fats results in changes to the physical, chemical and rheological properties of the finished products. Therefore, the degree of compatibility between these vegetable fats and cocoa butter is important to ensure that high quality chocolate and confectionery products can be produced. Incompatibility of the fat blends may give rise to bloom formation and poor quality products.

In this study, the degree of compatibility of binary blends of CBE, CBS and palm-mid fraction (PMF) derived from palm oil with deodorised cocoa butter (DCB) was investigated. The binary blends of CBE, CBS and PMF with DCB (10%-90%) were analysed for their solid fat content (SFC), differential scanning calorimetry (DSC) melting characteristic and polymorphic forms.

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EXPERIMENTAL

Materials

CBE (IV 32.4), CBS (IV 0.3) and PMF (IV 41) were purchased from Soctek Edible Oils Sdn Bhd, Pasir Gudang, Johor. DCB (IV 32.7) was obtained from Kepong Koko Sdn Bhd, Klang, Selangor, Malaysia.

Sample Preparation

The samples were melted at 80°C for 30 min in an oven to destroy all the crystal history. Binary blends of CBE:DCB, CBS:DCB and PMF:DCB within the range of 10% to 90% (wt/wt) were prepared. The blends were subjected to the various analyses described below. Triplicate measurements were carried out for each analysis.

Solid Fat Content

Solid fat content (% SFC) of the blends at various temperatures was measured according to MPOB Test Methods (2005). Each sample was melted at 70°C for 30 min to erase all crystal memory. Approximately 3.0 g of the melted sample was pipetted into a pulsed nuclear magnetic resonance (pNMR) tube (10.0 mm diameter, 1.0 mm thickness and 180 mm height). The tubes were chilled at 0°C for 90 min, and kept at the desired temperatures for 30 min prior to measurement.

Crystal Polymorphism by X-ray Diffraction

The polymorphic form of the blends was analysed using an EnrafNonius model FR 592 (Enraf Nonius, Delft, The Netherlands) X-ray diffractometer. The instrument was fitted with a fine focus copper X-ray tube. The sample holders were flat stainless-steel plates with rectangular holes. The samples were melted at 70°C and then tempered at 10°C for 1 hr. The short spacing of the β′ forms were at 4.2 and 3.8Å while that of the β form was at 4.6Å (Souza *et al.*, 1990). Levels of β′ and β crystals in the mixtures were estimated by the relative intensities of the short spacing at 4.2 and 4.6Å. Measurements were carried out in duplicate.

Thermal Properties by Differential Scanning Calorimeter

Thermal properties of the samples were measured using a DSC-7 (Perkin-Elmer, Norwalk, CT). Calibration was carried out using an indium standard for the high temperature range and *n*-decane for the sub-ambient temperature range. Samples, weighing 3-5 mg, were hermetically sealed in aluminium pans with an empty pan serving as a reference. The samples were heated to 70°C for 10 min to destroy crystal memory. The samples were then cooled from melt (70°C) at 5°C min^{-1} to -40°C and held for 10 min before being reheated to 70°C at 5°C min^{-1}. Both the melting and cooling thermograms were recorded.

RESULTS AND DISCUSSION

Solid Fat Content (%)

Figures 1a, 1b and *1c* show the SFC of the blends at various temperatures. There were no changes in SFC of the CBE:DCB blends at all measured temperatures. However, SFC of the CBE:DCB blends were drastically reduced from 73% at 25°C to 0.5% at 35°C as shown in *Figure 1a*. This could be due to the steep melting profile of DCB and CBE which is required for the manufacture of a good chocolate. According to Willner and Weber (1994), the requirement for high quality PMF as a CBE fat component is a very steep melting curve for SFC with values of at least 40% at 30°C and no tailing above 37°C.

For the CBS:DCB blends, the addition of 20% to 60% of CBS at 25°C resulted in a decrease in SFC from 37% to 29%, which gradually increased when higher amounts of CBS were added. The eutectic effect was obvious at 20°C and 30°C. However, for the PMF:DCB blends, SFC decreased when more than 10% of PMF was added, and these blends showed eutectic effects at all measured temperatures. The eutectic effects could be due to the different types of triacylgycerols present in the blends, the incompatibility of the two oils used and their intermolecular packing. According to Timms (1984), the eutectic effect is desirable if the blend is going to be used for the production of margarine and shortening. Therefore, the SFC results for both CBS and PMF in this work showed their compatibility with DCB is at 10% and 20%, respectively.

Polymorphic Forms

Table 1 shows the polymorphic forms of CBE:DCB, CBS:DCB and PMF:DCB blends at various concentrations of the component fats. The CBE:DCB blends crystallised to form a strong β in a mixture of β + β′ polymorphic form. The CBS: DCB and PMF:DCB blends crystallised to form a strong β′ in a mixture of β + β′ polymorphic forms. This was due to CBS and PMF, which are β′-form tending, crystallising out earlier to dominate the crystallisation process.

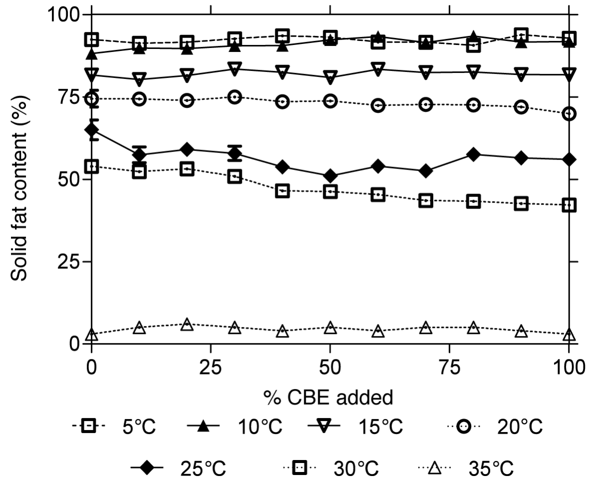

Figure 1a. Solid fat content (%) of cocoa butter equivalent (CBE): deodorised cocoa butter (DCB) blends at various tempering temperatures.

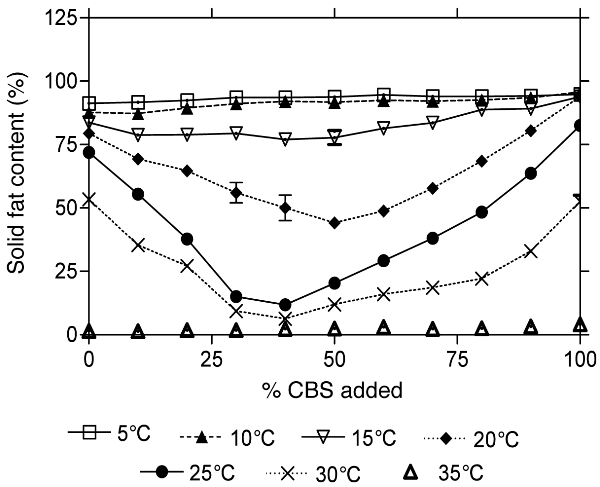

Figure 1b. Solid fat content (%) of cocoa butter substitute (CBS): deodorised cocoa butter (DCB) blends showing eutectic effects at 15°C to 30°C with the addition of CBS.

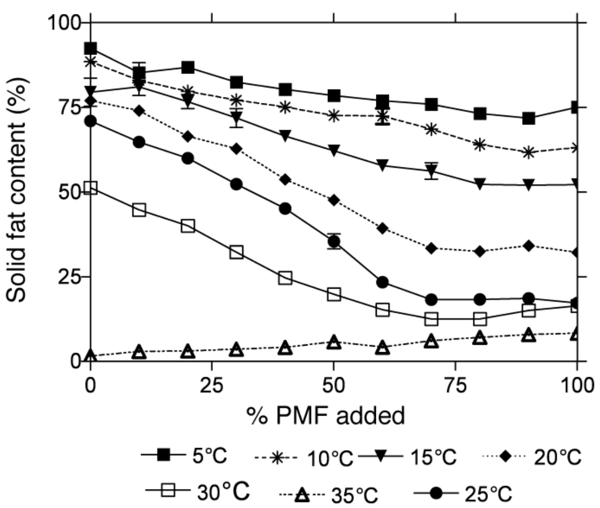

Figure 1c. Solid fat content (%) of palm-mid fraction (PMF): deodorised cocoa butter (DCB) blends showing eutectic effects at all crystallisation temperatures with addition of PMF.

TABLE 1. POLYMORPHIC FORM OF THE BLENDS

Sample ratio (w/w)	Polymorphic form		
	CBE:DCB	CBS:DCB	PMF:DCB
0:100	β +β′ (β>β′)	β +β′ (β>β′)	β +β′ (β>β′)
20:80	β +β′ (β=β′)	β′	β′>>>β
40:60	β +β′ (β>>β′)	β′	β′>>>β
50:50	β +β′ (β>>β′)	β′	β′>>>β
80:20	β +β′ (β=β′)	β′	β′
100:0	β +β′ (β=β′)	β′	β′

Note: CBE - cocoa butter equivalent.
DCB - deodorised cocoa butter.
CBS - cocoa butter substitute.
PME - palm-mid fraction.

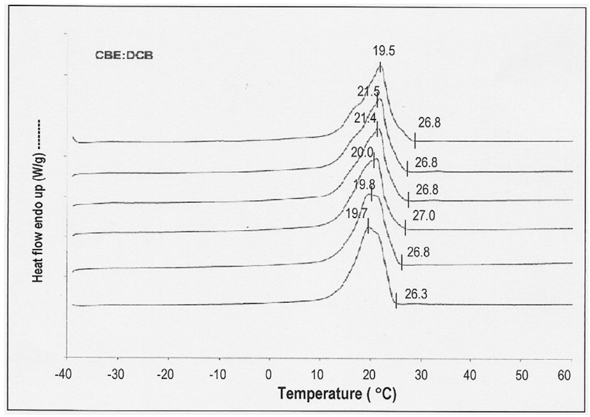

Figure 2a. Differential scanning calorimetry (DSC) melting characteristics of cocoa butter equivalent (CBE): DCB blends.

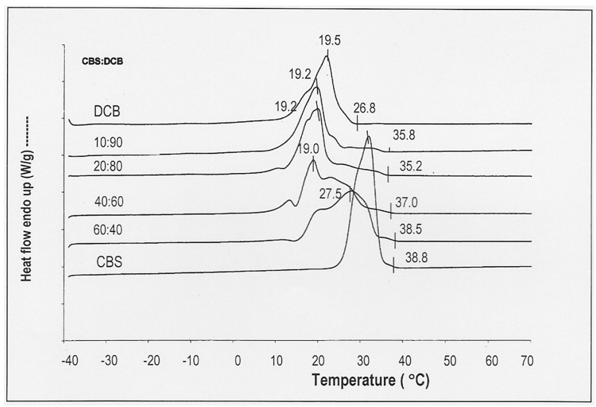

Figure 2b. Differential scanning calorimetry (DSC) melting characteristics of cocoa butter substitute (CBS): DCB blends.

DSC Melting Characteristics

Figure 2a shows the DSC melting thermograms of CBE and cocoa butter (CBE:DCB) blends. There were no changes in terms of their peak maxima (± 19.5°C) and melting temperature (± 27.5°C) for all concentrations. Hence, the addition of CBE did not affect the melting behaviour of the cocoa butter which indicated that they were compatible with each other. On the other hand, *Figures 2b* and

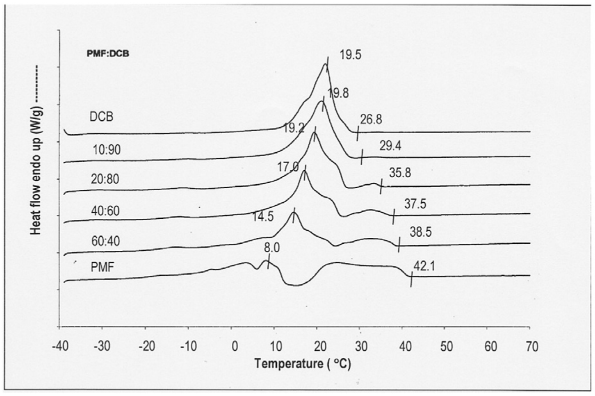

Figure 2c. Differential scanning calorimetry (DSC) melting characteristics of palm-mid fraction (PMF): DCB blends.

2c show the incompatibility of CBS and PMF with cocoa butter as indicated by the presence of two prominent melting peaks at higher concentrations. The peak maxima (broader peak) started to change and melted at higher temperatures with the addition of 20% of CBS and PMF into DCB.

CONCLUSION

Based on this study, CBE was observed to be fully compatible with cocoa butter, whereas CBS and PMF were observed to show compatibility up to 10% and 20% concentrations in the blends, respectively. Above these concentrations, eutectic behaviour, *i.e*. non-compatibility, was evident. Hence, for the production of a good chocolate product, the addition of 10% CBS and 20% PMF is recommended.

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REFERENCES

ANON. (1996). Vegetable fats in chocolate. The facts. url: http://www.Loders Croklaan/, accessed on 20 September 2001.

JEFERY, M S (1990). New diary technology and its impact on the chocolate industry. *Penn. Manufacturing Confectioners' Association, 15(13)*: 1-10.

MPOB (2005). Methods of testing for palm oil and palm oil products. *MPOB Test Method*. MPOB, Bangi.

PETERSSON, B (1988). The use of cocoa butter replacers. *The Manufacturing Confectioners, 68(6)*: 110-115.

SOUZA, D V; de MAN, J M and de MAN, L (1990). Short spacings and polymorphic forms of natural and commercial solid fats: a review. *J. Amer. Oil Chem. Soc., 67*: 835-843.

TIMMS, R E (1984). Phase behavior of fats and their mixtures. *Progress in Lipid Research, 23*: 1-38.

TIMMS, R E (1996). Cocoa butter equivalents and other SOS-type fats. Paper presented at the Conference of the Society of Chemical Industry Oils and Fats, United Kingdom, 15-16 October 1996.

WONG, S (1996). Dry fractionation of palm and palm kernel oils for speciality fats in the Asean sub-continent. Paper presented at the Conference of the Society of Chemical Industry Oils and Fats, United Kingdom, 15-16 October 1996.

WILLNER, T and WEBER, K (1994). High-pressure dry fractionation for confectionery fat production. *Lipid Technology, 4*: 57.