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Effect of tamarind (*Tamarindus indica*) extracts leaves on the sensory quality of a local refreshing sorrel (*Hibiscus sabdariffa*) calyces-based beverage

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Abstract

Sensory quality of food has been of increasing concern over the past decade but little about this quality is known for most of the modified local products made from Africa. The purpose of this study was to evaluate the sensory attributes of "foléré" (sorrel) beverage blended with two extracts from tamarind leaves. The beverage was prepared and different blended samples with either ethanolic or acetone extracts (50 mg/ml) from tamarind leaves were formulated and stored at room temperature. Two control samples without tamarind extracts were prepared and stored at room and refrigerated temperatures. The sensory properties of the samples were assessed using descriptive 9-point hedonic scale. The results revealed significant differences ($p < 0.05$) between samples according to the appearance/color, taste, aroma and overall acceptability. However, there was no significant difference in terms of flavour/odor (from 6.0±1.89 to 6.8±1.14 and 6.0±2.06 to 6.1±2.42) and texture (from 7.7±0.82 to 8.0±1.49 and 6.6±2.27 to 7.6±1.17) between non-blended samples and those blended with ethanolic extracts, respectively. The samples blended with ethanolic extract were by far most globally accepted by 80% (20% of dislike) of the panellists compared to those blended with acetone tamarind extract which were only accepted by the same panel at 40% (60% of dislike). Aroma ($r = 0.860$; $p < 0.05$) and texture ($r = 0.896$; $p < 0.05$) of the samples appeared to be the main attributes that well defined the global acceptability of the final modified beverage. The results of this study suggests that ethanolic extract from tamarind leaves could be used as natural enhancer without really affecting the acceptability of the "foléré" beverage.

Keywords: traditional beverage, sorrel-based "foléré" beverage, tamarind leaves, natural enhancers, sensory evaluation

Introduction

In the food science literature, four categories of product characteristics are established to define food quality: nutritional value, processing quality, hygienic-toxicological quality and sensory quality [1]. Among these categories, sensory quality is one of the major key determinant of consumer choice for a product. Over the past decades, the application of the sensory evaluation to quantify consumer preferences has been on the rise [2]. In Africa, many locally and enriched products have been evaluated based on the sensory quality [3, 4]. In Cameroon, the red dried calyces of *Hibiscus sabdariffa* (Roselle) are used for preparing a local homemade beverage called "foléré" [5]. Due to its non-alcoholic, refreshing nature and low cost, fresh and no modified "foléré" beverage is highly appreciated by the population of the hottest parts of Northern Cameroon and taken as natural substitute to the expensive manufactured non-alcoholic drinks. "Foléré" beverage considered as a ready to be served drink is not only taken to quench taste, but also as an indigenous functional concoction. Moreover, the high nutritious contents [4] makes it prone to microbial contamination and spoilage. Many studies had reported important load of bacteria, fungi and spore-forming bacteria in "foléré" beverage [5, 6]. This poor hygienic quality of the "foléré" beverage affects its shelf life which is generally a day at room temperature and is a major limitation to its large-scale production. Therefore, it appears urgent to explore various preservation methods that could be employed simultaneously to extend the shelf life of this beverage and enhance its sensory quality. So far, chemical additives have been used to improve the flavour and shelf life of indigenous non-alcoholic beverages [7] but their side effects on the health of consumers tend to give more preference for the use of plant extracts as natural preservative approach. Several plants used by man as aliment have shown to inhibit microbial growth [8] and many spices such as garlic, ginger, clove, nutmeg, lemon and *Moringa* have long been as enhancers of locally made beverages [3, 9]. The availability and inexpensive nature of spices have trilled the interest of producers of local foodstuffs and beverages, who have embraced the use of these precious plants not only for flavoring but also for preservation. Tamarind tree is a plant with an evergreen leaves which belongs to the dicotyledonous Leguminosae family and Caesalpiniaceae subfamily [10]. The use of tamarind in Northern Cameroon is gaining great interest in folk medicine [11] and its fruits are used as food supplement. The plant parts have been characterized to be rich in carbohydrates, proteins, fats, fibres, and some vitamins such as thiamine, riboflavin, niacin, ascorbic acid and β-carotene, calcium, tartaric acid and potassium, flavonoids and other polyphenols [12]. A Report of authors [13] recently revealed that acetone and ethanolic extracts of tamarind leaves were active against food spoilage and poisoning bacteria as *B. subtilis*, *B. cereus*, and *S. aureus*. The same study showed that both crude extracts might be efficient for increasing the

shelf life of the "foléré" beverage from 1 to 5 days at room temperature. Meanwhile, the effects of these crude extracts on the sensory quality of the beverage remain uncovered. Within this frame, the purpose of this study was to investigate the sensory property based on some quality attributes of the "foléré" beverage blended with both ethanolic and acetone extracts of tamarind leaves.

Materials and methods

Plant material

Dry calyces of *H. sabdariffa* and fresh leaves of *Tamarindus indica* were collected respectively from the "abattoir" market and the nursing farm (longitude 10°35'43,5" N and latitude 14°18'45,0" E) both located in Maroua, Far-North Region, Cameroon. The plant materials were manually pre-treated to remove all unwanted debris and deteriorated parts. Both plant materials were further identified by botanical experts from the Department of Biological Sciences of the Faculty of Science of the University of Maroua, Cameroon.

Preparation of *Tamarindus indica* extracts

The fresh tamarind leaves were washed using running sterile de-ionised water and shade-dried at 45°C in a hot air drier (Isotemp® Oven Model 718F) for 2 days, then powdered using an electric blender (MLynek Laboratory JNY Tip WZ/2, Poland), sieved, and transferred into clean bottles. The extracts were prepared using maceration technique as described by author [14]. Fifty (50) grams of the powder were immersed into 200 mL of each solvent (ethanol and acetone) in a 500 mL conical flask. The mixture was shaken ceaselessly for 24 hours at room temperature. The extracts obtained were filtered rapidly through Whattman N°2 filter paper. The solvents were evaporated and the obtained filtrates were concentrated to a solid form under reduced pressure at 65°C up to dryness using an air-dried vacuum (Rotavapor R-124, Buchi, Switzerland). The resulting extracts without any trace of the solvent were stored at 4°C for further use.

Preparation of "foléré" drink

The "foléré" beverage was prepared according to the method previously described by Bayoï et al. [5]. Two hundred grams of the roselle dried-calyces were weighed and cleaned with distilled water. They were mixed with 4 litres of distilled water and boiled for 45 minutes. After cooling at room temperature, the mixture was filtered into a clean bowl, and the filtrate-nectar was mixed with 180 grams of sterile granulated sugar and further diluted with two litres of sterile distilled water and stirred. About 350 mL of the beverage produced was introduced into separate sterile glass bottles. Four test samples were prepared and blended with either ethanolic or acetone extracts (50 mg/mL). For each tamarind leaves extract, the blended samples were kept for zero and four days before assessment. Two other control samples without the plant extracts were added, stored at room and refrigeration temperature. All the samples were pasteurised at 70°C for 30 min. At the end, we had 6 sets of samples divided into 3 main groups:

1. "Foléré" drink without tamarind extract
2. "Foléré" drink + ethanolic tamarind extract (50 mg/mL);
3. "Foléré" drink + acetone tamarind extract (50 mg/mL).

Samples were prepared in two sessions; the first session consisted the preparation of blended samples that were kept for four days before assessment and the second session involved the preparation of blended and non-blended samples that were to be assessed the very day (samples kept for "zero" day). The choice of the concentration of extract and time/temperature of storage was based on the previous work conducted by author [13].

Sensory evaluation

Descriptive sensory test was carried out in the Food Technology laboratory, IRAD Maroua using ten untrained panellists (19-32 years of age: 5 males and 5 females) chosen among students, academic and staff members of the University of Maroua, Cameroon. The panellists were recruited according to their experience with the beverage, motivation, availability and health status (aguesia or no anosmia). Before the sensory evaluation, three training sessions were undertaken which lasted for 30 minutes in each session. Six sensory attributes were identified to characterize the organoleptic properties of the "foléré" samples. The "foléré" beverage samples (25 ml) were randomly served to every panellist one at time in transparent plastic cups labelled with random digits codes. Each sample was tasted by sipping and the palate was immediately rinsed with mineral water before passing to the next sample. To rate the beverage, the panellists used a 9-point hedonic scale starting from 1 for dislike extremely to 9 for like extremely [15]. The attributes evaluated were the appearance/color, taste, aroma, flavour/odor, texture and overall acceptability of the beverage samples. The sample codes for sensory analysis are presented in Table 1.

Table 1: Preparation, storage conditions and sample codes of blended and non-blended "foléré" samples

Digit codes	Samples preparation	Samples labelled
221	"Foléré" without tamarind extract stored at refrigeration temperature before testing the same day	FR-0
121	"Foléré" without tamarind extract stored at room temperature before testing the same	FNR-0
112	"Foléré" with ethanol extract of tamarind leaves (50 mg/mL) stored at room temperature before testing the same day	FEE-0
212	"Foléré" with ethanol extract of tamarind leaves (50 mg/mL) stored for 4 days at room temperature before testing	FEE-4
322	"Foléré" acetone extract of tamarind leaves (50 mg/mL) stored at room temperature before testing the same day	FAE-0
132	"Foléré" with acetone extract of tamarind leaves (50 mg/mL) stored for 4 days at room temperature before testing	FAE-4

Statistical analysis

Measurements were done in triplicate and the results were presented as mean ± Std. The data were subjected to one-way analysis of variance (ANOVA) to determine the mean differences among the beverages samples. Whenever significant differences in ANOVA ($P<0.05$) were detected, the HSD Tukey's multiple range test was applied to discriminate pair of means significantly different at $p < 0.05$ using STAGRAPHICS software centurion version 16.1.11 (Technologies Inc., Virginia, USA). Principal Component

Analysis (PCA) and radar plots were performed to assess the correlation between different sensory attributes of beverage samples, and the relationship between the different kind of "foléré" beverage samples, using SPSS Statistical program (SPSS20, IBM Inc., Armonk, New York, USA) and Excel program (Office 2013, MICROSOFT Corp., Redmond, Washington), respectively.

Results

Sensory evaluation of blended and non-blended "foléré" samples

Appearance/color

The results of the sensory analysis only based on appearance/color of the different samples are listed in table 2. The score varied between 3.5 to 7.4 for blended samples and 6.6 to 7.7 for non-blended samples. There were significant differences between samples blended with acetone extract (FAE-0 and FAE-4) and those with ethanol extract (FEE-0 and FEE-4) likewise those samples without extract (FR-0 and FNR-0). At all levels, appearance and color of "foléré" samples blended with acetone extract was the least appreciated by the panel with dislike percentage of 80 % and 50 % respectively for FAE-0 (score 3.5±1.9) and FAE-4 (4.5±2.84) samples. Contrary to FEE-0 (score 7.4±1.08), FR-0 (score 7.7±0.48) and FNR-0 (score 6.6±0.84) samples blended with ethanol extract and kept at room temperature, non-blended and kept at refrigerated and room temperature respectively which had the best appearance and color attribute with 0% of dislike.

Table 2: Appearance/color appreciation of different blended and non-blended "foléré" samples

Scale point description	Assigned value	Frequency of responses					
		FNR-0	FR-0	FEE-0	FAE-0	FEE-4	FAE-4
dislike extremely	1	0	0	0	1	0	2
dislike very much	2	0	0	0	3	0	1
dislike moderately	3	0	0	0	1	0	1
dislike slightly	4	0	0	0	3	2	1
neither like nor dislike	5	0	0	0	0	0	2
like slightly	6	6	0	3	1	1	0
like moderately	7	2	3	1	1	3	1
like very much	8	2	7	5	0	2	1
like extremely	9	0	0	1	0	2	1
Total responses		10	10	10	10	10	10
Mean ± std		6.6 ± 0.84^{bc}	7.7 ± 0.48^{c}	7.4 ± 1.08^{c}	3.5 ± 1.90^{a}	6.9 ± 1.79^{c}	4.5 ± 2.84^{ab}
Percentage "dislike" responses		0	0	0	80	20	50

FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "Foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day. Mean ± std in the same line not followed by the same letter were different at $p < 0.05$. Percentage "dislike" of each sample represented ratio of panellists who rated samples with a score lower than 5.

Flavour/odor

The results of the flavour/odor of "foléré" beverages are summarized in table 3. There was no significant variation in the flavour/odor of blended samples and non-blended samples. The results according to flavour and odor scores and dislike percentages showed that the "foléré" samples blended with acetone extract were the least appreciated (scores of 4.5±1.27 and 4.5±2.32) and the most rejected with 40 % and 60 % of disliking for samples tested the same day (FAE-0) and those kept for 4 days at room temperature before testing (FAE-4) respectively. The "foléré" samples blended with ethanol and tested after 4 days of storage (FEE-4) and the non-blended samples left at room temperature before testing the same day (FNR-0) displayed the highest scores of 6.1±2.42 and 6.8±1.14.

Aroma

The results of aroma appreciation of both blended and non-blended "foléré" beverage samples are presented in table 4. There was a significant variation ($p<0.05$) in the aroma of the "foléré" samples blended with acetone extract, tested the same day FAE-0 (score 4.6±2.01) or after 4 days of storage FAE-4 (score 4.7±2.06) and the "foléré" blended with ethanol extract and tested the same day FEE-0 (score 6.1±2.42). Furthermore, all the samples were significantly different from the control sample tested the same day after refrigeration, FR-0. In terms of aroma appreciation, samples blended with acetone extract and kept for four days before testing (FAE-4) were the most rejected with 50 % of dislike compared to the control samples kept at room temperature and tested the same day (FNR-0) that were the most appreciated with only 10 % of dislike with a of score 6.9±2.26.

Table 3: Flavour/odor quality of different blended and non-blended "foléré" samples

Scale point description	Assigned value	Frequency of responses					
		FNR-0	FR-0	FEE-0	FAE-0	FEE-4	FAE-4
dislike extremely	1	0	0	0	0	0	1
dislike very much	2	0	0	0	1	0	0
dislike moderately	3	0	2	1	1	2	4
dislike slightly	4	0	0	1	2	1	1
neither like nor dislike	5	2	1	0	4	0	0
like slightly	6	1	2	1	2	2	1
like moderately	7	4	4	3	0	3	2
like very much	8	3	0	2	0	1	1
like extremely	9	0	1	2	0	1	0
Total responses		10	10	10	10	10	10
Mean ± std		6.8±1.14[a]	6.0±1.89[a]	6.0±2.06[a]	4.5±1.27[a]	6.1±2.42[a]	4.5±2.32[a]
Percentage "dislike" responses		0	20	20	40	30	60

FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "Foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day. Mean ± std in the same line not followed by the same letter were different at $p < 0.05$. Percentage "dislike" of each sample represented ratio of panellists who rated the samples with a score lower than 5.

Table 4: Aroma of blended and non-blended "foléré" beverage samples

Scale point description	Assigned value	Frequency of responses					
		FNR-0	FR-0	FEE-0	FAE-0	FEE-4	FAE-4
dislike extremely	1	1	1	0	0	0	0
dislike very much	2	0	0	0	2	0	2
dislike moderately	3	0	0	4	2	2	1
dislike slightly	4	0	2	0	0	0	2
neither like nor dislike	5	1	0	2	3	1	1
like slightly	6	1	1	0	0	3	2
like moderately	7	1	3	3	3	1	1
like very much	8	5	2	1	0	2	1
like extremely	9	1	1	0	0	1	0
Total responses		10	10	10	10	10	10
Mean ± std		6.9±2.26[a]	6.8±0.48[c]	6.1±2.42[a]	4.6±2.01[b]	5.1±2.02[ab]	4.7±2.06[b]
Percentage "dislike" responses		10	30	40	40	20	50

FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "Foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day. Mean ± std in the same line not followed by the same letter were different at $p < 0.05$. Percentage "dislike" of each sample represented ratio of panellists who rated samples with a score lower than 5.

Taste

The taste scores of "foléré" samples are summarized in table 5 below. There was a significant difference ($p < 0.05$) in the taste of blended samples (FAE-0, FAE-4 and FEE-4) and non-blended control samples (FR-0 and FNR-0). However, no significant difference was observed between blended "foléré" samples. The taste of the non-blended and blended samples was globally well appreciated because more than 50% of the panel accepted the taste of each type of sample except for the samples blended with ethanol extract and stored for 4 days before testing. The non-blended samples refrigerated FR-0 and non-refrigerated (FNR-0) stored at room temperature before testing the same day had the greatest taste acceptability (scores 7.3±1.89 and 8.0±0.67) with 0% and 20% of dislike respectively. The samples blended with acetone extract and tested the very day after storage at room temperature, FAE-0 (score 5.3±2.00) and those blended with ethanol extract and kept for 4 days before testing, FEE-4 (score 4.5±2.46) were rejected at 40%. We also noticed that the taste score of the samples blended with ethanol extract decrease with storage time from 6.0 to 5.3 respectively after 0 and 4 days of storage.

Table 5: Taste of blended and non-blended "foléré" beverage samples

Scale point description	Assigned value	Frequency of responses					
		FNR-0	FR-0	FEE-0	FAE-0	FEE-4	FAE-4
dislike extremely	1	0	0	0	0	2	0
dislike very much	2	0	0	0	0	0	3
dislike moderately	3	0	0	1	3	2	0
dislike slightly	4	2	0	2	1	1	0
neither like nor dislike	5	0	1	1	1	0	2
like slightly	6	0	1	1	2	3	1
like moderately	7	2	1	2	1	1	2
like very much	8	3	1	3	2	1	2
like extremely	9	3	6	0	0	0	0
Total responses		10	10	10	10	10	10
Mean ± sd		8.0 ± 0.67^{c}	7.3 ± 1.89^{bc}	6.0 ± 1.89^{abc}	5.3 ± 2.00^{ab}	4.5 ± 2.46^{a}	5.2 ± 2.44^{ab}
Percentage "dislike" responses		20	0	30	40	50	30

FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day. Mean ± std in the same line not followed by the same letter were different at $p < 0.05$. Percentage "dislike" of each sample represented ratio of panellists who rated samples with a score lower than 5.

Texture

The texture scores of both blended and non-blended "foléré" beverage are listed in table 6. We noticed that the mean scores varied between 3.1 to 7.6 for the blended samples and 7.7 to 8 for the non-blended samples. There was a significant difference between the texture of both samples blended with acetone extract, tested the same day FAE-0 (score 3.1±1.52) or after 4 days of storage FAE-4 (score 3.1±1.97) and samples blended with ethanol extract, tested the same day FEE-0 (score 7.6±1.17) or after 4 days of storage FEE-4 (score 6.6±2.27) at room temperature. This result also revealed that the texture of samples blended with ethanol extract of tamarind leaves was less appreciated after storage of the samples. According to the percentage of dislike, "foléré" samples blended with acetone extract were the most rejected with 90% of the panellists who disliked these samples because of their texture. Whereas the samples blended with ethanol extract and tested the same FEE-0 displayed 0% of disliking of the same quality attribute.

Table 6: Texture of blended and non-blended "foléré" samples

Scale point description	Assigned value	Frequency of responses					
		FNR-0	FR-0	FEE-0	FAE-0	FEE-4	FAE-4
dislike extremely	1	0	0	0	1	0	1
dislike very much	2	0	0	0	4	1	4
dislike moderately	3	0	0	0	4	0	2
dislike slightly	4	0	0	0	0	1	2
neither like nor dislike	5	0	1	1	0	0	0
like slightly	6	1	1	0	1	3	0
like moderately	7	2	1	3	0	0	0
like very much	8	6	1	4	0	3	1
like extremely	9	1	6	2	0	2	0
Total responses		10	10	10	10	10	10
Mean ± std		7.7 ± 0.82^{a}	8.0 ± 1.49^{a}	7.6 ± 1.17^{a}	3.1 ± 1.52^{b}	6.6 ± 2.27^{a}	3.1 ± 1.97^{b}
Percentage "dislike" responses		0	0	0	90	20	90

FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "Foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day. Mean ± std in the same line not followed by the same letter were different at $p < 0.05$. Percentage "dislike" of each sample represented ratio of panellists who rated the samples with a score lower than 5.

Overall Acceptability

The overall acceptability scores of both blended and non-blended "foléré" samples are compiled in table 7. The samples blended with ethanol and tested the very day FEE-0 (score 6.3±2.75) or after 4 days of storage FEE-4 (score 5.2±2.74) were highly accepted than those blended with

acetone extract and tested the very day FAE-0 (score 3.9±2.03) or after 4 days of storage (score 4.6±2.32) at room temperature. This result also revealed that storage time decrease the acceptability of "foléré" samples blended with ethanol extract and slightly upgrade that of the samples blended with acetone extract from tamarind leaves. The samples blended with acetone extract were the least accepted by the panel with 50 % and 60 % of dislike for samples tested the same day FAE-0 or after 4 days of storage FAE-4 at room temperature respectively. At the same time, samples blended with ethanol extract were among the most accepted samples with only 20% of dislike for those tested the same day (FEE-0) and 40% for those tested after 4 days of storage (FEE-4) at room temperature. Even if the non-blended samples stored at room temperature before testing the same day FNR-0 (score 7.4±1.17) appeared to be highly accepted than those blended with ethanol extract from tamarind leaves and tested in the same conditions FEE-0, they were similarly appreciated with only 20% of dislike.

Table 7: Overall acceptability of blended and non-blended "foléré" beverage samples

Scale point description	Assigned value	Frequency of responses					
		FNR-0	FR-0	FEE-0	FAE-0	FEE-4	FAE-4
dislike extremely	1	0	0	1	2	1	0
dislike very much	2	0	0	1	1	0	3
dislike moderately	3	0	0	0	1	1	2
dislike slightly	4	0	1	0	1	2	1
neither like nor dislike	5	1	0	1	2	0	1
like slightly	6	1	1	0	3	1	0
like moderately	7	1	0	2	0	3	1
like very much	8	6	4	4	0	2	2
like extremely	9	1	4	2	0	0	0
Total responses		10	10	10	10	10	10
Mean ± sd		7.4 ± 1.17^{c}	7.8 ± 1.62^{c}	6.3 ± 2.75^{bc}	3.9 ± 2.03^{a}	5.2 ± 2.74^{ab}	4.6 ± 2.32^{ab}
Percentage "dislike" responses		0	10	20	50	40	60

FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "Foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day. Mean ± std in the same line not followed by the same letter were different at $p < 0.05$. Percentage "dislike" of each sample represented ratio of panellists who rated the samples with a score lower than 5.

Radar plots analysis

The comparison between the blended (FEE-0, FEE-4, FAE-0 and FAE-4) and non-blended "foléré" (FR-0 and FNR-0) samples is presented in the radar plots of figure 1. As shown in that figure, all the samples were significantly different among the sensory attributes ($p < 0.05$). We noticed that the storage time slightly upgraded the general appreciation of samples blended with acetone extracts of tamarind leaves (FAE-0 and FAE-4) while the reverse was observed for the samples blended with ethanol extract (FEE-0 and FEE-4).

Correlation and multivariate analysis

To simplify analysis of the correlations between sensory attributes measured during the testing of "foléré" beverage samples, the principal component analysis (PCA) was applied to six variables shown in figure 2. The variables were reduced into two principal components PC1 and PC2 which accounted for 55.95% and 36.77% respectively and explained together 92.72% of the total variance after the varimax rotation.

The PCA showed that variables as appearance/color, texture and odor/flavor contributed strongly and positively for the PC1 axis. While, PC2 axis was mainly assigned to the taste of the beverage samples. This variable was highly loaded to the positive side of the main component PC2. Analysis of Pearson correlations of table 8 showed that the overall acceptability were both significantly correlated to the texture ($r = 0.896$; $p < 0.05$) and aroma ($r = 0.860$; $p < 0.05$). Furthermore, the texture was highly and positively correlated to odor and flavor ($r = 0.937$; $p < 0.01$) in one hand and appearance and color ($r = 0.958$; $p < 0.05$) on the other hand. PCA scores showed that "foléré" samples were separated into three distinct groups formed by non-blended samples, samples blended with acetone extract and samples blended with ethanol extract of tamarind leaves.

Spacing observed inside the group formed by both samples blended with ethanol extract confirms the reduction of the sensory quality with storage time for those specific samples. The weak spacing between both samples blended with acetone extract indicates their homogeneity. Given that the position of both observation located in negative side of space formed by the two main components, we can confirm that the sensory quality of samples blended with acetone extract was slightly improved by increasing of storage time. PCA analysis showed that the control non-blended samples were found to be more appreciated according to their taste while the samples blended with ethanol extract were appreciated according to their appearance and color.

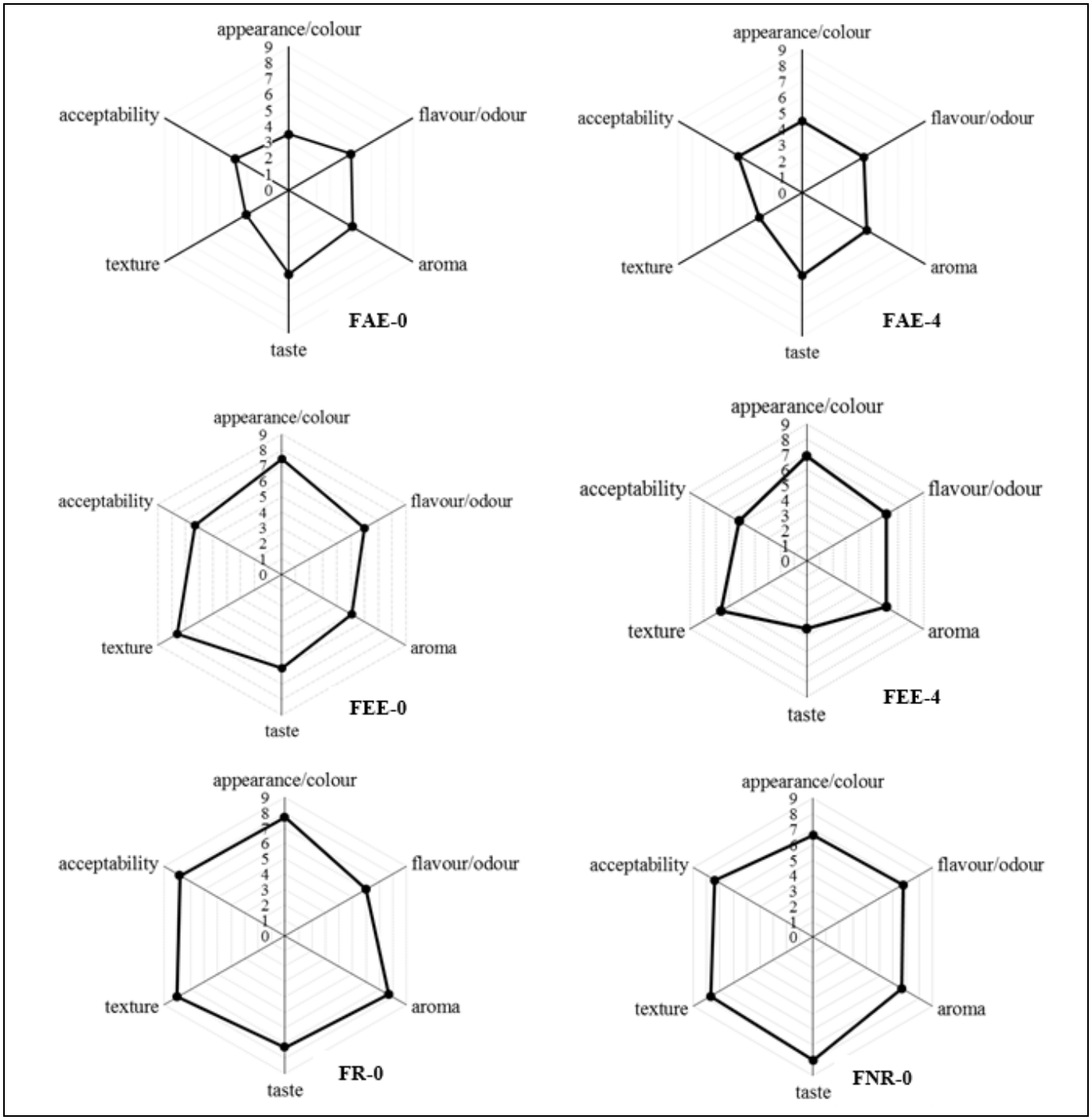

Fig 1: Radar plots of blended and non-blended "foléré" beverages. Sensory evaluation scores in the plot are means of triplicate analysis by 10 panellists. FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "Foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day

Table 8: Pearson (r) correlation coefficients among sensory attributes of blended and non-blended "foléré" beverage.

Variables	Appareance/ Color	Odor/Flavour	Aroma	Taste	Texture	Overall acceptability
Appareance/Color	1					
Odor/Flavour	0.849*	1				
Aroma	0.732	0.729	1			
Taste	0.435	0.602	0.665	1		
Texture	0.958**	0.937**	0.775	0.608	1	
Overall acceptability	0.831*	0.819*	0.860*	0.854*	0.896*	1

(*) Pearson correlation values were statistically significant at $p < 0.05$. (**) Pearson correlation values were statistically significant at $p < 0.01$.

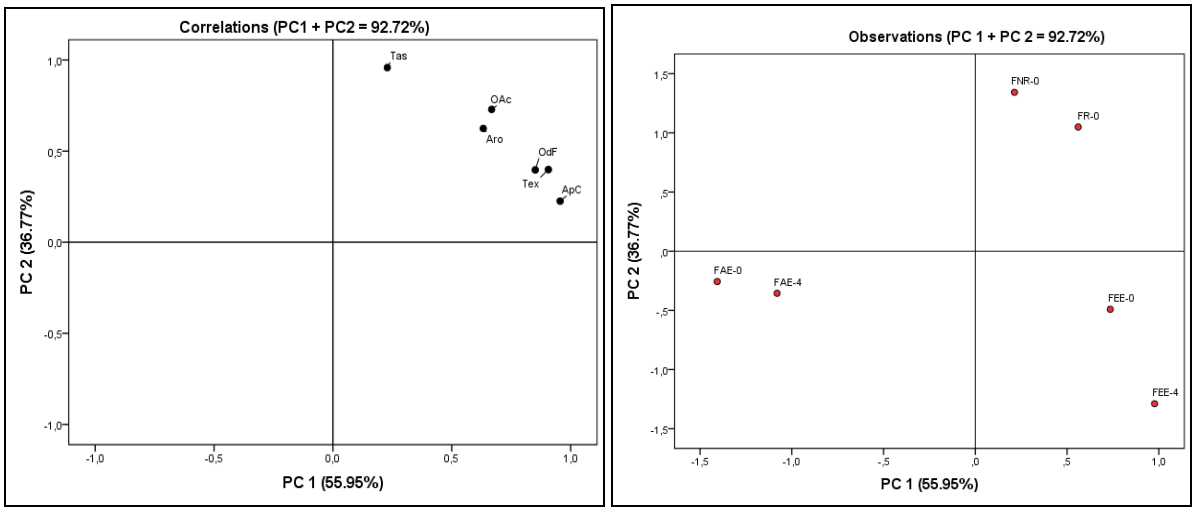

Fig 2: Principal component analysis of correlation loadings (left) and scores (right) plots derived using sensory attributes values of the blended and non-blended "foléré" samples. Aro: Aroma; ApC: Appearance and color; Tas: Taste; Tex: Texture; OAc: Overall acceptability; OdF: Odor and flavour. FAE-0 = "Foléré" blended with acetone extract, stored at room temperature and tested the same day; FAE-4 = "Foléré" blended with acetone extract and stored for 4 days at room temperature before testing; FEE-0 = "Foléré" blended with ethanol extract and stored at room temperature before testing the same day; FEE-4 = "Foléré" blended with ethanol extract and stored for 4 days at room temperature before testing; FNR-0 = "Foléré" non-refrigerated and tested the same day; FR-0 = "Foléré" refrigerated and tested the same day.

Discussion

The sensory evaluation of these beverages revealed that most samples were palatable, but the sensory attributes varied with the type of "foléré" samples. These attributes varied significantly between the blended and non-blended "foléré" samples ($p < 0.05$). The varying attributes of the blended samples could be due to the limited solubility of acetone extract in the aqueous matrix of the "foléré" beverage. This has negatively impacted on the appearance, texture and finally contributed to the poorest score of the "foléré" samples blended with acetone extract of tamarind leaves. The similarities observed between the non-blended "foléré" beverage samples and those blended with ethanolic extract from tamarind leaves for the sensory attributes as appearance/color, flavour/odor, aroma and taste could be due to the presence of organic and phenolic acids in the tamarind extract which act as color and olfactory enhancers of food products [8]. This also indicates that the addition of ethanolic extract of tamarind leaves did not have negative effect on the sensory attributes of the "foléré" beverage previously mentioned. Appearance/color and taste are some of the most important key determinant of consumer choice. These attributes are in compliance with both some of the experience quality and search quality (color, smell, taste, texture, flavour, among others) of a food commodity [1]. Subsequently, the more attractive the sensory attributes of appearance/color and taste, the more consumers are willing to purchase as reported by authors [16]. Though, there was no significant differences in the appearance/color and taste of samples blended with the same extract. Similar findings were recently reported by authors [17] who indicated that the addition of date fruit extract did not have negative effect on the appearance of the roselle beverage. More so, it was shown that apart from blending "foléré" beverage, preservation technique had greater impact on the sensory attributes [18]. Though, refrigerated samples turned to be the most appreciated, but cool preservation techniques are challenging in many sub-Saharan countries as Cameroon where we have regular power outage and the use of generators is much costly to local producers. Apart from refrigeration, the evaluation of similar beverages blended with either lemon, ginger, garlic, moringa or date fruits have shown to enhance sensory attributes of "foléré" beverage [3, 9, 19]. This enhancing of sensory quality could probably be due to the presence of secondary plants' metabolites. The presence of these metabolites in the *Tamarindus indica* crude extracts gives satisfactory protective properties against invasive organisms as reported by authors [12, 20] among which we have food spoilage and food poisoning organisms known for their deteriorative characters in foods which have great impact on the sensory quality [21].

Conclusion

In a nutshell, the sensory quality of "foléré" beverage significantly changed from one attribute to another. The non-blended samples were more appreciated than those blended with the organic extracts from tamarind leaves. But, the addition of ethanolic extract from tamarind leaves in the "foléré" drink did not really affect the behaviour of the panel because more than 50% of the panellists still accepted the modified product even after 4 days of storage at room temperature. "Foléré" samples blended with ethanolic extract were by far most appreciated than similar ones blended with acetone extract. However, the storage time negatively affected the sensory quality of the samples blended with ethanolic extract and slightly improved some sensory attributes of the samples blended with acetone extract of tamarind leaves. For a better understanding of the changes in sensory quality of the blended samples, further characterization of these extracts needs to be done in order to clearly identify the compounds of each extract of tamarind leaves which could be positively or negatively affect the sensory quality of the modified "foléré" beverage.

Competing interests

The authors have declared that no competing interest exists. The beverage used for this research are commonly and

predominantly use products in our research area. There is absolutely no conflict of interest between the authors and producers of the beverage because we do not intend to use this product as an avenue for any litigation but for the advancement of knowledge.

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