Characterization of Sludge Palm Oil

Nuzul Amri Ibrahim* and Ainie Kuntom*

ABSTRACT

A total of 12 analyses were carried out on sludge palm oil (SPO) to determine the most suitable parameters for characterizing this oil. The parameters usually employed for characterizing palm oil are free fatty acid (FFA) content, slip melting point, moisture and impurity content, iodine value (IV) and colour. All these parameters were found to be unsuitable for characterizing SPO as the variations were very high. Based on our studies on characterizing SPO, we conclude that DOBI value of 1.7 was the most suitable parameter as 85% of the SPO samples analysed had DOBI values below 1.7.

ABSTRAK

Sebanyak 12 analisis telah dijalankan ke atas minyak sawit keladak untuk menentukan parameter yang paling sesuai bagi tujuan pencirian minyak tersebut. Parameter yang kerap digunakan bagi tujuan pencirian minyak sawit ialah kandungan asid lemak bebas, takat lebur, kandungan lembapan dan bendasing, nilai iodin dan warna. Kesemua parameter tersebut didapati tidak sesuai untuk tujuan pencirian minyak keladak kerana data yang diperolehi mempunyai variasi yang besar. Daripada kajian kami, bagi tujuan pencirian minyak sawit keladak, nilai maksimum DOBI sebanyak 1.7 adalah didapati paling sesuai berbanding dengan parameter lain kerana 85% daripada sampel minyak sawit keladak yang dianalisis mempunyai nilai DOBI kurang daripada 1.7.

INTRODUCTION

Oil losses in a palm oil mill lower the oil extraction rate. Oil is lost in the sterilizer condensate and sludge separator discharge. These two waste streams are mixed in a sludge pit for oil recovery before discharge into the effluent treatment plant. The recovered oil is referred to as SPO, which is of lower quality than crude palm oil (CPO) due to its high FFA and moisture and impurity contents. SPO can be used for non-edible applications such as the production of laundry soaps, fatty acids and candles. Since it is a traded commodity, there is a need to characterize the oil so that it can be distinguished from CPO. Several studies related to characterization of SPO have been carried out. Ainie *et al.* (1995) characterized the oil by its moisture content (below 2%), FFA(5% - 45% as palmitic acid), peroxide value (PV) (1.36-21.81 meq kg^{-1}), IV (40.0-55.9), saponification value (173.8 - 197.9 mg KOH g^{-1} oil) and unsaponifiable matter (0.082% - 0.910%). Siew *et al.* (1989) recommended the use of a quality index, Y, to characterize CPO and SPO. The equation for Y is derived from the discriminant function (Tan *et al.*, 1982) which is based on the difference between Y_1 and Y_3 as shown below:

$$Y_1 = 47.76\,X_1 + 0.81\,X_2 + 17.74\,X_3 - 0.17\,X_4 - 86.69$$

$$Y_3 = 47.46\,X_1 + 0.18\,X_2 + 1.74\,X_3 - 0.30\,X_4 - 59.40$$

Where

Y_1 = CPO

Y_3 = SPO

X_1 = $E^{1\%}_{269}$

X_2 = Carotene content (ppm)

X_3 = DOBI

X_4 = PV (meq kg^{-1})

The final equation $Y_1 - Y_3$ which gives the quality index, Y, as deduced by Siew *et al.* (1989) is thus:

$$Y = 0.3\,X_1 + 16\,X_3 + 0.13\,X_4 - 27.23.$$

Based on a survey on 812 CPO samples, Siew *et al.* (1989) graded CPO and SPO according to their Y values as shown in *Table 1*. The study also found that a good correlation

* *Malaysian Palm Oil Board, P.O. Box 10620, 50720 Kuala Lumpur, Malaysia.*

between Y and DOBI was obtained with r^2 = 0.972. The good correlation was due to DOBI being the dominant factor in the calculation of Y.

Tan *et al.* (1982) reported that CPO can be distinguished from SPO by applying discriminant functions. In the same study, a DOBI of 1.3 maximum and a colour of 6R minimum were recommended to classify SPO meant for export. DOBI was selected to be the single quality specification due to its sensitivity and relationship to carotene content and ultraviolet absorption at 269 nm. The colour specification was included so as to exclude any refined or semi-refined product.

Siew *et al.* (1989) recommended a Y value of zero and below, which is equivalent to DOBI of 1.7, as the specification for SPO. However, the study was performed on CPO to grade the oil as excellent, good, fair and poor according to the Y values shown in *Table 1.* The oils with Y values of zero or below were graded as SPO or its equivalent quality. Therefore, the purpose of this study is to characterize SPO for trading purpose by using DOBI as the key parameter. The advantage of using DOBI is that one does not have to analyse the parameters, namely, $E^{1\%}_{269}$, DOBI and PV as required by Y to characterize the oil. This study evaluates the suitability of using a Y value of zero or below (DOBI < 1.7) as recommended by Siew *et al.* (1989) and also other parameters by performing various analyses on pure SPO samples for characterization.

MATERIALS AND METHODS

Materials

SPO samples were received through PORLA from various palm oil mills in Peninsula Malaysia. Of the 303 samples received in four batches, only 66 samples were analysed for 12 quality parameters. The rest of the samples were discarded from the study due to too much water content and solid particles. Samples with more than 15% water content were discarded from the study because they were considered as not true SPO samples. Furthermore, since the purpose of this study is to characterize the oil for trading purposes, we have to take the buyers' perspective into consideration. Buyers would like to buy SPO that contains as little water as possible. Some of the samples contained too much solid particles which were visible to the eyes. These could cause difficulties in filtration and, therefore, they were discarded too. The samples were collected from four sampling points, namely, storage tank, effluent pond, separator discharge and sterilizer condensate.

TABLE 1. CPO

Y	Grade
Below 0	SPO or its equivalent quality
1 – 10	Poor
11 – 20	Fair
21 – 25	Good
Above 25	Excellent

Source: Siew (1988).

Methods

The samples were analysed according to the PORIM Test Methods (1995) for moisture content, impurities, FFA, anisidine value (AV), IV, saponification value, colour, DOBI, carotene content, $E^{1\%}_{233}$ and $E^{1\%}_{269}$.

RESULTS

The results for the quality parameters of the SPO samples are shown in *Table 2.* CPO data are also included for comparison. The FFA content of the samples showed a very wide variation. The lowest value was 1.2% while the highest value was 86.7%, with a mean value of 36.4% and a standard deviation of 27.9%. The mean moisture content was 3.3% with a standard deviation of 3.6%. The range was 0.08% to 14.8%. The range obtained for impurities (non-soluble in n-hexane) was 0.05% to 12.9% with a mean value of 0.39% and a standard deviation of 1.7%.

The range of carotene for the SPO was 7.7 ppm to 678.2 ppm with a mean value of 241.4 ppm and a standard deviation of 200.1. The lowest DOBI value obtained was 0.02 and the highest was 3.16 which gave a mean value of 0.73 and a standard deviation of 0.92. As for the PV, the range was from 1.8 meq kg^{-1} to 41.4 meq kg^{-1}. Its average value was 9.4 meq kg^{-1} and the standard deviation was 8.0. Based on 53 samples, the range of AV was 0.7 to 39.2 with a mean value of 14.1 and a standard deviation of 9.4. Thirteen samples could not be analysed because of the difficulty in obtaining accurate absorbance readings. $E^{1\%}_{233c}$ and $E^{1\%}_{269c}$ were 4.3 and 1.3 respectively. The range of $E^{1\%}_{233c}$ was 1.2 to 8.3 with a standard deviation of 2.3, whereas $E^{1\%}_{269c}$ was 0.12 to 3.2 and its standard deviation was 0.8.

The lowest IV was 5.4 and the highest was

55.3, The average value was 42.8 with a standard deviation of 13.7. The range of saponification value was from 143.9 to 284.7 and its mean and standard deviation were 239.8 and 25.1 respectively. All the colour values obtained were in the red, yellow and blue regions, except for 12 samples which did not have blue readings. The mean value for each colour was 20.1 for red, 52.6 for yellow and 7.9 for blue.

DISCUSSION

SPO is considered to be of inferior quality compared to CPO. However, out of the 66 samples analysed, six of them had similar qualities as CPO in terms of carotene content (more than 500 ppm), DOBI (more than 2.3) and FFA (less than 5% as palmitic acid). This could be due to the fact that sizable amounts of freshly produced CPO was unintentionally discharged (lost) into the sludge pit due to machine breakdown, high wear and tear in machine parts (nozzles of centrifuges) or other operational problems which led to a spillage of CPO.

From *Figures 1* to *5*, it can be seen that a very wide range of results were obtained for each parameter. The results were subjected to statistical analyses by applying Kolmogorov-Smirnov (K-S) normality tests. According to the test:

i. A test that passed indicated that the data matched the pattern expected as if the data were drawn from a population with a normal distribution; and

ii. A test that failed indicated that the data varied significantly from the pattern expected as if the data were drawn from a population with normal distribution.

From our observation, almost all the laboratory analyses failed the K-S normality test because most of the data varied significantly from the normal distribution. This made characterization of the SPO almost impossible. There seemed to be very few dominating factors and among these few, DOBI seemed to be the most dominant. Based on the results of these analyses, it was observed that SPO samples had high FFA, moisture, impurities, PV, AV, $E^{1\%}_{233c}$, $E^{1\%}_{269c}$ and saponification values while generally low values were observed for carotene content, DOBI, colour and IV.

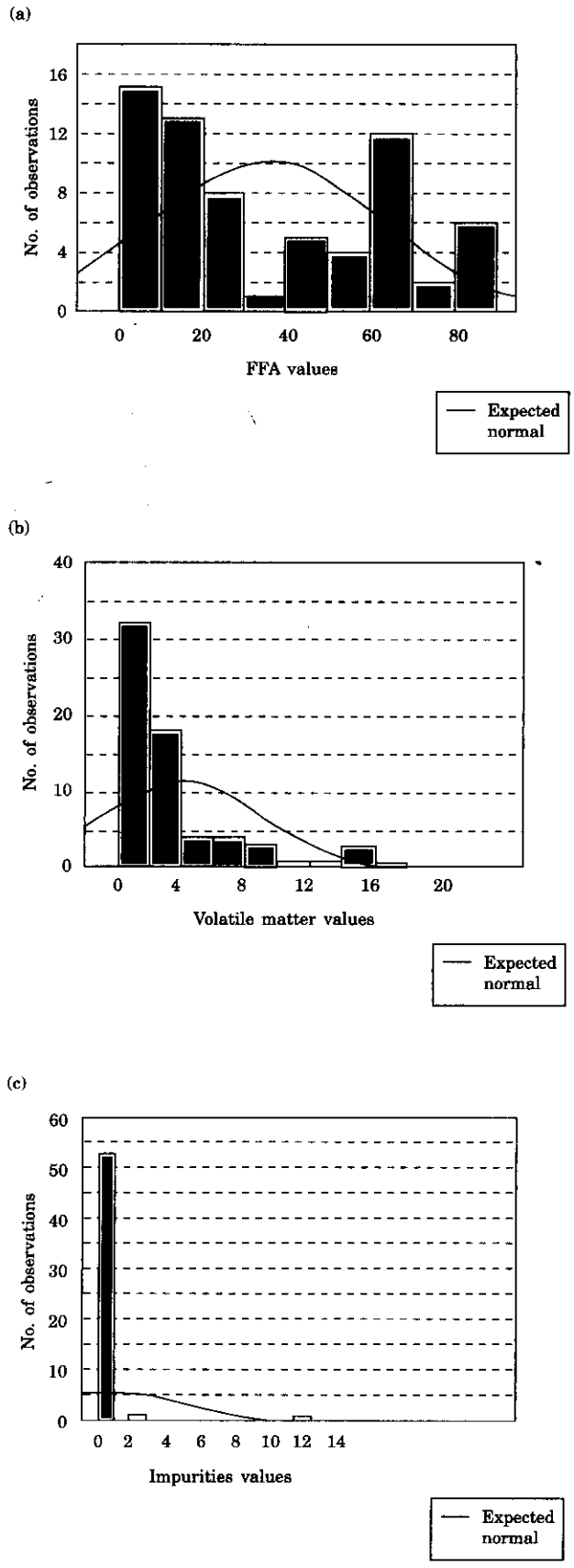

Figure 1. Distribution of FFA, volatile matter and impurities into various groups.

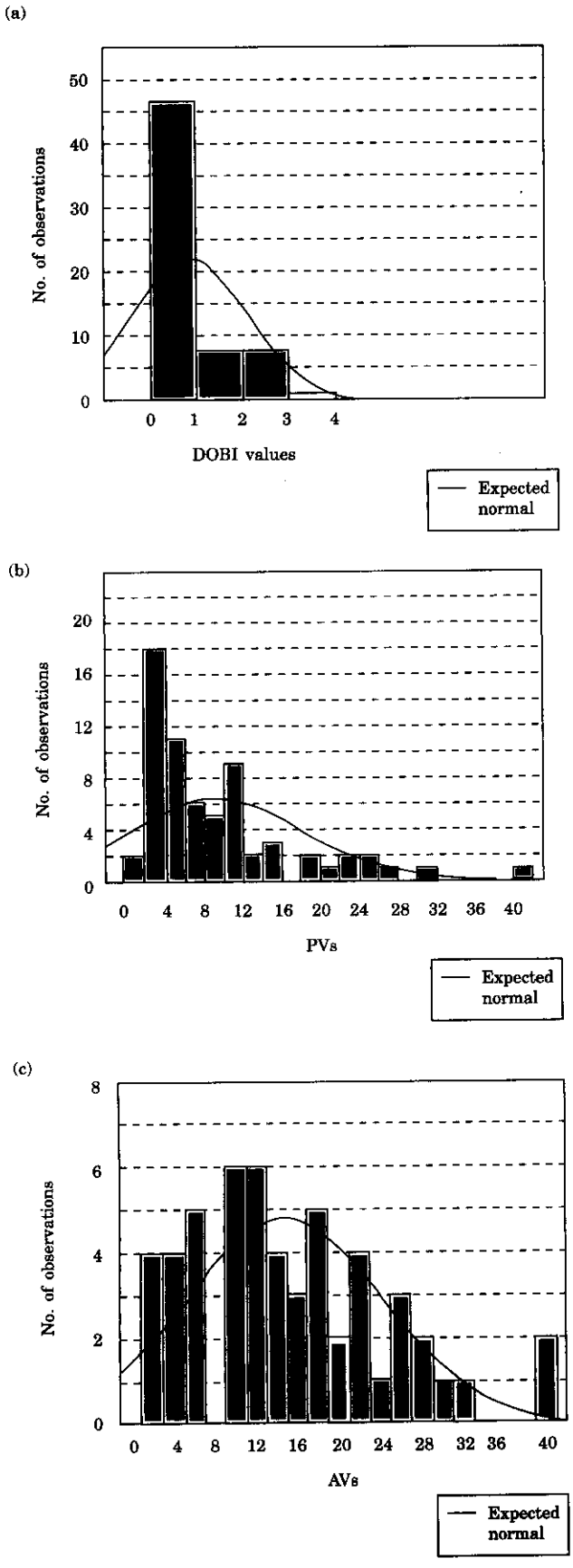

Figure 2. Distribution of DOBI, PV and AV into various groups.

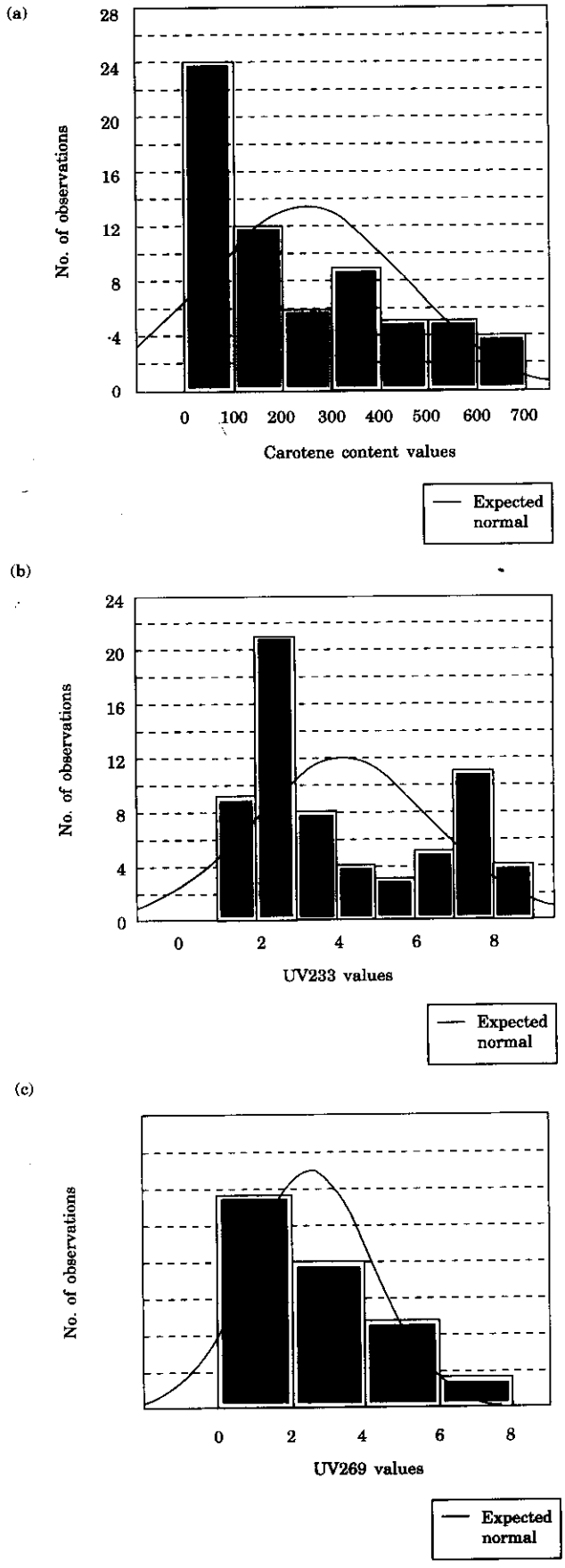

Figure 3. Distribution of carotene content, UV233 and UV269 into various groups.

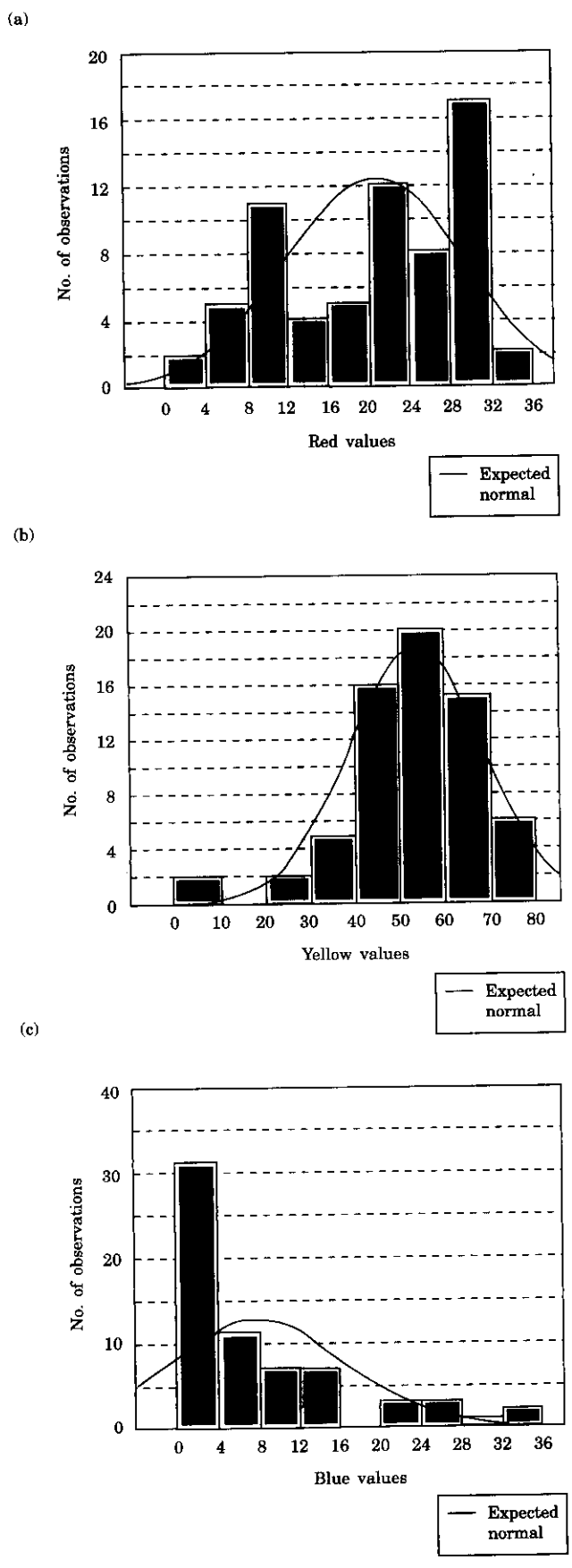

Figure 4. Distribution of colour into various groups.

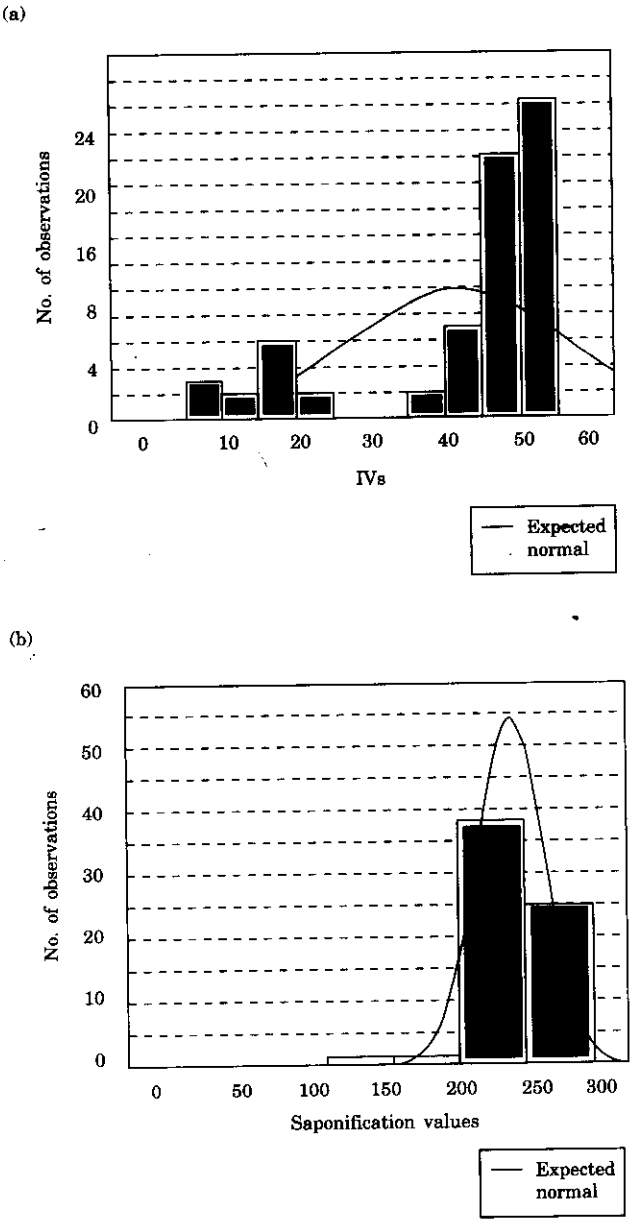

Figure 5. Distribution of IVs and saponification values into various groups.

If characterization of SPO was based on FFA, M&I and IV, the common parameters for palm oil, it would be very difficult to set the limit for each parameter due to the very wide range of results obtained. If the mean value for FFA, *i.e.* 36.4%, was taken as the minimum value for the characterization, only about 43% of the samples would be categorized as SPO (*Figure 1a*). IV was not suitable because 36% of the samples had similar IV as that of CPO (*Figure 5a*). Other parameters too were not suitable for specification of SPO, except for DOBI.

The study by Siew *et al.* (1989) recommended that oils with Y of less than zero should be categorized as SPO. From *Table 3*, it is found that the equivalent DOBI value is 1.7. As shown in *Table 2*, a wide range of DOBI

TABLE 2. QUALITY PARAMETERS OF SPO AND CPO

Parameter	SPO				CPO[a]
	Sample size(n)	Mean deviation	Standard	Range	Mean
Moisture content, %	66	3.3	3.6	0.08-14.79	0.18
Impurities, %	55	0.39	1.7	0.05-12.89	0.03
FFA, % as palmitic acid	66	36.4	27.9	1.18-86.66	3.2
AV	53	14.1	9.4	0.70-39.22	4.7
PV, meq kg^{-1}	66	9.4	8.0	1.77-41.36	0.7
IV	66	42.8	13.7	5.4-55.3	52
Saponification value	65	239.8	25.1	143.9-284.7	not available
Colour Red	66	20.1	8.9	1.0-34.1	not available
Yellow	66	52.6	15.0	2.7-75.6	not available
Blue	66	7.9	9.0	0.0-33.3	not available
DOBI	66	0.73	0.92	0.02-3.16	2.7
Carotene, ppm	66	241.4	200.1	7.7-678.2	582
$E^{1\%}_{233c}$	66	4.3	2.3	1.2-8.3	1.31
$E^{1\%}_{269c}$	66	1.3	0.8	0.12-3.19	0.3

Source: [a]Tan *et al.* (1999).

TABLE 3. CORRELATION BETWEEN Y AND DOBI

Y	DOBI
Below 0	Below 1.68 (1.7)
1 – 10	1.78 – 2.30 (1.8 – 2.3)
or 1 – 5	1.74 – 1.99 (1.8 – 2.0)
6 – 10	2.05 – 2.30 (2.1 – 2.3)
11 – 20	2.36 – 2.92 (2.4 – 2.9)
21 – 25	2.99 – 3.24 (2.4 – 3.2)
Above 25	Above 3.24 (3.3)

Source: Siew *et al.* (1989).

values was obtained, that is from 0.02 – 3.16. Out of 66 samples analysed, 85% of the samples had DOBI values of less than 1.7 (*Figure 2a*). The samples with DOBI greater than 1.7 could be fresh CPO lost from the milling process, which, if left longer in the effluent pond or sludge pit, would deteriorate further. We also checked the DOBI of the samples collected by Tan *et al.* (1982) and found that 87% of the 47 samples had DOBI of less than 1.7. This shows that the maximum DOBI value of 1.7 as recommended by Siew *et al.* (1989) is suitable to be used as the key parameter to characterize SPO.

CONCLUSION

DOBI appears to be the most useful parameter for characterizing SPO compared to the other parameters tested. For characterization, we recommend that SPO should have a maximum DOBI value of 1.7.

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