THE

New Guinea Agricultural Gazette.

RECENT EXPERIMENTS IN THE CURING OF NEW GUINEA CACAO.

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In a recent publication,* a broad description of the curing of cacao was outlined, based on observations made by the writer whilst in Trinidad, and was intended to act as a guide to planters in the Territory, until such time as curing experiments could be carried out in this Territory.

Through the courtesy of Mr. H. J. Washington, Kabaira Plantation, and Mr. W. R. Huntley, Vunakambi Plantation, it was possible to commence a series of fermentation and drying experiments.

Although the experiments are not yet complete, it is considered that the data available at present should be published, and are therefore embodied in this paper.

Fermentation.

Twelve experiments were conducted, the beans being fermented at varying depths, and for different periods.

One type of box, the "Vunakambi", was used for the first four experiments, and later, another type, the "Kabaira" was introduced, and the two types were used throughout the remaining eight experiments.

The "Kabaira" box measured 4′ x 3′ 10″ x 2′ and drainage holes $\frac{3}{8}$″ diameter were spaced at random in the floor. The "Vunakambi" box measured 5′ 5″ x 2′ 11″ x 1′ 9″, and had drainage holes in the floor $\frac{3}{8}$″—$\frac{1}{2}$″ diameter, spaced 3″—$3\frac{1}{2}$″ apart. Both types were constructed with sawn timber one inch in thickness.

The boxes were placed nine inches above ground level; in a large barn made of bush materials (limbom sides, sac-sac roof) with earth floor, a large opening in front, and two windows in each side.

Each box was scraped and thoroughly cleaned before receiving the beans, and no metal was allowed to come into contact with the mass during fermentation.

The beans were changed from one box to another every forty-eight hours, particular care being taken to ensure that the beans from the sides went into the centre, those from the top and bottom to the centre, and those from the centre to the sides, top, and bottom. A wooden "spatula", made by affixing the top of a "kerosene" case to a handle, was used for changing.

* E. C. D. Green.—"The possibility of developing an economic cacao industry in the Mandated Territory of New Guinea after a study of the industry in Trinidad, and a suggested policy for that development." *Bulletin*, No. 2, Department of Agriculture, T.N.G.

In all experiments the mass was covered with banana leaves, which were renewed after each "turning".

During fermentation, average temperatures were recorded in the centre, and at the sides of the mass, every twenty-four hours, also prior to and immediately after "turning".

The following table (No. 1) shows the box dimensions, depth of beans and period of fermentation, in respect to each experiment.

TABLE No. 1.

Experiment No.	Box Dimensions.	Depth of Beans.	Period of Fermentation.
			Hours.
1	5′ 5″ x 2′ 11″ x 1′ 9″	8″	120
2	5′ 5″ x 2′ 11″ x 1′ 9″	8″	144
3	5′ 5″ x 2′ 11″ x 1′ 9″	12″	120
4	5′ 5″ x 2′ 11″ x 1′ 9″	12″	144
5	5′ 5″ x 2′ 11″ x 1′ 9″	21″	144
6	4′ 0″ x 3′ 10″ x 2′ 0″	21″	144
7	5′ 5″ x 2′ 11″ x 1′ 9″	12″	156
8	4′ 0″ x 3′ 10″ x 2′ 0″	12″	156
9	5′ 5″ x 2′ 11″ x 1′ 9″	21″	156
10	4′ 0″ x 3′ 10″ x 1′ 9″	21″	156
11	5′ 5″ x 2′ 11″ x 1′ 9″	12″	162
12	4′ 0″ x 3′ 10″ x 2′ 0″	12″	162

In tables Nos. 2 and 3, the temperatures, recorded in each experiment every twenty-four hours, and the average temperatures during fermentation, are set out in degrees Fahrenheit.

In experiments Nos. 1, 3, 5, 6, 7, 8, representative samples of beans, taken from the centre, sides top and bottom of the mass were removed for drying, and fermentation of the remaining beans allowed to proceed.

Observations During Fermentation.

During the period of fermentation, observations were recorded every twenty-four hours in respect to appearance and colour changes in the beans and pulp.

In all instances the pulp was whitish when fermentation commenced, and at the expiration of the first twenty-four hours very little change in colour had occurred.

At the end of forty-eight hours the pulp was a very light brown, and the interior of the beans was dry and close textured.

After seventy-two hours the pulp had changed to light brown, a certain amount of bean swelling had taken place, and in experiments Nos. 5, 6, 9, 10, the interior of the bean was moist. There was a slight reduction in the original internal violet to purple colour, a reddish tinge being noticed, and the cotyledons had commenced to separate.

At ninety-six hours the pulp was a rich light brown colour, beans were very swollen. In experiments Nos. 5, 6, 9, 10, the beans were filled with a very light brown liquid, reddish tinge was pronounced, and separation of the cotyledons noticeable. In experiments 1, 2, 3, 4, 7, 8, 11, 12, the internal condition of the bean was similar to that at seventy-two hours in experiments Nos. 5, 6, 9, 10.

TABLE No. 2 (Centre of Mass).

Experiment No.	Hours.												
	0.	24.	48.	48.*	72.	96.	96.*	120.	144.	144.*	156.	162.	Average.
1	78	98	103.5	98.5	110	108	101	108	..	..	..	..	105.9
2	78	98	103.5	98.5	110	108	101	108	95	..	..	..	104.1
3	78	94	101	90	120	111	103	120	..	..	..	..	109.2
4	78	94	101	90	120	111	103	120	102	..	..	..	108
5	78	107.5	110	97	119	120	111	115	110	..	..	..	113.6
6	78	106	113	97	120	120	110	112	108	..	..	..	113.2
7	78	105	107	96	111.5	110	101	112	102	98	110	..	108.2
8	78	98	109	101	118	109.5	105	113	107	100	112	..	109.5
9	78	107.5	110	97	119	120	111	115	110	104	114	..	112.2
10	78	106	113	97	120	120	110	112	108	103	112	..	113
11	78	105	107	96	111.5	110	101	112	102	98	110	116	109.2
12	78	98	109	101	118	109.5	105	113	107	100	112	113	109.9

TABLE No. 3 (Sides of Mass).

Experiment No.	Hours.												
	0.	24.	48.	48.*	72.	96.	96.*	120.	144.	144.*	156.	162.	Average.
1	78	97	105	92.5	106	105	100	102	..	..	..	..	103
2	78	97	105	92.5	106	105	100	102	92	..	..	..	101.2
3	78	97	97.5	90	112	105.5	102	115	..	..	..	..	105.4
4	78	97	97.5	90	112	105.5	102	115	100	..	..	..	104.5
5	78	109	105	96	108	118	107	109	107	..	..	..	109.3
6	78	102	106	96	107.5	117	109	104	104	..	..	..	106.8
7	78	105	104	94	105	107	100.5	103	99	95	103	..	103
8	78	98	105	101	114	103.5	102	107	98	97	106	..	105.3
9	78	109	105	96	108	118	107	109	107	103	109	..	109.3
10	78	102	106	96	107.5	117	109	104	104	101	105	..	106.4
11	78	105	104	94	105	107	100.5	103	99	95	103	107	103.5
12	78	98	105	101	114	103.5	102	107	98	97	106	110	105.9

* Denotes after changing.

At one hundred and twenty hours the drying of experiments Nos. 1 and 3 was commenced, the pulp was a rich brown colour, beans were swollen, contained a small amount of light brown liquid, cotyledons were slightly separated, and the skin of the bean was taut. The beans in experiments Nos. 5, 6, 9, 10, contained a large amount of liquid which was slightly darker in colour than at ninety-six hours, the internal purplish colour had become a purplish-red to red, and the cotyledons were apart. The beans in the other experiments were similar to those in experiments Nos. 1 and 3.

After one hundred and forty-four hours the beans in experiments Nos. 2, 4, 5, 6, were removed for drying. Those in experiment No. 2 were mouldy, adhering to each other, pulp was a dark brown to black, and there was a musty aroma. In experiments Nos. 4, 5, 6, no mould was present, the beans were swollen, a large amount of pulp was adhering, purplish colour still pronounced, liquid slightly darker in colour.

At one hundred and fifty-six hours, when the beans from experiments Nos. 7, 8, 9, 10, were taken out to dry, those at a depth of 12" showed the same rich brown pulp colour as those at 21", but the liquid was a lighter brown, the cotyledons were not separated so much, and the purplish-red tinge was still present. The beans at 21" showed a reddish-purple internal colour, and the liquid was dark cinnamon to chocolate in colour.

After a hundred and sixty-two hours, when the beans from experiments Nos. 11 and 12 were removed for drying, the pulp colour was a rich brown, liquid being still a lightish colour; internally the beans were red to reddish-purple, and the cotyledons were well apart.

Loss in Weight Due to Fermentation.

Two experiments were conducted to ascertain the loss in weight during fermentation. The periods of fermentation were 156 hours and 162 hours, the depth of beans in experiment No. 9 (Table No. 1) was 21", and in experiment No. 11 (Table No. 1) 12", the "Vunakambi" type of box was used in both instances.

The following table No. 4 sets out the results obtained:—

TABLE No. 4.

Experiment No.	Original Weight Beans in Box.	Weight to Dry.	Loss in lb.	Per cent. loss.
	lb.	lb.		
9	1,036	876	160	15.44
11	681	583	98	14.39

Drying.

An improvised drying platform which could be covered with a tarpaulin, was constructed at the Government Demonstration Plantation, Keravat. All the beans fermented in experiments Nos. 9 and 11 were dried by the writer, but only representative samples were taken from the other experiments, the remainder of the beans being despatchd to Kabaira and Vunakambi Plantations.

The period allowed for drying was seven days, and this period was found to be sufficient.

During the first day of drying the beans were spread at a depth of two inches, and during the second, third and fourth days the depth was increased to three inches.

On the morning of the fifth day the beans were heaped and "danced", imparting a polish and removing the slight mould that had appeared on the fourth day. After "dancing", the beans were spread to a depth of 2" until noon, after which the depth was increased to 3".

During the sixth and seventh days, the beans were four inches deep.

Throughout the whole period of drying the beans were constantly turned, but not heaped during the night.

Table No. 5 shows the hours of sunlight and the times at which rain fell during the seven days of drying.

TABLE No. 5.

Day of Drying.	Hour placed to Dry.	Hour when Rain Commenced.	Period of Sun.	Remarks.
	a.m.	p.m.	hrs.	
1st	6	2	8	
2nd	7	2.30	7½	Light rain to 6.30 a.m.
3rd	7.30	1.30	6	Light rain to 7 a.m.
4th	6.30	1.45	7¼	Slight mould showing
5th	7	4	9	Beans "danced"
6th	6.30	..	10½	
7th	6.30	..	10½	Drying completed

At the expiration of drying, the percentage of under-fermented beans was calculated, observations were made in respect to the pulp and beans, and the loss of weight ascertained.

Table No. 6 shows the amount of under-fermented beans, and in Table No. 7 is set out the loss in weight during drying, and total loss in fermentation and drying.

TABLE No. 6.

Experiment No.	Per cent. Under-fermented.	Observations.
1 ..	14.68	Beans were very hard, number had germinated, those under-fermented were cheesy, purplish, astringent. Beans had a good external colour
2 ..	13.20	Beans were hard, number had germinated, those under-fermented were cheesy, purplish, astringent. Sample was a very bad colour externally
3 ..	10.72	Beans were hard, close textured, those under-fermented were astringent and purplish
4 ..	6.53	Big percentage of beans were hard when dry, good external colour
5 ..	2.10	Very few hard beans, no totally cheesy beans, good external colour, very little pulp
6 ..	2.22	Similar to Experiment No. 5
7 ..	1.47	Not much pulp, few hard beans, good external colour, no totally cheesy beans, slight purple tinge in the under-fermented beans, very slight astringency
8 ..	1.65	Similar to Experiment No. 7
9 ..	.92	Beans broke cleanly, good aroma, external colour good
10 ..	.94	Similar to Experiment No. 9
11 ..	1.08	Improvement on Experiments Nos. 7, 8, beans had a clean break, internal colour chocolate brown, slight astringency noticeable, aroma good
12 ..	1.14	Similar to Experiment No. 11

TABLE No. 7.

Experiment No.	Weight Beans to Dry.	Weight Dry Beans.	Loss in lb.	Per cent. Loss.	Total per cent. Loss Ferment, Drying.
9	876	477	399	47.83	63.27
11	583	318	265	45.45	59.84

Discussion.

Reference to Tables Nos. 2, 3, shows that when the cacao was fermented at a depth of 8", the average temperature recorded at the centre and sides of the mass was much lower than at 12" and 21"; also at a depth of 12", the temperatures were lower than at 21".

The difference in temperature between that at 8" and 12", was approximately the same as between 12" and 21".

Experiments Nos. 1, 2, indicate that a fermentation period of 120-144 hours, at a depth of 8" in the type of box used is insufficient, and, as shown by Experiment No. 2, when the average temperature at the end of 144 hours was less than that at 120 hours, the beans were black, mouldy, and had an offensive smell.

With the depth of beans at 12", and an average temperature in the centre and sides of 109.2 and 105.4 degrees respectively, and the fermentation period 120 hours (Experiment No. 3), the percentage of under-fermented beans was high, but the colour and smell was good, and mould was not evident. When the period was extended to 144 hours (Experiment No. 4), and an average temperature of 108 and 104.5 degrees respectively at the centre and sides was obtained the external colour of the pulp and beans was still good, no mould was present, although the percentage of under-fermented beans was still high.

In Experiments Nos. 7, 8, when the fermentation period was extended to 156 hours, the average temperature at the centre and sides was 108.2–109.5, and 103-105.3 degrees respectively. The beans were not mouldy, the external appearance was good, and the amount of under-fermented beans had been reduced to 1.47-1.05%.

When fermentation proceeded for another six hours (162 hours, Experiments 11-12), the average temperature at the centre and sides was still maintained, no mould appeared, the external colour was good, and the amount of under-fermented beans had dropped to 1.08–1.14%.

At a bean depth of 21", a fermentation period of 144 hours (Experiments 5, 6), and average temperatures at the centre and sides of 113.2–113.6, and 106.8–109.3 degrees respectively, no mould was present, external colour was good, and the under-fermented beans amounted to 2.19–2.22%, compared with 13.29% at 8", and 6.53% at 12".

When the beans at 21" depth were fermented for 156 hours, (Experiments 9, 10), with an average temperature at the centre and sides of 112.2–113.0, and 106.4–109.3 degrees respectively, no mould was present, the external bean colour showing at 144 hours had been maintained, and the amount of under-fermented beans was reduced to .92–.94%.

The data obtained up to the present, indicate that the average temperature, which appears to be correlated with the depth of beans relative to the dimensions of the box, is an important factor in fermentation. With a large box and a small amount of beans, the average temperatures obtained were low, and the percentage of under-fermented beans high, compared with the higher temperatures and larger quantities of beans.

Furthermore, after a period of 144 hours (Experiment No. 2), when a reduction in temperature of 13 degrees in the centre, and 10 degrees at the sides had occurred, thereby reducing the average temperature, the beans developed a bad external colour, an unpleasant odour, and mould.

At a depth of 12" in the two types of boxes used, it appears that either a longer period than 162 hours will have to be adopted, or the beans heaped during the first and second nights of drying.

In both types of boxes the depth of 21" gives good results, and if the beans were to be heaped during the first night of drying, the percentage of under-fermented beans would be further reduced.

Some modification is required if small amounts of beans are to be fermented successfully, and experimentation along the lines advised by Briton-Jones* is worthy of trial.

That a loss in weight does occur during fermentation and drying, has been proved on many occasions,(1). (2). (3). (4) and the figures obtained with New Guinea cacao are commensurate with those obtained elsewhere.

Summary and Conclusions.

Boxes of different dimensions were used, and varying depths of beans were fermented for different periods.

The greater the depth of beans, the higher were the average temperatures recorded.

A fermentation period of 120 and 144 hours, at a depth of 8"–12" was not successful with the type of box used.

At 156 and 162 hours, fermentation was successful at a depth of 21" and 12" respectively, but a slight alteration in the method of drying appears necessary.

Further experimentation in curing is required, particularly for small quantities of beans.

The loss of weight which occurred during curing, is comparable with that in other countries.

Acknowledgments.

The writer desires to acknowledge his appreciation of the assistance given by Messrs H. J. Washington and W. R. Huntley, who, by providing boxes and material made it possible for the experiments to be conducted.

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* H. R. Briton-Jones, *The Diseases and Curing of Cacao*, pp. 135, 136, 187.

(1) De Verteuil, J., *Preparation of Cacao for Market*, Department of Agriculture, Trinidad and Tobago, 1933.

(2) Hart, J. H., *Cacao, Its Cultivation and Curing*, 1911.

(3) Johnson, W. H., *Cocoa, Its Cultivation and Preparation*, 1912.

(4) Van Hall, C. J. J., *Cacao*, 2nd Edition, 1932.