



Ginger Nectar Formulation Based on Oleoresin Using a Central Composite Design

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Authors' contributions

This work was carried out in collaboration among all authors. Author GHMB supervised the whole investigation. Author DS designed the study, performed the experiment and wrote the manuscript assisted with authors AC and YN. Authors BLO and YNK performed the statistical analysis of the results and checked the revised manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims : This study aims to determine the organoleptic characteristics of different formulations nectars elaborated with ginger oleoresin.

Study Design : Ginger nectars were formulated, using a composite central plan, from oleoresin or ginger rhizome, lemon juice and sugar. Then, they were subjected to sensory analyzes.

Place and Duration of Study : The study was conducted, between November and December 2017, at the Biochemistry and Food Sciences Laboratory of the Félix Houphouët-boigny University.

Methodology : Seventeen (17) nectars formulas were established by considering varying amounts of three ingredients: oleoresin (X1), sugar (X2) and lemon juice (X3) according to a composite experimental plan. The acceptance of these nectar formulas with consumers has been estimated. The intensities of perception of their color, texture and flavor were also evaluated relative to the artisanal nectar of ginger taken as a control. The sensory evaluation was carried out by panels of tasters.

Results : The hedonic analysis indicates that in addition to the control Ft accepted at 91.43% by the tasters, the formulations F2; F8; F12; F13 and F14 are preferred in proportions ranging from 57.14% to 77.15%. The intensities of the organoleptic characteristics of these nectars are translated by sensory profiles. The formulations F2; F8; F12; F13 and F14 are yellow while the control is brown. As regards the texture, the control has a turbidity more pronounced than the formulations. While the intensities of the fluidity and homogeneity are higher for formulations F2; F8; F12; F13 and F14 than the control. In addition, the control Ft appears sweeter and more acidic than the formulations. This character is also observed in the flavors of gnamankou and lemon.

Conclusion : The formulations F2; F8; F12; F13 and F14 close to the witness would be indicators for producers of ginger nectar.

Keywords: Nectar; ginger rhizome; ginger oleoresin; composite central plan; sensory analysis.

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) is a plant species of tropical and subtropical regions cultivated for its aromatic rhizomes [1]. The ginger rhizome is a spice known for millennia for its culinary values. It is used as spice to enhance the taste of food. It also has many medicinal properties [2]. Thus, ginger rhizomes were used in traditional Chinese medicine to relieve pains resulting from arthritis, rheumatism and sprains [3]. These functional properties of ginger have been attributed to the antioxidant power of the constituents of its essential oil and its oleoresin [4].

The oleoresin extracted from the ginger rhizome is brown in color and also contains many rhizome characteristics [5]. It is the origin of the pungent flavor of ginger. Some studies of composition of the ginger oleoresin have revealed major constituents including gingerol, shogaol and zingerone [5]. These compounds belong to the group of polyphenols or antioxidants of plant origin [6]. Antioxidants of plant origin are compounds capable of trapping the free radicals permanently generated by the human body in response to external aggressions [7]. In view of their great biological importance to health, plant-derived antioxidants are of great interest and their use is more strongly recommended as a substitute for synthetic antioxidants such as butyl hydroxyanisole (BHA) and butyl hydroxytoluene (BHT) which have been shown to be toxic and carcinogenic [8]. Indeed, gingerol and its derivatives, from ginger, are biomolecules active in the prevention and treatment of gastric and

colorectal cancers, prostate and ovaries [9]. In the food industry, their antioxidant property is used to inhibit microbial and fungal growth to conserve food [10]. However, in Ivory Coast ginger is still consumed in the raw state, sometimes in the form of pellets, but mostly used to produce an artisanal drink commonly called "gnamankoudji" [11]. Yet the producers of this drink are confronted with a starch deposit that is often depreciated by many consumers. There is also the problem of the low water solubility of ginger oleoresin. This results in the elimination of this fraction during the production of ginger juice resulting in more or less pronounced loss of its pungent flavor and its antioxidant power. In response, some producers of ginger juice use pepper to restore the pungent flavor generally appreciated by consumers. The ginger rhizome is a spice known for millennia for its culinary values. It is used as spice to enhance the taste of food. It also has many medicinal properties. Thus, ginger rhizomes were used in traditional Chinese medicine to relieve pains resulting from arthritis, rheumatism and sprains. These functional properties of ginger have been attributed to the antioxidant power of the constituents of its essential oil and its oleoresin. Inflammatory disorders such as gastritis, esophagitis, and hepatitis, which are caused not only by infectious agents such as viruses, bacteria, and parasites but also by physical and chemical agents like heat, acid, cigarette smoke, and foreign bodies, are recognized as risk factors for human cancer [12]. Ginger consumption before exercise might reduce naturally occurring quadriceps muscle pain during moderate-intensity cycling exercise. This effect may be due

to anti-inflammatory effect of ginger and further investigation need to prove it in human [13].

The production of nectar from oleoresin extracted from ginger could in this case seem like solution for producers and consumers, considering the antioxidant and taste potentialities of this fraction. The present work aims to be a contribution to the valorization of ginger through the sensory characterization of nectars formulated with ginger oleoresin using a plan of composite experimentation.

2. MATERIALS AND METHODS

2.1 Biological Material

The biological material consists of ginger oleoresin supplied by Gazignaire (France); lemons (*Citrus aurantifolia*), ginger rhizomes (*Zingiber officinale roscoe*) from the towns of Tiassalé and Herman-Kono and refined cane sugar purchased commercially. Rhizomes and lemons were purchased from 3 different vendors,

between November and December 2017, at the rate of 5 kg and 2 kg per vendor respectively.

2.2 Production of Nectars Based on Ginger Oleoresin

2.2.1 Standard production of nectar

In 1000 ml Erlenmeyer flask containing 1 g of oleoresin, 5 ml of ethanol 96% was added. The mixture was homogenized until complete dissolution of the oleoresin. Then 500 ml of distilled water, 50 ml of lemon juice and 100 g of refined cane sugar were added to the obtained solution. This step was followed by the addition of sufficient quantity of distilled water for the total dissolution of sugar. The mixture was filtered through a sieve of mesh size 75 µm of diameter, then transferred to a 1 L test tube and the volume was brought to the mark with distilled water. The nectar thus formed was packaged in a 1 L glass bottle and refrigerated (Fig. 1).

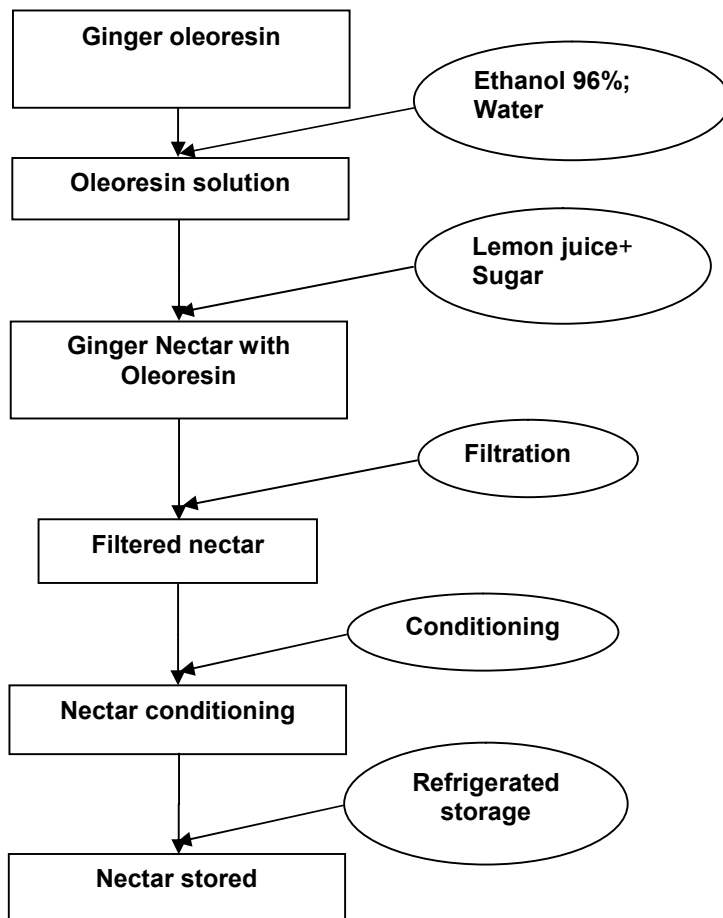


Fig. 1. Diagram of ginger oleoresin nectar manufacturing

2.2.2 Nectar formulation based on ginger oleoresin using composite central plan

A composite central plan (CCP) was used to develop different oleoresin-based nectar formulas for different proportions of the influencing parameters. Thus, the experimental field of the study consisted of 3 factors that take into account the oleoresin / nectar ratio (X1), the sugar / nectar ratio (X2) and the ratio of lemon juice / nectar (X3) (Table 1). The resulting composite central plan comprises 8 factorial tests, 6 star-shaped tests and 3 trials at the center of the experimental domain, either 17 formulations to be carried out (Table 2). Axial values were determined using equation 1.

$$X_k = X_{cent} + Z_k \times \frac{X_{max} - X_{min}}{Z_{max} - Z_{min}} \quad (1)$$

With;

- X_k= factor coded value,
- X_{cent}= actual value of the same factor at the center;
- Z_k= coded value of the limit of variation.

2.3 Production of Nectars from Ginger Rhizomes

The ginger rhizomes were soaked in water for 1 hour and peeled to remove sand and dandruff. Then, the rhizomes were crushed then 100 g of ground material was diluted in 500 mL of water. The mixture was filtered through sieve of mesh size 75 µm. The filtrate was decanted for 30 minutes and the supernatant was separated from the pellet. To the supernatant, 100 g of sugar and 50 ml of lemon juice were added. The mixture was filtered and transferred to 1 L test tube and the volume was brought to the mark with distilled water. The nectar thus formed was stored in 1 L glass bottle and conserved in the refrigerator for further analysis as control formulation (Ft). Each ginger oleoresin or ginger rhizome nectar production trial was undergone hedonic and descriptive analysis.

2.4 Sensory Analysis of Nectars

The ginger oleoresin-based nectars, formulated from the composite central plan, were subjected to sensory analyzes from tasting tests conducted at the Biochemistry and Food Sciences Laboratory of the Félix Houphouët-Boigny University. Descriptive tests and hedonic assessment tests were performed. These elaborate formulas have been tested against nectar produced from ginger rhizomes.

2.4.1 Descriptive analysis

The descriptive sensory analysis of nectars based on ginger oleoresin was intended to objectively clarify the intensity of perception of their sensory properties. Thus, the analyzes consisted of evaluating the intensity of the coloration (yellow, brown), the aroma (gnamankou and lemon), the flavor (sweet, acidic and pungent) and the texture (fluid, homogeneous and turbid) of the nectars. These analyzes required a panel of human subjects previously trained to recognize and identify the perceived levels of descriptors.

Selection and training of panelists: 25 volunteers were recruited on the basis of their availability and ability to distinguish aromas, colors, flavors and textures from liquid foods. These people were trained in the methodology of analysis and appreciation of the qualitative characteristics of ginger nectar and then learned about the taste areas of the language. At the end of the selection tests, a panel of 15 qualified tasters was formed. These tasters were familiarized of commercially available ginger nectars during 8 tasting sessions before performing the sensory description of the formulated nectars.

Descriptive analysis of nectars based on ginger oleoresin: The actual nectar tasting based on ginger oleoresin was realised by serving each panelist with 30 mL of each nectar sample in disposable plastic glasses of the same

Table 1. Experimental parameters of the composite central plane

	Coded levels/ Actual values				
Main factors (X)	-1,682	-1	0	+1	+1,682
Oleoresin / nectar ratio (m/v) : X ₁	0.025/100	0.041/100	0.063/100	0.085/100	0.1/100
Ratio sugar / nectar (m/v) : X ₂	1/100	2.82/100	5.5/100	8.18/100	10/100
Ratio of lemon juice / nectar (v/v) : X ₃	1/100	1.81/100	3/100	4.19/100	5/100

Table 2. Experimentation of the composite central plan

Test group	N° Essais	Real values of the parameter levels		
		X1 (m/v)	X2 (m/v)	X3 (v/v)
Factorial assays	1	0.041/100	2.82	1.81
	2	0.085/100	2.82	1.81
	3	0.041/100	8.18	1.81
	4	0.085/100	8.18	1.81
	5	0.041/100	2.82	4.19
	6	0.085/100	2.82	4.19
	7	0.041/100	8.18	4.19
	8	0.085/100	8.18	4.19
Assays in star	9	0.025/100	5.5	3
	10	0.1/100	5.5	3
	11	0.063/100	1/100	3
	12	0.063/100	10/100	3
	13	0.063/100	5.5	1/100
	14	0.063/100	5.5	5/100
Assays in center	15	0.063/100	5.5	3
	16	0.063/100	5.5	3
	17	0.063/100	5.5	3
	Niveau -1	0.041/100	2.82	1.81
	Niveau +1	0.085/100	8.18	4.19
	Niveau 0	0.063/100	5.5	3

X_1 = oleoresin/nectar ratio (m/v); X_2 = sugar/nectar ratio (m/v); X_3 = ratio of lemon juice/nectar (v/v)

appearance and coded. The different samples were presented monadically to each panelist in a randomized order. After placing each sample in the mouth, the panelist then indicated the value of the perceived intensity for each evaluated parameter. A rating scale of these intensities, 14 cm in amplitude, has been designed for this purpose: the mark at 0 cm indicates the total absence of perception of the sensory parameter whereas at 14 cm the parameter is extremely perceived [14]. Rinsing of mouth with milk and water after each sample is done by the panelists.

Hedonic analysis: The hedonic analysis was conducted with a group of 60 untrained people, between the ages of 20 and 40, all genders included. Each nectar was appreciated for the pleasure of its characteristic aroma, flavor, texture and color. Overall acceptance of each sample was also estimated. For this analysis, 30mL of each ginger nectar was served to the tasters in plastic glasses of the same appearance and coded, in random order. After the sample was placed in the mouth, the panelist's satisfaction with each descriptor was expressed on a scoring sheet provided for this purpose. This sheet has a scale of 9 points of amplitude; level 1 reflects total dissatisfaction with the sample parameter, while level 9 indicates the extreme pleasure that is felt [15].

2.5 Statistical Analysis

For descriptive sensory analysis data, the homogeneity of means was evaluated by one-way analysis of variance (the nectar formula), using the Statistical Program for Social Sciences software (SPSS 22.0, USA). As for hedonic analysis, khi-square test (X^2) for comparison of proportions has been performed [16]. In addition, multivariate principal component analysis (PCA) was performed using the STATISTICA version 7.1 software to structure the variability between the nectars and their sensory descriptors.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Descriptive sensory profile of nectars

Coloration of the nectars: The coloration of formulations is analyzed through the yellow and brown colors (Fig. 2). The intensity of yellow color varies between 10.20/14 and 1.83/14. It is more intense in formulations F4 (8.83/14), F12 (9.16/14), F14 (9.20/14), F11 (9.41/14), F9 (9.45/14), F8 (9.79/14), F15 (10.08/14), F16 (10.08/14), F17 (10.08/14) and F10 (10.20/14). While this coloration is practically absent (1.83/14) in the control (Ft). This control formulation has a high intensity of maroon color (10.08/14) unlike test formulations (0.00/14).

Texture of the nectars: The texture of the formulations is analyzed through the determination of turbidity, homogeneity and fluidity (Fig. 3). The turbidity varies from one formulation to another ($p < 0.001$): the control appears more turbid (10.67/14) whereas the oleoresin-based formulations have only turbidity values of between 2, 13/14 (F10) and 5.54/14 (F13). On the other hand, the tasters estimate that the formulas F2, F3, F4, F5, F8, F9, F10, F14, F15, F16 and F17 are more homogeneous ($p < 0.012$), with values varying between 11.96/14

and 12.92/14. The control has the lowest homogeneity value (9.67/14). Nevertheless, all the analyzed formulations have a good fluidity, oscillating between 10.79/14 and 12.58/14, without statistically differentiating the formulations at 5% risk ($p < 0.236$).

Flavor of the nectars: The flavors of the nectars evaluated are sweetness, acidity, piquancy and astringency (Fig. 4). The sweet taste of the nectars varies according to the formulas ($p < 0.001$). Thus, the control Ft (11.67/14)

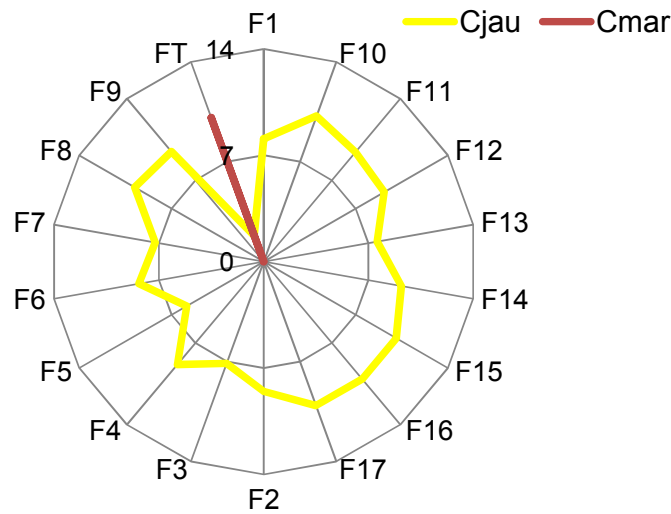


Fig. 2. Intensity of yellow (Cjau) and brown (Cmar) coloration of nectars formulated with ginger

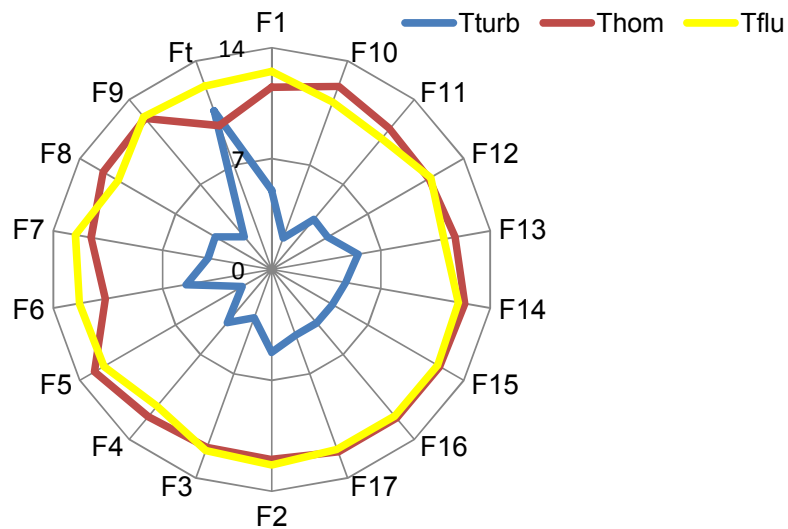


Fig. 3. Level of perception of the turbid (Tturb), homogeneous (Thom) and fluid (Tflu) appearance of the nectars formulated with ginger

and the sample F12 (11.75/14) have the highest values of sweetness whereas the formulation F11 appears less sweet. The acidic flavor has values between 2.50/14 and 9.29/14 and also differentiates the formulations ($p < 0.001$). The formulation F5 is considered more acidic while the lower acidity is perceived in the formulation F13. Furthermore, the formulations F2 (6.92/14), F11 (6.96/14), F15 (7.42/14), F16 (7.42/14), F17 (7.42/14), F10 (8,17/14) and Ft (8,42/14) had pungent flavors statistically superior ($p < 0.001$) to those seen in the formulations F5 (3.00/14) and F9 (3.13/14). As for the astringent flavor, it is generally less expressed in the formulations studied; the averages fluctuating between 0.69/14 and 6.21/14. However, Fig. 3 shows that formulations F1 (6.00/14) and F8 (6.21/14) contain greater astringency ($p < 0.001$) compared to the insignificant astringency of formulations F9 (0.69/14), F4 (1.25/14), Ft (1.50/14), F13 (1.58/14) and F12 (1.83/14).

Aroma of the nectars: The values of the gnamankou (ginger) and lemon flavors of the formulated drinks and the control are presented in Fig. 5. The gnamankou aroma is statistically invariable in formulations (3.53/14 to 7.25/14). But it is more intense ($p < 0.001$) in control Ft made from ginger rhizomes (11.17/14). A clear variation of lemon aroma is also obtained in the drinks. For this descriptor, the formulation F14 provides the greatest intensity (9.79/14), while F13 produces the least (2.92/14).

3.1.2 Sensory acceptance of formulations

The sensory acceptance of the formulations considered pleasant by the tasters is presented in Table 3. Thus, in addition to the control Ft, the formulations F2, F8, F12, F13 and F14 are generally accepted by the tasters. Indeed, the control formulation (Ft) is accepted by almost all the panelists (91.43%). For the oleoresin-based test formulations, the proportions of tasters who accepted them ranged from 57.14% to 77.15%; while 8.57% to 34.28% of tasters do not accept or reject these formulations. In contrast 8.57% to 22.86% of the tasters did not accept the nectar formulations against 0.00% for the control.

3.1.3 Description of sensory variability of nectar formulations

At the end of the principal component analysis, 5 components, with eigenvalues between 0.12 and 6.08, make it possible to describe the sensory variability of the formulations (Table 4). Among these 5 factors, the first two components (1 and 2) have respective eigenvalues of 6.08 and 2.7 and express 79.82% of the total variability. These components made it possible to represent in the plane the correlation between the formulations and the sensory descriptors (Fig. 6). The projection in the plan 1-2 of the principal component analysis shows the correlations of Sensory descriptors (Fig. 6a) and formulations (Fig. 6b) on the two axes of this plan. It is

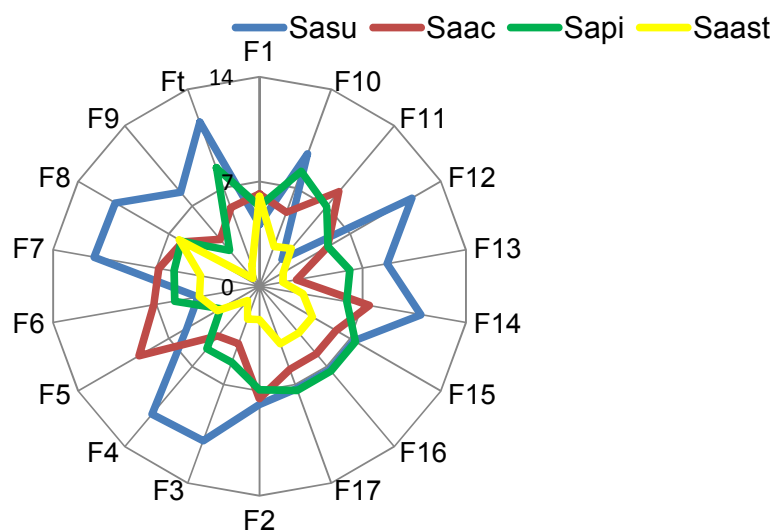


Fig. 4. Intensity of flavors sweet (Sasu), acid (Saac), piquant (Sapi) and astringent (Saast) of the nectars formulated with ginger

Table 3. Percentage of panelists reflecting their preference for acceptance of ginger oleoresin nectar samples and control

Levels of appreciation		1	2	3	4	5	6	7	8	9	Percentage of acceptance (%)	X ²	p
General trend		Dissatisfaction			NANR		Acceptance						
Theoretical distribution (%)		11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11	11.11			
Formulation	Ft	0.00	0.00	0.00	0.00	8.57	37.14	25.71	20.00	8.57	91.42	132.91	<0.0001
	F12	0.00	0.00	5.71	8.57	8.57	28.57	34.29	2.86	11.43	77.15	107.93	<0.0001
	F8	5.71	0.00	2.86	11.43	20.00	22.86	25.71	8.57	2.86	60	65.31	<0.0001
	F2	0.00	0.00	2.86	17.14	20.00	42.86	11.43	5.71	0.00	60	143.2	<0.0001
	F14	0.00	2.86	0.00	20.00	20.00	34.29	11.43	8.57	2.86	57.15	97.64	<0.0001
	F13	0.00	0.00	0.00	8.57	34.28	31.43	17.14	2.86	5.71	57.14	131.44	<0.0001

NANR: neither accepted nor rejected; F: formulation; X²: Khi-square statistical test value; P: value of the observed probability.

The values of P <0.05 indicate a significant difference between the percentages of panelists corresponding to the levels of appreciation of each sensory parameter.

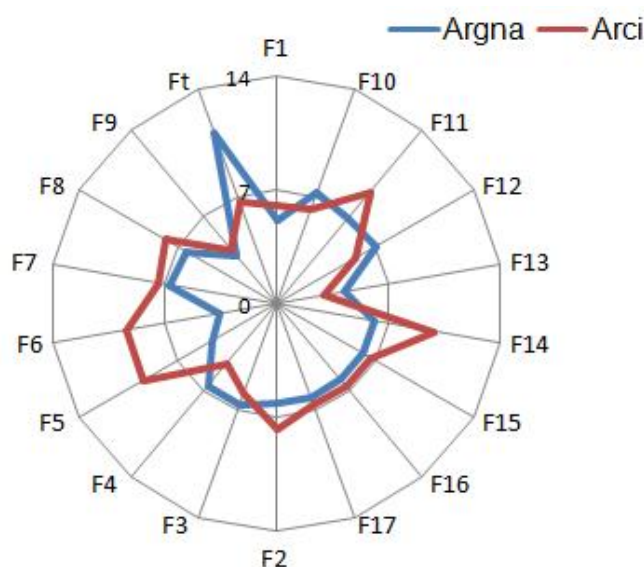


Fig. 5. Intensity of perception of aroma of gnamankou (Argna) and lemon (Arci) of nectars formulated with ginger

observed that the turbidity, fluidity, the brown color, the pungent flavor and the gnamankou aroma are positively correlated with the component 1, as is the control Ft. The control nectar is therefore distinguished by larger values of these parameters. Concerning the formulations, f2 and f14 are characterized by the most intense sensory values relating to acid flavor and lemon aroma; while f8 and f12 have greater homogeneity and a more pronounced yellow color.

3.1.4 Composition of most accepted nectar formulas

Table 5 shows the composition of sugar, lemon juice and oleoresin or broyat of ginger of formulations F2, F8, F13, F14 and Ft having been accepted by more than 50% of panelists. The oleoresin content of 1 L of formulations F2, F8, F13 and F14 ranged from 0.63 g to 0.85 g. While, the amount of sugar of these formulations is between 28.20 g and 100 g and the volume of lemon juice varies between 18.10 mL and 50 mL. However, 1 L of the control formulation is made

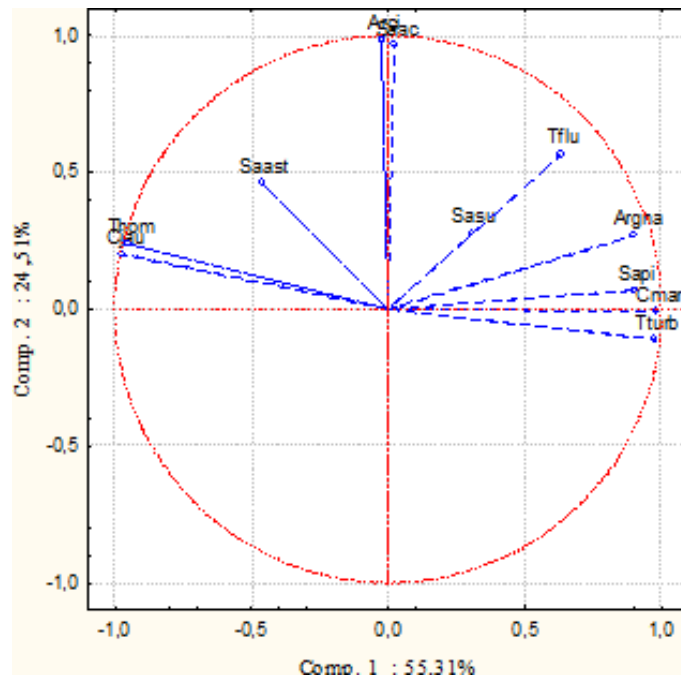
from 100 g of crushed ginger, 100 g sugar and 50 ml of lemon juice.

4. DISCUSSION

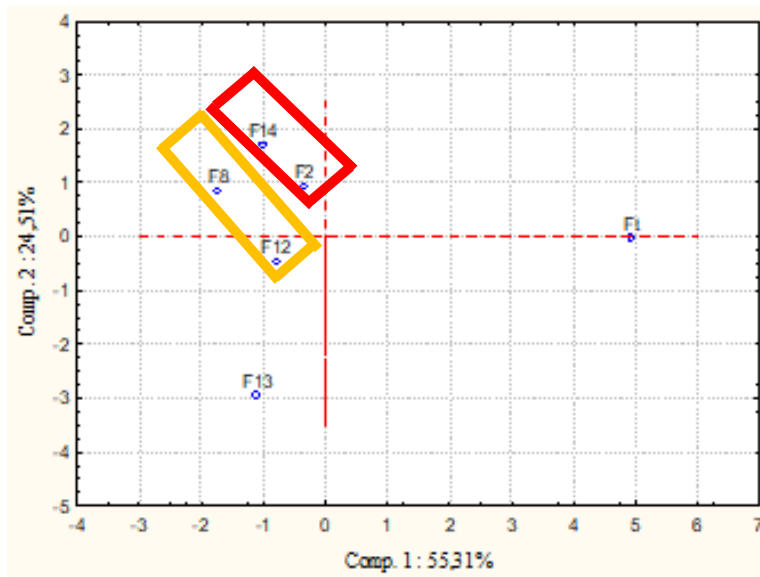
The analyzed nectar formulas have different sensory profiles in view of the quantitative variability of their composition. Among the nectar formulas, the samples F2, F8, F12, F13 and F14 had greater acceptance indices (57.14% to 77.15%), although below the acceptance of the control produced with the traditional method (91.42%). The difference in pleasantness between control and composite formulas of nectars could be attributable to habituation consumers to the pleasures procured by the "gnamankou". This nectar is usually produced without prior processing and with some typical characteristics such as coloration, turbidity and flavor of ginger. Indeed the sensory profiles show that the formulations F2, F8, F12, F13 and F14 are weakly astringent, less turbid but more fluid and colored (yellow), compared to the control which is clearly more

Table 4. Matrix of eigenvalues and percentage variability expressed by the 5 factors of the principal component analysis applied to the sensory descriptors of nectars formulated with ginger

Components	1	2	3	4	5
Eigenvalues	6.08	2.7	1.43	0.67	0.12
Variability expressed (%)	55.31	24.51	13.01	6.12	1.06
Cumulative variability expressed (%)	55.31	79.81	92.82	98.94	100



A



B

Fig. 6. Distribution of sensory descriptors (A) and ginger nectar formulas (B) in Comp.1-Comp.2 factorial plan of principal component analysis (PCA)

Thom: homogeneity, Tflu: fluidity, Tturb: turbidity, Saast: astringency, Sasu: sweet, Saac: acid, Sapi: piquancy, Cmar: brown, Cjau: yellow, Argna: gnamankou, Arci: lemon

turbid, dark and pungent. Nevertheless, acceptances by more than 50% of consumers is already considerable for a new food product that

is not well known to consumers. Indeed the rhizomes contain residues of proteins and lipids to varying proportions [17], but mainly of the

Table 5. Composition of 1L of nectar formulations accepted at more than 50%

Formulations	Oleoresin (g)	Sugar (g)	Lemon (ml)	Broyat of ginger (%)
Ft	0.00	100.00	50.00	100.00
F12	0.63	100.00	30.00	00.00
F8	0.85	80.81	40.19	00.00
F2	0.85	28.20	18.10	00.00
F14	0.63	55.00	50.00	00.00
F13	0.63	55.00	10.00	00.00

starch, observable by a whitish deposit after the production of nectar and whose intensity increases with the time of conservation [11]. It is therefore this more complex composition of the ginger-based nectar which could be at the origin of its turbidity, dark coloration, compared to oleoresin-based nectars freed from a part of its protein, lipid and starch [11]. However, ginger starch has a very strong cohesive structure that can withstand digestive enzymes [11]. As a result oleoresin-based nectar could be more digestible than this based on ginger rhizomes. Also, the color difference observed may be due to the presence of curcumin, demethoxycurcumin and 6-dehydrogenodione, which are pigments that cause the yellow color of ginger [18]. In fact, not containing starch, oleoresin is naturally viscous in appearance and better fluidification requires greater dilution. Nevertheless, this sensory characteristic does not seem important enough in the overall acceptance of nectar since several formulas have displayed a fluidity comparable to the witness without however meeting the consent of panelists. Moreover, homogeneity being a good indicator of nectar quality, this factor appears to favor the development of oleoresin-based nectar formulas, especially the F8 and F12 formulations, which are among the most accepted by panelists. The difference in gnamankou aroma observed between the control and different formulations is related to the volatile compounds of the essential oil that are practically absent in oleoresin [6,5]. The addition of ginger essential oil or other fruit juices to oleoresin-based formulations may improve this observed gnamankou aroma deficit. The acid flavor and lemon aroma were well correlated with formulas F2 and F14 among the accepted formulations. These two parameters reflect the presence of acidic substances such as organic acids. The antimicrobial effect of organic acids is known. They also have an aperitif power and stimulate the secretion of saliva and gastric and intestinal juices useful for digestive mechanisms [19]. Consumption of the formulas F2 and F14 would provide the benefits associated with organic acids in foods. With the pungent flavor,

the F10 formula that was accepted by less than 50% of panelists, and the witness have comparable values, the highest. The difference in pungent flavor is attributable to the proportion of oleoresin in the different formulations. This observation shows that the pungent flavor, although characteristic of ginger, is not the key parameter of the appreciation of its nectar. In addition, the piquancy aspect is concentrated in oleoresin, through its polyphenolic compounds including gingerol and its derivatives, which are antioxidant substances beneficial to the health of consumer [7]. Like nectar of rhizomes, ginger oleoresin nectar would provide consumers with the necessary compounds to fight flatulence, sore throat, constipation, transport sickness, nausea, vomiting, etc [20]. Since these antioxidants are preservatives, the nectars formulated with oleoresin could be preserved more sustainably [21]. Ginger oleoresin nectars are better at nectar of ginger rhizomes for some sensory descriptors (color, homogeneity, acidity) and less obvious for others (gnamankou aroma, turbidity, pungent flavor). However, several formulas could be accepted on a large scale by consumers. Longer storage coupled with sensory improvements could promote wider acceptance of these products by consumers. In addition, for the producer, the use of oleoresin would be an advantage for a better profitability of ginger rhizomes. Because ginger oleoresin (non-volatile fraction) can be produced from ginger residues after extraction of essential oil. These two products, of great added value, could be extracted from ginger rhizomes.

4. CONCLUSION

In this study, a composite central plan was applied for the formulation of ginger oleoresin nectars. The sensory profiles of these nectars have been established and the formulations sensorially acceptable have been identified. It appears that the formulations F2, F8, F12, F13 and F14 are the best accepted (57.14% to 77.15%) with a strong yellow coloring, good homogeneity (F8 and F12) and more marked

acidity (F2 and F14). The witness has some appreciable features such as gnamankou aroma, pungent flavor and fluid texture. The great advantage of oleoresin-based formulations is the very low turbidity (no starch deposition) and the simple handling of oleoresin. This work made it possible to highlight indicators guiding the choice of the best combinations of parameters such as the volume of lemon juice, the amounts of oleoresin and sugar for a better formulation of oleoresin-based nectars. So these formulations could be improved by their combination with other fruit juices (pineapple, hibiscus, mint etc).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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