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Minimal processing of cassava

The cultivation of cassava (*Manihot esculenta* Crantz) is the basis of food consumption in various tropical countries (Altieri, 2002). However, post-harvest preservation has long been a concern for industries and producers, as one of the largest obstacles to the use of the cassava roots is its high perishability, due to its very restricted shelf-life when stored in environmental conditions. In Brazil, an estimated 23% of cassava root production is lost after harvesting, due to a lack of knowledge on adequate storage techniques (Bezerra et al., 2002). Two phenomena have been identified as responsible for the deterioration of the roots: one of these is of a physiological or an enzymatic nature (primary deterioration), whilst the other is of a microbiological nature (secondary). The primary deterioration, which can occur approximately 48 hours after harvesting, is caused by the discoloration and appearance of bluish streaks or veins in the pulp's vascular system. This is the initial cause linked to the lack of acceptability of *in natura* roots in markets. The secondary deterioration, which follows the primary deterioration, is caused by microorganisms that contribute to the decomposition of the product (Alves et al., 2005; Cereda & Vilpoux, 2004; Silva et al., 2003).

The combination of the knowledge of processing technology and that of post-harvest physiology has led to an increase in the minimally processed product segment. Minimal processing technologies emerged in the market as a response to the demand for easily prepared and convenient products, and is an alternative to achieving a longer product shelf-life (Nachiluk & Antoniale, 2008; Silva et al., 2003). Minimally processed cassava production has been proposed as an alternative to extend the root supply time and to provide a more practical product (Alves et al., 2005; Bezerra et al., 2002; Lund et al., 2005).

Nevertheless, minimal processing should be undertaken with caution, as the stripping and cutting stages are damaging and stressful for the plant's tissues, which can lead to an increase in respiration and production of ethylene, as well as darkening reactions, oxidation of lipids and increased water loss. When the plant tissue is cut or damaged, enzymes and substrates come into contact. Whereas these are previously separated by different cellular envelopes, the cutting and damaging causes them to move freely within the tissue and, upon contact, react with each other to form dark pigments (Coelho, 1992). Size reduction procedures, such as cutting and slicing, which provide the consumer with conveniently prepared meals, and which are one of the differentiating characteristics of minimally processed products in comparison to *in natura* vegetables, can contribute greatly to microbial growth. The cutting leads to the removal of the protective outer skin, therefore exposing the inner tissues, which begin to release "juices" that serve as nutrients to the development of the microbiota (Cantwell, 1992; Silva et al., 2003).

A small-scale minimal processing study was conducted at the Food Science and Technology Laboratory of the *Embrapa Mandioca e Fruticultura Tropical* centre, which will be described in this document. The preparation flowchart used was based on the suggested steps by Vilpoux & Cereda (2003), with some modifications, and included the following steps: root selection, washing, sanitization, cutting, peeling, sanitization, drainage, weighing, packaging and storage (Figure 1).

Process description

Reception: The cassava must be harvested on the same day of processing, or the previous day, and must be stored overnight. The roots that are received from the field must be stored in plastic boxes or burlap sacks, and kept in a ventilated area until processing time.

In the case of cassava that has been harvested the day before processing, it can be stored overnight in water tanks. The length of time during which it is immersed in water cannot exceed 12 hours, to

prevent the fermentation of the roots and, consequently, their deterioration. To minimize the risk of fermentation, it is possible to add chlorine to the water (10 mg/kg). Storage in water simplifies the next day's peeling (Vilpoux & Cereda, 2003). It is recommended to prepare the chlorine solution (10 mg/kg) with 5.0 mL of commercial 2% sodium hypochlorite solution or 0.83 mL of commercial 12% chlorine for 10 litres of solution.

Selection: The roots should be selected based on a uniform shape and size.

A sample of roots which represents the batch to be processed, should be cooked to evaluate the quality of the selected batch. Only the roots that have the necessary qualities should be processed, such as a normal cooking time of up to 30 minutes, counted after the water boils at ambient pressure.

Washing: The cassava roots should be immersed in water to loosen the dirt and then brushed to remove the adhered organic matter (Figure 2a).

First sanitizing: After washing, the roots must be sanitized with the skin on, using a sodium hypochlorite solution (200 ppm of active chlorine), for 15 minutes. Prepare the hypochlorite solution with 100 mL of commercial 2% sodium hypochlorite solution or 16.7 mL of commercial 12% chlorine for 10 litres of solution (Figure 2b).

Cutting and peeling: The cutting and peeling is usually done manually with a stainless-steel knife. The tips of the roots should be discarded, and the middle section should be cut into cylinders approximately 6 cm long, which should be peeled, removing the inner skin, and split in half (Figures 2c and 2d).

The daily yield of manually peeled roots can vary greatly depending on the quality of the cassava. Considering good quality roots, a worker can peel up to 200 kg per day (weight measured in peeled cassava); and in the case of poor-quality roots, productivity can be equal to or less than 80 kg per day. Decreasing post-harvest cassava storage time, with processing of roots harvested, at the most, the previous day, and overnight water storage, allows for improved peeling productivity. The processing of thicker roots can also increase the speed of peeling (Vilpoux & Cereda, 2003).

For cassava, the removal of the skin, inner skin and tips can range from 25% to 30% of the roots' total weight, and may exceed 40% in thinner roots. This percentage is influenced by the same factors as those taken into account for peeling speed. Among the losses, the tips contain a potentially useful residue for the mass production of dumplings (Vilpoux & Cereda, 2003). The processing climate must be refrigerated, around 12°C.

Second sanitization: After peeling, the cylinders must be immersed in chlorinated water (20 ppm of active chlorine) for 2 minutes. Prepare the hypochlorite solution with 10.0 mL of commercial 2% sodium hypochlorite solution or 1.7 mL commercial 12% chlorine for 10 litres of solution. The water used in this step can be reused for the initial washing of the roots (Figure 2e).

Drainage: After the sanitization step, place the roots in sieves to remove excess water (Figure 2f).

Packaging and weighing: Pack the cassava pieces into polyethylene and nylon bags, which contain a barrier to water vapour and oxygen gas (Figure 2g). The roots should be weighed in portions ranging from 200 g to 2 kg, according to consumer market requirements (Figure 2h). Remove the air from the bags and seal using a vacuum sealer. The sealer used can be a manual machine, such as the one shown in Figure 2.

Storage: The packages should be stored in cold chambers at 5 ± 1°C or in refrigerators at temperatures ranging from 7 to 10°C. The product shelf-life can vary from 15 to 30 days, depending on hygiene and temperature conditions and on the type of packaging used during processing.

According to Vilpoux & Cereda (2003), a storage temperature of 4°C is ideal. At this temperature, minimally processed cassava products can be preserved for up to four weeks, without darkening or development of undesirable microorganisms. Above this temperature, respiration of the roots can stew the packaging, impairing the presentation of the product.

The final product has a good appearance; however, it must be emphasized that variations in the product may occur due to factors such as the quality of the raw material used, and product processing and storage temperatures.

Figure 1. Steps of minimal processing of cassava

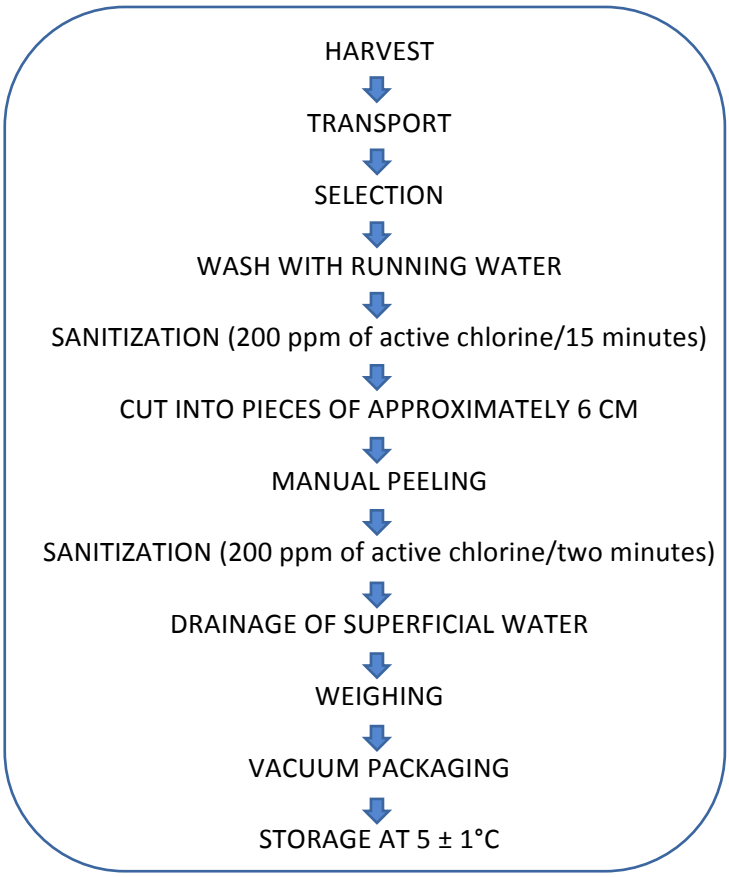

Figure 2. Minimally processed cassava production steps: (a) washing, (b) sanitization (200 ppm of active chlorine/15 minutes), (c) cut into pieces of approximately 6 cm, (d) manual peeling, (e) sanitization (200 ppm of active chlorine/two minutes), (f) drainage of superficial water, (g) packaging, (h) product weighing, (i) vacuum sealing, and (j) final product.