THE FERMENTATION AND CURING OF CACAO IN CEYLON

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ALTHOUGH the practice of preparing cacao beans for the market by fermenting them is extremely old, the theoretical basis of the process is not yet completely understood. As would be expected from what is largely an empirical practice, the technique of cacao fermentation varies widely in different countries. Ceylon methods of fermentation have always been characterized by the relatively short duration of the sweating process and workers, both in this country and elsewhere, have suggested that a longer period in the sweat box should lead to an improvement in the quality of the finished product. Knapp (1935 a) for example, complains that the quality of Ceylon estate cacao has fallen off considerably in recent years, and attributes this decline in quality to the application to Forastero cacao of a fermentation technique appropriate only to cacao of the Criollo type. As will be explained later, the European owned estates produce by the use of the methods which Knapp deplores, a cacao of excellent fracture and aroma. That most of the cacao placed on the market by small-holders in this country is practically unfermented is undoubtedly true, but the poor quality of small-holders' cacao is not completely due, as is often supposed, to the unsatisfactory nature of the sweating technique which they adopt. In the present paper the writer will describe in some detail the methods of cacao fermentation employed by the estates and by the small-holders, and will suggest modifications in the small-holders' technique which should bring the latters' finished product nearer the manufacturer's ideal.

VARIETIES OF CACAO

The present day classification of the species *Theobroma cacao* Linn. is extremely complex and unsatisfactory. This is largely due to the fact that the so-called varieties are unstable hybrids. For all practical purposes it is only necessary to recognize the existence of beans of two kinds, *viz.*, Criollo beans, which are white in cross section, and Forastero beans which have a purple

section. In hybrids both types of beans may be found in the same pod. The Forastero character is dominant, and a tree grown from a purple bean may produce pods containing a mixture of purple beans and white beans. The pure white Criollo character is recessive and breeds true to type.

Ceylon cacao had, at one time, a considerable amount of Criollo in its composition, but recent years have seen a gradual disappearance of the Criollo types, partly as a result of the greater susceptibility of these to disease, and partly due to deliberate substitution of predominantly Forastero types by the planters. Forastero types are preferred because they yield more, are more robust and produce a more desirable type of branching.

The area under cacao at the Experiment Station, Peradeniya, includes a collection of Nicaraguan Criollos and Old Ceylon Reds—varieties reputed to contain a high percentage of Criollo beans. The proportion of Criollo beans in pods of the Old Ceylon Reds was found on examination to range from complete absence in some pods to 68 per cent. in others. The record in table I. of the analysis of the contents of a random sample of ten Nicaraguan Criollo pods, illustrates the composition of this variety.

TABLE I.—NUMBER OF BEANS

Pod	Criollo	Intermediate	Forastero	Total
1	0	25	0	25
2	10	20	0	30
3	9	19	0	28
4	10	18	1	29
5	1	5	20	26
6	4	23	0	27
7	1	21	0	22
8	0	24	0	24
9	5	25	0	30
10	13	12	0	25

THE ESTATE TECHNIQUE

The process of sweating.—The pods are opened in the field by means of a transverse cut with a knife or preferably by a blow with a wooden mallet. Incidentally, it may be mentioned here that husks should not be left piled up under the cacao trees for any considerable length of time as this may cause a partial chlorosis of the leaves. The practice of burying husks in pits in the cacao plantation should be discouraged as it promotes root diseases (Briton-Jones, 1934). Cacao husks provide excellent manure for fodder grass areas, and several Ceylon estates get rid of their husks in this way.

The wet beans are transported in baskets to the fermenting shed or "pulping house"—the latter term is a survival of the old coffee days—which accommodates the sweat boxes. The sweat boxes are usually of timber. Wood of the *lunu-midella* tree (*Melia composita* Willd.) is often employed. The writer has occasionally seen cement sweat boxes on some of the smaller estates. The boxes are rectangular, and on the bigger estates they are about 8 feet long, 4·5 feet broad and 4 feet deep. Each box is large enough to hold one day's picking. The boxes have slatted bottoms which allow the draining off of the sweatings (Fig. 2). The sides consist of planks running in vertical grooves and can be removed to permit easy filling and unloading of the boxes. No iron nails are used in the construction of sweat boxes on account of the possibility of corrosion by the acetic acid produced in fermentation and of the danger of staining the beans. A fermenting shed usually houses a set of about four sweat boxes. The site of the fermenting shed is determined by the nearness of a suitable water supply. In order to eliminate the need for pumping up water, the fermenting shed is often located below ground level. The fermenting shed should be well ventilated, but should at the same time provide adequate protection against rain and cold winds.

The wet beans are stacked in sweat boxes and covered with coir matting. The wet beans usually arrive at the fermenting shed between 4 P.M. and 7 P.M. On the following morning (6 A.M. to 9 A.M.) the beans are wetted and turned over into fresh sweat boxes, where they are allowed to remain for a further 24 hours. Wooden shovels are used for turning the beans over. This practice of turning the beans over promotes aeration of the mass of sweating beans, ensures even distribution of the yeast inoculum and results in a more homogeneous final product.

The pulp of the cacao bean contains about 10 per cent. reducing sugars, probably in the form of glucose and fructose (Knapp, 1937), and provides an ideal substratum for the growth of micro-organisms. After the beans have been in the sweat box for some time, the pulp is seen to be covered with yeast cells (*Saccharomyces* spp.). These yeasts are evidently the result of infections which had occurred after the pods had been opened. The glucose in the pulp is fermented by these yeasts into carbon dioxide and alcohol. The alcohol is subsequently oxidized by acetic acid bacteria into acetic acid.

As a result of the subjection of the wet beans to a 36- to 40-hour period in the sweat box, most of the pulp disintegrates and drains off in the form of sweatings, which contain, among other things, a mixture of the products of alcoholic and acetic

acid fermentation mentioned above. At the end of the 36- to 40-hour period, the beans are transferred to wicker-work baskets, and are washed and well shaken with a view to removing as much of the remaining pulp as possible.

In Ceylon, planters regard the sweating process merely as a convenient means of ridding the bean of its pulp, and the process of drying is considered the only part of the technique that is of any consequence. In most other cacao producing countries, on the other hand, emphasis is placed on the sweating process, which in the case of purely Forastero cacao, may last as long as six days. One of the functions of the sweating process is said to be the removal of the astringency and bitterness of the bean. As Criollo beans contain less of the astringent and bitter principles than Forastero, a shorter period of sweating suffices for the Criollo type. In Ceylon, however, a short period of sweating is employed for a type of cacao, which despite its Criollo admixture, is predominantly Forastero. One result of the longer sweating in other countries is the great rise in temperature of the mass of fermenting beans. The temperature may be as high as 50° C. on about the fifth day. Much importance is attached by most authorities to this rise in temperature, as this is held to be the factor responsible for the killing of the bean. The death of the bean allows the free diffusion of intracellular enzymes and promotes desirable internal changes in the bean. Under estate conditions in Ceylon, the temperature maxima in sweat boxes are not sufficiently high to be lethal to the beans, but, as will be explained later, the development of lethal temperatures in the sweat box does not appear to be necessary for the production of good quality cacao.

The process of drying.—The beans after being washed free of pulp, are spread on coir matting on the sun-drying floor or barbecue. The barbecue is either cemented or of brick covered with a tar wash. The attractive reddish colour of the shell in the cured bean can be secured only by sun-drying and is determined by the first two to three days of drying. The red colour is apparently produced by the action of sunlight on catechin or some other compound in the shell (Knapp, 1937). Whenever possible the whole process of drying is completed in the sun. This is often prevented by wet weather or by lack of accommodation on the barbecue when pickings are heavy. Accordingly, after the preliminary 2 to 3 days drying in the sun, the rest of the curing process is usually carried out by means of hot air in drying lofts. The drying lofts consist of a set of two or three slatted floors covered with coir matting. Flue pipes conducting hot air from a furnace run horizontally below the slatted floors (Fig. 1). The rate of drying of the beans

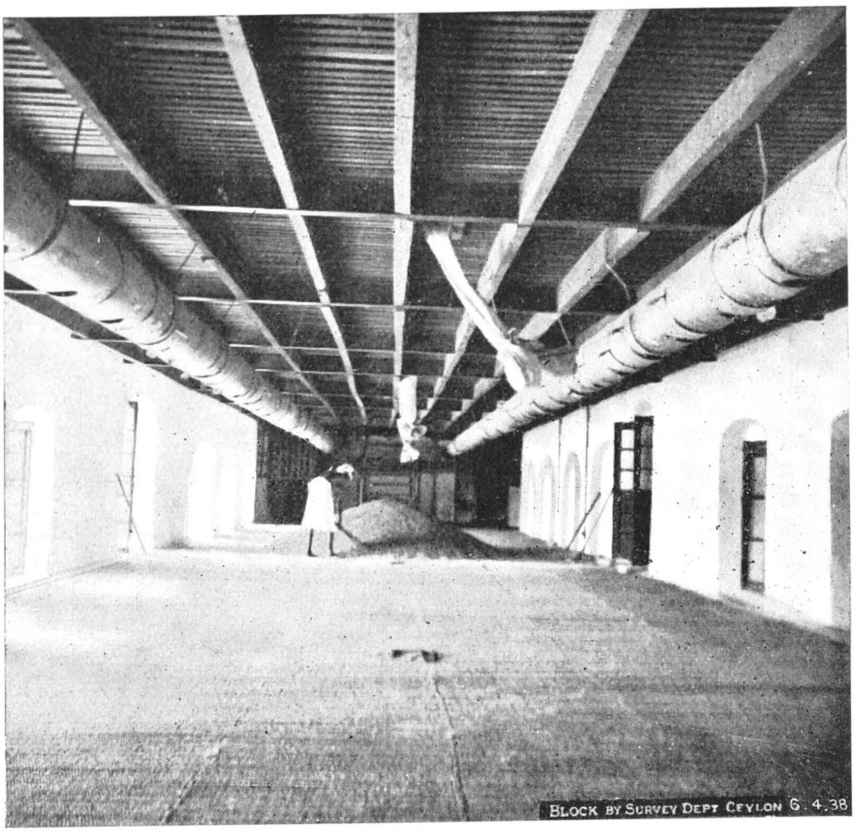

FIG. 1.—CACAO DRYING-LOFT.

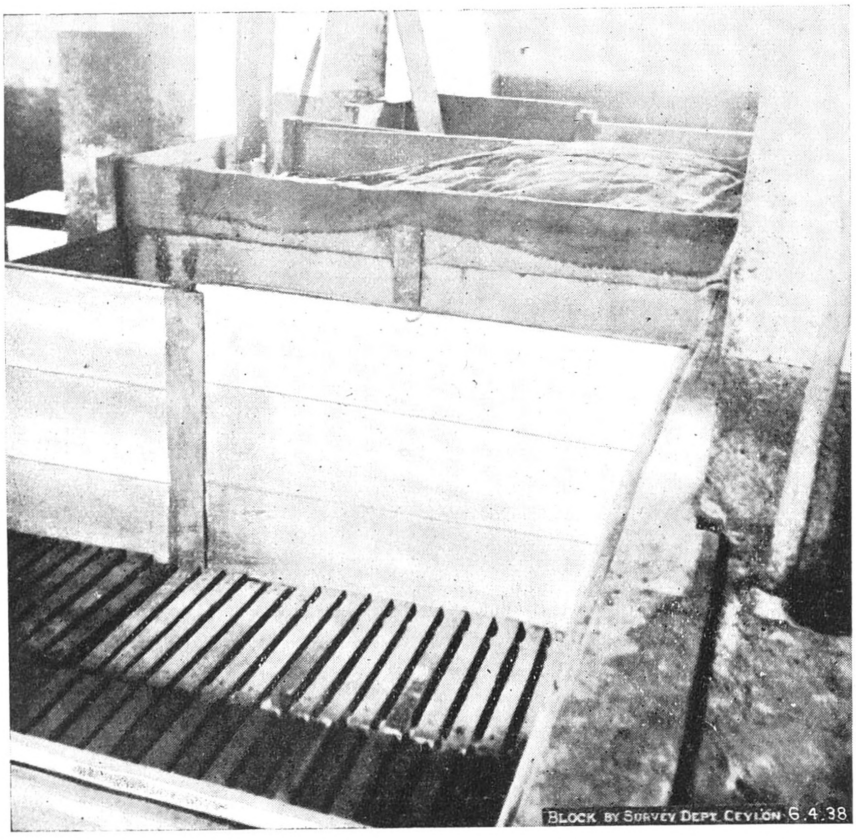

FIG. 2.—CACAO SWEAT-BOXES.

spread out on the coir matting is controlled by regulating the volume of hot air proceeding from the flue pipes. The beans both on the barbecue and on the drying lofts are periodically turned over with wooden rakes to ensure uniform drying.

Drying programmes representing the routine practice on two big estates in Ceylon are given below :—

1. *On estate A*—

1st day—8	to 10	hours	in	the	sun	
2nd day—3	to 4	,,	,,			
3rd day— 3	to 4	,,	,,	or	in	the drying lofts.
4th day— 3	to 4	,,	,,	,,	,,	,, ,,
5th day— 3	to 4	,,	,,	,,	,,	,, ,,
6th day—(no drying)						
7th day— 8	to 10	,,	,,	,,	,,	,, ,,

2. *On estate B*—

1st day—6	to 7	hours	in the sun
2nd day—4½		,,	,,
3rd day—5		,,	,,
4th day—5½		,,	,,
5th day—6		,,	,,
6th day—6		,,	,,
7th day—6		,,	,,

At night the beans are heaped up or bagged in sacks. The mass of bagged beans often exhibits a considerable rise in temperature. Briton-Jones (1934) attributes this rise in temperature to the continued activity of yeast cells on the residual pulp on the shell. Knapp (1937) suggests that the oxidation of tannins inside the bean may contribute to this temperature rise.

In sunny weather drying can be completed in seven to ten days. During rains as long a period as 15 days may be needed. When curing is complete the cacao is graded by hand on the basis of bean size before despatch to the estate agents in Colombo.

Black cacao.—The fungus *Phytophthora palmivora* Butl. causes considerable damage to the cacao crop, especially during wet weather. In certain areas 15 to 20 per cent. of the pods annually harvested are affected by *Phytophthora* pod-rot. If infection occurs when the pod is comparatively mature, the beans though damaged are not rendered completely valueless. Beans of this type are dried without sweating and placed on the market under the name " black cacao ".

THE SMALL-HOLDERS' TECHNIQUE

The contents of the villager's sweat box include a considerable proportion of beans from immature pods and from pods attacked by *Phytophthora*. The villager piles the wet beans in a shallow wicker-work basket or in a wooden packing case with a perforated bottom, and covers them with plantain leaves. The period of fermentation in the sweat box is about the same as in the case of estate cacao, *viz.*, 36 to 40 hours. The average villager does not turn his beans over after 12 hours. On account of the small quantity of cacao handled at each sweating —sometimes as small as 5 to 6 lb. and rarely more than 50 lb.— the ratio of exposed surface to volume is large, and the temperature maxima in the sweat box are accordingly very much lower than in the case of estate cacao.

After sweating, the beans are washed free of pulp and spread out to dry on jute hessian. The duration of the drying process varies from 6 to 12 days, according to the weather. The rate of drying is usually very much faster than under estate conditions on account of the relatively smaller bulk of beans dried at each operation ; and the resulting cacao is often slaty. The villager performs the whole of the drying operation in the sun. Well dehydrated village cacao has accordingly a more marked rose colour than estate cacao. Lack of facilities for drying in wet weather often results in severe moulding of the beans.

Many villagers however sell their beans to a petty dealer after partially drying them for two to three days. The drying is carried to completion by the petty dealer. This deplorable trade in partially dried beans is responsible to a considerable extent for the inferior break or fracture of the small-holder's finished product.

If as a result of moulding, the small-holder fails to secure an attractive appearance on the shell, attempts are made, either by himself or by the petty dealer who handles his cacao, to colour the beans with anatto or brick dust.

QUALITY IN CACAO

The small-holder judges the quality of his cured cacao purely on the appearance of the shell. The shell, apart from its incidental use as cattle food, is commercially valueless. What the manufacturer demands is a well-fermented bean of good fracture. The disappearance of the pigment, cacao purple, from the cotyledons is a fairly reliable criterion of efficient fermentation of Forastero cacao. There is no marked difference in colour between the kernel of a well-fermented Criollo bean and a badly fermented one. But the deep chocolate brown of a well-fermented Forastero kernel presents a striking contrast

to the purplish slaty section of a poorly fermented bean. The persistence of the purple pigment in unfermented and poorly fermented Forastero beans provides the manufacturer with a valuable index to accompanying differences in flavour and aroma of the final product. The poorly fermented Forastero kernel is bitter and astringent, and when roasted fails to develop the chocolate aroma characteristic of well fermented cacao. Other features of well fermented beans are the crispness and open-grained texture of the cotyledons, and the separation of the shell from the cotyledons (Knapp, 1935 b).

SWEAT BOX TEMPERATURES

The sequence of desirable internal changes mentioned above is in part at least initiated in the sweat box and is probably associated with the death of the bean. Emphasis has usually been placed on the importance of high sweat box temperatures as the agency responsible for the death of the bean. Under Ceylon conditions the killing of the bean appears to be effected by factors other than high sweat box temperatures, *e.g.*, by the alcohol and acetic acid developed as by-products in the sweating process. The results of an experiment on the temperature changes occurring in sweat boxes under Ceylon conditions, are recorded in table II.

TABLE II

Temperature		Air Temperature	Time
Estate Technique (618 lb.)	Small-holders' Technique (54 lb.)		hrs. mins.
25°C. ..	23·5°C. ..	27°C. ..	0 0
25° ..	23° ..	17° ..	14 30
26° ..	23° ..	29° ..	20 30
27·2° ..	24° ..	25° ..	23 45
32·8° ..	24° ..	26° ..	41 0

The estate technique of sweating was compared with that of the small-holder. In the case of the latter, 54 lb. of wet beans were sweated in a wicker-work basket. In the former, 618 lb. of wet beans were placed in a wooden sweat box of the type normally employed on estates. The mass of cacao fermented in a single sweat box on a big estate is usually rather larger. In the case of the estate technique, the temperature during sweating did not exceed 33°C. and was unlikely to have been lethal to the beans. The temperatures recorded are fairly typical of temperatures attained under estate conditions

in Ceylon and, as the bigger estates, despite the comparatively low temperature maxima reached in their sweat boxes, turn out a finished product of very high quality, it appears that the development in the sweat box of temperatures lethal to the beans is not essential for the production of high grade cacao.

WASHING

In Ceylon, both estate and small-holders' cacao is subjected to vigorous washing before transference to the drying platform. The desirability of this procedure has been questioned by (Knapp, 1937). This thorough washing contributes to the attractive appearance of the finished product, but tends to make the shell brittle and consequently predisposes the bean to insect attack. The possibility of prejudicing buyers abroad would, however, prevent Ceylon estates from abandoning the practice. Besides, washing reduces the danger of mould formation.

DISCUSSION

In most attempts made in other countries at improving the small-holder's technique interest has centred round the sweating process. It has been argued above that even in the case of predominantly Forastero cacao, a long period in the sweat box and the consequent development of high temperatures are unnecessary for the production of good quality cacao. If the period in the sweat box is short as is the case in Ceylon, the importance of slow and careful drying can hardly be over-estimated. Sweating becomes little more than a convenient device for dissolving the pulp off the bean and the drying operation becomes the fermentation process *par excellence.* Internal enzyme reactions initiated in the sweat box can proceed and conclude satisfactorily only under conditions of protracted and well regulated drying.

Generally speaking, slow drying produces a good quality bean. The slowness of the drying process is limited by the risk of moulding. The danger of rapid drying is always a problem in small scale fermentation, and attempts at improving the small-holder's technique should include devices for retarding the rate of dehydration.

The final moisture content of the cured cacao should not exceed 8 per cent. (Scott, 1928) if the risk of subsequent mould formation is to be eliminated. Excessive drying makes the beans brittle and hence more liable to insect invasion.

The villager's sweating and drying problems are partly due to deficient technical knowledge and partly the result of difficulties inherent in small scale fermentation, and can be

solved by the adoption of co-operative fermentaries under expert supervision. Co-operative fermentation of peasants' cacao has been successfully accomplished in Trinidad and Tobago, and may meet with success in this country. The question of adapting the superior estate technique to small scale sweating and drying will not arise then.

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