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Production and Characterisation of Drinks Using Local Ferments from Ripe Mombin Plum (*Spondias mombin*) Fruit

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Abstract

Spondias mombin is a fruit tree that belongs to the Anacardiacae family, native to Brazil. In effect, In Côte d'Ivoire, the fruits of *Spondias mombin* are very little known to the population. This ignorance of the fruit of *Spondias mombin* is due to the fact that there are few studies and little processing aimed at valuing this fruit. Thus, in order to enhance this fruit, biochemical, physicochemical and phytochemical analyzes and a transformation by alcoholic fermentation were carried out on the juice extracted from this fruit at maturity by carrying out different formulations and using different yeasts. The analyzes focused on the determination of pH, titratable acidity, Brix degree, humidity, ashes, fibers, tannins, polyphenols, flavonoids. The results revealed that the different alcoholic beverages obtained have a pH between 2.1 and 2.3; titratable acidity from 7.13 meq/L to 12.43 meq/L; soluble solids at 5˚Brix and they had a density between 0.98 and 0.99, as well as an alcohol percentage ranging from 2% to 11%. These parameters give this fermented drink a real potential for use by consumers and food processing industries.

Keywords

Spondias mombin, Alcoholic Fermentation, Ripe Fruit Juice, Local Ferment

1. Introduction

The fruits are mostly produced in tropical countries which by their climate allow a great variability of fruit species. The fruit can be defined as being a plant food, with a generally sweet flavor and consumed raw or processed [1]. The fruits are processed a lot because they are full of many nutritious and nutritional qualities.

For example, they may be used for there formulation of musts who will be subject to a fermentation alcoholic to produce fermented beverages [2]. Fermented beverages occupy an important place in the diet. These drinks result from a major biochemical reaction which is fermentation. This reaction is essentially due to the action of microorganisms [3]. It consists of the degradation of carbohydrate substrates without the use of oxygen [4]. However, questions may arise as to the strain of yeast to be used, the appropriate fermentation temperature, the type of treatment to be subjected to the fruits for the preparation of musts; because there is no technology specific to tropical fruits [2]. Alcoholic beverages result from the process of alcoholic fermentation involving microorganisms such as yeasts of the genus *Saccharomyces sp*. The use of these yeasts would be due to their potential for alcohol production, also their tolerance towards high levels of ethanol. Moreover, these yeasts produce certain compounds which impart certain flavors to the final products thus improving their organoleptic and nutritional qualities [5]. However, studies by [4]. [6]-[8] showed that the use of other yeast strains other than the genus *Saccharomyces* as well as the association of several yeasts would be the basis of alcoholic fermentations. Also [8] showed that the alcoholic fermentation carried out using different sources of yeast ensured variability in flavor and in the alcohol content of the beverages produced. Work on fermented drinks in general and in particular in sub-Saharan Africa has revealed that they contain high concentrations of microorganisms such as yeasts and live bacteria. Palm wine and sorghum beer are, among others, those beverages that have a high potential for yeast isolates used in industry [9]. Côte d'Ivoire is one of the sub-Saharan countries with great variability and fruit production. But this production is subject to many post-harvest losses. In order to reduce this situation, the processing of these fruits is necessary. One of the alternatives is the production of alcoholic beverages from low-value or wild fruits that are readily available such as the mombin plum (*Spondias mombin*).

This fruit has been the subject of several scientific studies, in the pharmaceutical field as well as in the food field. In several countries around the world given its many virtues [10]-[14]. On the other hand, in Côte d'Ivoire, this fruit is undervalued and the studies have been mainly based on the pharmaceutical effects without however extending to the food component.

Faced with the changes that mark the agricultural and agri-food sector, the question of local products and their promotion has become important [15]. It is necessary that transform these products through more accessible processes with a view to real recovery.

The objective of this work is therefore to enhance the juice of the mombin plum fruit by producing an alcoholic beverage using ferments of traditional and industrial origin.

2. Material and Methods

2.1. Material

The biological plant material is essentially the ripe fruit of the plum mombin

(*Spondias mombin*), tchapalo lees, palm wine lees and also baker's yeast. The samples were taken from three sites, namely in Abidjan (6˚38'48" North latitude and 4˚42'18" West longitude), then at Botro (7˚38'18" north latitude, 4˚49'29" west longitude) and finally, in Bouaké (7˚41'00" north latitude and 5˚01'59" longitude West). The ripe fruits were collected in the morning, under mombin plum trees, then were put in boxes and transported to Abidjan then to the laboratory of the unit educational research of Biochemistry and Food Sciences for the different analyses. Samples of *Tchapalo* lees and palm wine ferment were taken from Riviera-Anono (Abidjan). As for the baker yeast, it was purchased from the CDCI supermarket in Koumassi. The various ferments were also sent to the Laboratory for carrying out the various analyses.

2.2. Methods

2.2.1. Sample Preparation

After sorting and abundant washing with tap water, the fruits were separated from their epicarp and kneaded by hand to obtain the pulp in the form of juice containing fibrous residues.

2.2.2. Physicochemical Characterization of Mombin Plum Fruit Pulp

The Brix degree was determined using a SODIAL (R) brand refractometer by depositing a drop of the sample on the prism of the instrument then directing it to a light source [16]. The pH is used to determine the concentration of H+ ions in the sample. It was determined using a pH meter (HANNA HI 8424) previously calibrated at pH 4.0 and 7.0 [17]. The titratable acidity was determined according to the method [18]. The dry matter content was determined according to the stoving method [19]. Density being the ratio between the density of a substance and the density of a reference substance (water), it was determined according to [20]. The ashes represent the mineral compositions of a sample. The method used to determine the ash was described by the [21] method which consisted of incinerating a sample until whitish residues were obtained.

2.2.3. Biochemical Characterization of Mombin Plum Fruit Pulp

The reducing sugars were assayed according to the method of [22]. which uses 3,5-dinitro-salycilic acid (DNS) as reagent. The principle is based on the reducing property of simple sugars. Indeed, pentoses and hexoses are transformed into furfural under the effect of heat. Furfural in the presence of phenolic derivatives such as DNS, produces a specific coloring of reducing sugars whose intensity is proportional to the quantity of reducing sugars in the medium. The total sugar content is determined using the sulfuric phenol method described by [23]. The principle of this method is based on the hydrolysis of the glycosidic bonds of sugars in a hot acidic medium for the formation of furfural derivatives. The aldehyde function and its furfural derivatives then condense with the hydroxyl of a phenolic compound to give reddish-colored acetals whose intensity is proportional to the concentration of sugars in the medium. The fiber content was determined according to the method described by [24].

2.2.4. Phyochemical Characterization of Mombin Plum Fruit Pulp

The reagent used is the "Folin-Ciocalteu" reagent for the determination of total polyphenols. The principle of the method is based on the oxidation of phenolic compounds by this reagent, it leads to the formation of a new molybdenum-tungsten complex of blue color which absorbs at 725 nm, the PPT assay is carried out by comparing the DO observed to that obtained by a gallic acid standard of known concentration [25]. The method for determining the flavonoid level is that of [26]. The principle of this method is based on the fact that in the presence of potassium acetate, the flavonoids react with the aluminum chloride to give a complex of yellow color whose intensity is proportional to the quantity of flavonoids present in the medium. The dosage of tannins was carried out according to the method described by [27]. The principle is stated as follows: tannins react in an acid medium with vanillin to give a yellow-colored complex whose intensity is proportional to the quantity of tannins present in the medium.

2.2.5. Determination of Alcoholic Strength by Volume

The alcoholic strength by volume was determined by the method [28], on 50 ml of the distillates using an alcoholometer coupled to a thermometer of the Alkoholometer nach Richter & tralles type. The alcoholmeter is immersed in the alcoholic solution and the title is then read.

2.2.6. Process of Alcoholic Fermentation of Mombin Plum Juice

The mombin plum juice, after being taken out of the freezer, was defrosted in order to make the different preparations of the different samples. Sample formulations: FS0; FS15; FS25; FT0; FT15; FT25; FB0; FB15; FB25, are shown in **Table 1**. The elaboration of the musts was done by adding a quantity of sugar solutions in order to increase the Brix degree of the juice. The preparation of the ferments was done each time with a quantity of 10 g of yeast. To do this, 10 g of the ferment of the tchapalo lees type were dissolved in 200 ml of water and 10 g of baker's yeast were also dissolved in 200 ml of water. The fermentation of the different formulations was carried out with the three types of ferments. For samples FT0, FT15 and FT25, 10 g of tchapalo lees type ferment dissolved in 200 ml of water were added. As for samples FS0, FS15 and FS25, 10 g of baker's yeast also dissolved in 200 ml of water were added. Finally, 10 g of the bandji lees type ferment dissolved in 200 ml of water which were added to the FB0, FB15 and FB25 formulations. After formulation of the samples, the worts were heated to a temperature of approximately 80˚C using a hot plate and were cooled. The purpose of pasteurization is to destroy a large number of germs pathogenic. Then each sample (FS0; FS15; FS25; FT0; FT15; FT25; FB0; FB15; FB25) was transferred to the fermentation devices. The fermentation device consisted of 02 bottles of 1.5 L and 0.5 L capacity, both connected through a drain pipe. The 1.5 L bottle contained the must and the ferment, the 0.5 L bottle contained water and the pipe allowed the evacuation of the CO_2. The bottle has been hermetically sealed so as to prevent any passage of air.

The fermentation lasted about 14 days at 30˚C. After the 14 days of fermentation, the fermented must was filtered using a No. 4 filter paper. Then the beverage

was heated to a temperature of approximately 70˚C for ten (10) minutes to inactivate the fermentation microorganisms and terminate the alcoholic fermentation. The drinks obtained were stored in bottles in the refrigerator.

2.2.7. Data Analysis

The results of the different analyzes were synthesized using the Excel spreadsheet and the Statistica 7.1 software which allowed the calculation of different means and the determination of their standard deviation.

Table 1. Formulation of the different samples.

Samples	FS10	FS15	FS25	FT10	FT15	FT25	FB10	FB15	FB25
Amount of juice (ml)	1000	500	500	1000	500	500	1000	500	500
Amount of sugar solution (ml)	0	500	500	0	500	500	0	500	500
Final brix degree (˚brix)	**10˚**	**15˚**	**25˚**	**10˚**	**15˚**	**25˚**	**10˚**	**15˚**	**25˚**

3. Results and Discussion

3.1. Results

3.1.1. Physicochemical, Biochemical and Phytochemical Characteristics of Mombin Plum Fruit Juice

Table 2 presents the results of the physicochemical, biochemical and phytochemical analyzes carried out on the samples of the mombin plum fruit juice.

Thus the juice has a pH value of 2.68 ± 0.3. The soluble dry extract is at 11 ± 2 ˚B. A titratable acidity of 213.00 ± 11.55 meq/L and a specific gravity of 1.43 ± 0.01. The juice ash is 0.716% ± 0.16%. The fibers are dosed at 0.25% in the juice and the reducing and total sugars amount respectively to 3.04 ± 1.27 mg/100 g and 4.04 ± 0.2 mg/100 g. The contents of flavonoids, total polyphenols and tannins are respectively 3.41 ± 0.07 mg/100 g; 38.22 ± 0.47 mg/100 g and 69.64 ± 0.45 mg/100 g.

3.1.2. Physicochemical, Characteristics of Mombin Plum Fermented Fruit Juice

The results of the physicochemical of fermented mombin plum fruit juice are listed in Table 3.

The pH values obtained for the different samples are between 2.1 and 2.7. The lowest value is that of the FT0 sample and the highest is the FB25 sample. Regarding the Brix degree, the value obtained is greater than 5˚B for all the different samples. Sample FB25 has the highest value (15 ± 1˚B). Titratable acidity measurements revealed a significant difference between all different samples. Thus, the values found are between 7.13 ± 1.5 mEq/L and 11.63 ± 1.1 mEq/L. The analysis of the parameters shows that at the level of the density, there is no significant difference. Thus, we have density values which are between 0.98 ± 0.01 and 1 ± 0.1. The percentage of alcohol obtained for the samples is between 2 ± 1 and 10 ± 1. The FS15 and FS25 samples have higher alcoholic degrees than all other samples, respectively 6 ± 1 and 10 ± 1.

Table 2. Physicochemical, biochemical and phytochemical characteristics of mombin plum juice.

Settings	Mombin plum juice
pH	2.68 ± 0.3
Brix	11 ± 2
Titratable acidity in mEq /L	213.00 ± 11.55
Dry matter	93.28 ± 1.98
Density	1.43 ± 0.01
Ash (%)	0.716 ± 0.16
Fiber content (%)	0.25 ± 0.00
Reducing sugar content (mg/100g)	3.04 ± 1.27
Total sugar content (mg/100g)	4.04 ± 0.2
Flavonoid content (mg/100g)	3.41 ± 0.07
Polyphenol content (mg/100g)	38.22 ± 0.47
Tannin content (mg/100g)	69.64 ± 0.45

Table 3. Physicochemical characteristics of mombin plum fruit juice fermented.

Sample	FS0	FS15	FS25	FT0	FT15	FT25	FB10	FB15	FB25
˚Brix	5 ± 1	6 ± 1	7 ± 2	5 ± 1	5 ± 1	7 ± 1	7 ± 1	11 ± 1	15 ± 1
pH	2.13 ± 0.1	2.23 ± 0.2	2.3 ± 0.1	2.1 ± 0.1	2.2 ± 0.1	2.4 ± 0.2	2.6 ± 0.1	2.6 ± 0.2	2.7 ± 0.1
Acidity (meq/L)	9.73 ± 1	8.5 ± 1.2	7.13 ± 1.5	12.43 ± 0.9	11.83 ± 1	11.02 ± 1.2	11.63 ± 1.1	11.64 ± 1.5	9.33 ± 1
Density	0.98 ± 0.01	0.985 ± 0.11	0.99 ± 0.1	0.99 ± 0	0.98 ± 0.01	0.99 ± 0	0.99 ± 0.01	0.9 ± 0.1	1 ± 0.1
Alcohol (%)	3 ± 1	6 ± 1	10 ± 1	2 ± 1	3 ± 1	4 ± 1	2 ± 1	2 ± 1	3 ± 1

3.2. Discussion

Mombin plum fruit juice has a value of 2.68. Which shows that mombin juice is acidic. This value is substantially similar to that of [29] whose value is 2.83 ± 0.01 obtained during a study on the nutritional properties of yellow mombin pulp. A study by [29] gave pH results between 1.5 and 2.3, therefore significantly more acidic. According to [30] the acidity of juices facilitates their rapid assimilation by the body because it only takes one hour to be digested.

The Brix or the percentage of soluble dry matter expressed in degrees Brix of the mombin plum juice is 11 ± 2˚ Brix. This value is lower than the results of [29] which is 14.9˚ Brix, but identical to the values obtained by [31] during the comparative study species of *Spondias* in Brazil. The soluble dry matter content of the juice of our sample is lower than that of grapes which is 16˚ Brix [32]. Note that the Brix degree of fruits is a good marker for identifying specific stages of development, ripening of fruits and helps in predicting their acceptability and preferences by consumers [33] [34].

The titratable acidity of the juice is equivalent to 1.86% citric acid. This value is

similar to that of [31] and [29] who obtained 1.52 ± 0.036 and 1.46 ± 0.01 respectively. Indeed, titratable acidity is an important parameter in determining fruit maturity. This maturity is one of the essential indicators in the evaluation of fruit flavor [35].

The dry matter content of mombin plum juice is 7.28% ± 0.51%. This value is higher than the results of [29] obtained on different species of the genus *Spondias*. These values vary between 9.46 and 12.44. Indeed, these high water contents define the freshness of the fruits and possibly their good juice yield [36]. In fact, the precautions to be taken for their storage and their transport must be greater, because they are very quickly perishable and favorable to the growth of certain spoilage microorganisms.

This study showed a proportion of 0.25% of fiber for mombin plum fruit juice. This value is similar to the results obtained by [37] studying the use of mombin plum fruit pulp as a substrate for biosurfactant production. However [29] and [38] obtained 1.87% and 4.2% ± 0.04% respectively. This difference could be due to the climate or to the soil of the areas where the fruits were collected. Fiber is essential for the proper functioning of intestinal transit and the overall health of humans [39].

Ripe mombin plum fruit juice contains an amount of ash of 0.716 ± 0.16(%). This ash content value is identical to that obtained by [29]. Also similar to the results obtained after the studies carried out by [29]. During this study the different varieties of *Spondias* with ash levels between 0.72% and 0.79%. On the other hand [37] obtained 1.58% ash during studies on the use of mombin plum fruit pulp. Obtaining the ashes makes it possible to evaluate the mineral content contained in the fruits.

The flavonoid content of the juice is 3.41 ± 0.07. This result is similar to that of [40] and [29]. Regarding the total polyphenol content of our sample, a value of 38.22 ± 0.47 was found. This result is slightly higher than 23.98 ± 1.527 mg/100 g, that obtained by [31] and identical to those of [41] 38.4 ± 1.2 mg/100g of dry matter. Polyphenols have antioxidant effects and prevent against oxidative stress, ie the attack on cells by free radicals [42] and can be used as additives in the food industry. The tannin content of the pulp of ripe fruits is 69.64 ± 0.45 mg/100 g. This result obtained is lower than the result of [43] with a value obtained of 314.78 ± 0.37 mg/100 g of fruit pulp. The differences may be due to the stage of fruit maturity.

The results of the physicochemical characteristics of the fermented juice obtained showed that the pH values decreased compared to those of the initial mombin plum juice (2.68). This shows that alcoholic fermentation would reduce the acidity of the juice. The pH of the FB25, FB10 and FB15 formulations are the highest compared to those of the other formulations. Indeed, the addition of sugar in the formulations allowed the microorganisms to produce a large quantity of alcohol, thus influencing the pH of the medium [44] [45]. In addition, statistical analyzes revealed no significant difference between the types of yeast used dur-

ing fermentation. This shows that the decrease in pH is not a function of the type of yeast during this fermentation. Moreover, our values are lower than those of [45]. Whose values vary between 3.82 and 3.98. This difference is linked to the raw material used for fermentation: the pulp of Balanites *Aegyptiaca* or Desert Date. It is a fruit that is less acidic in nature with a pH of 5.35 [46].

For the Brix degree, the results decrease significantly after the fermentation of the mombin juices. Indeed, the dry matter which expresses the share of fermentable sugars in the must is 10 ± 1˚ Brix, therefore rich in sugars and sufficiently acidic which facilitated its fermentation. The degradation of sugar was significant leading to a decrease in the Brix degree.

The results obtained on the drinks show a significant resemblance between the values of the densities of the different samples. While the results show a drop in density from the fruit juice to the drink obtained by fermentation. This decrease in density is due to the fact that the must after being fermented was filtered in order to collect the liquid and eliminate the nerve and also because the sugar would be transformed into alcohol and a decrease in mass in the form of carbon dioxide would be carried out. Our results are in line with the results obtained by [45] on the study of alcoholic fermentation.

Concerning the percentage of alcohol, the results showed that there is a significant difference between the drinks. The drinks FT0, FS0, FB0, FB15 and FB25 have a low percentage of alcohol while that of FS25 and FS15 is high. This difference is due to the fact that the FS25 and FS15 samples are richer in sugar because they have undergone sugar additions.

This induced the production of a large amount of alcohol. Also, the results showed a significant difference between FT15, FB15 and FS15; and between FT25, FB25 and FS25 which are two formulations having received the same amount of sugar. We then have a high percentage of alcohol for the drink FS15 (5% ± 1%) compared to FT15 and FB15 (3% ± 1%) also a very high percentage of alcohol (10% ± 1%) for FS25. This could be explained by the type of ferments used. Indeed, the FS15 and FS25 formulations are obtained by using *Saccharomyces cerevisiae* while those of FT15 and FT25 by the local ferment used to obtain *Tchapalo* and *Bandji*. The difference is due to the purity of the yeast. *Saccharomyces* is 100% pure while *tchapalo* and *bandji* yeast are not purified. *This demonstrates that the Saccharomyces cerevisiae* yeast is interesting and effective for carrying out the alcoholic fermentation of mombin plum juice. Moreover, our results are in line with those of [45] who also highlighted the performance of *Saccharomyces saccharomyces* yeast.

4. Conclusion

The objective of this work was to contribute to the valorization of mombin plum fruits (*Spondias mombin*) through the fermentation of the juice extracted from it. The alcohol content of the drink from pure fruit juice is low, while that of the juice supplemented with white sugar is close to that of commercial beers and wines.

The potentials presented by the alcoholic drink of ripe mombin plum fruit juice (*Spondias mombin*) could arouse interest for many consumers, for food industries and breweries. In addition, this aspect could raise farmers' incomes by creating new jobs in areas with high production of this fruit.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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