COMMUNICATION II
Moisture Determination of Cocoa Beans by Microwave Oven

ABSTRAK

Analisa statistik telah dijalankan antara kaedah menggunakan ketuhar mikrogelumbang dan kaedah menggunakan ketuhar udara panas (air-heated oven) untuk menentukan kandungan kelengasan dalam bijian koko. Didapati kedua-dua kaedah menunjukkan kejituan yang sebanding, tetapi kaedah menggunakan ketuhar udara panas memberi kejituan yang lebih baik. Masa yang diperlukan untuk mengeringkan bijian koko adalah lebih kurang 30 minit dalam kaedah yang dicadangkan berbanding dengan 16 jam dalam kaedah umum.

ABSTRACT

A statistical trial was conducted to compare microwave oven and air-heated oven methods for moisture determination of cocoa beans. The findings indicate that both methods are comparable in accuracy but better precision is obtained by the air-heated oven method. The time required for drying of cocoa beans is about 30 minutes by the proposed method as against 16 hours by the conventional technique.

INTRODUCTION

The main drawback in using moisture meters such as Protimeter Grainmaster and Aqua-Boy for moisture determination of cocoa beans is that they are not suitable for testing beans which contain high moisture, particularly in excess of about 12%. Thus their use for quick tests on cocoa beans is limited to beans at its final stage of drying and production beans.

In most of the modern cocoa factories in Malaysia, at the first stage of the drying process beans are required to be partially dried in circular driers to about 23 ± 2% moisture. (HMPB 1983) In order to monitor the moisture content of these beans, and in the absence of other acceptable methods, one has to resort to the conventional air-heated oven method. However, the procedure requires 16 hours of drying time and therefore does not allow fast feedback to management for effective process control.

The above shortcomings prompted the author to experiment with a drying method which would be satisfactory in terms of speed and accuracy of results. The microwave oven method is developed by Lim (1976) for drying of palm fruits products and subsequently, similar work by Tan & Lee (1982) confirms that the technique offers fast and accurate results. This paper describes the work undertaken to evaluate the suitability and speed of microwave oven for moisture determination of cocoa beans and its comparison with air-heated oven in terms of accuracy and precision. The studies are on fermented beans, *ex-circular* drier beans and production beans.

MATERIALS AND METHODS

Apparatus

For the air-heated method, a Memmert oven, Model 30 ul, electrically heated and thermostatically controlled, was used for moisture tests.

For the microwave method, a National Microwave/Convection oven, Model NE-7980 with an input power of 600 watts was used.

A dessicator with silica gel as a desiccant was used to keep samples dry while they were cooling.

A Moulinex grinder was used for grinding the cocoa beans. To ensure no overheating of samples due to heat friction, grinding was stopped every 5 seconds.

An A & D electronic balance, Model ER-180A, capable of weighing to 0.1 mg was used for weighing.

Petri dishes made of pyrex glass of size 90 x 20 mm depth were used to contain ground samples for moisture tests. The thickness of the bean layer in petri dish for drying was about 5 mm.

A L-shaped wire was fabricated for stirring purposes.

Drying Time

From the results of preliminary trials, the selected drying time using microwave oven was 4 x 5

minutes (4 times heating for 5 minutes each) with 3 minutes cooling intervals.

The power control was set to "High" for the drying. During the drying period, only one stirring with a L-shaped wire was required and that was after the second round of heating had been completed. For the air-heated method, the temperature was set at $103 \pm 2^{\circ}C$ and drying took 16 hours.

Sampling

To compared the means of moisture content of beans, (accuracy), each sample of about 50 grams was ground and divided into sub-samples of about 10 ± 1 g each. One sub-sample was dried in the microwave oven and the other sub-sample dried in the air-heated oven. There were six samples per batch of test and ten batches of tests were carried out for each type of bean.

To compare variations within samples (precision), 5 samples of cocoa bean of about 150 grams were taken and ground in a grinder. From each sample, twelve sub-samples of 10 ± 1 g were obtained, of which six sub-samples were dried in the microwave oven while the other six in the air-heated oven.

RESULTS AND DISCUSSION

The mean moisture content of the ten batches of fermented bean samples by microwave is 50.97% and 50.69% by air-heated method. The difference between them is statistically not significant as shown by the F-test (Table 1). This means that both methods are comparable in accuracy. The net variance of moisture content of sub-samples by microwave oven is 0.146% and by air-heated oven it is 0.042%; the difference between them is statistically significant at 95% confidence limit (Table 4). However, the variation within samples by microwave oven is still within acceptable limits as indicated by a coefficient of variation of 0.75%.

The mean moisture content of the ten batches of ex-circular drier beans by microwave is 23.57% and by air-heated oven is 23.54%; the difference between them is statistically not significant at the 95% confidence limit (Table 2). Thus both methods are comparable in accuracy. The net variance of the sub-samples by microwave and air-heated oven is 0.049% and 0.011% respectively. The difference between them is significant at 95% confidence limit (Table 5).

The microwave oven method gives significantly higher variation in moisture content within samples. However, the variation within samples by microwave oven technique is still very much within acceptable limits. The coefficient of variation within samples by the microwave oven method is 0.94%, which is very small indeed.

The mean moisture content of production beans determined by the microwave and air-heated methods is 7.23% and 7.49%, respectively. The difference between them is statistically insignificant (Table 3). Therefore both methods are

TABLE 1
Analysis of variance — Moisture content of fermented beans.

Source of variation	D.F.	S.S.	M.S.	F-Test
Between 10 batches of samples	9	13.9851		
Microwave oven vs air-heated oven	1	0.0218	0.0218	0.37*
Error	9	0.5233	0.0581	
Between 20 sets of samples	19	14.5302		
Within microwave oven	50	164.2389	3.2848	0.94*
Within air-heated oven	50	175.3544	3.5071	
Total:	119	354.1235		

* Not significant at 95% confidence limit.

DF — Degree of Freedom   MS — Mean square   SS — Sum of square

TABLE 2

Analysis of variance — Moisture content of ex-circular drier beans.

Source of variation	D.F.	S.S.	M.S.	F-Test
Between 10 batches of samples	9	212.0550		
Microwave oven vs air-heated oven	1	0.0327	0.0327	1.04*
Error	9	0.2834	0.0315	
Between 20 sets of samples	19	212.3711		
Within microwave oven	50	384.4143	7.6883	1.29*
Within air-heated oven	50	298.8001	5.9760	
Total:	119	895.5855		

TABLE 3

Analysis of variance — Moisture content of production beans.

Source of variation	D.F.	S.S.	M.S.	F-Test
Between 10 batches of samples	9	42.1699		
Microwave oven vs air-heated oven	1	0.0011	0.0011	0.09*
Error	9	0.1128	0.0125	
Between 20 sets of samples	19	42.2838		
Within microwave oven	50	48.1811	0.9636	0.98*
Within air-heated oven	50	49.0305	0.9806	
Total:	119	139.4954		

* Not significant at 95% confidence limit.

comparable in accuracy. The variance of moisture content is 0.015% by microwave and 0.003% by air-heated oven; the difference between them is statistically insiginificant at 95% confidence limit (Table 6). Nevertheless, the variation within samples by microwave oven is acceptable as shown by the coefficient of variation of 1.69% which is within acceptable limits.

Correlation coefficient values (Table 7) indicate a high degree of correlation between the two methods for the determination of moisture content of cocoa beans.

The repeatability or precision error of the test method would depend on the number of sub-samples tested. The expected precision errors using the two methods are tabulated in Table 8.

To obtain reproducible results, samples must be stirred well during the cooling intervals of the drying process. Our studies show that stirring of samples during the second cooling interval is adequate to give accurate moisture results.

To avoid the risk of burning the samples, good quality petri dishes made of pyrex glass should be used.

CONCLUSION

The results of the trial showed that the microwave oven method can be adopted for rapid determination of moisture content of cocoa beans. The accuracy of the proposed method is comparable to that by air-heated oven technique for moisture determination. Although better precision is obtained by the air-heated method, the precision of the proposed method is acceptable for process control purposes.

TABLE 4

Analysis of variance — moisture content of sub-samples of fermented beans.

| Source of variation | D.F. | | S.S. | | M.S. | | M.D. | | F-Test |
	Microwave	Air-heated	Microwave	Air-heated	Microwave	Air-heated	Microwave	Air-heated	
Between samples	4	4	311.6765	271.9478					
Within samples	25	25	3.6537	1.0595	0.1461	0.0424	0.3822	0.2059	3.45*
Total:	29	29	315.6537						

*Significant at 95% confidence limit.

TABLE 5

Analysis of variance — moisture content of sub-samples of ex-circular drier beans

| Source of variation | D.F. | | S.S. | | M.S. | | M.D. | | F-Test |
	Microwave	Air-heated	Microwave	Air-heated	Microwave	Air-heated	Microwave	Air-heated	
Between samples	4	4	300.5707	318.1897					
Within samples	25	25	1.2194	0.2614	0.0488	0.0105	0.2209	0.1025	4.67*
Total:	29	29							

*Significant at 95% confidence limit.

TABLE 6

Analysis of variance — moisture content of sub-samples of production beans

| Source of variation | D.F. | | S.S. | | M.S. | | M.D. | | F-Test |
	Microwave	Air-heated	Microwave	Air-heated	Microwave	Air-heated	Microwave	Air-heated	
Between samples	4	4	25.0723	25.9002					
Within samples	25	25	0.3696	0.0857	0.0149	0.0034	0.1221	0.0583	4.35*
Total:	29	29	25.4419	25.9859					

*Significant at 95% confidence limit.

TABLE 7

Correlations of moisture content obtained by
microwave oven and air-heated oven methods.

Type of sample	Linear Correlation Coefficient, r	Regression Equation
Fermented beans	0.968	$Y = 0.997X + 0.185$
Ex-circular drier beans	0.994	$Y = 1.017X - 0.431$
Production beans	0.997	$Y = 1.045X - 0.325$

X — % moisture by microwave oven method.
Y — % moisture by air-heated oven method.

TABLE 8

Repeatability or precision error in standard deviation.

Fermented Beans	Microwave oven	Air-heated oven
1 out of 6	0.38	0.21
2 out of 6	0.27	0.15
3 out of 6	0.22	0.12
4 out of 6	0.19	0.11
5 out of 6	0.17	0.09
6 out of 6	0.16	0.09
Beans ex-circular dryer		
1 out of 6	0.22	0.10
2 out of 6	0.15	0.07
3 out of 6	0.12	0.06
4 out of 6	0.11	0.05
5 out of 6	0.09	0.04
6 out of 6	0.09	0.04
Processed Beans		
1 out of 6	0.12	0.06
2 out of 6	0.08	0.04
3 out of 6	0.07	0.03
4 out of 6	0.06	0.03
5 out of 6	0.05	0.03
6 out of 6	0.05	0.02

1 out of 6 means to take 1 sub-sample from 6 for testing of moisture
content.

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