

Research Article

Production of cocoa butter equivalent from mango seed almond fat and palm oil mid-fraction

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Abstract

The purpose of this research was to produce cocoa butter equivalent from the blend of mango seed almond fat (MAF) from “Keaw” variety mango kernels and palm oil mid-fraction (POMF). Seven MAF-POMF blends with different proportions (100/0, 90/10, 80/20, 70/30, 60/40, 50/50 and 0/100 (%wt) of MAF to POMF) including cocoa butter were characterized using various techniques. Fatty acid composition was determined by Gas Chromatography-Flame Ionization Detector (GC-FID) and the results showed that all seven blends had palmitic acid, stearic acid and oleic acid as the main fatty acid components similar to cocoa butter, however with varying amounts. The study of solid fat content (SFC) as a function of temperature revealed that all blends except 50/50 and 0/100 melted completely at body temperature (37⁰C) resulting in no waxy sensation when consumed. However, only the 80/20 blend exhibited a melting behaviour closest to that of cocoa butter ($p < 0.05$), especially between 32⁰C and 40⁰C where the fat experienced a sharp decrease in SFC as the temperature increased and approximated the slip melting point (SMP) of cocoa butter. As a result of this, the 80/20 blend had the most potential for future use as cocoa butter equivalent.

Keywords: mango seed almond fat, palm oil mid fraction, cocoa butter equivalent, fatty acid composition, solid fat content, SFC, SMP, POMF, Thailand

Introduction

Cocoa butter (CB) is the fat extracted from the *Theobroma cacao* seeds [1, 2] that is commonly used as an ingredient in several confectionery products, especially in chocolate due to its specific properties. CB is mainly solid at temperatures below 25°C, but it is almost entirely liquid at body temperature (~37°C) [1]. CB is one of the most expensive vegetable fats consisting mainly of palmitic acid (C16), stearic acid (C18:0) and oleic acid (C18:1) and a trace amount of lauric acid (C12) and myristic acid (C14) [3, 4]. As only a few countries cultivate cocoa, supply of CB can be unstable [5, 6], so industries have tried to look for alternative vegetable fats that have chemical and physical properties similar to CB but are cheaper.

Cocoa Butter Equivalent (CBEs) have been used in chocolate products for many years. They are vegetable fats which have chemical and physical properties similar to cocoa butter [7]. They can be added to cocoa butter in any proportion without causing significant softening or hardening effects [1]. Similar to CB, the majority of fatty acids contained in CBEs are palmitic acid, stearic acid and oleic acid. According to the 2003 EU regulations, only six vegetable oils/fats can be used in EU chocolate and mango seed almond fat is one of them.

Mangoes (*Mangifera indica* L.) are one of Thailand's most economically important fruit. Particularly the Keaw variety which has been used as raw material for many canned fruit products. Only the mango flesh is utilized by these factories, resulting in a vast amount of mango peel and seeds being discarded as waste. Mango kernels contain a type of fat called mango seed almond fat (MAF) that is high in stearic acid content.

Palm oil is fractionated in multiple stages giving rise to several fractions that are suitable for different applications [8]. For example, palm oil mid-fraction (POMF) has been extensively used in confectionery products. POMF has an iodine value less than 36 g I₂/ 100 g oil and hence it does not give any waxy taste [7]. Also, POMF has been used to produce CBEs by blending with other vegetable fats in order to increase palmitic acid content.

The aim of this research was to produce CBE for use in chocolate products from the mixtures of MAF and POMF.

Materials and Methods

Materials

Mango seeds, of the Keaw variety, were kindly supplied by a canned fruit factory in Ratchaburi province, Thailand. The seeds were cut open and the seed kernels were removed. The kernels were kept in polyethylene bags at -18°C until further use. Cocoa butter was purchased from Sino-Pacific Trading (Thailand) Co., Ltd. Palm oil mid-fraction was obtained from Morakot Industries PCL (Thailand). The standard fatty acid methyl esters were purchased from AccuStandard, Inc. (USA). Lauric acid (C12), Myristic acid (C14), Palmitic acid (C16), Palmitoleic acid (C16:1), Stearic acid (C18), Oleic acid (C18:1), Linoleic acid (C18:2), Linolenic acid (C18:3), Arachidic acid (C20), Behenic acid (C22) and Lignoceric acid (C24) were used as external standards.

Crude fat extraction and purification

Before fat extraction, mango seed kernels were dried in a vacuum oven, using a method adapted from Solis-Fuentes and Duran-de-Bazua [9], at 65^oC until the moisture content was less than 10%. Then the dried kernels were finely ground and stored in polyethylene bags at 4^oC until extraction. Crude MAF was extracted using Soxhlet extraction method at 140^oC for 6 hours [9] and was purified using an adaptation of the Wesson method [9, 10]. The purified fat was blended with POMF into seven proportions (100/0, 90/10, 80/20, 70/30, 60/40, 50/50 and 0/100 (%wt) of MAF to POMF). All blends including CB were characterized using various techniques and methods.

Characterization of fatty acid composition

Fat was converted to fatty acid methyl esters using AOAC official method 969.33 [11]. Fatty acid methyl ester analysis was performed in a Shimadzu GC-2010 with flame ionization detector. The system had an ATTM-WAX capillary column (50 m long, 0.25 mm internal diameter and 0.20 mm film thickness.) Compound identification was carried out using external standards of eleven types of fatty acids methyl esters. Helium was the carrier gas. N₂ and air were makeup gases. Column flow was 0.5 ml/min and controlled initial pressure at 120^oC of 93.2 kPa. Injection temperature was 210^oC. The oven temperature program was held for 3 mins at 120^oC, increasing by 10^oC/min to 220^oC, holding for 30 mins and increasing by 5^oC/min to 240^oC, holding for a further 30 mins. Split ratio was 100:1 and the detector temperature was 280^oC.

Characterization of physicochemical properties

Iodine value was analyzed using an automatic titrator (Mettler Toledo DL58). Saponification value was analyzed using PORIM Test Method no. p3.1 [12]. Slip melting point was analyzed using PORIM Test Method no. p4.2 [12]. Solid fat content (SFC) was determined by pulse Nuclear Magnetic Resonance (pNMR) (Bruker the minispec, mq20) using AOCS Cd 16b-93 revised in 2000; Direct Method. [13].

Results and Discussion

Crude fat extraction

Crude MAF extracted using Soxhlet extraction method for 6 hours amounted to 7.28 ± 0.19% (dry basis). According to Solis-Fuentes and Duran-de-Bazua [9], crude fat of Manila mango kernels extracted using the same method amounted to 5.28-11.26% (dry basis).

Fatty acid composition

Fatty acid compositions of all mixtures and CB are given in Table 1 and were compared to the percentage area of the GC chromatogram. The results show that, like CB, all fat blends were composed mainly of palmitic acid, stearic acid and oleic acid. The fatty acid compositions of all blends were significantly different ($p < 0.05$) from one another. The amounts of palmitic acid, stearic acid and oleic acid in MAF were 5.39%, 46.55% and 41.09% respectively. Hence, MAF is a good source of stearic acid and oleic acid (mainly SOS triglyceride, where S = Stearic acid and O = Oleic acid), whereas POMF is a source of palmitic acid and oleic acid. (mainly POP triglyceride, where P = Palmitic acid and O = Oleic acid).

Table 1. Fatty acid composition* (%) of the mixtures and cocoa butter.

Mixture ratio	Percent of			
	Palmitic acid (C16)	Stearic acid (C18)	Oleic acid (C18:1)	Other fatty acids
100:0 (MAF)	5.39 ± 0.03	46.55 ± 0.09	41.09 ± 0.09	6.97 ± 0.16 ^c
90:10	10.34 ± 0.10	42.84 ± 0.07	40.02 ± 0.11	6.80 ± 0.28 ^c
80:20	16.26 ± 0.07	37.25 ± 0.05	39.60 ± 0.02	6.88 ± 0.05 ^c
70:30	19.84 ± 0.15	33.93 ± 0.06	39.22 ± 0.03 ^a	7.01 ± 0.12 ^c
60:40	24.93 ± 0.05	28.64 ± 0.07	39.12 ± 0.07 ^a	7.31 ± 0.10 ^b
50:50	29.11 ± 0.05	24.67 ± 0.03	38.69 ± 0.05	7.52 ± 0.11 ^b
0:100 (POMF)	51.65 ± 0.13	4.21 ± 0.01	35.63 ± 0.08	8.51 ± 0.04
Cocoa butter	25.82 ± 0.13	36.53 ± 0.04	33.49 ± 0.10	4.17 ± 0.02

Note: a, b, c mean no significant different at $\alpha = 0.05$ ($p < 0.05$)

* Values represent the average of triplicates ± standard deviation (SD).

Physicochemical properties

Iodine value

Iodine value (IV), which represents the amount of unsaturation contained in fatty acids, of all fat blends and of CB are given in Table 2. The higher the iodine number, the more unsaturated fatty acid bonds are present in a fat. The result showed that IVs of all fat mixtures were not significantly different from one another ($p < 0.05$) but were significantly higher than IV of CB, indicating that CB had the smallest degree of unsaturated fatty acids and hence was the hardest fat. From Table 2 it can be seen that the fat from Kaew mangos had an IV of 36.43 g I₂/ 100 g oil, which was lower than the IV of fat from Manila mangos (47.7 g I₂/ 100 g oil) [9].

Table 2. Iodine value (Iv) of the mixtures and cocoa butter.

Blends	Iv (g I ₂ /100 g oil)
MAF (100:0)	36.43 ± 0.18 ^b
90:10	37.12 ± 0.23 ^b
80:20	37.78 ± 1.19 ^b
70:30	37.47 ± 0.05 ^b
60:40	37.81 ± 0.38 ^b
50:50	36.95 ± 0.43 ^b
POMF (0:100)	37.04 ± 1.36 ^b
CB	29.37 ± 0.90 ^a

Note: a, b indicate no significant difference at $\alpha = 0.05$ ($p < 0.05$)

Saponification value

Saponification value (Spv) represents the number of milligrams of potassium hydroxide or sodium hydroxide required to saponify 1g of fat under the conditions specified. It is a measure of the average molecular weight (or chain length) of all the fatty acids present [14]. Spv increases when molecular weight decreases. From Table 3, it can be observed that pure POMF (0:100) had the highest Spv. As the amount of POMF in the fat blends decreased, Spv decreased proportionally. Compared with all fat blends, Spv of pure MAF (100:0) was the lowest. The Spv of Manila MAF was reported as 189.0 mg KOH/g oil [9]. As can be seen

from the table, Spv of CB was not significantly different from the Spv of 70/30, 60/40 and 50/50 blends ($p < 0.05$).

Table 3. Saponification value (Spv) of the mixtures and cocoa butter.

Blends	Spv (mg KOH/g oil)
MAF (100:0)	185.37 ± 2.79 ^b
90:10	187.41 ± 1.55 ^b
80:20	187.79 ± 0.89 ^b
70:30	190.88 ± 1.04 ^a
60:40	191.59 ± 1.55 ^a
50:50	192.37 ± 0.38 ^a
POMF (0:100)	196.66 ± 0.81
Cocoa butter	190.70 ± 1.13 ^a

Note: a, b indicate no significant difference at $\alpha = 0.05$ ($p < 0.05$).

Slip melting point

Slip melting point (SMP) is an important value because it was used to consider which of the fat blends was most suitable to be used as CBE. Table 4 shows that the SMPs of all mixtures were significantly different from that of cocoa butter ($P < 0.05$). However, the SMP of the 80/20 blend was the closest to CB.

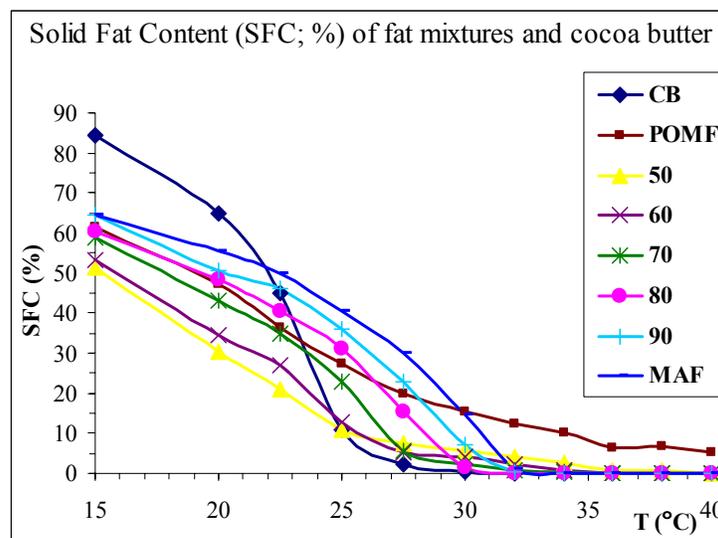
Table 4. Slip melting point* (⁰C) of the mixtures and cocoa butter.

Blends	SMP (⁰ C)
MAF (100:0)	35.7 ± 0.1
90:10	30.8 ± 0.0
80:20	29.3 ± 0.0
70:30	32.1 ± 0.1
60:40	32.9 ± 0.1
50:50	33.2 ± 0.1
POMF (0:100)	39.8 ± 0.1
CB	27.8 ± 0.0

Note: * values represent the average of triplicates ± standard deviation (SD).

Solid fat content

SFC at a given temperature represents the percentage of solid fat crystallized at that particular temperature. A plot of SFC versus temperature generally gives the melting behaviour of fats. The analysis of SFC of the fat mixtures and CB at different temperatures between 15-40⁰C provided the results shown in Figure 1. It can be seen from the figure that at 32-40⁰C the 80/20 (%wt) blend exhibited the melting behaviour closest to that of cocoa butter ($p < 0.05$).



Note: * each mixture line represents the average of triplicates.

Figure 1. Solid fat content* (%) of the mixtures and cocoa butter at 15 - 40°C.

Conclusions

MAF obtained from the “Keaw” mango kernels could be an alternative source of edible oil. With the right proportion, a fat blend between MAF and POMF could be used as CBE. The 80/20 (%wt) blend mainly consisted of three fatty acids that were also the main fatty acid components of CB. In addition, the melting behaviour and SMP of the 80/20 (%wt) blend were closest to that of CB. As a result of this, the 80/20 (%wt) blend had the most potential for future use as CBE.

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