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SENSORY ANALYSIS OF THE FRUIT JUICE OF PALMYRAH PALM (BORASSUS AETHIOPUM): A DECISION MAKING TOOL

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ABSTRACT

Systematic training of panelists to generate terms that describe and quantify the sensory characteristics of Borassus juice enabled the profiling of the product. The experimental study was conducted at the University of Cocody (Ivory Coast). Sixteen students and employees were selected as judges based on willingness to consume Borassus juices and no history of negative allergic reactions. The judges were further screened using triangle tests and ability to determine varying intensities of selected descriptors for tropical fruit juices (sweetness, bitterness, sourness, saltiness). The training sessions were held twice a week for two months. Reference standards for each descriptor as well as unstructured scaling consisting of a horizontal 15 cm line with anchor points were used. A consumer test using a three point acceptability scale (tastes great, acceptable, unacceptable) was used. Bitterness was the dominant descriptor, followed by sweetness. Saltiness and sourness had minimum contribution to the taste of the juices. Sugars/ bitter compounds combination play an important role in the flavour characteristics and in the consumer acceptability. Free sugars were determined by HPLC in the extracted Borassus juice. The dominant sugar was sucrose (47 mg/ml) followed by glucose (24.6 mg/ml) and fructose (16.5 mg/ml). A glucose / fructose ratio close to 1, and a glucose+fructose/ sucrose ratio close to 1 both of which are good indexes of authenticity of Borassus juices. Majority of the consumer panel (93%) found the juice acceptable or excellent (tastes great). The results represent a major breakthrough for the improvement of the incomes of poor populations in savannah regions of Western Africa via the creation of juice processing units. Juice processing is a better alternative than wine making because sap harvesting methods leads to the death of the palm. The populations of Borassus are highly endangered due to the lack of reforestation of the degraded areas. Preservation of the biodiversity in rural areas will benefit from this research.

Key words: Sensory, Panel, acceptability, pectinase, *Borassus aethiopum*

INTRODUCTION

A descriptive sensory panel can detect and describe sensory properties of a consumer product [1, 2, 3]. A trained panel of assessors is an analytical instrument to accurately analyze both the qualitative and quantitative sensory components of a food product [4, 5]. The flavour, appearance, aroma, aftertaste and sound properties of a product are qualitative aspects that instrumental devices alone cannot provide [6, 7]. To be efficient, substantial training is required before the panel becomes a reliable sensory instrument [8-14]. Descriptive analysis allows relationships between descriptive sensory and physico-chemical analysis and consumer preference highly desirable in food industry [1]. Several other uses of descriptive sensory analyses include quality control, sensory mapping and product matching [15, 16]. In Ivory Coast, Borassus aethiopum Mart. (Arecaceae) produces an important quantity of fruits rich in carbohydrates with about 65% of fermentable sugars [17, 18]. However, there is a lack of knowledge about the descriptive sensory analysis of the juice for food beverage development. Therefore, the objective of this study was to use a taste evaluation panel to determine the sensory profile of the juice. We also used a consumer panel to assess the market potential of the juice produced.

MATERIALS AND METHODS

Preparation of Borassus juice

Freshly harvested mature Palmyra palm (B. aethiopum, Mart) fruits (orange colour) were peeled with a knife. The pulp was cut into small pieces and pureed in a blender. About 5 kg portions of puree were preheated at 45-50 ^{o}C for 5 minutes in water bath and cooled at 35 ^{o}C. A commercial pectinase (Rapidase) was added individually to the puree batches at the rate of 0.50 mg/kg. The rate used was the average usage rate recommended for other fruits. A total volume of 100 ml of distilled water was added to the Borassus purees before homogenization and incubation at 35 ^{o}C for 2 hr. At the end of the incubation period, the pectinase was inactivated by heating the purees at 50-55 ^{o}C for 4-5 min. Following the enzyme treatment, a hydraulic press fitted with a press cloth (3 mm sieve diameter) was used to extract juice from the puree. The extracted juices were filled into sterilized glass bottles and refrigerated. Figure 1 shows the flow chart of Borassus juice processing.

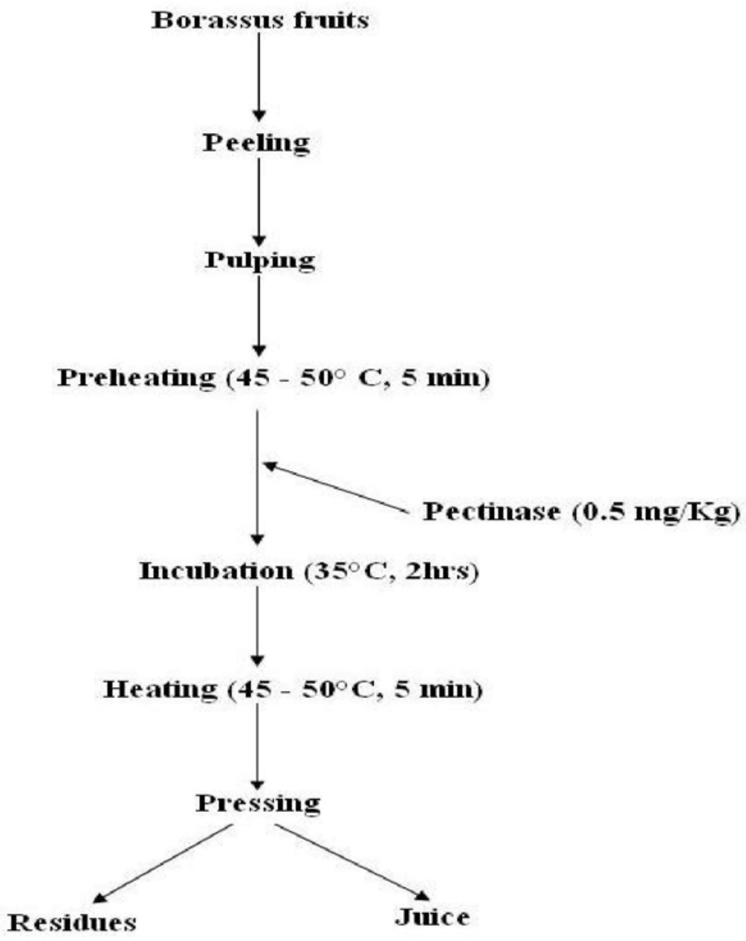

Figure 1: Borassus juice processing

Juice pasteurization

The extracted juice was heated in a small steam kettle with constant stirring to 80 ^{0}C. The juice was held for 10 min at that temperature and hot filled into sterilized 330 ml glass bottles, capped and cooled to 25 ^{0}C.

Descriptive analysis

The sensory descriptive panel consisted of 16 students and employees from the University of Cocody (IVORY COAST). Of the 16 panellists (aged 17-28) 8 were men and 8 women (all students). Of the 8 men 6 were students and 2 were laboratory technicians. The judges were selected based on willingness to consume Borassus juices and no history of negative allergic reactions. Panelists were further screened using triangle tests and ability to determine varying intensities of selected descriptors generated by the panel for tropical fruit juices. Participation in all sessions was required. The training sessions (1-2 h) were held twice a week for two months. Unstructured scaling consisting of a horizontal 15 cm line with anchor points was used. Each anchor point was labelled with a word or expression. The panelists

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generated 4 descriptors for Borassus juice sensory analysis (Table 1). Reference standards were provided to the panelists for each descriptor developed (Table 2). The samples used in the sensory sessions were refrigerated and served just before tasting. Drinking water was used for mouth rinsing to minimize carry over effect. Each sensory attribute was evaluated on a separate line and panelists scored by making a vertical line across the horizontal line at the point that reflected their perception of the magnitude of that property [19].

The ratings were then converted to numerical scores by measuring the distance of the marks from the left end of the line in units of 0.1 cm. A score of 1 was equivalent to 1 cm on graphical scale [20].

Consumer panels

A consumer test using a three-point acceptability scale (tastes great, acceptable, unacceptable) was conducted using 76 students (40 males and 36 females) from the University of Cocody (Ivory Coast) between the ages 17-25 [21, 22]. The students were selected based on willingness to consume Borassus juices and no history of negative allergic reactions. A sample volume of 30 ml of Borassus juice was served in a three-digit coded cup and presented to each student for evaluation. Students were asked to indicate their acceptability and to identify the descriptor (sweetness, acidity, saltiness, bitterness) that contributed to their answer. Results were expressed as a percentage for each category (acceptable, tastes great, unacceptable).

Sample preparation and HPLC analysis of sugars

The separation of sugars was performed on an HPLC system [23]. The juice was centrifuged at 11,000 g for 15 min and filtered through a C18 Waters Sep Pak. The mobile phase consisted of deionized water running at a flow rate of 0.6 ml/ min through the system. A sample volume of 10 µl of the supernatant was injected onto a cationic exchange column (Shodex SC1011 Waters) at 75 °C (isocratic conditions for 30 minutes); equipped with a precolumn 6 mm x 50 mm (Shodex 1011P Waters). The sugars were quantified against accurately determined concentrations of known sugar standards. A mixed working standard was prepared from the stock standard mixtures of the individual sugar to contain 1 % (w/v) D-glucose, D-galactose, sucrose, ribose, and fructose in 1 % (v/v) ethanol and 0.5 % (w/v) maltotetrose in deionized water. Concentration of the sugars in the juice samples was determined by relating the area under the peaks of the mixed standard of known concentration to that of the samples.

Proximate analysis

Proximate analysis was conducted to determine total sugars, moisture content, dry matter, acidity of pasteurised and unpasteurised juices using the methods suggested by AOAC [24].

Effect of pectinase concentration and duration of incubation on the yield of juice

Various pectinase concentrations (0, 0.125; 0.25 and 0.5 mg/kg of pulp) were added to Borassus puree samples and incubated for 30, 60, 90 and 120 min to evaluate their effects on the yield of Borassus juice at fixed temperatures of 30, 35, and 40 °C.

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Effect of temperature and duration of incubation on the yield of juice

Various temperatures **(**30, 35, and 40 °C) and duration of incubation (30, 60, 90 and 120 min) were used to evaluate their effects on the yield of Borassus juice at fixed pectinase concentrations (0, 0.125, 0.25 and 0.5 mg/kg of pulp).

Effect of pectinase concentration and duration of maceration on the total sugars

Various pectinase concentrations (0, 0.125, 0.25 and 0.5 mg/kg of pulp) were added to Borassus puree samples and incubated for 30, 60, 90 and 120 min to evaluate their effects on the total sugars content of Borassus juice at fixed temperatures 30, 35, and 40 °C.

Statistical analysis

Analysis of variance of the data was applied according to a factorial design with three factors including temperature (30, 35, 40°C), incubation time (30, 60, 90, 120 min) and enzyme concentration (0, 0.125, 0.25, 0.50 mg/kg). The effects of each factor on the responsevariables (juice yield, pH, total sugars, acidity, dry matter), as well as the effects of interactions between factors were studied. Significance was accepted at $p \leq 0.05$ using the Statistical Analysis System software (SAS).

RESULTS

Fresh juice

The juice yield from puree (72%) was rich in sugars including glucose, sucrose and fructose. Glucose had the highest concentration (62.4 mg/ml), followed by sucrose (53.4 mg/ml) and fructose (33.6 mg/ml) (Table 3). However, nonidentified high molecular weight oligosaccharides were present in the processed juice (Figure 4). The fresh juice with a pH of about 3.74 had a sweet bitter taste and a desirable aroma. Ethanol was present at a concentration of 1.47 g/l.

Pasteurized juice

Heat pasteurization of the Borassus juice was effective to produce a higher concentration in total sugars (172.9 mg/ml) including glucose (73 mg/ml) and fructose (46 mg/ml). There is a rise in the pH (3.78) of the juice as well as the dry matter (15.9%).

Descriptive panel

After training, panelists used the vocabulary developed by the panel consistently. Occasional sessions were conducted for recalibration. The bitterness and sweetness attributes were dominant in all sessions. Saltiness and acidity were minimal in Borassus juices (Figure 2).

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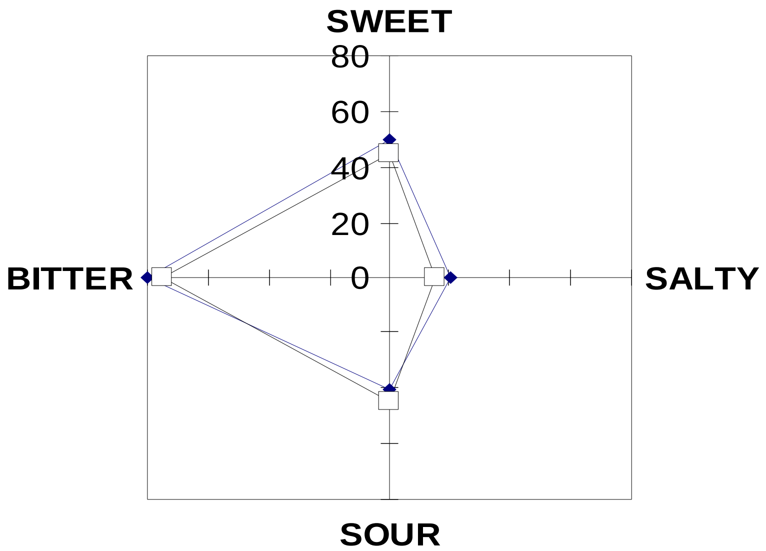

Figure 2: Sensory profile for Borassus juice (data for two replications)

Consumer acceptability

Consumer acceptability was evaluated as the percentage of panelists that rated the Borassus juice as acceptable, tastes great or unacceptable [22]. Combining acceptable and tastes great data, 69 consumers (93%) found the Borassus juice an acceptable product (Figure 3).

Figure 3: Acceptability of Borassus juice

Of the consumers who accepted the Borassus juice, 97% preferred the bitterness, 1% the sweetness, 1% the acidity and 1% for unknown reasons. These reasons were also identified by consumer population who found the Borassus juice unacceptable. Of the segment of the population who did not accept the Borassus juice 96% disliked the bitterness, 2% the acidity, 1% the sweetness and 1% for unknown reasons.

HPLC quantification of sugars

Borassus juice contains sugars found in many fruit juices including sucrose, glucose and fructose and is deficient in neutral sugars such as galactose, arabinose and xylose (Figure 4).

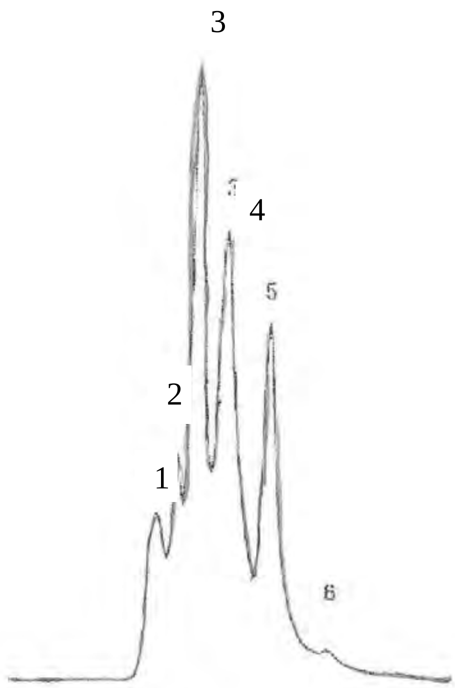

Figure 4 : Contents of free sugars in Borassus juice 1, 2 : Oligosaccharides ; 3 : Sucrose ; 4 : Glucose ; 5 : Fructose ; 6 : Ethanol

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Effect of pectinase concentration, duration of maceration (incubation time), temperature and their combinations on yield, pH, sugars, acidity and dry matter (see summary of ANOVA table 4). The analysis of variance shows that all the factors studied influenced the yield of juice made from the pulp of fresh Borassus fruit ($p < 0.05$).

DISCUSSION

The pectinase used at the recommended level and incubation time degraded the pulp and led to improved juice extraction. Indeed, the pulp of most fruits is by no means easy to press since these fruits often lack endogeneous pectinolytic enzymes. The use of commercial pectinase preparations is necessary to facilitate pressing and to ensure high yields of juice and colored materials from various fruits and vegetables [25]. The easy pressing of the pulps as well as the increased juice yields can be attributed to a loss of water binding capacity of the degraded pectin [25]. In working as pressing aids, pectic enzymes help avoid a particularly vexing problem such as the delayed release of juice from fresh fruits before spoilage. Borassus pulp contains considerable quantities of pectin in addition to hemicelluloses and cellulose [26].

Glucose (62.4 mg/ ml) had the highest amount followed by sucrose (53.4 mg/ ml) and fructose (33.6 mg/ ml). The sweet character of the juice is due to large amounts of free sugars (Table 3). The ratio of glucose/fructose and glucose + fructose/ sucrose was close to 1 could be used as an aid to establish authenticity and identity of the fresh Borassus juice. Similar ratios for free sugars have been found in pineapple juice [27]. The presence of ethanol (1.47 g/l) is due to fermentation of the ripe fruit before or after harvesting by yeasts and bacteria [17]. The absence of galactose, arabinose and xylose is due to the fact that these sugars are pectin-bound [23]. Bitterness was the characteristic that determined the preference of consumers. Bitter sensation is not by itself appealing to most people. However, the combination of bitter compounds with other components of the Borassus pulp produced a unique pleasant taste. In many tropical fruits the sugar/ acid ratio determines the maturity and preference of tasters. Borassus the sugar /bitter compounds ratio would likely be a good indicator for the preference of consumers because bitter compounds alone are not usually acceptable to consumers [28].

Ethanol was absent due to its evaporation during heat processing of the juice. The increase in sugars concentrations is likely due to the hydrolysis of polysaccharides present in the Borassus pulp. Indeed hydrolysis of glycosidic bonds joining monosaccharide units in oligo and polysaccharides can be catalyzed by either acids or enzymes. The extent of depolymerisation, which has the effect of reducing viscosity, is determined by the acid strength, time, temperature, and structure of the polysaccharide. Generally, hydrolysis occurs most readily during thermal processing, because many foods are somewhat acidic [29]. The average values obtained for total sugar ranged from 0.705 to 1.26 g / ml, which is similar to previously reported values by other workers [17]. However, these values are very high when compared with those obtained in the rehydrated pulp juice (0.140 g / ml) [26]. This difference is probably related to the treatment applied to the fruit flesh. Indeed, rehydration proposed by these authors has not been very effective in the complete recovery of the sugars present in the dried material. The dry matter is increased for the pasteurized juice because the higher temperature used disrupt the cells membranes to yield juice with higher total solids, more non-sugar solids, tannins and pigments [25].

CONCLUSION

The sensory profile of Borassus juice has been established. Consumer panel found the juice acceptable. Therefore, the Borassus juice has a potential on the marketplace. The descriptive sensory analyses results may also be used to track product changes over time to understand shelf life and packaging effects, to investigate the effects of ingredients or processing variables on the final sensory quality of a juice, and to investigate consumer perceptions. Development of Borassus juice should increase producers economic resources and could reduce post-harvest losses.

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Table 1: Sensory descriptors generated for Borassus juice

Descriptor	Definition
Sweet	Taste stimulated by sugars like fructose, sucrose
Sour	Taste stimulated by acids such as malic and citric acid
Salty	Taste stimulated by sodium chloride
Bitter	Taste stimulated by caffeine

Adapted from [7,30]

Table 2: The reference standards and their intensities for the various descriptors

Descriptor	Reference standard	Intensity (150-mm scale)
Sweet	5% sucrose solution	50
	8% sucrose solution	80
	10% sucrose solution	100
Sour	0.05% Citric acid solution	20
	0.08% Citric acid solution	50
	0.15% Citric acid solution	100
	Youki pamplemousse[R]	65
Salty	0.20% sodium chloride solution	25
	0.35% sodium chloride solution	50
Bitter	0.05% caffeine solution	20
	0.08% caffeine solution	50
	Tonic[R]	65
	Sunbitter[R]	125

R: Products are registered trademarks

Table 3: Proximate analysis of pasteurized and unpasteurized Borassus juice

Treatments	pH	Acidity meq.g/l	Dry matter (%)	Total sugar(mg/l)	Fructose (mg/ml)	Glucose (mg/ml)	Sucrose (mg/ml)	Ethanol (g/l)
Unpasteurised juice	3.72 **a**	92**a**	15.13 **a**	616.46**a**	16.48**a**	24.57**a**	47.14**a**	-
Pasteurised juice	3.83 **b**	75**b**	18.38 **b**	1190.86**b**	40.39**b**	42.97**b**	69.43**b**	-

Means in a column with same letter are not significantly different

Table 4: Summary of ANOVA data of effect of enzyme concentration, temperature, maceration time (incubation) and interactions on the yield, pH, total sugars, acidity and dry matter of Borassus juice

Factors	Yield[4]	pH[5]	Total sugars[6]	Acidity[7]	Dry matter[8]
Main effects					
Enzyme[1]	**S**	**S**	**S**	**S**	**S**
Temperature[2]	**S**	**S**	NS	**S**	NS
Incubation[3]	**S**	**S**	**S**	NS	**S**
Interactions					
Enzyme **x** Temperature	**S**	**S**	NS	**S**	NS
Enzyme **x** Incubation	**S**	**S**	NS	NS	NS
Temperature **x** Incubation	NS	**S**	NS	NS	NS
Enzyme **x** Temperature **x** Incubation	NS	NS	NS	NS	NS

NS indicates no significant effect ($p > 0.05$), **S** represents a significant effect at $p \leq 0.05$

[1]Enyme concentration, [2]Temperature of incubation, [3]Incubation time, [4]Yield (% w/w), [5]pH, [6]Total sugars (mg/l), [7]Acidity (meq g/l), [8]Dry matter (% w/w)

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