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(RESEARCH ARTICLE)

Physicochemical, microbiological and sensory properties of mango juice made from dried mango powder

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Abstract

Côte d'Ivoire, a mango-exporting country in the sub-region, is facing the problem of post-harvest losses estimated at 65 % of national production. It is therefore necessary to find preservation techniques not only to mitigate the reduction of these post-harvest losses, but also to find derived products that can be available even after the campaign period. The aim of this study is to produce and characterize a new edible juice based on dried mango powder. To do this, the mango pulps divided into three batches were dried at 40 °C, 50 °C and 60 °C then reduced to powder. The powder thus obtained was rehydrated to produce juice. The physicochemical, microbiological and sensory characteristics were determined. The results revealed that pH of the juices is between 4.48 and 4.66 while the titratable acidity is between 0.0 and 0.4 %. The results also showed the presence of vitamin C (144.44 to 288.88 mg/100g), polyphenols (2.35 to 3.90 mg GAE/100g), flavonoids (1.35 to 1.65 mg QE/100g). According to Jora standard No. 39 (2017), the contaminating microorganisms (GAM (5.8 to 6 x 10^5 CFU/g), Total coliforms (1.4 to 2.09 x 10^5 CFU/g), Staphylococci (total absence)) present show that these were generally of satisfactory or acceptable quantity. Only yeasts and molds (3.02 to 3.8 x 10^5 CFU/g) were abundant. The organoleptic parameters of the different juices are quite satisfactory. The organoleptic parameters of the different juices are quite satisfactory. This work opens a way to valorize mango.

Keywords: Mango; Juice; Physicochemical; Microbiological; Sensory properties

1. Introduction

Mango is one of the world's most important tropical fruits, ranking second in global production after bananas [1, 2]. It is widely produced, consumed, and highly valued worldwide. Global annual mango production was estimated at approximately 55.03 million tonnes and 54.83 million tonnes in 2019 and 2020, respectively [3]. Asia accounts for 74.31 % of total production, followed by the Americas (12.82 %) and Africa (12.76 %). There are approximately 1,000 mango varieties cultivated worldwide. In Ivory Coast, the mango tree (*Manguifera indica*) is present throughout the country, but the areas where climatic conditions are favorable for cultivation for the production of good quality fruit are mainly in the northern half of the country) [4]. Today, it plays a very important role in the economic development of the northern region of Côte d'Ivoire. The third largest fresh fruit exported after bananas and pineapples, mangoes represent 80% of export crops in volume and approximately 4 % of GDP [5]. Despite the economic and nutritional importance of mangoes, their use is limited by enormous post-harvest losses in the mango industry. Overall, these losses are estimated at approximately 80 % worldwide [6] and 65 % in Côte d'Ivoire. To minimize post-harvest losses of mangoes, several preservation methods are used to preserve mangoes. Thus, the transformation of mangoes into dried mangoes has been considered, but these methods are still limited because their level of use in foodstuffs remains low. We must therefore find a way to reprocess them into products useful to all. It is in this logic that this study was initiated in order to contribute to the reduction of post-harvest losses of mangoes by means of processing and also to compensate for the shortage of mangoes after the end of the campaign period. The general objective of this study is to produce a new edible

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juice based on dried mango powder. This work paves the way for the valorization of mango, a highly prized fruit whose nutritional potential can be exploited.

2. Materials and Methods

The study was conducted on Kent variety mangoes (Figure 1) purchased at the Korhogo market in northern Côte d'Ivoire.

Figure 1 Unpeeled (A) and peeled (B) mangoes of Kent variety

2.1. Mango Powder Production

Upon receipt, the healthy mangoes were soaked in hot water for 15 minutes before being peeled to eliminate germs on the skin. Once peeled, the pulp was separated from the pits and then cut into thin slices (thickness less than or equal to 1 cm). The mango slices were divided into three batches and then steamed at three different temperatures, namely 50 and 60 °C for 48 hours. The steaming process at 40 °C was stopped after 5 days. The dried mangoes were then ground and sieved.

2.2. Production and determination of juice Brix level

Two sets of 10 test tubes were used. Each set of tubes, each containing 1 to 10 mL of distilled water at 60 °C, was filled with 1 g of powder P50 and 1 g of powder P60. The tubes were vortexed to ensure homogenization, and the Brix level was measured on the contents of each tube using a refractometer. The concentration used was that of the tube corresponding to a Brix level between 13.5 and 14. Once the concentrations were determined, the powdered quantities were hydrated with water heated to 60 °C and then homogenized using a ladle. The resulting juices were filtered, refined, bottled, and pasteurized at 80 °C for 15 minutes. Once pasteurized, the bottles were cooled for 30 min before being placed in the refrigerator for analysis.

2.3. Physicochemical Analysis of Powders and Juices

The pH of the juices was measured using a pH meter and the titratable acidity was determined using the method described by [7]. Carbohydrates were determined using the difference method. The method described by [8] was used to determine vitamin C. Polyphenol and flavonoid content were determined using the methods of [9] and [10]., respectively.

2.4. Microbiological Analysis of Juices

2.4.1. Preparation of the Inoculum

Since juices are liquid, they constitute the stock suspensions. For this study, the stock suspensions of the juices were obtained by homogenizing 10 mL of juice into a sterile test tube over a Bunsen burner flame. From the stock suspensions obtained, successive decimal dilutions up to 10^{-4} were obtained by adding 1 mL of the lower dilution to 9 mL of 0.1% peptone water each time, according to standard NF V 08-010 [11].

2.4.2. Seeding of culture media

Table 1 Culture medium and culture conditions of research microorganisms

Germs	**Standard**	**Culture medium**	**Criteria Jora N °39 (2017)**	**Temperature and incubation time**
Mésophilic aérobic Germs (MAG)	Standard NF/08-05	Plate Count Agar (PCA)	$\leq 5.10^7$	30°C for 72 hours
total Coliforms (TC)	Standard ISO 4832	Violet Red Bile agar Lactose (VRBL)	$\leq 3x10^5$	37 °C for 24 hours
Staphylococcus	Standard NF/V 08-057-1 nov 1994	Baird- Parker	$\leq 10^3$	37° C for 48 hours
Yeasts and molds		Sabouraud	$\leq 10^5$	30 °C for 3 à 5 days

2.4.3. Enumeration

The count of microorganisms was calculated using the following formula:

$$N=\sum Colonies / (n_1+ 0,1n_2) \times d \times v$$

With:
N: number of microorganisms
n_1: number of dishes in the first dilution considered
n_2: number of dishes in the second dilution considered
d: the smallest dilution considered
v: volume of the inoculated sample

2.5. Sensory Analysis

Sensory analyses were performed using the sense organs (eye, tongue, smell, touch) (descriptive analysis) by 50 untrained individuals. The parameters determined were color, taste, odor, and appearance. These parameters were determined on raw juice without any food additives.

2.6. Statistical Analyses

Statistical analyses of the results were performed using STATISTICA 7.1 software. The results were expressed as mean ± ESM where each value represents a minimum of 5 rats (n = 5). All data were tested for one way analysis of variance (ANOVA) followed by Tukey's HSD test. The analysis of variance compares the significance of the difference observed between the samples analyzed according to the probability threshold of 0.05.

3. Results

3.1. Physicochemical Analyses of Dried Mango Powder

Physicochemical composition of different dried mango powders of Kent variety is presented in Table 2. This analysis shows that vitamin C (222.22 ± 38.48), polyphenol (18 ± 0.01) and total carbohydrate (83.76 ± 3.52) contents of powder (P50) are similar ($p < 0.05$) to those of the powder (P60) (166.66 ± 57.74; 20 ± 0.03; 90.53 ± 5.74 respectively). However, the powder (P50) has significantly higher flavonoid contents ($p < 0.05$) than the powder (P60).

Table 2 Biochemical composition of dried mango powders

Parameters	powders		
	40°C	50°C	60°C
Flavonoids (mg QE/100g)	ND	21 ± 0.02^{b}	12 ± 0.01^{a}
Polyphenols (mg GAE/100g)	ND	18 ± 0.01^{a}	20 ± 0.03^{a}
Vitamin C (mg/100g)	ND	222.22 ± 38.48^{a}	166.66 ± 57.74^{a}
Carbohydrates (%)	ND	83.76 ± 3.52^{a}	90.53 ± 5.74^{a}

3.2. Physicochemical parameters of the juices

Various physicochemical parameters of the juices are shown in Table 3. Statistical analysis of these results shows that for polyphenol and flavonoid contents, juice P60 has significantly higher values than P50 juice. However, the vitamin C contents of P50 and P60 juices are statistically identical (288.88 ± 101.83 and 144.44 ± 50.91 mg/100g, respectively).

Table 3 Physicochemical parameters of juices

Parameters	Dried mango juice	
	Juice P50	Juice P60
pH	4.66 ± 0.03^{b}	4.48 ± 0.08^{a}
Titratable Acidity (%)	0.04 ± 0.00^{a}	0.4 ± 0.00^{a}
Vitamin C (mg/100g)	288.88 ± 101.83^{a}	144.44 ± 50.91^{a}
Flavonoids (mg QE/g)	1.35 ± 0.03^{a}	1.65 ± 0.03^{b}
Polyphenols (mg GAE/g)	2.35 ± 0.23^{a}	3.90 ± 0.51^{b}

3.3. Microbiological Parameters of Juices

Figure 1 presents the results of the germ counts. In both juices (P50 and P60), the highest numbers of MAG were found (6×10^5 and 5.8×10^5 cfu/g, respectively). This was followed by yeasts and molds (3.8×10^5 and 3.02×10^5 cfu/g, respectively), and finally total coliforms (2.09×10^5 and 1.4×10^5 cfu/g, respectively). The germs number counted in the juice P50 was higher than in the juice P60. Staphylococci were absent in both juices.

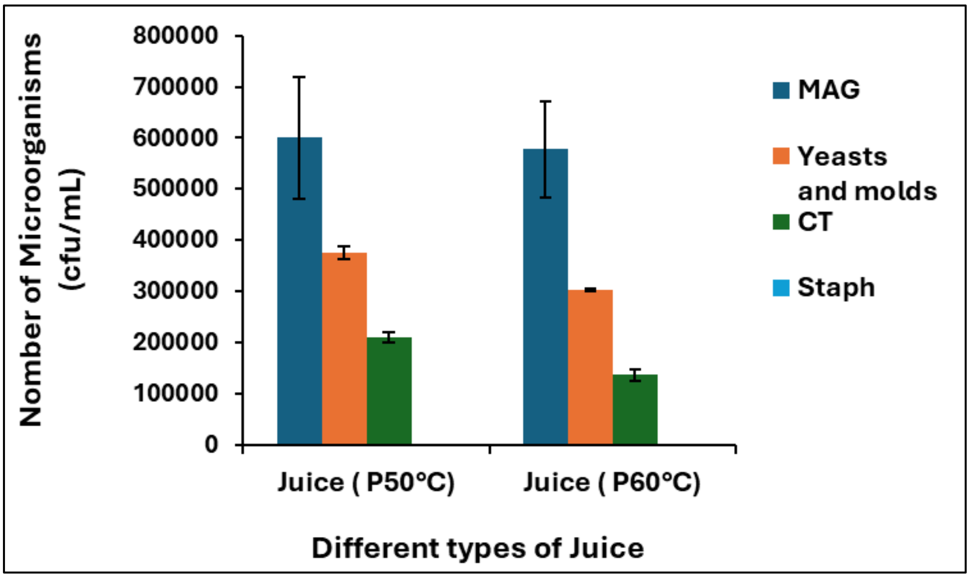

Figure 2 Microbiological characteristics of juices

3.4. Sensory parameters of juices

Without any food additives, the dried mango juice from P50 has a sweet flavor and is slightly acidic. It is orange in color with a slightly viscous appearance and a pleasant, but underdeveloped, mango odor. As for the P60 juice, the results showed that it also has a sweet flavor and an orange color, with a very well-developed mango aroma. It has a viscous appearance and is the most appreciated by the panelists. The various results are illustrated in Table 4.

Table 4 Sensory parameters of juices

	Juice P50	Juice P60
Color	Orange	Orange
flavor	Acid	Sugary
odor,	Pleasant	Pleasant
texture	Viscous	Viscous

4. Discussion

Vitamin C content decreases in P60 powder. This decrease is also observed in juices. It could be due to the drying temperature of mango pulp. Indeed, under the heat effect, vitamin C is likely to be denatured. According to [12], vitamin C losses could be explained by its thermo-sensitivity, which corroborates the previous statements. The vitamin C content (powder (166.66 ± 57.74 and 288.88 ± 101.83) and juice (144.44 ± 50.91 and 288.88 ± 101.83) are higher than those of [3] who obtained respectively 84.49 mg/100g and 42.81mg/100g for fresh pulp and mango powder during his work. Vitamin C is known for its antioxidant properties that protect cells and tissues of human body against free radicals and oxidative stress [14]. Average nutritional requirements of the population is 15-100 mg/day depending on the age of individual, with the exception of breastfeeding women [15]. Dried mango powder and juices would cover this vitamin C need of consumers.

The polyphenol contents of the flours (18 ± 0.01 and 20 ± 0.03 mEq GAE/100g respectively for powder P50 and P60) and juice (2.35 ± 0.23 and 3.90 ± 0.51 mEq GAE/100g respectively for juice P50 and P60) studied are within range of those of 14 mango varieties (0.77 to 37.64 mg/100 g of fresh pulp) [16]. Phenolic compounds are antioxidants beneficial for human health [14]. They would prevent against neurodegenerative and cardiovascular diseases and cancer [17]. From this point of view, dried mango powder would be a significant source of phenolic compounds.

Regarding flavonoids, a significant decrease in their content was observed during drying (F 50 powder P50 (21 ± 0.02 mg QE/100 g) and P60 (12 ± 0.01 mg QE/100 g)). This could be due to temperature effect, as it is mentioned above that prolonged drying at high temperatures may alter the nutritional quality of the products. Our dried mango powder have higher flavonoid values than Tommy mangoes (4.74 ± 0.73 mg QE/100 g) [18] but fall between the values of 8 Chinese mango varieties (6.28 to 90.92 mg rutin/100 g) [14]. Dietary flavonoids play a central role in modern medicine and the development of new substances. Recently, greater attention has been paid to quercetin, considered a cardioprotective flavonoid with beneficial effects on other cellular systems [19].

The results of this study showed that the acid pH of the juices (4.66 and 4.48) makes them microbiologically stable products. The titratable acidity (0.04 ± 0.00 and 0.4 ± 0.00) is identical at the juice level. However, the values obtained are lower than those of [20] who obtained respectively 0.19 % and 0.30 % for samples of fruit juices marketed in the popular market of Ouargla. This difference could be explained by the presence of minimal concentrations of citric acid in the mangoes which served as raw materials for the production of these juices.

Microbiological analyses of different juices (P50 and P60) produced revealed a fairly considerable presence of mesophilic aerobic germs (6×10^5 and 5.8×10^5 cfu/g respectively), yeasts and molds (3.8×10^5 and $3.02\ 10^5$ cfu/g respectively) and total coliforms (2.09×10^5 and 1.4×10^5 cfu/g). These values are significantly higher than those of [20] who obtained 5×10^3 cfu/ml; 1.4×10^3 cfu/ml and 1.7×10^2 cfu/ml respectively for mesophilic aerobic germs, yeasts and molds and total coliforms in fruit juices sold in the Ouargla popular market. However, for mesophilic aerobic germs and total coliforms, the values obtained following the count are higher than the acceptable concentration described in Jora standard No. 39 (2017) (5×10^6 and 3×10^3 cfu/ml respectively), but lower than the unacceptable concentration (5×10^6 and 3×10^5 respectively). Regarding yeasts and molds, their concentrations in both juices are well above the unacceptable concentration (10^5) described in this standard. The complete absence of Staphylococci in both juices could be explained by the fact that the pasteurization temperature would have eliminated all vegetative forms. This confirms the statements of [21] who stipulate that a simple heat treatment of the food (pasteurized juice, for example) can destroy these Staphylococcus germs. In light of all these observations, the two juices produced could be classified as hygienically acceptable.

Sensory analysis of a product involves assessing consumer preferences. In this regard, sensory analysis is essential to evaluate the quality and acceptability of a new product by consumers. Aspects such as color, flavor, odor, and texture significantly influence consumers' initial impressions [22]. The organoleptic parameters of the different juices are quite satisfactory, however the slightly acidic taste detected at P50 juice would be due to the high acidity level in the flour which has been hydrated.

5. Conclusion

Results of this study prove that dried mango pulp powerd is a good source of carbohydrates, vitamin C, polyphenols and flavonoids. Despite the effect of temperature, the nutritional values remain significant for consumer needs. These products should be promoted because they have remarkable characteristics. Therefore, although the powerd can be used for other purposes, its use in fruit juice production appears to be an inexpensive and effective solution for fruit juice companies. This work paves the way for the development of mango, a highly prized fruit whose nutritional potential can be harnessed.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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