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Physico-Chemical Properties and Quality of Palm-Based Vegetable Ghee

(Ciri-Ciri Fiziko-Kimia dan Kualiti Minyak Sapi Sayuran Berasaskan Minyak Sawit)

I. NOR AINI*, H. HANIRAH, C.H. MAIMON,
S. ZAWIAH & Y.B. CHE MAN

ABSTRACT

Samples of trans-free vegetable ghee were made using palm oil/palm stearin/palm olein (PO/POs/POo) blends (set A) and using palm oil/palm stearin/palm kernel olein (PO/POs/PKOo) blends (set B). Palm stearin of iodine value (IV) 30 was used in this study. The products were evaluated for their physical and chemical properties. Changes in quality during storage were monitored during a period of 16 weeks. Most of the vegetable ghee were granular (grainy) and had a shiny appearance. Chemical analyses indicated that vegetable ghee consisting of PO/POs/POo had higher IV (47.7-52.4) than the PO/POs/PKOo vegetable ghee due to their higher content of unsaturated fatty acids, 46.0-50.0% compared to 36.6-45.0% in Set B. Decreasing the amount of palm oil while increasing palm stearin in the formulations resulted in higher slip melting point (SMP) and higher yield values. Eutectic interaction was noted in PO/POs/PKOo blends. The crystals in samples PO/POs/POo (set A) were predominant in the ß' polymorphic form. One formulation in set B (B4) exhibited ß crystallinity. Free fatty acids (FFA) were lowest in samples PO/POs/POo 80:5:15 (A4) and PO/POs:/PKOo 80:5:15 (B4) throughout storage. There was no clear trend on anisidine value (AV) while IV remained almost constant. Selected vegetable ghee, A4 wasused to shallow fry roti canai *and for cooking* nasi minyak. *Sensory evaluation on these two products revealed that there was no significant difference (P < 0.05) in texture, taste and overall quality between samples A4 and B4.*

Keywords: Palm stearn; vegetable ghee

ABSTRAK

Sampel minyak sapi sayuran yang bebas asid lemak trans dibuat menggunakan adunan set A iaitu minyak sawit/stearin sawit/olein sawit (PO/POs/POo) dan adunan set B iaitu minyak sawit/stearin sawit/olein isirung sawit (PO/POs/PKOo). Stearin sawit dengan nilai iodin (IV) 30 digunakan dalam kajian ini. Produk-produk dinilai daripada segi ciri fizikal dan kimia. Perubahan kualiti semasa penyimpanan dikaji selama 16 minggu. Kebanyakan sampel mempunyai hablur yang kasar dan permukaan yang kelihatan berkilat. Analisis kimia menunjukkan sampel minyak sapi sayuran berasaskan PO/POs/POo mempunyai nilai iodin lebih tinggi (47.7-52.4) daripada sampel berasaskan PO/POs/PKOo disebabkan kandungan asid lemak tidak tepu yang lebih tinggi, 46.0-50.0% berbanding 36.6-45.0% dalam set B. Apabila kandungan minyak sawit dikurangkan dan kandungan stearin sawit ditingkatkan di dalam formulasi, didapati takat lebur dan penghasilan meningkat. Interaksi eutektik dilihat pada adunan berasaskan PO/POs/PKOo. Hablur dalam sampel PO/POs/PKOo (set A) kebanyakannya dalam bentuk β'. Satu formulasi dalam set B (B4) menunjukkan hablur dalam bentuk β. Kandungan asid lemak bebas adalah paling rendah dalam sampel PO/POs/PKOo 80:5:15 (A4) dan PO/POs/PKOo 80:5:15 (B4) sepanjang tempoh kajian. Tiada corak yang jelas tentang nilai anisidin (AV) tetapi nilai iodin (IV) tidak banyak berubah. Minyak sapi sayuran sampel A4 digunakan untuk menggoreng roti canai dan membuat nasi minyak. Penilaian deria ke atas produk-produk ini menunjukkan tiada perbezaan yang bererti (P < 0.05) dari segi tekstur, rasa dan kualiti keseluruhan antara sampel A4 dan B4.

Kata kunci: Minyak sapi; stearin sawit

INTRODUCTION

Initially, vegetable ghee which is also known as vanaspati was produced using a single hydrogenated oil, for example cottonseed or groundnut oil. As the industry grew, products based on blends of oils or animal fats were produced. Presently, soybean, rapeseed, cottonseed, and palm oil (PO) are the most commonly used oils in the formulation of vegetable ghee. These oils usually have to be hydrogenated in order to achieve the required characteristics for vegetable ghee. Hydrogenation is a fairly costly process and produces undesirable *trans* fatty acids (TFA). Most of the TFA content in the human diet derived from the partial hydrogenation of fats. Several published reports have indicated that TFA have a negative impact on plasma lipoprotein profile by lowering high-density lipoprotein (HDL) cholesterol and raising the low-density lipoprotein (LDL) cholesterol. Margarine, shortenings and vegetable ghee are manufactured by hydrogenation of vegetable oils, during which a reduction in the unsaturation of oils and an increase in the isomerization at the double bonds take place. Hence, there is a worldwide concern about the consumption of these hydrogenated fats. Legislation in the USA requires manufacturers to list TFA on the nutrition facts label of conventional foods and some dietary supplements as of January 1, 2006 (Wilson 2004). There is an urgent need to develop vegetable ghee like products having similar physical properties but with no TFA to meet the demands and requirements of health-conscious consumers. In India, about 1.1 million metric tons of vegetable ghee is being produced annually, and a large amount is utilized in confectionery, bakery and ready-to-eat foods (Jeyarani & Reddy 2005). Palm oil, which has a melting point between 33-39°C and IV of 50-55 has similar physical characteristics to vegetable ghee, and therefore does not require hydrogenation. In this context, palm oil is as a suitable alternative to hydrogenated fats.

MATERIALS AND METHODS

MATERIALS

PO (IV 50), POs (IV 30), POo (IV 55) and PKOo (IV 22) were obtained from local refineries. The oils were melted and mixed according to the formulations shown in Table 1. The products were poured into plastic tubs and kept at 5°C. They were later stored at room temperature for further analyses.

PHYSICO-CHEMICAL ANALYSES

IV**,** fatty acid composition (FAC), SMP, solid fat content (SFC), texture evaluation, PV, FFA and AV were determined according to MPOB Test Methods (2005). X-ray diffraction analysis was used to determine the polymorphic forms of fat crystals as described previously (Nor Aini et al. 1999). Appearance and consistency of vegetable ghee were noted by physical observation.

TABLE 1. Formulation of vegetable ghee

Oil Blend ratios					Code
Palm oil/palm stearin/palm olein (PO/POs IV 30/POo)					
80	:	10	:	10	A1
60	:	20	:	20	A2
40	:	30	:	30	A3
80	:	5	:	15	A4
Palm oil/palm stearin/palm kernel olein (PO/POs IV 30/PKOo)					
80	:	10	:	10	B1
60	:	20	:	20	B2
40	:	30	:	30	B3
80	:	5	:	15	B4

RESULTS AND DISCUSSION

Most of the vegetable ghee samples were granular (grainy) and had a shiny appearance. Samples in set B were more granular than those in set A. This characteristic grainy structure is very important in India, Pakistan, Bangladesh, and certain Middle Eastern countries. By comparison, vegetable ghee produced by Malaysian manufacturers are not as granular as those produced by Indian manufacturers. Malaysian consumers are more concerned with the flavour of the product.

IV of vegetable ghee in set A consisting of PO/POs/POo blends ranged from 51.1 to 52.4. On the other hand, vegetable ghee in set B containing PO/POs/PKOo had lower IV ranging from 39.9 to 48.7. The lower IV in set B was due to the FAC of PKOo which had more saturated fatty acids (i.e. C8:0, C10:0, C12:0 and C14:0) than POo present in set A samples (Table 2). These fatty acids were virtually absent in set A samples containing POo. The total saturated fatty acids in set A samples ranged from 49.1 to 53.0% while in set B it ranged from 53.9 to 62.7%. Samples in set A contained more unsaturated fatty acids,

TABLE 2. Fatty acid composition and iodine value of vegetable ghee samples

Code	Sample	Fatty acid composition (% wt)									Total saturated fatty acid	Total unsaturated fatty acid	Iodine value
		C8:0	C10:0	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	Others			
	PO/POs/POo												
A1	80:10:10	-	-	0.3	1.1	44.5	4.1	39.5	9.5	1.0	50.0	49.0	51.9
A2	60:20:20	-	-	0.3	1.1	46.0	4.2	38.2	9.3	0.9	51.6	47.5	51.1
A3	40:30:30	-	-	0.2	1.2	47.4	4.2	37.0	9.0	1.0	53.0	46.0	51.3
A4	80:5:15	-	-	0.3	1.1	43.5	4.2	39.5	10.5	0.9	49.1	50.0	52.4
	PO/POs/PKOo												
B1	80:10:10	0.5	0.4	4.5	2.4	42.1	4.0	36.4	8.6	1.1	53.9	45.0	48.1
B2	60:20:20	0.9	0.7	8.6	3.5	41.3	3.9	32.9	7.4	0.8	58.9	40.3	45.5
B3	40:30:30	1.4	1.1	12.9	4.8	38.7	3.8	30.0	6.6	0.7	62.7	36.6	39.9
B4	80:5:15	0.7	0.6	6.6	2.9	39.0	4.1	35.6	9.4	1.1	53.9	45.0	48.7

namely C18:1 and C18:2 (total unsaturated fatty acids ranged from 46.0 to 50.0%) compared to samples in set B (total unsaturated fatty acids ranged from 36.6 to 45.0%). The unsaturated fatty acids account for the higher IV of samples in set A.

Vegetable ghee sample A4 recorded the lowest SMP of 37.2°C followed by sample B4 (38.0°C) (Table 3). SMP of these two samples were lower than SMP of the hydrogenated commercial sample (38.5°C). Decreasing the amount of PO while increasing POs in the formulations resulted in higher SMP in both sets of samples A (37.2 to 46.8°C) and B (38.0 to 48.2°C).

X-ray diffraction analyses showed that samples A1 and B1 were in the ß' polymorphic form. Both of these samples contained 80% PO, 10% POs, and 10% of either POo (A1) or PKOo (B1). ß' crystalline form is predominant in set A samples (A2 and A3) while sample A4 contained equal amounts of ß' and ß. Set B samples also contained more ß' and ß polymorphic form, with the exception of B3 which exhibited a ß crystallinity.

The changes in PV during storage are presented in Figure 1. The results showed that there was an increase in PV for vegetable ghee samples during storage. Samples A4 and B4 showed significantly high initial (3.50 and 3.15) and final (13.70 and 14.00) PV compared to other samples. This was because they contained less stearin which made them less stable and easy to oxidize and form peroxides. Samples in set B generally were more stable to oxidation than those in set A. The initial PV of set A samples ranged from 0.70 to 3.50 while their final PV at 16 weeks of storage ranged from 10.00 to 13.70. In set B, the initial PV ranged from 0.30 to 3.15 while the final PV ranged from 7.50 to 14.00.

Changes in FFA content during storage of vegetable ghee samples are presented in Figure 2. FFA was lowest in samples A4 and B4 throughout storage. Their initial FFA levels were 0.06 and 0.08% while their final FFA levels were 0.12 and 0.13% respectively, the increases in FFA was 0.06% for sample A4 and 0.05% for sample B4. Although samples in set A were found to be less stable to oxidation than samples in set B, set A samples were generally more stable to hydrolysis than set B samples containing palm kernel olein. Hydrolysis which gives rise to FFA is less problematic in palm oil products than in palm kernel oil products. FFA liberated from a hydrolytic reaction oxidized at a faster rate than bound fatty acids, and could breakdown into methyl ketones, lactones and ester.

Aldehydes content in the samples were not constant during storage and fluctuation in the results indicated that

TABLE 3. Slip melting point and polymorphic form of vegetable ghee samples

Sample code	Sample	Slip melting point (°C)	Polymorphic form
	PO/POs/POo		
A1	80 : 10 : 10	39.2	ß'
A2	60 : 20 : 20	42.3	ß'>>>ß
A3	40 : 30 : 30	46.8	ß'>>ß
A4	80 : 5 : 15	37.2	ß' = ß
	PO/POs/PKOo		
B1	80 : 10 : 10	41.2	ß'
B2	60 : 20 : 20	47.3	ß'>ß
B3	40 : 30 : 30	48.2	ß
B4	80 : 5 : 15	38.0	ß'<ß
C	Commercial sample[a] (hydrogenated)	38.5	

[a]Godrej Vegetable ghee, manufactured by Godrej Food Limited, Mumbai, India

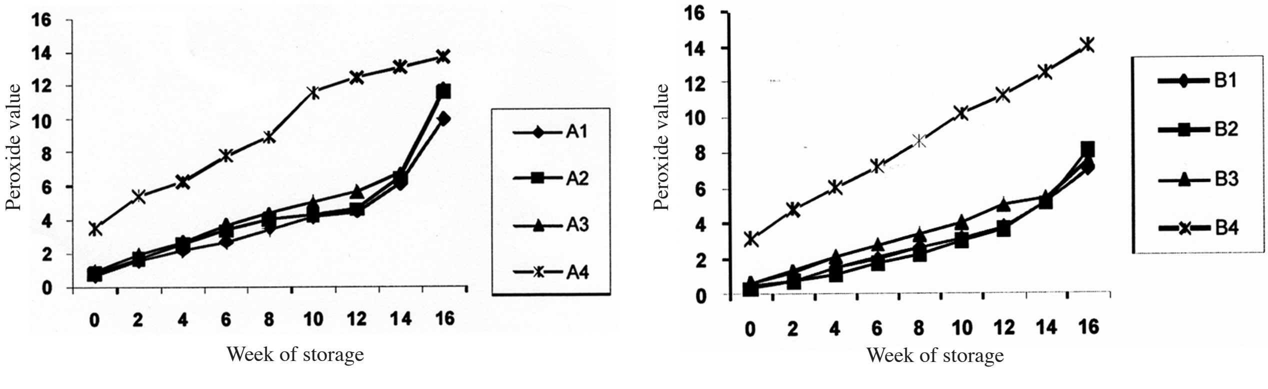

FIGURE 1. Changes in peroxide value with storage time

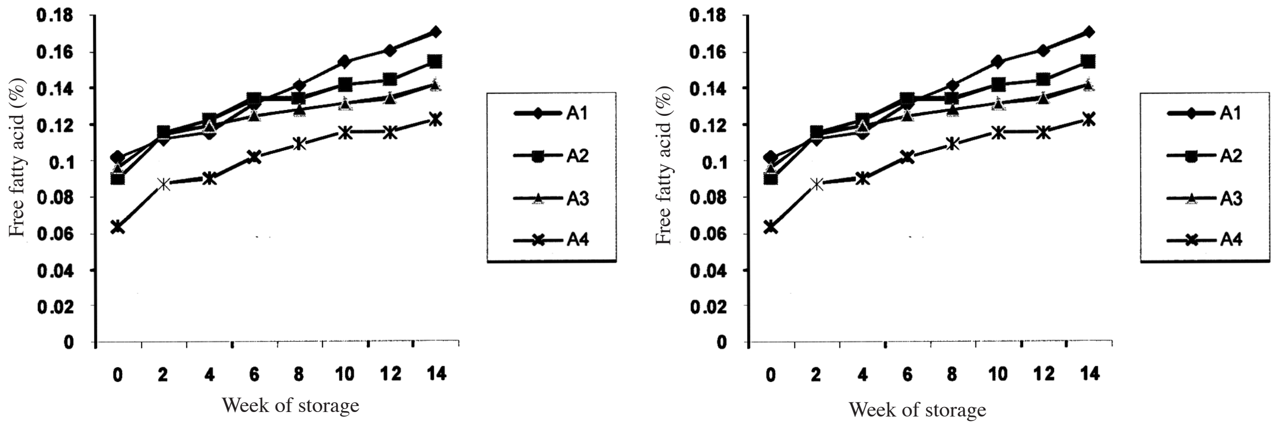

FIGURE 2. Changes in free fatty acid with storage time

there was no clear trend on the AV. Nevertheless, it was noted that AV was maximum in set A samples between week 4 to 8. For samples B2, B3 and B4, AV was maximum at a later time, between 12 to week 14.

Two out of nine samples of vegetable ghee were selected for sensory evaluation. The samples were A4 and B4. Samples A4 and B4 were selected because of their SMP which were within the range of Malaysian Standard (1984). *Roti canai* and *nasi minyak* cooked with samples A4 and B4 were rated as moderately good to very good. There was no significant difference in aroma, texture, taste and overall quality of *roti canai* heated with vegetable ghee A4 or B4 (Table 4). On the other hand, *nasi minyak* cooked with vegetable ghee A4 received significantly ($P<0.05$) higher score for aroma than that cooked with vegetable ghee B4 (Table 5). There was no significant difference between the samples in terms of texture, taste and overall quality. It was noted that the colour of *nasi minyak* cooked with sample A4 was more intense than that one cooked with sample B4.

TABLE 4. Sensory scores of *roti canai*

Sensory Attributes	*Roti Canai*	
	A4	B4
Aroma	7.07[a]	7.20[a]
Texture	6.73[a]	7.13[a]
Taste	7.07[a]	7.20[a]
Overall Quality	7.13[a]	7.27[a]

Evaluation Scale: 1 (extremely poor) to 9 (extremely good). Each value is the mean of 15 observations. Mean within each row with the same superscripts are not significantly different ($P > 0.05$)

CONCLUSION

Formulation has an effect on physico-chemical properties and quality of vegetable ghee. R*oti canai* and *nasi minyak* prepared with palm-based vegetable ghee were of good quality. Palm oil and palm products are good alternatives to hydrogenated fats for vegetable ghee production.

TABLE 5. Sensory scores of *nasi minyak* with vegetable ghee

Sensory Attributes	*Nasi Minyak*	
	A4	B4
Aroma	7.67[a]	6.73[b]
Texture	6.27[a]	6.87[a]
Taste	7.40[a]	6.93[a]
Overall Quality	7.67[a]	7.00[a]

Evaluation Scale: 1 (extremely poor) to 9 (extremely good). Each value is the mean of 15 observations. Mean within each row with the same superscripts are not significantly different ($P > 0.05$)

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I. Nor Aini*, H. Hanirah & C.H. Maimon
Malaysian Palm Oil Board
No. 6, Persiaran Institusi,
Bandar Baru Bangi
43000 Kajang, Selangor D.E.
Malaysia

S. Zawiah &Y.B. Che Man
Faculty of Food Science and Technology
Universiti Putra Malaysia
43400 UPM Serdang, Selangor D.E.
Malaysia

*Corresponding author; email: aini@mpob.gov.my

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