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Confectionery Fats from Sal (*Shorea robusta*) Fat and Phulwara (*Madhuca butyracea*) Butter

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ABSTRACT

Stearins from sal fat and phulwara butter were blended in selected proportions to obtain confectionery fats or cocoa butter extenders. The sal fat stearin was obtained by removing about 20% olein from sal fat by acetone fractionation at 15°C, and the phulwara butter stearin was obtained by two-stage acetone fractionation. In the first stage of phulwara butter fractionation, a small amount of stearin (equal to 10% by weight of butter) was removed from the phulwara butter. The resulting olein was further fractionated at 15°C to obtain stearin (yield 65% by weight of olein). The blends containing 75–85% of sal fat stearin and 15–25% of phulwara butter stearin had solidification properties and solid fat indices close to those of cocoa butter. These blends could be used as cocoa butter extenders. Cocoa butter extenders which impart a greater cooling sensation in the mouth were prepared by decreasing the proportion of sal fat stearin to 50–67% in the blend. The blends containing 50:50, 67:33, 75:25 and 85:15% of sal fat: phulwara butter stearins were compatible with cocoa butter when admixed even at equal proportions. The tolerances of the blends towards milk fat were similar to that of cocoa butter. Thus, a series of cocoa butter extenders or confectionery fats, having a narrow melting range and melting profiles similar to those of cocoa butter could be prepared by altering the proportion of sal fat and phulwara butter stearins in the blends.

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INTRODUCTION

India produces a wide variety of so-called minor oilseeds of tree origin, with a total potential of about 6·7 million tonnes (Anon., 1971). Of these, some oilseeds, e.g. sal (*Shorea robusta*), mango (*Mangifera indica*), kokum (*Garcinia indica*), phulwara (*Madhuca butyracea*), mowrah (*Madhuca latifolia*) and dhupa (*Vateria indica*) give hard fats, or vegetable butters which, by virtue of their physico-chemical properties, appear to be suitable for use in chocolate and confectionery as partial or total replacers of cocoa butter.

Among these, sal is perhaps the most promising with a potential of 0·7 million tonnes of fat (CFTRI, 1980). Cocoa butter substitutes have been prepared from sal fat by fractionation, hydrogenation and blending (Bhambhani *et al.*, 1972; Shenoy & Ganapathy, 1979; Pairaud *et al.*, 1982; Ghosh Chaudhuri *et al.*, 1983). In general, stearic acid-rich fats or fat fractions are much harder than cocoa butter. The hardness of these fats or fat fractions can be reduced by incorporating fats or fat fractions rich in palmitic acid (Rossell, 1967; Traitler & Diffenbacher, 1985). In the present investigation, phulwara butter, which is rich in palmitic acid, was chosen for this purpose. Phulwara (*Madhuca butyracea*), a large deciduous tree, belongs to the same genus (Fam. Sapotaceae) as *Madhuca latifolia* or *longifolia*, commonly known as mowrah. The almond-shaped kernels contain 60–70% fat, which is rich in palmitic acid (see Table 3). The fractions of sal fat and phulwara butter were mixed in various proportions to obtain hard butters suitable for use in chocolate and confectionery as cocoa butter extenders.

MATERIALS AND METHODS

Refined and bleached sal fat was procured from M/s Speciality Fats P. Ltd., Khamgaon, India. Phulwara seed kernels were procured from Khadi and Village Industries Commission (KVIC), Pithoragarh, India. The fat from phulwara kernels was extracted by means of a Handler baby expeller. The crude fat was washed with hot water and refined with alkali.

Solvent fractionation

Two hundred grams of sal fat was dissolved in 400 ml of acetone by warming to 45°C. The fat solution was gradually cooled to 15°C and held at this temperature for 2 h. It was then filtered to separate a stearin and an olein fraction. The solvent from the two fractions was removed under vacuum. The yield of stearin (SFr. 1) was 80%.

Two hundred grams of phulwara butter was dissolved in 400 ml of acetone by heating to about 45°C. The solution was cooled to 25°C and held at this temperature for 4 h. The partially crystallized mass was filtered to remove about 10% stearin. The olein was further cooled to 15°C and held at this temperature for 3 h and filtered. The solvent from the stearin (middle fraction, PFr. 2, yield 65% by weight of olein) was removed in a rotary flash evaporator under reduced pressure.

Sal fat stearin fraction (SFr. 1) and phulwara butter middle fraction (PFr. 2) were mixed in various proportions; namely 85/15, 75/25, 67/33, 50/50.

Cooling curve

The cooling curves of the samples were obtained using Shukoff's flask, according to the procedure described by Wilton and Wode (1963).

Dilatometry

Dilatation studies were carried out according to the British Standard procedure, Method 2 (Anon., 1976) and the solid fat indices (SFI) were calculated from the dilatation values.

Differential Scanning Calorimetry (DSC)

A Mettler TA-3000 DSC was used in the study. The heat flow of the instrument was calibrated using indium. The PT-100 sensor was calibrated using indium, zinc and lead. To ensure homogeneity, the samples were heated to 60°C to destroy all crystal nuclei and about 20 mg was accurately weighed into a standard aluminium pan, the covers of which were then crimped in place. An empty aluminium pan with pierced lid was used as a reference. The pans with samples were chilled at 0°C for 1 h and tempered at 25–26°C for 40 h, followed by holding at 0°C for 1 h prior to introduction into the DSC cell. Thermograms of the samples were recorded by heating at a rate of 2°C/min from 0°C to 45°C. The peak temperature, heat of fusion (ΔH) and melting profile were directly recorded.

Analysis of triglycerides

The triglycerides (TG) of the samples were purified by passing them through a silica gel column and eluting the column with benzene (AOAC, 1980). The purified triglycerides were analyzed by silver nitrate TLC on 20 × 20 cm glass plates spread with 250 μ thick silica gel G containing 15% silver nitrate. The plates were activated at 130°C for 2 h. The samples dissolved in chloroform were applied, and the plates were developed in a mixture of benzene/chloroform (55/45 v/v). The chromatograms were sprayed with 0·01% 2′,7′-dichlorofluorescein in methanol/water (90:10 v/v). The fluorescent spots were then scanned using a Camag T scanner (Fluorometer, model III) under the following conditions: lamp 110–851, primary filter 110–810, secondary filter 2A and range selector at 3. The relative percentages of individual spots were calculated from peak areas.

For determining fatty acid compositions of TG, the individual spots from chromatograms were eluted with diethyl ether. The eluted samples were then saponified with alcoholic KOH, neutralized and made distinctly acidic with HCl. The liberated fatty acids were extracted with diethyl ether and were methylated using diazomethane. The fatty acid methyl esters were analyzed by GLC.

Gas–Liquid Chromatography (GLC)

A CIC gas chromatograph equipped with flame ionization detector, operating under the following conditions, was used for the analyses of fatty acid methyl esters. Column: 2·4 m × 0·3 cm S.S. column packed with 15% DEGS coated on chromosorb W (60/80 mesh). Column temperature, 180°C. Injector temperature, 240°C. Carrier gas (N_2), 15 ml/min. Hydrogen, 20 ml/min.

The peaks were identified by comparing the retention times with those of authentic standards. The area of peaks was measured by triangulation and the results were expressed as percentages (by weight) of the components in the sample.

RESULTS AND DISCUSSION

The stearin fraction of sal fat showed high SFI at 32·5 and 35°C, which indicated that the products containing such a hard fat fraction would not have desirable eating qualities. It has been reported that incorporation of a palmitic acid-rich, palm oil fraction depressed the SFI values, of stearic acid-rich shea or sal fat (Traitler & Diffenbacher, 1985). Further, the phase diagram of a binary mixture of 2-oleodipalmitin (POP) and 2-oleodistearin (SOS) appears to suggest that solid solutions were formed up to a concentration of 60% POP, and the system appears to be eutectic with 65% POP (Rossell, 1967). This depression in solids content of stearic acid-rich fats or fat fractions, when palmitic acid-rich fats are incorporated, was made use of to prepare, from sal fat, cocoa butter extenders having better eating qualities. For this purpose, the palmitic acid-rich phulwara butter was chosen.

The stearin fraction (SFr. 1) of sal fat was mixed with the middle fraction (PFr. 2) of phulwara butter in various proportions from 50 to 85%. The blends containing 75–85%, preferably 85%, of sal fat fraction and 15–25%, preferably 15%, of phulwara butter fraction had physical properties very close to those of cocoa butter (Fig. 1 and Table 1). Cocoa butter extender (CBE 1) consisting of 85% of SFr. 1 and 15% of PFr. 2 showed solidification properties similar to cocoa butter as revealed by the cooling curve (Fig. 1). It also showed a steep melting profile like cocoa butter (Fig. 2), and almost the same heat of fusion (Table 2). In addition, like cocoa butter, CBE 1 consisted of about 90% of monounsaturated disaturated (GS_2 U-type) triglycerides

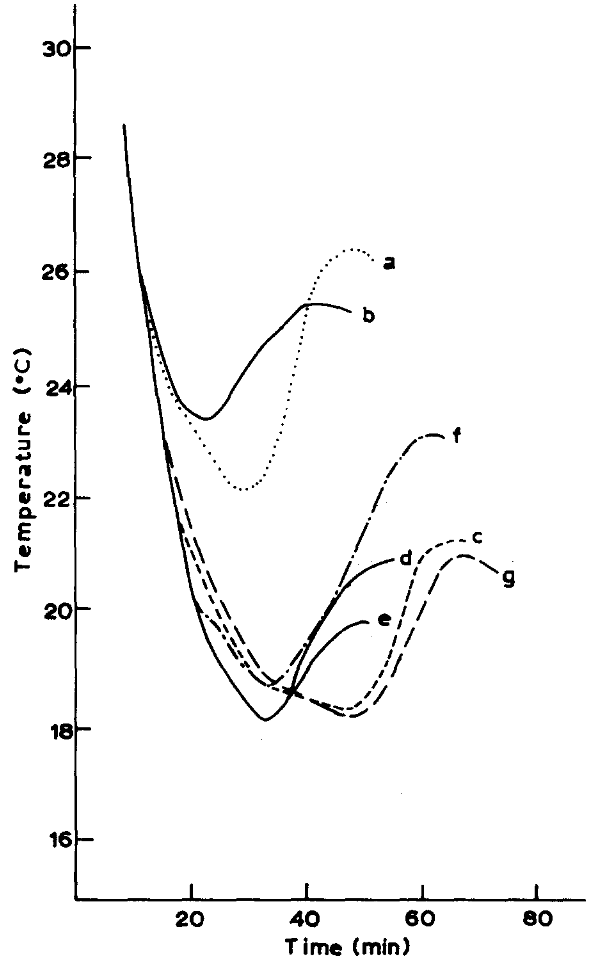

Fig. 1. Cooling curves of a, Sal fat stearin (SFr. 1); b, Phulwara butter middle fraction (PFr. 2); c, SFr. 1 + PFr. 2 (85/15); d, SFr. 1 + PFr. 2 (67/33); e, SFr. 1 + PFr. 2 (50/50); f, (c + Cocoa butter (50/50); g, Cocoa butter.

TABLE 1
Solidification Properties and Solid Fat Indices (SFI) of Cocoa Butter Extenders from Sal Fat and Phulwara Butter Factions

Sample	*Cooling curve characteristics*				*SFI at °C*					
	Temperature (°C)		*Time (min) for attaining*		*20*	*25*	*30*	*32·5*	*35*	*37*
	Min.	*Max.*	*Min.*	*Max.*						
1. Sal fat stearin (SFr. 1)	22·1	26·3	30	50	81·2	81·0	73·4	60·2	35·2	7·0
2. Phulwara butter middle fraction (PFr. 2)	23·0	25·3	22	44	70·6	66·0	42·0	20·0	7·2	4·0
3. CBE 1 (SFr. 1 + PFr. 2 (85/15))	18·2	22·2	47	65	77·0	75·4	66·4	47·6	15·0	—
4. SFr. 1 + PFr. 2 (75/25)					70·6	67·0	54·0	31·6	3·0	—
5. CBE 2 (SFr. 1 + PFr. 2 (67/33))	18·0	20·9	34	54	67·0	61·6	45·0	22·0	0·7	—
6. CBE 3 (SFr. 1 + PFr. 2 (50/50)	18·1	19·8	33	49	68·6	60·0	32·4	7·0	—	—
7. CBE 1 + Cocoa butter (50/50)	18·6	23·1	35	64	79·0	75·0	61·0	38·7	8·8	—
8. CBE 1 + Cocoa butter (25/75)					89·0	79·0	60·5	29·2	5·6	—
9. CBE 2 + Cocoa butter (25/75)					82·0	78·0	55·0	22·4	3·0	—
10. CBE 3 + Cocoa butter (25/75)					84·0	78·0	51·0	17·2	1·4	—
11. Cocoa butter	18·2	20·9	47	67	90·0	86·0	57·0	28·5	1·4	—
12. (8) + Milk fat (85/15)					68·0	58·0	40·0	14·4	0·5	—
13. Cocoa butter + Milk fat (85/15)					68·5	—	35·0	12·0	1·0	—

(Table 3). CBE 1 was compatible with cocoa butter even at the 50% level, as revealed by cooling curves and solid fat indices (Fig. 1 and Table 1). However, it showed slightly lower SFI at ambient temperatures (20–25°C), and higher SFI at 32·5 and 35°C compared to cocoa butter; the SFI values of CBE 1 admixed with cocoa butter at the 25% level were similar to that of cocoa butter (Table 1). CBE 1 had better tolerance towards milk fat compared to cocoa butter as revealed by SFI values (Table 1). These results reveal that the CBE 1 is suitable for use as a cocoa butter extender in high-grade chocolate and confectionery and will have good stand-up properties

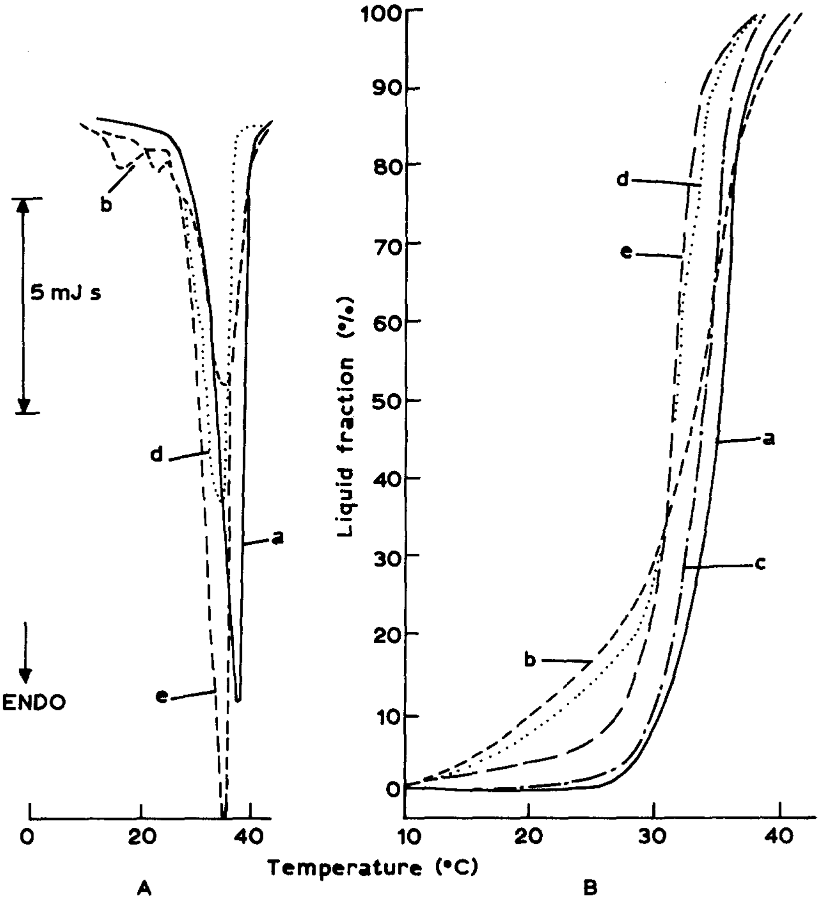

Fig. 2. DSC A, Heating curves and B, Melting profiles of a, Sal fat stearin (SFr. 1); b, Phulwara butter middle fraction (PFr. 2); c, SFr. 1 + PFr. 2 (85/15); d, SFr. 1 + PFr. 2 (75/25); e, Cocoa butter.

TABLE 2

Melting Peak Temperatures and Heats of Fusion (ΔH) of Stable Forms of Cocoa Butter Extenders from Sal Fat and Phulwara Butter Fractions

Sample	*Peak temperature*[a] (°C)	ΔH[a] (*J*/*g*)
1. Sal fat SFr. 1	36·2	119
2. Phulwara butter PFr. 2	35·0	91
3. CBE 1	35·0	110
4. Cocoa butter	32·7	121

[a] By DSC.

TABLE 3

Fatty Acid and Triglyceride Compositions of Cocoa Butter Extenders from Sal Fat and Phulwara Butter Fractions

	Sal fat SFr. 1	*Phulwara butter PFr. 2*	*CBE 1*	*Cocoa butter*
Fatty acid (%)				
Palmitic	6·6	66·3	16·0	32·8
Stearic	53·0	3·9	45·6	31·8
Arachidic	6·9	—	6·0	—
Oleic	33·0	27·7	32·2	35·3
Linoleic	—	0·6	—	—
Triglyceride[a] (relative %)				
Trisaturated (GS_3)	—	3·0	—	—
Monounsaturated disaturated (GS_2U)	80·6	85·0	90·0	90·0
Monosaturated diunsaturated (GSU_2)	11·5	7·0	8·0	5·0

[a] By $AgNO_3$–TLC fluorometry.

at high storage temperatures. The blends containing lower proportions (<85%) of SFr. 1 showed lower SFI at all temperatures compared to CBE 1 (Table 1). However, these blends, e.g. CBE 2 and CBE 3, when mixed with cocoa butter, showed SFI values similar to cocoa butter at ambient temperature (20–25°C), but slightly lower values at 32·5°C (Table 1). This may be an advantage, where the ambient temperatures are low. Thus, by varying the proportions of sal fat and phulwara butter fractions, a range of hard confectionery butters, suitable for use under various climatic conditions, could be prepared.

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