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Baby Cassava: An Alternative Marketing Strategy for Freshly Cut Cassava

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Abstract

There are many procedures for obtaining minimally processed fruits and vegetables, aiming at adding value and maintaining the quality for a longer period. Cassava is a root that adapts to minimum processing technology, because the tissues are more resistant, what helps in obtaining different cut shapes and formats. However, it is a root susceptible to browning and microbiological contamination. In this chapter, methodologies and procedures are described to obtain alternative formats for minimally processed cassava, which was generally denominated "*babycassava*", called "*babytolete*", "*cateto*", and "*rubiene*". Besides that, some preharvest and postharvest factors that influence the shape and quality of "*babycassava*" formats will be addressed. It was verified that preharvest factors could influence the quantitative and qualitative aspects, resulting in browning of the minimally processed root. Some of the factors studied seem to regulate key enzymes in which they mediate oxidative reactions that cause browning, such as polyphenol oxidase and peroxidase, and other enzymes that participate in the reactive oxygen species (ROS) elimination process. In this way, the turning stage of "*babycassava*" manufacturing removes the parenchyma, minimizing the effect of browning-related enzymes.

Keywords: *babycassava*, minimally processed, browning, quality, market

1. Introduction

In recent years, changes in eating standards have led to higher consumption of fruits and vegetables, and consumers are looking for quality foods that are healthy, safe, and practical.

Minimally processed products are an alternative to consumer demand, offering convenient, highly nutritious, and healthy products, while maintaining the freshness of fruits and vegetables *in natura*. Vegetables are considered minimally processed when they remain fresh, despite being physically altered.

Basically, minimum processing goes through the steps of selection and classification, peeling, cutting, sanitization, rinsing, spinning, and packaging. All these steps are aimed at providing the consumer with a fresh, healthy product, that is easy to prepare and that maintains high food quality, freshness, and safety. However, during and after minimal processing, plant tissues are more susceptible to biochemical and physiological stresses when compared to intact plants. Because of this, the proper handling of the vegetables from the harvest to the processing and the use of low temperatures are necessary to promote stability and maintenance of high quality in shelf life [1].

“*In natura*” roots are marketed in bark, usually dirty, or sometimes peeled, immersed in water or frozen. However, this type of product does not offer food safety to consumers. Therefore, maintaining the quality of cassava roots in markets or consumers' homes for days has been a great challenge for the agro-industrial development of this root.

The main technological challenge faced is to keep cut cassava roots without symptoms of browning. Deterioration is divided into two processes: primary or physiological deterioration and secondary or microbiological deterioration [2–5]. The postharvest physiological deterioration (PPD) profoundly affects processing, as well as root marketing. It is triggered by mechanical damage, an unavoidable result of the harvesting operations. The PPD then proceeds from the site of the damage, eventually causing general discoloration of the vascular parenchyma along the root [6, 7]. The physiological deterioration is usually the cause of reduced root acceptability. It may be observed by dark streaks in the root vascular tissue that subsequently spread and cause a more general brown discoloration, leading to unsatisfactory cooking quality and unpleasant odor and taste. The microbiological deterioration is caused under aeration conditions by the *Pseudomonas* sp. bacteria [8], and under low oxygen tension, *Bacillus* sp. are predominant, causing rot and increased acidity, fermentation and softening of the roots, and usually occurs when the roots have already become unacceptable because of physiological deterioration [9].

Alternative and innovative formats named “*babycassava*” are being studied and developed. Some investigations focusing factors pre and postharvest were made [10, 11]. The “*babycassava*” designation, proposed in this chapter, regards “*babytolete*”, “*cateto*”, and “*rubiene*” formats. In all cases, these shapes add value to cassava; they can make consumer's life easier for cooking faster and not requiring pressure cooker. Besides that, these are different and attractive shapes.

This chapter will show procedures for “*babycassava*” obtaining, and some factors before and after harvest that can influence “*babycassava*” quality.

2. Procedures for obtaining ‘*Babycassava*’

Cassava processing should be done in a cold ambience and with maximum agility, due to its susceptibility to browning. Based on this, a general flowchart is presented in **Figure 1**. The

steps in red marked are stages considered critical in the process and that deserve attention in physiological aspect [12].

To obtain “*babycassava*”, the following steps are followed: once harvested, the cassava roots are transported to the minimum processing unit, where they are selected, weighed, and washed in running water with the help of a brush to remove dirt. The ends are removed and cooled in ice water for 5 minutes, and they are cut transversely into 6-cm pieces. The segments are peeled with the aid of a stainless steel knife (Figure 2). The 6-cm segments should be cut transversally to the middle, resulting in 3-cm long segments. A longitudinal cut must be made to obtain the “*babytolete*” format. To obtain the “*cateto*” shape, the edges of the 3 cm fragments should be removed, creating cube-shaped pieces. Then, the cassava cubes were turned for 120 seconds, finally getting into the shape called “*cateto*”. The “*rubiene*” format will be obtained from 3-cm long segments. A longitudinal cut is made, and soon after, the turning is performed for 120 seconds. The turning made in cassava is similar to that already known in carrots, “*babycarrots*” [13].

After obtaining the three types of “*babycassava*” (“*babytolete*”, “*cateto*”, and “*rubiene*”), the products are immersed in ice water for 10 seconds to perform the initial rinsing, then immersed in sanitizing solution with concentrations of 200 and 5 mg L⁻¹ of active chlorine, for 10 minutes at each concentration to reduce microbial contamination.

After the sanitization, the centrifugation step in a domestic centrifuge is done. The centrifugation time for 200 g of “*babytolete*” is 30 seconds, and for 800 g of “*cateto*” or “*rubiene*” shapes, it is 60 seconds [12]. These times are sufficient to remove excess water acquired during the sanitization step. After that, they should be packed. Among the various types of packaging, it

Washing, Selection and Cooling

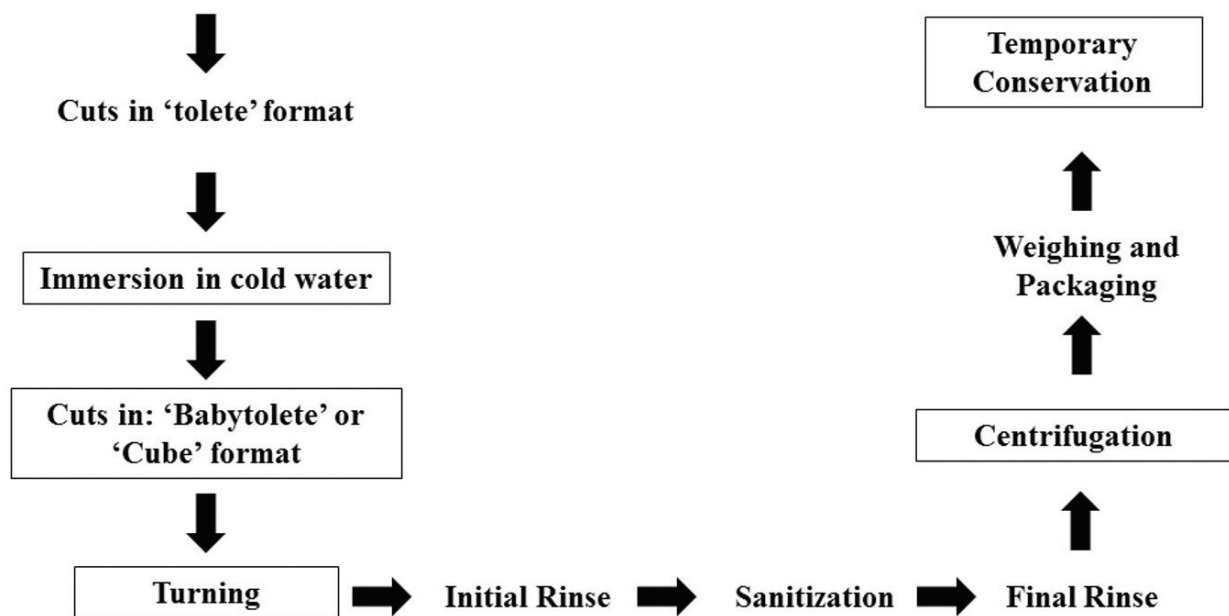


Figure 1. Minimum processing operational flowchart of cassava in “*babycassava*” format. Steps marked in red are considered critical in that they influence the browning.

is recommended to use polypropylene packaging. Once packaged, the products should be stored in refrigerated display units at $5 \pm 2^\circ\text{C}$ and $90 \pm 5\% \text{RH}$.

In general, proposed flowcharts are alternatives to the formats studied and have been perfected for other roots, such as yam and sweet potato in the “baby” format. These formats make the product more attractive and different from what has already been found in the market, with the advantage of good yields (Table 1).

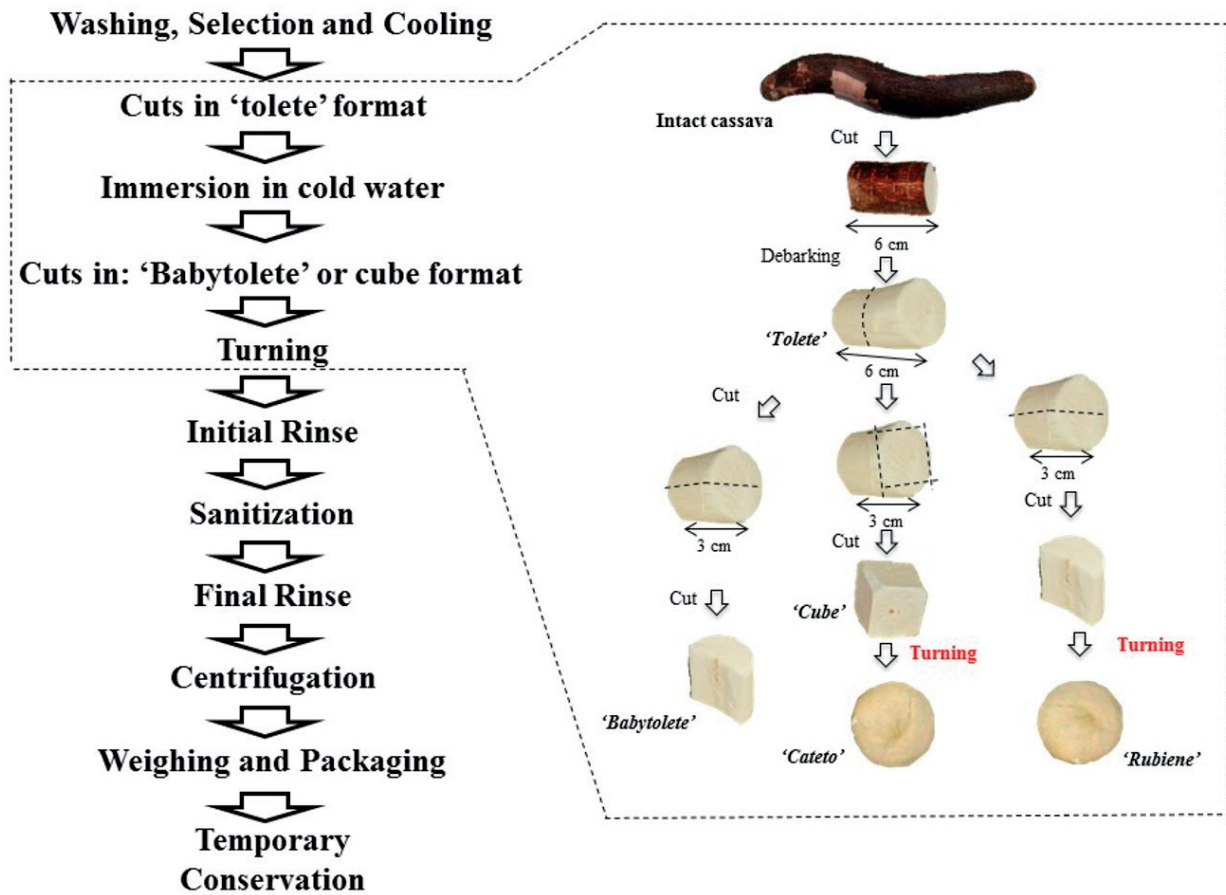


Figure 2. Cutting stages for “babytolete”, “cateto”, and “rubiene” formats obtaining.

Agroindustrial yield (%)

Babytolete	Cateto	Rubiene
81 ± 5	40 ± 5	60 ± 5

Data of Freire et al. [10] and Brito et al. [11].

Table 1. Yield agroindustrial of *babycassava*: babytolete, cateto, and rubiene formats.

3. Pre and postharvest factors that influence the quality of 'babycassava'

3.1. Preharvest factors

It is believed that several factors influence cassava final quality. However, it is worth considering crop factors such as population density and harvest ages.

The population density seems to be more involved in root shape, with respect to morphology, number of roots per plant (**Figure 3A**), diameter of the roots (**Figure 3B**), and productivity (**Figure 3C**). Although it was reflected in thinner minimally processed roots, helping to obtain the 'babycassava' (**Figure 4**), it did not influence the acceptance made by a sensorial panel composed of 50 people at Federal Rural University of Pernambuco (**Figure 4**). People preferred larger pieces to the detriment of smaller ones (**Figure 4**). This is due to the local custom of consuming large roots and not making the proposal of producing small roots for immediate consumption invalid.

On the other hand, age of harvest influences minimally processed root qualitative aspects in regard to browning. Based on the deterioration of the minimally processed root in the "babytolete" and "cateto" or "rubiene" formats, it was developed a subjective scale of grades ranging from 5 (best grade) to 1 (worst grade). Score 3 was set as an acceptance limit, and the overall score corresponds to the average of the scores for each "babycassava" [14] (**Figure 5**).

Based on the visual scale, it is observed that roots harvested later (360 and 420 days after planting), become more susceptible to browning, compared to those harvested earlier (300 days after planting) (**Figure 6**). One of the explanations for these results seems to be related to the ability of cassava tissues to enzymatically combat reactive oxygen species (ROS), through catalase and superoxide dismutase activity [15], as well as signaling control involving calcium and programmed cell death [16].

According to the data presented, it is verified that crop management, related to density and mainly age of harvest, are decisive factors for the quality of the root in which the objective is minimum processing. Voluntary impositions in the cuts cause browning of the tissue. Thus, roots harvested earlier are more suited to minimum processing.

3.2. Postharvest factors

Cassava roots have a short shelf life due to PPD. Fresh cassava roots are traditionally marketed without postharvest treatment and therefore should reach the consumer in a short time before deterioration becomes visible. PPD makes roots quickly unfit for consumption and therefore nontradable. The short lifespan of roots severely limits marketing options, increasing the likelihood of losses, and overall marketing costs. Extension of the useful life of cassava roots would result in large annual savings [17].

PPD begins when the root is separated from the parent plant and resembles the changes that occur in plant response to injury, thus triggering a series of biochemical reactions. These reactions may include the accumulation of several secondary metabolites, for example,

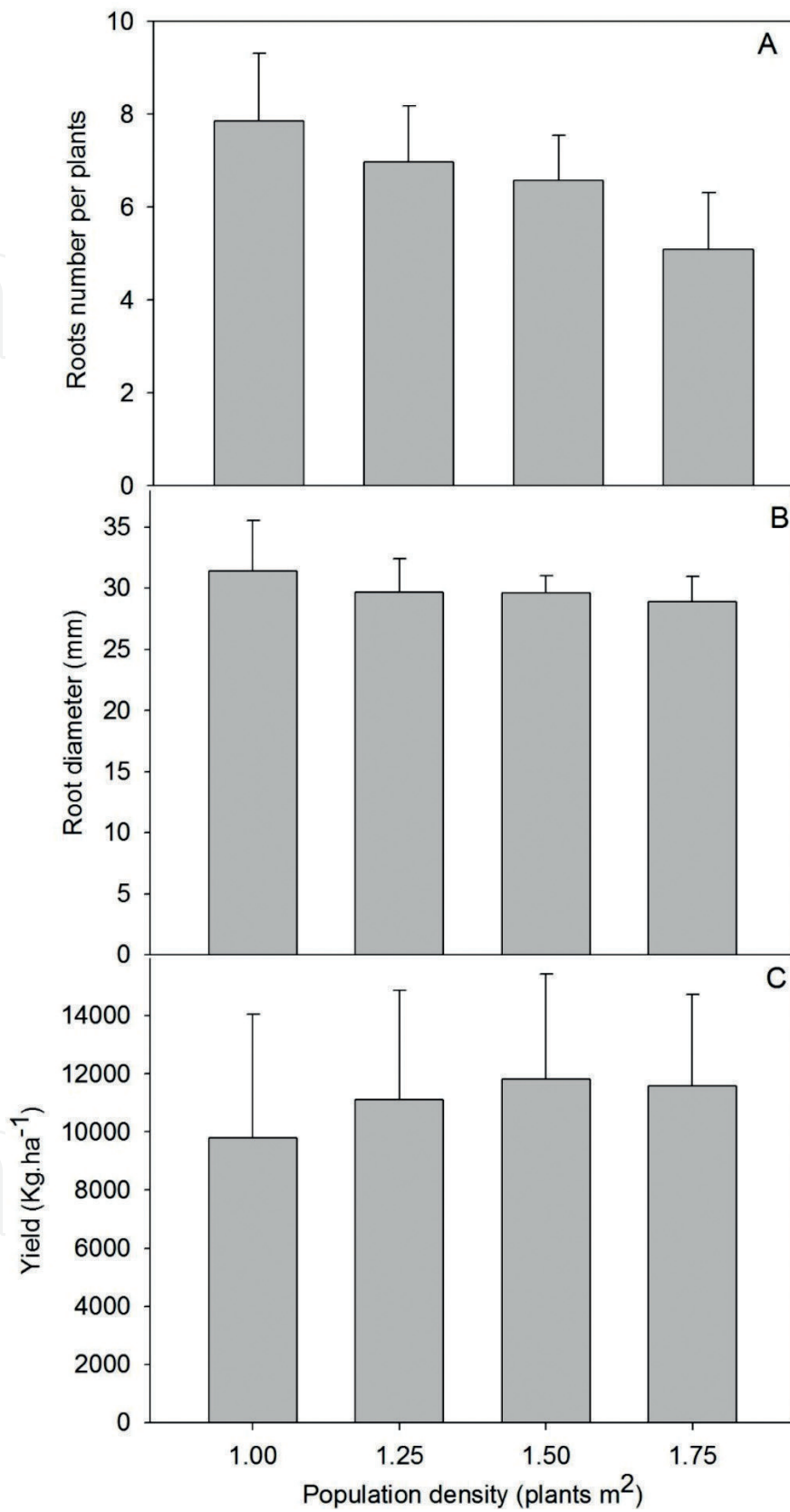


Figure 3. Number of roots per plant (A), root diameter (B), and yield (C) of cassava planted at densities: 1.0, 1.25, 1.5, and 1.75 plants m⁻².



Figure 4. Cassava minimally processed planted at 1.0 (A), 1.25 (B), 1.50 (C), and 1.75 (D) plants m^{-2} . The numbers below of the figures are means of acceptance test conducted with 50 people at the Rural Federal University of Pernambuco, Brazil. Equal letters on the same line indicate that there was no significant difference between the samples at 5% probability level.

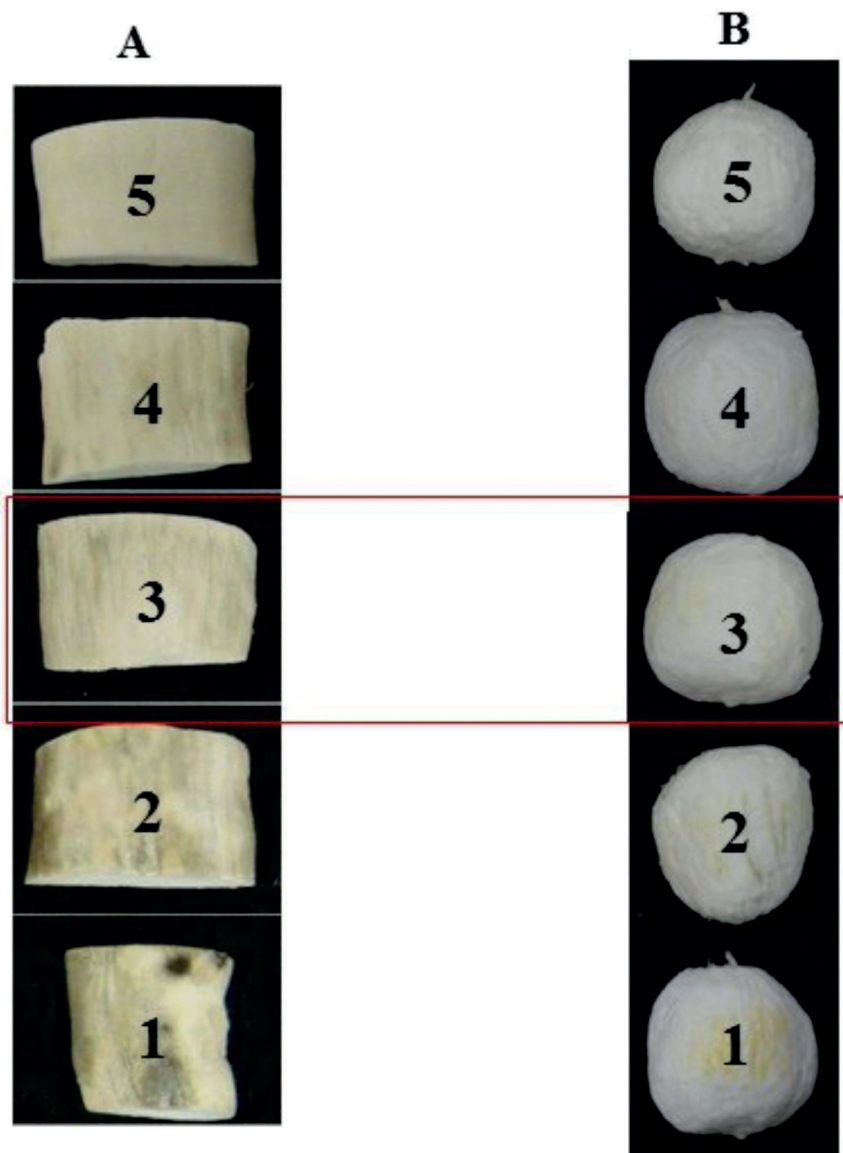


Figure 5. “Babytolete” and “cateto” formats in different grades in the subjective evaluation according to Freire et al. [10]. Note that the shape “cateto” (B) does not darken intensively compared to “babytolete” (A) format. The notes corresponding to three (3), marked in red, represent commercial acceptance limit.

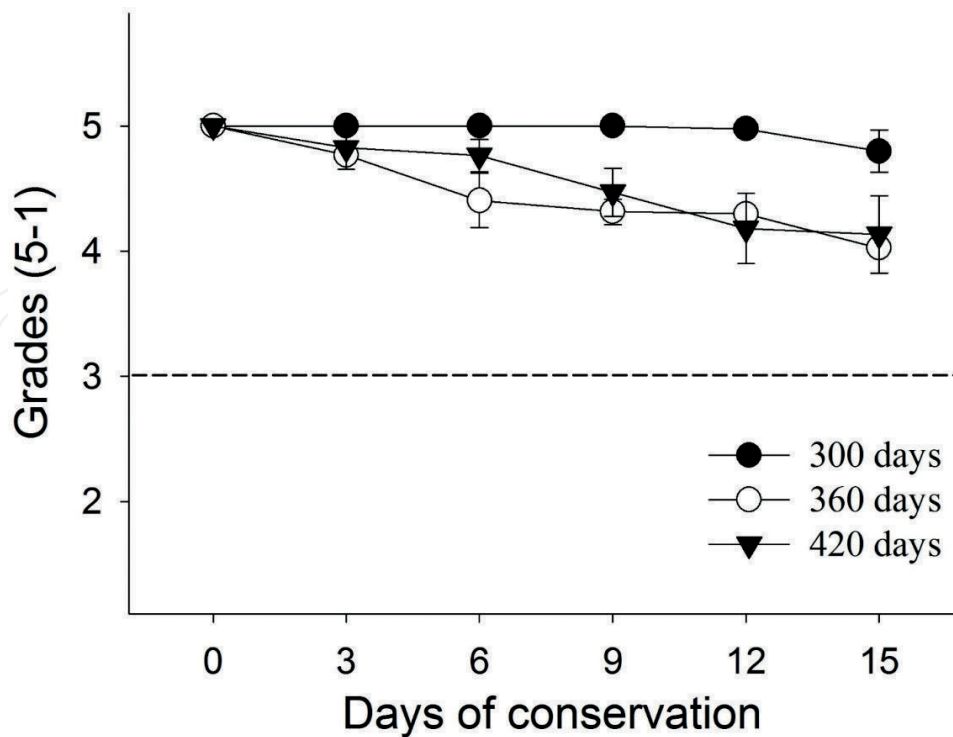


Figure 6. General appearance in minimally processed cassava harvested at different ages. All kept at 5°C for 15 days. The dotted line represents commercial acceptance score limit.

hydroxycoumarin, and an increase in the enzymatic activity of polyphenol oxidase. Secondary metabolites, enzymes, and polysaccharides are activated in response to physiological stress induced [3]. These compounds appear to play an important role in reducing or delaying the process of physiological deterioration. Ref. [3] studies the biochemical profiles of different cassava cultivars. These authors hypothesized that changes in the metabolism and enzymatic activities of tissues that were in wound-induced deterioration serve as indicators of tolerance or susceptibility of genotypes to PPD. One of the results obtained in this study was that the main hydroxycoumarin identified in cassava was scopoletin. Tolerant cultivars for PPD showed higher amounts of this compound. Scopoletin indices increased during PPD, suggesting that scopoletin should be involved in reducing the rate of deterioration in the early stage of PPD. Additionally, high levels of ascorbic acid, polyphenol oxidase, dry matter, and protein correlated with lower deterioration rates [8].

Among the postharvest factors that influence cassava conservation, it is important to note the handling during the minimum processing, emphasizing immersion in ice water; formats; turning and centrifuging (**Figure 1**). The handling stages after minimum processing are storage conditions, packaging, and storage temperature.

Immersion of the raw material in ice water (around 5°C) for 1 hour after harvesting and also in the sanitization and rinsing stages can be done to reduce the respiration transiently, as well as ethylene production and enzymatic activity in carrots [18]. In case of cassava, cooling also helps in the peeling and decreases the browning [12].

Therefore, the hydrocooling is a viable and effective alternative practice, proceeding before the minimum processing operations, to reduce the responses associated to stress, especially those caused by the field heat and those visible in the products. In the same way, roots must also be cooled, in order to remove the field heat and lower metabolic activity.

Turning is another step that is considered critical in the process. Turning removes the superficial tissue by abrasion. In carrots, the turning is done using two turners, one for the removal of the periderm and another to make the rounding of the edges, making them more attractive [14]. In the case of cassava, the periderm is removed with the aid of blades, only a turning machine is required whose purpose is to round the edges. However, it has been found that a short turning period causes surface browning in the conserved pieces (**Figure 7**). Possibly the most internal tissues are composed of differential cells without secondary phloem, in which they are the main site of browned striae. After 120 seconds of the turning process, approximately 5 mm is removed from the surface, making remaining surface cells less responsive to browning. This is evidenced by the high activity of enzymes that can cause browning, such as polyphenol oxidase (PPO) and peroxidase (POD) (**Figure 8**).

Thus, when the surface is removed, composed by the secondary phloem, the “*babycassava*” becomes more tolerant to the browning during the conservation (**Figure 9**). The results show that the turning technique can be an alternative to maintain quality of minimally processed cassava.

On the other hand, the turning must be carried out with maximum hygiene. One more stage is added to the flow chart, and the machine must be clean and properly sanitized, as it can become an inoculum source for contamination as seen in **Figure 8**, using a qualitative evaluation of *Pseudomonas* spp. (**Figure 10**).

Inadequate temperature, such as 10°C, can accelerate microbiological contamination, in relation to 5°C (**Figure 10**). Therefore, the conservation at 5°C is the most suitable for sale in retail, regardless of the format, as both reduce physiological changes as the browning, as well as possible symptoms of disorders of a microbiological nature.



Figure 7. “*Rubiene*” from cv. Mossoró, harvested at 12 months and turned (1.5 kg) by 30 seconds (A), 60 seconds (B), and 120 seconds (C) and maintained for 11 days at $5 \pm 2^\circ\text{C}$. The circles in yellow highlights the browning.

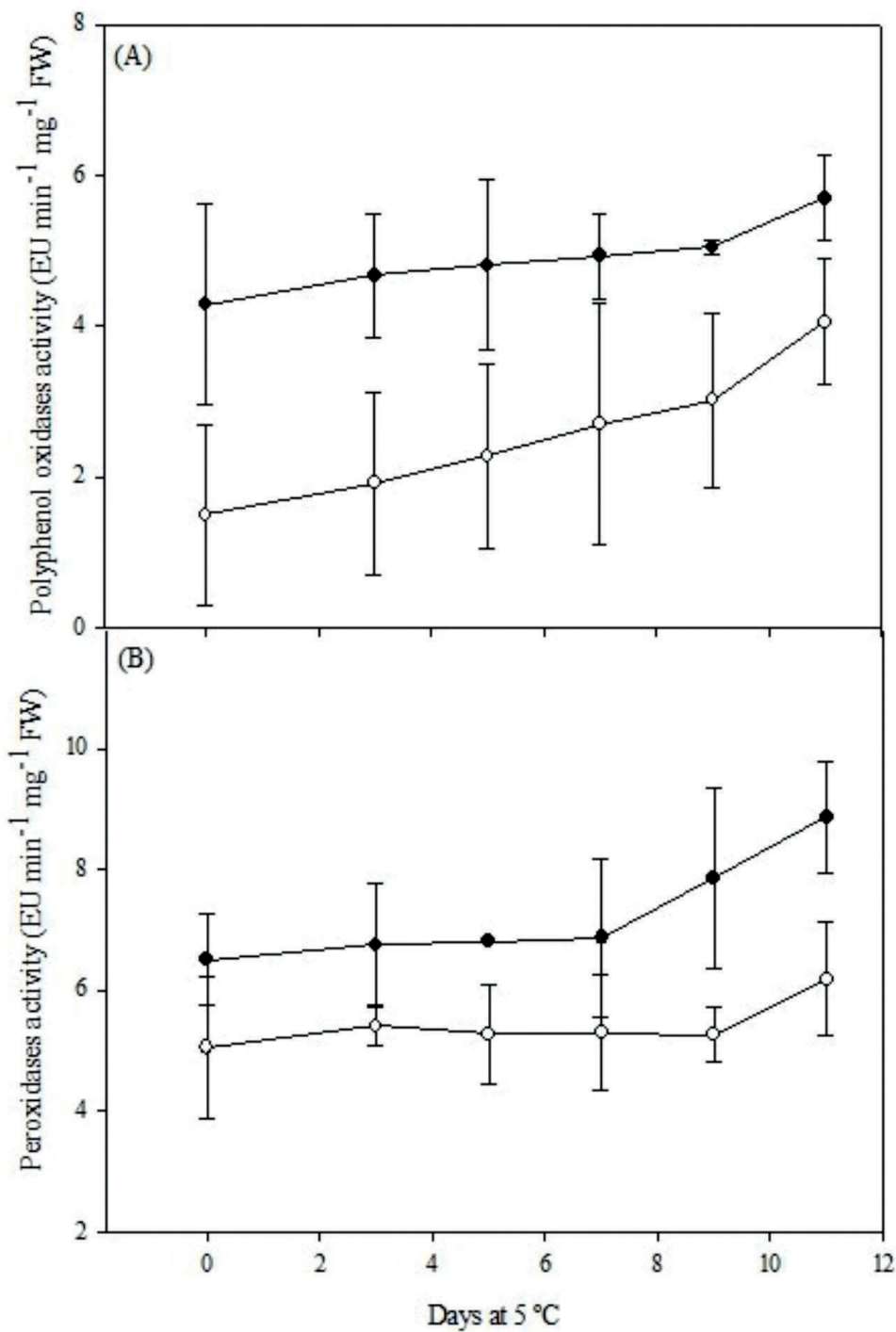


Figure 8. Polyphenoloxidases (A) and peroxidases activity (B) in roots of cassava cv. Mossoró harvested at 14 months and minimally processed in “Babytolete” (●) and “Rubiene” (○) shapes stored at 5°C and 90 ± 5% RH for 0, 3, 5, 7, 9, and 11 days. The vertical bars represent the standard deviation from the mean and the minimal significant difference (MSD) at 5%. Data for three replications.

When “*babycassava*” is marketed at 10°C or without refrigeration, it should not exceed 12 hours until consumption [12]. This is important as in the case of the institutional market, that is, industrial kitchens, schools, companies, among others, in which consumption takes place in a few hours or even after a short period of transportation at room temperature.



Figure 9. Pieces of “babytolete” (A, not turned) and “rubiene” (B, turned for 120 seconds), of sweet cassava cv. “Mossoró” at 7 days at 10°C.

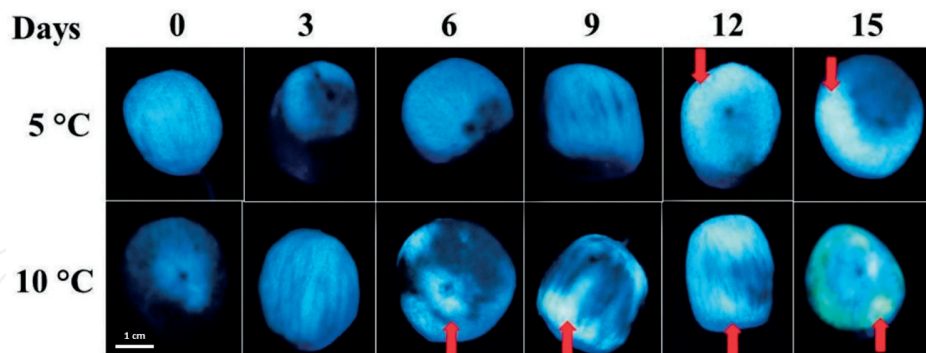


Figure 10. Fluorescence emission of “rubiene” pieces kept at 5 and 10°C for 15 days. The red arrows indicate the incidence of *Pseudomonas* sp. The photos were captured by a semi-professional digital camera (Nikon; D3100 14.2 megapixels) coupled to the darkroom (CN-6; Vilber Lourmart) with incidence of ultraviolet light, 365 nm, with filter 1 × 6 Watts and power 220 V 50/60 Hz (VL-6.L; Vilber Lourmart).

Conservation of minimally processed products for marketing is generally done in refrigerated shelves, whose temperatures are between 5 and 10°C. In addition, the minimally processed cassava can be transported and consumed for 12 hours at room temperature or 12 days at 5°C [11]. This can be an extremely strong inducer for precipitating darkening, by an increase of the activities of enzymes cited and increasing the susceptibility of microbial growth. The changes

in the biochemical markers associated to phenolic compounds can be an important tool to coordinate browning and shelf life of minimally processed cassava.

This chapter showed that some factors of the medium, before harvest, during, and after minimal processing, in the temporary conservation, are modulators of enzymatic activity. The age of harvesting seems to be of extreme importance for an increase in the enzymatic activity. The later the harvest, the greater the PPO and POD activity of the roots in the conservation, suggesting that old roots are more sensitive to browning. This physiological response does not seem to occur in roots grown at different densities, because only diameter, shape, and other agronomic characteristics are modified with different densities of planting [19].

In addition, the manufacturing process of the '*babycassava*', such as the turning, in which with parenchyma removal by turning, reduced browning and the activity of associated enzymes to browning. This is also extended to temperature, packaging, among other postharvest factors not discussed in this review.

4. Summary and conclusions

Population density seems to have more influence on the productive aspect and root morphology. However, harvest time seems to be more related to quality, once that young roots are more tolerant at browning. This seems to be related to the oxidative metabolism involving the enzymes polyphenol oxidase (PPO) and peroxidase (POD), and other enzymes that take part in the process of elimination of reactive oxygen species (ROS).

In postharvest, the process of obtaining "*babycassava*" using turning, "*cateto*" and "*rubiene*" are alternatives to minimize browning and microbiological growth, allied to the storage temperature, help to keep "*babycassava*" quality for longer time.

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