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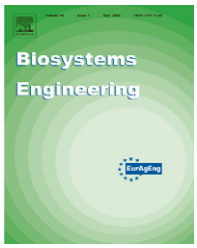

Research Paper: PH—Postharvest Technology

Ultrastructural analysis of drying damage in parchment Arabica coffee endosperm cells

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The objective of this work was to evaluate and compare the alterations in the structure of coffee seed endosperm subjected to different temperatures and drying conditions. The seeds were dried at 40, 50 and 60, with an airflow of 0.33 $m^3 s^{-1} m^{-2}$. After drying, 10 seeds were randomly selected and prepared for the histochemical tests with Sudan IV and scanning and transmission electron microscopy, according to the laboratory's routine techniques. The histochemical results showed that, for the coffee parchment beans dried at 40 °C, there was no change in the cellular integrity of the plasma membrane and vesicles. In contrast, in the endosperm of parchment coffee beans dried at 60 °C, fused oil bodies that gave rise to large droplets in the intercellular space were observed, indicating a rupture of the vesicles and plasma membrane. Scanning electron microscopy showed that, for the parchment Arabica coffee beans dried at 40 °C, the internal cellular content remained intact and full of cellular material and the space between the plasma membrane and the cell wall was empty. However, in seeds dried at 60 °C, a rupture of the cells was observed, represented by occluded intercellular spaces, indicating a leaking of part of the protoplasm. The results from the transmission electron microscopy corroborated the undamaged and the damaged structure of the coffee parchment beans dried at 40 and 60 °C, respectively.

1. Introduction

The drying of coffee is one of the most important processing stages, and involves the removal of water from the coffee parchment beans into the surrounding environment until the beans reach an equilibrium moisture content. Several researches (Berbert *et al.*, 1994; De Grandi *et al.*, 2000; Freire, 1998; Guimarães *et al.*, 1998) have evaluated the drying system, the reduction of the energy consumption and the dryer's efficiency. Recently, the importance of post-harvest treatments for coffee bean quality has received increasing attention, and several studies describe the impact of the wet and dry processing on the physiology and quality of coffee (Bytof *et al.*, 2000). Nevertheless, ultrastructural analyses which occur upon drying are not well understood.

Inappropriate handling of coffee cherry before and after picking, such as the use of high temperatures and drying rates, can lead to a degeneration of the plasma membrane. The alterations in the structure of the plasma membrane and its deteriorating capacity to act as a semipermeable barrier are the main factors responsible for the decrease of quality in coffee (Amorim, 1978; Salazar *et al.*, 1994). Studies have shown

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Table 1 – Summary description of the coffee cup classification system

Flavour	Classification characteristics
Strictly soft	Low acidity, mellow sweetness, pleasant mouth-feel
Soft	Same characteristics as strictly soft, only less accentuated
Softish	Same characteristics as soft, only less accentuated
Hard	Lacks sweetness and softness
Rioysh	Iodine, medicine-like inky flavour from microbe-tainted beans
Rio	Same characteristics as rioysh, only more accentuated

that, after desiccation, the plasma membrane is one of the first points of damage. Ultrastructural analysis of the endosperm tissues is essential to verify these works.

In a study of the sensitivity of coffee embryo to desiccation, Brandão Júnior (2000) found that greater ultrastructural damage, such as coalescence of lipids and probable rupture of the membrane, occurred in unripe than semi-ripe coffee berries. The degree of the damage was also influenced by the coffee species. The study found that the species *Coffea canephora* was more sensitive to desiccation than the *Coffea arabica* and its cells presented advanced deterioration of the membrane structures, even after reaching maturity. On the other hand, the *C. arabica* seeds became more tolerant to desiccation during the maturation process.

The beverage and presence of defects are the most important criteria to evaluate the quality of coffee. In Brazil, coffees are officially categorised by reference to a flavour scale (Brasil, 2003) as presented in Table 1.

The concentration of lipids in the endosperm tissue is related to the quality of the beverage. Studies have shown a greater concentration of lipids in the coffee soft beverage with well-defined droplets inside the protoplasts in the seeds' outer rims. Nevertheless, the lipids were observed to be homogeneously distributed throughout the whole tissue surface of the hard and rioysh coffee beverage (Goulart, 2002). In these types of coffee, the lipids fill the intercellular spaces without forming well-defined droplets. Despite these works, ultrastructural analyses of the endosperm membrane submitted to different drying temperatures are still lacking.

The objective of this study was to evaluate the effect of different drying air temperatures on the resultant structure of the endosperm cells of parchment Arabica coffee.

2. Material and methods

2.1. *Experimental design*

The Arabica coffee, variety Catucai, was harvested manually using the stripping system. Four replications were done in 45 days with two pickings of approximately 0.9 m^3 of coffee fruits for each repetition. The coffee was then separated according to the density of the fruits using a mechanical washer. The cherry fruits were peeled to obtain the parchment coffee which was carried to a concrete ground on the evening it was picked and spread in layers of approximately 1 cm depth. The coffee was separated into 12 equal portions, six of which remained on the ground for 1 day and the remaining six for 3 days to reduce the moisture content. The samples were stirred during the day every 30 min. Thus, the parchment coffee remained on the ground for 1 and 3 days before artificial drying to obtain two levels of moisture content. After solar drying, the moisture content was determined at the start of the drying process in the dryers. This was carried out by the oven method at 105 ± 3 °C for 24 h (Brasil, 1992). The coffee was then dried in three dryers of fixed layers 0.13 m thick, using an airflow of 0.33 $m^3 s^{-1} m^{-2}$ (Agullo & Marenya, 2005) and three average temperatures (40, 50 and 60 °C). The temperature and relative humidity of the ambient air were monitored using a thermohygrograph.

2.2. *Experimental dryer*

The apparatus used in this study is shown in Fig. 1. It consisted of a fan (A), an air duct (B), a plenum chamber (C) and a drying chamber (D) measuring 0.61 m by 0.61 m by 0.61 m. The plenum chamber contained a group of 3400 kW electrical circuits to heat the air. The drying chamber, which received four of the 12 samples dried on the ground, was composed of four removable sections (Fig. 1E). Each section received an average of 0.01 m^3 of coffee.

When the final moisture content of 11% (w.b.) was achieved, the coffee was cooled with ambient air to interrupt the water-removing process. After cooling, samples were taken to determine the coffee's final moisture content (Brasil, 1992). The dried coffee was then stored in polythene bags until cleaning and the histochemical and ultrastructural analyses.

In this study, the defective grains were removed before the analyses were carried out so that they would not interfere with the results.

2.3. *Histochemical and ultrastructural analyses*

For each drying temperature and solar drying period, samples composed of 10 parchment coffee beans were randomly removed from the bulk coffee.

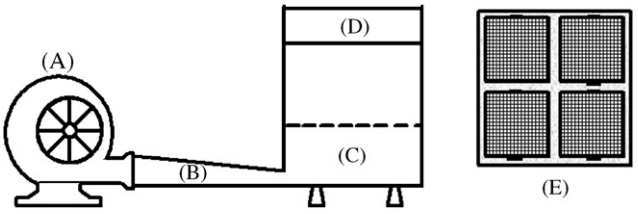

Fig. 1 – Schematic of the experimental apparatus used to dry the parchment coffee: (A) fan; (B) air duct; (C) plenum chamber; (D) drying chamber and (E) removable sections of drying chamber.