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Influence of Post-Harvest Storage Technologies on Weight and Rate Losses and Sensory Profile of Cola Nuts (*Cola nitida*) Produced in Côte d'Ivoire

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Abstract

The conservation of cola nuts (*Cola nitida*) poses a real problem in Côte d'Ivoire because of the post-harvest losses. The objective of this study was to evaluate the impact of post-harvest technologies on organoleptic and physical properties of cola nut during storage. A biopesticide, glucose syrup and bio-pesticide + glucose syrup were applied to fresh cola nuts before conditioning and kept at 28˚C for 6 weeks. Physicochemical and sensory analyses were performed to check the quality of the nuts during storage. The results showed that the biopesticide keep cola nuts better than the others methods with only 11.66% ± 3.04% and 13.66% ± 3.95% of loss rates for white and red cola nuts respectively. Cola nuts treated with bio-pesticide retain significantly their freshness with 62.00% ± 1.15% of moisture for white nuts and 64.00% ± 2.00% of moisture for red nuts compared to those treated with glucose syrup and bio-pesticide + glucose syrup (56.66% ± 1.15%). Cola nuts treated with biopesticide have a better acceptability compared to those subjected to others treatments. The use of biopesticide for the storage of cola nuts minimizes the losses and maintains the quality whatever the type of cola.

Keywords

Cola nitida, Storage, Post-Harvest Losses, Biopesticide, Glucose Syrup, Quality

1. Introduction

Cola nuts are the cotyledons of some species of Cola, a genus of trees belonging

to the family Sterculiaceae [1]. About 40 Cola species have been described in West Africa; however, the Cola species of economic importance are *C. acuminate* and *C. nitida* [2]. *C. nitida* is the most cultivated in Côte d'Ivoire [3] and the major production is intended to exportation in several African countries as fresh cola nuts. But, *Cola nitida* (vent.) Schott Endl. is the most important and widely cultivated in Côte d'Ivoire and others main areas of tropical forest of West and Central Africa. The bulk of cola nuts produced in West Africa, in particular in Côte d'Ivoire is consumed locally and exported to Nigeria, Mali and Burkina Faso as fresh nuts. The nuts are consumed for their stimulant properties and their taste and are traditionally used in Western and Central Africa during weddings funerals and ritual sacrifices. They are also used in the pharmaceutical and food industries to produce cardiac stimulants, laxatives, sedatives and sodas [4]. In Africa, the cola nuts chewed for its alkaloid properties (caffeine, kolanin and theobromine), which dispel sleep, thirst and hunger. There seems to be a slight preference for white kola nuts over red. Consumed fresh for these many uses, the post-harvest conservation of cola nut is a real problem for stakeholders in the sector. Cola is attacked by weevils (*Balanogastriskolae*) and fungi (*Aspergillus niger*, Penicillium *sp*) that can cause 30% - 70% losses during storage [5]. To limit losses, these actors use conservation techniques using chemical pesticide treatments of organochlorine, organophosphorus and pyrethroid families [6]. However, intoxications and pollution related to the use of chemical pesticides are serious environmental and public health problems. Chemical pesticides are, by their nature, dangerous and toxic products even at very low doses. They are responsible for chronic diseases such as cancer, liver and kidney diseases that affect nearly 750,000 people in tropical and subtropical countries [7]. The excessive use of chemical pesticides in agriculture is a serious cause of concern. It is, therefore, important that alternative, environmentally friendly methods of plant protection are adopted, such as integrated pest management techniques, including the use of biopesticides. The potential of biopesticides for promoting sustainable agriculture has been known for many years [8]. In spite of these advantages, the use of biopesticides in Côte d'Ivoire is almost absent in agriculture especially in the production and the treatment of cola nuts. This paper aimed to investigate the potential of biopesticide in the maintaining of the quality of the cola nuts during storage.

2. Material and Methods

2.1. Cola Nuts and Treatment Product

Fresh film-coated cola nuts were collected in cola marketing area (Anyama) in the District of Abidjan (Côte d'Ivoire) and put in a sterile polythene bags. A biopesticide namely "TopBio" (based on Neem) and "PATISFRANCE" (Glucose syrup as coating agent) were used for the treatment of cola nuts. "TopBio" was selected from 3 harmless biopesticides to humans (TopBio, Silico Sec and Agrimor Pestop) after an acute toxicity study on rats and a microbiological test on

Aspergillus niger, *Aspergillus flavus* and *Penicillium sp* responsible of the contamination of kola nuts. Polystyrene trays, food cartons and a crate have allowed to the storage of cola nuts.

2.2. Cola Nuts Treatment and Storage

A mass of 120 kg of freshly picked, film-coated cola nuts was used for the study. After dehulling, sorting and washing, 40 kg of dehulled cola nuts (20 kg of red nuts and 20 kg of white nuts) were used for the implementation of 4 post-harvest conservation technologies per typology of cola nuts (8 samples of 5 kg including 4 of white cola nuts and 4 of red cola nuts) (Figures 1-3). Thus, the first sample was treated with "TopBio" (soaking in the solution diluted to 10 mL/L of water per 1 kg of nuts for 30 min). After draining, the nuts removed with the solution were packaged in the trays. With the second "PATISFRANCE" technology, the nuts were packaged directly into the trays containing diluted glucose syrup at 63%. For the third technology "TopBio + PATISFRANCE" the nuts were first treated with biopesticide and packaged in trays containing diluted glucose syrup. The latest technology "control" consists of nuts coordinated only in trays. The processed cola nuts were put in the polystyrene trays packaged in cartons and kept for 6 weeks (Figures 3-5).

Figure 1. Cola nuts dehulled, sorted and washed (Control).

(a) (b)

Figure 2. Products used for treatments (a) biopesticide "TopBio"; (b) glucose syrup "PastiFrance".

(a) (b)

Figure 3. Packaging nuts in trays (a) nuts treated with biopesticide; (b) nuts treated with glucose syrup.

Figure 4. Packaging trays in cartons.

Figure 5. Storage of cartons in box.

2.3. Physicochemical Analysis

The degree of infection was expressed as the percentage of infected cola nuts after each treatment as mentioned by Equation (1) [9]. Moisture was determined according to the [10] method. The degree of infection and the moisture were measured each week during the 6 weeks of storage.

$$TP = \frac{NI}{NT} \times 100 \quad (1)$$

2.4. Sensory Descriptive Analysis

The evaluation of the organoleptic characteristics of treated cola nuts was done

by 15 usual tasters-consumers of cola nuts, noting from 0 to 8 the criteria of appreciation that are: the color, the taste, the brightness, the browning, the aging, the texture and the general appreciation. Each week, the descriptive test was made according to [11].

2.5. Statistical Analysis

Physicochemical analyses were performed in triplicates and the results were expressed by means ± standard deviation (SD). Statistical significance was established using analysis of variance (ANOVA) models to estimate the main effects and their interaction effects. Means were separated according to turkey's multiple range analysis ($P \leq 0.05$), with the help of the software XLSTAT (Version 19.6). Sensory data were expressed as profile.

3. Results

3.1. Degree of Infection Cola Nuts (Rate Losses)

During storage, the losses were very high (100% ± 0.00% of infection) in both cola nuts treated with "PATISFRANCE" (glucose syrup) and "TopBio + PATISFRANCE" (bio-pesticide + glucose syrup) after 6 weeks regardless of the typology of the nuts (**Figure 6**). However, losses were weak with nuts treated with biopesticide "TopBio" (11.11% ± 3.04% and 13.00% ± 3.95% for white and red cola nuts respectively) (**Figure 6**). The cola nuts without treatment (control) had a loss rate of 23% ± 1.42% for white nuts and 24% ± 1.27% for red nuts (**Figure 6**).

3.2. Moisture

The variation of cola nuts moisture during storage is shown in **Table 1**. The moisture of the nuts treated with biopesticide + syrup decreased significantly from 62.80% ± 1.15% to 56.66% ± 1.15% for the white nuts and from 64% ± 2.00% to 56.66% ± 1.15% for red nuts. These moisture data were significantly the same with those of the nuts treated with glucose syrup (62.80% - 56.66% and 64% - 56.66% for the white nuts and red nuts respectively). However, the moisture of nuts treated with the biopesticide and the control remained significantly ($P \leq 0.05$) constant during storage (62% ± 1.15% for white nuts and 64% ± 2.00% for red nuts) regardless of the typology of the nuts.

3.3. Sensory Analysis

Organoleptic characteristics deteriorated during storage regardless of the type of nuts and applied technologies. However, biopesticide and the control retained significantly organoleptic characteristics better (good general appreciation, good texture and taste) than glucose syrup and biopesticide + glucose syrup. Glucose syrup and bio-pesticide + glucose syrup provoked the rapid degradation of the organoleptic characteristics of cola nuts from the first four weeks (**Figures 7-10**) with bad texture, taste and general appreciation.

Table 1. Evolution of moisture in cola nuts according to treatments during storage.

Cola nuts	week	Treatments			
		Bio pesticide + Glucose syrup	Bio pesticide	Glucose syrup	Control
White cola nuts	0	62.80 ± 1.15a	62.80 ± 1.15a	62.80 ± 1.15a	62.80 ± 1.15a
	2	59.33 ± 0.00ab	64.00 ± 0.00a	56.00 ± 2.00b	62.66 ± 2.30a
	4	57.33 ± 1.15ab	63.33 ± 0.00a	56.66 ± 1.15b	63.33 ± 0.00a
	6	56.66 ± 1.15b	63.33 ± 0.00a	56.66 ± 2.30b	62.00 ± 2.00a
Red cola nuts	0	64.00 ± 2.00a	64.00 ± 2.00a	64.00 ± 2.00a	64.00 ± 2.00a
	2	60.00 ± 2.00ab	64.00 ± 2.00a	57.33 ± 2.30b	64.00 ± 0.00a
	4	56.00 ± 0.00b	64.00 ± 1.15a	56.66 ± 1.15b	65.33 ± 1.15a
	6	56.66 ± 1.15b	64.00 ± 2.00a	56.66 ± 1.15b	64.00 ± 2.00a

Mean ± standard deviation, n = 3. Values in the same column with different alphabetical letters are significantly different at the 5% level according to the Tukey test of variance analysis.

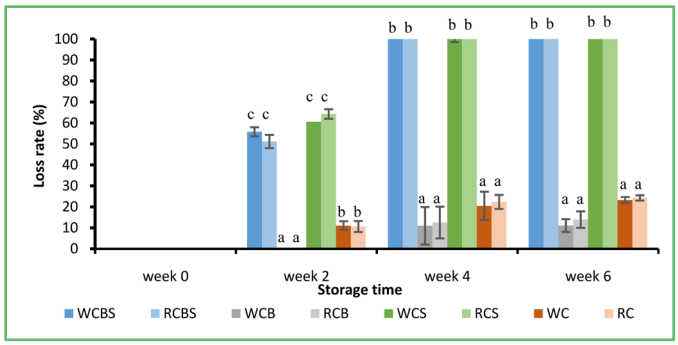

Figure 6. Evolution of loss rates of red and white cola nuts during conservation. WCBS: white cola nuts treated with biopesticide + glucose syrup, RCBS: red cola nuts treated with bio-pesticide + glucose syrup, WCB: white cola nuts treated with biopesticide, RCB: red cola nuts treated with biopesticide, WCS: white cola nuts treated with glucose syrup, RCS: red cola nuts treated with glucose syrup, WC: white cola nuts without treatment, RC: red cola nuts without treatment. Mean ± standard deviation, n = 3. In the same week, histograms with different alphabetical letters are significantly different at the 5% level according to the Tukey test of variance analysis.

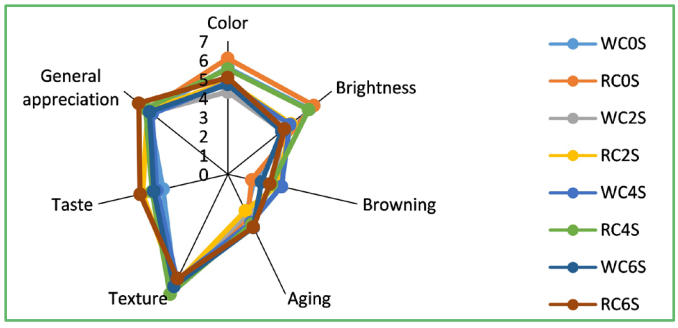

Figure 7. Sensory profile of cola nuts during conservation depending on without treatment. WC0S: white cola nuts control; RC0S: red cola nuts control; WC2S: white cola nuts at 2 weeks; RC2S: red cola nuts at 2 weeks; WC4S: white cola nuts at 4 weeks; RC4S: red cola nuts at 4 weeks; WC6S: white cola nuts at 6 weeks; RC6S: red cola nuts at 6 weeks.

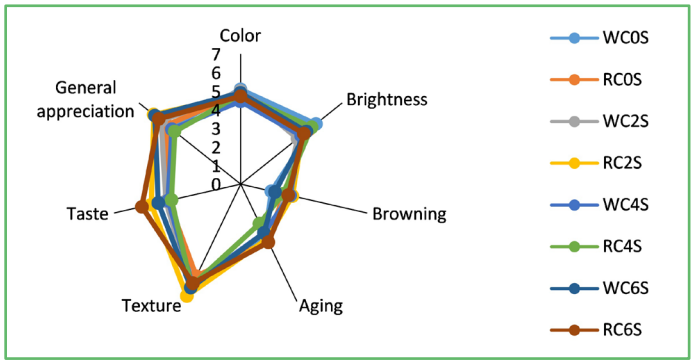

Figure 8. Sensory profile of cola nuts during conservation depending on treated with bio-pesticide. WC0S: white cola nuts control; RC0S: red cola nuts control; WC2S: white cola nuts at 2 weeks; RC2S: red cola nuts at 2 weeks; WC4S: white cola nuts at 4 weeks; RC4S: red cola nuts at 4 weeks; WC6S: white cola nuts at 6 weeks; RC6S: red cola nuts at 6 weeks.

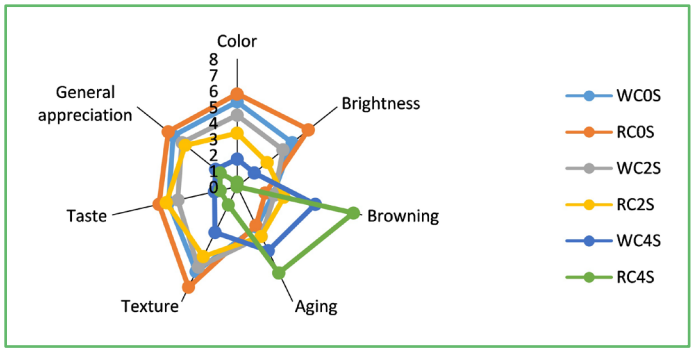

Figure 9. Sensory profile of cola nuts during conservation depending on treated with biopesticide + glucose syrup. WC0S: white cola nuts control; RC0S: red cola nuts control; WC2S: white cola nuts at 2 weeks; RC2S: red cola nuts at 2 weeks; WC4S: white cola nuts at 4 weeks; RC4S: red cola nuts at 4 weeks.

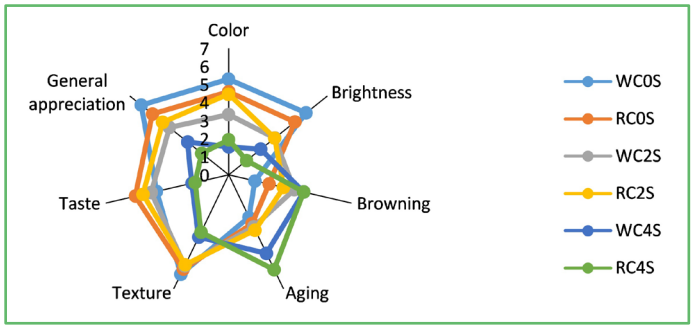

Figure 10. Sensory profile of cola nuts during conservation depending on treated with glucose syrup. WC0S: white cola nuts control; RC0S: red cola nuts control; WC2S: white cola nuts at 2 weeks; RC2S: red cola nuts at 2 weeks; WC4S: white cola nuts at 4 weeks; RC4S: red cola nuts at 4 weeks.

4. Discussion

Regarding to the losses (infections), there was very low in cola nuts treated with biopesticide (11.11% ± 3.04% and 13.00% ± 3.95% for white and red nuts re-

spectively) compared to the control (23% ± 1.42% for white nuts and 24% ± 1.27% for red nuts). The results obtained would be due to the reduction of the proliferation of insects and mold in stocks by the biopesticide. Indeed, neem-based biopecticides contain azadirachtin, a molecule capable of disrupting the morphogenesis and embryonic development of insects [12]. Our results have been correlated with those of [13] and [14] in which the use of biopesticide has reduced the proliferation of insects and during cabbage and rice conservation. Also, the non-proliferation of the fungal flora could also be due to antifungal effects of the active compounds of the biopesticide solution. The very high losses (100% ± 0.00% of infection) in nuts treated with glucose syrup and nuts treated with bio-pesticide + glucose syrup (100% ± 0.00% of infection) are due to the change in the physical appearance of nuts marked by enzymatic browning.

The moisture maintained in the cola nuts treated with biopesticide and those of the control during storage. The biopesticide therefore had no influence on the moisture content of the nuts. The maintaining of the humidity rate would be due to packaging. In this study, styrofoam trays associated to carton are a barrier to oxygen and light which limited the breathing and transpiration of cola nuts. Over-permeable packaging will result in rapid loss of moisture, which will be accompanied by wilting and wrinkling of the product as mentioned by [15]. The loss of freshness of cola nuts treated with glucose syrup and those treated with biopesticide + glucose syrup is explained by the migration of glucose in nuts (osmosis).

The organoleptic characteristics of the cola nuts, such as the color, the texture and the taste, as well as the overall appreciation of the nuts, were preserved in the nuts treated with biopesticide and the control. The results obtained could be due to the fact that the biopesticide had no effect on the organoleptic characteristics of kola nuts. According to [6], the conservation of organoleptic characteristics is strongly linking to the types of packaging. The depreciated organoleptic qualities of cola nuts treated with glucose syrup and nuts treated with biopesticide + glucose syrup would be due to the glucose syrup that is responsible to the enzymatic browning. Indeed, treatment with glucose in the cell walls of nuts, hence the release of phenol compounds. Nuts are rich in polyphenol oxidase; in the presence of oxygen, these enzymes catalyze the reaction. Enzymes oxidize phenol compounds to quinones that polymerize to brown products [16]. Several studies on fruit have also described this phenomenon [17]. These characteristics could negatively affect the sale of these nuts. This hypothesis is corroborated to the studies of [6] who showed that consumers choose cola nuts in relation to their colors, tastes, crisp textures, sizes and juices.

5. Conclusion

The biopesticide and the control were appropriate methods of cola nuts storage in term of loss reduction and infection with a good preservation of moisture and organoleptic parameters regardless of the typology of the nuts. For an efficiency

of this conservation technology it is recommended to sort the nuts and soaked them in a solution of "TopBio" diluted to 10 mL/L of water per 1 kg of nuts for 30 min. Thereafter, pack the treated nuts in materials that are light and oxygen-proof.

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