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Monitoring of stability evolution of micro filtered black plum nectar from Côte d'Ivoire during storage

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Abstract

Food industry and more specifically that of juices in Côte d'Ivoire, is gradually turning to local fruits. New products, sometimes derived from wild fruit species, are appearing on the market. The savannah plum tree (*Vitex doniana*) hitherto undervalued, is experiencing renewed interest due to its socio-economic importance for local populations. Its black plum fruit, rich in bioactive compounds, has been semi-industrially transformed into nectar. However, without the addition of preservatives, this nectar faces a probable reduced shelf life. The nectar used for this study was developed from fruits harvested in three (3) regions of northern Côte d'Ivoire. Monitoring of the evolution of biochemical parameters of this nectar, during storage, was carried out by conventional methods of biochemical analysis. At the end of this study, it appears that acidity and soluble dry extract of the nectar studied increases with rise in storage temperature. Vitamin C losses are reduced when the storage temperature is low. The more the shelf life of the nectar increases, the more it registers a drop in its nutritive value. To take full advantage of the benefits of this black plum nectar, it is best to store it at refrigeration temperature (4 °C) for a maximum of ten (10) weeks.

Keywords: *Vitex doniana*; Black plum; Microfiltered nectar; Food monitoring; Product shelf life; Storage time

1. Introduction

The vital importance of fruits in the field of food and human health no longer needs to be demonstrated [1]. Adulated for their organoleptic and nutritional qualities [2], they are consumed fresh and for some, transformed into various by-products of which juices and nectars constitute a significant part. This transformation, in addition to making available to the populations the benefits of fruits in all seasons, constitutes a considerable local economic benefit. In Africa, the search for new forest nutritional resources is leading the agri-food industry to gradually turn to local fruits [3, 4]. We thus find, more and more on the Ivorian market, natural fruit juices and nectars, sometimes made from long-neglected wild species. *Vitex doniana*, which is an integral part of these plants, is a deciduous tree belonging to Verbenaceae family [5]. All parts of the plant are used for the various socio-economic needs of populations in the rural world [6]. Its fruit, the popular black plum [7] has medicinal properties and has an interesting food value [5]. Its dark purple, floury and sweet pulp is rich in bioactive compounds [8, 9, 10]. A semi-industrial transformation process without preservatives and including tangential microfiltration made it possible to transform the pulp into nectar. The resulting product is, however, confronted with a shelf life which remains very limited. Also, no referenced study reports the impact of temperature and storage time on its nutritional components. In order to have a notion of the qualitative variation that this black plum nectar could undergo during its storage, this study is devoted to monitoring the evolution of certain

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biochemical parameters during its storage at three (3) different temperatures for twelve (12) weeks. The choice of these temperatures made it possible to follow the variations in the quality of these nectars stored under refrigeration conditions, at room temperature in temperate and tropical climates. The choice of storage time responds to the need to be able to predict an optimal use-by date of the natural nectar of black plums.

2. Material and methods

2.1. Material

Samples of nectars, made from the pulp of ripe black plums using a semi-industrial manufacturing process without addition of preservatives and including cross-flow microfiltration [11], were inverted into sterile tubes transparent then placed at three (3) different temperatures (4 °C, 20 °C and 32 °C) for three (3) months.

2.2. Methods for analyzing the biochemical parameters of microfiltered nectar

In order to follow the evolution of this nectar quality during storage, certain biochemical parameters, in particular pH, titratable acidity, soluble dry extract and vitamin C content, likely to impact nutritional quality of this nectar were assessed weekly during storage time.

2.2.1. Assessment of the acidity of microfiltered nectar

pH determination

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

Determination of titratable acidity

The titratable acidity (in mEq.mL-1) was determined according to the colorimetric method described by the French standard NF V05-101: 1974 [12].

10 mL of 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):

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

2.2.2. Determination of the soluble dry extract (SDE)

The 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 nectar were placed on its lens and the reading of the Brix degree was made after five (5) seconds. The tests were repeated three (3) times for each sample.

2.2.3. Assessment of Vitamin C

The vitamin C concentration (in mg/100 g) was determined according to the method of Tillmanns *et al*. (1932) [13]. To 10 mL of sample, 10 mL of metaphosphoric acid was added to stabilize the vitamin C. The 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 (Ve) of a solution of 2,6-dichlorophenolindophenol (2,6-DCPIP). The calibration of the 2,6-DCPIP solution was previously done with a volume (Vs) of pure ascorbic acid. Another solution prepared from metaphosphoric acid/acetic acid was also titrated with one volume (V0) 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

3.1. Evolution of the acidity of microfiltered nectar during storage

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

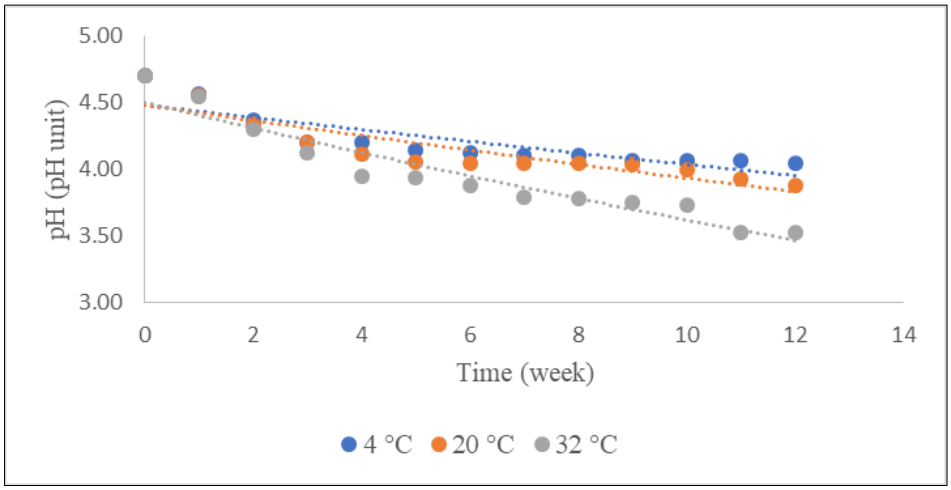

Figure 1 Evolution of the pH of microfiltered nectar during storage

Analysis of Figure 1 shows that after the first week of storage, there is a decrease in the pH value of microfiltered nectar. This value remains substantially identical whatever the storage temperature. From the second week, the reduction in pH accelerates and is all the more pronounced the higher the storage temperature. For nectar stored at 4 °C, the pH tends to stabilize at the end of the ninth week and this until the twelfth. The regression coefficients are between 0.74 and 0.91. This shows a certain correlation between the variation of the pH and the storage temperature.

Figure 2 shows an increase in titratable acidity of microfiltered nectar during storage. During the first two (2) weeks, its variation is almost identical for the three (3) temperatures.

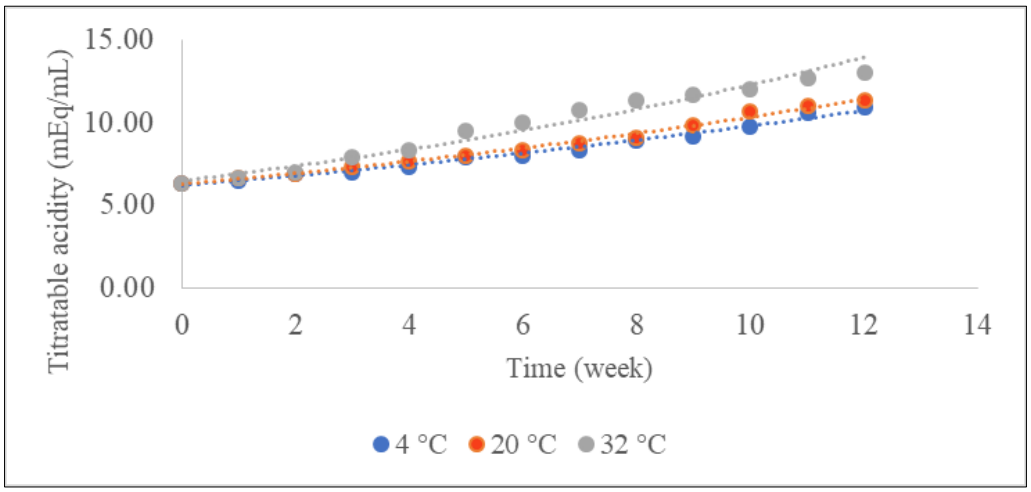

Figure 2 Evolution of titratable acidity of microfiltered nectar during storage

Beyond this period until the end of the twelve (12) weeks, the variation of the titratable acidity depends on the storage temperature of the nectar. It is all the more accentuated as this temperature is high. Thus, titratable acidity is highest at 32 °C and lowest at 4 °C. The regression coefficients are between 0.96 and 0.99.

3.2. Evolution of the soluble dry extract of microfiltered nectar during storage

As can be seen in Figure 3, the soluble dry extract of microfiltered nectar increases during storage for all temperatures.

This figure shows the evolution of the soluble dry extract of microfiltered nectar during storage at 4 °C, 20 °C and 32 °C. It is noted that from the first week of storage, this parameter records constantly increasing values until the end of the storage time. This evolution is a function of the storage temperature. The highest values are recorded for the lowest temperatures. The regression coefficients are between 0.93 and 0.97.

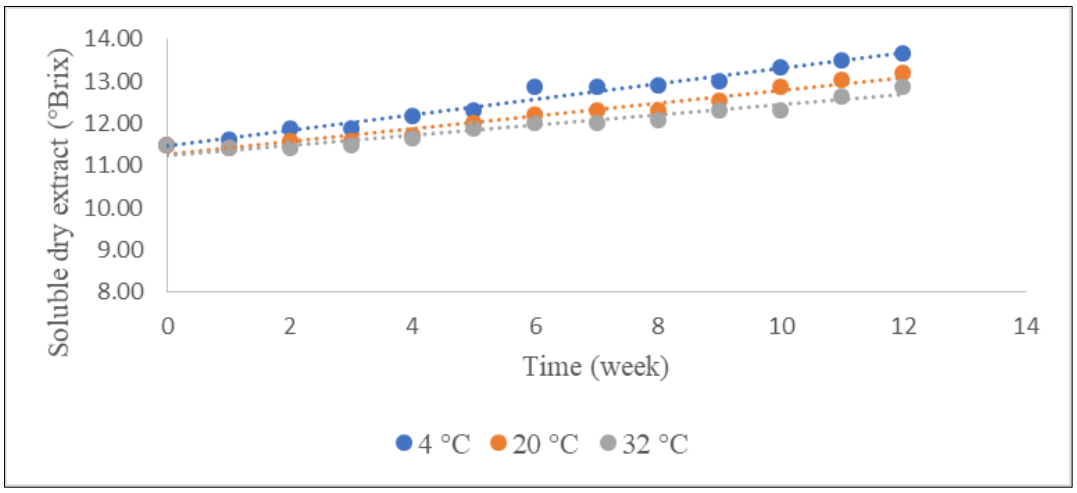

Figure 3 Evolution of the soluble dry extract of the microfiltered nectar during storage

3.3. Variation in vitamin C content of microfiltered nectar during storage

3.3.1. Evolution of the vitamin C content of microfiltered nectar

The results obtained after monitoring changes in vitamin C content are shown in Figure 4.

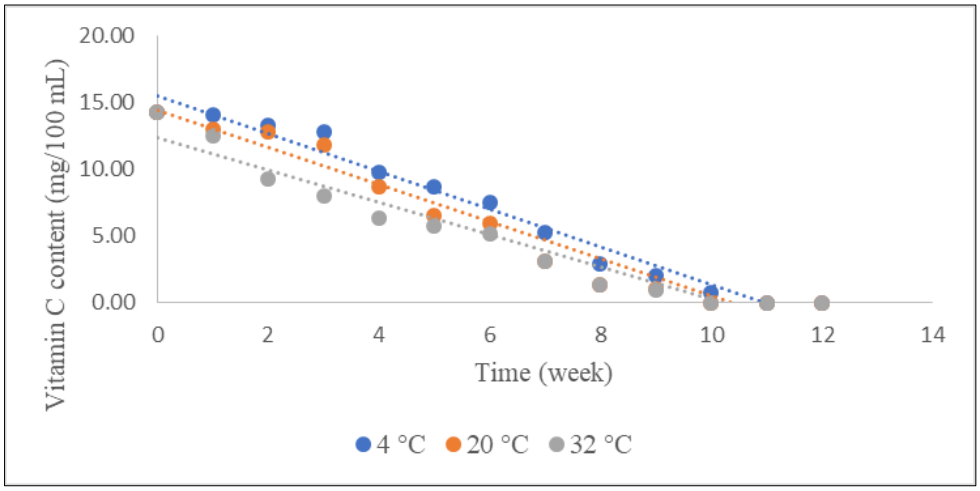

Figure 4 Evolution of vitamin C content of microfiltered nectar during storage

In Figure 4, we see that the vitamin C content of microfiltered nectar decreases continuously during storage time. However, this reduction is a function of the storage temperature. Indeed, it is all the more pronounced as the storage temperature is high. The regression coefficients are between 0.941 and 0.974.

3.3.2. Characterization of the degradation kinetics of vitamin C in nectar

In order to predict the evolution of the vitamin C content of nectar over time, the kinetics of the degradation of this vitamin as a function of the storage temperature of the nectars was produced using two (2) models that are that of Arrhenius and that of Bigelow. Figure 5 presents the resulting curves of these models for microfiltered nectar.

During the storage of microfiltered nectar, the thermal degradation of vitamin C follows first order kinetics. The regression coefficients are between 0.871 and 0.927 and the logarithm of vitamin C concentrations is proportional to the treatment time.

Figure 6 (a) and (b) represent respectively and more precisely, the effect of temperature on the rate constant of the vitamin C degradation reaction and the decimal reduction time in the case of microfiltered nectar.

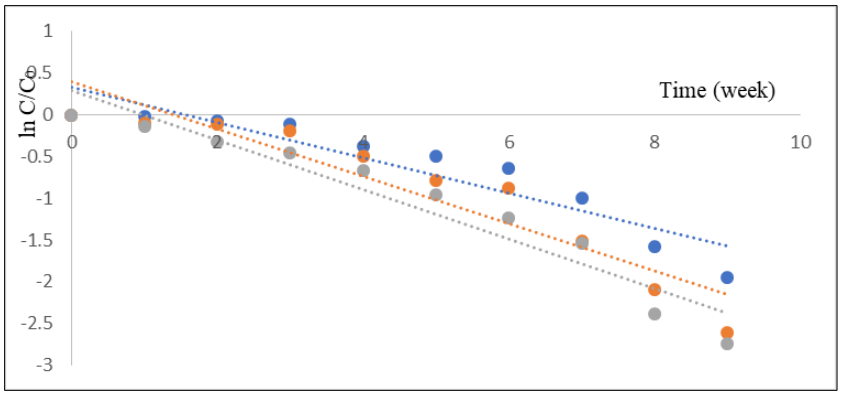

Figure 5 Kinetics of thermal degradation of vitamin C of microfiltered nectar as a function of storage time

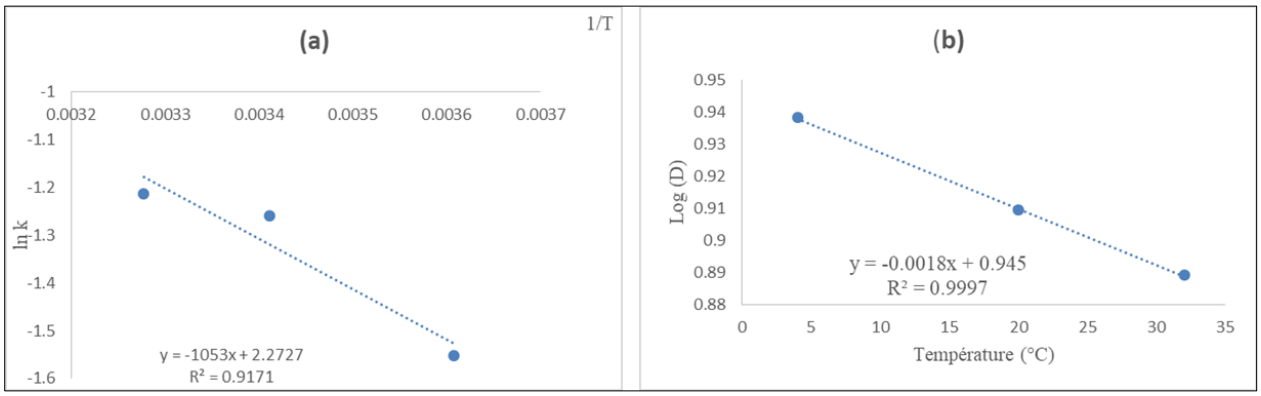

Figure 6 (a) Arrhenius diagram representing the influence of the storage temperature of the microfiltered nectar on the rate constant k – (b) Bigelow diagram of the decimal logarithm of the D value as a function of temperature

The regression coefficients of these two (2) plots show the strong correlation between storage temperature, velocity coefficient and decimal reduction time. The degradation of vitamin C in this nectar follows first-order kinetics.

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

As shown in the table below, the decimal reduction time decreases with increasing temperature. While the velocity coefficient k increases with increasing temperature. These parameters explain the losses recorded for this heat-sensitive vitamin during the storage of microfiltered nectar.

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

Temperature	Arrhenius's model			Bigelow's model		
	k (s-1)	Ea (kJ/mol)	R2	D (s)	z (°C)	R2
4 °C	0.212	28.75	0.917	3.854	34.00	0.999
20 °C	0.284			3.561		
32 °C	0.297			3.517		

4. Discussion

After the first week of storage, there is a decrease in the pH value of the microfiltered nectar. In general, pH and temperature rank high among the most important indicators of food quality and safety. In the case of this nectar, there is a decrease in pH reflecting an acidification of the medium which is a function of the storage temperature. This is in accordance with the results of [14] for seedless lime juice and [15] for natural orange juice. Thus, during storage, the higher the storage temperature, the more acidic the pH of the nectar becomes. [16] also found this reduction in pH when storing papaya, pineapple and watermelon juices at different temperatures. According to work done by [17], [18] and [19] on fruit juice, this decrease in pH could be explained by the deterioration of the characteristics of fruits juices, the biochemical reactions as well as the microbial action that occurred during the storage period.

Figure 2 shows an increase in titratable acidity of microfiltered nectar during storage. During the first two (2) weeks.

According to the results obtained, there is an increase in titratable acidity with the increase in the storage temperature of the nectar. This reflects an increase in the proportion of organic acids present in nectars [19]. These organic acids contribute to the particular flavor and palatability of the nectar and their increase is probably due to the transformation of pectin into galacturonic acid, as observed by [20] for the mixture of apple and apricot juice and [15] for orange juice.

From the above, it is observed that during the first weeks of storage, the acidity of the nectar at the three (3) temperatures is approximately identical. Beyond the fourth week, it registers an increase which is a function of the storage temperature. This state could in the long run lead to its organoleptic alteration [21, 22] because too high acidity would tend to reduce the sensation of sugars and would affect the color of the nectar [23].

The increase in the value of the Brix degree, desirable to preserve the quality of nectars [24] would be explained by the transformation (acid hydrolysis) of polysaccharides (starch, pectin and cellulose) into monosaccharides and oligosaccharides [25, 26] when the medium is acidic.

The vitamin C content of this nectar registers a gradual decrease throughout the three (3) months of follow-up depending on the storage temperature. This observation was made in Uganda by [27] for passion fruit juice (purple variety) stored at different temperatures in transparent bottles, as well as by [28] for orange juice concentrate.

The degradation of the vitamin C content of the nectar would be due to the oxygen present in the container, to the heat or to the light [23, 29]. During the storage of nectar, this destruction would be particularly due to the temperature and the duration of storage [30].

Indeed, during storage, this vitamin is subject to anaerobic degradation favored by acidity and temperature [23]. In an acidic and hot environment, ascorbic acid undergoes dehydration and decarboxylation which lead to the formation of intermediate substances such as carbon dioxide and furfural [31]. These compounds, in particular furfural, can bind to amino acids and lead to the formation of hydroxymethyl furfural, a precursor of brown pigments [32].

The destruction of this vitamin in the microfiltered nectar is characterized by an activation energy value (Ea) of 28.75 kJ/mol and that of a decimal reduction factor (z) equal to 34 °C. These results corroborate those obtained by [33] during this work on the study of the degradation of vitamin C in citrus juice

5. Conclusion

This study allowed us to establish the influence of storage time and temperature on the stability of acidity (pH and titratable acidity), soluble dry extract and vitamin C content of the microfiltered nectar produced from the pulp of ripe black plums from Côte d'Ivoire.

We can thus deduce that temperature and storage time have an effect on the biochemical stability of black plum nectars. Taking into account correlation that exists between the parameters studied, the method best suited to the conservation of these products remains refrigeration at 4 °C. However, if at this temperature the microfiltered nectar retains its nutritional value better, the shelf life remains a limiting factor in its nutritional and organoleptic stability. The optimal use-by date for nectars without the addition of preservatives does not exceed ten (10) weeks.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

We authors declare no conflict of interest whatsoever.

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