COFFEE

Small-Scale Processing

technical brief

Agricultural and botanical aspects

The two most important species of coffee are *Coffea arabica* (Arabica coffee) (over 70% of world production) - and *Coffea canephora* (Robusta coffee). Two other species which are grown on a much smaller scale are *Coffea liberica* (Liberica coffee) and *Coffea dewevrei* (Excelsa coffee).

Arabica (Coffea arabica) This is a shrub or small tree with relatively small glossy leaves and small fragrant white flowers. Arabica coffee usually receives a premium for its superior flavour and aroma. Arabica is more suited to higher cooler climates (600-2000m altitude and 15-20°C).

Robusta (Coffea canephora) There are many different Robusta varieties. In general, they can thrive in hotter lowland areas (below 900m altitude and over 20°C). Robusta coffee is preferred for instant coffee production since the yield of soluble solids is relatively high.

Liberica (Coffea liberica) This is a larger tree with large leaves and berries. It can tolerate hot and wet conditions. Liberica coffee is grown in Malaysia and in West Africa, but only very small quantities are traded as demand for its flavour characteristics is low.

Harvesting

Selecting seeds Good coffee cannot be made from poorly harvested coffee cherries. Only large and fully ripe berries from disease-free, pest-free and high-yielding trees should be selected. The coffee cherries should be picked when they are bright red all over. At this stage, the bean can be squeezed out from the pulp by applying light pressure between finger and thumb. Small shrivelled, lightweight and abnormal berries or dry, over-ripe berries should not be used.

Processing There are two ways coffee can be processed - dry ('natural') processing and wet ('fermented and washed') processing. Wet processing is regarded as producing a higher quality product. The dry process, also known as unwashed or natural coffee, is the oldest method of processing coffee but it is now limited to regions where water or infrastructure for machinery is scarce.

Dry processing

Drying

The entire cherry after harvest can be placed in the sun for 10-14 days to dry on tables or in thin layers on concrete drying areas. Once the skin is dry, the pulp and parchment are removed from the bean. The bed depth should be around 3 cm and the cherries should be raked frequently to prevent mould-growth, fermentation or discoloration. However, contamination by dust and dirt blown onto the produce is a problem, and rain can soak the produce very quickly.

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Solar drying

Figures 1 and 2 are designs for two solar driers - the solar cabinet drier and the Exell solar drier. The coffee should be placed in the trays in the solar drier no deeper than 3 cm and it is better if the whole tray area is covered.

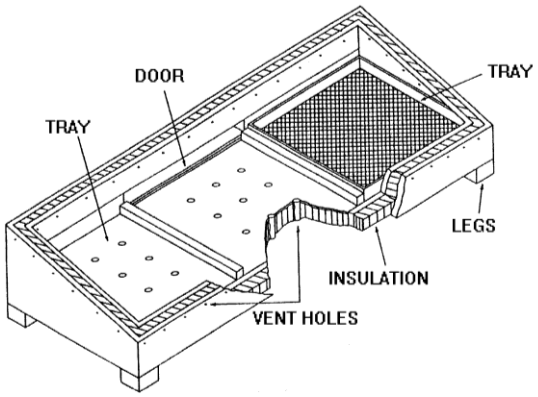

Figure 1 : The solar cabinet drier

The drier should be filled with coffee as early in the day as possible so that all possible sunlight hours are used. The coffee should be stirred regularly so that a uniform colouration is formed. At night, the crop should be transferred to a cool dry room to prevent moisture condensing on the coffee.

Artificial driers

In the wet season solar drying of produce is difficult and alternative driers are necessary.

Hulling The dried cherry is then hulled to remove the pericarp. This can be done by hand using a pestle and mortar or in a mechanical huller. The mechanical hullers usually consist of a steel screw, the pitch of which increases (and therefore the pressure) as it approaches the outlet so removing the pericarp.

Cleaning The hulled coffee is cleaned by winnowing.

Wet processing In this method the cherry is squeezed in a pulping machine or pestle and mortar which removes the outer fleshy material (mesocarp and exocarp) leaving a bean covered in mucilage. This mucilage is fermented and dispersed. The bean is then washed and dried.

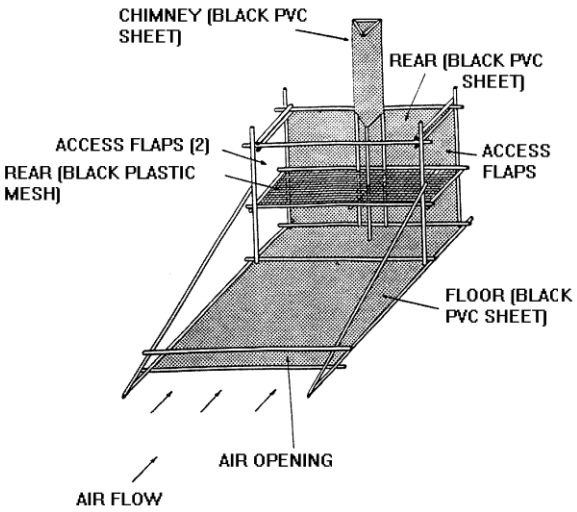

Figure 2 : The exell solar drier

Pulping This involves the removal of the outer red skin (exocarp) and the white fleshy pulp (mesocarp) and the separation of the beans from the pulp. Immature cherries are hard and green and very difficult to pulp. If the coffee is to be wet-processed, correct harvesting is essential. The two most common pulpers most suitable for small-scale units are the drum and the disc pulpers.

Drum pulpers (Figure 3)

This pulper comprises a rotating drum with a punched sheet surface and adjustable breast plate between which the coffee cherries are pulped. The pulp and the beans are then separated using a simple gravity system. The distance between the drum and the breast plate has to be adjusted so that the pulp is removed without the beans being damaged.

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These can be manually operated but larger scale units are normally fitted with a motor.

Disc pulpers

The same concept is involved with the disc pulper except that the pulp is removed using abrasion by a rough disc.

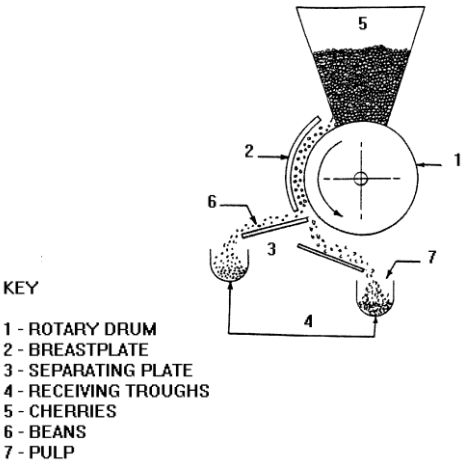

Figure 3 : Separation of pulp and beans

Mucilage removal The amorphous gel of mucilage around the bean consists of hemicelluloses, pectic substances and sugars and is insoluble in water. This mucilage can be removed by chemical methods or warm water but, for small-scale units, the only feasible method is fermentation. Fermentation involves the beans being placed in plastic buckets or tanks and left until the mucilage has been broken down by natural enzymes and bacteria. The coffee should be stirred occasionally and every so often a handful of beans should be tested by washing them in water. If the mucilage can be washed off and the beans feel gritty rather than slippery, the beans are ready.

Drying The beans should then be washed and dried immediately to prevent spoilage and the development of off-flavours. To prevent cracking the coffee beans should be dried slowly to 10% moisture content (calculated on a wet-basis) using the same drying methods described above.

Hulling and cleaning After drying the coffee should be rested for 8 hours in a well ventilated place. The thin parchment around the coffee is removed either by hand, in a pestle and mortar or in a small huller. The hulled coffee is cleaned by winnowing.

Roasting and Grading

The final flavour of the coffee is heavily dependant on how the beans are roasted. Roasting is a time- and temperature-dependant process. The roasting temperature needs to be about 200ºC.

The degree of roast is usually assessed visually. One method is to watch the thin white line between the two sides of the bean, when this starts to go brown the coffee is ready. As preferences vary considerably from region to region, the locally-acceptable degree of roast will need to be assessed.

Coffee beans can be roasted in a saucepan as long as they are continually stirred. A small improvement is made by roasting the coffee in sand, as this provides a more even heat.

A roaster will produce a higher quality product. The simplest roaster is basically a tin can with a handle so that it can be rotated slowly over a fire. There are various other roasters suitable for larger scale units.
Coffee is graded by size, shape, odour, density and colour.

Grinding

It is easy to assess the quality of whole coffee beans. However, ground coffee beans produce a brown powder which can be easily adulterated. Because of this there is often market resistance to ground coffee. This market resistance can only be overcome by consistently

producing a good product. There are basically two types of grinders - manual grinders and motorized grinders.

Manual grinding mills An experienced operator can grind about 20kg in an eight hour day. However, this is hard and tedious work. The grinding mills need to be set so that they produce the desired degree of fineness of ground product which satisfies the end-user. For small-scale production (up to 100kg/day) a series of these grinders is all that is needed. Motorised grinders are available for larger scale production units.

Motorised grinding mills Horizontal plate, vertical plate or hammer mills are suitable for grinding coffee. A grinding mill has to be placed in a separate and well-ventilated room because of the fine particles of coffee dust generated during milling. These particles can be an irritant.

Instant coffee

To produce an instant coffee, the soluble coffee solid and volatile compounds have to be extracted and then dried into a powder or granules. The production of instant coffee is unsuitable for small-scale enterprises as it requires expensive machinery such as an extractor and a freeze- or spray-drier. However a general description is provided below.

Prestripping Sometimes the volatile compounds in coffee (of which there are over 700) are removed before the extraction of soluble coffee solids. This is usually done by passing steam through a bed of ground and roast coffee.
The initial steam pressure has to be high enough for the steam to pass through a static bed of coffee. The extracts and steam are condensed to give a mixture of water and volatile compounds. These compounds can be condensed and collected using a tubular condenser with chilled water flowing through it.

Extraction of soluble coffee solids The extraction of soluble coffee solids is usually done using water as the solvent. Extraction is continued until the solution obtained is 15-25% w/w coffee extract. The extraction is usually done at 175ºC since at 100ºC the extracted solids are difficult to dry. There are three ways the solids can be extracted.

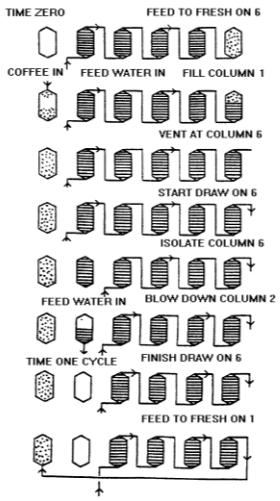

Figure 4 : Percolation batteries

Percolation batteries This is the most common method. The roasted and ground coffee is held in a series of 5-8 vessels. Hot water is passed through the vessels and, when the soluble coffee solids have been fully extracted from each vessel, it is isolated from the battery and spent coffee discharged. A new vessel replaces this exhausted vessel (see Figure 4). As the extraction takes place at 175ºC, the system needs to be under pressure. A solution of 15-25% w/w of soluble material is produced which can then be dried.

Countercurrent system Coffee is fed continuously into the bottom of an inclined cylindrical vessel and moved upwards by two helicoidal screws rotating at 10-22 revolutions per hour. Hot water enters the top and the extracted solids in solution exit at the bottom. The vessel is pressurised and kept at 180ºC by the use of temperature jackets.

Slurry extraction Coffee and water are agitated together in a tank and separated using a

centrifuge.

Drying

The extracts can be dried in a spray drier, freeze drier or a drum drier.

Spray drying Spray drying requires that the concentrated coffee solutions extracted are 'atomised' to form droplets (10-200 micrometers in diameter) and then sprayed into a current of heated air (150-300ºC) in a large drying chamber, this is usually a concurrent air flow. Complete and uniform atomisation is required. For coffee drying, a centrifugal atomiser is usually used. The liquid is fed to the middle of a rotating bowl (peripheral velocity of 90-200m/s). This produces droplets with diameters of 50-60 micrometers in a uniform spray. The droplets are dried very rapidly (1-10 seconds) due to the very large surface areas. The dry powder is removed from the base by a screw conveyor or a pneumatic system.

Freeze drying Freeze drying takes place by sublimation (ie a solid material transforming directly to vapour without passing through a liquid stage). The coffee solution is slowly frozen in conventional freezing equipment. The frozen material is put under reduced pressure and heated. As long as the pressure in the freeze drier is below the vapour pressure at the surface of the material, it will sublime directly to vapour without melting. The vapour needs to be removed by a vacuum pump and is condensed on refrigeration coils. The final drying stage involves evaporative drying (desorption). This is achieved by raising the temperature to near ambient whilst retaining the low pressure.

Coffee needs to be frozen as a foam (by gas inclusion) to prevent formation of a glassy vitreous frozen material.

Drum drying This is rare nowadays. It involves the extracts being dried by direct contact on a heated cylindrical surface.

Packaging and Storage

Materials Packaging of coffee (especially if it is ground) requires polypropylene. Polythene cannot be used as the flavour components diffuse through it. The use of laminates is popular but more expensive. Glass is also a suitable container.

Simple sealing Polypropylene bags can be sealed using simple hand-operated electric sealing machines.

Storage The optimal conditions for storage are low temperature, low humidity and pest-free in a shaded area. To prevent pests entering the store, the roof should be completely sealed. Mosquito netting should be placed over the windows, and the doors should be close-fitting.

Processing Waste

Coffee pulp If not treated, this will give rise to unpleasant odours and attract flies and insects. It can be converted into animal feed, soil conditioner, or used for caffeine extraction and biogas production.

Waste water Care needs to be taken to prevent water from the processing, polluting local rivers or lakes.

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Equipment suppliers

This is a selective list of suppliers and does not imply endorsement by Practical Action

Cape Australia: Coffee-Processing Machinery
C.A.P.E. Australia
179 Broken Head Road
Newrybar, NSW, Australia 2479
Tel: (02) 6687 1004 International: +61 2 6687 1004
Fax: (02) 6687 1335 International: +61 2 6687 1335
Email: cape@zentvelds.com.au
http://www.capeau.com.au/coffee_equipment.html

W M McKinnon & Company Limited
25, Mettupalayam Road ,
Narasimhanaickenpalayam,
Coimbatore - 641 031.
Tamil Nadu
India.
Tel: +91 - (0)422 - 2460829 / 2460988,
Fax:+91 - (0)422 - 2461903
E-mail: mckinnon.india@vsnl.com
http://www.mckinnon.co.in/Gen/Contact.asp

Alvan Blanch
Chelworth
Malmesbury
Wiltshire
SN16 9SG
United Kingdom
http://www.alvanblanch.co.uk
Tel: +44 (0) 666 577333
Fax: +44 (0) 666 577339
Coffee Huller, used for the hulling of coffee. Power: Diesel/Petrol/Electric.
Coffee Pulper. 300-4000 kg/hour Power: Manual/Electric/Diesel/Petrol
Coffee Grinder KF1800 used for the grinding of coffee after roasting.
Coffee Roaster. Capacity: 100 kg/hour of Power: Gas/Electric

Rajan Universal Exports Manufacturers PVT Ltd
Post Bag
No. 250
162, Linghi Chetty Street
Chennai - 600 001
India
Tel: +91 44 5341711 / 5340731 / 5340751 / 5340356
Fax: +91 44 5342323
Coffee Pulper / Drum Pulper used for pulping coffee beans on a small-scale.
Capacity: 300 kg/hour Power: Manual/Electric

Autopack Machines Pvt Ltd
101-C, Poonam Chambers, Dr. Annie Besant Road,
Worli, Bombay - 400 018. India
Tel: +91-22-24964926 / 24910593
Fax: +91-22-24924806 / 24974800 / 24934406
autopack@bom3.vsnl.net.in / sales@autopackmachines.com
http://www.autopackmachines.com/

Marden Edwards Limited
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Fax: +44 (0)1202 861 400
Email: sales@mardenedwards.com
http://www.mardenedwards.com/
Packaging machines

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References

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- From Crop to Cup: Conventional Trade in Coffee
- Single Estate Coffee: Crop to Cup
- Agro-Industry Profiles: Coffee
  SECTORAL LIBRARY: INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT, 1986. This review of the coffee processing industry explores all aspects of the industry from cultivation practices to processing and marketing. It discusses primary processes such as wet processing, fermentation, washing, drying and hulling, and secondary processes such as grading, sorting, shipping, decaffeination, blending, roasting, grinding and the preparation of soluble coffee. Marketing aspects coffee storage and environmental concerns are also addressed
- Coffee
- Coffee: botany, biochemistry and production of beans and beverage.
  Clifford MN and Willson KC (Editors). London, Croom Melm, 1985.
- **Coffee** Wrigley G. London, Longman, 1988.

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