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Dilution Ratio and Pasteurization Effects on the Physico-chemical Characteristics of the Pulp of *Saba senegalensis* of Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. Author AC designed the study, wrote the protocol and managed the literature searches. Author YEK managed the analyses of the study, performed the statistical analysis and wrote the first draft of the manuscript. The other two authors participated in the correction. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The objective of this study was to evaluate the effect of dilution ratio and pasteurization on physico-chemical parameters of *Saba senegalensis* pulp in the context of its recovery.
Study Design: The experimental set-up was of a completely randomized design.
Place and Duration of Study: This study was carried out in the Department of Food Science and Technology, at the Laboratory of Food Biochemistry and Tropical Product Technology (BATPTL) of Nangui Abrogoua University, Abidjan, Côte d'Ivoire, between June and August 2019.
Methodology: The pulp collected from the fruit was diluted according to the following pulp/water ratio (RPW; v/v): 1:0.5; 1:1 and 1:1.5 and pasteurized at 75°C at different times (5 min, 10 min and 15 min). The pH, titratable acidity (TA), Total soluble solid (TSS), vitamin C, β-carotene and the colour were determined on the different samples.
Results: The results obtained during this study showed that all the physico-chemical parameters evaluated, except pH, are affected during dilution while during pasteurization only vitamin C and β-

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carotene are affected. During the respective dilutions, 50%, 62% and 66% of the vitamin C concentration decreased as well as 53%, 74% and 76% of β-carotene. It also led to a decrease in total soluble solid (TSS) of 32%, 50% and 59%. Following the pasteurization of each diluted pulp12%, 45% and 50% on average of the vitamin C are lost at the respective pasteurization time (5 min, 10 min and 15 min respectively). For β-carotene the content decreases (50%) within the first 5 minutes and remains constant during the last 10 minutes of pasteurization.

Conclusion: During *Saba senegalensis* fruit processing into nectar, dilution and pasteurization factors must be considered in order to ensure the physico-chemical quality of the beverage. The physico-chemical characteristics were more affected during dilution than in pasteurization.

Keywords: Saba senegalensis; pulp; dilution; pasteurization; physico-chemical parameters.

1. INTRODUCTION

Saba senegalensis is an indigenous climbing plant belonging to the Apocynaceae family. It is found in the wild in Côte d'Ivoire, Burkina Faso, Gambia, Guinea, Mali, Niger, Guinea-Bissau, Senegal, Tanzania and Ghana [1]. Its fruit is called zaban (in Bambara or Dioula), malombo (in the Congo Basin), maad (in Wolof), wèda (in mooré) and côcôta in Côte d'Ivoire. The fruit consists of a globular shell coating seeds with very soft and juicy yellow pulp [2]. The fruit is a source of provitamin A (β-carotene = 189.62 ± 1.33 µg/100 g) [3] and contains protein (4.83 ± 0.01 g/100 g), dietary fibre (7.97 ± 0.85 g/100 g), and minerals such as magnesium (894.9 ± 0.32 mg/100 g) and calcium (209.0 ± 0.51 mg/100 g) [4]. The nutritional value of the fruit is 379.32 kcal/100 g with 74.23% available carbohydrates [5]. According to some authors, *Saba senegalensis* contains very high antioxidant activities (17.57 mmol AEAC/100 g for pulp) [6,7]. In Côte d'Ivoire, previous studies [8,9,10] in the ethnobotanical field have shown the use of leaves, roots and fruit in health. They are used to treat certain diseases such as dysentery, diarrhea and cough [11]. There is an important trade of *Saba senegalensis* fruit in the country. The fruit is generally consumed fresh without any processing. However, these fruits could be transformed into products such as juice, nectar or jam. It could also be used in other preparations such as cakes. The transformation of this fruit into juice or nectar as part of its recovery requires the control of dilution and pasteurization for maintaining the nutritional and sensory quality, indeed several studies have shown that dilution and pasteurization affect the nutritional quality of foods [12,6]. The objective of this study was to evaluate the effect of dilution and pasteurization on the physico-chemical parameters of *Saba senegalensis* pulp.

2. MATERIALS AND METHODS

2.1 Study Material

The fruits of *Saba senegalensis* (Fig. 1) were collected at the local market in the municipality of Abobo in Abidjan (Côte d'Ivoire) and transported to the Laboratory of Food Biochemistry and Tropical Products Technology (LBATPT) for the various analyses.

Fig. 1. Fruit of *Saba senegalensis*

2.2 Method

2.2.1 Preparation of the pulp

The fruits were sorted and washed to remove dirt, dust and adhered unwanted material. The globular shell containing the seeds coated with yellow pulp was broken with a stainless-steel knife, and the pulp was separated from the grains and collected in a container.

2.2.2 Dilution and pasteurization of the pulp

The collected pulp was diluted (Fig. 2) by adding tap water in the following proportion of pulp: Water, (v / v): 1:0.5; 1:1 and 1:1.5. The diluted pulps were pasteurized using a water bath (Memmert, France) whose temperature was set up at 75°C. Samples were pasteurized at 5 min, 10 min and 15 min.

2.2.3 Physicochemical analyses

2.2.3.1 Determination of pH

The pH of the samples was determined according to the method [13]. It was measured with a digital pH meter (Hanna instruments, France).

2.2.3.2 Determination of acidity

Titratable acidity (TA) was determined using the method [14]. This measurement was performed by neutralizing the total titratable acidity with a sodium hydroxide solution (NaOH 0.1 N). The evolution of the neutralization was monitored using a phenolphthalein coloured indicator.

2.2.3.3 Total soluble solid (TSS)

Total soluble solid (TSS) was determined by measuring the refractive index using a portable refractometer (FG-113 Brix/ATC 0-32% refractometer, France).

2.2.3.4 Vitamin C content

The vitamin C content was determined according to the method described by [15]. A pulp sample (10 g) was stabilized with 10 ml of metaphosphoric acid/acetic acid solution and measured under magnetic agitation with 2-6-dichlorophenol-indophenol calibrated by the appearance of persistent champagne pink coloration, for 15 seconds.

2.2.3.5 β-carotene content

A quantity of 10 g of sample was weighed and ground in 40 ml of ethanol. The shredded material was spilled into a separating funnel to which 50 ml of hexane was added. The supernatant was sampled, and 50 ml of hexane was added again. Once again, the supernatant was removed and this time it was evaporated in the oven at 45°C for 24 hours. A quantity of 4 ml of the sample was taken and the optical density (OD) reading was taken with a spectrophotometer at 450 nm [16].

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A B C D

Fig. 2. Diluted pulps of *Saba senegalensis*

A) Control; B) Diluted at pulp/water (v/v) ratio 1:0.5; C) Diluted at pulp/water ratio (v/v) 1:1; and D) Diluted at pulp/water ratio (v/v) 1:1.5

2.2.3.6 Colour measurement

The colour evaluation was performed by a measurement in the CIE-L*a*b* space using a type colorimeter (CM-5, Konica Minolta Sensing Americas Inc., US).

2.3 Statistical Analysis of Data

The physico-chemical analyses were carried out in triplicate. The values are averages ± standard deviation. The results of the analyses were subjected to an analysis of variance (ANOVA) at a level of significance of 0.05 with XLSTAT software (Version 19.6). In case of significant differences in samples, the Tukey Test was used to determine which samples would differ from each other.

3. RESULTS AND DISCUSSION

3.1 Effect of Dilution on the Pulp of *Saba senegalensis*

3.1.1 Evolution of the pH and the acidity

The evolution of pH and titratable acidity during dilution has been presented in Fig. 3a and 3b respectively. The results showed that the acidity of the pulp gradually decreases with increasing dilution while the pH remained constant (2.85±0.21). Titratable acidity decreased from 2.20 ± 0.20% (control) to 1.08 ± 0.02% (dilution 1:1.5).

The pH stability despite dilutions can be attributed to the buffer effect of the solution, obtained by the presence in the pulp of weak organic acids, partially salified by strong bases. The buffer effect of the solution is caused by the absorption or release of the hydrogen ion (H^+) by the weak organic acids present in the solution. According to [17], some of the weak acids in the juice are salified by the mineral elements absorbed by the plant. It therefore seems logical to assimilate *Saba senegalensis* pulp with buffer solutions, whose pH is independent of acid richness and depends only on the ratio of acid concentration to salt concentration. The results obtained in this study corroborate those of [18]. Four beverages used in their study demonstrated a high degree of resistance to pH increase, indicating a high intrinsic buffering capacity. The pH varied very little with the increasing of the dilution rate compared to the citric acid and hydrochloric acid controls. On the other hand, the titratable acidity of each of the beverages decreased in proportion to the increase in dilution, which reduced the acidity of the beverage. As for the variation in titratable acidity, it could be explained by the level of dilution used. Indeed, as the level of dilution increased, the amount of pulp decreased, as did the titratable acidity. The decrease in titratable acidity was also obtained during the dilution of Mangrove apple juice (*Sonneratia caseolaris*) [19].

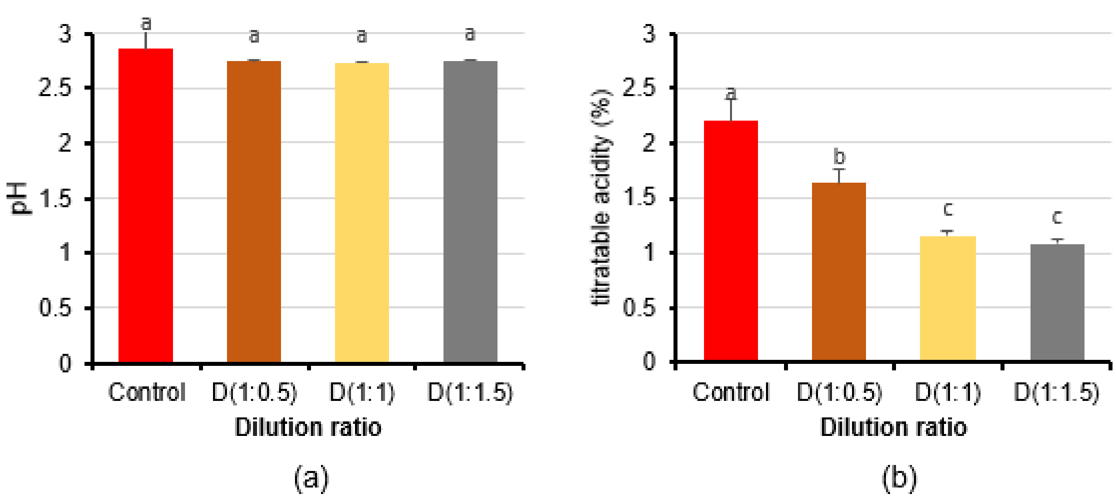

Fig. 3. pH and titratable acidity of *Saba senegalensis* pulp during dilution
Histograms with different alphabetic letters are significantly different at the 5% level according to the Tukey test of variance analysis. Mean ± standard deviation, n = 3

3.1.2 Evolution of total soluble solid (TSS), vitamin C, β-carotene and colour parameters

The evaluation of total soluble solid (TSS), vitamin C, β-carotene and the colouring parameters during dilution are presented in Table 1. For these physico-chemical characteristics studied, quality decreases with increasing of dilution. Total soluble solid (TSS) decreased significantly ($P < .001$) and reached 7.73 ± 0.20 at dilution 1:1.5. The vitamin C and the β-carotene concentrations decreased with increasing of dilution ($P < .001$). Regarding colour, the intensity of the parameters a*, b* began to decrease from the dilution 1:0.5. As for the parameter L*, it started to decrease at the dilution 1:1.5.

The large variation in total soluble solid (TSS), vitamin C, β-carotene and colouring parameters is apparently related to the level of dilution used. Indeed, as the level of dilution increased, the quantity of pulp decreased, total soluble solid (TSS), vitamin C, β-carotene and colour decreased. These results corroborate those of [20] who evaluated the effect of dilution on the physico-chemical characteristics of jamun wine. In addition, β-carotene is responsible for the specific colour of juices [12]. The decrease in β-carotene content during dilution resulted in a colour change.

3.2 Effect of Pasteurization

3.2.1 Evolution of pH and titratable acidity

Fig. 4 shows the evolution of the pH of the different diluted pulp during pasteurization. Variance analyses revealed that the pH (P=.66) of each diluted pulp did not change during pasteurization. The titratable acidity (TA) of the diluted pulp was presented in Fig. 5. For each diluted pulp the acidity value remained constant ($TA_{1:0.5}$=2.20%; $TA_{1:1}$ = 1.61%; $TA_{1:1.5}$= 1.08%).

The variation in pasteurization time had no influence on these physico-chemical characteristics. These results are identical to those of [6] who observed during the pasteurization of *Saba senegalensis* nectar a consistency in pH and acidity.

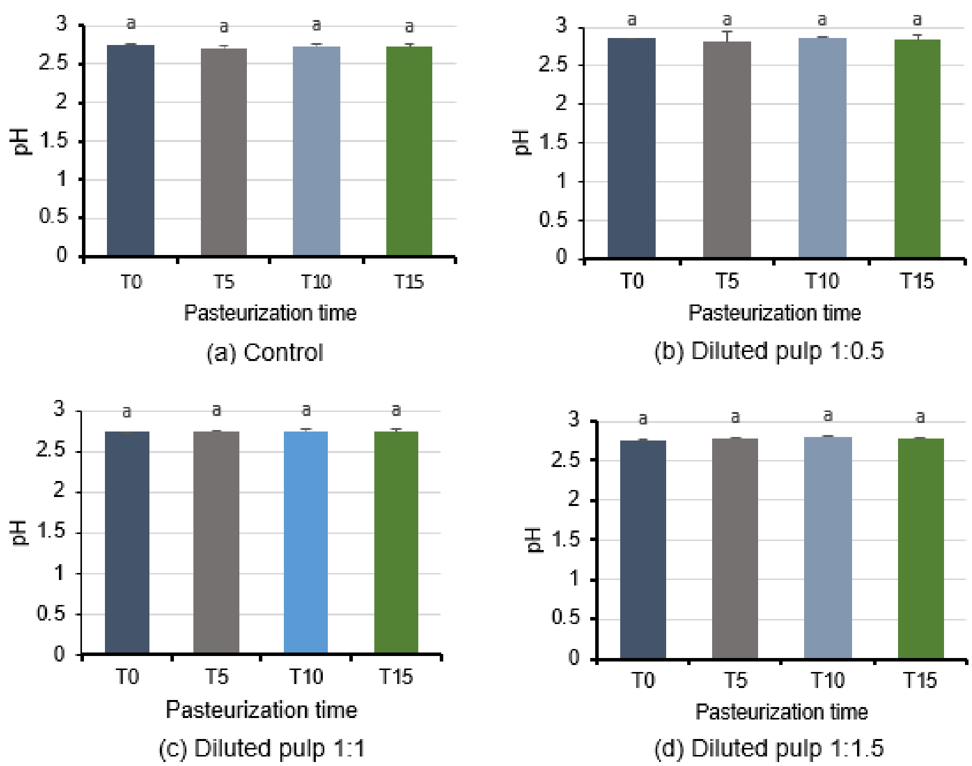

Fig. 4. pH of *Saba senegalensis* pulp during pasteurization

Histograms with different alphabetic letters are significantly different at the 5% level according to the Tukey test of variance analysis. Mean ± standard deviation, n = 3

Table 1. Evolution of total soluble solid (TSS), vitamin C, β-carotene and colour parameters of *Saba senegalensis* pulp during dilution

Parameter	Dilution ratios				*Pr > F*
	control	**1:0.5**	**1:1**	**1:1.5**	
TSS (°Brix)	19.60±0.10^{a}	13.96 ±0.83^{b}	9.80±0.10^{c}	7.73±0.20^{d}	< .001
Vita C (mg/100 g)	24.00±0.10^{a}	12.00 ±0.98^{b}	9.20±0.36^{c}	8.30±0.30^{cd}	< .001
β-carotene (µg/100 mg)	178.85±1.67^{a}	85.10±0.02^{b}	45.23±0.90^{c}	42.60±1.01^{cd}	< .001
L*	40.70±0.83^{a}	40.40±0.05^{a}	40.00±1.22^{a}	38.16±0.15^{b}	< .001
a*	-1.40±0.17^{a}	-3.20±0.36^{b}	-4.26±0.77^{bc}	-4.73±0.23^{c}	< .001
b*	24.80±3.14^{a}	20.13±0.20^{ab}	17.63±4.04^{b}	16.66±0.05^{b}	< .001

TSS: Total soluble solid; Vita C: vitamin C; L: representing clarity, a*: representing the red axis, b*: representing the yellow axis. Mean ± standard deviation, n = 3. The values of the same line assigned different alphabetic letters are significantly different at the 5% level according to the Tukey test of variance analysis*

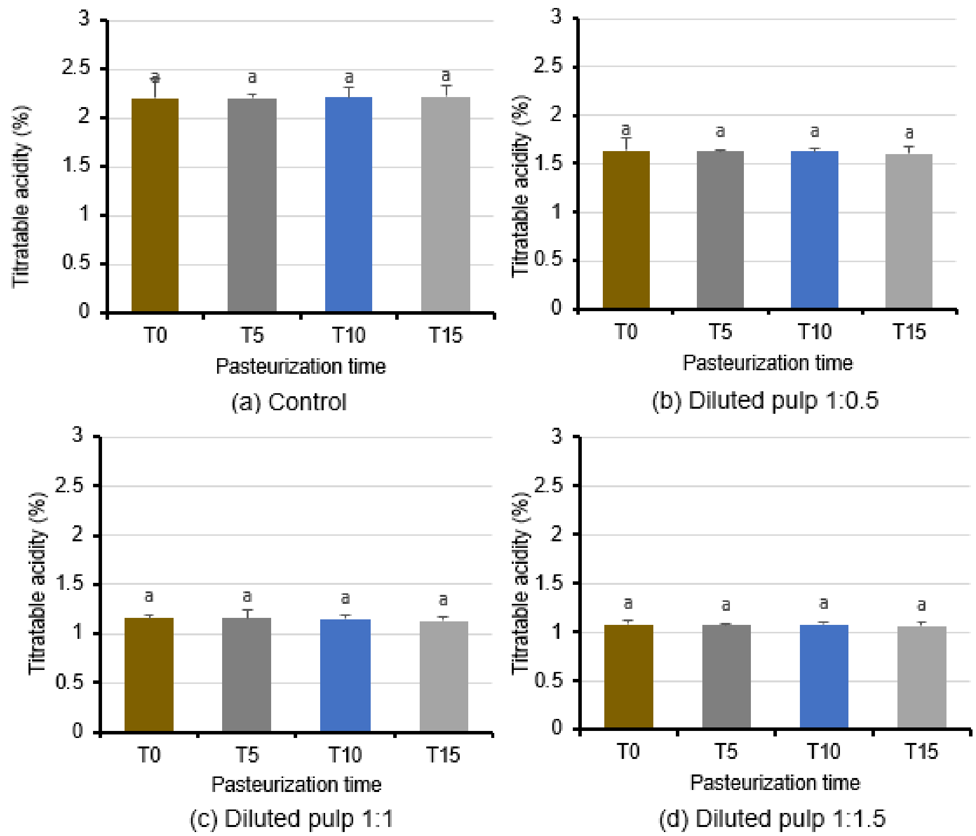

Fig. 5. Titratable acidity of *Saba senegalensis* pulp during pasteurization

Histograms with different alphabetic letters are significantly different at the 5% level according to the Tukey test of variance analysis. Mean ± standard deviation, n = 3

3.2.2 Evolution of total soluble solid (TSS), vitamin C, β-carotene and colour parameters (L*, a*, b*)

The evaluation of total soluble solid (TSS), vitamin C, β-carotene and colour parameters during pasteurization are presented in Tables 2 and 3 respectively. There is no significant difference between total soluble solid (TSS) values and the colour parameters (L*, a*, b*) during pasteurization for each diluted pulp. In contrast to these values, the analysis of variance revealed a significant difference (P < .001) in vitamin C and β-carotene levels. The vitamin C content decreased in proportion to the increase in pasteurization time. As for the β-carotene content, it decreased during the first five minutes of pasteurization and remains constant during the other ten minutes.

Table 2. Evolution of total soluble solid (TSS), vitamin C, β-carotene during pasteurization

Parameter	Pasteurization (75°C)					Pr > F
	Dilution ratios	T 0 min	T 5 min	T 10 min	T 15 min	
TSS (°Brix)	Control	19.6±0.1^{a}	19.43±0.83^{a}	19.6±0.1^{a}	19.53±0.20^{a}	.51
	1:0.5	13.96±0.83^{a}	13.13±0.11^{a}	13.13±0.25^{a}	13.13±0.05^{a}	.29
	1:1	9.80±0.1^{a}	9.80±0.1^{a}	9.93±0.051^{a}	9.83±0.01^{a}	.32
	1:1.5	7.73±0.20^{a}	7.68±0.05^{a}	7.67±0.05^{a}	7.71±0.057^{a}	.21
Vita C (mg/100 g)	Control	24.36±0.10^{a}	21.74±0.28^{a}	13.88±0.10^{b}	10.52±0.26^{b}	< .001
	1:0.5	12.00±0.98^{a}	10.30±0.80^{b}	8.73±0.26^{c}	5.87 ±1.66^{d}	< .001
	1:1	9.27±0.36^{a}	7.72±0.42^{b}	6.97±0.80^{c}	4.86±0.66^{c}	< .001
	1:1.5	8.33 ± 0.30^{a}	6.53±0.22^{b}	5.62±0.10^{c}	4.51±0.30^{c}	< .001
β-carotene (µg/100 mg)	Control	178.85±1.67^{a}	118.81±0.40^{b}	109.40±0.12^{b}	106.83±0.56^{b}	< .001
	1:0.5	85.10±0.02^{a}	35.03±0.22^{b}	34.63±0.15^{b}	34.99±0.09^{b}	< .001
	1:1	45.23±0.90^{a}	26.51±0.11^{b}	26.11±0.20^{b}	26.19±0.11^{b}	< .001
	1:1.5	42.60±0.42^{a}	10.43±0.11^{b}	10.11±0.11^{b}	10.11±0.11^{b}	< .001

TSS: Total soluble solid; Vita C: Vitamin C. Mean ± standard deviation, n = 3. The values of the same line assigned different alphabetic letters are significantly different at the 5% level according to the Tukey test of variance analysis

Table 3. Evolution of colour during pasteurization

Colour parameter	Pasteurization (75°C)					Pr > F
	Dilution ratios	T 0 min	T 5 min	T 10 min	T 15 min	
L*	Control	40.70±0.83^{a}	40.36±1.27^{a}	39.63±1.56^{a}	40.33±0.55^{a}	.31
	1:0.5	40.40±0.05^{a}	39.60±0.34^{a}	39.60±0.50^{a}	39.50±0.00^{a}	.18
	1:1	40.00±1.22^{a}	39.20±0.69^{a}	39.16±0.77^{a}	39.06±0.45^{a}	.12
	1:1.5	38.16±0.15^{a}	38.10±0.30^{a}	38.10±0.11^{a}	38.00±0.20^{a}	.42
a*	Control	-1.40±0.17^{a}	-1.76±0.25^{a}	-2.13±0.63^{a}	-2.20±0.10^{a}	.09
	1:0.5	-3.20±0.36^{a}	-3.26 ±0.15^{a}	-3.36±0.15^{a}	-3.23±0.25^{a}	.89
	1:1	-4.26±0.77^{a}	-3.93±0.11^{a}	-3.93±0.15^{a}	-3.86±0.25^{a}	.54
	1:1.5	-4.73±0.23^{a}	-4.76±0.05^{a}	-5.06±0.05^{a}	-4.80±0.30^{a}	.76
b*	Control	24.80±3.14^{a}	25.26±4.10^{a}	21.70±3.38^{a}	20.60±0.36^{a}	.17
	1:0.5	20.13±0.20^{a}	20.73±0.05^{a}	20.53±0.37^{a}	20.50±0.26^{a}	.50
	1:1	17.63±4.04^{a}	19.33±0.70^{a}	19.30±0.60^{a}	18.50±0.36^{a}	.21
	1:1.5	16.66±0.05^{a}	16.60±0.10^{a}	16.61±0.30^{a}	16.53±0.58^{a}	.74

L: representing clarity, a*: representing the red axis, b*: representing the yellow axis. Mean ± standard deviation, n = 3. The values of the same line assigned different alphabetic letters are significantly different at the 5% level according to the Tukey test of variance analysis*

The decrease in vitamin C may be explained by the high sensitivity of this vitamin to heat. According to [6], temperature and processing time are the main parameters that influence the degradation of this compound. The results obtained by [21] indicate that the vitamin C content of orange juice decreases at temperatures between 60°C and 85°C. Similarly, for [22], where the vitamin C content of the pomegranate treated for 15 to 90 minutes at 70°C decreased from 0.168 to 0.138 mg/100 ml. In addition, the content of β-carotene during pasteurization is less affected than that of vitamin C in *Saba senegalensis* pulp. According to [23], β- carotene is more resistant to heat treatment than vitamin C. Its degradation requires in addition to heat treatment other factors such as oxygen and light. The most labile vitamins during cooking are retinol and vitamin C [24].

4. CONCLUSION

The results of this study reveal that dilution affected most of the physico-chemical characteristics while pasteurization affected only the vitamin c content and β-carotene. Thus, dilution and pasteurization factors must be considered in order to ensure the physico-chemical quality of the beverage. The vitamin C content decreased in proportion to the increase in pasteurization time. As for the β-carotene content, it decreased during the first five minutes of pasteurization and remains constant during the other ten minutes. It is therefore recommended not to dilute the pulp too much during the preparation of the nectar.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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