Journal of Oil Palm Research Vol. 11 No. 1, June 1999, p. 11-22

AN ACCURATE AND PRECISE METHOD OF DETERMINING OIL TO BUNCH IN OIL PALM

Keywords: Oil palm oil to bunch determination, accuracy and precision.

CHAN K S,* SOH A C* and CHEW P S*

*Applied Agricultural Research Sdn. Bhd.,
c/o P.O. Box Sg. Buloh, 47000 Sg. Buloh, Selangor, Malaysia.

This paper describes a simple oil balance method for the determination of oil to bunch (O/B) and kernel to bunch (K/B) whereby the tedious manual process of removing the mesocarp is eliminated by cutting the fruit longitudinally into two halves. After drying and removing the dried kernels, the dry mesocarp and shell are reduced into fine particles using an electric grinder which also homogenizes the sample leading to greater accuracy in oil determination. Comparison of this method with the routine Blaak's bunch analysis method showed that Blaak's method gave OIB results which were higher than those of the oil balance method by an average of 15% of the mean OIB. On the other hand, the OIB and KIB figures obtained by the oil balance method agreed closely with the mill oil and kernel extraction rates after taking into account harvesting and processing losses.

Linear regression analysis showed that OIB decreased as bunch weight increased mainly due to a decreasing oil content of the fruits.

The results of a sampling exercise verified that the oil balance method was accurate with the estimates differing from the true values by about 1% unit for OIB and 2% units for KIB. Greater precision was obtained with fruit samples taken from all the fruits which had been stripped from the spikelets after three days compared to fruits from intact spikelet samples taken on the first day. After quantification of the coefficients of variation (CV) of the bunch

component ratios, the CVs or precisions of estimating O/B and K/B using different sampling systems were computed.

INTRODUCTION

Oil to bunch (O/B) figures obtained by the hunch analysis method of Blaak *et al.* (1963) seldom agree with the oil extraction rates (OER) from palm oil mills even after allowing for oil losses during processing (Hor et al., 1996). Lim and Toh (1984) showed that Blaak's method tended to overestimate the O/B ratio due to positive systematic errors in the various bunch component ratios used to calculate it. To overcome bias introduced by the loss of moisture in every step of the analytical process, the authors proposed a method based only on the quantity of oil and kernel produced. This was expected to be better than the total mass balance method because weight discrepancies from moisture losses could be ignored. However, the technique is very time consuming and therefore impractical for large numbers of big bunches *as* a lot of work is involved in the manual depericarping of the very large number of fruits.

This paper describes a method for estimating the oil and kernel content of fruits based on the quantity produced and which eliminates the tedious manual depericarping process.

EXPERIMENTAL

Sampling and Testing Procedures

A schematic diagram of the sampling procedure is shown in *Figure 1*. The weight of the fresh fruit bunch (FFB) was recorded immediately after harvesting. The bunch was then chopped with an axe to separate the spikelets from the stalk. After discarding the stalk and debris, all the spikelets and loose fruits were thoroughly mixed and divided into four quarters. After weighing the quarters, an one eighth (1/8) sample (stratified random sampling based on spikelet size per stratum) was taken from each quarter and set aside. Three days later, all fruits from the four spikelet samples and the four quarters were stripped and weighed. The weight of all the fruits (three days old) divided by the weight of all the spikelets (initial weight) gave the fruit to spikelet ratio (F/S) of the bunch. An alternative sampling scheme *was* to sample fruits from all quarters when they had been stripped after three days of storage. Thus, the two fruit sampling procedures were: sampling fruits while they were still intact on the spikelets and sampling fruits stripped from spikelets after three days.

The fruits from each sample were cut into halves longitudinally and dried in an oven at 80°C overnight. After drying, the fruits were weighed to determine the dry fruit to fresh fruit ratio (DF/F). The kernels were then separated and weighed and the dry kernel to fruit ratio (DK/F) and the dry mesocarp and shell to fruit ratio (DMS/F) obtained. The dried mesocarp and shell from both halves of the fruits were ground in an electric grinder. Two test portions of about 10g each were taken and dried overnight to remove any remaining moisture. The oil to dry mesocarp and shell ratio (O/DMS) was determined using the Soxhlet extraction method.

Three experiments were carried out using this procedure.

Experiment 1: Comparison between Oil Balance Method and Blaak's Method in Estimating O/B and K/B

Twenty eight bunches of 10-20kg weights from different *dura* x *pisifera* (*DxP*) progenies were taken. After sampling for Blaak's bunch analysis determination, the remaining spikelets were used for the new procedure outlined above.

Experiment 2: Comparison between Oil Balance Method's O/B and K/B Estimates with Mill's OERs

Approximately, six bunches per week were harvested from commercial fields (Chemara *DxP*) planted in 1970-73 and 1976-77 and analysed with the Oil Balance Method from February to April 1996. The minimum ripeness standard for harvesting was one loose fruit per bunch and only undamaged bunches were used. All loose fruits were collected and included in

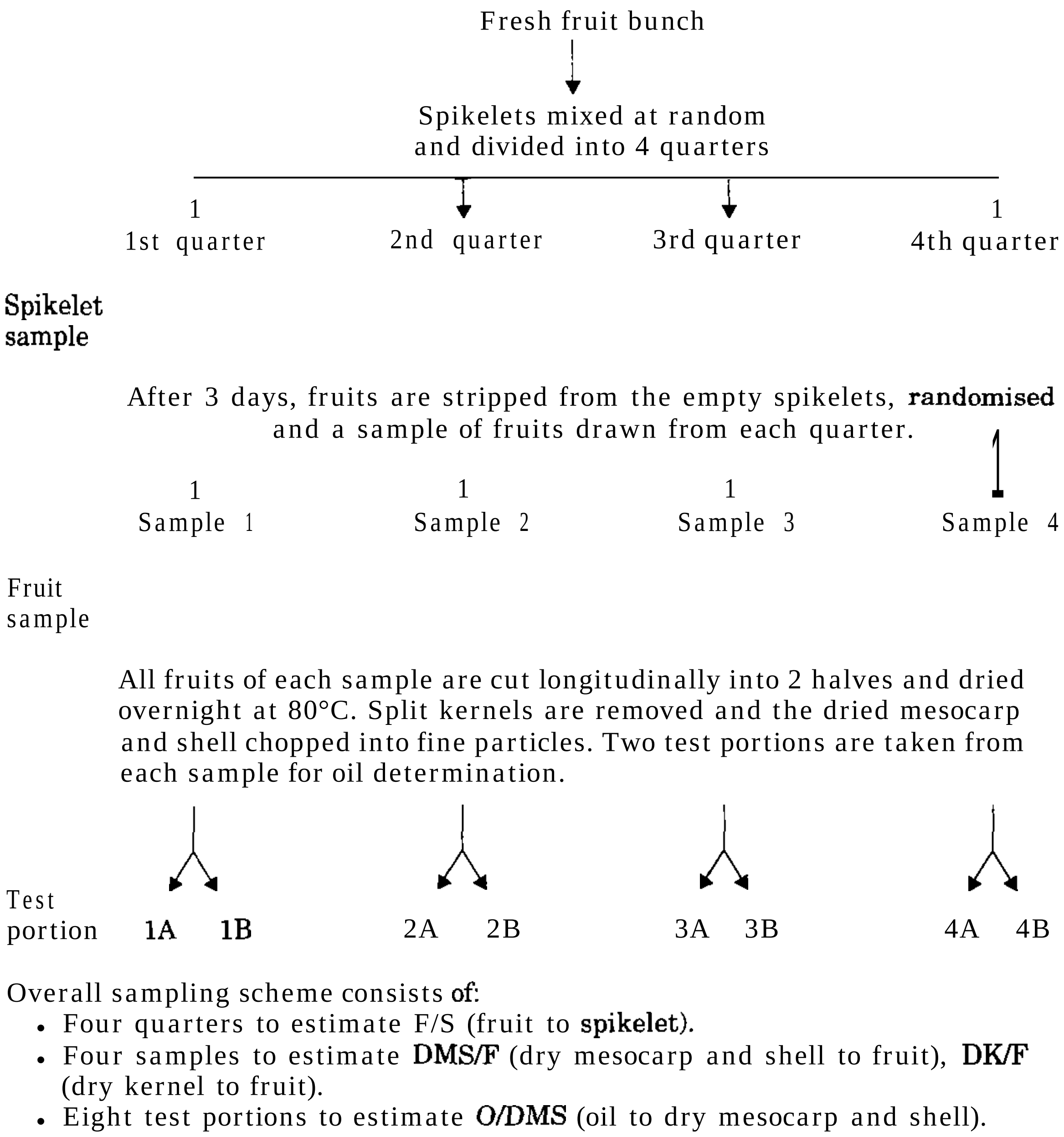

Figure 1. Sampling scheme for OIB determination.

the bunch weight. A total of 45 bunches with weights ranging from 26kg to 60kg was taken.

Experiment 3: Verifying the Accuracy of the Method

Another 21 bunches from the commercial plantings (Chemara *D* x *P*) were sampled from Tuan Mee Estate following the same fruit quality criteria. Bunch weights ranged from 17kg to 27kg. In addition to analysis of fruits from intact spikelet samples and detached fruit samples, the remaining fruits from all quarters were also analysed in order to determine the true values (from whole bunch) of the bunch component ratios.

RESULTS AND DISCUSSION

Experiment I: Comparison between Blaak's Method and the Oil Balance Method

The O/B results from Experiment 1 obtained by the Oil Balance Method (O/B_2) and Blaak's Method (O/B_1) are summarized in ***Table*** I. Blaak's Method produced higher O/B figures compared with the Oil Balance Method with differences ranging from -0.7% to 9.9% units. The mean difference of 3.3% units was very highly significant. In a similar exercise by Lim and Toh (1984), the difference was 3.7% units. In this exercise, mean O/B_1 exceeded mean O/B_2 by 15%. Linear regression analysis showed very highly significant regression between the two sets of O/B values with R = 0.856. The relationship between O/B_2 (y) and O/B_1 (x) was represented by the equation, $y = 2.57 + 1.034x$.

Experiment 2: Comparison between Oil Balance Method's O/B and K/B Estimates with Mill's OERs and KERs

The mean O/B_2 figure obtained from Experiment 2 is given in ***Table*** 2. In order to compare it with the mean OER at Tuan Mee Palm Oil Mill during the period, only bunches weighing 26kg to 40kg were used as their mean weight (35.1kg) was close to the mean bunch weight

TABLE 1. OIL BALANCE METHOD *VS.* BLAAK'S METHOD IN DETERMINATION OF OIL TO BUNCH (O/B) (Experiment 1)

	Bunch wt. (kg)	Oil balance method (x) % O/B_2	Blaak's Method (y) % O/B_1	Difference (y-x)
Range	10.4-19.7	14.9-29.5	16.5-33.9	-0.7-+9.9
Mean	13.8	22.1	25.4	3.3***
CV%	16.6	16.9	17.6	66.2
t paired value				8.0***
n=28				

* [illegible] 0.1% [illegible]
n = number of bunches.
cv% = coefficient of variation.

TABLE 2. OIL BALANCE METHODS O/B AND K/B ESTIMATES vs. MILLS OERs AND KERs (Experiment 2)

	Oil balance method			Mill results		
	Bunch wt. (kg)	O/B_2[a] %	K/B_2[b] %	Month	OER[c] %	KER[d] %
Mean	35.1*	22.6	7.00	Feb.	19.30	7.07
SE	0.64	0.50	0.20	Mar.	19.55	7.02
CV%	12.3	15.0	19.6	Apr.	18.79	6.77
n	45					

* excludes bunches > 40kg.
n = number of bunches.
cv% = coefficient of variation.
[a] O/B = oil to bunch.
[b] K/B = kernel to bunch.
S.E. = standard error of mean.
[c] OER = oil extraction rate.
[d] KER = kernel extraction rate.

of actual crop at the mill. According to Chan (1981), oil loss from mill processing averaged about 8% of the oil recovered. There was also the need to account for oil loss due from loss of loose fruits during harvesting. A factor of 0.855 is routinely used by IRHO (Institut Recherche pour les Huile et Oleagineux) to account for field and mill losses when converting laboratory O/B to mill OER. Multiplying the O/B_2 (22.6%) by 0.855 gave 19.3% OER which agreed closely with the mill figure. As for the K/B_2 figures, the mean value was similar to the mill KER even without correcting for losses because the moisture content of mill kernels was 5%-6% higher than that of dried kernels from the Oil Balance Method.

A linear regression of bunch weight (x) against its O/B_2 (y) showed highly significant regression with an R value of -0.426. Their relationship might be represented by the equation $y = 29.6 - 0.205x$. The negative regression coefficient means that O/B_2 (y) decreased as bunch weight (x) increased. O/B_2 was obtained from the product of fruit to bunch (F/B) and oil to fruit (O/F). There was no significant regression between bunch weight and F/B but a highly significant regression between bunch weight (x) and O/F (y) represented by the equation, $y = 50.44 - 0.362x$ with R value of *-0.482.* Thus, the phenomenon of lower O/B with increasing bunch weight could be explained by the decreasing oil content of the fruits as the bunch became larger. The decreasing oil content could be a consequence of thinner mesocarp or oil content in the mesocarp or both.

Experiment 3: Verification of Accuracy of Oil Balance Method

The accuracy of the Oil Balance Method was verified by comparing the estimated mean values of the bunch component ratios obtained from the samples against their true values from analysing the whole bunch. The data for DF/F, DMS/F and DK/F are shown graphically in *Figures* 2 to 7. The graphical representations and linear regression analyses appeared to indicate that fruit samples gave more accurate estimates of DF/F, DMS/F and DK/F than spikelet samples.

Comparison of the results in ***Table 3*** showed that for DF/F ratio, the mean value from the spikelet samples differed from the true value by 0.74% unit and the paired t test showed the difference to be highly significant. However for fruit samples, the difference was very small and not significant. Presumably when intact spikelets samples were removed from the bulk quarter for three days, they lost more moisture and produced a higher DF/F ratio. Also, it is better to sample stripped fruits, as a more representative sample is likely to be obtained.

For DMS/F, the mean difference for the spikelet samples was 0.19% unit and was slightly lower than the mean difference of 0.36% unit for the fruit samples. For DK/F, the mean difference for the spikelet sample was 0.22% unit but for the fruit samples, the mean difference was negative at -0.19% unit. As DF/F = DMS/F + DK/F and a positive mean difference was obtained for DMS/F, therefore a negative mean difference was expected for DK/F as the DF/F in fruit samples was rather constant. Examination of the standard deviation (SD) of differences showed that fruit samples gave a lower variation than spikelet samples. The lower SD led to significant t values for the difference between fruit sample mean and the true mean. However, the differences were small and acceptable.

Table 4 compares the true values of O/DMS% with values estimated from the two types of samples. The results showed very good agreement between the true O/DMS and the mean values estimated from spikelet and fruit samples as well as their test portions. The main reason for this close agreement could be the better homogenization of the dry mesocarp and shell by the grinding. Comparison of the standard deviations (SD) showed that the variation between samples/test portions in a bunch was lower in fruit samples than in spikelet samples, again probably due to the more representative nature of fruit samples.

Finally, the true oil to bunch (O/B,) and true kernel to bunch (K/B_2) were compared with their estimated values from fruit samples in ***Table*** 5. For the six bunches tested, the paired t values showed no significant difference

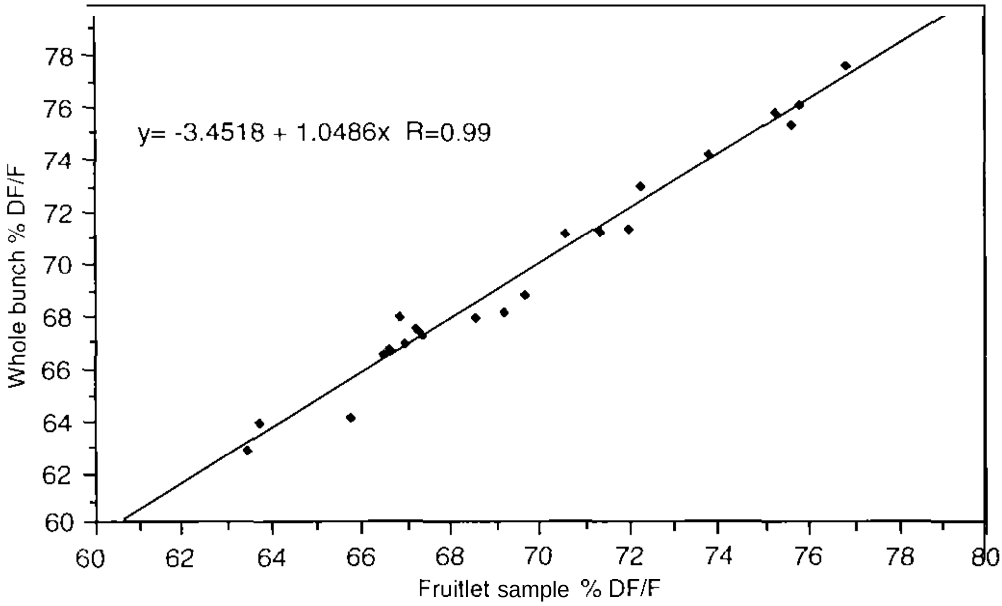

Figure 2. True value of % DFIF (dry fruit to fresh fruit) from ***whole bunch versus estimated value*** *from fruit* ***sample.***

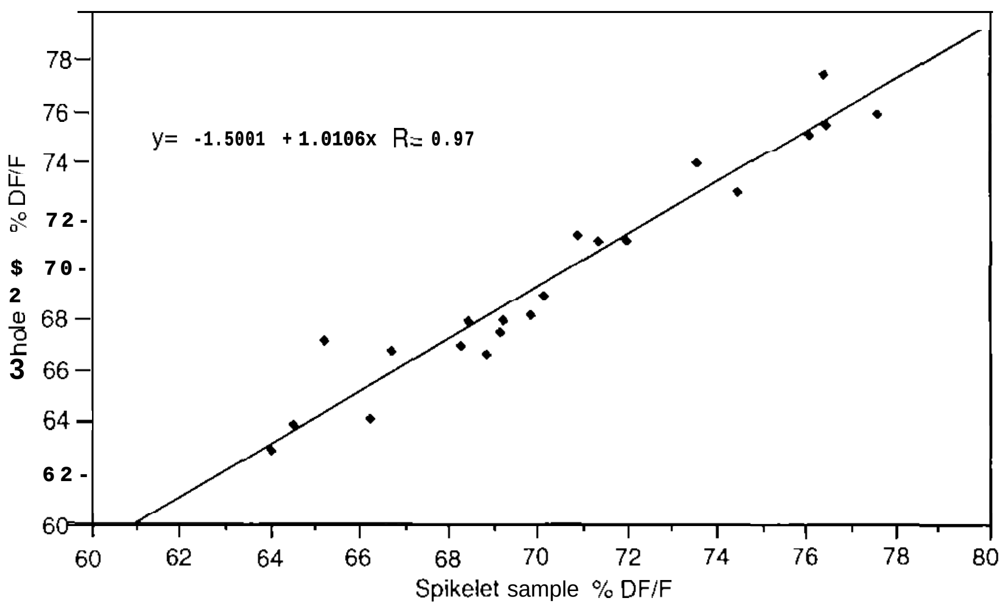

Figure 3. True value *of %* ***DF/F*** *(dry fruit to fresh fruit) from whole bunch* ***versus estimated value*** *from* ***spikelet sample.***

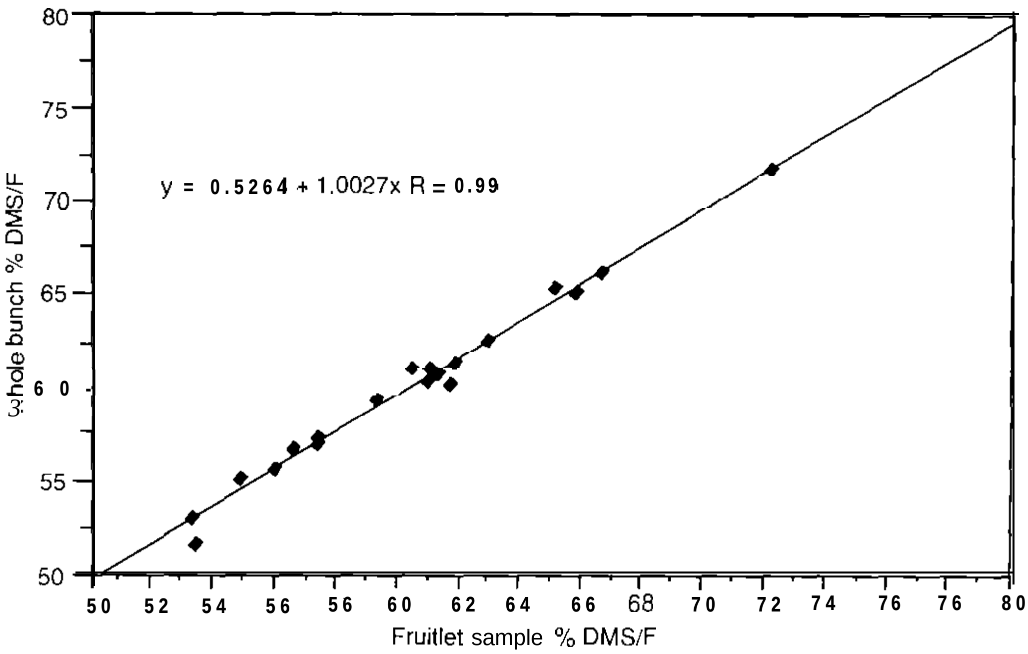

Figure 4. True value of % DMS/F (dry mesocarp and shell to fruit) from whole bunch versus estimated value from fruit sample.

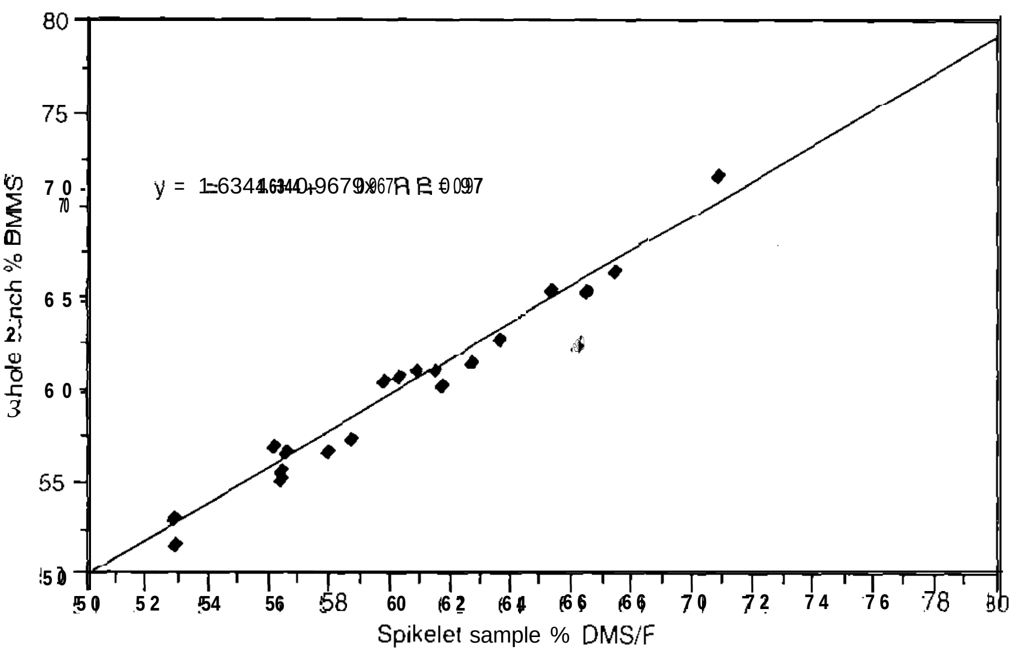

Figure 5. True value of % DMS/F (dry mesocarp and shell to fruit) from whole bunch versus estimated value from spikelet sample.

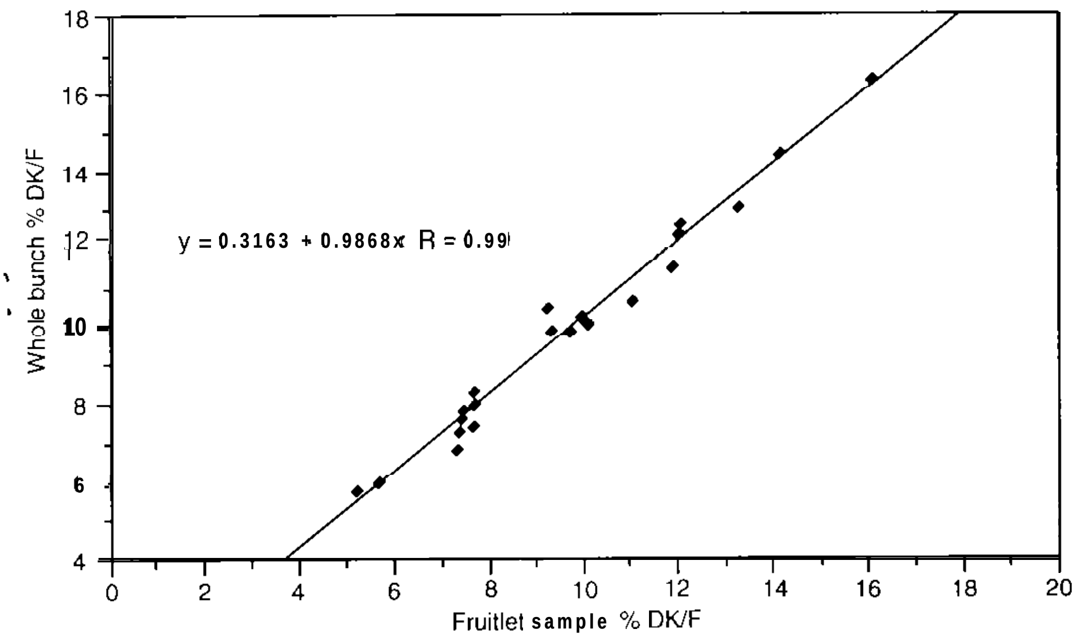

Figure 6. True value of % DKIF from whole bunch versus estimated value from fruit sample.

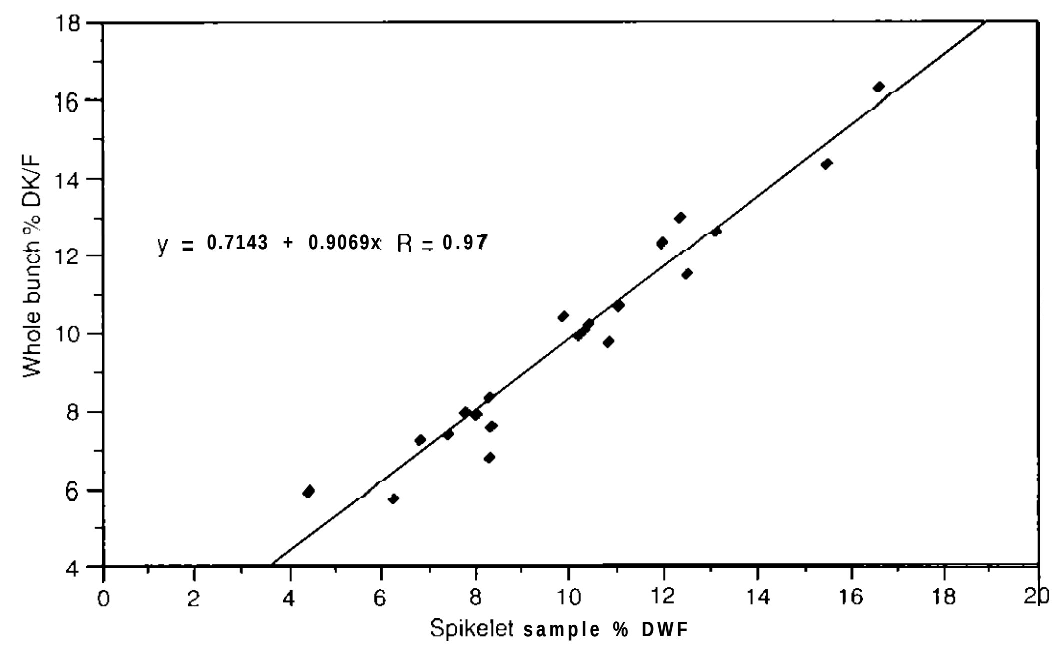

Figure 7. True value of % DKIF from whole bunch versus estimated value from spikelet sample.

TABLE 3. COMPARISONS OF THE DIFFERENCES BETWEEN THE TRUE VALUES OF FRUIT COMPONENTS AGAINST THEIR ESTIMATED VALUES DERIVED FROM SPIKELET AND FRUIT SAMPLES

	DF/F%[b] [a]True value = 69.65		DMS/F%[b] [a]True value = 59.85		DK/F%[b] [a]True value = 9.79	
	Spikelet sample	Fruit sample	Spikelet sample	Fruit sample	Spikelet sample	Fruit sample
Mean value	70.40	69.71	60.04	60.21	10.01	9.60
Mean difference[c]	0.74**	0.06	0.19	0.36**	0.22	-0.19*
S D (diff.)[e]	1.07	0.65	1.26	0.55	0.17	0.40
t paired value[d] n= 21	3.17**	0.42	0.73	3.08**	1.42	2.18*

n = number of bunches.
[a] True value = whole bunch value.
[b] DF/F = dry fruit to fresh fruit, DMS/F = dry mesocarp and shell to fruit, DK/F = dry kernel to fruit.
[c] Mean difference = mean value of samples - mean true value.
[d] * significant at 5%,** significant at 1% using t test paired.
[e] S.D. (diff.) = standard deviation of difference of means.

TABLE 4. COMPARISONS OF TRUE VALUES OF OIL TO DRY MESOCARP AND SHELL (O/DMS) WITH ESTIMATED VALUES OBTAINED FROM VARIOUS SAMPLES

Bunch No.	True value[a] % ODMS	Spikelet sample[b]		Spikelet test portion[c]		Fruit sample[d]		Fruit test portion[e]	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	65.7	65.7	0.43	65.7	0.78			n.d.	
2	66.0	66.0	0.75	66.2	0.72			n.d.	
3	72.6	72.6	0.53	72.1	0.93	72.6	0.27	72.9	0.50
4	67.1	67.4	0.41	67.2	0.45	67.0	0.22	67.3	0.40
5	53.0	52.3	1.40	52.8	1.40	52.8	0.69	53.3	0.54
6	66.5	66.7	0.20	67.3	0.94	66.8	0.18	66.5	0.29

Notes:
S.D. = standard deviation.
[a] Determined by extracting all dried mesocarp and shell of whole bunch.
[b] Mean of 4 spikelet samples taken from 4 quarters.
[c] Mean of 8 test portions taken from 4 spikelet samples.
[d] Mean of 4 fruit samples taken from 4 quarters.
[e] Mean of 8 test portions taken from 4 fruit samples.

between the true and estimated values of O/B_2 and K/B_2. The mean difference was + 0.3% unit for O/B_2 and -0.12% unit for K/B_2. In relative terms, they worked out to be + 1.3% and -1.9% of the mean true O/B_2 and K/B_2 respectively. In terms of accuracy, the Oil Balance Method appeared to be very good.

In other words, when a parameter is obtained by multiplying several components and the CVs of the individual components small, its CV is approximately equal to the sum of the CVs of the individual components. The CVs for estimating O/B and K/B using different sampling systems are summarized in ***Table 8.***

$$O/B = \left[\frac{\text{Total spikelet wt. (S)}}{\text{Bunch wt. (B)}} \times \frac{F}{S} \times \frac{DMS}{F} \times \frac{0}{DMS}\right] \times 100\% \quad (1)$$

$$K/B = \left[\frac{\text{Total spikelet wt. (S)}}{\text{Bunch wt. (B)}} \times \frac{F}{S} \times \frac{DK}{F}\right] \times 100\% \quad (2)$$

Since O/B and K/B were obtained by multiplying several components (Equations 1 and 2), the CV of each was calculated as follows:

Mean x, $x = x \pm t\ Sx$ where Sx = Standard deviation of x

Mean y, $y = y \pm t\ Sy$, where Sy = Standard deviation of y

t = normal deviate of desired probability

Mean xy, $xy = xy\ [1 \pm t\ (Sx/x + Sy/y) + t^2 Sx/x\ Sy/y$

$= xy\ [1 \pm t\ (CVx + CVy) + t^2 CVxCVy]$

When CVx, CVy are small, the equation can be approximated to

$xy \approx xy\ [1 \pm t\ (CVx + CVy)]$

So, $CVxy \approx CVx + CVy$

PRECISION OF SAMPLING AND TESTING

From the bunch analysis of 66 bunches weighing 17kg to 60kg in Experiments 2 and 3, the CVs of the bunch component ratios were determined (*Table 6*). For the estimation of fruit to spikelet ratio (F/S) from four quarters of the bunch, a finite population correction (Cochran, 1953) was used to correct the CVs in *Table* 7. With the CV of the bunch component ratios thus quantified, it was possible to compute the precision of estimating O/B and K/B using the equations as shown below.

Precision was satisfactory for O/B but poorer for K/B when one quarter of the bunch was used for estimation. Better precision was obtained when two quarters of the bunch were used.

CONCLUSION

The Oil Balance Method for the determination of O/B and K/B in fresh fruit bunches was found to give accurate results. Sampling of fruits from fruits stripped from the spikelets after three days gave a more representative sample than sampling of intact spikelets on the first day. Precision was satisfactory for O/B but poorer for K/B when one quarter of the

TABLE 5. COMPARISON OF THE TRUE OIL TO BUNCH (O/B) AND KERNEL TO BUNCH (K/B) AGAINST THEIR ESTIMATED VALUES DERIVED FROM FRUIT SAMPLES

Bunch No. & weight (kg)		O/B			K/B		
		True	Estimated	Difference	True	Estimated	Difference
1	17.32	24.5	25.1	0.6	6.30	6.04	-0.26
2	17.70	23.9	23.9	0.2	6.14	5.90	-0.24
3	23.51	23.3	23.0	-0.3	4.34	4.26	-0.06
4	20.10	26.5	27.1	0.6	7.80	7.70	-0.10
5	26.69	16.6	16.1	0.5	7.54	7.26	-0.28
6	25.30	24.0	24.2	0.2	6.46	6.70	-0.24
Mean		23.0	23.3	0.3	6.43	6.31	-0.12
(%)		(100)	(101.3)	(1.3)	(100)	(98.1)	(-1.9)
t paired value				2.1 n.s.			1.5 n.s

n.s. = not significant at 5% level.

TABLE 6. COEFFICIENTS OF VARIATION (CV) OF BUNCH COMPONENT RATIOS DERIVED FROM ANALYSIS OF SAMPLES FROM EXPERIMENT 2 AND EXPERIMENT 3

	DK/F[a]	DMS/F[b]	O/DMS[c]
Mean value	10.4	58.8	64.1
CV (%)			
Between bunches	24.9	7.8	10.2
Between samples	6.1	2.1	1.1
Between test portion			1.2

[a]DK/F = dry kernel to fruit, [b]DMS/F = dry mesocarp and shell to fruit.
[c]O/DMS = oil to dry mesocarp and shell.

TABLE 7. COEFFICIENTS OF VARIATION (CV) OF FRUIT TO SPIKELET (F/S) ESTIMATED FROM FOUR QUARTERS OF THE BUNCH AFTER FINITE POPULATION CORRECTION (FPC)

No. of quarters used for estimation	% CV after FPC'
1	1.94
2	1.12
3	0.65
4	0

'CV derived from analysis of variance = 2.24%.

$$\text{Corrected CV} = \frac{2.24}{\sqrt{n}} \times \frac{\sqrt{N-n}}{\sqrt{N}}$$

where N = 4 and n = No. of quarters used for estimation

TABLE 8. COEFFICIENTS OF VARIATION (CV%) FOR ESTIMATING INDIVIDUAL BUNCH AND FRUIT COMPONENTS USING DIFFERENT SAMPLING SCHEMES

F/S		DMS/F		O/DMS		DK/F		O/B*	K/B**
No. of quarters	CV %	No. of samples	CV %	No. of tests	CV %	No. of samples	CV %	CV %	CV %
1	1.94	1	2.10	2	1.39	1	6.10	5.43	8.04
2	1.12	2	1.48	4	0.98	2	4.31	3.58	5.43
3	0.65	3	1.21	6	0.80	3	3.52	2.66	4.17
4	0	4	1.05	8	0.69	4	3.05	1.74	3.05

* CV (O/B) = CV (F/S) + CV (DMS/F) + CV (O/DMS)
** CV (K/B) ≈ CV (F/S) + CV (DK/F)

bunch was used for estimation. Better precision was obtained when two quarters of the bunch were used. Comparison of O/B figures obtained by Blaak's Method and the Oil Balance Method showed that the former tended to give a higher estimate than that of the latter by an average of about 15%. The O/B and K/B values obtained by the Oil Balance Method appeared to agree closely with the mill oil and kernel extraction rates after taking into account harvesting and processing losses. Linear regression analysis showed that O/B decreased as bunch weight increased due to a decreasing *oil* content of the fruits.

It should be pointed out that this method gives accurate and precise estimates of the oil and the kernel contents in the bunch primarily of use *in* estimating mill extraction rates. The method does not give unbiased estimates of F/B, M/F, S/F, K/F and O/DM components which are of interest to the breeder in his palm selection for which Blaak's Method was originally intended. However with some modifications, it may be possible to adapt this method for routine plant breeding use.

ACKNOWLEDGEMENTS

The authors wish to thank the company, Applied Agricultural Research Sdn. Bhd. for permission to publish this paper and their colleagues for useful discussions. The cooperation of the Manager of Tuan Mee Estate and the advice on statistics by Mr. Chow Chee Sing of PORIM are gratefully acknowledged.

REFERENCES

BLAAK, G; SPARNAAIJ, L D and MENENDEZ, T (1963). Breeding and inheritance in oil palm. Part II. Methods of bunch analysis. *J. W. Afr. Inst. Oil Palm Res., 4:* 146-155.

CHAN, K S (1981). The estimation of mill oil losses. *The Selangor Planters' Association Journal 1981.*

COCHRAN, W G (1953). *Sampling Techniques.* John Wiley & Sons, Inc. New York.

HOR, T Y; SOH, A C; CHAN, K S; CHEW, P S and GOH, K J (1996). Studies on oil palm bunch characteristics' effects on oil extraction ratio. In *Proceedings of the International Conference on Oil and Kernel Production in Oil Palm -A Global Perspective.* (eds. Rajanaidu, N; Henson, I E and Jalani, B S). Kuala Lumpur. p. 229.255.

LIM, K H and TOH, P Y (1984). The accuracy and precision of bunch analysis. *Worksp. Proc. Palm Oil Res. Inst. Malaysia No. 8,* Kuala Lumpur. p. 91-109.