

COFFEE

Harvesting And Processing For Top Quality Coffee

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INTRODUCTION

Quality is fast becoming the key word in the coffee trade. As the quantity of world coffee increases, more and more importance is placed on quality. If Hawaiian producers are to hold their place in the coffee market, it is imperative that they compete against world trade with a top quality product.

This is an especially important consideration for coffee growers in the Islands. The quantity produced here is small by comparison. Hawaiian producers can only compete on the basis of quality.

How important a quality product can be may be illustrated in the following dollars-and-cents example: if Hawaii producers were to receive only *one cent less* per pound on, for example, an output of 10 million pounds, the loss to Hawaii's coffee growers would be \$100,000. Two cents less per pound would, of course, mean the loss would double.

Kona coffee has been known throughout the world for its high quality for over a century. Recently it has drawn world attention for its high-acre production. It is both interesting and important to note, however, that when coffee producers and scientists from Central America, Brazil and Asia came to the islands in 1954 to participate in the Coffee Information Exchange Program sponsored by the Foreign Operations Administration in conjunction with the farmers of Kona and the University of Hawaii, they were impressed by two things—advanced coffee cultural practices, and backward processing practices.

Their visit gave impetus to the program of growers and scientists here for the improvement of processing practices and the quality of coffee. Since their visit, some progress has been made in this direction. But there is much yet to be done.

And paramount among considerations which must be made in the coffee quality improvement program is the fact that the fully ripe coffee berries, when picked from the tree, are as good as the coffee will ever be. *There is nothing yet known that can be done to improve the quality of coffee after harvesting.* There is no such thing as *curing* in coffee processing, as is sometimes supposed.

The producer must, therefore, aim at the best quality fruit he can produce while it is still on the tree. Only carefully applied cultural practices can achieve this end. Once harvested, the quality of the bean cannot be improved by presently known processing methods.

On the other hand, *coffee can be ruined* in many ways after it is picked. One of the secrets in the production of quality coffee is to process the berries *as soon as possible* after harvesting, and thus to avoid deterioration of the bean.

Another reason in favor of rapid processing of coffee is in the fact that only by this means can weight loss be to some extent controlled. Soon after the coffee is picked it is subjected to some kind of metabolic action in which the carbohydrates in the bean are changed to carbon dioxide, which is lost in the atmosphere. The process continues until the bean is "killed" or dried to a point where this action ceases.

According to various reports of studies conducted, the rate of weight loss is greatest during the fermentation process when from three to four percent of the weight of green coffee is lost.

If the coffee is completely processed within a period of from 24 to 36 hours, instead of over a period of several days, as is the case in some processing methods, as much as six percent of the green weight of the beans can be saved.

In this circular the authors hope to indicate some of the more important factors for consideration in harvesting and processing methods aimed at a high quality product.

It will be stressed that *coffee can be reduced in quality through improper processing*, although it cannot be improved in quality in the processing after harvest.

This circular will discuss harvesting and processing, up to but not including roasting, step by step. *Principle recommendations*: harvest at the proper stage of ripeness, and maintain quality through proper processing methods executed as *rapidly* as possible.

Structure of the Coffee Fruit

Since there is a great deal of terminology which grows out of certain characteristics of the coffee fruit, and since the steps in both harvesting and processing arise out of the structure of the berry, it is believed a brief description of the fruit itself would be of value here. This is especially true in view of the large number of new producers who have gone into the coffee field and know very little about it except what they may read in the present series of circulars.

The description will be entirely non-technical, and it is suggested that new growers who wish more detailed information contact the local office of the Agricultural Extension Service.

The coffee fruit is commonly called a *cherry* because of its resemblance to that fruit. It normally contains two seeds which are flat on one side and develop in the center of the cherry with the flat sides adjacent to one another. In some instances only one of the two ovules, i.e., one bean, is produced. In such cases the bean is round and called a *peaberry*. Where, in rare instances, three beans develop, they are roughly triangular in shape.

These beans are covered with a thin membrane called the *silver skin* in the coffee trade. A small portion of this skin is usually found on the cleft of the bean when it is ready for roasting, at which time the bean is referred to as *green coffee*.

The silver skin is in turn covered by a parchment skin which is very tough and difficult to remove. The coffee, when dried in Kona and ready for the miller, is covered by this skin and is therefore called *parchment coffee*.

A coating of slimy, mucilaginous matter covers the parchment skin. It is this coating which is removed through either chemical or mechanical means, or by natural fermentation after pulping of the harvested coffee, and before it is washed and dried.

A pulpy flesh lies between this mucilaginous coating and the outer skin of the berry. This flesh is called *pulp* after removal. It is the bright, red outer skin, together with the shape and size of the fruit, which has given it its common name, and which so attractively adorns the trees just prior to harvest as the berries ripen.

POINTS TO REMEMBER

Finally, the authors would like to note seven steps in the harvesting and processing of coffee in which great care must be taken by the grower if he wishes a high quality product. These are listed below and will be discussed on the following pages.

1. Harvest only mature coffee cherries.
2. Observe care in handling harvested coffee before processing.
3. Take care of your pulping machine.
4. Use care in removing mucilaginous material from the parchment skin before drying.
5. Drying is an important and vital step.
6. Hulling is an important and vital step.
7. Grading is an important and vital step.

In the pages to follow, note carefully the recommendations and warnings which apply to each of these steps, and put them into practice on your farm. In this way you will be employing the results of many years of experience, research, and study in the management of your orchards.

HARVESTING

Only fully ripe coffee should be harvested in Hawaii. This is the most important single fact to be borne in mind by the grower. Immature and over-ripe coffee is of inferior quality, and nothing can be done in the processing of it to improve that quality.

Coffee does not generally mature all at once, however, and so there is some difficulty in putting this principle into practice. Berries in several stages of development may be found on any one tree, and various economic factors, not the least of which is cost of harvesting in terms of man hours of labor, is an important determining factor in harvesting practices.

In Brazil, for instance, where only one round of picking is done in any field, all cherries, whether green, ripe or over-ripe, are stripped off the trees onto the ground at harvest time. The berries are then raked into piles. The leaves, soil particles and other foreign matter are removed by screening or winnowing, with branches, stones and what-have-you being picked off by hand, after which the berries are sent off to the drying grounds. Berries which had fallen prior to stripping are usually raked up first and kept separately for processing.

In Colombia, according to a statement recently made by Dr. Hernan Uribe Arango and Dr. Alberto Machado of the Centro Nacional de Investigacion de Cafe of Chinchina, Colombia, only the fully ripe berries are picked, selectively and carefully, every other week during the harvesting season. Dr. Uribe, who is director of the station, and Dr. Machado visited Kona with the authors in mid-July, 1956. Colombia produces most of the world's supply of the highest grade, mild coffee.

In Hawaii, where the labor cost of harvesting is expensive (\$20.00 per 100 pounds of cherry, 1985) four to eight rounds of picking is the usual practice in any one season, with a month's interval between each picking. The number of rounds depends to a large extent upon the elevation. In upper areas of Kona the coffee is ripening almost all year around, while in lower areas ripening occurs over a period of up to almost four months.

This being the case, pickers are permitted to harvest three types of berry: 1) *green ripe*, or mature green, which is mature coffee although not fully ripe, and carries a yellowish-green skin; 2) *hard ripe*, which is mature and red in color although still firm; and 3) *soft ripe*, which is mature, red to dark red, soft and juicy.

These three types, or what might be called *stages* of ripeness were found, as reported in the Hawaii Agricultural Experiment Station Annual Report for 1937, to have similar results in a cupping test conducted at the Kona Branch Experiment Station.

A danger in picking the *green ripe* berries which should be noted, however, is in the fact that at this stage the berry does not have sufficient mucilaginous coating to protect it (i.e., aid it in sliding between pulping surfaces) in the pulping process, with the result that some injury may occur during the process which will lower the quality of the beans. This also applies to over-ripe and dried up cherries which may be found on the tree.

At the peak of the season in Kona, experienced pickers harvest between 200 and 400 pounds of coffee per day. If quality is to be insured, it is imperative that these pickers be instructed not to harvest immature beans, a tendency which will

increase rather than decrease as the amount of coffee increases and the number of pickers available per harvest acre becomes fewer.

HARVESTING EQUIPMENT

The equipment needed for the picking of coffee is simple and inexpensive. The items required include at least these four: *baskets* for the individual picker, *holding hooks* for bringing branches into position for picking, and *containers* for transport of large quantities of berries from the orchards to the processing area.

Coffee pickers in Hawaii use baskets made of pandanus leaves. The capacity of these baskets is generally about 20 to 25 pounds of harvested berries. The baskets may be suspended from the shoulder or fastened with a belt around the picker's waist.

The *holding hooks* are usually made of three to four-foot long coffee or guava sticks to which a string or cord is attached. The length of the cord is adjusted to the picker's height, in relation to the average height of the trees. The sticks are usually about 1½ inches in diameter at the thickest end. A loop of wire tied onto the cord affords a place for the picker's foot, which can be inserted to hold the hooked branch in place while the picker removes coffee with both hands free. The picker must be carefully instructed not to bend branches to the breaking point.

Ladders are needed for picking when cherries are too high off the ground to be reached with the aid of holding hooks alone. It is recommended that pruning practices which will keep the trees low enough to make ladders unnecessary be used, but when this is not possible, a combination of ladder and hook will usually facilitate picking.

The ladders are generally constructed in such a way as to fold for easy carrying, with a center hinge inserted in a divided top crosspiece so that the picker's weight will hold the ladder rigidly in place. This type of ladder seems to be one of the safest, especially since coffee is often grown in rough and irregular terrain.

Other types of equipment may be found desirable by individual growers. The above items are essentials in any orchard.

PROCESSING

There are two processing methods, called the *dry method* and the *wet method*.

Brazil uses the former, in which coffee cherries are dried whole without pulping and are milled when thoroughly dried, removing the dehydrated pulp, parchment skin and silver skin. The product is the green bean of the trade, ready for grading and bagging for export. This method is not used in Hawaii.

In the *wet method*, the removal of the pulp, fermentation of the mucilaginous material on the parchment skin, and washing precede drying, after which the coffee is graded and bagged for shipment. Most countries producing mild coffee use the wet method. Hawaii and Colombia are in this category. Discussion to follow will pertain to practices and procedures in the wet method.

CARE OF HARVESTED COFFEE BEFORE PULPING

One of the chief causes of quality deterioration in Hawaii is the decomposition of cherry pulp before pulping. Both before and after peak harvesting, farmers who are not aware of the detrimental effects which are taking place, leave the harvested berries in bags or boxes for more than 48 hours, and in some cases for several days, with the result that much of the mucilaginous coating of the bean is already decomposed before pulping and the bean is eventually damaged in the pulping process.

And since the heat generated by fermentation of the pulp causes the bean itself to ferment, resulting in discolored, "sour beans," this is a double-edged problem. The sour characteristic of beans which have fermented is one of the worst defects in quality of coffee. Don't let this happen in your orchards.

Recommendation: Pulp coffee on the same day it is harvested, within 12 hours if possible. Never delay more than 48 hours in any case. And if over-ripe cherries are present in the harvested coffee, the pulping must be done sooner—immediately if possible. *Never leave coffee cherries on the roadside or in the pulping house for more than a day.*

In Colombia, where coffee is pulped the same day it is harvested, according to Dr. Uribe, the harvested berries are dumped into water before pulping. This allows the grower to separate dried coffee, immature coffee, and the over-ripe berries, which will float, from the better quality, ripe berries, which will not. The floaters are then pulped separately. The floatation method is to be recommended where practicable, since it eliminates the poor from the good coffee and prevents jamming of the pulper due to the lack of mucilage over the bean (see discussion of floatation method of grading used in Colombia, pp. 13 and 14).

The modern pulper depends upon the mucilage on the bean for effective separation of the pulp and bean. If the cherries are either over-ripe or dried up the mucilage will have fermented. The beans, without mucilage, will not slip through the pulper grooves readily and must be forced out. In the process the rough surface of the drum will nick, scratch, or chip the bean. Good beans, stuck behind one which is not slippery, will also be damaged.

PULPING

In Hawaii, the drum type pulper is used. This machine consists of a drum, about a foot and a half to two feet in diameter, which revolves at high speed during the pulping process. The drum has a roughened surface. As it revolves the cherry coffee is forced between it and a fixed plate where the berry is squashed and the beans are separated from the pulp.

The pulp is then ejected from the pulper. The space between the drum and the plate, through which the pulp is carried out of the machine, is not large enough to accommodate the beans, however. Accordingly, grooves are provided in the plate through which the beans can move, facilitated by the slippery, mucilaginous coating on the parchment skin which is abundantly present when the berry is fully ripe. The beans which slip through these grooves are ejected out of the opposite side of the machine from the pulp.

Care of the Pulper

The pulping machine should be cleaned and overhauled every year. It is advisable to adjust every operating part of the machine so that the beans which are run through it in the ensuing season will not be damaged.

The extent of damage that can be done may be illustrated in this way: The normal revolution of the pulper, when operating, is about 225 RPM. If even one defective point in the machine were to nick or otherwise damage *one bean only* per revolution, the pulper could damage 13,500 beans per hour or about six pounds of parchment coffee. Multiply this by a full day's operation, then by the out-put of the machine throughout an entire season, and it is easy to see how high the loss could be. *Be sure your pulper is in top operational condition for the season. Insure this by inspection, adjustment and repair before harvest time.* If you don't, you lose money.

DEMUCILAGING

The coffee seeds which have come out of the pulper are covered with parchmen skin over which is found a thick layer of mucilaginous matter. This mucilage is insoluable in water, slimy, and very difficult to dry. Even when it is dehydrated in the oven or in an artificial drier, the mucilage will absorb moisture and become sticky as soon as the bean is exposed to the air. Sun drying these mucilage-coated coffee beans in the parchment stage takes a long time because the coating picks up moisture each night and the drying effect of the sunlight during the day is thus retarded. Accordingly, this mucilage must be removed before drying the beans.

There are five methods now being used to remove this mucilage: natural fermentation, chemical demucilaging, mechanical demucilaging, enzyme action, and hot water demucilaging. These will be briefly discussed below.

1. Natural fermentation.

This was the only method used until recently, and is still the most commonly used. It consists of placing the freshly pulped coffee in a fermentation vat where bacteria and fungi decompose the mucilage to a soluble material which is readily washed off with water.

This method works best at a temperature of between 80° F. and 90° F. Too high a temperature will ruin the quality of the coffee, while too low a temperature will retard fermentation.

The fermentation vat is usually made either of wood or concrete. The former is the better of the two because it seems to hold the natural heat generated by the fermentation process itself more than does the concrete, so that the temperature gradually rises without artificial heating, even when the weather is relatively brisk. Live steam is generally introduced into the vats made of concrete as a means of warming the fermenting berries.

In Hawaii wooden vats are generally made of *redwood*. The vats themselves are usually four feet deep, four feet wide, and six feet long. *Note:* the vat should be cleaned and washed thoroughly after each batch of coffee is fermented, in order to remove all undesirable odors.

As the coffee comes out of the pulper it falls into the vat. It is important that a relatively large volume of coffee be placed in the vat if possible, so that heat from fermentation will not dissipate as soon as it is generated, in which case it will take longer to complete the process.

When the vat is at least half, and preferably more than half full, about 14–18 hours will be required to complete the fermentation. The length of time required, however, depends upon the prevailing temperature, is faster in warmer and slower in colder climates. In Colombia, for instance, it takes about 30 hours to ferment a vat of coffee berries.

The fermentation must be stopped as soon as the mucilage is completely broken down. This can be determined by a very simple test: wash a handful of the beans from the vat in clean water. If they are no longer slippery, the fermentation is complete. Experience will teach the grower, however, how to judge the approximate time it will take to complete fermentation of a given amount of coffee in the vat under temperature and other conditions with which he will be familiar.

CAUTION: *If the beans are left in the vat too long after fermentation is completed, they may be ruined.* The first reaction in the fermentation process is the breaking down of the mucilage into simple compounds such as sugar and protein by action of certain bacteria and fungi.

When the amounts of various sugars and proteins increase, other bacteria begin to work on them. In particular, certain putrefactive bacteria will attack the proteins and break them up into foul smelling by-products. The coffee beans will absorb these odors if left in the vat for a time after completion of the fermentation process. The putrefactive bacteria will also work on the proteins in the bean itself, especially when the bean has been damaged by the pulper.

The result may be discolored beans characterized by foul odors, known as "sour beans." A few of these can ruin the quality of an entire batch.

Thus it becomes immediately obvious that the beans must be washed with clean water as soon as fermentation is completed. After washing, drain the water off the beans and dry them.

In Hawaii, draining is done by shaking the beans on a "shaker" machine equipped with frames having screen bottoms. As the beans are being shaken they move toward the drying platform or drier. Clean water is sprinkled on them as they move, thus washing them as clean as possible.

Finally, be sure that in cleaning the pulper, the fermentation vats and the shakers, no beans are left after the operation is completed. These may ferment and become sour before the next batch is processed. One sour bean is a serious defect.

2. Controlled Enzyme Action

In order to eliminate the dangers involved in the natural fermentation process, several other methods have been devised to demucilage coffee. One of these is referred to as *enzyme action* (a *controlled* fermentation process).

In *natural* fermentation the type of enzyme cannot be controlled. Hence there are several types of reactions, including putrefaction, taking place simultaneously. By adding certain enzymes artificially, however, the reaction can be controlled. Certain types of depectinizing enzymes are now being produced commercially for use with this method.

When 0.2 percent of the weight of the pulped beans of this special enzyme preparation is added to the pulped beans, and the temperature of the mixture maintained at 75°F to 85°F, the mucilage can be completely broken down in less than one hour. However, since the enzyme preparation is expensive, the amount recommended for commercial demucilaging is 0.025 percent of the weight of the pulped beans. This will require from 5 to 10 hours, depending upon the temperature, for complete mucilage breakdown.

3. Chemical Demucilaging

It is known that mucilage on certain other seeds, such as those of the tomato, can be removed with dilute solutions of certain alkali, such as caustic soda or wood ash. This was first applied to coffee only a few years ago. The mucilage on pulped coffee can be broken down in a few seconds if the pulped bean is mixed in a 6 percent solution of caustic soda. However, the solution usually used is 2 percent caustic soda. This will slow down the reaction and require bigger volumes of solution, but the result will be a saving in the cost of the chemical.

Machines have been devised to mix the pulped coffee bean with the required amount of solution and then wash off the broken down mucilage in one continuous operation. The mucilage is removed from any bean in a matter of minutes. The bean is ready for drying a few minutes after emerging from the pulper.

It has been repeatedly proved that alkali-treated coffee beans are not affected in any way as far as the quality of the finished product is concerned. Alkali-treated beans will germinate just as well as beans demucilaged by fermentation when the bean is used for seed.

One disadvantage of this method, however, is the added cost and the corrosiveness of the chemical. Caustic soda is also hard on human skin. This method is not recommended for family-type, small farms.

4. Mechanical Demucilaging

Several types of mechanical coffee demucilaging machines have been devised in the last few years but the "aqua pulpa" and the Hess-type coffee washer are the two most popular. Both are being manufactured commercially.

The aqua pulpa is a complicated machine using a combination of friction and water jets. It can pulp and demucilage simultaneously or simply demucilage pulped coffee. The machine requires considerable power (18 to 24 h.p.) and a high volume of water. It is not suitable for places like Kona where power rates are high and water is limited.

The Hess-type coffee washer is a heavy machine in which batches of coffee are rocked back and forth very rapidly in square compartments. The mucilage is stripped off the bean by mutual friction, i.e., one bean knocking against another. The standard machine now sold in the United States, generally, does not have a large enough capacity to take care of the coffee being pulped by one of the standard pulpers now being used in Hawaii.

The chief faults of this machine are its high cost, relatively high power requirement (3 h.p. for a machine demucilaging at the rate of 20 bags of cherry per hour) and its bulkiness. The reciprocal action (back and forth movement) of its main moving part makes it necessary to anchor the machine on a solid foundation such as concrete. The machine is also very difficult to clean after each run.

Recently a new machine (referred to as the "Fukunaga-type") was developed at the Kona Branch Experiment Station. This machine, using only a one h.p. motor, will demucilage coffee at a rate of 30 bags of cherry per hour, the same rate as the standard pulper now made in Hawaii. It employs rotary motion, hence has little vibration and can be made portable. It is easy to clean. This machine is now available in Kona, Hawaii.

5. Warm Water Demucilaging

The mucilage on the coffee bean can be removed if the pulped coffee is agitated vigorously in luke warm water (110-120°F). The Fukunaga-type demucilaging machine is most adaptable to this method of demucilaging. When warm water is used a much smaller model, using only a ½ h.p. motor, will demucilage at the rate of 30 bags cherry per hour.

GRADING COFFEE AFTER FERMENTATION

In Colombia, a country which is extremely quality conscious, fermented coffee is separated into three grades during the washing process by passing it through concrete troughs known as *grading channels*. Although this is not necessarily recommended for Hawaii, some discussion of the process will be given to illustrate the care with which Colombian producers grade and handle for quality and thus gain the small per pound increase in price which amounts to large sums in the country's total output.

This piece of equipment is about 1½ feet deep, 1½ feet wide, and 65 feet long. There are three connecting washing channels, each separated by a gate. The first has a one percent grade, the second three-quarters of one percent, and the third, one-half of one percent.

When the fermented coffee is placed in the first channel, it is stirred. As the water is running into the second channel on a one percent grade, all floating coffee will enter the second channel over the water gate which is a few inches below the water level. What remains in the first channel is considered the highest grade coffee.

The floating coffee which remains in the second channel is again stirred. The lightest will float high on the water and move to the third channel over the second water gate. What remains (i.e., is not light enough to float out) will fall in the second general grading classification.

Coffee beans which are light enough to float out into the third connecting channel will be classified as the third grade coffee. Beans which will float out of the third grading channel will be marketed as a separate grade.

It will be noticed from the above that the best and heaviest coffee will sink. The shrivelled, over-ripe and immature berries will ride high enough in the water to be carried on into the two lower-grade channels. These should be processed separately from the top grade coffee.

The same principle applies, as recommended elsewhere in this series, for the separation of floaters before pulping in Hawaii so that inferior beans may be processed separately and thus a product of higher overall quality be maintained.

DRYING

As soon as the coffee beans are demucilaged and washed, they are dried. This may be done by sun drying or in artificial driers. A combination of both is most popular.

Sun Drying

On small farms the beans are dried entirely on drying platforms. The beans are spread evenly over the drying area and turned over from time to time. Provision is made to protect the beans from rain, usually in the form of movable roofs over the platforms.

In Colombia the coffee is dried on movable trays which can be pushed under a roof whenever rains threaten. In other Latin American countries covered bins are provided on the drying ground. The beans are shoved into these bins at night or when rains threaten. In some places the beans are merely piled on a slightly raised portion of the drying yard and covered with tarpaulin.

It takes from four to six days to completely dry the coffee beans when sunny weather prevails. If the weather is cloudy it takes much longer. The thickness of the beans on the drying area also affects the drying time.

If the drying is done entirely in the sun, a considerable area for drying becomes necessary. On larger plantations this area becomes tremendous. If bad weather prevails the problem becomes serious. In the past, before artificial drying became established, it was necessary at times to store incompletely dried beans to make room in the drying yard for freshly processed coffee. This was done either by spreading the partially dried beans on the warehouse floor or by storing the beans in open bags. These practices were dangerous because the beans were subjected to molding and even fermentation if the moisture content was not low enough.

Moldy and fermented coffee is not accepted on the open market.

Drying By Artificial Means

In recent years, artificial drying has become increasingly more popular.

On some plantations the beans are dried in the artificial dryer right after washing. However, in most places a combination of sun drying and artificial

drying is practiced. Here the bean is first dried in the drying yard for 24 to 48 hours or longer, after which it is placed in the artificial drier.

There are several types of driers in use, the most popular of which is the rotary type. This consists of two concentric, perforated drums. The outer drum is closed at the ends while the inner drum is open at one end. The drums are mounted horizontally on the same shaft. Coffee is placed between the two perforated drums. Hot air is forced into the inner drum through the open end while the drums are rotating. The hot air escapes into the coffee chamber through the perforations of the inner drum. The heated air picks up moisture and escapes through the perforations on the outer drum.

Stationary driers were recently introduced. These driers are essentially enclosed, shallow trays with screen bottoms. Coffee is placed on the tray and heated air is forced through the coffee via the screen bottom. Various other types of driers, such as the "cascade" type, are being introduced and may someday replace the rotary type.

Air is heated either by steam or oil flame. Use of gas is still limited. If oil or gas is used the heating may be either direct or indirect. In the direct-type heaters the combustion products are blown directly through the coffee. Only efficient, high pressure nozzle-type burners should be used for this type of heating. Driers using a gas flame employ direct heating since gas normally burns clean and without objectionable combustion products.

In the indirect heaters the warmth is extracted by a stream of air in a heat exchanger. With these any type of burner may be used since the fumes do not pass directly through the coffee. However, the design of the heat exchanger is very important. A poor heat exchanger may result in the loss of considerable heat up the chimney.

In artificial drying, the temperature and air volume are very important factors to consider. Overheating will ruin the quality of the coffee. It has been found that the coffee bean is ruined if it is heated to above 150°F. Such coffee will have lost its aroma. Although the coffee, if it is moist, will not actually reach this temperature even if heat up to or above 150°F is introduced, for safety's sake the temperature of the incoming air should never be raised to 150°F. *Note: The most effective temperatures lie between 135° and 140 F.* Lower temperatures are preferable, especially in the stationary type driers. Approximately 130°F is ideal for this type of drier. Although lower temperatures insure the coffee against spoilage, the type of drying will be prolonged.

Caution: There is another danger in overheating, especially when the moisture content of the bean is fairly high. When moist beans are subjected to high temperatures a condition called "case hardening" occurs. In case hardened coffee, the outer surfaces of the beans dry too fast, causing a hard shell to form. The interior of the bean then becomes difficult to dry, since moisture has difficulty in escaping through the hardened shell. Such beans, even when they look completely dry, often cannot be hulled since the interior of the bean is still soft. They would not keep even if hulling were possible.

In Colombia, according to Dr. Uribe, the most important principle in artificial drying is that heat should be introduced at a low temperature at first, and gradually increased with time. This lessens the possibility of case hardening. Coffee is sun-dried for a day before it is placed in the drier, according to Dr. Uribe.

The starting temperature in the drier, Dr. Uribe said, is 35°C (95°F) in Colombia. The heat is then gradually raised to 60°C (140°F). The usual drying period under this system is about 30 hours.

The volume of air should be sufficient to prevent any condensation to take place on the walls of the drier or on the beans furthest away from the air intake. Insufficient air causes "sweating" (actually condensation on the surface of the bean) which results in poor quality coffee.

All heaters should be equipped with thermostats to control the temperature of the drying air. The fuel input (hence the flame) should be so regulated that the burner will maintain the required temperature without being cut off by the thermostat at short intervals. The ideal arrangement would be one in which the flame would not go out at all. For example: If the flame could be adjusted to maintain an air temperature of 135°F while the thermostat was set to cut off at 140°F, the flame would not go out and the thermostat would act as a safety device. (However, the flame setting might need changing if the outside air temperature varied considerably).

Air should not be recirculated while the moisture content of the beans is high. Recirculation of a portion of the air may be done when the beans are fairly dry, however. Coffee driers usually are not equipped for recirculation of the air in any case.

The dryness of the bean, whether dried in the sun or by artificial means should be checked from time to time. This may be done by removing the parchment of a bunch of coffee beans by rubbing them between the palms of both hands. If the parchment does not rub off the chances are that the bean is not sufficiently dry. However, it might be a good practice to peel the parchment off a few beans to more accurately examine their condition.

When the parchment is removed from the wet beans just out from the fermentation tank they are soft and light in color. As they begin to dry, they turn dark amber, almost black. As they dry further, they turn to a very light, lettuce green. The beans should also be hard at this stage. They may be tested for hardness by biting. If they are not quite dry, they will give to the bite. If they are dry they will break if bitten hard enough. When stored the light green gradually turns to a darker green; hence, the name *green coffee*.

The moisture content of the beans right after washing varies from 50 to 55 percent, depending upon the amount of surface moisture. The dry beans should have a moisture content of about 12 percent. In general the moisture varies from 11 to 13 percent. Beans having moisture contents higher than 13 percent will turn an opaque white upon storage. Such beans are unacceptable on the open market.

Electronic moisture meters are becoming very popular. With such devices the moisture content of coffee beans can be determined in a few minutes. Most of the larger plantations have access to one. However, such meters are beyond the means of small farmers, hence experience in judging the dryness of the bean by observation is vital. *Note: Underdrying will cause quality deterioration. Overdrying will result in weight loss.* However, it is safer to overdry than to store *underdried coffee*.

The bean dried on the farm still has the parchment and silver skin coverings. The dried bean at this stage is called *parchment coffee*. Properly dried parchment coffee can be stored for several months. In the past there has been some demand

for "aged" coffee where the beans were stored or "aged" for a few years before roasting. The beans were stored as parchment coffee.

HULLING AND GRADING

Coffee is processed only to the parchment stage on most farms. The parchment is then sold to the larger plantations or to the millers who hull the coffee.

Hulling is the process in which the parchment and silver skin covering the green bean are removed. Several different types of hullers are available for this, but in general only two types are widely used today. In one type the parchment is rubbed off by friction, while in the other the parchment is "cut" and stripped off. The latter method is considered better because no heat is generated during the hulling. The friction type, on the other hand, generates considerable heat. In some types of friction hullers, the operation is completed in three stages, with the beans subjected to air blasts between stages to cool them. This air blast also removes the chaff. *Remember:* The quality of the coffee is impaired if overheated at any stage.

After the parchment skin (or hull) is removed, considerable amounts of silver skin are still attached to the green bean. This is especially true when the hulling is done by cutting action. The amount remaining on the bean depends upon the coffee. Silver skin on some coffee comes off more easily than others. The silver skin on coffee grown at lower elevations in Kona, for example, is generally harder to remove than is the skin on coffee grown in the upper areas. In the past the silver skin was rubbed off the bean with special polishers. This is not done very much today, however, since it was found that the silver skin did not affect the quality of the roasted coffee.

Grading

The hulled coffee beans are next separated according to size in mechanical graders. The peaberry type beans are also separated from the flat beans. They are just as good as the regular beans and command the same price.

The grading is first done by separating the beans according to thickness. This is done by "screening" the beans through parallel bars. The bars are closer together at one end than at the other. The coffee is dropped in the narrow end. The flatter beans fall first while the thicker ones fall last. Peaberries, being thicker, drop out last, together with the largest beans which are normally thicker than the smaller ones.

After grading through parallel bars the beans are further separated through the use of screens with round holes of various diameters. Since peaberry coffee beans generally are of smaller diameter than the flat beans, they go through the screen with the smallest holes in each set of different size screens. The flat beans are then further separated into various sizes.

The number of grades into which the coffee is separated varies with locale; in Kona, Hawaii, the coffee is separated into 4 grades of type 1 and type 2 beans.

In the United States trade, size of beans does not determine the grade, however. The grades are evaluated by the number of imperfections contained in one pound of green coffee, with grades ranging from No. 2 to No. 8. No. 1 coffee is perfect coffee and its occurrence is both remote and highly improbable; hence it is not listed. Coffee graded lower than No. 8 is not admitted into the United States.

Although the grading is based upon the number of imperfections in a pound of coffee, grading by size will indirectly determine the quality since most of the imperfections are contained in the smaller grades.

In order to raise the quality of size-graded green coffee, various schemes are used to separate out the imperfections. Some of these imperfections, including shells, "quakers" (immature beans), stones, etc., have different specific gravities (heaviness) than do the sound beans, hence they can be separated mechanically. Various types of machines are used to separate out the lighter and heavier beans. Air separators are most commonly used.

Many imperfections cannot be separated by specific gravity differences. Sour beans, for instance, and some types of black beans are among these groups. Here electronic devices which separate the coffee according to color have been used and are still being used in a few places. These machines do not do as good a job as hand sorting because the color differences between good and bad beans are not always sufficiently distinct for accurate discrimination.

Hand sorting is perhaps the most common method used so far. It is still being used in some Latin American countries. In Hawaii labor costs are so high that hand sorting was abandoned a few years ago.

After the coffee is hulled and graded, it is bagged and shipped to consuming countries. No coffee is roasted in the producing countries for export to consuming countries, principally because of the fact that roasted coffee will not keep as long as green coffee, regardless of the type of packing. Green coffee can, if necessary, be stored for several years.

SUMMARY

Because harvesting and processing are, after proper cultural practices in the field, the *key to quality*, the following summary is presented with the intent of emphasizing essential steps in both.

- 1) Pick only ripe coffee.
- 2) Pulp within a *maximum period* of 48 hours, or within 24 hours whenever possible.
- 3) Storage in bags or boxes *longer than 48 hours* will deteriorate quality through fermentation.
- 4) Overhaul the pulper annually at the beginning of the harvest season and always keep it in good working condition.
- 5) Remove shrivelled, dry coffee and over-ripe coffee through floatation before pulping.
- 6) Mechanical desliming *immediately after pulping* will decrease the loss in net weight which occurs under fermentation.
- 7) The use of a *clean* wooden vat and a large quantity of coffee beans is recommended for effective fermentation. A clean vat is essential.
- 8) Wash beans with clean water before drying.
- 9) Dry coffee *thoroughly*, either by sun heat or by artificial means.
- 10) If artificial drying is to be undertaken, *never heat beyond 150°F*. It will ruin the coffee. The best temperature range is between 135°F and 140°F.
- 11) After drying, hull, grade and bag carefully for marketing.

Remember, one cent per pound more on a 10 million pound crop will bring \$100,000 extra to Hawaii's growers.

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