MARDI Res. J. 17(1) 1989: 37–44

Cocoa butter characteristics of Malaysian clonal cocoa

A. H. G. Chin*

Key words: cocoa butter, clones, physico-chemical characteristics

Abstrak
Lima klon koko (*Theobroma cacao* L.) iaitu KKM 1, KKM 2, KKM 5, KKM 6 dan KKM 7, yang telah disyorkan oleh MARDI, telah dikaji mutu lemak kokonya.

Analisis kimia dan fizikal, komposisi dan kelakuan semasa pendinginan dan pencairan telah dijalankan. Data yang didapati menunjukkan bahawa lemak koko daripada klon-klon baru serupa dengan lemak koko Malaysia yang biasa diperdagangkan, walaupun terdapat perbezaan komposisi antara klon dan juga antara sampel. Justeru itu, lemak koko daripada klon-klon ini adalah lebih keras dan mempunyai suhu pencairan yang lebih tinggi berbanding dengan lemak koko Ghana.

Abstract
Five new cocoa (*Theobroma cacao* L.) clones, KKM 1, KKM 2, KKM 5, KKM 6 and KKM 7, which were recommended by MARDI, have been examined for their cocoa butter quality.

Analyses of the chemical and physical properties, composition and cooling/melting behaviour of the fat showed that Malaysian cocoa butter from new clonal materials was similar to that from commercially planted materials, despite inherent differences in composition amongst clones and between samples. It is therefore harder and has a higher melting point than Ghanaian cocoa butter.

Introduction

The first generation clones of cocoa *Theobroma cacao* L., KKM 1, KKM 2, KKM 5, KKM 6 and KKM 7 were launched on 28 October 1983 at Hilir Perak MARDI Station (Anon. 1983). These clones were recommended for planting not only for their good quality but also for their high yield potential of up to 4 000 kg/ha. In this way, MARDI hoped to upgrade the quality of Malaysian cocoa beans and alleviate some of the problems faced by cocoa smallholders such as small and variable bean size (Mohd. Hashim and Noraini 1982) and low cocoa butter content. Later on 16 January 1986, eight more clones of disease-resistant stock were introduced. As yet these clones are only available as budwood, and commercialization to the stage of ready-to-plant trees has still to be realized (Sapiyah 1986).

Cocoa butter from commercially available planting materials in Malaysia (Mcb) has been studied (Chin and Nushirwan 1984) and found to contain a higher percentage of high melting solids than Ghanaian cocoa butter (Gcb). This

*Food Technology Division, MARDI, P.O. Box 12301, 50774 Kuala Lumpur
Author's full name: Mrs Annie Chin nee Sim Hooi Guat

makes Mcb a harder and therefore more desirable butter, especially for use in chocolate in the summer or in tropical climates.

In this study, the cocoa butter characteristics of these new clones, KKM 1, KKM 2, KKM 5, KKM 6 and KKM 7, were examined in comparison with Mcb and Gcb.

Materials and methods

Clonal cocoa beans

All samples of KKM 1, KKM 2, KKM 5, KKM 6 and KKM 7 were obtained from Jerangau MARDI Station. The cocoa pods were split and the cocoa beans removed. The beans from each clone were placed in a separate net bag so that the mono-clonal beans could undergo the normal shallow fermentation and processing together with other commercial beans, and yet could be easily separated out after the process. A sample of approximately 2 kg of dried fermented beans was obtained from each clone in 1985, and then again in 1986.

Extraction of fat

Cocoa butter was obtained from 500 g of cocoa beans using a 10-t hydraulic press (APEX Construction Ltd., London WI and Dartford) as described by Chin and Nushirwan (1984).

Analysis

Description of methods used for analysis of cocoa butter is as given by Chin and Nushirwan (1984) except for differential scanning calorimetry (DSC).

The empirical tests carried out included free fatty acid (FFA), Iodine value (IV), saponification value, unsaponifiable matter and clear melting point.

Composition studies consisted of fatty acid and triglyceride composition by gas liquid chromatography. The overall degree of saturation and unsaturation were estimated by addition of saturated and unsaturated fatty acid percentages respectively.

Cooling and melting behaviour were studied via Jensen cooling curves, solid fat content using Nuclear Magnetic Resonance and DSC.

In the DSC method, about 3 mg of cocoa butter, melted at 70 °C for 30 min, was accurately weighed into an aluminium sample pan which was then covered and the lid crimped in place. The sample was tempered at 0 °C for 90 min, 26 °C for 40 h, again at 0 °C for 90 min, and then left at ambient temperature (25 °C) for at least 1 h. The sample was introduced into a Perkin Elmer DSC–2 (Connecticut, U.S.A.). During the DSC run, the samples were surrounded with nitrogen at a pressure of 1.4 kg/cm^2 and cooled by Intracooler I with intermediate subambient accessory. The following were the operating conditions:

Heating/cooling rate	5 °K/min
Range	5 mcal/s
Pen range	5 mV
Chart speed	10 mm/min

Heating scans were run from 273 °K to 323 °K and cooling from 323 °K to 273 °K.

Statistical analysis

The analytical data were examined for differences amongst clones and between times of sampling by analysis of variance (ANOVA).

Results and discussion

Clonal and sampling variations

The data obtained for cocoa butter in the two sampling seasons for the five clones were examined by ANOVA for each variable. KKM 1 and KKM 6 clones had cocoa butter of high FFA, whilst KKM 5 and KKM 6 cocoa butter had high saponification values and KKM 1 cocoa butter had high unsaponifiable matter (*Table 1*). Cocoa butter from KKM 2 had significantly higher C18 fatty acid

Table 1. Analysis of clonal cocoa butter – ANOVA table of significance and mean values

Variable	Clonal effects	Mean values KKM 1	KKM 2	KKM 5	KKM 6	KKM 7
FFA (% wt. as oleic acid)	*	0.58a	0.51b	0.54ab	0.59a	0.56ab
Clear melting point (°C)	**	34.2b	34.6a	34.1b	34.4ab	34.3ab
Iodine value (mg I_2/100 g fat)	ns	34.3a	33.5a	34.6a	33.7a	35.0a
Saponification value (mg KOH/g fat)	*	196.4b	197.5ab	198.6a	198.7a	198.0ab
Unsaponifiable matter (% wt.)	*	0.75a	0.60ab	0.54ab	0.63ab	0.50b
Fatty acid compositon (%)						
Major fatty acids						
C16	**	27.3a	25.7c	27.1a	27.4a	26.2b
C18	**	35.2b	36.1a	34.6bc	34.0c	34.9b
C18:1	**	32.5c	33.6b	33.6b	34.2a	33.9ab
C18:2	**	3.1a	2.5b	2.6b	2.3b	2.6b
C20	ns	1.2a	1.2a	1.2a	1.1a	1.3a
Minor fatty acids						
C14	ns	0.1a	–	0.1a	0.1a	0.1a
C16:1	ns	0.5a	0.4a	0.4a	0.5a	0.5a
C17	ns	0.2a	0.4a	0.4a	0.3a	0.3a
C18:3		–	–	–	0.1	–
Estimated saturation (%)		64.0	63.4	63.4	62.9	62.8
Estimated unsaturation (%)		36.0	36.5	36.6	37.0	37.0
Triglyceride composition (%)						
C50	**	21.0a	19.0b	21.0a	21.3a	19.7b
C52	*	46.8ab	46.5b	47.2a	46.8ab	47.3a
C54	**	30.2c	32.4a	30.1c	29.8c	31.4b
C56	*	2.0ab	1.9abc	1.7bc	2.1a	1.6c
Jensen cooling curve						
T max	ns	29.0a	29.8a	29.7a	29.3a	29.3a
ΔT	ns	4.6a	4.6a	4.7a	4.5a	4.5a
$Q = \frac{\Delta T}{\Delta t}$	ns	0.26a	0.27a	0.27a	0.24a	0.26a
Solid fat content (%) at						
20 °C	ns	81a	84a	84a	81a	82a
25 °C	ns	77a	80a	80a	78a	78a
30 °C	ns	61a	62a	62a	59a	61a
32.5 °C	ns	25a	27a	26a	22a	26a
35 °C	ns	0	0	0	0	0
Differential scanning calorimetry						
ΔH (cal/g)						
Melting (ß polymorph)	ns	26.1a	30.3a	24.1a	28.6a	32.5a
Cooling (α polymorph)	ns	12.4a	14.6a	10.4a	12.5a	15.3a
Heating (α polymorph)	ns	16.4a	19.1a	14.2a	16.8a	18.9a
Transition temperature (°C)						
Melting (ß polymorph)	ns	34.6a	34.2a	33.3a	33.5a	34.3a
Cooling (α polymorph)	ns	12.7a	13.3a	13.6a	13.2a	13.9a
Heating (α polymorph)	ns	20.7a	21.9a	20.8a	20.2a	22.0a

a,b,c variables with mean values having the same letter are not significantly different at 5% level.
*5% level of significance
**1% level of significance
ns = not significant
– = less than 0.05
Sampling time: 1985, 1986

Table 2. Analysis of cocoa butter from different times of sampling – ANOVA table of significance and mean values

Variable	Effects of sampling time	Mean values	
		1985	1986
FFA (% wt. as oleic acid)	**	0.45b	0.66a
Clear melting point (°C)	ns	34.3a	34.3a
Iodine value (mg I_2/100 g fat)	*	33.3b	35.2a
Saponification value (mg KOH/g fat)	ns	197.5a	198.2a
Unsaponifiable matter (% wt.)	*	0.66a	0.55b
Fatty acid compositon (%)			
Major fatty acids			
C16	**	26.9a	26.6b
C18	**	34.5b	35.5a
C18:1	**	33.7a	33.4b
C18:2	*	2.7a	2.5b
C20	**	1.4a	1.0b
Minor fatty acids			
C14	ns	0.1a	0.1a
C16:1	ns	0.4a	0.5a
C17	ns	0.3a	0.3a
C18:3	ns	–	–
Estimated saturation (%)		63.2	63.5
Estimated unsaturation (%)		36.8	36.4
Triglyceride composition (%)			
C50	**	20.9a	19.9b
C52	*	46.7b	47.1a
C54	**	30.3b	31.2a
C56	**	2.0a	1.7b
Jensen cooling curve			
T max	ns	29.3a	29.5a
ΔT	ns	4.5a	4.6a
$Q = \frac{\Delta T}{\Delta t}$	ns	0.27a	0.25a
Solid fat content (%) at			
20 °C	ns	83a	81a
25 °C	ns	78a	79a
30 °C	ns	62a	59a
32.5 °C	ns	28a	23a
35 °C	ns	0	0
Differential scanning calorimetry			
ΔH (cal/g)			
Melting (ß polymorph)	ns	28.3a	28.3a
Cooling (α polymorph)	ns	12.8a	13.2a
Heating (α polymorph)	ns	24.6a	24.6a
Transition temperature (°C)			
Melting (ß polymorph)	ns	32.6a	35.3a
Cooling (α polymorph)	ns	13.4a	13.3a
Heating (α polymorph)	ns	20.8a	21.4a

a,b,c variables with mean values having the same letter are not significantly different at 5% level.
*5% level of significance
**1% level of significance
ns = not significant
– = less than 0.05
Clones: KKM 1, KKM 2, KKM 5, KKM 6, KKM 7

compared with that from other clones, together with reasonably high C18:1 and C18:2 acids, which together accounted for the high C54 triglyceride. At the same time it had significantly low C16 fatty acid which resulted in low C50 and C52 triglycerides. To some extent this was reflected in the high melting point of cocoa butter from KKM 2 clone. Cocoa butter from KKM 1, KKM 5 and KKM 6 clones on the other hand had significantly high C16 fatty acid, with correspondingly high C50 triglyceride and low melting points.

Iodine values of cocoa butter were not significantly different amongst clones indicating that the differences in unsaturation of the fatty acids and triglycerides had offset each other resulting in similar overall degree of unsaturation and saturation amongst the clones (*Table 1*). Similarly, the differences in composition of cocoa butter amongst the clones did not significantly affect their solidification and thermal behaviour as was indicated by no significant differences in solid fat content, Jensen cooling curve and differential scanning calorimeter data.

There were highly significant differences between the 2 years of sampling, for FFA, C16, C18, C18:1 and C20 fatty acids and C50, C54 and C56 triglycerides (*Table 2*). Differences were slightly significant for Iodine value, unsaponifiable matter, C18:2 fatty acid and C52 triglyceride. However, these differences in composition and chemical properties had no significant effect on the physical properties of the cocoa butter, such as solid fat content, Jensen cooling curve, differential scanning calorimeter characteristics, and melting point.

Comparison between Mcb and Gcb

Comparison studies with previously obtained data for commercial Malaysian cocoa butter and Ghanaian cocoa butter (Chin and Nushirwan 1984) were made with the mean characteristics of cocoa butter from these five clones, termed clonal cocoa butter (ccb). This is because there were no significant differences in characteristic physical behaviour of cocoa butter amongst clones or between sampling years.

The melting point of ccb was similar to that of Mcb but higher than that of Gcb, and the reverse was true for Iodine value, which is similar to that of Mcb but lower than that of Gcb (*Table 3*). This shows that ccb contained the expected higher percentage of high melting fat solids which is the characteristic good quality of the present day commercial Mcb. This is confirmed by *Figure 1* which shows the similarity of solid fat content of the ccb and Mcb, and their higher

Table 3. Characteristics of clonal cocoa butter in comparison with Malaysian and Ghanaian cocoa butter

Characteristics	ccb (mean* ±SD)	Mcb+	Gcb+
Iodine value (mg I_2/100 g fat)	34.2 ± 1.57	34.6	36.9
Saponification value (mg KOH/g fat)	197.8 ± 1.29	191.4	190.2
Unsaponifiable matter (% wt.)	0.61 ± 0.162	0.59	0.52
Clear melting point (°C)	34.3 ± 0.20	34.5	33.4
Free fatty acid (% wt. as oleic acid)	0.56 ± 0.121	0.79	1.19

*mean of 5 clones
+Source: Chin and Nushirwan (1984)
ccb = clonal cocoa butter
Mcb = Malaysian cocoa butter
Gcb = Ghanaian cocoa butter

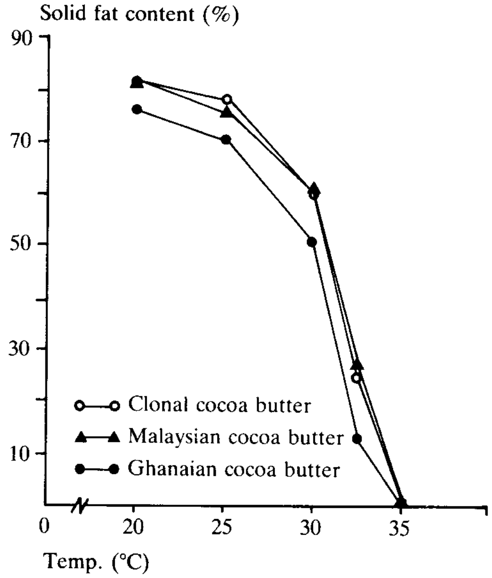

Figure 1. Solid fat content of clonal cocoa butter in comparison with Malaysian cocoa butter (1984) and Ghanaian cocoa butter

percentages than Gcb. Thus ccb is also a harder butter than Gcb.

Other characteristics such as unsaponifiable matter and FFA of ccb were also similar to those of Mcb. However, saponification value was unusually higher in ccb than in either Mcb or Gcb. This is possibly a reflection of its higher percentage of lower molecular weight C16 fatty acid (*Table 4*). The estimated percentage saturation of ccb (63.3) was closer to that of Mcb (63.5), and higher than that of Gcb (61.6). This substantiates the fact that ccb and Mcb have more high melting solid fats and are therefore harder butters than Gcb. The higher saturation of ccb was accounted for by the higher amounts of C16 fatty acid and lower levels of C18:1 and C18:2 fatty acids than in Gcb, which was reflected in the higher low carbon number C50 and C52 triglycerides and lower high carbon number C54 triglyceride content than in

Table 4. Composition of clonal cocoa butter in comparison with Malaysian and Ghanaian cocoa butter

Composition (%)	ccb (mean* ±SD)	Mcb+	Gcb+
Fatty acid			
C14	0.07 ± 0.035	0.07	0.11
C16	26.76 ± 0.714	25.17	25.44
C16:1	0.49 ± 0.050	0.31	0.32
C17	0.35 ± 0.040	0.33	0.27
C18	34.96 ± 0.922	36.78	34.76
C18:1	33.57 ± 0.640	33.42	34.73
C18:2	2.61 ± 0.308	2.57	3.10
C18:3	–	0.20	0.23
C20	1.20 ± 0.256	1.18	1.06
Estimated saturation	63.3	63.5	61.6
Estimated unsaturation	36.7	36.5	38.4
Triglyceride			
C50	20.39 ± 1.064	16.46	17.27
C52	46.91 ± 0.516	44.60	45.90
C54	30.78 ± 1.131	35.56	34.68
C56	1.86 ± 0.347	2.34	2.11

*mean of 5 clones
+Source: Chin and Nushirwan (1984)
– = less than 0.05
ccb = clonal cocoa butter
Mcb = Malaysian cocoa butter
Gcb = Ghanaian cocoa butter

Table 5. Cooling and melting behaviour of clonal cocoa butter in comparison with Malaysian and Ghanaian cocoa butter

Differential scanning calorimetry	△H (cal/g)			Transition temp. (°C)		
	ccb (mean* ±SD)	Mcb+	Gcb+	ccb (mean* ±SD)	Mcb+	Gcb+
Melting (ß polymorph)	28.3 ± 3.74	28.9	24.5	34.0 ± 1.47	33.4	33.3
Cooling (α polymorph)	13.0 ± 2.31	14.7	13.3	13.3 ± 0.58	15.0	14.7
Heating (α polymorph)	17.1 ± 2.41	17.5	13.9	21.1 ± 0.88	22.4	22.9

Jensen cooling curve	ccb (mean* ±SD)	Mcb+	Gcb+
T max	29.4 ± 0.49	29.6	29.9
△T	4.6 ±0.27	5.5	5.6
$Q = \frac{\Delta T}{\Delta t}$	0.26 ± 0.035	0.27	0.28

*mean of 5 clones
+Source: Chin and Nushirwan (1984)
ccb = clonal cocoa butter
Mcb = Malaysian cocoa butter
Gcb = Ghanaian cocoa butter

Gcb. In the case of Mcb, however, higher saturation was due to higher levels of C18 fatty acid and the corresponding higher amounts of C54 triglyceride.

The cooling and melting behaviour in *Table 5* shows higher heat capacities (△H) and transition temperature of the melting ß polymorph in the differential scanning calorimetric studies of both ccb and Mcb than that of Gcb. This confirms the higher melting behaviour and therefore the harder nature of cocoa butter of Malaysian origin in comparison with that from Ghana. In the cooling and heating curves of the α polymorph, however, ccb showed lower △H and transition temperatures than Mcb and even Gcb. This is possibly due to its higher percentage of C16 fatty acid. Similarly in the Jensen cooling curve, T max and Q values of ccb were comparable with Mcb and Gcb showing good tempering characteristics of the butter, however, △T was somewhat lower in ccb confirming the cooling characteristics observed by DSC.

Conclusion

Malaysian cocoa butter from the new recommended KKM 1, KKM 2, KKM 5, KKM 6 and KKM 7 clones are not different in general characteristics and behaviour from each other and from Mcb of commercially planted cocoa, despite some inherent differences in composition amongst clones, between samples, and between clonal and commercial materials. This is because their overall percentages of saturated to unsaturated fatty acids are similar, but the percentage saturation is higher than that of Gcb. Therefore cocoa butter from the new recommended clones maintains the high melting standard which is characteristic of Malaysian cocoa butter and is harder than Gcb.

Acknowledgements

The author wishes to thank Dr Mohd. Musa Mohd. Jamil, Director of Cocoa Research Division, who provided the samples of dried fermented cocoa beans; Mr Nushirwan Zainuddin, Mr Misli Sulaiman and Ms Yeap Swee Kee for technical assistance.

References

Anon. (1983). Pengisytiharan koko MARDI. *Berita Penyelidikan, MARDI* ***22***: 1

Chin, A. H. G. and Nushirwan, Z. (1984). Characteristics of Malaysian cocoa butter. Paper presented at The 1984 international conference on cocoa and coconuts, progress and outlook ISP/MCGC 15–17 Oct. 1984, Kuala Lumpur

Mohd. Hashim, H. and Noraini, M. K. (1982). Malaysian cocoa supply and quality. *Proc. food conference, 1982,* 16–20 May 1982, Singapore (Theng, C. Y., Kwik, W. L. and Fong, C. Y., ed.) p. 177–87. Singapore: Singapore Institute of Food Science and Technology

Sapiyah, S. (1986). Klon-klon koko baharu. *Berita Penyelidikan, MARDI* ***20***: 5

Accepted for publication on 13 July 1988