COFFEE QUALITY AND SAFETY MANUAL

© 2004. Embrapa Informação Tecnológica
Qualquer parte desta obra poderá ser reproduzida, desde que citada a fonte.

This manual was developed in Brazil for the Brazilian coffee sector, under the National Food Safety Programme (PAS)

The views expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.

NATIONAL CONFEDERATION OF INDUSTRY – CNI
SENAI NATIONAL COUNCIL
Armando de Queiroz Monteiro Neto
Diretor-Presidente

SESI(Industry Social Service) NATIONAL COUNCIL
Jair Antonio Meneguelli
Presidente

NATIONAL AGENCY FOR SANITARY SURVEILLANCE – ANVISA
Cláudio Maierovitch P. Henriques
Diretor-Presidente

Ricardo Oliva
Diretor de Alimentos e Toxicologia

NATIONAL CONFEDERATION OF COMMERCE – CNC
SENAC (National Service for Commercial Learning) NATIONAL COUNCIL
SESC (Commerce Social Service) NATIONAL COUNCIL
Antônio Oliveira Santos
Presidente

NATIONAL CONFEDERATION OF AGRICULTURE – CNA
SENAR (National Service for Rural Learning) NATIONAL COUNCIL
Antônio Ernesto Werna de Salvo
Presidente

EMBRAPA– BRAZILIAN AGRICULTURAL RESEARCH CORPORATION
Clayton Campanhola
Diretor-Presidente

Mariza Marilena T. Luz Barbosa
Diretora-Executiva

Herbert Cavalcante de Lima
Diretor-Executivo

Gustavo Kauark Chianca
Diretor-Executivo

SENAI – NATIONAL DEPARTMENT
José Manuel de Aguiar Martins
Diretor Geral

Regina Torres
Diretora de Operações

SEBRAE – NATIONAL DEPARTMENT
Silvano Gianni
Diretor-Presidente

Luiz Carlos Barboza
Diretor Técnico

Paulo Tarciso Okamotto
Diretor de Administração e Finanças

SESI – NATIONAL DEPARTMENT
Armando Queiroz Monteiro
Diretor-Nacional

Rui Lima do Nascimento
Diretor-Superintendente

José Treigger
Diretor de Operações

SENAC – NATIONAL DEPARTMENT
Sidney da Silva Cunha
Diretor Geral

SESC – NATIONAL DEPARTMENT
Marom Emile Abi-Abib
Diretor Geral

Álvaro de Mello Salmito
Diretor de Programas Sociais

Fernando Dysarz
Gerente de Esportes e Saúde

SENAR – NATIONAL SERVICE FOR RURAL LEARNING
Antônio Ernesto Werna de Salvo
President of the Deliberative Council

Geraldo Gontijo Ribeiro
Executive Secretary

Tania Barretto Simões Corrêa
Otniel Freitas-Silva
Sara Chalfaoum
Dilma Gelli
Team

CONTENTS

PREFACE

The Programme for Food Safety (PFS) was created on August 6, 2002, and had its origins in the HACCP (Hazard Analysis and Critical Control Points) Project initiated in April 1998 through a partnership between CNI/SENAI and SEBRAE. The main purpose of the PFS is to guarantee the production of food that is safe to human health and the satisfaction of consumers, forming one of the pillars for the success of agriculture and livestock from the farm to the consumers' table. Additional benefits will accrue through the generation of new jobs, services, income and other opportunities. The programme is being developed by the industry, food, transportation, distribution, special actions and countryside sectors, in articulated projects.

The SFP–Countryside Sector was conceived through technical and financial cooperation between SENAI, SEBRAE and EMBRAPA, with the aim of instructing producers, technicians and businessman involved in primary production on the adoption of Good Agricultural Practices (GAP), using the principles of the Hazard Analysis and Critical Control Points (HACCP), to mitigate or avoid physical, chemical and biological hazards, in order to secure consumer's food safety. It focuses on food and environmental safety, and specifically on advising small family producers, as well as being an integration tool with other SFP programmes.

The HACCP system (the Brazilian acronym is APPCC), which originated in the United States in the 1950's, has been recognized by Brazilian government institutions such as the Ministry for Agriculture and Food Supply, Ministry of Health and Ministry of Science and Technology, as a tool to help meet Brazilian legislative requirements.

At the international level, HACCP is recommended by the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO), the World Commerce Organization and Codex Alimentarius.

This recognition and synthesis of efforts between the Programme and Systems ensure the production of quality agricultural products for the internal market, besides allowing an increased competitiveness at the international market.

This publication is part of a collection of documents that are aimed at producers, technicians, rural businessmen and others interested in the use of GAP in the consistent application of management systems for the adequate control of food risks and hazards.

PRESENTATION

Brazilian agriculture and livestock have experienced major advances in recent years, especially with regard to productivity.

However, primary production has presented various limitations regarding the control of physical, chemical and biological hazards. This is mainly because of the gret care required during both pre- and post-harvest procedures, in order to avoid hazards that might lead to diseases transmitted by food..

At the international level, and in the context of global markets and a global economy, there has been an increased demand by consumers for safer foods and environmental sustainability.

In order to improve competitiveness, it is essential to let rural producers know that a change in their habits, practices, and attitudes regarding the processing of food products, will be of value.

The PFS, based on GAPs and focusing on HACCP in order to promote Integrated Production (IP), has the general objective of building up preventative measures for food safety, with the function of detecting gaps in the production chain for future preventative action.

With this tool, it will be possible to help ensure the safety and quality of products, increase production, productivity and competitiveness, and comply with Brazilian legislation, whilst attending to the demands of the international market.

Through partnership and cooperation between SENAI, SEBRAE and EMBRAPA, this manual is now available. It is based on current knowledge and technology, as well as suitable empirical research and a comprehensive literature review of the subject.

1 - INTRODUCTION

The growing concern with the safety and improvement of food product quality has led both public and private institutions to develop and utilize several quality systems and programmes. Those Quality Systems based on established rules, e.g. the ISO 9000 series (NBR-19000) and Total Quality Management (TQM) developed from a need to optimize specific processes in order to rationalize the means of control and their associated resources.

Recent data regarding diseases originating from food associated with the consumption of agricultural products have raised the prominence of public health amongst governments, consumer protection associations and producers, and galvanised work on ensuring quality-based, safe products.

HACCP has been shown to be a fundamental element of modern management systems aimed at guaranteeing the quality of a product from the perspective of consumer health.

One of the requirements for the implantation of HACCP and Good Agricultural Practices is a defined set of practices that allow the environment and conditions of work to be more hygienic, efficient and appropriate, thus optimizing the whole production process. The knowledge and development of good practices allow the production to be systematic and programmemed, with obvious advantages for productivity and quality. Some GAP items deserve special attention, particularly those related to hygiene practices and the use of pesticides that are potentially toxic, and therefore, must be registered, monitored, recorded and corrected as soon as deviations that may compromise the final product or people's health are detected. These items or programmes are highlighted as Standard Procedures for Operational Hygiene (SPOH). The adoption of GAP, especially SPOH, performed in an efficient way, is extremely important for the implementation of a HACCP system.

The HACCP system consists of first defining the hazards (hazard analysis) associated with the product in question, including all stages of production such as selection of seeds or cultivars, sowing, harvesting, cleaning at the level of primary production, processing, commercialization, and/or preparation of a given raw material or food product. Following hazard analysis, the steps in which control is critical to prevent, minimize or eliminate hazards need to be characterized. Subsequently, procedures to monitor these critical limits and corrective actions should be established, so that deviations can be observed. The HACCP system provides a more specific focus on hazard control than do traditional procedures of quality control and inspection.

In the specific case of coffee, a flowchart must be prepared and adjusted for each aspect of cleaning, processing and transportation, indicating the main hazards and critical control points for each situation. When there is any modification in the flowchart, it should be thoroughly revised.

The HACCP system is preventive in character - all the steps of the production chain are analyzed and where it is considered critical, control measures are applied.

This document is a contribution to the various production sectors of the coffee agribusiness, and seeks the same benefits of the HACCP system as those applied by the industry, which are:

a) To confer a preventive control character to the operations of cultivation, harvest and post-harvest management, storage, transportation and commercialization;
b) As a guide towards selective attention to the control of critical points along the coffee production/ handling chain;
c) To systematize and document measures for the control of critical points;
d) To guarantee the production of safe food;
e) To provide an opportunity for increasing productivity and competitiveness.

2 - PRODUCTION SYSTEMS

Although a HACCP system is adequate to guarantee food safety control, it should not be considered as a totally independent system. It is integrated with prerequisite programmes. In the guidelines of the Codex Alimentarius, for example, the HACCP system is attached to the Hygiene Code of Practice for Food Production.

The principles of the HACCP system are indicated not only for one element of the production chain, but for the control of all of it. The success of the HACCP plan depends on the successful implementation of recommended Good Agricultural Practices and the Standard Procedures of the Operational Hygiene. These are the prerequisite programmes for the HACCP.

There are two main species of coffee – *Coffea arabica* and *Coffea canephora*. Arabica coffee (*Coffea arabica*) is regarded as the higher quality species, being the only one that can be consumed pure, without any blending. Arabica coffees are classified as “Brazils” (Brazilian origin) and “milds” (those from other countries, mainly Colombia). The two best known varieties are “Tipica” and “Bourbon”, although other varieties have been developed. The average arabica coffee plant is a massive bush with dark-green oval leaves. The fruits are also oval and contain two flat seeds. Arabica coffee represents about 70% of total world production.

Robusta coffee (*Coffea canephora*) produces beans which are generally blended with arabica to increase the flavour and body of the resulting coffee. The word “robusta” derives from one variety of *Coffea canephora* that is cultivated in large scale. Robusta beans are smaller than arabica beans. Robusta coffee, responsible for 30% of the world production is cultivated in Western and Central Africa, in Southeast Asia and in Brazil, where it is known as “*conillon*”.
Coffee cultivation in Brazil started in 1727, with the introduction of the first seedlings of *Coffea arabica cv*, originating from Guyana, with the Tipica, Arabica

and Crioulo varieties being the first to be cultivated. Several cultivars were developed over the years with some mutations, and at the moment the one that is broadly cultivated is the "Catuaí", with a large number of enhanced lineages bearing both red and yellow mature fruits.

Both robusta and arabica coffee plantations produce a first harvest 3 or 4 years after being planted, and are profitable for between 30 to 40 years. Both species demand plenty of sunlight and rain. The arabica coffee plants grow well in seasonal climates, with temperatures varying from 15 to 24 °C. Robusta coffee develop better in equatorial climates with a range of temperature between 24 to 29 °C.

In 2001, coffee production in Brazil was approximately 19,410,000 sacks of hulled arabica beans, and 7,290,000 sacks of robusta beans as shown in Figure 1.

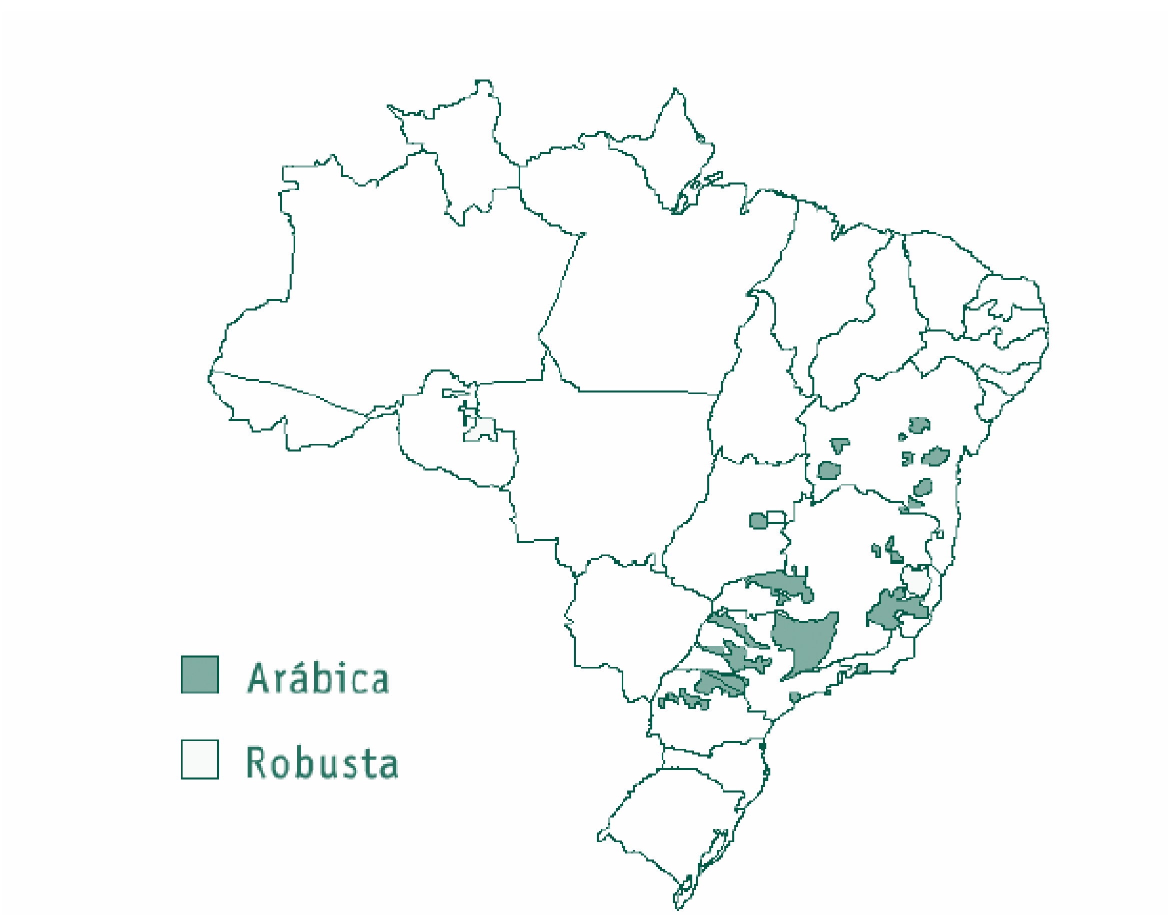

Figure 1 – Map showing distribution of coffee cultivation in Brazil.

The world market is supplied basically by four groups of coffee, as designated by the International Coffee Organization (ICO): Colombian Milds, Brazilian Naturals (also known as Unwashed Arabicas, and also includes coffee from Ethiopia, for example), Other Milds, and Robustas. The classification made up of natural arabicas is an oligopolic, wuth key producers being Brazil and Ethiopia. This kind of coffee is obtained from drying the whole fruit, without prior removal of the husk and mucilage, and can present nuances of flavour and odour typical to the places of origin. However, if the raw material used is heterogeneous and resulting from the presence of fruits that were harvested at different stages of ripening, care must be taken with the harvest and the other stages of preparation, to preserve and guarantee the safety and sensorial characteristics of the final product.

Brazil also takes part of the robusta coffee world market, whose final quality, though considered inferior when compared to arabica coffee, depends in part on the care taken during cultivation and hulling process.

2.1 - Good Agricultural Practices (GAP) for coffee cultivation and hulling

In a GAP programme applied to coffee cultivation and processing, the different types of hazards that could affect final consumer safety should be considered as priority, as well as those related to aspects of product quality. In the GAP programme the stages of cultivation, harvest, drying, storage and transportation are considered

2.1.1 - Cultivation

Extant cultivation conditions exert a major influence on the safety and quality aspects of coffee production. Factors such as climate, plantation care, sanitary treatment of the coffee plants, fertilization, harvest care, etc, can all influence bean contamination and the resulting beverage quality.

The optimization of some operations that affect product safety are of critical importance, especially plant sanitary actions. The purpose of monitoring pests, diseases and weeds is to limit the use of pesticides, hence minimizing contamination of the beans.

In coffee cultivation, the selection of suitable climatic zones avoiding those areas prone to frost, is critical. A minimum annual temperature of lower than 1°C is a meteorological element determinant for the risk of frost, being related to a probability of higher than 25% that frost will occur. In the states of Parana, Sao Paulo and Minas Gerais, there are regions that are more prone to the occurrence of frost than elsewhere. Important measures for frost prevention in coffee plantation are as follows:

1. Choice of plantation area:
   - The terrain must have steepness over 5%. Coffee should be planted only halfway to the top of the slope.
   - Coffee should never be planted in terrain depressions.
   - Coffee should be planted on the north face of the terrain.

2. Planting intercalating trees[1] for the plantation establishment:

[1] Intercalating trees are known in Brazil as '*Grevileas*'.

- '*Grevilea*' trees should be planted according to the following criteria. Each plant should be 10 -14 m apart. Inside the coffee plantation, the tree distribution should be approx. 70 plants/ha. Protection against frost should start three years after the trees have been planted.

3. Planting '*guandu*'[2] at the first year of plantation formation:
   - Planting guandu should be done according to the following criteria: sow one line of common guandu in the line between the dense coffee rows, in the period of October/November. In May, the guandu will completely cover the coffee trees. Protection with guandu promotes a temperature rise of 2 to 4℃ during the night.

4. Covering coffee with plant residues:
   - Another way to prevent frost damage is to cover coffee plants with a thick layer of plant residues the day before suspected frost. After the frost risk is over, this protective layer should be removed. This procedure promotes complete protection against severe frost – it is crucial that there is adequate covering of the coffee plantation for it to be effective.

5. Piling up soil close to the coffee tree trunk:
   - At the beginning of May, soil should be piled up close to the trunk of young coffee plants, for up to two years after planting out. This soil should be removed in August. Soil piled up around the trunk protects coffee plants against a "shin frost".
   - A direct protective measure against frost is the burial of newly-planted seedlings the day before a suspected frost. These seedlings should be uncovered within 20 days after the end of the frost risk.

Another limiting factor for coffee cultivation is a lack of water. The criteria determining potential water deficit are:

- Areas suitable for coffee growing:
  Arabica: Dha<150 mm
  Robusta: Dha<200 mm
- Marginal areas:
  Arabica: Dha: 150 to 200 mm
  Robusta: Dha: 200 to 400 mm

Preventive measures against water deficit include:
- Observing careful climate zoning of the crop
- Providing forestation and/or installation of an irrigation system

2.1.2 - Harvest planning and execution

The harvest should be planned when about 70% of the fruits (cherries) are ripe. Careful maintenance and repair must be undertaken on all machinery, equipment

[2] '*Guandu*' is the Brazilian term used to describe leguminous 'Pigeon peas' (*Cajanus flavus*).

and materials to be used. Materials, such as sacks, spreaders and clothes must also be acquired in advance so that the harvest is completed within a maximum period of two to three months for large plantations.

The size of terraces and dryers must be calculated so that they can accommodate the drying of fruits as soon as they arrive at the drying area, thus allowing the harvest to follow its normal flux. Paved terraces must be revised and repaired as needed. The whole drying area must be cleaned in order to eliminate any residue leftover from previous crops.

Harvest labour must be calculated using the yield technical coefficients for manual, mechanical or mixed harvest.

Before the harvest, the operation called '*arruação*' must be completed. This is the manual or chemical cleaning of the area beneath the coffee trees, with the purpose of facilitating the harvest and reducing the conditions suitable for the rapid deterioration of the fruits that fall either before or during the harvest.

When the crop presents a very heterogeneous maturation of fruits, it is recommended that fruits that fall to the ground before harvest (i.e. gleanings) are collected so as to avoid prolonged contact of those fruits with the ground, which can cause defects such as black beans and '*ardido*' beans.

The harvesting process is of great importance in obtaining a high quality product, justifying the care to be taken with: determination of the best moment to start the harvest, the duration of harvest, as well as the harvest method that is more suitable for a given region and/or size of plantation.

The harvest in Brazil is carried out over a short period of time, generally starting in April/May, with variations depending on the region and on the climatic conditions prevailing at the time. Usually a mixture of fruits with different degrees of maturation, color, moisture content and density are obtained, and the following types are predominant:

- Immature fruits, with 50-70% moisture content;
- Cherries (ripe coffee), with 50-70% moisture content;
- Raisins (overripe coffee), with 35-50% moisture content;
- Floats, with 25-35% moisture content;
- Dry coffee, with <25% moisture content.

The best beverage is provided by mature cherries, once those fruits are processed appropriately. Immature coffee will result in a beverage of inferior quality, besides provoking a decrease in yield. No more than 5% of immature coffee is recommended in the total harvest, with a 20% maximum tolerance. Raisins and gleanings are more prone to microbial contamination inside the pulp, which can result in different types of fermentation, with a negative impact on cup quality. In light of this it is important to get a predominance of cherries in the final harvest; it is recommended that the harvest is performed more than once, obviously taking account of cost/benefit ratios of doing so.

Although it is desirable to harvest only ripe cherries, harvesting methods vary greatly, and do not always harvest ripe cherries alone.

The producer must observe the ideal moment for harvesting. Typically this is when there is a maximum of ripe cherries and a minimum of immature fruits 5%, and without an excessive fall of dried fruits.

Manual stripping must be done with the aid of clean plastic sheets, or similar, laid under the coffee trees in order to avoid contact of harvested fruits with the soil, thus avoiding potential the fungal contamination.

2.1.3 Dry pre-processing with wagging

Strip-picking must be completed over clothing, and the gleanings separated from fruits recently harvested. Pre-cleaning is completed while the harvested coffee is still at the plantation, for removal of bigger impurities such as leaves and sticks. This is known as ‘wagging’.

After either manual or mechanical harvesting, a new operation of sweeping the ground must be undertaken, to eliminate those fruits that fall outside the cloth or the harvesting machine. These fruits must be discarded.

2.1.4 Dry processing

Wagging

Immediately after harvesting, coffee is submitted to the 'wagging' operation, with the purpose of removing gross impurities that are mixed with the fruits. The harvested coffee must be forwarded as soon as possible to the processing plant, and should not be left piled up within the plantation, waiting for transportation. The harvested coffee must be placed immediately in the vehicle, or in sacks, and transported for drying on terraces. The harvested coffee should never be stored for prolonged periods of time either in vehicles or the sacs, so as to minimize possible fermentation, which can take place due to the high moisture content of the fruits.

Whenever possible, the producer should choose varieties which present maturation uniformly.

Processing is made up of a series of practices, from harvesting itself through to storage. It involves important steps that must be monitored for the preservation of characteristics of safety and sensory quality of the final product, such as cleaning, preparation and drying.

Dry processing can be done through the 'natural method'. Coffee fruits, after washing and the separation of fractions containing ripe cherries and immature fruits, on one side, and floats on the other, are forwarded for drying on terraces or in artificial dryers. This kind of processing can also be conducted with previously dehusked ripe cherries and immature coffee, keeping the mucilage layer that surrounds the beans. In this way the beans are dried further.

Hydraulic separation or washing

In Brazilian conditions, where strip harvesting predominates, harvested fruits present varying degrees of ripening. When the harvest is completed with fruits presenting different stages of ripening, after drying the mixture of mature and immature beans results in an inferior cup quality.

During the washing process, some of the fruit floats on the surface of the water - these are termed "floats". This kind of coffee is composed of those fruits dried while still attached to the branch, immature fruits, malformed and 'milky' fruits.

A large number of the dry fruits and raisins will have undergone some degree of fermentation, which are undesirable in achieving a good cup quality. The portion of fruits that float can reach more than 20% when the reproductive cycle occurs under unfavorable conditions such as: pest attack, diseases, unfavourable climate, or poor nutrition, all of which can induce malformation of the coffee fruit.

The other portion of the coffee which submerges is composed of fruits that are either half- or completely ripe. It is a more uniform coffee, to which subsequent treatment can be applied with a greater possibility of success.

Besides these factors, the washing process has the advantage of providing a pre-cleaning of the product, separating impurities and increasing the lifetime of driers and hulling machines.

The washing must be done in the same day of the harvest and the washed coffee must not be piled up, being immediately transported to the drying spot, in the case of dry-processing.

2.1.5 Drying

This operation is of great importance from the safety perspective, as well that of quality. Coffee drying is comparatively more difficult to complete when compared with other grains. Besides the high sugar content of the mucilage, coffee fruits generally also present a high moisture content at the beginning of the process.

Drying can be done on terraces or with the aid of mechanical driers. Sometimes pre-drying is initially undertaken on the terrace, and the process then completed in mechanical driers. The drying terrace must be adequately built, and a paved terrace is recommended to allow for easier cleaning.

Terrace drying (natural)

Natural drying involving coffee exposed to sunlight on terraces is common in Brazil. Despite the fact that solar energy does not present a real cost in the drying operation, there are some disadvantages such as the low yield of this energy, demanding a great period of time for the drying process, and the requirement of large areas for building drying terraces. Besides these issues, there is also the risk that the coffee can become re-wetted. Thus, some care during the drying process must be observed:

a) Spreading

At the beginning coffee is spread out in thin layers, with a gradual increase in the thickness of the layer, according to the progress of the drying process. The fruits must be protected from rain and dew during the whole of this process. The thickness of the layer of cherries during drying must not exceed 4cm, and the coffee should not stay on the terrace for more than 3 days.

The fruits must be turned over at least 10 times a day, in order to accelerate drying and avoid the risk of fermented and mouldy beans.

Avoid drying the harvested fruits directly on the ground. Fungi spores from other harvests may remain in the soil and contaminate fungi-free cherries. Use terraces with a smoother surface (e.g. tiled), well maintained and clean.

b) Piling up

After the second day of drying, the fruits should be piled up in lines 15-20 cm thick, spreading them out the following early morning.

If it rains, the piles are bigger, arranged along the slope of the terrace. Moving the piles should be done as often as possible, to ventilate the fruits and avoid fermentation. After any rain the piles should be turned over until drying is complete.

Moist cherry coffee can be piled up only after half drying is done. The final phase of drying happens when the moisture content in the beans reaches 20-25%. At this point coffee must be piled up in the afternoon and covered with canvas. This operation should be started around 3 pm, when air humidity is lower. The following morning it should be spread out again, around 10 am, in order to avoid excessive cooling and moisture reabsorption.

c) Final terrace drying

At the end of the drying process the coffee should be between 11-13% moisture content. The total drying time in a terrace varies between 10-20 days, depending on the different regions and climate conditions prevailing during the drying period. The practical determination of this final point can be done based on the observation of the hardness and colour of the beans, by the ratio volume/weight, in which one liter natural coffee weighs about 420-450 g. The determination of moisture content can be done through the use of appropriate meters.

It is important to emphasize that the final moisture content in the coffee beans is critical for the safety and quality of the product. To achieve mositure content levels below 11%, coffee demands labour and terrace area for longer periods of time, besides losing weight with a riskm of breaking beans during the hulling process. With moisture content values above 13%, beans bleach faster during storage, and have a higher risk of rotting. At this stage, there is the maximum risk for development of the fungi *Aspergillus ochraceus* and *Penicillium verrucosum*, which have the potential to produce ochratoxin A (OTA), a potential carcinogen. Within the range between 11-13% moisture content, there is little or no possibility of the growth of these OTA producing species and, therefore, no risk of OTA.

The free water present in the interior of the beans is termed water activity (A_w), which is the most important factor in food composition. It is biologically associated to the air humidity among the beans. The water activity plus temperature must be monitored because they constitute the most important factors for the production of OTA. A_w should not exceed 0.75%, as fungal development and OTA production can occur above this value.

Artificial Drying

As there are different models of dryers commercially available, it is advisable to use those with an indirect fire furnace (heat exchanger) or with a gas burner, to avoid impregnation of the coffee beans with a smokey smell. Dry coffee husks are recommended as fuel, but well-dried wood can also be used. The drier must be loaded with coffee fruits presenting the same moisture content, which allows optimization of the drying process (higher speed and less fuel consumption). The coffee from the beginning of the harvest, containing many ripe cherries and immature fruits, has a high moisture content and should be pre-dried in terraces or pre-drier before going to the drier itself.

The drying temperature is extremely important; it should never exceed 45℃, measured inside the coffee mass, and should not exceed 80℃ at the air entrance of the drier. When there is a high percentage of immature fruits, the temperature of the coffee mass should be lower than 30℃, to avoid defects such as dark-green and black-green beans. The drying process should not be too fast, in order to guarantee uniformity, safety and low cost of the operation, and will normally takie between 24 and 36 hours.

Summary of points to be considered when using terraces:

a) Do not mix different lots of coffee;
b) Spread out the coffee fruits, whether washed or not, at the same day of harvest, in thin layers 3-5 cm thick and proceed with the piling up in small piles. In case there is a large percentage of immature fruits, higher piles can be used (about 10 cm high), however there is no need to turn over the beans frequently (once per hour).
c) Turn over the coffee at least eight times a day, according to sunlight positioning. The worker's shadow should be in front of him or behind him, so that the small piles built while the fruits are being turned over do not shade the rest of the coffee.
d) After the second day of terrace drying, pile up the fruits in small piles 15-20 cm high, at the end of the afternoon and spread them out the following morning. This procedure will speed up the drying process and avoid remoistening from overnight dew.
e) In the case of rain, pile up the fruits in bigger piles, following the direction of terrain steepness. These piles should be turned over as often as possible, to allow maximum air contact with the coffee volume. When the rain stops, the piles should be turned over until the terrace is completely dry. After spreading out the coffee, one should return to step b).
f) Never pile up coffee ripe cherries before the half-dry point (this is indicated as when a cherry is no longer sticking when squeezed). Piling up at this point is one important operation due to the property of heat exchange characteristic of natural coffee, providing homogeneity during the drying process.
g) Pile up the coffee around 3 pm and, if possible, cover with canvas till the next morning.
h) Spread out the coffee around 9 am, when air humidity is adequate and as described in step c), turn it over until 3 pm, when it should be piled up again.
i) Continue the process until the drying process is finished (beans bearing 11-12% moisture content), collecting the cold coffee in the morning and keeping it in the storage facilities.

Small 'crowns' or 'half-moons' can be built on the terrace. These are small walls 5 cm high and 3 cm diameter, whose purpose is to serve as a base for piling up the coffee, thus avoiding rain fall to get inside the covering canvas.

The terraces should be built avoiding humid places, such as depressions, the vicinity of dams, or shaded spots close to buildings.

2.1.6 - Storage

Bulk storage of coffee is completed in special storage facilities (called '*tulhas*' in Brazil) , once the coffee is hulled and packed in burlap sacks.

Coffee beans should preferentially be stored as natural or parchment coffee, because in that way they retain the product quality properties. Inadequate storage conditions may confer odd flavors to the coffee liquor (e.g. woody, mouldy, etc).

Beans should be kept in storage facilities for a minimum period of 30 days. Facilities should be built in places with plenty of sunlight, ventilation and drainage, with a room temperature of 20ºC and maximum air humidity of 65%. It is fundamental to keep the coffee beans at 11-12% moisture content, as they are highly hygroscopic, and can absorb air moisture if kept in environments with high humidity. It is also advisable that the storage facilities are dark, so that the coffee beans (especially hulled beans) do not lose their colour due to excessive light exposure.

2.1.7 – Hulling

Hulling is the post-harvest operation that removed husks and skins from the beans, and transforms the dry fruit (natural or parchment coffee) into green coffee. The hulling operation should be done as close as possible to export/commercialization, in order to maintain the product's original characteristics.

Depending on the conditions that the coffee has been dried in, or even due to changes that might occur during storage, it can be convenient to take the product carefully through ventilated storage driers, in order to homogenize the moisture content and make the material suitable for hulling. In case a high temperature drier is used to solve a high humidity problem, care must be taken not to hull the product while it is still warm. Natural cooling of the beans avoids them breaking.

A hulling facility should contain hold the following equipment:

a) Sieve set: a set of sieves with different types of holes, so that the coffee can be separated from impurities (large and small). It must be located between the inferior part of the bean receiver compartment ('moega') and the stone picker.
b) Metal and stone picker: generally linked to a venting system. Its purpose is to separate heavier impurities, including husked coffee from natural coffee and from parchment pieces. A magnetic system within the equipment removes metal pieces.
c) Husker: Linked to a ventilation system and composed of a set of metal revolving blades, plus one fixed one. These blades are adjustable, and have

the purpose of removing the husk and parchment from the beans. The husk plus parchment are removed by ventilation, and the beans go down to a special compartment of the hulling machine ('sururuca'). There, clean beans are separated from those with the husk or parchment still attached. The clean beans proceed to the polisher and the others are returned to the husker.

d) Classifier: separates coffee by size, shape and density. It is made up of a set of sieves with different sizes and types of holes, and adjustable air columns, which separate light impurities and malformed beans.

Hulling facilities that are more sophisticated hold machines such as densitometric separators and electronic pickers.

Other equipment such as balances, sackers/seamers and transporter must be available to make up an ideal hulling facility.

Most small producers, without the ability to invest in their own machinery or without the availability of cooperative services, generally use the services of mobile hulling facilities.

2.1.8 – Coffee Storage

In the case of hulled coffee, it should be stored in 60 kg sacks that are properly stacked. The storage area must be clean, protected from sunlight and rain and well ventilated. The usage of jute sacks is advantageous as they are resistant, and facilitate closing any openings made during sampling. As mentioned before, natural coffee can be stored in bulk, using silos or appropriate storage facilities, due to its massive volume and elevated storage cost. In spite of the protection of the husk, there is the possibility of physical and chemical changes, especially in the upper layers of stored coffee, if the silos do not have an active ventilation system and good protection against both humidity and rain.

In producing countries hulled coffee or green coffee is traditionally stored in 60 kg sacks instead of being stored in bulk. In spite of various disadvantages, storage in sacks allows segregation of lots, which is an important aspect, considering that the product is generally evaluated by cup testing and its origin, besides other quality standards.

Besides facilitating access to different lots, air circulation among the sacks, easy inspection and sampling are important factors to be considered during coffee storage using sacks. It is possible to keep the product stored for relative long periods (over three years), without any increased risk of deterioration.

2.1.8.1 – Conventional storage in sacks

Almost all hulled coffee in Brazil is stored in sacks, technically arranged at the storage house. The coffee sack is adapted well to small scale handling and commercialization. This type of storage has advantages and disadvantages, relative to the bulk systems of storage in silos, and that must be taken into account before any decision on storage is made. Some advantages are:

- Manipulation of different amounts of coffee simultaneously;
- Individualization of products within the same lot;
- Possibility of removal of any localized deterioration, without moving the whole lot;
- Allows for a smaller initial investment with the installation.

Some disadvantages:

- High cost of the sacks, which must be replaced, as they are not permanent material;
- High moving cost, as it demands labour;
- Requirement of large area per ton stored;

Some points relative to construction, which influence the utilization of the storage facility, must be carefully observed when deciding to use sacks:

- The installation of doors in order to facilitate loading and unloading operations;
- The doors must be installed in the same alignment, in opposite walls, facing each other;
- Walls must be at least 5 m high inside the storage room;
- The walls must be smooth, avoiding crevices and ending up in with an inclination of about 45 degrees ('*meia-cana*') close to the floor and never at a right angle. Closing the sides of the walls, near the floor and the roof, to avoid access to rodents, birds and insects to the interior of the storage room;
- Placing of lateral venting windows, protected by screens and adjustable openings;
- Installation of extraction fans ('*lanternins*'), arranged for good air circulation;
- Utilization of transparent tiles, to improve natural illumination (minimum 8%) of covered area;
- The floor must be impermeable, made of concrete, and placed at least 40 cm above the original ground;
- There must be marquees over each door to allow loading and unloading operations in rainy days;
- For maximum use, the floor area must be planned according to the platforms, main and secondary roads;
- Installation of systems for prevention and fighting of fire.

2.1.8.2 – Storage facility floor

The characteristics of the materials employed in the construction and covering of the floor must be chosen with special attention, because it involves technical and economic aspects that are linked directly with the preservation of coffee quality.

The material mainly used in the construction of storage floors is concrete. However, in some unfavourable conditions, wood is also used and the floor is constructed raised above the ground level. Each of the following materials presents certain advantages and disadvantages:

a) **Wood**: has good characteristics of heat insulation, helping to avoid large fluctuations in temperature inside the storage facility. Its main disadvantages are:
    - High cost, relative to concrete;
    - It is not impermeable;
    - It has reduced durability.

b) **Concrete**: has the advantage of being more inexpensive and has greater durability. It is not a heat insulator, but is impermeable. The impermeability must be completed using appropriate techniques and products. The employment of platforms over concrete floors is expensive but necessary obligatory. Inside the storage facility, empty spaces for corridors must be calculated for; between the piles, and between the piles and the walls, to facilitate inspection and handling of the product.

Besides the disadvantages listed above associated with storing sacks, bleaching and reduction of specific mass can be other problems related with this type of coffee storage. Both of these can cause a reduction in price depending on the severity of the problem.

Finally, during the storage of coffee in sacks, the amount of light over the sacks must be carefully monitored; in an illuminated environment with light composed of certain wavelengths, coffee may suffer changes from the colour that is commercially desired, and which is considered an indicator of product quality.

Storage in sacks offers some advantages such as:

a) It allows handling of lots that vary in type, moisture content and quantity;
b) It does not require sophisticated equipment and operation for handling;
c) Storage problems that might occur in one or more sacs can be solved without removing the whole lot;
d) Low cost of initial installation.

In storage using sacks, some points must be taken into account, seeking an increased efficiency and the protection that the storage facility can offer to the product:

e) Excess light must be avoided because it changes the colour of the beans;
f) Provide controllable and protected openings to the walls and roof, for natural air removal;
g) Install extractor fans if possible;
h) Provide impermeable flooring or build floors above the ground;
i) Use platforms, even if the floor is impermeable, to allow the circulation of air at the base of the piled sacks.

Although not widespread among coffee producer countries, bulk storage of hulled coffee is a procedure that has been adopted by producers and companies in Brazil that commercialize large amounts of coffee bearing uniform characteristics.

Apart from the modifications required for conventional storage systems, a good aeration system is also required for bulk storing over long periods of time. This system must also have a method for measuring temperature, in order to maintain the mass of coffee beans in a temperature and moisture environment suitable for good marketability.

An objection to the bulk system is the difficulty to perform precise inventories. Any small oscillation in the apparent density or compacting of the bean mass may cause huge errors in the evaluation of stocks, which does not occur when sacs are used. The importance of precise investments in the amount that is stored is simply due to the fact that coffee is a more expensive product than other kinds of grains.

The main advantage of bulk storage is that is allows mechanization, reducing substantially the amount of labour required, when compared with conventional storage methods.

2.1.9 – Transportation

Some procedures are important to maintian the safety and quality of coffee during transportation:

- Cover sacks during transportation and storage to prevent re-wetting;
- Load and unload containers on dry days or undercover;
- Ensure that containers and pallets are completely dry;
- Prevent re-wetting of the top layer of sacks;
- Implement quality control in order to guarantee adequate moisture content of coffee beans.

3 – Production Flowcharts

3.1 – Pre-harvest stage

Planting		Intercrop planting Legume planting
Cultivation	Culture care	Litter Piling up soil
Harvest		Pesticide use Fertilization Irrigation

3.2 – Post-harvest stage (stripping coffee)

Wagging

Transport for hulling

Washing

Separation

Immature fruits	Floats (raisins and dry fruits)
Terrace drying	Terrace drying
Bulk storage	Bulk storage
Packing in sacks	Packing in sacks

4. Production hazards

Hazards are classified according to their nature, and can be biological, physical or chemical.

During cultivation, processing and hulling, coffee can be subject to chemical, physical and biological contamination. Product quality may also be compromised by poor handling practices or fraud. The implementation of GAP can minimize contamination; however, the identification of critical points is fundamental for the successful implementation of a HACCP system.

The hazards most commonly found in coffee are:

4.1 – Chemical Hazards:

4.1.1 – Mycotoxins

Mycotoxins are toxic metabolites produced by some species of fungi, mainly from the genera *Aspergillus* and *Penicillium*. Many of them present toxic and degenerative effects to the consumer, with nephrotoxic and possibly carcinogenic and teratogenic actions. In the specific case of coffee, the most important mycotoxin is ochratoxin A (OTA), produced by *Aspergillus ochraceus*, *A. carbonarius*, *A. wentii* and some other species. In the international market, there are many restrictions related to the presence of this mycotoxin in coffee. There is a tendency of the European Economic Community and Codex Alimentarius to establish lower tolerance limits for it. The fungus *A. ochraceus* may be present in coffee fruits while still in the field, but surveys indicate that its occurrence is not very frequent. The fungus is naturally present in the soil, and the contamination mechanism is still unknown. Some factors might influence the intensity of infection, for example, perforation of fruits due to bore attacks and other insects, plant nutritional deficiency, etc.

Independently of the intensity of fruit contamination, drying is considered critical. Depending on how it is conducted and its duration, there will be a greater or smaller possibility of fungi development and therefore, production of OTA. The stage where coffee fruits present moisture content ranging from 14-28% is particularly important, in which the fungus develop more rapidly in the fruits; some researchers recommend that the coffee should not remain at this level of moisture for more than 3 days. When moisture content comes down to 11-13%, the fungus no longer has the relevant conditions to develop, even if it is present.

For these reasons, conditions of transportation and storage must be rigorously controlled; variations in temperature and relative air humidity at the storage facilities may allow the re-moistening of beans and development of contaminating fungi. Thus monitoring environmental conditions during coffee transportation and storage is one important critical point of control.

4.1.2 – Pesticide Residues

When technical recommendations for the appropriate use of pesticides (fungicides, insecticides and herbicides) are not followed, there might be excessive contamination of the coffee fruits. Although processing conditions minimize the risks of excess residues in the final product, the optimization of pesticide use is of critical importance. Following the principles for Good Agricultural Practices, the proper use and management of pesticides, the observation of periods when pesticide levels are safe, as well as the agronomical recommendations, constitute some of the requirements that must be provided.

The main pests and diseases, pesticides and their period to reach safe levels are available in Attachment I.

5. Application of the HACCP System

5.1 – Company/Product Characterization Forms

- **Form A – Company/Property Identification**

Social Security Number:
Address:
Zip: City: State:
Phone number: Fax:

Technician:

Supervisor of the safety programme:

Identification of agricultural product (as it leaves the farm):

Destination and purpose of the production:

- **Form B – Organization chart**

Producer/Manager

Coordinator of the Safety Programme

Person in charge of the company/property that is charged with the implementation of the safety programme, analyzing and reviewing it systematically, together with management personnel.

Person in charge for the production/process management, taking part of the periodical review of the Plan together with Senior Management.

Person in charge for the elaboration, implementation, monitoring, verification and continuous improvement of the production/process; must be directly linked to Senior Management.

- **Form C – HACCP team/ Safety Programme Team**

Name	Occupation at the Company

Date: Approved by:

- **Form D – Product/Property Characterization**

Agricultural Product:
Lot:
Date of lot final production:
Important characteristics of the final product: *(pH, Aw, moisture content, Brix, etc):*
Moisture content:
Aw:
Brix:
Other *(specify)*:
Classification:
Usage of the product by consumer or user:
Packaging characteristics:
Local of Product Sale:
Instructions displayed on the packaging:
Special controls during distribution and commercialization:
Date: Approved by:

Form E - Inputs used in the primary production

Inputs used in the pre-harvest:
Type of soil:
Fertilizer:
Water used for irrigation:
Agrochemicals:
Other *(specify)*:

Inputs used in the post-harvest:
Water used for washing:
Surface impermeabilizer:
Accessories:
Packaging:
Other *(specify)*:
Date: Approved by:

5.2. Hazard Analysis
5.2.1 – Form G: Hazard Analysis for the Pre-Harvest – Product: Coffee

Stages of the Process	Hazards	Justification	Severity	Risk	Preventive measures
Planting	Biological hazard: none Physical hazard: none Chemical hazard: none				
Cultivation/Use of Pesticides	Biological hazard: none Physical hazard: none Chemical hazard: pesticide residues	Inadequate use or non accomplishment of the period to reach safe levels	High	Medium	GAP: Follow application procedures and accomplishment of agronomical recommendations and manufacturer's instructions
Cultivation/Use of Mineral Fertilizers	Biological hazard: none Physical hazard: none Chemical hazard: none				
Cultivation/Irrigation	Biological hazard: none Physical hazard: none Chemical hazard: none				
Harvest	Biological hazard: none Physical hazard: none Chemical hazard: Ochratoxin	Damaged and spoiled fruits, in advanced stage of maturation facilitate development of Ochratoxin producing fungi.	High	Medium	GAP: Pest control procedures, harvest in the right stage of maturation with majority of fruits in ripe cherry stage. Training and qualification of harvesting labor. Harvest planning, observing the uniformity of fruit maturation.

Date: Approved by:

5.2.2 – Form G: Hazard Analysis for the Post-Harvest – Product: Coffee

Stages of the Process	Hazards	Justification	Severity	Risk	Preventive measures
Wagging	Biological hazard: none Physical hazard: leaves, stones, sticks Chemical hazard: none	Frequent occurrence due to the stripping process	Medium	High	GAP: training and qualification, maintenance of wagging sieves.
Transportation for hulling	Biological hazard: none Physical hazard: none Chemical hazard: none				
Washing	Biological hazard: none Physical hazard: none Chemical hazard: none				
Separation	Biological hazard: none Physical hazard: none Chemical hazard: Ochratoxin A (OTA)	Possibility of OTA occurrence on floating coffee	High	Medium	Efficient separation and maintenance of separation of the floating coffee from the immature and ripe cherries, up to the end of the process. Training and qualification of operators.
Drying in terraces (ripe cherries, immature and floats)	Biological hazard: none Physical hazard: none Chemical hazard: Ochratoxin A (OTA)	Contamination and/or development of OTA producing fungi	High	High	GAP: Terrace installations, hygiene programme, spreading procedures, piling up and turning over. Assurance of a fast and uniform drying process until maximum moisture content of 13%.
Bulk storage (ripe cherries, immature and floats)	Biological hazard: none Physical hazard: insects and rodents Chemical hazard: Ochratoxin A (OTA)	Failure in the integrated pest control programme, allowing proliferation. Inadequate storage conditions (ventilation, humidity, temperature, etc) which favors development of OTA producing fungi.	Low High	Medium High	GAP: MIP programme, installation hygiene. Good Storage Practices and control of conditions such as temperature and relative air humidity in the storage facility.
Packing in sacks (ripe cherries, immature and floats)	Biological hazard: none Physical hazard: none Chemical hazard: none				
Expedition	Biological hazard: none Physical hazard: none Chemical hazard: none				

Date: Approved by:

5.3 – Determination of CP/CCP
5.3.1 – Form H: Determination of CP/CCP in the Pre-Harvest Stage – Product: Coffee

Stage	Significant Hazards (biological, chemical and physical)	Is the hazard controlled by the pre-requirement programme? If so, is it important to consider it as a CP?	Question 1 – Are there preventive measures for the hazard?	Question 2 – This stage eliminates or reduces the hazard to acceptable levels?	Question 3 – The hazard can be increased to unacceptable levels in another stage?	Question 4 – The hazard can be eliminated or reduced to acceptable levels in a later stage?	CP/CCP
Cultivation/use of pesticides	Chemical hazard: pesticide residues	Yes/Yes					CP
Harvest	Chemical hazard: Ochratoxin A	Yes/Yes					CP
Wagging	Physical hazard: leaves, stones and sticks	Yes/Yes					CP
Separation	Chemical hazard: Ochratoxin A	Yes/Yes					CP
Terrace Drying (ripe cherries, immature and floats)	Chemical hazard: Ochratoxin A	No	Yes	No	Yes	No	CCP1 (Q)

Date: Approved by:

5.3 – Determination of CP/CCP
5.3.2 – Form H: Determination of CP/CCP in the Post-Harvest Stage – Product: Coffee

Stage	Significant Hazards (biological, chemical and physical)	Is the hazard controlled by the pre-requirement programme? If so, is it important to consider it as a CP?	Question 1 – Are there preventive measures for the hazard?	Question 2 – This stage eliminates or reduces the hazard to acceptable levels?	Question 3 – The hazard can be increased to unacceptable levels in another stage?	Question 4 – The hazard can be eliminated or reduced to acceptable levels in a later stage?	CP/CCP
Bulk storage (ripe cherries, immature and floats)	Physical Hazard: insects and rodents	Yes/Yes					CP
	Chemical Hazard: Ochratoxin A	No	Yes	No	Yes	No	CCP2 (Q)

Date: Approved by:

5.4 – Summary of the HACCP Plan

5.4.1 – Form I: Summary of the HACCP Plan in the Pre-harvest Stage – Product: Coffee

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Cultivation/use of pesticides	CP (Q)	Pesticide residues	GAP: Procedures of application and accomplishment of agronomical recommendations and manufacturer's instructions	Obedience to the prescriptions of the manufacturer's agronomical recommendations	**What?** Use of pesticides. **How?** Visual observation. **When?** Each application. **Who?** Operator	Increase period of time to reach safe levels, equipment calibration; correction of solutions and application	spreadsheet	Training programme of usage and application procedures; supervision; Programme for sample collection and analysis; programme for equipment calibration.
Harvest	CP (Q)	Ochratoxin	GAP: Procedures for pest control; harvesting at the maturation stage with predominance of ripe cherries; training and qualification of harvesting labor; harvest planning, observing uniform maturation of the fruits.	Minimum of 70% ripe fruits.	**What?** Fruits **How?** Visual observation. **When?** During harvest **Who?** Harvesting labor.	Interrupt harvest; pick selectively only ripe cherries.	spreadsheet	Training and qualification programme; field supervision; harvest plan review.

Date: Approved by:

5.4.2 – Form I: Summary of the HACCP Plan in the Post-harvest Stage – Product: Coffee

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Wagging	CP (F)	Leaves, stones, sticks	GAP: Training and qualification; sieve maintenance.	4% impurities	**What?** Impurities. **How?** Visual observation. **When?** Each process. **Who?** Person in charge of the operation.	Reprocess (repeat wagging)	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses.
Separation	CP (Q)	Ochratoxin	Separate effectively and keep separation of the float coffee from the immature and ripe cherries; Training and qualification of operators.	Less than 2% of floats in the separated ripe cherries and immature fruits.	**What?** Floats **How?** Visual observation. **When?** Each separation **Who?** Person in charge of the operation.	Reprocess (repeat separation)	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses.
Terrace drying (ripe and immature cherries, and floats)	CCP1 (Q)	Ochratoxin	GAP: Terrace installations, hygiene programme, spreading procedures, piling up and turning over the coffee fruits on the terrace; assure a fast and uniform drying process until a maximum moisture content of 13%.	Maximum 13% moisture at the end.	**What?** Moisture **How?** Moisture meter. **When?** Daily. **Who?** Supervisor.	Optimize drying; increase the number of times coffee is turned over; decrease thickness of the layer of coffee beans; supplement with mechanical drying.	Control spreadsheet	Supervision and analyses of the spreadsheet; Programme for sampling and analyses

5.4.2 – Form I: Summary of the HACCP Plan in the Post-harvest Stage – Product: Coffee

Stage	CP/CCP	Hazard	Preventive measures	Critical Limit	Monitoring	Corrective Action	Recording	Verification
Bulk storage (ripe and immature cherries, and floats)	CP (F)	Insects and rodents	GAP: MIP programme, installation hygiene.	Absence of pest evidence.	**What?** Pest evidence. **How?** Visual observation. **When?** Daily **Who?** Supervisor	Identify MIP	Pest evidence spreadsheet	Training and qualification programme; inspection.
	CCP2 (Q)	Ochratoxin	Good practices of storage and control of temperature and humidity inside the storage facility.	Maximum 13% moisture in the beans, maximum 70% humidity inside the storage facility.	**What?** Bean moisture and environment humidity. **How?** Moisture meter (beans) and hygrometer (environment). **When?** Daily. **Who?** Supervisor.	Correct environmental humidity (ventilation); Reprocess coffee drying.	Bean moisture and environment humidity spreadsheet	Supervision, spreadsheet analysis; programme for sample collection and analyses of OTA and moisture.

Date: Approved by:

6 – GLOSSARY

Bean: Final product of the hulling process. Natural coffee can also be considered as beans.

Borer: Coleopteran beetle (*Hypothenemus hampei*) which attacks coffee cherries generating defects in the beans.

Cherry: Ripe fruit of the coffee plant, whose color may be red or yellow, depending on the variety.

Classification: Set of operations which sort the coffee beans into categories. The most common are the ones based on bean type, sieve mesh and cup type.

Cleaning coffee: See hulling.

Cloth: aid used in the harvest to avoid the coffee fruits to be deposited directly over the soil.

Control (substantive): final condition of a process, stage or procedure which was conducted respecting pre-established limits (product/ process under control).

Control (verb): action that maintains a process, stage or procedure, within pre-established limits.

Control Measure (preventive measure): any action or activity that may be used to prevent, eliminate or reduce a hazard to consumer health. Control measures refer to the sources and factors that interfere in the hazards such as: possibility of introduction, survival and/or multiplication of biological agents and introduction and permanence of chemical and physical agents in the food. According to the Codex Alimentarius, the term control measure is considered more adequate than preventive measure.

Control Points (CP): in this manual it is considered a control point all the points or steps that may affect the safety of the product, however its control is conducted priory by programmes and procedures which are managed by Good Practices (pre-requisite-programmes).

Critical Control Point (CCP): any point, stage or procedure where control (preventive) measures can be applied in order to keep a significant hazard under control, with the objective of eliminating, preventing or reducing risks to the consumer's health.

Critical Limits: attributes or pre-established values for a given variable (eg temperature, moisture, contamination) which if not attended to can reduce the safety of the final product.

Cup (beverage, drink): classification commonly used at the commercialization of coffee according to its flavor and aroma. Types of beverages:

- Strictly soft – extremely mild flavor
- Soft – mild flavor
- Moderately soft – moderately mild flavor
- Hard – astringent flavor
- Rioy – undesirable flavor
- Rio – strongly undesirable flavor

Cup test: test carried out by trained professionals to classify the coffee according to the beverage characteristics.

Decision diagram (decision tree): sequence of questions used to identify Control Points (CP's) and Critical Control Points (CCP's).

Defect: Characteristics of the beans which lower their quality and reduce the commercialization price. (Ex.: Sticks, beans with borer perforations, empty beans, green beans, "ardido" beans, etc).

Drier: equipment fueled by gas, wood or coffee husks, used to promote moisture removal from the bean.

Drying: process of reduction of moisture content in the coffee fruit until it reaches 11-12%.

Dry process: processing of the coffee without removal of the husks or mucilage.

Floats: coffee fruits that are separated by floating in the washer separator.

Flowchart: graphical, sequential and ordinate representation of all the operation stages of production or elaboration of any product.

Gleanings: coffee picked from the ground.

Green defect: defect caused by the presence of immature fruits in the lot, which is very harmful for the beverage.

Harvest: the process of removing fruits from the coffee plant and its preparation for transportation to the processing installations.

Hazard: chemical, biological or physical contaminant, or a condition of the product that may cause any damage to the consumer's health or physical integrity, considered unacceptable, and loss of food integrity and quality.

Hazard Analysis: identification and evaluation of potential perils, of physical, chemical or biological nature, which present risk to consumer health or physical integrity.

HACCP: Hazard Analysis of Critical Control Points.

HACCP Plan: document elaborated for a specific product/process, according to a logic sequence, where all the stages and justifications for its structure are stated.

Hulled coffee: coffee that has been through the process of hulling and is ready for commercialization (bulk).

Hulling: process of husk removal, cleaning and simple classification of coffee. It is normally carried out in cooperatives, storage houses, and mobile unities or in the property.

Husked cherry: Coffee that has been cleaned through the wet process, which lost the mesocarp and the exocarp, without removal of the mucilage.

Husks: Structures that are external in relation to the coffee beans.

Immature fruits: fruits which did not complete the maturation stage.

Logical Sequence of the HACCP System: composed of 12 steps. The first five steps are: Team set up; description of the product; purpose of product use; elaboration of production flowchart (flux diagram) and confirmation "in loco" of the flowchart. The other 7 steps are composed by the stages of the HACCP System.

Mechanical harvest: Harvest carried out with the aid of machines.

Mesocarp: Intermediate layer of the fruit rich in sugars and fibers.

Mould: Fungi.

Monitoring: planned sequence of observations and measurements, properly recorded, which allow analyzing and evaluating whether a hazard of a certain stage, point or procedure, is being kept under control, that is, the respective critical limit is being attended.

Mucilage: Mucilage layer which surrounds the seed.

Mucilage removal: removal of the sugar and pectin layer (mucilage) around the parchment through fermentation.

Natural coffee: Coffee that has been produced through the dry process in its final drying stage. It is composed of the coffee bean and the whole husk.

Ochratoxin A – OTA: toxic metabolite produced by fungi from the species *Aspergillus ochraceous*.

Organization chart: diagram which shows the functional relationship between the sectors of a propriety/company.

Parchment: endocarp.

Pillar: see hulling.

Principles of the HACCP System: set of 7 principles: analyses of hazards and preventive measures; identification of critical control points; establishment of critical limits; establishment of monitoring processes of critical control points; establishment of corrective actions; establishment of verification procedures; establishment of recording procedures.

Pre-requisite programme: procedures including Good Agricultural Practices (GAP) and GMP (Good Manufacturing Practices). Good practices include Standard Procedures of Operational Hygiene (SPOH) which constitute the hygienic-sanitary basis for the adequate implantation of HACCP.

"Rained": Coffee which was exposed to rain fall while drying in the terrace.

Raisin coffee: intermediate drying stage between the dry fruit and the cherry.

Record: specific document for data/results/specific readings.

Remains ("Rechaço"): lots of hulled coffee that are returned.

Risk: represents the estimated probability of the hazard manifestation or the sequential occurrence of several risks. The risk might not be quantified, but must be evaluated or estimated.

Roasting: thermal process of transformation of the dried bean to roasted beans.

Roasted and ground coffee: the most commercialized type of coffee that has been through the process of roasting and grinding.

Roasted coffee; hulled beans which have been through the process of roasting.

Sack: bag in which the hulled coffee is commercialized, usually made of jute.

Safety Limit: values or attributes appropriate to the critical limits which are adopted as safety measure to reduce the possibility of not been accomplished.

Sample: Portion of coffee used for research purposes (analyses of OTA, fungi, etc) or for classification for commercialization.

Sampling: process of collecting samples.

Sieve: classification of the bean according to its size ranging from sieves 17 to 8.

SPOH (Standard Procedures of Operational Hygiene): procedures that are established based on criteria of GAP selection items considered of critical importance in hygiene. They are items which deserve a careful control, priority, and good detailing, adopting monitoring programmes, records and auditing. There are eight SPOH's : water quality; hygiene of the surfaces contacting food; prevention of crossed contamination; worker's hygiene; prevention of contamination by agents of biological, chemical or physical nature; adequate identification, utilization and storage of pesticides; employer's health; control of insects, diseases and weeds.

Street: space between two lines of piled coffee.

Suspended terrace: structure made with screen held by wood and used to dry coffee.

"Talhao": group of plants, defined by the producer, according to characteristics such as age, variety, management, etc.

Terrace: area where the drying process is carried out. It can be made of bare ground, concrete, asphalt or it can be suspended.

"Tulha": storage facility present in the farms, used to store the natural coffee or hulled beans.

Type: classification in a scale from 2 to 7 according to the number of defects.

Verification: use of methods, procedures and tests for evaluation, audit, inspection and calibration, with the purpose of assuring that the HACCP plan is in accordance with the HACCP System and that it is accomplished operationally and/or needs modification and revalidation.

Wagging: pre-cleaning done while the harvested coffee is still at the plantation, for removal of bigger impurities such as leaves and sticks.

Washer: first equipment which coffee goes through in the terrace. Its main function is to separate the floats from the ripe and unripe cherries.

Wet process: processing of the coffee with the removal of the husk and/or mucilage of the cherries involving the use of water.

7 – Attachments

Attachment I – Principal pests and diseases of the coffee plant and allowed pesticides:

a) Principal pests

Insects and mites

Etiological agent – scientific/popular name	Control with allowed pesticides Commercial product/dose/volume

Attachment II –

1 – Coffee Drying System

Because of the harvesting method employed, coffee is composed of a mixture of immature and mature fruits (cherries and unripe fruits), raisins and dried fruits, leaves, branches, soil and stones, and must be cleaned and separated in various fractions, in order to be dried separately. The set composed by these operations is called preparation or pre-processing and can be carried out through the dry process, that is, drying the fruits completely, resulting in natural coffee or terrace coffee, or, alternatively, through the wet process, which consists of drying the fruits without their husks (dehusked cherries), whose mucilage has been partially or completely removed. In case the mucilage removal is carried out by fermentation (the technique frequently used in Colombia), the product is called pulped or washed coffee.

2 – Pre-cleaning

The pre-cleaning operation consists in the removal of impurities such as leaves, sticks, soil, etc. These residues should be preferentially left in the plantation, so that they do not become sources of contamination in processing units.

Pre-cleaning can also be carried out by forced ventilation, or by machines which use air and sieves to separate impurities.

3 – Dry pre-processing

After the harvest (be it through stripping and picking the fruits from the ground, or using a piece of cloth, or using machinery), coffee should be submitted immediately to the separation of impurities, which can be done by manual wagging, forced ventilation, or by using air-driven separators and sieves (pre-cleaning machines). Even with the removal of impurities (sticks, soil, stones, leaves, etc), coffee must pass through a hydraulic separator (washer), in which separation is done according to the maturation stage of the fruits, i.e, separating the floats (dry fruits, fruits with borer perforations, malformed and immature fruits) from perfect fruits or cherries, which will be dried and stored separately.

In general, in spite of having their efficiency reduced, hydraulic separators or washers can also carry out the separation of heavy impurities. However, it is very difficult to separate the floats from light impurities. Washing or separation is an important operation during dry processing because besides maintaining the quality potential of newly harvested coffee, it also reduces the wearing out of the machinery during the cleaning, drying and hulling processes.

The washers used in the washing and separation of the coffee are made of bricks, whose disadvantage is the exaggerated consumption of water, which, depending on the project, and the amount of impurities present in the coffee, can be superior to five liters of water per liter of coffee. They can be built for a water consumption of up to 10,000 liters per hour.

If there is a shortage of water, one option is to use a mechanical washer whose average consumption is one liter of water per 30 liters of coffee. The difference between the water consumption of both washers is due to the fact that in the brick washer, in general, the greater part of the water is used for the transportation of the coffee, while in a mechanical washer, the transportation is done mechanically. Besides the reduced consumption of water and reduced labour use, mechanical washers occupy a smaller space and can be easily moved.

After separation of impurities and washing, the coffee is sent for preparation though either dry-processing (which consists of terrace drying, mechanical pre-driers and driers) or, alternatively, it is processed via wet-processing, where before drying, the coffee is subjected to dehusking, washing and mucilage removal.

4 – Wet pre-processing

Wet pre-processing is the first stage in producing dehusked-washed and pulped coffee. In Central America, Mexico, Colombia and Kenya, known producers of pulped coffee, the product attains good market prices, because, in general, the resulting beverage is ‘soft’.

Pulping coffee is nothing more than the removal of the husks from the cherries using a mechanical pulper, with further fermentation of the mucilage and washing of the beans. Pulped coffees have the advantage of decreasing considerably the terrace area required and the time necessary for drying. The required volumes of driers, storage houses and silos can be reduced by up to 60%. These advantages are due to bean uniformity and low moisture content, about 50% b. u., as compared to drying the whole fruit. The coffee can also be only dehusked, whose difference from the pulped coffee is the lack of fermentation step, and much of the mucilage remains during the drying process.

Mucilage removal through fermentation is a solubilization process and digestion of the mucilage by naturally occuring enzymes. If fermentation is poorly conducted it can harm the quality and value of the coffee on the external market.

5 – Drying

Despite the fact that storage is less complicated, drying coffee is comparatively more difficult to carry out than other products, due to its high initial moisture content, generally around 60%. Therefore, the speed of deterioration at the first stage of the drying process is higher, potentially causing a reduction in the quality of the product. Therefore, coffee must be dried immediately after harvest and stored in conditions that allow the maintenance of the quality of the product after drying.

Independently of the drying method used, the following aspects should be stressed in order to obtain success in post-harvest processing:

a) Avoid undesirable fermentation during the process;
b) Avoid extremely high temperatures (coffee tolerates drying air temperature close to 40°C for one or two days, 50°C for a few hours and 60°C for less than one hour without suffering damage).
c) Dry the beans in the shortest time possible until 18% b.u. moisture content.
d) Try to obtain a product that presents uniformity in colour, size and density.

5.1 – Drying Systems

In Brazil, depending on the technological aspects involved, two methods for drying coffee are basically used: natural drying on terraces or artificial drying using mechanical driers.

In the terrace drying, the product is spread over pavements, which can be made of cement, bricks, compacted soil or asphalt. This method is the most commonly used by the producers in at least one of the drying process stages. However, the slower drying rate and exposure of the product to biological agents, together with the possibility of occurrence of unfavorable climatic conditions at the time of harvest,, as can happen in Southern Bahia and Northern Espirito Santo and part of the Zona da Mata in the state of Minas Gerais, causes loss of coffee quality.

5.2 – Drying in conventional terraces

The exclusive use of terraces by many coffee growers is due to the lack of technological information and very often to the lack of concern about the qualitative characteristics of the product after the drying process. It can also be due to low income and technical know-how available on the property.

On the terrace, the development of microorganisms on the surface of the fruits, and any increase in the respiration rate and temperature are factors that accelerate the fermentation process. In spite of all these risks, small and medium producers use the terraces solely and intensively in the coffee drying process.

During the terrace drying process, coffee is dried through the action of solar irradiation. It is advisable, during drying, to work with homogeneous lots, considering the time of harvest as well as the maturation stage or moisture content, to obtain a uniform final product of good quality.

In general, due to the characteristics of most of the mechanical driers available, the drying process after harvest or after washing (i.e where ther is a high moisture content) is more difficult, due to the difficulty of product flow inside the drier. Therefore, to accelerate the drying process, artificial drying must be combined with terrace drying.

A recommended practice is drying the coffee in terraces or pre-driers until the beans reach a half-dried state (i.e. 35-40% m.c.). Then final drying is carried out in a mechanical drier up to the point of bulk storage in "tulhas", or until moisture content reaches 22%, so that they can be submitted to complementary drying, in ventilated silos, during storage, until a satisfactory moisture content suitable for the market is reached.

The conventional terrace can be built with cement, bricks or asphalt, and the product should be dried and distributed in a thin layer.

Preferentially, drying must be done in concrete terraces, which are more efficient and present lower risks that could compromise quality.

In general, after washing and separation by density differences (cherries and floats), the producers spread coffee on the terrace, in layers of 4cm maximum thickness. For this operation, spreading carts are generally used, which allows a uniform distribution of the product on the terrace.

5.3 – Drying at high temperatures

In order to obtain a good quality coffee, it is necessary to take special care in the control of temperature of the mass of beans, from the moment in which coffee presents moisture content lower than 35% u.b. For moisture contents lower than this value, depending on the drying system used, there is a tendency of the temperature of the mass of beans to equilibrate with the temperature of the drying air. This tendency is caused by the difficulty of migration of moisture from the inner layers to the outer layers of the beans.

The maximum air temperature afforded by the beans in a conventional drier is 70°C at the time of harvest. Higher temperatures are harmful to the product, as many beans that do not move around sufficiently inside the drier become superdried, while other beans reach an ideal moisture content (11-12% u.b.), what makes the subsequent roasting process difficult to control.

On the Brazilian market, there is a great variety of industrialized models of driers available for the coffee producer, or models that the farmer, with the aid of a technician, can build in his own farm. For the good functioning of most driers made in Brazil, the mass of coffee must not present an excess of water, therefore the beans must pre-dried in terrace or in pre-driers, such as the rotating or the fixed layer drier, model UFV.

5.3.1 – Drying in column driers

In this type of drier, coffee beans remain in vertical columns built of perforated plaques and are submitted to an air flux which is perpendicular to the layer of the product. When the beans are moving, the drier is called ‘crossed-flux’. For this type of drier, the temperature of the air or the mass of coffee must not exceed 70°C or 45°C respectively, for periods greater than two hours.

The adoption of one or another brand of drier must be based on producer preference, on the ease of operation and maintenance and, additionally, on an economic analysis. It is recommended to check that the drier bears a good resting chamber and adequate systems for controlling the temperature, air flux and bean flux.

5.3.2 – Drying in a rotating drier

This type of drier if composed of a horizontal tubular cylinder, or one that is slightly tilted, which turns on its longitudinal axis at a speed ranging from 1 to 15 rpm. In the case of a continuous drier, the moist product reaches the higher part of the cylinder through a transporter and comes out of the lower part by gravity. The drying air is introduced into the cylinder in the same direction or, in the case of tilted driers, in the opposite direction to the product’s trajectory.

A very common type used as coffee pre-drier or drier is composed of a horizontal cylinder that is not tilted, with injection of drying air in a chamber located at the center of this cylinder, which goes through the mass of product perpendicularly to the axis of the drier.

5.3.3 – Lot drying with fixed bed

The fixed bed drier has been largely used in the pre-drying or in the coffee drying. In this case, the recommended temperature for the drying air is 50°C. The coffee layer, depending on the condition of the product, can range from a few centimeters to 0,5 m thick. In a fixed layer drier, the product must be revolved to homogenize the drying at regular intervals of three hours. In the case of driers with 5,0 m diameter, the operator may revolve the product carefully and try to carry out the operation in no less than 30 min.

Differently from most mechanical driers, with the fixed bed drier it may not be necessary to pre-dry on terraces when climatic conditions are not favourable. This type of drier can also be used as pre-drier in more complex systems.

5.3.4 – Concurrent flux drier

In the concurrent flux drier, the air and the product flow in the same direction inside the drier. High evaporation rates occur in the upper part of the layer, once the air with higher temperature meets the product with a higher moisture content. The intense and simultaneous exchanges of energy and mass at the entrance of the drier (air/product) cause a rapid reduction in the initial temperature of the drying air, and in the moisture content of the product. For this reason the product temperature remains considerably below the initial temperature of the drying air. These driers are characterized by high energy efficiency and by the high quality of the final product.

5.3.5 – Drying and aeration of coffee

The drying and aeration of coffee consists essentially in cooling the beans after the drying step. This is not done in the cooling zone of the drier, but in the "tulha" storage facility, with forced aeration.

Coffee is removed from the drier, without having been allowed to cool and containing a moisture content some 2% higher than the recommended content for storage. Before going through aeration, the mass of coffee is kept at rest and is cooled slowly so that the excess moisture is removed.

The purpose of the resting period is to allow moisture redistribution in the interior of the bean as well as in the mass of coffee beans, which takes 6 to 10 hours. In the cooling stage, a flux of 0,5 m^3 of air per minute must be used per ton of coffee. With the recommended flux of air, depending on the final temperature of the product and time of rest, 2.5% moisture content can still be removed, using the residual energy left in the coffee beans.

After being cooled at room temperature, the coffee should be transferred to storage facilities ("tulhas") which, if possible, must hold an aeration system. Whenever the resting of the product is carried out inside these storage facilities, the operator can only turn on the aeration system when they are loaded at least half of its capacity. In both cases, the dynamic capacity of the drier can be increased up to 100%.

In summary, the process of drying-aerating can be applied in the following way: when the coffee beans reach a moisture content of about 14% u.b., they must be removed while still hot (over 45°C), placed in the aerated storage facilities, and left at rest for at least six hours. Afterwards they must be cooled until they reach room temperature. In order to obtain a higher efficiency of the drying-aeration, it is recommended that at the end of the process, the temperature of the coffee mass is raised to 55°C for one hour, at the most.

5.4 – Partitioned Drying

The partitioned drying, indicated for driers not holding a resting chamber or that hold a low static capacity, consists of drying the coffee beans partially during a certain period of time and then removing them from the drier. They are left to rest in resting storage facilities (without aeration). After the pre-established resting period, coffee must be returned to the drier for a new drying period.

Similarly to the drying-aeration process, the bean internal moisture content will be redistributed and the temperature of the mass of coffee will be more homogeneous. This homogenization occurs because of the moisture migration from the center of the bean to the outer layers, facilitating the removal of moisture in the next drying stage. Research indicates that the higher the number of partitioning, and the longer the resting periods (maximum of ten), the smaller the real drying time. Therefore, partitioned drying is a process that allows the improvement of the quality of coffee and increases the drier capacity, and to obtain this advantage, the number of resting storage facilities must be dimensioned economically.

5.5 – Drying with solar energy

In spite of being the primary source of energy mostly used and present a relative success when the terrace is used, the employment of direct solar energy for drying the beans in deep layers can only become viable in drying systems using low temperatures. The high levels of energy necessary (120,000 – 300,000kJ/h) in mechanical driers of medium capacity makes its application unviable in high temperature systems.

5.6 – Terrace – solar hybrid and biomass

The hybrid terrace, or terrace-drier, is nothing more than a conventional terrace, preferentially made of concrete, where a ventilation system is adapted with air heated by a furnace, to dry the coffee in the absence of direct solar radiation or on rainy days. Each module of the hybrid terrace must have an area of approximately 10,0 x 15,0 m. The terrace-drier is built with tubing along the longest dimension (either central or lateral), to release air at specific points in the terrace. This is accomplished through openings leading to six drying chambers in a fixed bed, or six secondary tubes, for drying transversal or longitudinal piles.

The main duct is coupled to a furnace, with a centrifugal fan, which makes a flow of 1,5 m of air possible. In the absence of direct solar radiation, incidence of rain and during the night, the product is placed in the drying chambers or piled up over the distribution ducts for drying with hot air. In both cases, covering must be provided for protection of the beans from precipitation. Therefore, drying can be carried out 24 hours a day, using solar energy in days with plenty sunshine and energy from biomass burning (wood or plant charcoal) during the absence of direct solar radiation.

5.7 – Drying with natural air at low temperatures

The drying systems with natural air at lower temperatures generally involve drying in silos. The natural coffee with moisture content above 25% u.b., is subject to rapid deterioration, demanding high fluxes of air for the drying and, depending on the climatic conditions, makes the system viable technically and economically.

The biggest advantage of drying with natural drying or at low temperatures, is that besides the enormous energy saving and increased yield of the driers, the final product presents uniform color and moisture content, providing a suitable roasting medium.

Drying the coffee in special storage facilities ("tulhas") or silos with forced ventilation using only natural air or with lower temperature is a very slow process. The low drying speed is due to the small air flux injected into the mass of beans and to the dependence of drying capacity of the air in its natural state. Once it is done inside the silo, it is also known as storage drying, because after drying the product may remain stored in the same silo.

The drier-storage silo presents some special characteristics which are not demanded for the silos employed only for storage: the floor must be made from metal pieces, with a minimum of 15 % perforated area, to promote the uniform distribution of air; and the fan must provide air enough to promote the drying of the whole mass of beans without deterioration, and the dimensions of the silo (diameter and height) and the product to be stored determine the potency of the fan to be used.

Once the small amount of air per unity of coffee mass slows down the process and the lower temperatures of the air diminish the capacity to evaporate water from the product, the process is more difficult in regions of high relative humidity. Sometimes, complementary sources of heat are used (electrical range, furnace and solar energy among others) to surpass this problem, which may however, promote a superdrying. This problem may be solved with the adaptation of a moisture meter and a temperature meter to the plenum chamber of the silo, to control the performance of the heat source.

Normally drying with natural air, the drying capacity of the room air and the small heating promoted by the fan (2 to 3°C) are enough to provide the final moisture content recommended for safe coffee storage. Drying systems with natural air and at lower temperatures projected and managed appropriately, are economical and technically efficient methods.

Drying with natural air or with lower temperature begins in the inferior layer of the silo and progress until it reaches the last layer, in the upper portion of the coffee mass. During this period of time, three moisture layers can be distinguished: In the first layer, composed of dried beans, the product reaches hygroscopic equilibrium with the air. In the second layer, called the drying front, moisture transference to the air tkes place. The thickness of this layer varies generally from 30 to 60cm. The third layer is formed by moist beans, whose moisture content is close to the initial because when air passes through this layer, it has its moisture removal capacity exhausted. The temperature in this layer is usually lower than the plenum temperature, once the air is cooled down due to the heat exchange with the product in the drying front.

The flow calculations of the drying air and the equipment choice must be done very carefully. The flow must be calculated so that it allows the drying front to reach the upper layers without deterioration of the product.

5.8 – Combined Drying

In order to solve possible problems due to unfavorable climatic conditions and high initial moisture content, some studies were made using the technique of combined drying (high temperature in the first phase and lower temperature or natural air in the second phase) for drying the coffee. In this system, after separating the coffee cherries appropriately by density, the fruits are pulped and washed to remove part of the mucilage layer. Afterwards, pre-drying is carried out in a fixed bed drier turning the layer of beans every three hours. The pre-drying can also be carried out in a rotating drier or in another drying system at high temperatures appropriate for coffee beans bearing high moisture content and part of the mucilage.

The drying air must be heated indirectly to avoid contamination of the product by smoke. In this phase, coffee must be dried until the moisture content reaches values close to 25% b. u. (depending on the climatic conditions for drying at lower temperatures) and afterwards be transferred to the complementary drying in silos, with natural or slightly heated air. Besides avoiding product deterioration, this procedure allows reduction of the drying time at high temperatures, increases the drier capacities and reduces total energy consumption by over 50%, in comparison with the traditional drying processes.

Independently of the type of pre-drying, it is important to stress that, in every stage of the processing, any kind of fermentation must be avoided in order to obtain a high quality coffee with natural flavor. To accomplish that, the operator of the combined drying system must be used to the process and be watchful to the operation of the ventilation system during the second drying stage.

Whenever thinking about the adoption of a combined system for drying coffee, the producer must consult a specialist with knowledge in coffee drying. Despite been apparently simple and of easily adapted to a system already in place on the farms, the combined drying system is dependent on the climatic conditions of the property, on the technologies used before the drying operation at lower temperatures and the level of training of the operator. This means that a system projected for a given property will not necessarily be suitable for other environmental conditions.

6 – Management of conventional terrace

At the beginning of terrace drying operations, when the moisture content of coffee is high or as it is removed from the washer, the surface of the terrace becomes completely wet. If part of the surface of the terrace is not exposed to immediate drying to remove the excess of water, the product is extremely susceptible to contamination, due to high moisture in the lower layer. In order to do so, the coffee layer must be opened up, at least in the first five days, forming small piles. The piles must be spread and then piled up again or in regular time intervals (never exceeding 60 minutes), with the aid of a utensil to gather the coffee beans. In every case, the operator must be careful so that part of the terrace is wiped and exposed to sunlight, so that its drying and the heating provide indirectly, the drying of the coffee on the next turning.

After the first days of drying (around the fifth day), when coffee is already partially dry, at around 3 pm, the product must be distributed in big piles, in the direction of the largest declivity of the terrain, which must be covered with canvas. The covering of the piled product favors the conservation of the absorbed heat during exposition to sun rays, which guarantees better distribution and homogenization of the moisture among the mass of beans.

The following day, around 9 am, the piles must be uncovered and removed from their night time location, in order to dry the pavement. Afterwards the product should be spread out over the terrace, repeating the operations completeed previously until the moisture content ideal for storage is reached (12% u.b.) or until half-drying is reached (30%), at which point it is suitable to start complementary drying in mechanical driers.

The terrace must be located in a smooth and well drained area, with plenty of sunlight, ventilated, at a lower level to the installations for reception and initial preparation, and above the installations for storage and hulling.

Whenever possible, the terrace should be divided in squares, in order to facilitate the drying of the lots according to their origin, moisture content and quality. To ease the rain water drainage, the terrace must be built at a 0.5 to 1.0 angle with drainage. These drains, measuring 0,4 x 0,25m must be built with steel with 50% perforation, with square holes 4mm wide at the most, to stop the passage of coffee beans. In the case of adopting circular perforations, the same percentage of perforation must be used, with smaller holes (maximum diameter of 2,0 mm).

The construction of protection walls 0,2m high and 0,15 m thick around the terrace is advisable, to avoid losses and mixture of material from different types of coffee.

At the final stage, after the half-drying point, dryithe coffee in piles, where the equilibrium of moisture content between the external layers and the inner part of the beans can be established. In order to achieve this, the coffee must be turned daily and exposed to sunlight for two or three hours and then piled and covered.

Attachment II

The market for organic products is predominantly composed by consumers that are aware of the questions concerning human health and questions of a social and environmental nature.

Organic agriculture is based on agro-ecological principles and natural resource conservation. The first and most important principle is respect towards nature. The producer must have in mind that dependence on non-renewable resources and nature's own limitations must be recognized, and the recycling of organic residues has great importance in the process.

The second principle is the diversification of crops. The diversification of species reduces the incidence of plant parasites because of the bigger abundance of natural enemies. Biodiversity is therefore a key element of sustainability.

Another basic and very important principle is that the soil is a live organism and in its management, the chemical, physical and biological aspects, must be considered. The maintenance of adequate levels of organic matter is fundamental for the preservation of the biological activity of the soil, and guarantees this equilibrium.

In organic agriculture the use of pesticides, synthetic fertilizers, hormones, genetically modified organisms and ionizing radiations are prohibited.

Choice of species and adequate cultivars

It is recommended that arabica cultivars Catucaí, Oeiras, Obatã, Tupi and Icatu which are resistant to the rust causing agent (*Hemileia vastatrix*), the main disease of coffee plants in Brazil, are used. Robusta coffee is naturally resistant to rust.

Preparation of seedlings

The main differences related to seedling growth for use in conventional or organic cultivation is in the formulation of the substrate to be used in bags or tubes and their disinfection process. The formulation usually includes worm compost, bovine manure or organic compost. The use of chicken bed still in use in Brazil, but is prohibited by the rules of the Codex Alimentarius and by the rules of the European Union. During the growth of seedlings a cover fertilization using composted animal manure, organic compost or worm compost is common. The handling of these residues must follow the recommendations of GAP (Good Agricultural Practices).

As fumigating agents are prohibited, the alternative and simple method for the seedling producer to disinfect the substrate to be used via exposure to sunlight. This is a physical disinfection method, based on increased temperature which consists in covering the moist substrate with a transparent thin plastic sheet (polyethylene) and exposing it to sunlight over several days. The soil moisture is important, because it contributes for the conduction of heat, allowing the temperature in the substrate reach lethal levels, inactivating plant pathogens and other germinating plant material.

Crop management

In the organic management of coffee plantations techniques for covering the soil with litter are frequently used (husks and various residues from plantations or from the agroindustry, such as coffee husks, sugar cane fiber, etc); live soil cover (vegetation that is cultivated or grows spontaneously kept covering the soil) and green fertilizers (plants that are cultivated in the local or brought from elsewhere, which are incorporated to the soil with the purpose to preserve the soil fertility, which can be used as a crop rotation, live-fences, wind breakers, surrounding strips and road edges). The use of plant biomass as source of organic matter represents one opportunity for the producer to decrease their dependence in relation to the use of manure. Additionally, the soil cover protects it against erosion and decreases the incidence of spontaneous plant growth.

In the organic coffee growth, the farm must be preferentially integrated to animal growth, with the purpose of ensuring manure production, thus reducing costs and avoiding the use of manure not allowed by certifying institutions. In this category is cow manure and manure from other farm animals such as pigs, chicken, rabbits, goats, horses, etc. In this case, the management of the animals must be carried out according to pre-established rules for the organic growth.

In the case of manure obtained outside the farm, the producer must be aware of its origin, especially with reference to the presence of chemicals and/or hormones, drugs and disallowed feed. Before being used, manures must be processed (stabilized naturally) or preferably, composted. Two are the reasons: the first is to avoid plant toxicity or plant “burning”. The second is that with the temperature increase during stabilization or composting it is possible to eliminate pathogenic microorganisms and reduce the presence of weed seeds.

Composting

This is the process of formation of humus from manure or other organic residue of animal or plant origin through microbiological decomposition. The material for composting may include husks and plant material from pruning, leaves and other materials of plant or animal origin such as feathers, scales, etc, mixed with dry manure. It is common to add thermophosphates and ash. Residues are disposed in layers, forming piles which must have their moisture and temperature controlled. After the first three days, the temperature in the interior of the pile reaches 55-70°C. The pile must be constantly turned so that all the material is subjected to the composting process. In general the compost will be ready in about 90 days.

According to Good Agricultural Practices recommendations, ensure that there is no contamination in the compost from heavy metals, which may occur in case there is no criteria in the choice of organic materials used in the compost. It is also recommended the adequate handling and storage of the manure, its main component.

When the compost is produced adequately, it is not harmful to human health and constitutes an excellent source of nutrients when used for the production of food. The amount of processed compost to be applied must be calculated according to the nitrogen amount recommended in function of the expected productivity and the content of this nutrient in the leaf tissue.

Worm compost

Worm compost is generally used only in the growth of seedlings because it demands more work. Worm composting is the biological transformation of organic residues, where worms act to accelerate the decomposition process. The worms act in the grinding of organic residues, liberating a mucus that promotes the development of a large population of microorganisms. This enhances the quality of the worm compost when compared to traditional compost.

The substrate used in the worm composting can be composed of the same residues used in the traditional composting. The manure must be pre-processed so that the temperature elevation does not harm the worms. All the handling of the manure during the stabilization stage and its use on the worm growing places must follow GAP recommendations.

Alternative control of plant pathogens and pests

The control of plant pathogens in organic agriculture, in general must be conceived through anti-stress measures, which allow the plants to express fully its natural mechanisms of defense. Sometimes however, mainly in function of temporary disequilibrium which causes stress, the use of susceptible cultivars and non controllable factors which determine the increase in pest incidence and diseases, it is necessary to use alternative pesticides. These may be homemade from substances that are not harmful to the human health or to the environment. Belonging to this group are formulations that have the following main characteristics: reduced cost, low or no toxicity to man and nature, besides not favouring the occurrence of resistant forms. Several liquid biofertilizers are included in this category, among others (“supermagro”, “Agrobio”, and “Vairo”, for example), the solutions (sulfate/calcium, “viçosa”, “bordalesa” among others), plant extracts (Neem, for example) and biocontrol agents.

Even if these products are classified as nearly non-toxic, it is necessary to follow GAP for the use of individual protection equipment in the moment of application, such as: large impermeable hat, impermeable boots and a suit with long sleeves.

Biofertilizers

Biofertilizers are products of varied formulation, obtained from the aerobic fermentation of manure. Liquid biofertilizers, besides being important sources of macro and micro nutrients, contains substances with potential to work as natural defenses when applied at regular intervals through leaves.

Solid biofertilizers, such as “Bokashi”, are also very efficient from the nutritional point of view.

Concerning liquid biofertilizers, one of the best known is “Supermagro”, originating from the aerobic fermentation of green bovine manure diluted in water and mixed with plant residues (leaves), animal residues (blood or liver), calcium, rock phosphate, bone meal or fish meal, mineral salts (copper sulphate and other micronutrients), molasses or sugar and milk or serum, and *Bacillus* solution. The resulting product is a dark liquid which is diluted and used in leaf applications supplementary to soil fertilization, especially in micronutrient application. It also acts as natural defense through beneficial bacteria, especially *Bacillus subtilis* which inhibits fungi growth and bacteria that cause plant diseases, besides increasing the resistence to insects and mites.

Another biofertilizer that is very popular is “Agrobio”, produced by the Agricultural Research Corporation from Rio de Janeiro (PESAGRO-RJ), which contains fresh bovine manure diluted in water, milk or serum, molasses mixed to mineral salts (borax or boric acid, wood ash, calcium chloride, sodium molibdate, iodine solution and ferric sulphate, cobalt sulphate, copper, manganese, magnesium and zinc sulphates, bone meal, meat meal, magnesium thermophosphate, molasses and the solids from castor bean seeds). “Agrobio” ready for use is dark in colour and has a characteristic odour of a fermented product. Its use is free of health risks, as microbiological tests completed to date did not detect fecal coliforms, pathogenic bacteria or toxins.

The fermentation process of biofertilizers lasts at least 30 days and during that period the biofertilizer must be frequently and vigorously mixed twice a day.

Four biofertilizer applications per year are enough for a coffee plant. Excess applications may cause the accumulation of micronutrients in leaf tissue. For that reason chemical analysis of leaves must be done in order to monitor the content of these nutrients in the plants.

Another simpler liquid biofertilizer which is also used is produced from the methanogenic or anaerobic fermentation of fresh bovine manure. The end of the process, which lasts 30 to 40 days, coincides with the cessation of methane gas production, when the mixture reaches a pH close to 7,0. The mixture is passed through a sieve and filtered for application. The biofertilizer “Vairo”, as it is called, is recommended in higher dosage (up to 30%) and demonstrates multiple uses, from the controlled action over certain pathogenic microorganisms to the promotion of flowering and root growth in cultivated plants, possibly through the action of plant hormones. As it is recommended for the “Agrobio”, analysis of leaf tissue in treated crops should be undertaken in order to monitor micronutrient contents.

Handling of these biofertilizers, manure and animal residues must follow GAP recommendations.

Handmade solutions

Sulfate and calcium solution –result from a reaction between correctly balanced between calcium and sulphur, dissolved in water and boiled, making a mixture of calcium polysulfates. Besides its fungicidal effect, it acts on mites and other sucking insects and also has repellent action over borers that attack woody tissues.

This solution is toxic to many plants, principally when the room temperature is high. It is also alkaline and highly corrosive requiring the use of IPE (Individual Protection Equipment) for application. The amount of solution to be prepared must be calculated carefully, because it loses its properties if stored and the residues must not be discarded in water wells, water courses, dams or reservoirs. Besides that, the application of the sulfate – calcium solution must be done at intervals of at least 20 days after the use of the copper based solutions (Bordalesa and Viçosa).

“Bordalesa” solution - colloidal light blue suspension, obtained through the mixture of a solution made of ground copper sulfate with a suspension made of calcium oxide or calcium hydroxide. The solution must have a pH close to neutral or be slightly alkaline. As the solution must be applied right after its preparation or at the most 24 hours later, the amount to be prepared must be calculated carefully because the residues must not be discarded in water courses, dams or wells. IPE to be used whenever the solution is applied. 15 to 25 day intervals to be followed between applications of the sulfate – calcium solution and the bordalesa solution.

“Viçosa” solution – An improved bordalesa solution developed by the Federal University of Viçosa. Recommended for the control of several plant pathogens such as the cercosporiosis of coffee plants; as it is supplemented with mineral salts (copper, zinc, magnesium and bore) it also works as leaf fertilizer. It must be observed however that urea cannot be used when the application is destined for organic agriculture, as its use is not allowed under present regulations.

Neem (*Azadirachta indica*) – Neem is a plant originating from India, where it has been used for over 2,000 years in the control of insects (e.g. white fly, caterpillars and insects that attack stored beans), nematoids, some fungi and bacteria. The main active substance found in this species is the Azadirachtin. In Brazil, Neem seed oil and leaf extracts for leaf application are available. IPE to be used whenever the solution is applied, and GAP recommendations followed.