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Effect of Different Fruit Blends on the Acidity of *Saba senegalensis* Pulp

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Abstract The acidity of *Saba senegalensis* pulp constitutes a major problem in its valorization. The aim of this study was to develop a mixture of fruit pulp to reduce its acidity. Therefore, dessert banana, papaya and pineapple fruits have been used as deacidifying agents in mixtures with *Saba senegalensis* pulp. These fruits were mixed in proportions ranging from 5% to 50%. The mixtures performing at pH 3 were used to study their organic acid, sugar content and sensory quality. The results showed that the efficient proportions to bring the *Saba senegalensis* pulp out of the highly erosive zone (pH < 3) were obtained at 25% of dessert banana. At this mixing ratio, the titratable aciity of *Saba senegalensis* pulp decreased from 30.9 ± 0.46 to 17.8 ± 0.34 with a reduction of 53%, 25% and 24% of the respective concentrations of citric acid, tartaric acid and malic acid and an increase of 50% of sugars. With regard to sensory quality, the addition of dessert banana to the blend contributed, as with pineapple and papaya, to increasing the acceptability of *Saba senegalensis* pulp. The reduction of the acidity of the pulp of *Saba senegalensis* with the addition of other fruit pulps is an advantage for the valorization of this fruit.

Keywords: *Saba senegalensis, deacidification, fruit pulp mixture, sensory quality*

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1. Introduction

Saba senegalensis is an indigenous plant belonging to the Apocynaceae family. It is also 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 *côcôta* in Côte d'Ivoire, *zaban* (in Bambara or Dioula), *malombo* (in the Congo Basin), *maad* (in Wolof) and *wèda* (in mooré) [2]. The fruit of *Saba senegalensis* consists of a globular shell enclosing seeds of very soft and juicy yellow pulp [3]. Locally, it is consumed directly with sugar, processed into juice or nectar and also used as a lemon substitute to add to cereal porridge [4]. It is used in certain diseases treatment such as dysentery diarrhea and cough [4]. Furthermore, it is a real source of provitamin A and vitamin C and has a very high antioxidant activity [5,6]. It contains protein, dietary fibres and minerals such as magnesium and calcium [5,6].

Consumption as food remains a possible way to benefit from its nutritional and medicinal potential. However, the fruit of *Saba senegalensis* is characterized by its high acidity with a pH between 2.42 and 2.85 [7,8,9]. At such pH value (pH < 3), fruit would be considered a highly erosive food that can cause dental erosion [10,11,12]. This dental erosion weakens the teeth and exposes it to abrasion and dental caries [12]. In addition, highly acidic foods tend to be rejected by consumers in terms of taste [13]. That could be a barrier to the valorization of *Saba senegalensis* pulp.

To reduce the acidity of beverages, consumers mostly resort to dilution [12]. However, this technique has proven to be inefficient on *Saba senegalensis* pulp as it behaves as a buffer solution. During dilution, the pH of *Saba senegalensis* pulp varies little [9]. Thus, the *Saba senegalensis* pulp acidity reduction by this technique will require the addition of a very large quantity of water which will lead to an important decrease in the nutritional quality of the pulp. Other techniques for deacidification of industrial food beverages such as salt precipitation, use of chitosan, ion exchange resins and electrodialysis exist [14,15,16]. But, in developing countries where the rate of installation of fruit processing plants is low, these techniques would be unsuitable in terms of cost for the actors. Salt precipitation has the advantage for being cheaper and easier to achieve. On the other hand, its usage poses a legislative problem because their addition to juices is not always allowed and consumers prefer natural products without chemical additives [14].

In addition to these acid reduction techniques, fruit mixture would be an alternative to the problems of chemical inputs, cost and quality. The use of fruit to reduce the acidity of juices would have a double advantage, namely technological and nutritional. This technology would make it possible to produce food products with decreased acidity without using chemical additives. In addition, the fruits used in this process would provide additional nutritional value through their initial nutritional composition.

The objective of this study is to contribute to the valorization of the fruit *Saba senegalensis* by reducing its acidity.

2. Materials and Methods

2.1. Study Material

The plant material consisted of *Saba senegalensis* fruits, dessert banana (*Musa triploid AAA*, Cavendish, cv Grande Naine), papaya (*Carica papaya* L.) and pineapple (*Ananas comosus*). The fruits of *Saba senegalensis* were collected at an advanced stage of maturity (yellow) in the area of Korhogo in the north of Côte d'Ivoire and those of the MD2 pineapple variety at the mature stage (green) come from Bonoua, a town located in the south of the country. The dessert banana of the cultivar Grande Naine and the mature (green) solo papaya were harvested in the Azaguié area, also in the southern part of the country. The collected fruits were transported to the Laboratory of Food Biochemistry and Technology of Tropical Products (LBATPT) of the University of Nangui Abrogoua in Abidjan. Commercial ripening of dessert banana, papaya and pineapple was observed by following the colouring of the pericarp. These three fruits reached the green turning yellow, yellowish-green and yellow stage respectively, taking into account the ripeness stages described by the [17].

2.2. Methods

2.2.1. Preparation of Fruit Pulps

The selected *Saba senegalensis* fruits were washed to remove dirt and most of the surface microorganisms. The globular shell containing the seeds coated with yellow pulp was broken with a stainless-steel knife. The pulp was separated from the seeds and collected in a container by mixing it by hand on a stainless-steel sieve of 2 mm mesh. The pulps obtained after peeling dessert banana, papaya and pineapple were mixed using a blender. The samples for the laboratory analyses were constituted by all the extracts obtained.

2.2.2. Preparation of the Blends

For each type of pulp mixture, 100 g formulations were prepared by varying the mass of fruit pulps used for acid reduction of *Saba senegalensis* pulp from 5% to 50%. Due to different water content of fruits, the formulations were made in proportion to the mass. Thus, for a proportion of 5%, 5 g of pulp (banana, pineapple or papaya) were added to 95 g of *Saba senegalensis* pulp. The mixtures were then homogenised using a magnetic stirrer for 2 min. Using dessert banana, papaya and pineapple, the mixtures were coded SBS, SPS and SAS, respectively.

2.2.3. Physicochemical analysis

Hydrogen potential (pH)

The pH was determined using a Hanna type pH meter (HI991001, Romania) [18]. Calibration of the apparatus was ensured by using two buffer solutions at pH 7.0 and 4.0 and this is done systematically before the pH measurements.

Titratable acidity (TA)

Titratable acidity was determined by the [18] method. This measurement was carried out by neutralizing the total titratable acidity with a sodium hydroxide solution (NaOH 0.1 N). The evolution of neutralization was followed by an indicator of phenolphthalein color.

Total soluble solid (TSS)

The Total soluble solid (TSS) was determined according to the method [19] using an ATRW2 plus refractometer (2009/230, Germany).

Organic acid determinations

The determination of organic acids in each sample was carried out according to the method of [20], using a high-performance liquid chromatograph (Shimadzu Corporation, Japan) consisting of a pump (Shimadzu LC-20A Liquid Chromatograph) and a UV detector (Shimadzu SPD-20A UV Spectrophotometric detector). All separations were performed in isocratic mode. Chromatographic separation of organic acids was performed with an ICSep ICE ORH-801 ion exclusion column (40 cm x 5 µm, Interchom, France) maintained at 35 °C using a Meta ThermTM oven (Interchrom, France). The eluent was sulphuric acid (0.004 N). The elution rate was 0.6 ml/min. The detector was selected at 210 nm. A 20 µl aliquot of the previously obtained filtrate was injected. Peak identification on the HPLC chromatogram was done by comparison with those obtained with the standards and based on the retention time of the analyzed molecules. The peak areas were automatically calculated from reference solutions of known content. The concentrations were expressed in mg/100g.

Determination of soluble sugars

To five (5) g of pulp, 50 ml of distilled water is added. After five (5) minutes of homogenization with a magnetic stirrer and 20 minutes of centrifugation at 4000 G (GMA laboratory centrifuge, D-37520, Germany), 50 ml of the supernatant was removed with a pipette, poured into a 200 ml volumetric flask and made up to the mark. Reducing sugars were determined according to the method of [21] in the presence of DNS (dinitrosalicylic acid). The color intensity was measured at 540 nm. The measurement of total sugars was carried out according to the method described by [22]. In the presence of phenol and sulphuric acid, the solution took on a yellow-orange color, the intensity of which is proportional to the carbohydrate concentration. The intensity of this coloration was measured at 490 nm. A UV spectrophotometer (AQUALYTIC AL800, Germany) was used throughout the two previous investigations. The amounts of total reducing agents and soluble sugars were expressed in grams per 100 g fresh weight. Glucose was used as a reference at 200 µg/ml.

2.2.4. Study of the Organoleptic Quality of Juices from Blends

The hedonic scoring test was used as prescribed by standard [23], to assess the impact of fruit pulp mixtures on the acceptability of *Saba senegalensis* pulp. A selection of sensory evaluators was first made to determine their personal aspects such as their potential reliability as panel judges (which also depended on their aptitude for food) and their availability [24]. Potential panelists were interviewed to determine if they had any food allergies or sensitivities. Sixty (60) untrained raters were selected to serve on the panel. Panelists were asked to rate the pulp samples on the sensory attributes of color, taste, acidity and odor. A linear scale ranging from 1 (I don't like) to 5 (I extremely like) was used to evaluate the degree of appreciation of the organoleptic characteristics. The order of presentation of the samples was completely random for each panelist. Mineral water and bread were available as neutralizers between samples to avoid carryover effects. The tests were conducted in a ventilated room free of odors and other disturbances that could alter the panel's perception.

2.2.5. Statistical Analysis

The data generated by the present study were statistically processed using the XLSTAT 11.19 statistical software. Analysis of variance (ANOVA) was used to process the data from the evaluation of the biochemical and sensory parameters. Whenever a significant difference ($P < 0.05$) was revealed, the ANOVA test was completed by Tukey's post ANOVA test in order to identify where the variables showed significant differences. Next, the determination of the Pearson correlation coefficient was done between the pH and the other biochemical parameters.

3. Results

3.1. Physicochemical Characteristics of Fruit Pulps

Table 1 presents the physicochemical characteristics of *Saba senegalensis*, dessert banana, papaya and pineapple pulps. The biochemical characteristics measured were pH, titratable acidity, soluble dry extract, total sugars and reducing sugars. The results obtained from the statistical treatment reveal the existence of a significant difference ($P < 0.05$) on all the parameters studied. The pulp of *Saba senegalensis* is characterized by its high acidity and low content of sugars. Its pH is 2.85 ± 0.08 and its total sugar concentration is 6.50 ± 0.39 g/100g. In contrast to *Saba senegalensis*, banana pulp recorded the highest concentrations of total and reducing sugars and had a pH of 4.67 ± 0.02. Papaya has a significantly higher pH ($P > 0.05$) than dessert banana, but with a lower concentration of total and reducing sugars ($P < 0.05$). This concentration of total and reducing sugars is however higher than those of *Saba senegalensis* pulp. As for pineapple, its sugar concentration is close ($P > 0.05$) to papaya, but its acidity is higher ($P > 0.05$) than those of banana and papaya. Of all the fruits, the total soluble solid (TSS) of *Saba senegalensis* pulp and sweet banana are the highest ($P < 0.05$).

3.2. Organic Acid Content of Fruit Pulps

Table 2 shows the organic acid content of the different fruit samples studied. 10 organic acids were characterized in the different pulps. In order of magnitude of concentration (mg/100g), these are citric acid, oxalic acid, malic acid, tartaric acid, lactic acid, ascorbic acid, propionic acid, succinic acid, fumaric acid and acetic acid. Propionic acid and succinic acid were found in trace amounts, while fumaric acid and acetic acid were not detectable. The results obtained from the statistical treatment revealed the existence of a significant difference ($P < 0.05$) in the organic acid composition of the different fruits. The pulp of *Saba senegalensis* is characterized by a high concentration of citric acid, malic acid, tartaric acid and ascorbic acid. The dessert banana is characterized by a high concentration of oxalic acid. Malic acid, tartaric acid and citric acid, oxalic acid are the predominant acids in papaya. In pineapple, citric acid, malic acid and oxalic acid were the predominant acids.

Table 1. Physicochemical characteristics of the different fruits in the study

Physicochemical parameters	Pulps			
	Saba senegalensis	Banana	Papaya	Pineapple
pH	2.85±0.08^{d}	4.67±0.02^{b}	4.75±0.10^{a}	3.63±0.03^{c}
TA (mEq/100g)	30.9±0.46^{a}	2.84±0.27^{b}	1.33±0.03^{b}	4.03±0.38^{b}
TSS (°Brix)	15.0±0.10^{a}	14.5±0.03^{a}	12.4±0.03^{b}	12.1±0.01^{b}
TS (g/100g)	6.50±0.39^{c}	15.8±0.7^{a}	8.67±0.66^{b}	10.6±0.03^{b}
RS (g/100g)	2.64±0.23^{c}	5.38±0.20^{a}	4.10±0.13^{b}	4.10±0.13^{b}

Values in the same row with the same letter are not significantly different from each other according to the Tukey multiple comparison test at the 5% level. Values are expressed as mean ± standard deviation (n = 3 trials). TS = total sugars, RS = reducing sugar.

Table 2. Organic acid concentration (mg/100 g) of different fruit pulps

Organic acids	Pulps			
	Saba senegalensis	Banana	Papaya	Pineapple
Malic acid	294 ± 8.53^{b}	71.0 ± 0.63^{c}	321 ± 6.31^{a}	302 ± 1.25^{b}
Tartaric acid	159 ± 4.35^{b}	12.3 ± 0.25^{d}	187 ± 4.48^{a}	99.3 ± 0.51^{c}
Oxalic acid	104 ± 4.84^{c}	588 ± 5.83^{a}	365 ± 3.62^{b}	150 ± 4.84^{c}
Citric acid	688 ± 11.4^{a}	361 ± 12.1^{b}	102 ± 1.30^{c}	671 ± 11.8^{a}
Lactic acid	6.70 ± 0.85^{b}	46.7 ± 5.09^{a}	11.3 ± 1.07^{b}	11.4 ± 2.00^{b}
Ascorbic acid	16.8 ± 0.63^{a}	0.33 ± 0.64^{c}	16.7 ± 0.5^{a}	2.74 ± 0.06^{b}

Values in the same row with the same letter are not significantly different from each other according to the Tukey multiple comparison test at the 5% level. Values are expressed as mean ± standard deviation (n = 3 trials). nd: not detected.

3.3. Evolution of pH during Mixing

The evolution of the pH of the mixtures was represented in Figure 1. The results obtained indicated a significant ($P < 0.05$) increase in pH in a linear fashion with the different proportions of mixtures. Banana had more impact on acidity reduction followed by papaya and pineapple. Up to 50% banana in the mixture, the pH of the *Saba senegalensis* pulp reached 3.25. With the 50% papaya and pineapple, the pH of the *Saba senegalensis* pulp reached 3.11 and 3.05 respectively. The effective proportions for bringing *Saba senegalensis* pulp out of the highly erosive zone (pH < 3) were obtained from 25%, 40% and 45% for sweet banana, papaya and pineapple respectively. These different mixing proportions were retained for the rest of the study.

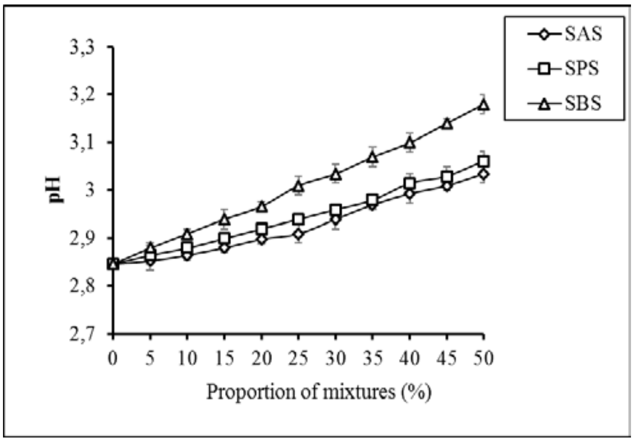

Figure 1. Evolution of the pH of fruit pulp mixtures as a function of the proportions of pulp blended. SAS= fresh *Saba senegalensis* pulp mixed with fresh pineapple pulp; SPS= fresh *Saba senegalensis* pulp mixed with fresh papaya pulp; SBS= fresh *Saba senegalensis* pulp mixed with fresh banana pulp.

3.4. Physicochemical Characteristics of Fruit Pulp Mixtures

The physicochemical properties of blended fruits pulp were represented in Table 4. The addition of dessert banana, papaya and pineapple at proportions of 25%, 40% and 45% respectively in the blends had a significant effect ($P < 0.05$) on all physicochemical parameters studied. The titratable acidity decreased significantly ($P < 0.05$) while the concentrations of total and reducing sugars increased ($P < 0.05$) with the addition of the different fruits pulp. The total soluble solid (TSS) decreased with the addition of papaya and pineapple pulps while it remained constant ($P > 0.05$) with that of banana.

3.5. Organic Acid Concentrations of Fruit Pulp Mixtures

The organic acid concentration of blended fruit pulp was presented in Table 5. The presence of banana, papaya and pineapple had a significant effect ($P < 0.05$) on organic acid concentration. Malic, tartaric, citric and ascorbic acid concentrations decreased significantly in all formulations. Citric acid was reduced by 53%, 39% and 42% with the addition of banana, pineapple and papaya respectively. Tartaric acid was reduced by 25%, 50% and 44% and malic acid by 24%, 30% and 40% with the addition of banana, pineapple and papaya respectively. The reduction of ascorbic acid was more pronounced with pineapple. In contrast to these different reductions, the intake of the fruits contributed to a significant increase in the concentration of lactic acid. The oxalic acid content increased with banana adding while it decreased with papaya and pineapple.

3.6. Correlation between the Evolution of pH and the Biochemical Composition of the Pulp Blends

Table 6 presents the Pearson correlation matrix between the evolution of pH and biochemical components in the mixtures. The matrix revealed that the increase of pH was negatively correlated with titratable acidity ($r = -0.98$; $p < 0.001$), citric acid concentration ($r = -0.99$; $p < 0.001$), tartaric acid ($r = -0.93$; $p < 0.001$), malic acid ($r = -0.95$; $p < 0.001$) and ascorbic acid ($r = -0.86$; $p < 0.001$). In contrast to these, reducing sugars ($r = 0.92$; $p < 0.001$) have a very strong positive correlation with the evolution of pH.

3.7. Evaluation of the Organoleptic Quality of the Mixtures

Table 3 presents the acceptability of consumers on certain organoleptic criteria of the blends produced from *Saba senegalensis*. The descriptors evaluated were color, acidity, taste, odor and general appreciation of the different Pulps presented. The descriptors were rated on a scale from 1 to 5, so for a rating below 3 the juice was considered unappreciable. In the case of this study, all the scores attributed to the Pulp descriptors were higher than 3 except for acidity. The acidity of the blends was more appreciated by the panelists while that of the control Pulp was rejected. In terms of other organoleptic parameters such as color, taste, odor and general appreciation, the pineapple blend was the most appreciated.

Table 3. Level of acceptability of *Saba senegalensis* pulp and fruit mixtures

Pulps	Acidity	Color	Taste	Odor
SS	$2,21 \pm 0,92^{b}$	$3,90 \pm 0,81^{ab}$	$3,58 \pm 0,59^{b}$	$3,42 \pm 0,88^{ab}$
SAS	$3,98 \pm 0,62^{a}$	$4,60 \pm 0,64^{a}$	$4,11 \pm 0,88^{a}$	$4,22 \pm 0,57^{a}$
SPS	$3,80 \pm 0,70^{a}$	$4,23 \pm 0,87^{ab}$	$3,99 \pm 1,01^{ab}$	$3,08 \pm 0,64^{b}$
SBS	$3,52 \pm 0,43^{a}$	$3,89 \pm 0,91^{ab}$	$3,59 \pm 0,62^{b}$	$3,71 \pm 0,69^{ab}$

Values in the same row with the same letter are not significantly different from each other according to the Tukey multiple comparison test at the 5% level. Values are expressed as mean ± standard deviation (n = 2 determinations). SS = fresh *Saba senegalensis* pulp; SAS= fresh *Saba senegalensis* pulp mixed with fresh pineapple pulp; SPS= fresh *Saba senegalensis* pulp mixed with fresh papaya pulp; SBS= fresh *Saba senegalensis* pulp mixed with fresh banana pulp.

Table 4. Physicochemical characteristics of fruit pulp mixtures

Physicochemical parameters	Control	Pulp mixtures		
	SS	SBS	SPS	SAS
TA (mEq/100g)	30.9 ± 0.46[a]	17.8 ± 0.34[b]	13.8 ± 0.08[c]	13.8 ± 0.07[c]
TSS (°Brix)	15.0 ± 0.10[a]	15.1 ± 0.57[a]	12.3 ± 0.57[b]	12.2 ± 0.57[b]
TS (g/100g)	6.50 ± 0.39[d]	7.79 ± 0.01[b]	7.41 ± 0.18[c]	8.44 ± 0.23[a]
RS (g/100g)	2.64 ± 0.23[d]	3.80 ± 0.04[c]	4.21 ± 0.06[b]	5.01 ± 0.13[a]

Values in the same row with the same letter are not significantly different from each other according to the Tukey multiple comparison test at the 5% level. Values are expressed as Mean ± Standard Deviation (n = 3 determinations). SS= fresh *Saba senegalensis* pulp; SAS= fresh *Saba senegalensis* pulp mixed with fresh pineapple pulp; SPS= fresh *Saba senegalensis* pulp mixed with fresh papaya pulp; SBS= fresh *Saba senegalensis* pulp mixed with fresh banana pulp, TS = total sugars, RS = reducing sugar.

Table 5. Organic acid concentration (mg/100g) of fruit pulp mixtures

Organic acids	Control	Pulp mixtures		
	SS	SBS	SPS	SAS
Malic acid	294 ± 8.53[b]	222 ± 4.70[b]	175 ± 4.33[d]	205 ± 8.60[c]
Tartaric acid	159 ± 4.35[b]	118 ± 5.92[a]	86.9 ± 3.61[b]	78.7 ± 4.97[b]
Oxalic acid	104 ± 4.84[c]	326 ± 3.82[a]	78.4 ± 4.96[c]	48.9 ± 4.12[c]
Citric acid	688 ± 11.48[a]	319 ± 16.8[b]	399 ± 17.81[b]	414 ± 8.72[b]
Lactic acid	6.70 ± 0.85[b]	33.27 ± 1.57[a]	10.03 ± 2.88[b]	10.6 ±1.28[b]
Ascorbic acid	16.8 ± 0.63[a]	11.5 ± 0.29[b]	12.5 ± 0.39[b]	6.10 ± 0.29[c]

Values in the same row with the same letter are not significantly different from each other according to the Tukey multiple comparison test at the 5% level. Values are expressed as mean ± standard deviation (n = 3 determinations). SS = fresh *Saba senegalensis* pulp; SAS= fresh *Saba senegalensis* pulp mixed with fresh pineapple pulp; SPS= fresh *Saba senegalensis* pulp mixed with fresh papaya pulp; SBS= fresh *Saba senegalensis* pulp mixed with fresh banana pulp.

Table 6. Correlation between the evolution of pH and other physicochemical parameters of the mixtures

Variables	PH	TA	ESS	St	Sr	AcM	AcT	AcO	AcC	AcL	AcA
PH	**1**	**-0.98**	-0.66	**0.88**	**0.92**	**-0.95**	**-0.93**	0.25	**-0.99**	0.59	**-0.86**
TA	**-0.98**	**1**	0.78	**-0.87**	**-0.95**	**0.98**	**0.98**	-0.08	**0.95**	-0.44	**0.87**
ESS	-0.66	0.78	**1**	-0.59	**-0.81**	**0.81**	**0.87**	0.53	0.58	0.20	0.67
St	**0.88**	**-0.87**	-0.59	**1**	**0.94**	-0.77	**-0.87**	0.13	**-0.92**	0.49	**-0.99**
Sr	**0.92**	**-0.95**	**-0.81**	**0.94**	**1**	**-0.90**	**-0.98**	-0.06	**-0.91**	0.32	**-0.96**
AcM	**-0.95**	**0.98**	**0.81**	-0.77	**-0.90**	**1**	**0.96**	-0.05	**0.90**	-0.38	0.78
AcT	**-0.93**	**0.98**	**0.87**	**-0.87**	**-0.98**	**0.96**	**1**	0.09	**0.90**	-0.28	**0.90**
AcO	0.25	-0.08	0.53	0.13	-0.06	-0.05	0.09	**1**	-0.33	**0.92**	0.00
AcC	**-0.99**	**0.95**	0.58	**-0.92**	**-0.91**	**0.90**	**0.90**	-0.33	**1**	-0.66	**0.88**
AcL	0.59	-0.44	0.20	0.49	0.32	-0.38	-0.28	**0.92**	-0.66	**1**	-0.37
AcA	**-0.86**	**0.87**	0.67	**-0.99**	**-0.96**	0.78	**0.90**	0.00	**0.88**	-0.37	**1**

pH = hydrogen potential, TA = titratable acidity, Ess = soluble dry extract, St = total sugars, Sr = reducing sugar, AcM = malic acid, AcT = tartaric acid, AcS = succinic acid, AcO = oxalic acid, AcC = citric acid, AcA = ascorbic acid, AcL = lactic acid.

4. Discussion

This study focused on the effectiveness of fruit pulp mixture for reducing the acidity of *Saba senegalensis* pulp. The main information that emerged was that, dessert banana, papaya and pineapple can be used to reduce the acidity of blended fruit pulp with *Saba senegalensis.* Among the three fruits used to reduce the acidity; banana was the most effective. The performance proportions for bringing *Saba senegalensis* pulp out of the highly erosive zone (pH < 3) were obtained from 25%, 40% and 45% addition of dessert banana, papaya and pineapple respectively. This performance for reducing acidity would therefore be related to the nature of the fruit used in the blend. Several studies have shown the effectiveness of fruit blends in reducing acidity. According to [25], the addition of 75% pineapple helped to reduce the acidity of cashew apple juice. The products that will be made out of these different acid-reduced formulations will be less aggressive to dental erosion. In the criteria used by [26] to characterise the acidity of fruits, the sugar content is related to organic acids. Thus, according to them, the more the sugar content of the fruit in the mixture is higher, the more it contributes reducing acidity. Banana, papaya and pineapple are rich in sugars and less concentrated in acids than *Saba senegalensis* pulp. In *Saba senegalensis* blends, the sugars provided by the other fruits modify the organic acid/sugar ratio of the pulp. The increase of pH in all mixtures was strongly correlated with the reduction of citric acid, malic acid and tartaric acid. This means that the pH increases significantly with the reduction of these organic acids in the *Saba senegalensis* mixtures. The intensity of the acidity of the fruit is related to the nature of the organic acids it contains [27]. The involvement of citric, malic and tartaric acids in fruit acidity has already been demonstrated by several studies [28,29,30,31]. According to these authors, citric acid is the most involved in the acidity of citrus fruits, while tartaric acid and malic acid are the main source of acid respectively in grape fruit and apples.

In addition to the involvement of the organic acid/sugar ratio in reducing the acidity of *Saba senegalensis* pulp, proteins are likely to precipitate organic acids [32]. They interact with organic acids to form amides through a covalent bond between the amine group of the proteins (the N-terminus) and the carboxyl group of the organic acid. The comparative study of the nutritional potential of the different fruits used in the mixtures carried out by [6] showed the high protein concentration of sweet banana, papaya and pineapple compared to *Saba senegalensis*. This high protein concentration provided by the fruits could therefore lead to a precipitation of organic acids from the pulp of *Saba senegalensis*.

The reduction in acidity, as measured by pH and titratable acidity, was also perceived in taste with the addition of other fruit pulps to the *Saba senegalensis* pulp. However, panelists felt that the addition of pineapple increased the acceptability of *Saba senegalensis* pulp more. The blend had more appreciable acidity, taste and aroma. With these sensory improvements, these juices could be more competitive in the market because according to [33], consumer preference is primarily based on the taste of the juice. Similar sensory improvements with the addition of pineapple in juice blends were also reported by [34].

5. Conclusion

This study showed that the fruit mixture is effective for decreasing the acidity of *Saba senegalensis* pulp. The three fruits used as deacidifying agents, namely banana, papaya and pineapple, have given satisfactory results. In order of effectiveness as a deacidifying agent, banana was the most effective, followed by papaya and pineapple. The addition of these fruits in the mixtures contributed to increase the acceptability of the acidity of the *Saba senegalensis* pulp by the panelists. The success of this study will contribute to the development of an alternative to the use of chemical additive for reducing the acidity in beverage made out of the *Saba senegalensis* fruits. And contribute to enhance its nutritional benefits for the consumer as well.

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