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Investigation in Sensory Properties of Liquid Extract Formulations Processed from *Capsicum spp* Varieties Sold in Abidjan

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Authors' contributions

This work was carried out in collaboration among all authors. Author SD designed the study, wrote the protocol and performed the statistical analysis of the data. Authors CA and NYBJ assisted the raw analyses and achieved the first draft of the manuscript. Author KNY assisted the literature search and worked the submitted manuscript. Author NC assisted in data recovering. Author BGHM supervised the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Peppers are common raw spices facing significant post-harvest lost in the handling train. This study was carried out to promote the production of pepper concentrate as spices extracts for foods.
Study Design: Composite extracts formulated from raw peppers extracts using Central Composite Design, and resulted formulations submitted to sensory analysis.
Place and Duration of Study: Laboratory of Biochemistry and Food Sciences, Department of Biochemistry, Training and Research Unit of Biosciences, Felix Houphouet-Boigny University, Abidjan, Côte d'Ivoire, between June and October 2018.

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Methodology: Using a central composite design, 25 peppers extract formulations (F1 to F25) were processed from raw extracts of four pepper varieties growing in Côte d'Ivoire, namely cultivars ''*pili pili*'' and ''*bill of bird*'' (*Capsicum frutescens*), ''*pepper baoulé*'' (*Capsicum annuum*), and ''*big sun*'' (*Capsicum chinense*). These formulations were then subjected to sensory descriptive and sensory acceptance analyses by panellists about the color appearance, the pungency flavor, the fluidity aspect, and the typical pepper aroma.
Results: The sensory perception of pungency, fluidity, and aroma didn't differentiate the formulations. But four formulations (F18, F20, F21, and F24) evidenced more intensive orange-yellowish appearance (4.44/7, 5.33/7, 4.33/7, and 4.67/7, respectively). From these formulations, samples F18 and F20 have been more enjoyed as food spices, with respective scores of 76.17% and 77.76% panellists.
Conclusion: Both formulations F18 and F20 could be used as significant baselines in peppers extract processing for food interests.

Keywords: Pepper extract; food spices; composite formulations; cultivars; processing.

1. INTRODUCTION

Pepper is a tropical plant species originating from Latin and Central America from which it has been scattered in European, African, and Asian countries [1,2]. It's a fruit-vegetable belonging to the *Capsicum* plant genus which different types are commonly classified according to the fruits properties and their uses [3,4]. This systematic genus was spelled by Valerius Cordus in 1506 [5] and recovers beyond 200 plant species gathered into numerous families such as the Solanaceae family, namely eggplants (*Solanum melongena*, *S. aethiopicum*), tomato (*Lycopersicum esculentum*), potato (*Solanum tuberosum*) or tobacco (*Nicotiana tabacum*). According to the plant taxonomy, about only thirty plant species of the *Capsicum* genus are known to be domesticated [6], most fluently consumed of which are *Capsicum annuum*, *C. frutescens*, *C. chinense*, *C. baccatum*, and *C. pubescens* [7]. The main fruits deriving from these plants display various sizes, shapes, and sensory flavour and heat [8,9]. They are generally associated to the pungency or spicy taste felt after ingestion as food spices.

The global production of pepper fruits was estimated to 2,204,652 tons in 2005 on the international market. From Africa, Nigeria, Egypt, and Ghana usually ensure regular provision of this raw product, with respective contribution of 33%, 21%, and 12% [10].

The pepper fruits are provided to the consumers right from farmers, producers, or are purchased from the traders as raw fresh vegetable, either dried or ground into powder. They are highly appreciated over the world since they are used as flavor exhausting in numerous food receipts. Pepper can be consumed right as fresh vegetable, but it's also ingested as food additive in frying, sauces or processed into canned products.

In Côte d'Ivoire, the yield of fresh pepper fruits is estimated between 5,000 and 10,000 tons/year [11]. The productions are traditional and intended to the local consumption. Unfortunately, the post-harvest pepper fruits are submitted to delicate storage concerns and hardly linger to display signs of deterioration, especially under intensive humidity seasons. Close to the slack processing of the raw product, these constraints of storage significantly impede the organoleptic and sanitary qualities of peppers, or even their availability on the markets. Thus, the post- harvest processing of peppers could enable the preservation of their main advantages, promote their availability, and facilitate their using. This work is achieved to analyze the sensory trends of peppers extracts formulations for better valorization.

2. MATERIALS AND METHODS

2.1 Materials

The raw material was constituted of concentrated liquid extracts of four pepper types, namely cultivars ''*pili pili*'' and ''*bill of bird*'' (*Capsicum frutescens*), ''*pepper baoulé*'' (*Capsicum annuum*) and ''*big sun*'' (*Capsicum chinense*). These extracts were provided by the Laboratory of Water Chemistry and Natural Substances located at the Felix Houphouët-Boigny National Polytechnic Institute (INPHB), Yamoussoukro.

2.2 Methods

2.2.1 Standard formulation of the composite peppers extracts

Slight samples volumes of 2 to 5 ml of each extract of the four pepper varieties were mixed

into a 250 ml flask and then homogenized. The use of a central composite design allows to control the quite volume to be considered from each extract for succeeding in various composite formulas of pepper extracts.

2.2.2 Central composite design for formulation of different composite pepper extracts

2.2.2.1 Utilization of the experimental domain

The Central Composite Design (CCD) used to prepare the composite formulations of the concentrated pepper extracts was drawn with an experimental domain integrating 4 factors (Table 1). These factors are constituted of the volumes of pepper extracts from the cultivars *''pili pili''* (X1), *''bill of bird*'' (X2), *''pepper baoulé*'' (X3), and *''big sun*'' (X4). Each factor presented a volumetric variation between 2 ml (the minimum) and 5 ml (the maximum) encoded with five levels (-2, -1, 0, +1, +2). From the axial experimental parameters of the CCD and according to the work of Feinberg (1996), a set of 25 formulations runs (F1 in F25) was generated, consisting in 16 factorial points, 8 axial points (2 axial points on each design variable), and 1 essay at the centre point of the experimental domain (Table 2).

For each encoded level, the quite volumetric value of the factors deriving from the CCD was determined using the following equation:

$$\mathbf{X_k} = X_{cent} + Z_k \times \frac{X_{max} - X_{min}}{Z_{max} - Z_{min}}$$

With X_k: quite value of the factor X for the formulation k; X_{cent}: value of the factor X at the centre; Z_k: value of the encoded level corresponding to the essay k; X_{max} (or X_{min}): maximum value (or minimum) of the factor X; Z_{max} (or Z_{min}): maximum value (or minimum) of the encoded levels.

The use of this formula at the overall encoded levels of the CCD permitted to get the different quite volumes of each pepper extract to be taken per composite formulation (Tables 3 and 4).

2.2.2.2 Formulation of diluted composite pepper extracts

From the final homogenized mixture of each formulation, 5 mL were collected into a 100 mL vial and the volume was adjusted at the dipstick with 96% ethanol reagent. Then, 25 mL of the resulted solution were introduced into another vial (1000 mL) and the volume also adjusted at the dipstick using distilled water. This diluted extracts were thereafter filtered upon a sifter of 75 µm mesh diameter, then kept into 1 L bottles and stored in freezer till analyses.

2.2.3 Sensory analysis of the pepper extracts formulations

The different formulations of pepper extracts (F1 to F25) were submitted to sensory evaluation at the Laboratory of Biochemistry and Foods Sciences (LaBSA), Felix Houphouët-Boigny University. These organoleptic analyses consisted in descriptive tests for determining the sensory profile, and tests for the hedonic appreciation of the formulations worked.

2.2.3.1 Descriptive sensory analysis

The descriptive analysis of formulations has been achieved with a panellist group of 12 volunteers considered as experts and constituted of available people aged between 20 and 40 years. This group has been filled after training sessions in sensory practices for enabling panellists to discern the taste areas of the tongue, to know the sensory descriptors as the colors, aromas, and flavors of the liquid foodstuffs and to fit their feeling degree.

The methodology of analysis and appreciation of the qualitative characters according to the requirements of the sensory analysis was used [12,13] and the expert panellists have finally been accustomed with the pepper extracts investigated.

Table 1. Definition of the experimental domain of the central composite design (CCD)

Main independent variables (X)	Minimum level	Maximum level
Pepper *''pili pili''* (mL): X_1	2	5
Pepper *''bill of bird''* (mL): X_2	2	5
Pepper "*big sun''* (mL): X_3	2	5
Pepper *''baoulé*'' (mL): X_4	2	5

Table 2. Encoded matrix of the central composite design

Group of Essays	Formulations	Encoded values of independent variables			
		X1	X2	X3	X4
Factorial Assays	F1	-1	-1	-1	-1
	F2	1	-1	-1	-1
	F3	-1	1	-1	-1
	F4	1	1	-1	-1
	F5	-1	-1	1	-1
	F6	1	-1	1	-1
	F7	-1	1	1	-1
	F8	1	1	1	-1
	F9	-1	-1	-1	1
	F10	1	-1	-1	1
	F11	-1	1	-1	1
	F12	1	1	-1	1
	F13	-1	-1	1	1
	F14	1	-1	1	1
	F15	-1	1	1	1
	F16	1	1	1	1
Axial Assays	F17	-2	0	0	0
	F18	2	0	0	0
	F19	0	-2	0	0
	F20	0	2	0	0
	F21	0	0	-2	0
	F22	0	0	2	0
	F23	0	0	0	-2
	F24	0	0	0	2
Centre Assay	F25	0	0	0	0
Value at level -1		2	2	2	2
Value at level +1		5	5	5	5
Value at level 0		3.5	3.5	3.5	3.5

Table 3. Presentation of the experimental parameters of the central composite design

Main independent variables (X)	Encoded levels / Quite values				
	-2	-1	0	+1	+2
Pepper ''*pili pili*'' (mL): X_1	2	2,75	3,5	4,25	5
Pepper ''*bill of bird*'' (mL): X_2	2	2,75	3,5	4,25	5
Pepper ''*big sun*'' (mL): X_3	2	2,75	3,5	4,25	5
Pepper ''*baoulé*'' (mL): X_4	2	2,75	3,5	4,25	5

The sensory description consisted in the assessment of the intensity of the coloration (red, yellow), the pepper aroma, and the pungency flavor from the formulations of pepper extracts. Beforehand, the samples of composite pepper extracts were served into bowls of similar aspect and three digits codes, then monadiquely and randomly provided to each panellist. After sensory observation, the feeling of the sensory parameter was scored by the panellist on a 7 points rating scale where the mark at the level 0 indicates the lack of sensory feeling and the mark at the level 7 shows the great presence of the sensory parameter.

At the end of the descriptive analysis, the composite pepper extract formulas revealing most significant sensory traits were selected and submitted to hedonic appreciation.

2.2.3.2 Hedonic analysis

The hedonic appreciation has been achieved by a group of 65 untrained people (men and women) of aged between 20 and 40 years. Each formulation was appreciated regarding the pleasure felt from the aroma, the flavor, and the main color.

Table 4. Presentation of the quite volumes of peppers raw extracts used in the PCC

Group of Essays	Formulations	Samples (mL)				Total peppers extracts mixture (mL)
		X1 (mL)	X2 (mL)	X3 (mL)	X4 (mL)	
Factorial Assays	F1	2.75	2.75	2.75	2.75	11
	F2	4.25	2.75	2.75	2.75	12.5
	F3	2.75	4.25	2.75	2.75	12.5
	F4	4.25	4.25	2.75	2.75	14
	F5	2.75	2.75	4.25	2.75	12.5
	F6	4.25	2.75	4.25	2.75	14
	F7	2.75	4.25	4.25	2.75	14
	F8	4.25	4.25	4.25	2.75	15.5
	F9	2.75	2.75	2.75	4.25	12.5
	F10	4.25	2.75	2.75	4.25	14
	F11	2.75	4.25	2.75	4.25	14
	F12	4.25	4.25	2.75	4.25	15.5
	F13	2.75	2.75	4.25	4.25	14
	F14	4.25	2.75	4.25	4.25	15.5
	F15	2.75	4.25	4.25	4.25	15.5
	F16	4.25	4.25	4.25	4.25	17
Axial Assays	F17	2	3.5	3.5	3.5	12.5
	F18	5	3.5	3.5	3.5	15.5
	F19	3.5	2	3.5	3.5	12.5
	F20	3.5	5	3.5	3.5	15.5
	F21	3.5	3.5	2	3.5	12.5
	F22	3.5	3.5	5	3.5	15.5
	F23	3.5	3.5	3.5	2	12.5
	F24	3.5	3.5	3.5	5	15.5
Centre Assay	F25	3.5	3.5	3.5	3.5	14
Value at level -1		2	2	2	2	
Value at level +1		5	5	5	5	
Value at level 0		3.5	3.5	3.5	3.5	

X_1= Volume of pepper extract from ''Pili pili''; X_2= Volume of pepper extract from ''bill of bird''; X_3= Volume of pepper from ''big sun''; X_4= Volume of pepper extract from ''pepper baoulé''

For this analysis, samples of pepper formulations were served as additive of cooked white rice, a food fluently consumed by local in the local dietaries. The dishes were provided have been served to each panellist in encoded plastic bowls in random order. Facing the dish sample, the hedonic feeling of the panellist was reported on a numeric rating scale provided thereby and displaying nine values; the level 1 translating the total disagreement and the number 9 indicating the full enjoyment for the sensory parameter felt [14]. The acceptance trends regarding the pungency flavor, the pepper aroma, the fluid texture, the coloration, and the global appreciation have thus been casted.

2.3 Statistical Analyses

The homogeneity of the data collected from the descriptive analysis was assessed through an analysis of variance according to the pepper extract formulation and using the Statistical Program for Social Sciences (SPSS 22.0, USA). Means were classified using Student Newman Keuls post-hoc test. For the hedonic acceptance, a test of Chi-Square (X^2) was achieved to compare the percentages got from each rating point [15]. Moreover, a principal main components analysis (PCA) has been casted using STATISTICA Software (STATISTICA version 7.1) as multivariate analysis to chart the variability between the pepper formulations and their sensory descriptors.

3. RESULTS

3.1 Descriptive Sensory Profile of the Pepper Extract Formulations

About the four descriptive descriptors assessed by the panellists, there isn't any statistical significant difference (P>0.05) recorded between

the samples of pepper formulations regarding the typical pepper aroma, the pungent flavor, and the fluid aspect. The typical pepper aroma and the pungent flavor are fairly or even weakly felt from the formulations, with respective averages of 2.45±0.88 to 4.11±1.36 and 2.67±1 to 4.22±0.83 upon the seven- range rating scale (Fig. 1). However, the samples displayed a distinct fluid aspect, with rating index between 4.22±1.48 and 5.78±0.83 (Fig. 2). On the other hand, the obviousness of the orange-yellowish appearance differentiates statistically (P <0.001) the peppers extract formulations studied. Thus, among the 25 formulations, the samples F18, F20, F21, and F24 display more intensive orange-yellowish appearance with respective averages of 4.44±1.01, 5.33±1.58, 4.33±0.50, and 4.67±1.12 upon the rating scale. Oppositely, the formulations F1, F5, F14, F16, F17, F23, and F25 record colorless appearance, with mean scores between 2.22/7 and 2.89/7 (Fig. 2).

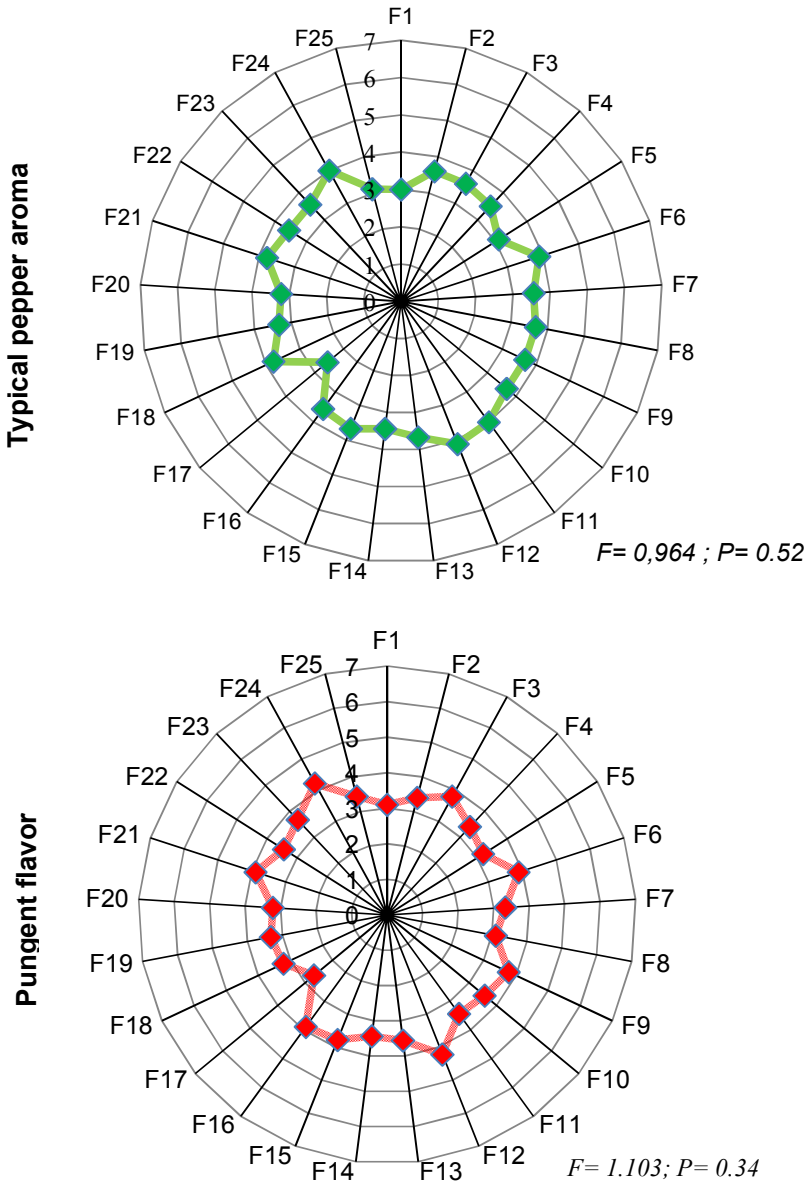

Fig. 1. Sensory perception scores of the typical pepper aroma and the pungent flavor felt from the 25 pepper extract composite formulations studied

F= value of the statistical Ficher test; P= statistical value of the probability test

According to their most significant distinctive orange-yellowish appearance as sole discriminative descriptive sensory parameter, the peppers extract formulations F18, F20, F21, and F24 have been considered for the hedonic sensory analysis.

3.2 Sensory Acceptance of the Peppers Extract Formulations

The hedonic analysis revealed significant variation from the acceptance scores rated for the peppers extract formulations F18, F20, F21, and F24. The statistical probability for difference between the nine appreciation points of each parameter is really significant ($P < 0.001$) from the X^2 proportions comparative test. Thus, the Table 5 reveals a sound sensory acceptance (scores 6 to 9) of the hedonic appreciation properties of dishes added with peppers extracts, with percentages between 65% and 98.4% for the orange- yellowish appearance, 50.78% and 61.89% for the pungent flavor, and between 58.72% and 71.41% for the typical pepper aroma. Generally, 71.42% to 77.76% panellists scored quite acceptance for dishes added with peppers extract formulations (Table 5).

On the other hand, rather weak percentages of disagreement or refusal (scores 1 to 4) are recorded. The refusal of peppers extract formulations is rated in proportions of 1.58% to 29.11% for the appearance, 31.64% to 44.34% for the pungent flavor, 22.03% to 33.32% for the typical pepper aroma, and 11.02% to 19.04% for the full appreciation. Doubtful panellists without any clear thought for samples' acceptance or refusal are estimated between 6.35% and 15.87%, 4.76% and 12.69%, 3.17% and 17.46%, and between 4.76% and 11.11% for respective orange-yellowish appearance, pungent flavor, typical pepper aroma, and global appreciation (Table 5).

Otherwise, among these formulations, the sample F24 generates the greatest acceptance rates in dishes, with scores of 98.4% appearance acceptance, 61.89% pungent flavor acceptance, 71.41% typical pepper aroma acceptance, and 77.76% global acceptance. This formulation is followed by F20 which is also more accepted for the appearance (76.17%), pepper aroma (68.82%), and global appreciation (76.17%) compared to formulations F18 and F21 (Table 5).

3.3 Sensory Variability of the Peppers Extract Formulations

The principal components analysis (PCA) generates three components (C1, C2, and C3) with respective eigenvalues of 3.29, 0.61, and 0.10 (Table 6). Both first components C1 and C2 ensuring respective 82.37% and 15.22% total variance were considered for drawing the PCA. The Fig. 3 casts the PCA results using the sensory parameters and the 4 advantageous pepper formulations. It shows significant

Table 5. General trend of the hedonic appreciation of the peppers extract formulations

Sensory variables	Formulations	% Sensory refusal (scores 1 to 4)	% Non-response (score 5)	% Sensory agreement (scores 6 to 9)
Orange-yellowish appearance	F18	17.45	15.87	66.65
	F20	12.6	11.11	76.17
	F21	29.11	6.66	65
	F24	1.58	6.35	92.04
Pungent flavor	F18	44.34	4.76	50.78
	F20	33.31	1269	53.95
	F21	31.64	7.93	60.3
	F24	33.31	4.76	61.89
Typical pepper aroma	F18	33.32	7.93	58.72
	F20	22.03	7.93	68.82
	F21	23.79	17.46	58.72
	F24	25.3	3.17	71.41
Global appreciation	F18	19.04	6.35	74.59
	F20	19.04	4.76	76.17
	F21	19.02	9.52	71.42
	F24	11.02	11.11	77.76

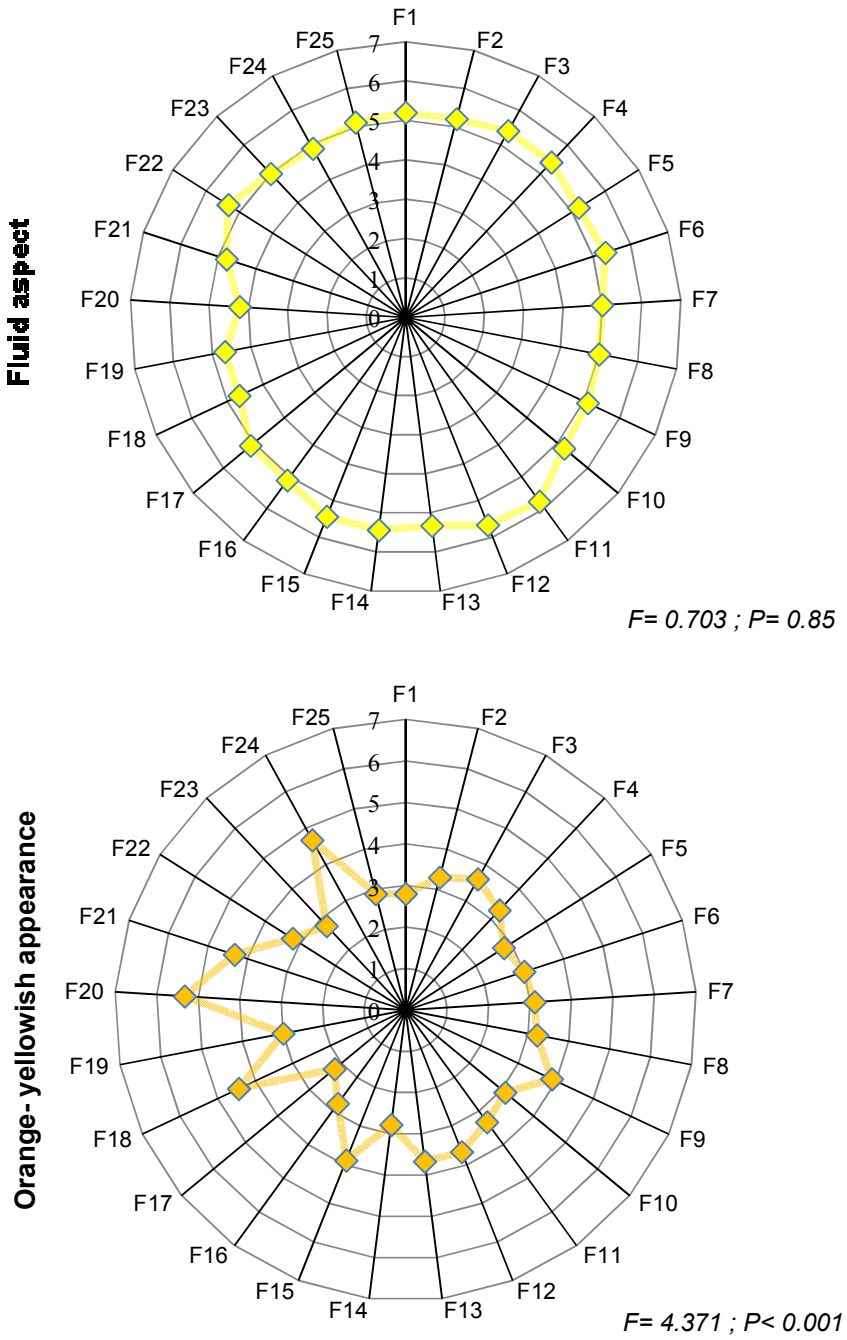

Fig. 2. Sensory perception scores of the fluid aspect and orange- yellowish appearance felt from the 25 pepper extract composite formulations studied

F= value of the statistical Ficher test; P= statistical value of the probability test

correlations between the component C1 and both sensory parameters and pepper formulations. Indeed, the pungent flavor, the typical pepper aroma, and the fluid aspect of the pepper extract are correlated to the negative part of C1 and are more felt from the formulations F21 and F24. The orange- yellowish appearance is correlated to the positive part of C1 and is more rated from the formulation F20 (Fig. 3).

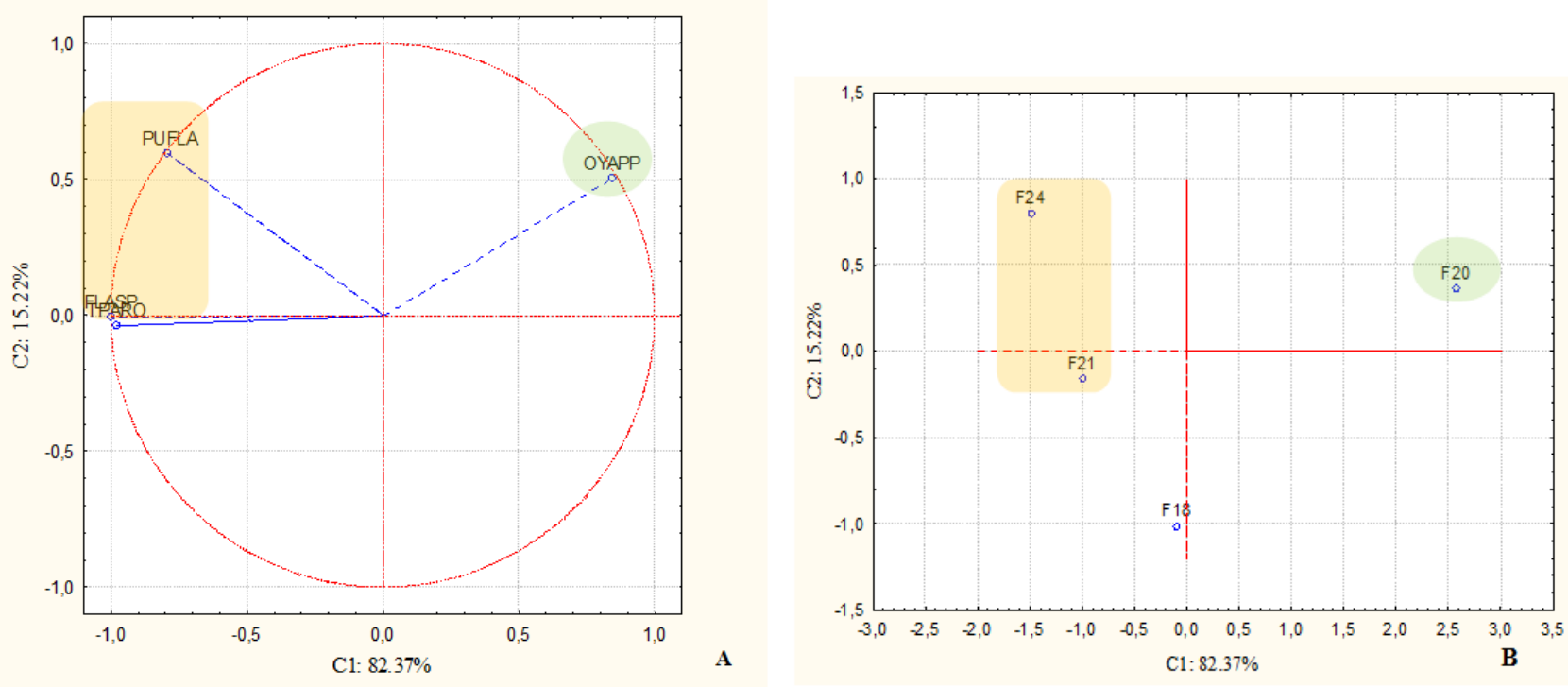

Fig. 3. Distribution of the sensory traits (A) and the significant formulation samples (B) of peppers composite extracts in the C1-C2 factorial draw of the principal components analysis (PCA)

PUFLA, pungent flavor; OYAPP, orange- yellowish appearance; FLASP, fluid aspect; TPARO, typical pepper aroma

Table 6. Eigenvalues and variances resulting from the principal components analysis

Components	C1	C2	C3
Eigen values	3.29	0.61	0.10
Variance (%)	82.37	15.22	2.41
Cumulated variance (%)	82.37	97.59	100.00

4. DISCUSSION

The organoleptic analysis from different formulations of peppers extract was about the appearance, the typical pepper aroma, the fluid aspect, and the pungent flavor of 25 peppers extract formulations. The orange- yellowish appearance was found more intensive from the formulations F18, F20, F21, and F24 compared to the other formulations. This obvious coloration could have been promoted by the different ratios of peppers extract used from the four varieties worked for the formulations. Indeed, the peppers *pili pili, bill of bird*, and *pepper baoulé* usually display nature red color at the full maturity stage.

In the 4 formulations aforesaid, the concentrations of these peppers extracts are more significant than that of the pepper Big Sun that becomes sallow at the full maturity stage. These formulations could also contain more pigments, antioxidant compounds supporting the red coloration of products. According to Hervert-Hernandez et al. [16], numerous pepper species record a large range of phytochemical compounds with evidenced antioxidant properties. The presence of pigments antioxidants could therefore justify the global orange appearance of the peppers extract formulations.

The three other sensory parameters (pungent flavor, pepper aroma, fluid aspect) didn't lead to any statistical difference between formulations. The capsaicin, responsible molecule of the pungency taste from peppers, as well as the aromatic substances, could be measured in global invarious contents over the formulations assessed.

Otherwise, the four formulations considered for the acceptance analysis were significantly more enjoyed than refused. The data indicated a great appreciation for formulations F24 and F20, with respective 77.76% and 76.17% panellists' satisfaction for the general acceptance. Formulations F20 and F24 could have recorded more general acceptance rate from panellists thanks to their appearance that was also more appreciated (76.17% and 98.4% acceptance, respectively) compared the appearance resulting from formulations F18 and F21 (66.65% and 65% acceptance, respectively). According to Bauer et al. [17], the color appearance is of essential characteristics for the appetizing trend of foods from the consumer. Peppers extract formulations F20 and F24 could therefore be more enjoyed in local dishes fluently consumed with addition of spices.

5. CONCLUSION

Pepper is known as taste strengthening additive for foods, providing therefore dishes with value-added in their organoleptic properties. The current investigation intended to produce peppers extract formulations as initiative in processing of this agricultural raw product. Regarding the sensory traits assessed, only the orange- yellowish appearance has been more evidenced from four pepper extract formulations among which the samples F20 and F24 have been more enjoyed by panellists. These formulations could therefore be promoted as technological baseline in the production of pepper extracts for foods for succeeding in more value-added for spices and more incomes for stakeholders in pepper production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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