Studies on Bleachability of Palm Kernel Oil, Olein and Stearin: Optimum Conditions and Effects on Composition and Quality

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ABSTRAK

Keadaan optimum ujian penapisan pada skala kecil bagi 'Seed Crushers and Oil Procesors Association' *(SCOPA) telah diselidiki. Keupayaan bagi tiga jenis agen peluntur iaitu* WAC Supreme, Pure-Flo, SBE Gold *dan dua jenis agen penyahgaman iaitu asid fosforik dan air telah dibandingkan. Sampel yang digunakan adalah minyak isirong sawit mentah dan pecahannya. Selain itu, kesan agen peluntur dan agen pemyahgaman keatas kualiti dan komposisi, minyak tersebut turut dikaji. Didapati bahan peluntur SBE Gold mempunyai keupayaan meluntur yang paling berkesan jika dibandingkan dengan yang lain. Keputusan menunjukkan bahawa asid fosforik merupakan agen penyahgaman yang lebih baik daripada air. Di samping itu, suhu optimum dan dos agen bahan peluntur bagi proses pelunturan untuk produk isirong sawit adalah 95°C dan 0.5% masing-masingnya.*

ABSTRACT

The optimization of small scale refining for the Seed Crushers and Oil Processors' Association (SCOPA) was studied. The performance of three types of bleaching earths; WAC Supreme, Pure-Flo, SBE Gold and two types of degumming agents; phosphoric acid and water were compared. The samples used were crude palm kernel oil and its fractions. The effects of bleaching earths and degumming agents on quality and composition of these oils were also investigated. SBE Gold earth had superior adsorptive cleansing capability when compared with the other bleaching earths. Results showed that phosphopric acid was a better degumming agent compared to water. It was found that the optimum temperature and dosage of clay for the bleaching of palm kernel products were at 95°C and 0.5% respectively.

INTRODUCTION

Two oils of commercial importance are produced from the oil palm. Palm oil is derived from the mesocarp (flesh) of the fruit and palm kernel oil (PKO) from the kernel. The kernel contains between 46%-54% oil with an average of 50% (Tan, 1994). About 12 t of PKO are obtained for every 100 t of crude palm oil produced. As a lauric-rich oil, the chemical and physical properties of kernel oil are very different from those of palm oil and very close to those of coconut oil. PKO is thus readily interchangeable with coconut oil in a variety of applications. However, PKO has an advantage in certain toiletry applications as its lower content of C8 - C10 fatty acids (Chin, 1983) makes the products less irritable to human skin.

PKO consists of about 99% triglycerides. Minor components are partial glycerides, free fatty acids and non-glyceridic components. The properties of PKO are largely governed by its chemical composition which, in turn, relates to the nature of fatty acids present and their distribution in the glycerol molecules (Chong, 1989). As PKO contains about 82% saturated fatty acids, it is stable against oxidation (Tan, 1992).

Crude PKO contains many impurities and undesirable components such as phospholipids,

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fatty acids, oxidation products, trace metals, odiferous matter and pigments. Refining removes these components to produce a light colour, odourless and palatable oil for human consumption.

PKO can be refined either by chemical (caustic soda) or physical (steam) processes although the latter is more commonly used in Malaysia. Physical refining was first introduced to Malaysia in 1975 and has since gained popularity amongst local refiners (Gian *et al.*, 1983). The refining of PKO poses no special technical problem, as local refiners are experienced in palm oil processing. This is further facilitated by PKO's light colour and excellent oxidative stability. Due to its low content of carotene and presence of shorter chain fatty acids, PKO needs less bleaching and a lower temperature for deodorization (Tang, 1987).

In physical refining, the crude oil is subjected to pretreatment followed by deodorization and deacidification. The pretreatment, comprising degumming and earth bleaching, yields a bleached oil or pretreated oil. The bleached oil is then deodorized. Degumming can be described as gum conditioning by the addition of acid as the removal of any undesirable minor constituents and impurities does not occur until filtration after earth bleaching (Siew, 1982).

This work compares the efficiency of two degumming agents - water and phosphoric acid for pretreatment of PKO before SCOPA bleaching. The effects of dosage and pretreatment conditions on the final thermally bleached oil are also investigated. The Lovibond colour of the final oil was used as a quality criterion for pretreatment and bleaching efficiency.

EXPERIMENTAL PROCEDURES

Materials

The oils used in this study were crude palm kernel oil (CPKO), crude palm kernel olein (CPKOL) and crude palm kernel stearin (CPKST) obtained from a local producer.

Three types of bleaching earths, namely, WAC Supreme (WAC S), SBE Gold (SBE) and Pure-Flo (PF) used, were supplied by Southern Edible Oil Industry (M) Sdn. Bhd., Kapar, Selangor.

Commercial phosphoric acid of 85% concentration was used for degumming.

Pretreatment and Thermal Bleaching

Figure 1 shows schematically the steps involved in the SCOPA bleachability test. Melted crude PKO or its fractions was weighed into a 3-neck round bottom flask. Degumming was carried out with 0.02% phosphoric acid or 0.2% by volume of water. It was then heated to 105°C under a nitrogen blanket before bleaching earth was added. After 15 min agitation, the hot oil-earth mixture was filtered through a Buchner funnel using Whatman No. 1 filter paper. The bleached oil was subjected to heat bleaching at 240°C under 1 mm-2 mm Hg pressure for 30 min, and then cooled under vacuum to 60°C. The final colour of the thermally bleached oil was determined in a Lovibond Type E Tintometer fitted with a 5.25 in cell.

Analytical Methods for Quality Parameters

Iron, phosphorus, acid value, peroxide value (PV), fatty acid composition and triglycerides were measured according to the PORIM Test Methods (PORIM Test Methods, 1995). Oxidative stability was determined with the Rancimat instrument by the method of Laubi and Bruttel (1986) using 2.5 g of oil sample and a temperature of 110°C.

RESULTS AND DISCUSSION

Table 1 shows the quality data of CPKO, CPKOL and CPKST. CPKOL was darker than CPKO and CPKST. The phosphorus and iron contents of CPKST were higher than those of CPKO and CPKOL.

Figure 2 is a graph of the residual colour of thermally bleached palm kernel oil (TBPKO) against the dose of bleaching earth used. It shows that the Lovibond colour decreased with earth dosage. The bleaching earth dosage was taken as optimum when the colour of the final thermally bleached oil after the SCOPA bleachability test showed no further improvement. This occurred

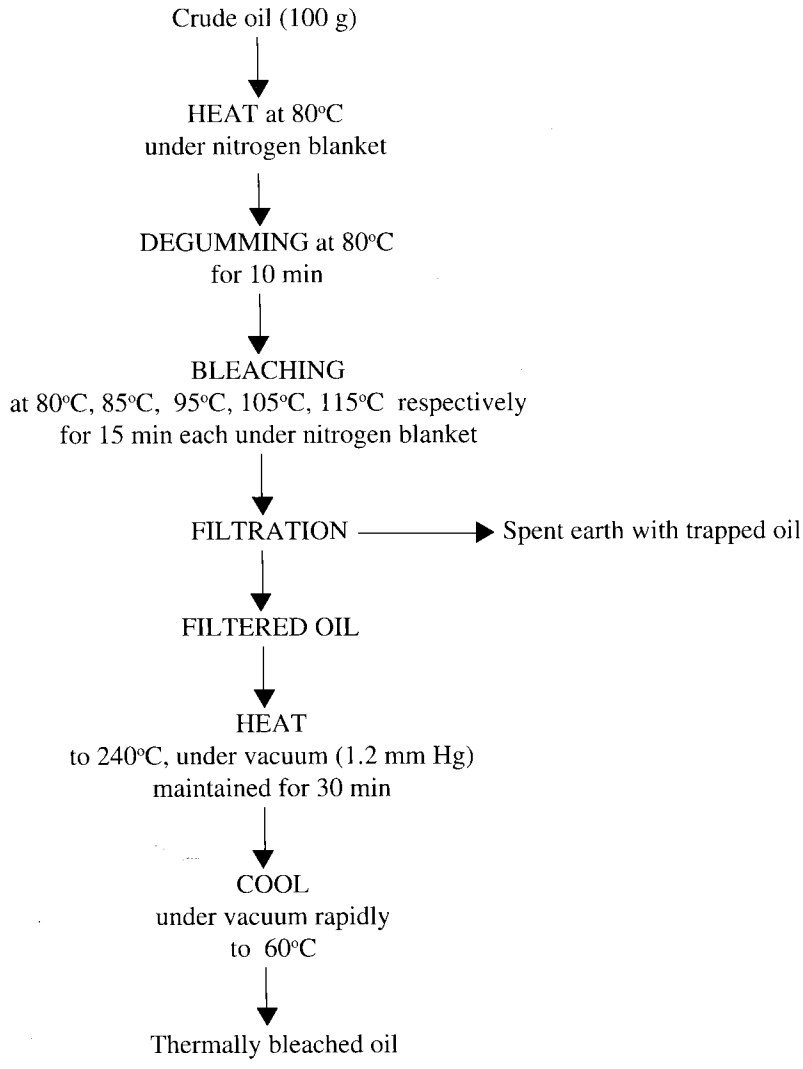

Figure 1. Flow chart of SCOPA bleachability test.

TABLE 1. QUALITY OF RAW MATERIALS

Sample	Lovibond colour (5.25" cell)		Fe (mg kg^{-1})	P (mg kg^{-1})
	R	Y		
CPKO	5.7	56	0.6	3
CPKOL	9.0	70	0.9	4
CPKST	4.1	79.9	1.2	5

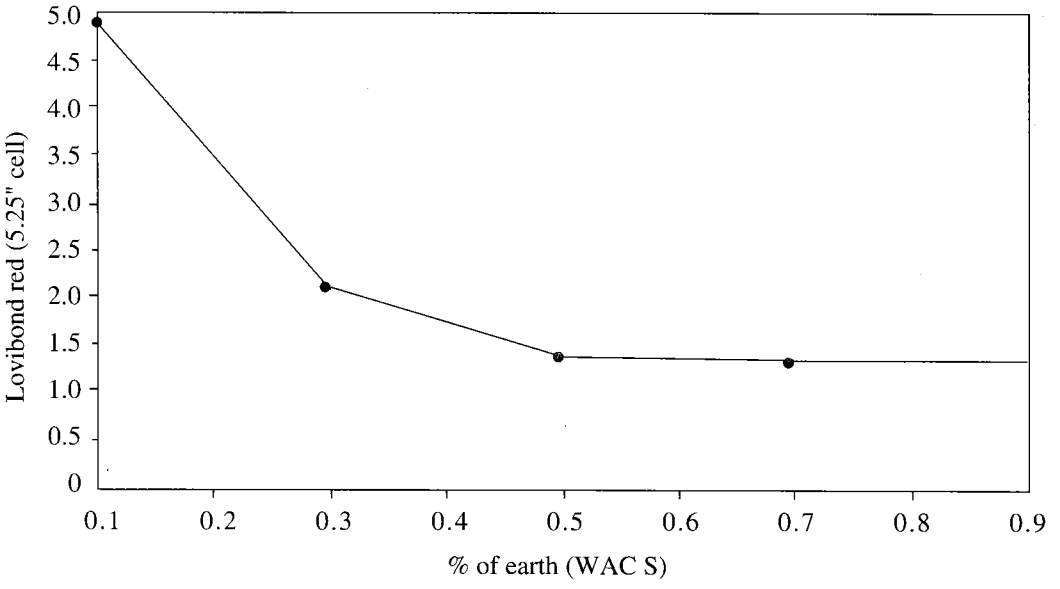

Figure 2. Colour of TBPKO versus dosage of bleaching earth.

at 0.5% bleaching earth. No further reduction was observed when the dose was increased. *Figure 3* shows the colour of the final oil after SCOPA bleaching versus temperature of the degumming process. With an increase in temperature, the colour of oil after SCOPA bleaching decreased to a steady value at 90°C. This was taken as the optimum bleaching temperature. The optimum conditions of 90°C and 0.5% earth dosage were used for all the other SCOPA bleachability tests for CPKO and its fractions.

Figure 4 compares the effectiveness of degumming and bleaching agents on the bleachability of PKO. Generally, degumming the crude oil with water or phosphoric acid and subsequent treatment with bleaching earth resulted in colour reduction. However, degumming with phosphoric acid gave a more noticeable colour reduction than with water. In SCOPA bleaching, the colour of earth-treated PKO was further reduced by thermal bleaching. When phosphoric acid was used as the degumming agent, SBE clay

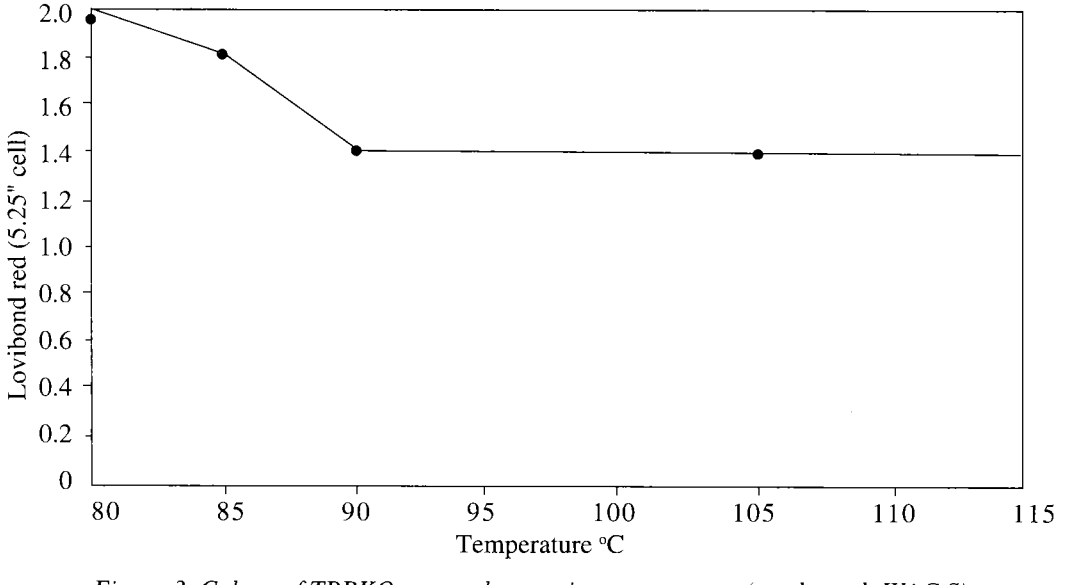

Figure 3. Colour of TBPKO versus degumming temperature (earth used: WAC S).

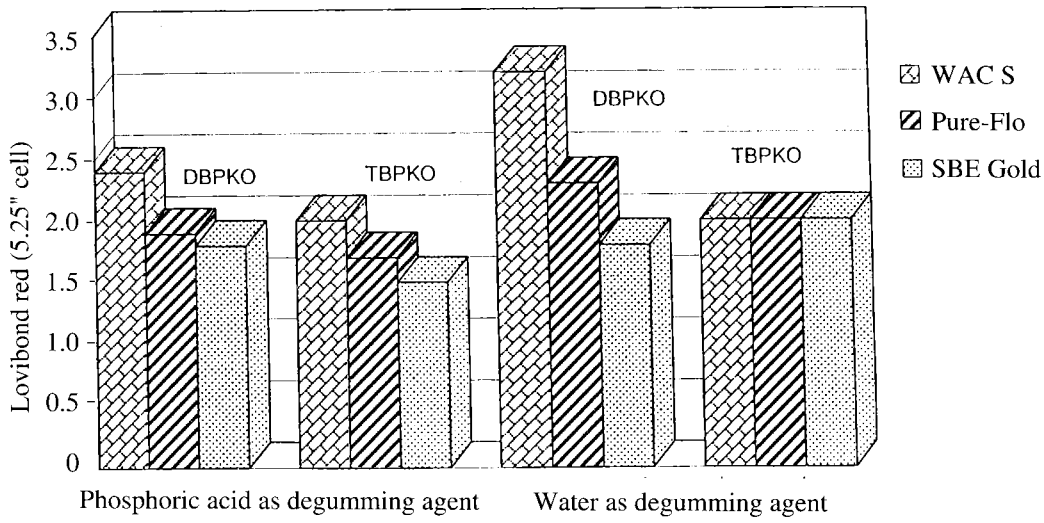

Figure 4. Effect of degumming and bleaching agents on the bleachability of palm kernel oil.

gave the lowest final Lovibond reading. In the case where water was used as degumming agent, the same was observed.

Figures 5 and *6* show the effectiveness of the degumming agents and bleaching clays in the bleaching of palm kernel olein (PKOL) and palm kernel stearin (PKST) respectively. The colour of CPKOL and CPKST was reduced after the pretreatment, in a similar manner to PKO. Thermally bleached palm kernel olein (TBPKOL) was lighter in colour after the thermal bleaching.

From *Figures 4, 5* and *6*, we concluded that degumming with phosphoric acid was better than degumming with water. SBE clay produced a better colour than WAC S clay and PF. The order of efficiency in terms of bleaching activity was SBE > PF > WAC S.

The PV (mg kg^{-1}) of CPKO, degummed bleached palm kernel oil (DBPKO) and TBPKO and its fractions are given in *Table 2*. The low, near zero, PV of the earth bleached oil indicated that the adsorbant clays were effective in removing hydroperoxides (primary oxidation product) from the crude oil. However, there was a slight increase in PV in the final oil after SCOPA bleaching possibly due to incomplete removal of hydroperoxides in the pretreatment stage. Thus, it is important to maintain a zero level of hydroperoxide at the pretreatment stage in order to avoid colour reversion in the deodorizer (Tang, 1988).

As indicated in *Tables 2, 3* and *4*, the free fatty acid (FFA) contents of CPKO, CPKOL and CPKST were 2.3%, 2.6% and 0.5% respectively. There were only slight reductions in the FFA contents after thermal bleaching.

Tables 2, 3 and *4* show the iron and phosphorus contents of PKO and its fractions. There were reductions of these elements by the pretreatment. The phosphorus contents of PKO and its fractions were 4 mg kg^{-1} or lower. The reductions showed that the bleaching earths were effective in absorbing phosphorus and iron from the crude oil. As iron is a pro-oxidant, it can catalyse the oxidation of PKO. Thus, a lower level of iron would help improve the oxidative stability of the oil.

Table 5 shows that CPKST had the longest Rancimat induction period compared to CPKOL and CPKO. This could be attributed to the fact that PKST has a higher content of saturated triglycerides making it more stable towards oxidation. The oxidative stability was further improved after thermal bleaching. Bleached PKO and PKOL, derived from treatment with phosphoric acid as a degumming agent, had better oxidative stabilities than those degummed with water.

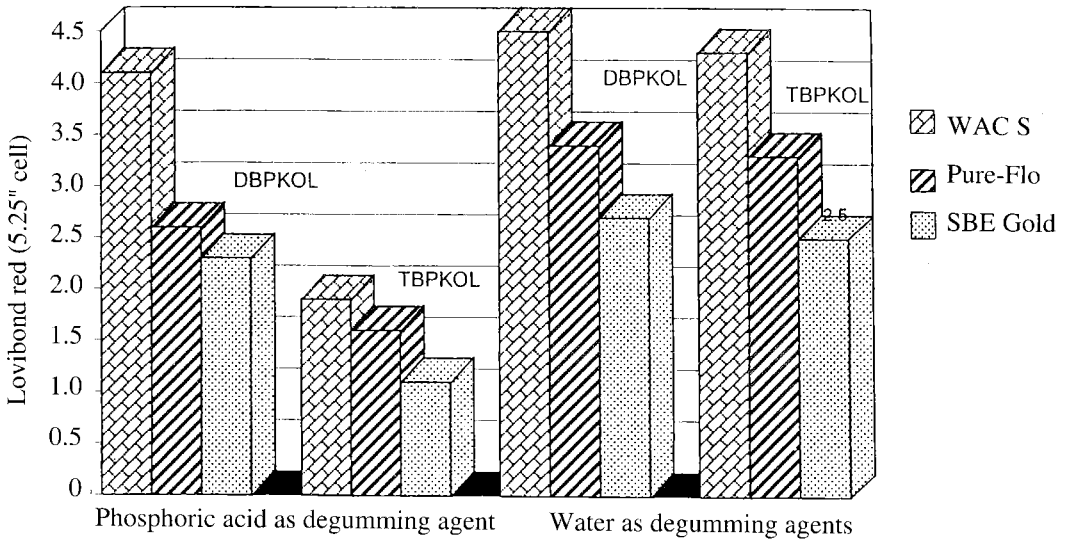

Figure 5. Effect of degumming and bleaching agents on the bleachability of palm kernel olein.

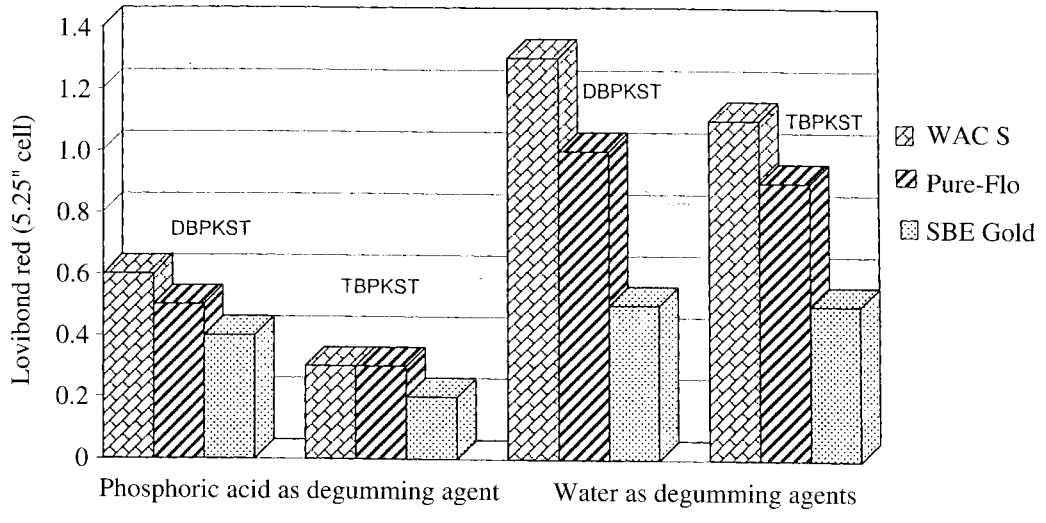

Figure 6. Effect of degumming and bleaching agents on the bleachability of palm kernel stearin.

Tables 6, 7 and *8* show the triglyceride compositions of PKO and its fractions, ranging from C28 to C56. PKOL had lower contents of C36 and C38 than PKO. As can be observed from the tables, there was no change in the triglyceride composition after refining.

Tables 9, 10 and *11* show the fatty acid composition (FAC) of PKO, PKOL and PKST. As indicated in *Table 9*, PKO is rich in lauric and myristic acids. It also contains a fair amount of short chain fatty acids (C8 - C10) which account for the soapy feel of hydrolysed PKO. *Table 11* shows that PKST has higher contents of C12 and C14 and lower contents of C8, C10 as well as C18:1 compared to PKO and PKOL (*Tables 9* and *10*). PKOL has low C12 and C14 but higher contents of C8, C10 and C18:1, . As a result, it is a liquid fraction. Data in *Tables 6, 7* and *8* suggest that refining does not affect triglyceride composition, while the data in *Tables 9, 10* and *11* show that there are insignificant effects on the FAC.

TABLE 2. QUALITY OF CRUDE PALM KERNEL OIL (CPKO), DEGUMMED BLEACHED PKO (DBPKO) AND THERMALLY BLEACHED PKO (TBPKO)

Sample code	PV (mg kg^{-1})	FFA (%) (as C12:0)	Iron PV (mg kg^{-1})	Phosphorus (mg kg^{-1})
CPKO	0.58	2.3	0.6	3
DBPKO-P/WAC S	0.09	2.3	0.4	2
TBPKO-P/WAC S	0.87	1.6	0.4	2
DBPKO-P/PF	0.09	1.7	0.6	2
TBPKO-P/PF	0.58	1.6	0.4	2
DBPKO-P/SBE	0.09	2.3	0.3	1
TBPKO-P/SBE	0.48	1.6	0.3	1
DBPKO-W/WAC S	0.09	1.9	0.4	1
TBPKO-W/WAC S	0.29	1.8	0.4	1
DBPKO-W/PF	0.09	2.3	0.4	1
TBPKO-W/PF	0.19	2.0	0.4	1
DBPKO-W/SBE	0.19	2.3	0.5	1
TBPKO-W/SBE	1.06	1.6	0.5	1

P - degummed with phosphoric acid.
W - degummed with water.
PKO - palm kernel oil.
WAC S - WAC Supreme.
PF - Pure-Flo.
SBE - SBE Gold.

TABLE 3. QUALITY OF CRUDE PALM KERNEL OLEIN (CPKOL), DEGUMMED BLEACHED PKOL (DBPKOL) AND THERMALLY BLEACHED PKOL (TBPKOL)

Sample code	PV (mg kg^{-1})	FFA (%) (as C12:0)	Iron (mg kg^{-1})	Phosphorus (mg kg^{-1})
CPKOL	0.39	2.64	0.9	4
DBPKOL-P/WAC S	0.00	2.57	0.3	2
TBPKOL-P/WAC S	0.95	2.00	0.3	2
DBPKOL-P/PF	0.09	2.63	0.4	3
TBPKOL-P/PF	0.48	1.03	0.3	2
DBPKOL-P/SBE	0.00	2.60	0.3	2
TBPKOL-P/SBE	0.00	1.29	0.3	2
DBPKOL-W/WAC S	0.09	2.58	0.5	2
TBPKOL-W/WAC S	0.29	2.01	0.5	2
DBPKOL-W/PF	0.09	2.60	0.4	2
TBPKOL-W/PF	0.30	2.10	0.4	1
DBPKOL-W/SBE	0.09	2.60	0.4	1
TBPKOL-W/SBE	0.38	1.76	0.5	1

P - degummed with phosphoric acid.
W - degummed with water.
PKOL - palm kernel olein.
WAC S - WAC Supreme.
PF - Pure-Flo.
SBE - SBE Gold.

TABLE 4. QUALITY OF CRUDE PALM KERNEL STEARIN (CPKST), DEGUMMED BLEACHED PKST (DBPKST) AND THERMALLY BLEACHED PKST (TBPKST)

Sample code	PV (mg kg^{-1})	FFA (%) (as C12:0)	Iron (mg kg^{-1})	Phosphorus (mg kg^{-1})
CPKST	0.20	0.5	1.2	4.9
DBPKST-P/WAC S	0.09	0.5	0.2	3
TBPKST/P/WAC S	0.09	0.1	0.2	3
DBPKST-P/PF	0.00	0.5	0.5	3
TBPKST-P/PF	0.00	0.1	0.3	3
DBPKST-P/SBE	0.00	0.5	0.4	2
TBPKST-P/SBE	0.00	0.1	0.5	2
DBPKST-W/WAC S	0.09	0.5	0.4	2
TBPKST-W/WAC S	0.09	0.1	0.5	2
DBPKST-W/PF	0.09	0.5	0.3	2
TBPKST-W/PF	0.09	0.1	0.4	2
DBPKST-W/SBE	0.00	0.5	0.4	1
TBPKST-W/SBE	0.00	0.1	0.4	1

P - degummed with phosphoric acid.
W - degummed with water.
PKST - palm kernel stearin.
WAC S - WAC Supreme.
PF - Pure-Flo.
SBE - SBE Gold.

TABLE 5. INDUCTION PERIOD OF OILS

Sample type	Induction period (hr)
CPKO	9.0
TBPKO-P/WAC S	17.7
TBPKO-P/PF	27.5
TBPKO-P/SBE	35.2
TBPKO-W/WAC S	4.6
TBPKO-W/PF	3.2
TBPKO-W/SBE	6.3
CPKOL	6.2
TBPKOL-P/WAC S	14.8
TBPKOL-P/PF	33.9
TBPKOL-P/SBE	27.0
TBPKOL-W/WAC S	2.7
TBPKOL-W/PF	2.6
TBPKOL-W/SBE	2.3
CPKST	25.6

Air flow : 20 ml^{-1} min^{-1}
Temperature : 110°C

TABLE 6. TRIGLYCERIDE COMPOSITIONS OF CRUDE PALM KERNEL OIL(CPKO) AND THERMALLY BLEACHED PALM KERNEL OIL (TBPKO) (%)

Sample code	C28	C30	C32	C34	C36	C38	C40	C42	C44	C46	C48	C50	C52	C54	C56
CPKO	0.3	1.3	6.5	8.5	21.1	16.1	9.7	9.0	6.9	5.4	6.4	3.1	2.5	2.8	0.2
TBPKO-P/WAC S	0.3	1.3	6.2	8.1	20.3	15.5	9.4	9.0	7.0	5.7	6.2	5.3	2.5	2.8	0.2
TBPKO-P/PF	0.3	1.3	6.3	8.3	20.7	15.8	9.6	8.8	7.1	5.8	6.3	3.9	2.6	2.8	0.2
TBPKO-P/SBE	0.3	1.3	6.4	8.3	20.7	15.8	9.6	8.8	7.1	5.8	6.0	4.1	2.5	2.8	0.2
TBPKO-W/WAC S	0.3	1.3	6.2	8.1	20.6	15.5	9.4	9.0	7.0	5.6	6.2	5.3	2.4	2.9	0.2
TBPKO-W/PF	0.3	1.3	6.4	8.3	20.7	15.8	9.6	9.0	7.1	5.8	6.0	4.0	2.5	2.8	0.2
TBPKO-W/SBE	0.3	1.3	6.4	8.4	20.8	15.8	9.6	8.9	7.1	5.7	6.3	4.0	2.5	2.7	0.2

TABLE 7. TRIGLYCERIDE COMPOSITIONS OF CRUDE PALM KERNEL OLEIN(CPKOL) AND THERMALLY BLEACHED PALM KERNEL OLEIN (TBPKOL) (%)

Sample code	C28	C30	C32	C34	C36	C38	C40	C42	C44	C46	C48	C50	C52	C54	C56	C58	C60
CPKOL	0.4	1.8	8.2	9.4	17.3	10.8	6.5	9.0	8.0	6.9	8.7	3.5	3.8	5.2	0.2	0.1	0.1
TBPKOL-P/WAC S	0.4	1.8	8.1	9.4	17.2	10.8	6.5	8.9	8.0	7.0	8.8	3.5	3.9	5.1	0.3	0.1	0.1
TBPKOL-P/PF	0.3	1.7	7.9	9.2	17.1	10.8	6.6	9.2	8.0	7.0	8.9	3.6	4.0	5.3	0.1	-	0.1
TBPKOL-P/SBE	0.4	1.7	8.0	9.2	17.0	10.7	6.5	8.9	8.1	7.1	9.0	3.6	4.0	5.3	0.2	0.1	0.1
TBPKOL-W/WAC S	0.3	1.7	8.0	9.3	17.2	10.8	6.6	9.0	8.1	7.1	8.9	3.6	3.9	4.9	0.2	0.1	0.1
TBPKOL-W/PF	0.4	1.7	8.0	9.2	17.1	10.8	6.6	9.0	8.1	7.0	8.8	3.6	4.0	5.2	0.3	0.1	0.1
TBPKOL-W/SBE	0.4	1.8	8.0	9.2	17.0	10.7	6.5	9.1	8.0	7.0	8.9	3.6	3.9	5.2	0.3	0.1	0.1

TABLE 8. TRIGLYCERIDE COMPOSITIONS OF CRUDE PALM KERNEL STEARIN(CPKST) AND THERMALLY BLEACHED PALM KERNEL STEARIN (TBPKST) (%)

Sample code	C28	C30	C32	C34	C36	C38	C40	C42	C44	C46	C48	C50	C52	C54	C56
CPKST	0.1	0.4	3.2	6.3	26.2	24.5	15.2	9.2	5.5	3.4	2.8	1.1	0.9	1.1	-
TBKST-P/WAC S	0.1	0.4	3.1	6.2	26.2	24.2	15.3	9.2	5.5	3.4	2.7	1.1	0.9	1.1	0.1
TBPKST-P/PF	0.1	0.4	3.1	6.1	26.1	24.6	15.4	9.3	5.6	3.4	2.7	1.0	1.0	1.1	0.1
TBPKST-P/SBE	0.1	0.4	3.1	6.2	26.1	24.5	15.3	9.4	5.5	3.4	2.7	1.1	1.0	1 .1	-
TBPKST-W/WAC S	0.1	0.4	3.2	6.3	26.6	24.9	15.5	9.3	5.6	3.4	1.4	1.1	0.9	1.1	-
TBPKST-W/PF	0.1	0.4	3.1	8.3	26.5	24.9	15.6	9.7	5.7	3.5	1.3	0.6	1.0	1.1	-
TBPKST-W/SBE	0.1	0.4	3.1	8.2	26.0	24.5	15.4	9.3	5.6	3.4	2.7	1.1	1.0	1.1	-

TABLE 9. FATTY ACID COMPOSITIONS OF CRUDE PALM KERNEL OIL (CPKO) AND THERMALLY BLEACHED PALM KERNEL OIL (TBPKO) (%)

Sample code	C6:0	C8:0	C10:0	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0
CPKO	0.3	3.4	3.2	48.5	16.8	7.8	2.0	15.1	2.6	0.1	TR
TBPKO-P/WAC S	0.3	3.3	3.1	48.5	16.9	7.9	2.0	15.1	2.5	0.1	0.1
TBPKO-P/PF	0.3	3.2	3.2	48.5	16.9	7.9	2.0	15.1	2.6	0.1	0.1
TBPKO-P/SBE	0.3	3.3	3.2	48.4	16.9	7.8	2.0	15.1	2.5	0.2	0.1
TBPKO-W/WAC S	0.3	3.2	3.1	48.3	16.8	7.9	2.0	15.2	2.6	0.2	0.1
TBPKO-W/PF	0.3	3.2	3.1	48.3	16.9	7.9	2.0	15.2	2.6	0.2	0.1
TBPKO-W/SBE	0.3	3.4	3.2	48.4	16.9	7.9	2.0	15.1	2.5	0.2	TR

TR = Trace.

TABLE 10. FATTY ACID COMPOSITIONS OF CRUDE PALM KERNEL OLEIN (CPKOL) AND THERMALLY BLEACHED PALM KERNEL OLEIN (TBPKOL) (%)

Sample code	C6:0	C8:0	C10:0	C12:0	C14:0	C16:	C18:0	C18:1	C18:2	C18:3	C20:0
CPKOL	0.4	4.6	3.6	43.6	13.2	8.2	2.3	20.4	3.6	TR	TR
TBPKOL-P/WAC S	0.4	4.6	3.6	43.5	13.2	8.4	2.3	20.3	3.5	TR	TR
TBPKOL-P/PF	0.4	4.5	3.6	43.4	13.2	8.3	2.3	20.4	3.6	0.1	0.1
TBPKOL-P/SBE	0.3	3.3	3.2	48.4	16.9	7.8	2.0	15.1	2.5	0.2	0.1
TBPKOL-W/WAC S	0.4	4.6	3.6	43.5	13.2	8.3	2.3	20.3	3.6	TR	0.1
TBPKOL-W/PF	0.4	4.5	3.6	43.5	13.2	8.3	2.2	20.4	3.6	0.1	TR
TBPKOL-W/SBE	0.4	4.5	3.6	43.5	13.2	8.3	2.3	20.4	3.6	TR	TR

TR - Trace.

TABLE 11. FATTY ACID COMPOSITIONS OF CRUDE PALM KERNEL STEARIN (CPKST) AND THERMALLY BLEACHED PALM KERNEL STEARIN (TBPKST) (%)

Sample code	C6:0	C8:0	C10:0	C12:0	C14:0	C16:0	C18:0	C18:1	C18:2	C20:0
CPKST	0.1	1.6	2.7	56.0	22.8	8.5	1.8	5.4	0.8	TR
TBPKST-P/WAC S	0.1	1.8	2.7	56.0	22.7	8.4	1.8	5.4	0.8	TR
TBPKST-P/PF	0.1	1.8	2.7	55.9	22.7	8.5	1.8	5.4	0.8	TR
TBPKST-P/SBE	0.1	1.8	2.7	56.0	22.8	8.5	1.8	5.3	0.8	TR
TBPKST-W/WAC S	0.1	1.8	2.7	55.9	22.7	8.5	1.8	5.3	0.8	0.1
TBPKST-W/PF	0.1	1.8	2.7	55.9	22.7	8.5	1.8	5.4	0.8	0.1
TBPKST-W/SBE	0.1	1.8	2.7	55.9	22.7	8.5	1.8	5.4	0.8	0.2

TR - Trace.

CONCLUSION

This study established that the optimum temperature and earth dosage for bleaching (on a laboratory scale) were 90°C and 0.5% by volume respectively. Phosphoric acid was a more efficient degumming agent than water. Triglyceride and fatty acid compositions were not affected by SCOPA bleaching. The efficiency of bleaching by the clays used was in the order SBE > PF > WAC S.

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