A NEW METHOD OF CURING SMALL QUANTITIES OF CACAO*

I. INTRODUCTION

CACAO produced by peasant proprietors accounts for approximately two-thirds of the world's total production, and this enormous quantity of cacao, in the neighbourhood of 350,000 tons annually has all the faults of cacao fermented in separate small quantities. Thus, peasants' cacao is recognised by manufacturers to be of inferior quality and lower value than estates' cacao, the lower quality being in large measure due to the inferior methods of preparation employed by small holders. In this article a new fermentation method is described with which it is possible to ferment separate small quantities of cacao so that the final product is equal in appearance and value to estates' fermented cacao.

CACAO FERMENTATION

The process of fermentation or "sweating" is the recognised method of preparing fresh cacao beans for the market throughout the cacao-producing countries of the world. The fermentation of the beans greatly improves the quality of the cacao from the point of view of the manufacturers who are prepared to pay a substantial premium in price for properly fermented beans. During recent years, a large number of scientific workers in different parts of the world have investigated fermentation problems, and they have accumulated valuable knowledge of the fundamental process involved. In spite of this, there has been little or no change in the cacao fermentation methods in common use today from those employed in ancient times, long before exact knowledge was available of the biological activities of enzymes, yeasts and bacteria.

The fermentation of cacao in large batches presents few difficulties to the experienced planter provided that reasonable care and supervision are exercised. The owner of a fairly large cacao property has therefore no difficulty in carrying out a proper fermentation, producing well-fermented cacao beans of the quality desired by the manufacturer. This may largely explain the lack of progress in the application of scientific theory to the practice of cacao fermentation. There is, probably, still room for improvement in the fermentation of estates' cacao, but, in order to supersede the older methods, any suggested new method would have to show an appreciable increase in quality of the final product, as well as being equally easy and cheap to apply. For the

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purpose of curing large batches of cacao, the chemist or biologist has not yet devised a method which gives a final product of such good all round quality as the traditional methods of fermentation.

FERMENTATION OF SMALL QUANTITIES OF CACAO

In the case of the small peasant proprietor (holding ten acres of cacao land or less), the fermentation problem presents an entirely different aspect. A single picking on a small property may often amount to no more thant fifty pounds to one hundred pounds of wet cacao, and the practical difficulties of obtaining a satisfactory product, when such small lots of cacao are fermented by the usual methods, are well recognised. The trouble arises through the large area of surface exposed in relation to the volume of the mass of cacao beans so that too great a loss of heat occurs. The high temperatures requisite for killing the embryo of the bean are therefore never attained, and the internal changes associated with proper fermentation do not take place or are incomplete. A small bulk of cacao is also apt to dry out too quickly. In an endeavour to increase the quantity of cacao available for fermentation, the small holder usually picks his cacao only at long intervals and includes unripe and overripe pods in his picking. The net result of all these adverse factors is that the majority of the beans are unfermented or only partially fermented, some are germinated, and those occurring at the edges are dried up and shrivelled, or may be covered with obnoxious and unsightly moulds. Peasants' cacao is therefore recognised by the manufacturers to be of poorer quality and lower value than estates' cacao.

The crux of the fermentation problem appears to be the protection of small quantities of cacao from excessive evaporation and cooling. If this can be done effectively and cheaply, then there is no reason why a good quality product should not be obtained by the ordinary method of natural fermentation which has proved satisfactory with large quantities under estate conditions.

In the course of biochemical investigations carried out by the Chemical Section of Cacao Research at the Imperial College of Tropical Agriculture, the necessity arose for fermenting separate small experimental samples of wet cacao. In connection with this work the writer has devised a solar fermenting frame which possesses the following advantages, (1) a blanket of warm air at a temperature ranging from 100°F. to 150°F. (38°C. to 65°C.) is maintained for a period of eight hours in the day, (2) a humid atmosphere can be maintained round the sweat box, thus preventing excessive evaporation, (3) the apparatus required is simply and cheaply constructed, (4) the source of heat costs nothing.

Details concerning the design and construction of this fermenting frame, and preliminary experiments carried out with the new method are published in the Fifth Annual Report on Cacao Research, 1936, Chemical and Ecological Section. In the present article, a brief outline is given of the new method of fermentation and of the design and construction of the fermenting frame. The

results of preliminary fermentation experiments are summarised, and the possible practical importance of the new method, as a solution of peasant fermentation problems, is discussed in detail. For full experimental details concerning the preliminary trials, and a discussion of various theoretical considerations involved in this new fermentation process, reference should be made to the original article in the Fifth Annual Report on Cacao Research.

II. THE SOLAR FERMENTING FRAME FOR CURING SMALL QUANTITIES OF CACAO

In most tropical countries where cacao is grown, the sun is a constant and reliable source of heat throughout the day-time. In Trinidad, there is an average of six to eight hours bright sunshine each day during the eight months in which the bulk of the cacao crop is picked. The temperature of dark-coloured objects exposed to direct sunlight and adequately insulated reaches an average maximum temperature of 150°F. or 65°C. It seemed feasible therefore to utilise this cheap and constant source of heat for producing temperatures whose range lies almost exactly within the optimum limits known to be necessary to ensure the proper fermentation of cacao beans. A simple adoption of the greenhouse or solar propagation principle enables sunlight to be used for heating the mass of fermenting beans.

DESIGN AND CONSTRUCTION OF THE SOLAR FERMENTING FRAME

The first experimental frame constructed on this principle consists of double-walled, double-bottomed wooden frame or cabinet of external measurements, 6 ft. by 4 ft. by 4 ft., a three-inch air space being left all round between the inner and outer walls. The air space may be packed with straw to provide more efficient insulation. The frame is painted black, inside and outside. It is provided with a closely-fitting moveable glass-paned cover. Two wooden planks fixed on edge along the bottom of the frame, support separate moveable sweat boxes at a height of eight inches above the bottom of the frame. Two sizes of sweat boxes were made, (*a*) 1 ft. by 1 ft. by 1 ft. holding 40 lb. of wet cacao and (*b*) 1 ft. by 1 ft. by 1½ ft. holding 60 lb. of wet cacao. The individual sweat boxes are provided with a lid or inverted box, which fits over and completely encloses the sweat box, leaving a space of half-an-inch between box and lid. The bottom and sides of the sweat boxes are perforated in order to provide aeration and drainage, but the top only of the lid is perforated. Boxes and lids are painted black on the outside only.

In theory, the solar frame should provide ideal conditions for the fermentation of small quantities of cacao. The sun's rays pass through the glass cover and are absorbed by the blackened walls and floor of the frame ; the black surface becomes heated and warms the air in contact with it, thus producing an envelope of hot air which is retained by the glass cover and completely surrounds the small sweat boxes supported in the centre of the frame. Cacao treated by this method is thus cured by a combination of natural fermentation and artificial heat treatment.

METHODS OF USING SOLAR FERMENTING FRAME

The cacao beans are placed in the small sweat boxes, enclosed in the frame and allowed to ferment in the normal manner, but the envelope of hot air surrounding the sweat boxes prevents the escape of heat produced by fermentation, and some heat is actually supplied by the sun to the fermenting beans during the hottest hours of the day. The sweat boxes should be well lined with banana leaves before putting in the wet beans and the top of the sweat box should be covered with banana leaves before putting on the lid. This lining of banana leaves helps to prevent evaporation, and serves as an additional insulation against the loss of heat during the cooler hours of the night.

PREVENTION OF EVAPORATION

In order to prevent excessive drying out of the small mass of cacao, the air inside the frame may be kept damp by placing wet sacking on the floor of the frame. The following arrangement for maintaining humidity was found to work very well in practice :— Wet sacking was placed on the floor of the frame and a kerosene tin (painted black) full of water was placed at each end of the frame with a piece of sacking dipping into the water and hanging over the side of each tin. This wick-like arrangement served to maintain the humidity of the air inside the frame for several days without any attention. *The above precautions for maintaining a humid atmosphere inside the frame are an essential feature of the process.* Unless these precautions are taken, the small mass of cacao will tend to dry out before fermentation is complete, and the final product obtained will be very poor quality.

If it is required to open the frame at any time during the fermentation period, either to inspect the fermenting cacao, or to renew the water supply, the glass cover should only be removed early in the morning within one or two hours of sunrise. At this time of day the temperature of the air inside the frame is only slightly higher than the temperature of the outside air, and the loss of heat due to the removal of the cover is negligible.

TIME REQUIRED FOR COMPLETE FERMENTATION

The length of the fermentation period will vary with different types of cacao. The right time to take the beans out of the frame can be determined by noting their appearance in the sweat box. Preliminary trials have shown that the best quality product was obtained from the solar fermenting frame when fermentation was allowed to proceed for *three days longer* than the normal period for the same type of cacao fermented in large batches under estate conditions.

III. RESULTS OF FERMENTATION TRIALS

TEMPERATURE AND HUMIDITY CONDITIONS INSIDE THE SOLAR FERMENTING FRAME

Records show that the air inside the solar frame has an average temperature throughout the 24 hours 33°F. higher than that of the outside air. When no precautions were taken to maintain humidity, the air inside the frame

became very dry, and the rate of evaporation was greater than that in the outside air. When no precautions were taken to maintain humidity, the air inside the frame became very dry, and the rate of evaporation was greater than that in the outside air. When precautions were taken to maintain humidity (by means of wet sacking, &c.) the air inside the frame remained very humid throughout the 24 hours, and the average rate of evaporation was only 50 per cent. of that in the outside air. Cacao fermenting inside the solar frame attained maximum temperatures of 121°F. to 124°F. Similar small quantities of cacao fermenting outside, under ordinary favourable conditions, attained maximum temperatures of 108°F. to 111°F. During the fermentation period the temperature conditions throughout the mass inside the solar frame are very regular and even, the mean temperature of the edges of the mass being the same as the mean temperature of the centre. In a small mass of cacao fermenting outside under ordinary atmospheric conditions, much lower temperatures were recorded in the surface layers than in the centre.

COMPARATIVE APPEARANCE AND VALUE OF CACAO FERMENTED IN THE SOLAR FRAME

In order to obtain an independent and completely unbiased estimate of the relative commercial value of the different final cacao samples, they were submitted for criticism and valuation to a large firm of cacao dealers in Port-of-Spain. A sample of cacao beans from the same picking, sweated and dried under estate conditions, was also submitted at the same time for comparative purposes.

The dealers reports showed that small lots of 40 lb. to 60 lb. wet cacao could be successfully fermented in a wooden sweat box enclosed in the solar fermenting frame. The final product of 15 lb. to 23 lb. dried, cured cacao beans was better fermented, had a better external and internal appearance, and a higher value on the local market than cacao fermented in large batches (2,000 lb. to 4,000 lb. wet weight) under the ordinary estate conditions obtained in Trinidad. The solar fermenting frame seemed to be very effective in producing an *even fermentation* throughout this small mass of cacao. The surface layers were free from mould and as well fermented as the central portion. This is in direct contrast to the results obtained with small lots of cacao fermented under ordinary conditions. The low value of these samples was largely due to the inferior quality of the surface layers, which either became mouldy or dried and shrivelled during the fermentation process.

IV. GENERAL CONCLUSIONS: POSSIBLE PRACTICAL APPLICATIONS OF THE SOLAR FERMENTING FRAME

The practical results of preliminary experiments with the new solar fermenting frame have greatly exceeded expectations. Maximum temperatures attained during fermentation inside the frame were 7°F. to 12°F. higher than the maximum temperatures attained by a similar small mass of cacao fermenting under ordinary favourable conditions outside the frame. The final

product obtained from the fermentation of 40 lb. to 60 lb. wet cacao was superior in appearance and value on the local market to estate cacao fermented in lots of 2,000 lb. to 4,000 lb. One of the most promising features of the method is that it ensures an *even fermentation* in a small mass of cacao. The surface layers are free from mould and as well fermented as the central portion, even though no turning was carried out, the mass being left undisturbed during the whole period of fermentation. Temperature records show that the mean temperature of the surface layers of the mass is the same as the mean temperature of the centre. Such even temperature distribution evidently eliminates the necessity for periodic turning, and ensures an even fermentation. With a small mass of cacao fermenting under ordinary conditions, much lower temperatures are recorded in the surface layers than in the centre, and frequent mixing or turning is therefore essential if an even fermentation is to be obtained.

The final quality of any cacao is the net result of variety or breed *plus* the treatment it receives in preparation for the market. It cannot be claimed therefore that improvement in fermentation methods could result in making the lower quality Forastero types of, say, the Gold Coast equal in quality to the Criollo or near-Criollo types of Venezuela or Ceylon. Nevertheless, it is the lower quality Forastero and Calabacillo types which stand most in need of proper fermentation in order to mitigate their harsher characteristics. The higher quality Criollo types can be fermented for a short period only if they are to retain their characteristic flavour and aroma. The Criollo type of cacao however, forms only a very small percentage of present world production. Approximately two-thirds of the total cacao crop of the world is low quality Forastero cacao produced by peasant proprietors, and this enormous quantity of cacao (about 350,000 tons annually) has all the faults of cacao fermented in separate small quantities.

The solar fermenting frame seems definitely to provide a method whereby very small quantities of cacao can be successfully fermented, so that the final product has all the charateristic appearances of the best estate fermented cacao. The new method would enable the peasant, no matter how small his property, to pick only the ripe cacao for fermentation. There would no longer be the same incentive to include unripe and overripe cacao in an endeavour to increase the bulk available for fermentation. This factor alone should result in a great improvement in the quality of peasants' cacao. In the present preliminary stage of these investigations, however, it is not possible to state definitely whether the method is economically feasible or worth while to the small holder. As far as capital and current expenditure is concerned the new method seems to be much superior to other semi-artificial methods hitherto suggested for the curing of cacao, but the cost of construction of fermenting frame used in these first experiments is probably still somewhat beyond the means of the small holder to whom the method should particularly

appeal. The essential features of the apparatus are a black absorbing surface and a glass-paned cover whereby the heat energy of tropical sunlight is trapped and utilised to warm the fermenting mass of cacao. Further experiments are contemplated utilising these principles, but constructing the frame in the simplest and cheapest manner. There are a number of other points which still remain to be tested. For instance, Dr. A. W. Knapp, Chief Research Chemist of Messrs Cadburys Ltd., has shown that cacao beans cured by artificial heat processes were deficient in flavour and aroma after roasting, and it is possible that cacao fermented in the solar frame may have some such defect. Future experimental samples should therefore be submitted to chocolate manufacturers for their criticism.

Before this method can be used by the small holder a number of practical difficulties remain to be overcome. The peasant will have to be persuaded to pick only ripe cacao for fermentation ; this will involve more frequent pickings which will be more costly and more troublesome. Again, proper drying as well as proper fermentation will have to be carried out if a good quality final product is to be obtained. Finally, some system must be evolved by which the peasant who takes the trouble to produce well fermented cacao will receive some price premium over his neighbour. According to a report by Professor C. Y. Shephard on his recent visit to the Gold Coast, no marked improvement in the preparation of cacao in this Colony is likely to occur until price discrimination is introduced. At present no premium is received by individual farmers who take great care in the preparation of their cacao because improved lots of cacao are too small to be recognised by merchants who handle thousands of tons.

The preliminary trials so far carried out with the solar fermenting frame are purely experimental, and serve merely to draw attention to the possibilities of the method, which, in view of the important practical considerations involved, may be thought worthy of trial by agricultural officers, who are in a position to decide the possibility of overcoming the above practical difficulties.

VI. SUMMARY

(1) A new method of fermenting separate small quantities of cacao is described. Details of the new method and preliminary fermentation experiments are fully described in an article to appear in the Fifth Annual Report on Cacao Research. The present article is a brief review of this paper, and stresses the practical applications of the solar fermenting frame as a possible solution of the fermentation problems of small holders.

(2) The bulk of the world's cacao crop is low quality Forastero or Calabacillo cacáo produced by peasant proprietors, and this very large total amount of cacao has all the characteristic faults of cacao fermented without special precautions in separate small quantities.

(3) The solar fermenting frame provides a method by which very small quantities of cacao (40 lb. to 60 lb. wet weight) may be successfully fermented, so that the final product has all the characteristic appearances of the best estate fermented cacao.

(4) The solar fermenting frame is cheap and easy to construct and costs practically nothing to use and maintain.

(5) The practical results of preliminary trials have greatly exceeded expectation, and this new fermentation method seems to be worthy of extended trials by agricultural officers who are in a position to decide the practical possibility of the solar frame, or of some simple modification of it.