

EVALUATING THE MECHANIZATION PROBLEMS OF COFFEE PROCESSING  
IN EAST AFRICA

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1. INTRODUCTION:

Processing of Arabica coffee at an estate starts with the operation of "picking the cherries" and finishes with "loading the dry parchment beans on to transport for taking to the hullers". Processing therefore includes all the various operations carried out at the estate factory.

The problem of mechanizing the processing operations are difficult, however, due to the varying estate size and the amount of crop handled at any time in a given estate. Sometimes the machinery carries idle capacity, while at other times they might be overloaded. The varying estate size makes the manufacturer's task also difficult, as more than one model at an economic price is required although the market for any particular model is rather small for mass production techniques to be utilized.

In planning an ideally "mechanized estate" from scratch or in mechanizing an existing estate the overall picture should be considered so that any particular machinery or equipment or installation easily fits in as part of the whole system, that is the estate, instead of an haphazard and piecemeal mechanization, which may increase only the operational cost without bringing any economic benefit to the estate through mechanization.

2. THE ESTATE PROCESSING STEPS:

Arabica coffee is processed at an estate in the following sequence, with only minor variations between estates:-

- (i) Pick the ripe cherries and transport them from the field to the factory.
- (ii) Load the cherries to the pulper hopper.
- (iii) Separate the cherry skins (waste product) after pulping and grade the beans into "floats" and "bulk".
- (iv) Prewash the graded beans and load into separate fermenting tanks. In an increasing number of estates, however, no prewashing is carried out before fermentation.
- (v) Ferment the beans for 20-50 hours, depending on the degree of ripeness and ambient temperature, with or without any turning over of the beans during fermentation.
- (vi) Wash extensively in the tank and in the final washing channel to separate the beans from the mucilage, along with further grading of the bulk in the washing channel into two or three grades.
- (vii) Collect the washed and graded beans in trays (at about 54% moisture) and transport to barbecues and/or drying tables for sun drying, or to mechanical driers for artificial drying, when they are "finished" later by exposure to sunlight for about 3 to 4 days to bleach the beans while they are still "wet", that is above 12% moisture.
- (viii) Transport the beans for storage either in bags or in bulk in ventilated/unventilated silos.
- (ix) Load on to transport for despatch to the hullers.

3. THE PRESENT STATE OF MECHANIZATION AND POSSIBLE DEVELOPMENTS:

The present state of mechanization with each of the above processes and their possible developments are now briefly reviewed below:-

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The cherries are hand-picked by visiting each tree at frequent intervals during the picking season (April-January) as they ripen at different times. They are transported to the factory either by human labour (as in contract picking) or carried to a central field collecting point, filled into sacks and loaded on to a tractor-trailer or a truck for transport to the factory, where the beans are again transferred to the pulper receiving hopper by hand. Although a satisfactory mechanical picker is not yet available, the transportation of the cherries can be mechanized by using a small or medium sized tractor and two hydraulic tipping trailers as follows:

Load the cherries directly on to the first trailer (after measuring the output of each picker) instead of filling them in sacks and then loading on to trailers or trucks. When the trailer is full, switch loading to the second trailer while the tractor driver takes the first trailer to the factory and tips the contents directly into the pulper receiving hopper. In some estates it might be necessary to build an earthen ramp sloping up to the hopper for the tractor-trailer to come alongside or to increase the capacity of the hopper, as picking usually starts in the morning while pulping may start after mid-day. The tractor driver would then drive back to the field collecting point with the empty trailer and take the second trailer to the pulper hopper when that is full and so on. This would ensure a continuous loading process and a maximum labour efficiency, as the cherries are man-handled only once during loading on to the trailer. Additional use of the tractor at the estate would be for normal cultivation work, further transportation in processing (as described later), or as mobile power to drive the pulper or a pump if electricity is not available.

The cherries are usually pulped by a disc type pulper, although some estates use a drum type pulper. The biggest drawback to the disc type pulper, in that the gap between the disc and the knife could not be set to deal with varying cherry sizes simultaneously, has been recently overcome by introducing the spring loaded Aagaard type nylon shoes. This innovation has also practically obviated the need of a repasser to deal with the small cherries. It is important to note here that the pulping of cherries should be as complete as possible, without any damage to the beans, so that fermentation may be even.

The pulper generally works most satisfactorily with red-ripe juicy cherries of even ripeness. A suitably modified version of an electronic colour sorting machine has been advocated for separating the cherries into different grades of ripeness before pulping, but because of the rather high initial cost its economic justification should first be established.

In practice, practically all estates grade the pulped beans before fermentation, although there is a certain amount of doubt about its usefulness, specially if care is taken to ensure that pulping is complete. In this connection, the remarks of a leading coffee machinery manufacturer is of interest, which states "..... it is questionable whether grading the parchment coffee by density before fermentation yield results compatible with the extra work involved, which also entails the use of more fermenting tanks. It is also doubtful that the heavy grade unfermented coffee will all grade out as heavy grade fermented coffee in the final washing channel .....". It will therefore be useful to study this aspect of coffee processing systematically and ascertain its economic benefits.

The primary grading of the beans before fermentation is done either by an Aagaard pre-grader (a recently patented mechanical device) or in a pre-washing channel, although a rotating inclined cage with three sizes of mesh (with the material entering at the higher level) in conjunction with a float chamber is also used. The Aagaard pre-grader, however, is generally being adopted by most of the estates.

The beans are fermented in a tank to separate the mucilage adhering to its parchment skin, under either shaded or open conditions, and the time required vary between 20-50 hours depending mainly on the ambient temperature and the degree of bean ripeness. During fermentation, in some estates the beans are turned over a few times and washed partially, while in other estates they are not so treated.

The fermentation time is too long under certain conditions, giving rise to undesirable off-flavours and recent experiments with pectic enzymes to hasten the process have been quite successful. A systematic study of the fermenting time and temperature relationship and the maximum safe temperature might enable a system of tank temperature regulation to be introduced by covering their surface and blowing either hot or cold air through the mass of the fermenting coffee.

A mechanical method of complete mucilage removal without damaging the beans is perhaps difficult to perfect because of their shape. A machine does exist, however, (the Aquapulpa) which removes most of the mucilage mechanically, and the effect of this or other mechanical means on the subsequent fermentation time should be investigated.

As the concrete or cement plastered walls and floors of the tanks are liable to corrosion by the acids produced during fermentation, a special type of corrosion-resistant paint is recommended to minimize the damage.

During fermentation, the labourers stand inside the tank to turn the beans with a rubberized or wooden ladle. The process is slow and messy, and can be mechanized by using a pump to transfer the beans from one tank to another. In some estates a prejudice exists against pumps for the mechanical handling of coffee beans, as they are considered to damage the beans. Recent investigations (1)\* have shown, however, that a number of commercially available pumps can handle wet coffee beans safely.

The beans are washed after fermentation in the tank and in the washing channel, using a plentiful supply of water, by a group of five or six labourers gently pushing the beans with wooden or rubberized shovels against the flow of water. During this process the beans are also graded, as the lighter beans come up to the top layers and are the first to reach the channel exit point.

Washing the beans after fermentation can be mechanized by pumping from one tank to another and allowing the water to drain away each time, carrying with it the mucilage. A machine working on an air-separation principle for the final grading of wet parchment coffee is being investigated (2), and initial results have been promising. It would be available for normal estate duty in the near future after further development, and may also be able to grade and skin-dry the wet coffee simultaneously.

The coffee trays (approximately 72" x 36", gross weight 56 lb., tare weight 10 lb.), are carried over considerable distances by two men, the useful weight per person being only 23 lb. Pumps for mechanical transport of coffee is strongly recommended, and in the better managed estates they are already used, with lengths of flexible hoses on the discharge side for delivering the beans near to the drying tables, barbecues or mechanical driers. If man-handling is still necessary, the trays could be replaced by an yoke placed horizontally across the shoulder of the labourer with a wiremesh container at either end, each holding 25lb. of beans, i.e. 50 lb. per person.

The beans are dried either in the sun or by mechanical driers, considerable work having been done on the latter system. In table drying, the beans are frequently hand turned to ensure even drying. A length of wooden beam equal to the width of the table, with prongs like a comb, drawn along the length of the table by two labourers walking on either side would provide a more effective stirring at a rate faster than hand turning by two labourers.

The dried beans are carried in bags by labourers to the storage space, which may be sited at a distance from the drying facilities and may not be adequately built. A properly designed storehouse sited near the drying facilities and a portable elevator-conveyor to transport the beans may prove economical under these circumstances. The tractor-trailer combination suggested earlier for transportation of cherry coffee could also be used to advantage for bulk handling of dry coffee if the storehouse is located at a distance. In some estates it might be necessary to widen the space between the drying tables, so that the tractor could be driven between them. The portable elevator-conveyor would also load the bags of dry parchment coffee from the store to the transport for despatch to the mills.

\* The numbers in parentheses refer to appended references.

4. CONCLUSIONS:

An endeavour has been made to present an overall picture of the mechanization problems of processing Arabica coffee, and suggestions made at appropriate places to improve the estate efficiency in the light of the present knowledge available. In designing a new estate factory the mechanization problems are simpler to those encountered with an existing set-up. In the latter case, however, a time and motion study of the entire operation for each estate is likely to point out the best possible solutions for them.

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