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Biochemical variation in traditional black plum nectar's quality during storage

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Abstract

In Côte d'Ivoire, the non-alcoholic beverage industry is gradually turning to fruits from local wild species. More and more products from the latter are entering the market. Black plum, fruit of *Vitex doniana*, very pleasant and rich in bioactive compounds, has been transformed into nectar without the addition of preservatives. As a result, this product remains subject to a possible alteration of its nutritional quality and to reduction of its shelf life. Monitoring of the evolution of certain biochemical parameters of traditional nectar of black plums stored at different temperatures, for three (3) months, was carried out with the aim of highlighting the influence of temperature and storage duration on its nutritional quality but also to be able to determine its best use-by date, in order to guarantee best preservation of nutritional qualities. Black plum nectar used for this work was made from fruits, harvested in three (3) regions of northern Côte d'Ivoire and using a process modeled on traditional technique. Biochemical analyzes was carried out using the classic methods analysis. At the end of this study, we note an increase in acidity and soluble dry extract of traditional nectar linked to the rise in storage temperature. Vitamin C losses are minimal when this storage temperature is low. The longer the shelf life of nectar, the more it registers a decline in its nutritional value. Temperature that allows better nutritional preservation of black plum traditional nectar remains that of refrigeration (4 °C). However, at this temperature, its shelf life cannot exceed ten (10) weeks if you want to enjoy its benefits.

Keywords: *Vitex doniana*; Black plum; Traditional nectar; Storage temperature; Shelf-life product; Storage time

1 Introduction

Due to their exceptional properties, fruits consumption is considered by many authorities as a public health issue and is the subject of nutritional recommendations at the global level by the United Nations Organization for Food and Agriculture (FAO) and the World Health Organization (WHO) [1]. In addition to the sale of fresh fruit, it is possible to valorize this raw material by transforming it into derivative products, of which juices and nectars constitute an important part. This transformation, in addition to making the benefits of out-of-season fruits available to populations, constitutes a significant local economic benefit. Overall, current average per capita consumption of fruit juice is increasing at a rapid rate in Africa. Consumers in this part of the world prefer a healthier lifestyle. They favor organic and natural products rather than chemically compounded products. In Côte d'Ivoire, the soft drink industry is gradually turning to local fruits [2]. There are more and more natural fruit juices and nectars on the market, sometimes made from the fruits of wild species that have long been undervalued. *Vitex doniana* species (Verbenaceae's family) remains under-exploited despite the interest it presents for local populations [3,4]. The fruit commonly called black plum of very

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good taste and high nutritional value, has important medicinal properties [5, 6, 7, 8]. Traditional nectar resulting from the artisanal transformation of the pulp of this fruit is however confronted with the influence of certain limiting factors during its conservation. However, no referenced study reports the impact of temperature and storage duration on the evolution of its nutritional composition. This study devoted to the monitoring of the evolution of certain biochemical parameters during its storage at three (3) different temperatures for twelve (12) weeks makes it possible to highlight the quality modifications likely to occur during its storage under conditions of refrigeration and room temperature in temperate and tropical climates.

2 Material and methods

2.1 Material

Samples of traditional nectars, made from the pulp of ripe black plums using a manufacturing process without the addition of preservatives and modeled on the artisanal model [9], were transferred in sterile transparent tubes then placed at three (3) different temperatures (4 °C, 20 °C and 32 °C) for one quarter.

2.2 Methods for analyzing the biochemical parameters of micro filtered nectar

In order to follow the evolution of the quality of traditional nectar during storage, certain biochemical parameters, in particular pH, titratable acidity, soluble dry extract and vitamin C content, likely to influence its nutritional quality have been were evaluated weekly during the storage period.

2.2.1 Assessment of the acidity of micro filtered nectar

pH determination

Traditional nectar's pH was determined by the potentiometric method, using a previously calibrated pH meter (HANNA HI 8424). The tests were repeated three (3) times for each sample.

Determination of titratable acidity

Titratable acidity ($mEq.mL^{-1}$) was determined according to the colorimetric method described by the French standard [10].

10 mL of traditional nectar were taken using a pipette and poured it into a beaker. The samples are then titrated with sodium hydroxide (0.1 N NaOH) after adding two (2) drops of phenolphthalein. The tests were repeated three (3) times for each batch. The titratable acidity is obtained according to the expression of equation (1)

$$A°(mEq/100g) = \frac{N_1.V_1.10^5}{m.V_0} \qquad \text{..... (1)}$$

2.2.2 Determination of the soluble dry extract (SDE)

Soluble dry extract was measured using a hand-held digital refractometer (ATAGO pocket PAL-α, Japan). After calibrating the refractometer with distilled water, a few drops of traditional nectar were placed on its lens and the reading of the Brix degree was made after five (5) seconds. Tests were repeated three (3) times for each sample.

2.2.3 Assessment of Vitamin C

Vitamin C concentration (in mg/100g) was determined according to the method of [11]. To 10 mL of sample, 10 mL of metaphosphoric acid was added to stabilize the vitamin C. Sample to be analyzed was obtained by taking 5 mL of the stabilized solution which was then measured in an Erlenmeyer flask with a volume (V_e) of a solution of 2,6-dichlorophenolindophenol (2,6-DCPIP). The calibration of the 2,6-DCPIP solution was previously done with a volume (V_s) of pure ascorbic acid. Another solution prepared from metaphosphoric acid/acetic acid was also titrated with one volume (V_0) of the 2,6-DCPIP solution. The tests were repeated three (3) times for all samples. The concentration of vitamin C ([vit C]) was evaluated by the expression of equation (2):

$$[\text{Vit C}] = \frac{2\,(V_e - V_0)}{(V_s - V_0)} \times 100 \text{..... (2)}$$

3 Results and discussion

Figure 1 shows the variation in pH of traditional nectar and Figure 2, that of titratable acidity during its storage at three (3) different temperatures: 4 °C, 20 °C and 32 °C.

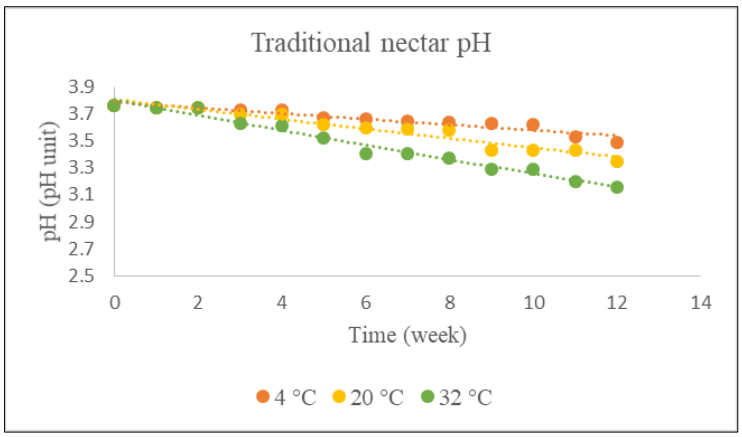

Figure 1 Evolution of the pH of traditional nectar during storage

With regard to figure 1, it can be seen that throughout first three (3) weeks of storage and for all the temperatures, pH begins to drop, but this remains very low. From the fourth week, the decrease in pH accelerates and is a function of storage temperature. The lower this temperature, the less acid the nectar becomes. The R^2 regression coefficients are between 0.90 and 0.97. This indicates the strong correlation between pH values and storage temperature.

In general, the most important indicators of food quality and safety are pH and temperature. In the case of traditional black plum nectar, a decrease in pH is observed. This therefore implies an acidification of the medium linked to the storage temperature. This is in accordance with the results of [12] for seedless lime juice and [13] for natural orange juice.

Thus, during storage, the higher the storage temperature, the more acidic the pH of the nectar becomes. [14] also found this reduction in pH when storing papaya, pineapple and watermelon juice at different temperatures. According to work done by [15], [16] and [17] on fruits juices, this decrease in pH could be explained by deterioration of the characteristics of fruit juices, the biochemical reactions as well as the microbial action that occurred during the storage period.

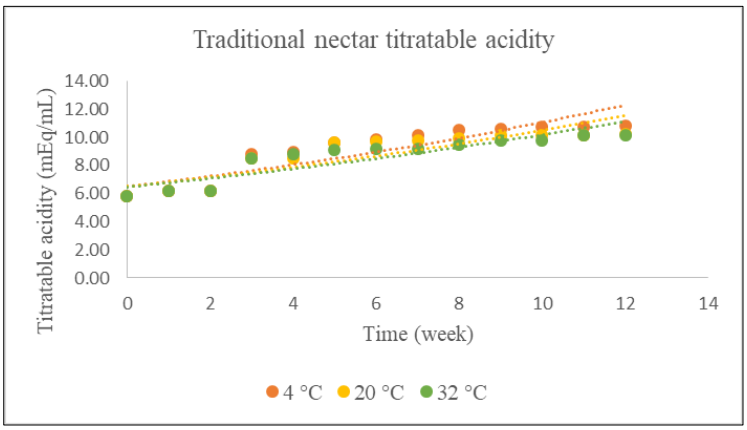

Figure 2 Evolution of titratable acidity of traditional nectar during storage

In Figure 2, it is observed that during the first three (3) weeks, the titratable acidity of traditional nectar increases. However, this increase remains substantially the same for the three (3) storage temperatures. From the fourth week, its increase depends on storage temperature. Thus, nectar stored at 32 °C has the highest titratable acidity. Next comes the one stored at 20 °C. Finally, the third stored at 4 °C has the lowest titratable acidity. The values of the R^2 regression coefficients are between 0.76 and 0.78.

According to results obtained, there is an increase in the titratable acidity with the increase in the storage temperature of the nectars. This reflects an increase in the proportion of organic acids present in nectars [17]. These organic acids contribute to the particular flavor and palatability of nectar and their increase is probably due to the transformation of pectin into galacturonic acid, as observed by [18] for the mixture of apple and apricot juice and [13] for orange juice.

We observe for this nectar that during first weeks of storage, the variation in acidity for the three temperatures is very low. Beyond the fourth week, it registers an increase which is a function of storage temperature. This state could run lead to a denaturation of nectar [19] because very strong acidity will tend to reduce the sensation of sugar [20].

3.1 Evolution of soluble dry extract of traditional nectar during storage

As can be seen in Figure 3, soluble solids content of product increases during storage for all temperatures.

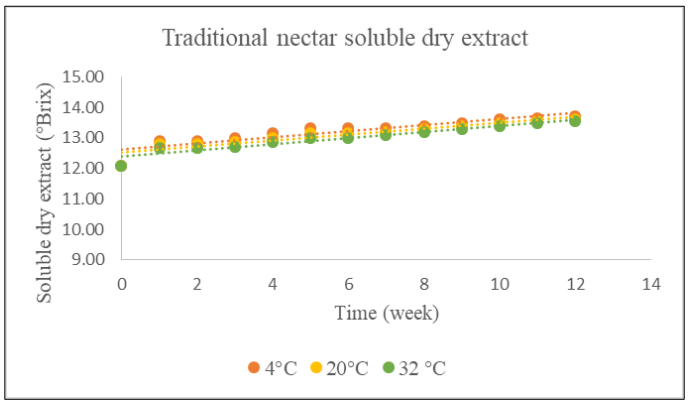

Figure 3 Evolution of soluble dry extract of traditional nectar during storage

This increase occurs from first week of storage for all temperatures. It records highest values for lowest temperatures. Note, however, that the difference between values of this parameter for all temperatures is not very large. The R^2 regression coefficients are between 0.89 and 0.96.

These results are in agreement with work carried out by [21] who found no significant difference between soluble solids values of juices stored at different temperatures. This increase in value of Brix degree would be explained by acid hydrolysis of polysaccharides into monosaccharides and oligosaccharides when medium is acidic [22]. According to [23] this could be due to the action of evaporation which causes the reduction of water and hence the increase in concentration of sugars in juice.

3.2 Variation in vitamin C content of traditional nectar during storage

3.2.1 Evolution of vitamin C content of traditional nectar

Results obtained after monitoring changes in vitamin C content are shown in figure 4.

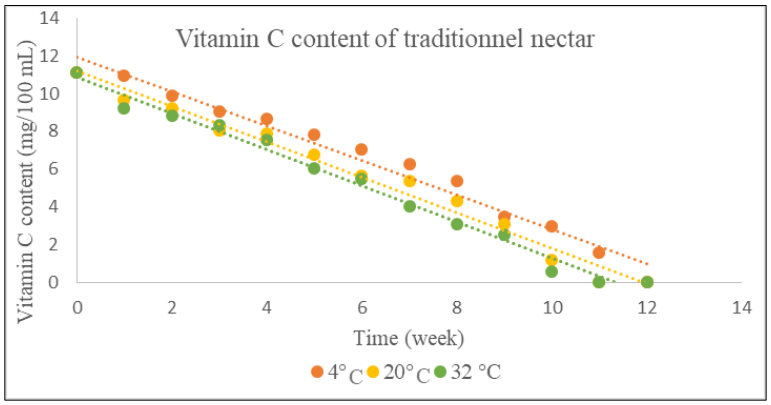

Figure 4 Evolution of vitamin C content of traditional nectar during storage

This figure shows that vitamin C content of traditional nectar registers a decrease from first week of storage. This decrease is a function of storage temperature. After 11 weeks of storage, the amounts of vitamin are nil for two (2) highest temperatures. At 4 °C, the content of this vitamin is canceled after the twelfth week. The R^2 regression coefficients varied between 0.97 and 0.98.

Amount of vitamin C in nectar gradually decreases during the three (3) months of follow-up depending on storage temperature. This observation was made by [24] for passion fruit juice (purple variety) and by [21] for orange juice stored at different temperatures in transparent bottles.

Vitamin C degradation would be due to oxygen present in the container, to heat or to light [20, 21]. During nectar storage, this destruction is particularly due to temperature and storage time [25].

Indeed, during storage, vitamin C can be subject to anaerobic degradation favored by acidity and temperature [26]. In an acidic and hot environment, ascorbic acid undergoes dehydration and decarboxylation which lead to the formation of intermediate bodies such as carbon dioxide and furfural [27]. Furfural can lead to the formation of brown pigments precursor, by binding to amino acids. Temperature therefore remains the most important factor affecting the stability of the vitamin during storage of fruit juices.

3.2.2 Characterization of kinetics of degradation of vitamin C in nectars

In order to predict evolution of vitamin C content of nectar over time, kinetics of degradation of this vitamin as a function of storage temperature of nectar was produced using two (2) models that are that of Arrhenius and that of Bigelow.

Figure 5 presents logarithms of vitamin C concentration of traditional nectar as a function of storage time.

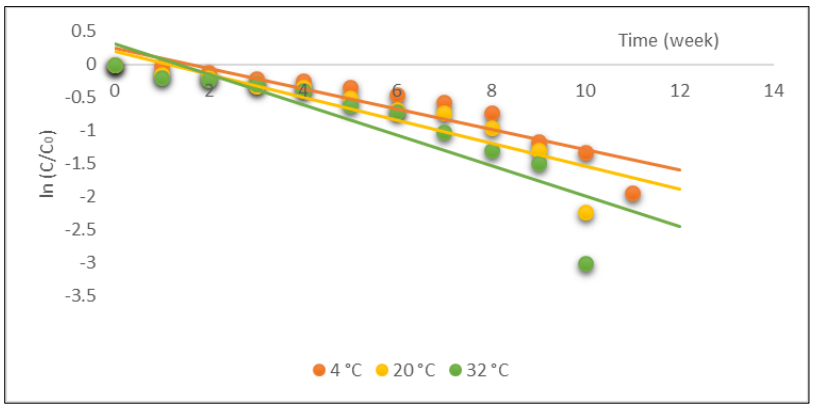

Figure 5 Kinetics of thermal degradation of vitamin C of traditional nectar as a function of storage time

In case of traditional nectar, thermal degradation of vitamin C follows first-order kinetics. Logarithm of vitamin C concentrations is proportional to treatment time and regression coefficients are between 0.776 and 0.901.

Figures 6 (a) and (b) respectively show more precisely effect of temperature on coefficient of vitamin C degradation rate and decimal reduction time in traditional nectar.

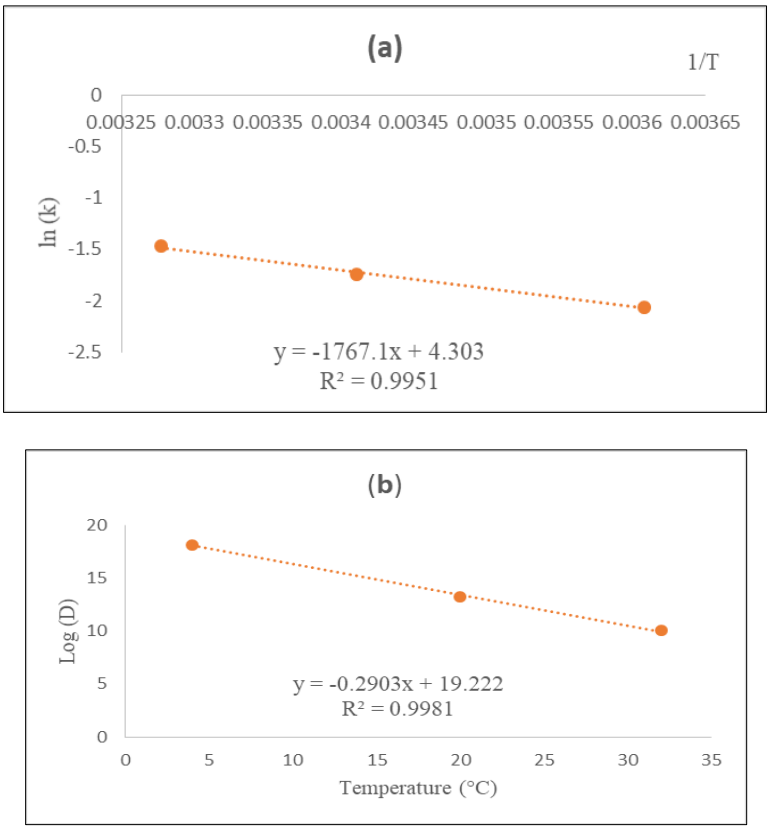

Figure 6 (a) Arrhenius diagram representing influence of traditional nectar storage temperature on rate constant k – (b) Bigelow diagram of decimal logarithm of D value as a function of temperature

Value of regression coefficients R^2 (0.995 and 0.998) of these figures shows that there is a strong correlation between storage temperature of this nectar, coefficient of destruction rate of vitamin C and decimal reduction time.

Table 1 indicates values of kinetic parameters which are activation energy (Ea), speed coefficient (k), decimal reduction time (D), and decimal reduction factor (z) between 4 °C and 32 °C for traditional nectar.

Table 1 Kinetic parameters of thermal degradation of vitamin C in traditional nectar

Temperature	Arrhenius's model			Bigelow's model		
	k (s-1)	Ea (kJ/mol)	R2	D (s)	z (°C)	R2
4 °C	0.830	14,69	0,968	2.489	18.21	0.998
20 °C	0.893			2.416		
32 °C	0.980			2.323		

Analysis of Table 1 shows that the lower storage temperature of traditional nectar, the lower the degradation rate coefficient. Conversely, a decrease in storage temperature of nectar leads to an increase in decimal reduction time. Hence increase in degradation of vitamin C with the rise in storage temperature of this nectar.

Activation energies and z factors of traditional black plum nectar show much lower values than those of baobab (*Adansonia digitata*) and bissap (*Hibiscus sabdariffa*) nectar according to [28].

4 Conclusion

Preserving nutritional quality of natural fruit juices and nectars remains a challenge across tropics. Their conservation requires a certain control of possible chemical and biochemical modifications that they could undergo.

This work has highlighted impact of storage time and temperature on variations in pH, titratable acidity, soluble solids content and vitamin C content.

The higher the storage temperature, the more the nutritional value of traditional black plum nectar is affected. Storing it at 4 °C seems to be the best suited to maintaining its quality, but storage time remains limiting factor because it does not exceed ten (10) weeks.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

Authors declare no conflict of interest whatsoever.

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