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Sensory Profile of Palm Syrups Produced from Oil Palm (*Elaeis guineensis* Jacq.) Sap during Storage and Consumer Preference

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Abstract

Syrup is a versatile ingredient widely used in the food industry as a flavouring and sweetener in confectionery, or as a coating in bakeries. With a view to adding value to the sap of the oil palm (*Elaeis guineensis* Jacq.), this study assesses the sensory characteristics of the palm syrup obtained from the sap during storage. Thus, palm syrup was produced from fresh and stored sap. The quantitative sensory profile of the syrup samples was then established, and the tasters' preferences were analysed. The results showed that syrup from fresh sap (SP0J) had higher sweetness and honey flavour intensities (37.83% ± 2.61% and 39.56% ± 2.49%, respectively) than syrup from stored sap. However, a decreasing trend in the intensity of these descriptors was observed between the first and fourth day of storage, even if the differences were not statistically significant. Inversely, that of the acid aftertaste increased. These sensory characteristics of the syrups guided the overall sensory appreciation of the tasters, who chose the SP0J syrup made from fresh sap as their first choice with an average rank of 1.29 ± 0.54 and the SP4J syrup as their last choice (4.16 ± 0.34). These results underline the importance of keeping the palm sap fresh to preserve the organoleptic qualities of the resulting palm syrup.

Keywords

Elaeis guineensis, Palm Syrup, Quantitative Sensory Profile, Preference, Overall Assessment

1. Introduction

Syrup is a versatile ingredient widely used in the food industry. It is used as a flavouring and sweetening agent in confectionery, as a coating to give bakery products a shiny surface, etc. [1] [2]. As well as improving the taste and texture of food, syrup can also have health benefits. Indeed, maple syrup reduces a number of cardiometabolic risk factors, including systolic blood pressure [2]. Syrup production therefore makes a huge contribution to the socio-economic development of the local population. In Canada, the transformation of maple sap into syrup has created an entire industry that has contributed to the socio-economic development of many Canadians, to the point where maple syrup is considered to be "blond gold" [3]. In Africa and in countries where the palm tree grows, the sap is used as a traditional drink [4] [5], which is still extracted in the traditional way. The sap of the oil palm (*Elaeis guineensis* Jacq.) is traditionally processed into a liqueur called "Koutoukou" in Côte d'Ivoire [6]. To date, no industrial use has been made of palm sap. Yet almost 290,000 ha of oil palm plantations are cultivated in Côte d'Ivoire [7]. Once the palms have become old, they are felled and replaced by young plants. These felled palm trees are reservoirs of sap that are abandoned to the "koutoukou" manufacturers. In an attempt to exploit this ancestral resource, Kouassi *et al.* [8] have shown that oil palm (*Elaeis guineensis* Jacq.) sap can be made into syrup with a yield of 18.68%. In fact, oil palm sap is characterised by its high sugar content of 26.03 ± 1.29 $mg{\cdot}g^{-1}$, glucose 153.24 ± 11.64 $mg{\cdot}g^{-1}$ and fructose 18.24 ± 8.14 $mg{\cdot}g^{-1}$ with a Brix degree of 6 [9]. This makes it a valuable raw material to produce palm syrup. However, the transformation of this sap into syrup by thermal evaporation is sensitive to changes in the physico-chemical characteristics of the sap due to the biochemical changes that can occur after harvesting [10]. According to these authors, the sap extracted from the palm trunk felled 60 days ago has a much better biochemical quality than that extracted from the palm felled on the same day. These different characteristics also affect the properties of the respective syrups produced, such as glucose content, colour, pH and reducing capacity [10]. The transformation of sap into syrup is therefore an opportunity for industrial development. In some countries like India [11], Indonesia [12] and Algeria [13], syrups from many palm species (*Borassus flabellifer*, *Phoenix dactylifera* L., *Cocos nucifera*, *Arenga pinnata*, *Nipah*, …) are produced and marketed locally. However, the characteristics of palm syrup need to be understood before large-scale production can begin. Given that palm sap ferments spontaneously under the action of micro-organisms [4] [5] [14], the aim of this study is to evaluate the sensory characteristics of palm syrup made from oil palm sap during storage.

2. Material and Methods

2.1. Material

The plant material used in this study is oil palm (*Elaeis guineensis* Jacq.) sap, freshly harvested after the palm has been felled.

2.2. Methods

2.2.1. Collecting the Palm Sap Samples

Palm sap was collected at 7 a.m. from a palm wine producer in the commune of Songon, in the south of Côte d'Ivoire. The first daily production of sap from old, freshly felled palms was considered. A volume of 20 litres of sap was collected in 5 sterile plastic containers of 4 litres each and transported in a cooler containing carboglasses. The sap was kept in the 4-litre containers and stored at laboratory temperature (20˚C - 25˚C). Daily samples of 4 litres were taken to produce palm syrup over a period of five days.

2.2.2. Production of Palm Syrup

Palm syrup was produced using the method described by Akpro *et al.* [15]. After filtration, the palm sap was thermally evaporated in a single phase for 60 minutes. To do this, 1 L of sap was heated to 120˚C for 30 min. Without interruption, the temperature was reduced to 100˚C for 10 min, then to 80˚C for 10 min, and finally to 60˚C for 10 min (Figure 1). During heating, the sap was continuously turned to accelerate the syrup and avoid any crust formation. After cooking, the syrup is cooled to room temperature and packaged in plastic bottles.

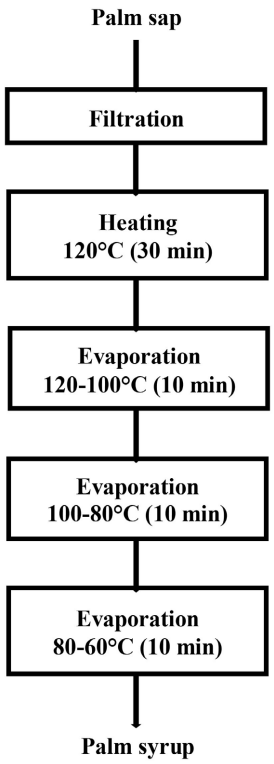

Figure 1. Palm syrup production process.

2.2.3. Sensory Analysis of Palm Syrup

1) Composition of the Panel

Two sensory analysis tests were carried out on the palm syrups produced. Firstly, a quantitative sensory profile was carried out with a panel of 25 trained tasters to

describe the different syrups [16]. Next, a preference ranking test was carried out with 60 naïve tasters (not officially trained). All these tasters were recruited from the Université Nangui ABROGOUA (Abidjan, Côte d'Ivoire) and ranged in age from 19 to 30. They were recruited based on their experience in sensory analysis, their availability, and their willingness to take part in the study. Verbal consent was obtained from the tasters, who also declared that they were not diabetics prior to their inclusion in the analysis. The organoleptic descriptors considered were the sweetness, honeyed flavour, and acidic aftertaste of the syrup samples produced.

2) Quantitative sensory profile test

The quantitative sensory profile was carried out in one session with 25 qualified tasters. Samples of palm syrup were evaluated against reference samples, including pure sucrose, honey, and lemon juice, for sweetness, flavour, and aftertaste, respectively. All the samples (palm syrups, table sugar syrup, honey, and lemon juice) were coded and presented simultaneously to the tasters. The intensity of the descriptors was determined on an unstructured linear scale with an origin (0) and an end (100). A scale is provided for each descriptor (sweetness, honeyed flavour, and acid aftertaste). The taster is then asked to taste the samples and mark vertical lines on the scale to indicate the position of the samples relative to their intensity [17]. Between two tastings, the taster rinsed his mouth with water.

3) Palm syrup classification test

The hedonic ranking test was used to determine consumer preferences. The tasters tasted and ranked the syrup samples according to their preference for the above-mentioned sensory descriptors and their overall appreciation of each sample. All the samples were presented to the tasters at the same time, in a randomized fashion to avoid any bias linked to the order of presentation. Tasters were provided with classification forms for data collection [17].

2.2.4. Statistical Analysis of Data

The data obtained from the analyses were entered into Excel, and STATISTICA.7 software was used for statistical processing. A one-factor analysis of variance (ANOVA 1) was performed to compare the means of the different variables (descriptors). Before carrying out the ANOVA, the equality of variances was verified using Levene's test [18] [19]. The homogeneity of variances was respected in all these analyses at the 5% threshold. When a significant difference was observed between the means of the variables, the ANOVA was completed by multiple comparisons (post-ANOVA test) using Duncan's test at the 0.05% threshold [20]. For the hedonic classification data, the Wilcoxon test for two linked samples was carried out [17].

3. Results and Discussion

3.1. Results

3.1.1. Sensory Profile of Palm Syrups

The sensory profile of the different palm syrup samples is presented in **Figure 2**.

The results show a significant difference ($p < 0.05$) between the characteristics of the syrup obtained from the sap of the day (SP0J) and those obtained from stored sap. The sweetness and honeyed aroma were very intense in the syrup obtained with palm sap from the day of extraction (SP0J), with levels of 37.83% ± 2.61% and 39.56% ± 2.49%, respectively. On the other hand, these descriptors decrease in intensity as the duration of palm sap storage increases, but do not show any significant difference. Regarding the acid aftertaste, the intensities were higher in the syrups made from stored sap, with a maximum of 38.87% for the syrup from day 4 (SP4J).

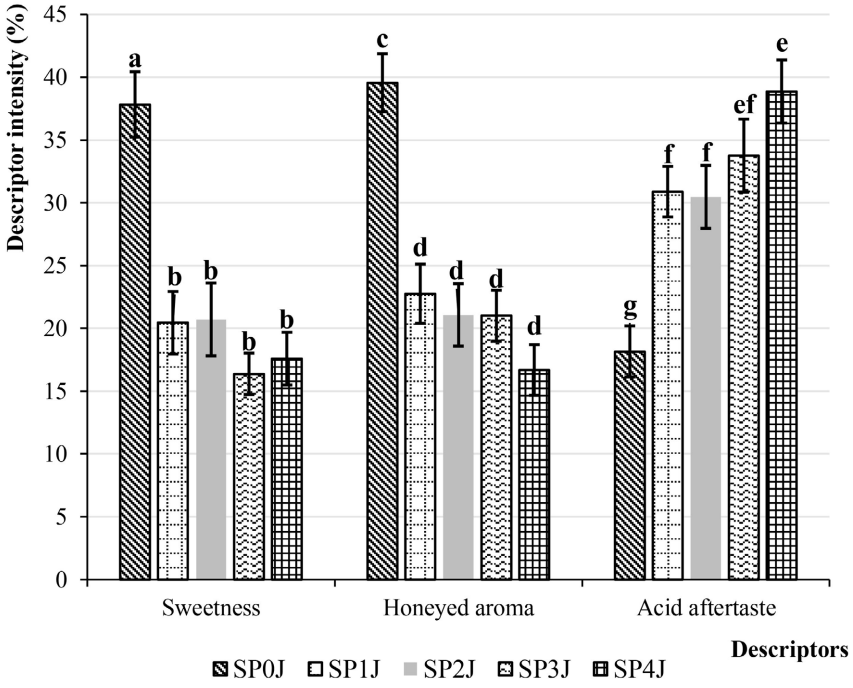

Figure 2. Quantitative sensory profile of different palm syrups. SP0J: Syrup made from the sap of the day; SP1J: Syrup made from sap stored for one day; SP2J: Syrup from sap stored for two days; SP3J: Syrup from sap stored for three days; SP4J: Syrup from sap stored for four days.

3.1.2. Panellists' Preference for Palm Syrup

Figure 3 shows the tasters' preferences for palm syrups according to the descriptors and their overall assessment. In terms of sweetness, the syrup from the day sap (SP0J) was the most preferred by the tasters with an average rank of 1.42 ± 0.53. The syrups from the first day's sap (SP1J) and the second day's sap (SP2J), which did not show any significant difference, came second. Syrups SP3J and SP4J were ranked third and fourth successively with mean ranks of 3.63 ± 0.16 and 4.29 ± 0.34, respectively. Considering the honeyed flavour, the SP0J syrup obtained the lowest average rank (1.68 ± 0.53), ranking it the most preferred. There was no significant difference ($p > 0.05$) between the mean ranks of the SP1J, SP2J, and SP3J syrups. These syrups occupy the second position of preference. Syrup SP4J had a mean rank of 3.97 ± 0.35. Regarding the acid aftertaste, syrups SP2J, SP3J, and SP4J

were the most preferred by the tasters with lower average ranks and no significant difference (2.63 ± 0.16 to 2.87 ± 0.16). Syrups SP1J and SP0J were the least preferred. Taking the whole samples, the tasters ranked SP0J syrup as their first choice (1.29 ± 0.54), SP1J syrup as their second choice (3.00 ± 10), SP2J and SP3J as their third choice (3.24 ± 0.15 to 3.32 ± 0.17), and finally SP4J syrup as their last choice (4.16 ± 0.34).

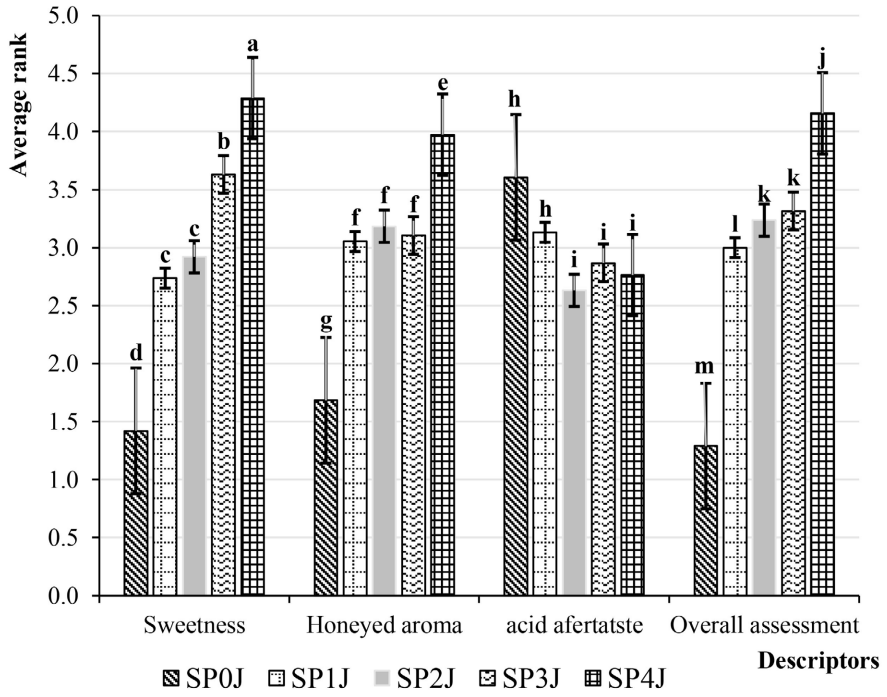

Figure 3. Tasters' preferences for different syrups. SP0J: Syrup made from the sap of the day; SP1J: Syrup made from sap stored for one day; SP2J: Syrup from sap stored for two days; SP3J: Syrup from sap stored for three days; SP4J: Syrup from sap stored for four days.

3.2. Discussion

The sensory evaluation of different syrups made from palm sap provided information on their sensory profiles and the tasters' preferences. The quantitative sensory profile of the syrups showed significant differences ($p < 0.05$) between the intensities of the sweet taste, honeyed aroma, and acid aftertaste of syrups made from fresh palm sap (day 0) and stored palm sap (days 1 - 4). The sweetness and honeyed aroma were more intense in the fresh syrup (SP0J), with values of 37.83% ± 2.61% and 39.56% ± 2.49%, respectively. The acid aftertaste is weak (1.29 ± 0.54).

These results can be explained by the high quantity of sugars still available in the sap on the day of extraction, with a low acid content [21]. Indeed, the thermal evaporation applied in the production of palm syrups has led to a concentration of sugar, which enters into Maillard reactions to develop the syrup's characteristic properties such as its colour, aroma, flavour, and antioxidant power [3] [22]. However, when the sap is preserved, spontaneous fermentation takes place to break down

the sugars, producing alcohol, organic acids, and carbon dioxide [23]. The reduction in the quantity of sugars and the increase in the acidity of the stored sap led to a drop in sweetness and honeyed flavour. At the same time, an increase in acid aftertaste was observed. However, no significant difference was observed between the sweetness and aroma intensities of syrups from stored sap over the four days.

The intensity of the acid aftertaste increases with storage time. Consequently, the peak intensity (38.87%) is reached in the syrup from sap stored for four days (SP4J). This increase in acidity is probably due to the formation of organic acids during fermentation.

Ranking the syrups based on tasters' preferences showed significant differences between the samples. Preferences evolved in the same direction for the descriptors sweetness and honeyed aroma. Syrup SP0J (day 0) is the most appreciated for its sweetness and aroma, while syrup SP4J (day 4) is the least appreciated. This preference for fresh sap syrup corroborates previous results showing a decrease in sugar content over time. However, the absence of any significant difference between the preferences for SP1J, SP2J, and SP3J suggests a more subtle evolution of the honey flavour over time. Regarding the acid aftertaste, the tasters' preference was for the SP2J, SP3J, and SP4J syrups, which showed a high intensity for this descriptor. This preference could be justified by the tasters' eating habits and culture [24]. According to these authors, the sensory traces left over the decades could guide certain food preferences. Similarly, Seddiki *et al.* [25] showed that consumers preferred the more acidic *Hmira* syrup (68.3%) (pH = 4.43 ± 0.15; free acidity = 13.15% ± 0.39%) to the less acidic *Tagazza* syrup (pH = 4.57 ± 0.08; free acidity = 12.43 ± 0.15) while the same panel reported that Robb Hmira was less sweet than the Tagazza variety, which was considered very sweet (75%).

The overall ranking of syrups shows a decreasing preference with storage time (SP0J > SP1J > SP2J, SP3J > SP4J). This trend suggests that the organoleptic characteristics observed previously guided the tasters' overall assessment [26]. Although SP0J syrup is preferred overall, the preference for SP2J, SP3J, and SP4J syrups in terms of aftertaste suggests that some changes during storage may be appreciated. This could open avenues for the development of products with different sensory profiles targeting different consumer segments. These results suggest that to obtain a syrup with optimal and preferable organoleptic characteristics, it would be desirable to produce it from fresh palm sap. The length of time palm sap is stored before syrup production should be minimized or controlled to preserve the desired sensory qualities.

4. Conclusion

This study shows that palm syrup tastes sweeter and has a honeyed aroma when produced from fresh sap. This syrup is more appreciated. The biochemical changes that occur when sap is stored alter the organoleptic characteristics of the resulting syrups. It is therefore important to control or reduce the length of time palm sap is stored to guarantee a syrup of superior quality.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Authors' Contributions

Kouakou Nestor Kouassi and Kouadio Benal Kouassi designed the study and were responsible for the overall coordination of the study. Kouadio Jescimiel Bathier Yao oversaw sample collection. Kouadio Benal Kouassi and Hadiowe Eliane Gnagne supervised sensory evaluation and data analysis. Kouadio Jescimiel Bathier Yao and Kouadio Benal Kouassi wrote the first draft of the paper. All authors read, revised, and approved the final version of the manuscript prior to submission.

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Conflicts of Interest

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

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