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Optimization of a Cocktail Based on Cashew Apple and Papaya Juice Using Mixing Design

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Abstract The very low level of processing of agricultural products in Ivory Coast is a real problem despite their nutritional importance. The alternative solution is therefore their valorization. To this end, a study of the formulation of a cocktail based on cashew apple juice and papaya juice by a mixing plan was conducted. After an appropriate choice of two variables, seven trials led to a mathematical model linking the responses (refractometer dry extract, total sugars and reducing sugars) to the factors (cashew apple juice and papaya juice rate). After conducting the trials and analyzing the data, the optimized formulation (F1) to maximize the refractometric dry extract, total sugars and reducing sugars contents is 50% cashew apple juice and 50% papaya juice with a global desirability of 0.994. This cocktail (F1) is sweet (11° brix), less astringent compared to the other formulations and has a phenolic content of 1.2 mg/mL Eq Gallic acid. This formulation has a vitamin C content of 115.37 mg/mL, an ash content of 0.37% and has a good microbiological quality. It provides energy with a value of 34.04 Kcal / 100 mL. In addition to being used as a drink, this richness makes it a potential substrate in the bioconversion of sugar materials, precisely in wine making.

Keywords: *optimization, cocktail, cashew apple, papaya, mixing design*

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1. Introduction

Cashew (*Anacardium occidentale L*) is a tree native to Mexico, Peru, Brazil and also the West Indies [1]. Cashew nut production in Côte d'Ivoire has undergone a notable increase from 6,000 tons in 1990 to 725,000 tons in 2015 [2], making Ivory Coast the world's leading producer of raw cashew nuts.

Today, the production amounts to more than 7.5 million tons of which the production in 2020 is 848700 tons [3].

The cashew tree provides for human consumption the nut and also the apple to which the nut is attached. The cashew nut is a gray or gray-brown, kidney-shaped achene when ripe [4]. The apple, on the other hand, is the hypertrophied stalk that that connects the tree to the nut [5,6]. The apple is the most important fruit organ in terms of weight, nearly 10 to 15 tons of apples are obtained for every production of about one ton of nuts [7].

The cashew apple is very rich in nutrients. It is made up of 85% juice, sweet and acidic. It is also rich in vitamin C (6 times richer than orange), carotenoids [8] and polyphenols [9]. Despite its high nutritional potential, most of its production is abandoned at the harvesting site [1]. This is due to the astringent taste of the juice, caused by its tannin concentration of 100-300 mg/100 mL [10]. Thus, cashew apple could be used not only as a nutritional beverage but also as a substrate in sugar bioconversion.

Cashew apple, alone or combined with other fruits, the main route of valorization that it is relevant to consider is the transformation into juice [4]. Some mixtures of fruits could be a necessity to improve the biochemical and sensory composition of juices [4].

To this end, the formulation of a cocktail with a non-astringent tropical fruit could not only enhance the value of cashew apple but also improve the biochemical composition and acceptability of this juice. For this purpose, papaya (*Carica papaya L*), could be used because it is a fruit appreciated by the population and rich in refractometric dry extract, total sugars, reducing sugars, vitamin C, A, beta-carotene, fiber and mineral elements [11]. In addition, it is a non-astringent fruit and less acidic at maturity. However, increasing the refractometric dry extract, total and reducing sugars content of this cocktail could be a great challenge. To meet this challenge, the method of mixing designs was adopted. These designs are techniques that allow the effects of various factors on the responses to be quantified and optimized in well-defined experimental domains.

The objective of this study is to formulate a cashew apple and papaya juice cocktail of good nutritional quality by a mixing design.

2. Material and Methods

2.1. Material

The plant material consisted of cashew apples (*Anacardium occidentale L)* (Figure 1) and papaya (*Carica papaya L)* (Figure 2). Yellow and red cashew apples as well as the solo variety N°8 of papaya were used. These raw materials come from Yamoussoukro, the political capital of Ivory Coast, in the Aries region, located between the forest and savannah zones.

Figure 1. Cashew apples

Figure 2. Papaya

2.2. Methods

2.2.1. Method of Production of Cashew Apple Juice

The harvested fruit consisted of apples and cashews. The apples were carefully separated from the nuts with a wire tied at both ends with small pieces of wood to avoid damaging them. The resulting apples were soaked in 100 ppm active chlorine bleach water for 15 - 20 minutes and then rinsed with clean water. After rinsing, the apples were then pressed using a ZBK220077-88LW74d (B) A pulp press. The juice was then filtered through a one millimeter diameter mesh screen and packed into one liter cans.

2.2.2. Method of Production of Papaya Juice

The papaya was soaked in 100 - 150 ppm active chlorine bleach water for 15 - 20 minutes and then rinsed with clean water. After rinsing and trimming, the papayas were then pressed using a ZBK220077-88LW74d (B) A pulp press. The resulting juice was then filtered through a one millimeter diameter mesh screen and packed into one liter cans. The production diagram of papaya and cashew apple juice is presented by Figure 3.

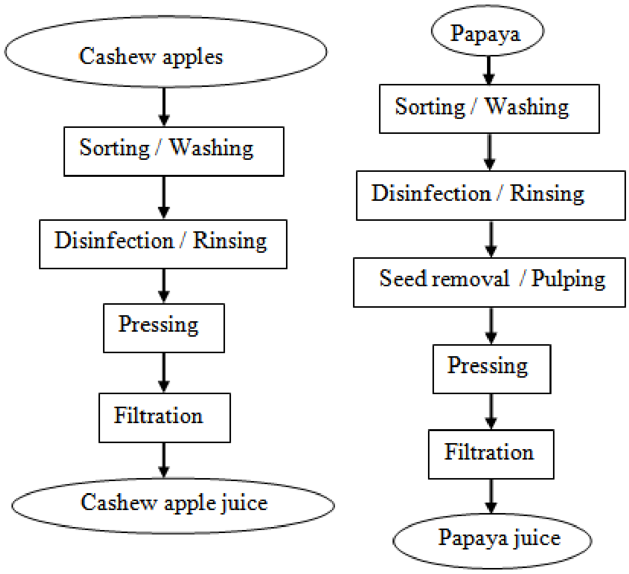

Figure 3. Diagram of cashew apple and papaya juice production

2.2.3. Formulation of the Cocktail by the Mixing Designs

Mixing designs are experimental designs that are used when studying a product consisting of several components. The different proportions of formulation of the cocktail based on cashew apple and papaya juice were obtained according to the simplex lattice design with two constituents and four equal parts (simplex lattice design {2;4}). For a binary mixture with four equal parts with constraints, we obtain seven (7) possible trials including five trials with two replicates [12].

In order to maximize the amount of cashew apple juice and minimize that of papaya in our study, the proportions vary from 0.5 to 1 or 50 to 100% for cashew apple juice while those for papaya are between 0 and 0.5 or 0 and 50%. The percentages of these different trials are represented in Table 1. The (controlled) variables or factors are cashew apple juice and papaya juice, and the responses are the parameters: refractometric dry extract (Y1), total sugars (Y2) and reducing sugars (Y 3). Each mixture totaled 1000 mL in a different 1500 mL capacity bottle.

Table 1. Proportion of different juices

Formulation	Cashew apple juice (X1)	Papaya juice (X2)
F1	0,50	0,50
F2	0,625	0,375
F3	0,75	0,25
F4	0,875	0,125
F5	1	0
F6	0,50	0,50
F7	0,75	0,25

$$X1 + X2 = 1 \quad (1)$$

All of these trials were conducted in a randomized fashion.

2.2.4. Modeling and Optimization of the Formulation

After the adjustment step of the mathematical model represented by a system of three equations, the optimal levels of each factor were determined to maximize the refractometric dry extract (Y1), total sugars (Y2) and reducing sugars (Y3). Taking into account the defined objective and constraints, the solution of this system was performed with the Office Excel 2013 software solver and the Design-Expert version 11 software.

2.2.5. Model Validation

Model validation was performed by determining the coefficients of variation (CV) between the calculated values (derived from the application of the optimal factor values to each equation) and the experimental values of each response (derived from complementary experimental testing of the optimal factor levels) and the correlation between these different values.

$$CV(\%) = \frac{|Vp - Ve|}{Vp}.100 \quad (2)$$

Vp: Predicted value and Ve: Experimental value .

2.2.6. Physico-chemical Analyses

2.2.6.1. pH

The pH was determined according to the AOAC method [13], 50 mL of juice was used to determine the pH after calibration of the pH meter (Model CYBERSCAN PH 11).

2.2.6.2. Titratable Acidity

The determination of titratable acidity was done by acid-base assay according to the AOAC method [13]. In the presence of two drops of phenolphthalein, 10 mL of juice contained in an Erlenmeyer flask was assayed with a sodium hydroxide solution (0.1 N). The pink color of the solution allowed to determine the volume of sodium hydroxide required to neutralize the titratable acidity contained in the samples. The titratable acidity was determined from the following formula

$$AT\ (g/L) = \frac{N_{NaOH} \times VNaOH \times 0.064}{V_E} 100 \quad (3)$$

VNaOH = volume of sodium hydroxide required for the determination (mL).
NNaOH = normality of the sodium hydroxide in meq / L
VE = volume of the test sample in mL
0.064 = milliequivalent gram of citric acid

2.2.6.3. Refractometric Dry Extract

The refractometric dry extract was determined by the AOAC method [13]. A drop of the juice cocktail was placed on the glass of the pocket refractometer (Model ATAGO POCKET REFRACTOMETER) to evaluate the number of suspended solids. The reading of the refractometric dry extract value was done in the light, at the eyepiece of the apparatus.

2.2.6.4. Ascorbic Acid Content

The ascorbic acid content is measured by the titration method with 2,6- dichlorophenolindophenol (2,6-DCPIP). The method consists of a reduction of 2,6- DCPIP and an oxidation of ascorbic acid into dehydroascorbic acid. It therefore allows a determination of the vitamin C content in its reduced form (ascorbic acid). Once the oxidation of ascorbic acid is complete, 2,6-DCPIP serves as a color indicator and its presence in solution gives a characteristic pink color [13].

2.2.6.5. Dry matter Rate

The dry matter content was determined according to the steaming method [13]. A crucible of mass Mo containing the sample of mass M1 (10 g) was placed in the oven at 105°C. After three hours, the crucible was cooled in the desiccator to prevent it from gaining moisture before being weighed and returned to the oven. After 30 minutes, the same operation was performed. It was repeated until the masses M2 were approximately the same with a difference of 0.05 g.

2.2.6.6. Protein Content

The protein content was determined according to the AOAC method [13]. Total nitrogen was determined by the Kjeldahl method after sulfuric mineralization in the presence of selenium catalyst. The nitrogen content was multiplied by 6.25 (nitrogen to protein conversion coefficient).

2.2.6.7. Fat Content

The fat content was extracted by hexane in a soxhlet extractor (Unid Tecator, System HT2 1045, Sweden). After evaporation of the solvent and drying of the capsule in an oven at 105°C for 30 minutes, the weight difference gave the lipid content of the sample [13].

2.2.6.8. Ash Content

The ash contents of the cocktails were determined according to the AOAC method [13]. It consisted in calcining five grams (5g) of juice cocktail in an oxidizing muffle furnace at 550 °C for 24 hours.

2.2.6.9. Total Carbohydrates

The total carbohydrate content was determined from the difference between the mass of the sample used and the mass of the non-carbohydrate elements it contains [13].

$$\%C = 100 - (M + P + F + A) \quad (4)$$

C: carbohydrates, M: moisture, P: protein, F: fat and A: ash

2.2.6.10. Energy Value

The energy value (EV) is calculated by applying the thermal coefficients [14] according to the following equation:

$$VE = (4 \times C) + (4 \times P) + (9 \times F) \qquad (5)$$

C: carbohydrates, P: proteins, F: fat.

2.2.6.11. Total phenolic content

The method of [15] was used for the determination of total polyphenols. A volume of 2.5 mL of diluted (1:10) Folin Ciocalteu reagent was added to 30 µL of the sample. The mixture was held for 2 min in the dark at room temperature, and then 2 mL of calcium carbonate solution (75 g/L) was added. Then, the mixture was placed for 15 minutes in a water bath at 50°C and then cooled rapidly. The absorbance was measured at 760 nanometers, with distilled water as a blank. A calibration line was performed with gallic acid at different concentrations.

2.2.6.12. Sugar Content

The total sugar content is determined according to the sulfuric phenol method as as stated by [16].

The method used for the determination of reducing sugars is the one using DNS as phenolic derivative. This method was described by [17].

2.2.7. Microbiological Analysis

The enumeration of total germs concerns mainly aerobic mesophilic bacteria after 72 h of incubation at 30°C on PCA agar. The method used is the one described by the NF V 08-051 standard [18].

The enumeration of yeasts and molds was performed according to the NF-V08-022 standard. The isolation medium used was Sabouraud agar with chloramphenicol (0.05 g/L). Incubation was performed at 37°C for 48 hours in an oven. Total coliforms (TC) and thermotolerant coliforms (THC) were isolated and enumerated on crystal violet and neutral red bile agar (VRBL) (Merck) and TBX agar (Biokar), respectively, according to French standards V 08-015 and V 08-053. After incubation for 24 hours at 37°C and 44°C respectively for TC and THC, the suspected colonies are red or purple for TC and blue for THC. The detection of *Salmonella* was performed according to the AFNOR V-08-013 standard [18]. The search for *Salmonella* was carried out in 3 steps which are successively, pre-enrichment with buffered peptone water and incubation was done at 37°C for 24 hours, enrichment with Rappaport medium followed by incubation at 37°C for 24 hours and finally isolation on Hectoen medium and incubated at 37°C for 24 hours.

The enumeration of sulfite-reducing Clostridium was done according to the standard [18]. In tubes containing TSN (Tryptone-Sulfite-Neomycin) agar in supercooling, 0.1 mL of the stock suspension and each decimal dilution were deeply plated and incubated at 46°C for 24 hours.

2.2.8. Sensory Analysis

The sensory analysis consisted of a descriptive test. The method consisted of evaluating and quantifying the appropriate descriptors (color, cashew apple aroma, mixed cashew/papaya aroma, smoothness, sweetness, acidity, astringency, and general appreciation) on a category scale. The intensity of the descriptors was assessed on a 10 cm unstructured scale. From 0 for less intense descriptor to 10 for extremely intense. The samples were presented to a panel of 15 judges. The judges were composed of women and men. The judges were selected on the basis of their availability and not having an aversion to the product. Their sensory acuity, motivation and ability to describe a product were also criteria for selection. This panel was trained in sensory analysis. The samples were coded (with three digits) and presented in a monadic way to each panelist.

3. Results and Discussion

3.1. Results

3.1.1. Response Modeling

After completing the seven trials of the experimental mixing design matrix, the experimental response values are presented in Table 2.

Table 2. Matrix of experiments, experimental design and experimental answers

Tests	Cashew apple	Papaya	Experimental answers: RDE	Total sugars	Reducing sugars
1	0,5	0,5	11	129,55	125,77
2	0,625	0,375	10	126,85	123,22
3	0,75	0,25	9,35	124,25	120,7
4	0,875	0,125	8,8	121,45	117,9
5	1	0	8,5	118,9	115,4
6	0,5	0,5	10,95	129,5	125,82
7	0,75	0,25	9,38	124,3	120,75

The values of the experimental responses are the averages of three determinations for each test. RDE : Refractometric dry extract (°B).

3.1.1.1. Refractometric Dry Extract (Y1)

According to the results of the analysis of parameters representing our responses from the different. From the results of the analysis of the parameters representing our responses from the different trials (Table 2), it can be seen that the refractometric dry extract content of the 7 trials varies between 8.5 and 11°B, the highest content was observed in trial 1 (50% cashew apple juice and 50% papaya juice sample) while the lowest content was observed in trial 5 (100% cashew apple juice sample). The combination of these factors has an impact on the RDE. The model equation is written in the following form:

$$\mathbf{Y_1} = 8,49926\mathbf{A} + 16,59399\mathbf{B} - 6,32147\mathbf{AB} \qquad (6)$$

3.1.1.2. Total Sugars (Y2)

The total sugars content of the 7 trials varied between 118.9 and 129.55 mg / mL, the highest content was observed in trial 1 (sample 50% cashew apple juice and 50% papaya juice) while the lowest content was found in trial 5 (sample 100% cashew apple juice). The interaction of these factors has an influence on total sugars. The model equation is written in the following form:

$$\mathbf{Y_2} = 118,86564\mathbf{A} + 139,95276\mathbf{B} + 0,464622\mathbf{AB} \qquad (7)$$

3.1.1.3. Reducing Sugars (Y3)

The reducing sugars content of the 7 trials varied between 118.9 and 129.55 mg / mL, the highest content was observed in trial 6 (sample 50% cashew apple juice and 50% papaya juice) while the lowest content was found in trial 5 (sample 100% cashew apple juice). The interaction of these factors has an influence on total sugars. The model equation is written in the following form:

$$\mathbf{Y_3} = 115,35485\mathbf{A} + 135,53791\mathbf{B} + 1,40303\mathbf{AB} \qquad (8)$$

The equation system established, using the three equations obtained, constitutes our mathematical model

$$\begin{cases} \mathbf{Y_1} = 8,49926\mathbf{A} + 16,59399\mathbf{B} - 6,32147\mathbf{AB} \\ \mathbf{Y_2} = 118,86564\mathbf{A} + 139,95276\mathbf{B} + 0,464622\mathbf{AB} \\ \mathbf{Y_3} = 115,35485\mathbf{A} + 135,53791\mathbf{B} + 1,40303\mathbf{AB} \end{cases}$$

With A: Proportion of cashew apple juice and B: Proportion of papaya juice and AB: interaction between A and B

3.1.2. Analysis of Variance of Responses and Model Validity

The analysis of variance (ANOVA), fit summary, and coefficient of determination R^2 of the suggested mathematical models representing the results of the binary mixture designs used are shown in Table 3, respectively. The statistical significance of the sources of variances of the models was set at 0.05. The p-value for each response is less than 0.05 and therefore significant. For the lack of fit, the value of each response is greater than 0.05, so the Lick of Fit is not significant. As for the coefficient of determination R^2, it defines the ratio of the variation of the responses that is explained by the model. All these coefficients are close to 1 (0.99). The R^2 values indicated that the mixture regression models accounted for 99% of the variability in the experimental data. Therefore, they were found to be adequate in estimating the attributes estimated in the study.

Table 3. Result of the analysis of variance of the parameters (answer)

Model	Quadratic		
	RDE (°B)	**Total sugars**	**Reducing sugars**
Mean	11,05±0,58	130,1±0,45	125,15±0,35
F	1770,13*	9387,83*	6006,62*
P	0,0001*	0,0001*	0,0001*
Lick of fit	$0,2590^{ns}$	$0,1232^{ns}$	$0,0824^{ns}$
R^2	0,9989	0,9998	0,9997
R^2-Adjusted	0,9983	0,9997	0,9995

*: Significant ($p \leq 0.05$), ns: Not significant ($p \geq 0.05$), RDE (°B) : Refractometric dry extract (degree brix)

3.1.3. Optimization and Verification of the Predictability of the Models

The objective of our study is to maximize the levels of the different responses (RDE, total sugars, and reducing sugars), while ensuring the proportion of cashew juice in the range of 0.5 to 1 or 50 to 100% and that of papaya from 0 to 0.5 or 0 to 50%. Table 4 indicates that the achievement of these maximum contents is possible with a global desirability of about 0.994 when the following optimal conditions are achieved: Cashew apple juice (A) = 0.5 or 50% and Papaya juice (B) = 0.5 or 50%. The results reported in Table 4 show that there is no significant difference between the experimental and predicted responses. This table also shows a comparison between the predicted and experimentally observed response values under the optimal conditions. Indeed, the coefficient of variation is respectively 0.72, 0.44 and 0.52 for RDE, total sugars and reducing sugars. In general, the coefficients of variation being all lower than 5%, far from 15%, the mathematical model established is thus validated in the experimental field thus defined.

Table 4. Result of the model validation test

Optimized proportions	50% Cashew apple juice	50% papaya juice	Global desirability of 0.994
Reponses	Y1	Y2	Y3
Experimental values	11,05±0,1	130,1±0,7	125,15±0,7
Predicted values	10,97	129,53	125,8
Coefficient of variation (%)	0,72	0,44	0,52

Table 5. Physico-chemical and biochemical parameters of different cashew apple and papaya juice formulation

Parameters	**Cashew apple juice**	**Optimized juice (F1)**	**Papaya juice**
pH	4,1±0,10	4,3±0,2	4,6±0,14
Titratable acidity (g/L Eq citric acid)	0,58±0,02	0,53±0,04	0,50±0,02
Refractometric dry extact (°B)	8,45±0,58	11±1	12,83±0,24
Moisture (%)	91,73±0,06	90,55±0,05	90,13±0,12
Dry matter (%)	8,27±0,06	9,45±0,05	9,87±0,12
Lipids (%)	0,08±0,01	0,08±0,01	0,09±0,01
Proteins (%)	0,7±0,1	0,83±0,12	0,9±0,08
Carbohydrates (%)	6,79±0,05	7,5±0,07	7,9±0,02
Total sugars (mg / mL)	118,9±0,45	130,1±0,35	145,93±0,35
Reducing sugars (mg / mL)	115,4±0,4	126,82±0,25	141,62±0,12
Total phenolic (mg / 100 mL Eq Gallic acid)	227,28±0,21	120,65±0,13	41,83±0,06
Vitamin C (mg / 100 mL)	290,84±0,77	115,37±0,34	47,22±0,51
Energy Value (Kcal/100mL)	30,68±0,5	34,04±0,3	36,01±0,5

The values are the averages of three determinations for each parameter.

Table 6. Mineral compositions of different formulations based on cashew apple juice and papaya juice

	Different formulations based on cashew apple and papaya juice		
Parameters	**Cashew apple juice**	**Optimized juice (F1)**	**Papaya juice**
Ash (%)	0,24±0,03	0,37±0,05	0,53±0,04
Calcium (mg / L)	210,5±4,5	316,6±6,71	332,3±5,19
Sodium (mg / L)	9,27±0,05	6,61±1,15	5,25±0,3
Magnesium (mg / L)	157,36±3,58	158,71±2,39	18,4±1,37
Potassium (mg / L)	1135,19±5,09	1406,88±5,39	1863,8±4,92
Fer (mg / L)	0,68±0,06	0,83±0,02	0,92±0,05
Zinc (mg / L)	0,14±0,03	0,13±0,02	0,12±0,01

The values are the averages of three determinations for each parameter.

3.1.4. Physico-chemical Properties of the Optimized Formulation

The different formulations were optimized in order to maximize the RDE, total sugars and reducing sugars contents. The formulation optimized with the Design-Expert version 11 software is F1. It consists of 50% cashew apple juice and 50% papaya juice. Its physico-chemical and biochemical composition is recorded in Table 5. Its pH, RDE, total sugars, reducing sugars, total phenolic and vitamin C are respectively 4.3±0.2, 11±1, 130.1±0.35, 126.82±0.25, 120.65±0.13 and 115.37±0.34. This formulation (F1) is also rich in mineral elements (Table 6) such as: calcium 316.6±6.71, sodium 6.61±1.15, magnesium 158.71±2.39, potassium 1406.88±5.39, iron 0.83±0.02, and zinc 115.37±0.34.

3.1.5. Microbiological Characterization of the Optimized Formulation

Table 7 presents the microbiological characteristics of the formulations. The aerobic mesophilic flora of the formulations is lower than 10^6, according to the French standard, whatever the food, the aerobic mesophilic flora must be lower than 10^6. Total coliforms and thermotolerant coliforms with colony forming units (UFC/mL) lower than 10 were observed in all formulations. *Salmonella*, sulfite-reducing anaerobes, yeasts and molds were not detected in any of the formulations. The results of the microbiological analysis show that the different formulations are of satisfactory quality.

Table 7. Microbiological characterization of different formulations based on cashew apple juice and papaya juice

	Different formulations based on cashew apple and papaya juice			
Germs	**Cashew apple juice**	**Optimized juice (F1)**	**Papaya juice**	**EU criteria., 2005**
AMG à 30°C	> 300ufc/mL	> 400ufc/mL	> 450ufc/mL	-
TC	3	4	3	10 ufc/mL
THC	2	2	2	10 ufc/mL
SRA	ND	ND	ND	ND
Salmonella spp	ND	ND	ND	ND
Yeasts	ND	ND	ND	ND

The values are the average of three tests for each germ. ND: Not detectable, AMG : Aerobic mesophilic germs, TC: Total coliforms, THC: Thermotolerant coliforms, SRA: Sulfite-reducing anaerobes.

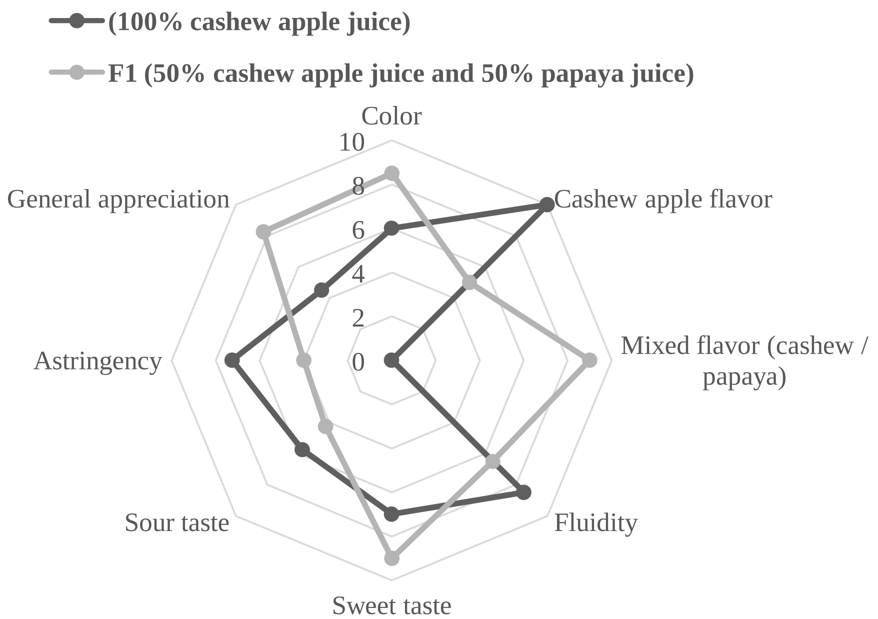

Figure 4. Sensory profile of formulations (cashew apple juice) and F1 (50% cashew apple juice and 50% papaya juice

3.1.6. Descriptive Test

Figure 4 shows the average sensory characteristics of the raw cashew apple juice and the optimized F5 drink (50% cashew apple juice and 50% papaya juice). The characteristics studied were: color, aroma, fluidity, flavor and astringency. The F1 formulation has a yellow-orange color while the raw cashew juice is yellow in color. The color of the F1 formulation is more appreciated by the tasters with an average of 8.5 against 6 for the raw cashew juice. This formulation (F1) has a much more pronounced mixed cashew apple and papaya). The raw cashew juice is more fluid compared to the F1 formulation. The F1 formulation is sweeter (9 cm) than the raw cashew juice (7 cm). This formulation is less acidic (4.25 cm) and less astringent (4 cm) than the pure cashew apple juice, which has an acidity of 5.75 cm and an astringency of 7.25 cm. Overall, the F1 formulation was well rated by tasters (8.5 cm).

3.2. Discussion

The analysis of variance presented in Table 3 suggests quadratic models. These models respectively relate responses (refractometric dry extract, total sugars and reducing sugars) to factors (cashew apple juice and papaya juice). Indeed, the interaction between the components of the mixture produces a good correlation with the quadratic model. The values of this correlation R^2 is close to 1 (R^2 = 0.99). They indicate that for all the answers there is a good adequacy between the studied models and the experimental answers. These results corroborate those of [19,20] carried out on the optimization of the formulation of a fruit drink by mixing designs. The closer the R^2 value is to 1, the better the model's goodness of fit is, the R^2-Adjusted is good. The R^2-Adjusted is a correction made to the R^2 value. The coefficients of variation (%) between the predicted and experimental values for each response have been calculated and the values found are less than 5%. The experimental values were in good agreement with the predicted values confirming the predictability and validity of the models [21].

The sensory profiles of the two formulations show that the F1 formulation (50% cashew apple juice and 50% papaya juice) is orange-yellow in color, less acidic and less astringent. This decrease in astringency could be explained by a decrease in polyphenol content. This seems to be in agreement with the low phenolic content of F1 which is 120.65±0.13 mg / 100 mL Eq Gallic acid. This content, naturally high in raw cashew juice [6] is responsible for the astringency of the latter [6,9]. The Brix values of the formulations are close to [1]. The raw cashew juice is appreciated as less sweet than the optimized formulation (F1). This is probably due to the concentration of sugars provided by the papaya juice.

The pH of the two formulations is 4.1 and 4.3 respectively with an acidity of 0.53 and 0.58 g/L citric acid. These values are close to those obtained by [22] on raw cashew apple juice with a pH of 4.15 and a titratable acidity of 0.48%. Fruit juices generally have a low pH because they are relatively rich in organic acid [23]. This acidic pH could determine the storage stability of juices [24,25]. Although the increase in titratable acidity reflects a decrease in pH, the titratable acidity determines the acidic taste of the juice while the pH determines its susceptibility to microbial spoilage or has antimicrobial properties and the low pH controls the growth of pathogenic microorganisms [26]. Quantification of the mineral elements of both formulations shows a significant amount of ash. The ash of the F1 formulation is composed in part of calcium (316.6 mg/L), followed by sodium (6.61 mg/L), magnesium (158.71 mg/L), potassium (1406.88 mg/L), iron (0.83 mg/L), and zinc (0.13 mg/L). The most abundant are potassium, calcium and magnesium. [26] reported similar findings on blended juices. Potassium is an essential mineral; it plays a role in the transmission of nerve impulses, helps maintain the body's water and acid balance, and prevents bone demineralization by preventing the loss of calcium in the urine [5,26]. Its deficiency is rare and its intake is useful in the prevention of hypertension [27]. Therefore, potassium intake can be increased from the consumption of citrus fruits. Magnesium plays an important role in the stability of the nervous system, in muscle contraction as an activator of alkaline phosphatase. Minerals are micronutrients that play an important role in the metabolic processes of the human body. Insufficient intake of micronutrients (minerals) has been associated with severe malnutrition, increased disease and mental disorders [28]. The consumption of fruits and vegetables improves the regulation of the body's mineral content and reduces the risk of cardiovascular disease and cancer. Apart from the minerals, the different formulations are rich in vitamin C. However, the raw cashew apple juice is the highest with a content of 270.84 mg/mL. This value is higher than that of the F1 formulation and the papaya juice. Thus, cashew apple juice is generally can be used to improve the nutritional quality of other tropical fruit juices with low vitamin C content such as mango, pineapple and papaya. Indeed, vitamin C plays an antioxidant role and has several benefits for health [26]. Ascorbic acid is used not only to fortify the food and losses during processing, but also contributes to the stability of the product [26].

The results of microbiological analysis of different formulations show that the environmental conditions are unfavorable for the development of microorganisms. These analyses are generally used to control the spoilage index of foods [29]. This could be explained by the fact that most bacteria do not grow at low pH, as is the case in the juices analyzed in the present study. The same observation was made by [25].

4. Conclusion

The use of the mixing design method method has allowed us to develop meaningful significant models with a good level of predictability predictability for estimating parameters such as RDE (°B), total sugars and reducing sugars of compound formulations (cashew apple juice and papaya juice) for their valorization. Coefficient of determination values also confirmed the high degree of correlation between observed and predicted values. The optimization showed that 50% cashew apple juice and 50% papaya juice can be used with a global desirability of 0.994 to maximize the RDE (°B), total sugars and reducing sugars contents. The prospect of adding value to cashew apples and papaya seems interesting for two reasons. On one hand, it is in line with the policies of valorization of fruits and vegetables in Ivory Coast, and on other hand, from a nutritional point of view, it gives birth to a new product rich in nutrients and beneficial for the consumers. Indeed, this richness makes this formulation a potential substrate in the bioconversion of sugar materials, specifically in wine making.

Importance of Current Research

This study is in line with the research approach of valorization of our agricultural products through the processing of cashew apple and papaya. Thus, it will not only reduce post-harvest losses, but also make these fruits available on the market all year round by proposing a new product.

Conflict of Interest

The authors of this manuscript declare that no conflicts of interest exist.

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