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Nutritional and Sensory Analysis of Milk Processed from Seeds of Sweet Pea (*Cyperus esculentus* L.) Consumed in Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration between all authors. Author BGHM designed and expertized the study. Author ABAA performed the laboratory analyses and wrote the first draft of the manuscript. Author KNY achieved the statistical analysis and the revisions of the manuscript. Author CA assisted the experiments implementation. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the nutritional and sensory parameters of milk processed from sweet pea seeds consumed in Côte d'Ivoire.
Study Design: Sweet pea seeds samples gathered from communal markets in Abidjan district were used to process milk using improved and traditional methods. Nutritive parameters and sensory traits analyzed.
Place and Duration of Study: The study was conducted in Laboratory of Biochemistry and Food Sciences, Biosciences Unit, at Félix Houphouet-Boigny University, between January and May 2015.
Methodology: Sweet pea seeds from nine communal wholesale markets were considered in three communes of Abidjan district, three markets from each. A pool of 50 kg of the overall sweet pea

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samples was constituted, and then processed for milk production using traditional cloth filtration and improved microfiltration. Milks were used for nutritional evaluation consisting in proteins, lipids, ashes, and carbohydrates contents, and caloric energy value, and then carbohydrates and fatty acids components. Furthermore, sensory analyses were performed for acceptance and description of four sensory parameters (flavour, aroma, appearance, and texture).

Results: The sweet pea milk is richer in carbohydrates (25.06%), lipids (15.30%), and fibers (16.51%) and contains 4.97% proteins. Starch and sucrose are the major carbohydrates components ($p_{-value}<0.05$), with respective contents of 146.99% and 88.55% from the raw milk, then 40.67% and 24.50% when milk is filtered. These milks are highly richer in unsaturated fatty acids ($p_{-value}<0.001$) including more than 66% monounsaturated fatty acids and over 15% polyunsaturated fatty acids. The sensory profile revealed close appreciation of the filtered sweet pea milk and the soya milk for the sweet flavour, the white appearance, and the fruit aroma, more than the raw sweet pea milk ($p_{-value}<0.01$). Both filtered milk and soya milk also recorded more acceptance than the raw sweet pea milk.

Conclusion: Thanks to the significant nutritive properties and sensory acceptance, the sweet pea milk, especially when quite filtered, could be more valorizing for increasing the profitability of this culture and addressing the nutritional concerns for populations.

Keywords: Carbohydrates; fatty acids; nutritional parameters; sensory analysis; sweet pea milk.

1. INTRODUCTION

Sweet pea (*Cyperus esculentus* L.) is an herbaceous species of the plant systematic family of Cyperaceae originating from the Mediterranean basin. Sweet pea produces tuberous seeds called almonds of ground tiger nuts [1,2]. Spain is the first world producer of sweet pea seeds with 9,000 tons from 2,450 hectares of land in 2012 [3]. In Africa, the sweet pea was brought by the Arab wandering traders and now cultivated in various areas, especially in Maghreb and Western Africa [4].

In Côte d'Ivoire, the sweet pea seeds, commonly called '*'tchongon''*, are cultivated in the Savannah areas. The fresh sweet pea seeds are consumed by several populations for lactogenous and aphrodisiac virtues supposed to be associated with it [5,6]. Also, in many African countries, such as Ghana, Senegal and Togo, such seeds are often used as food sets during harshen periods [7].

However, more valorization is accounting from these seeds after application of technologies. Indeed, they are processed into oil with significant content in polyunsaturated fatty acids, endorsing sweet pea seeds into group of nutritive and healthy properties products (Dubois et al., 2007). From Spain, greatest technologies are recorded for the sweet pea seeds. These seeds are used in formulation of '*'horchata de chufa''*, a special milk with large consumption as exotic drink and belonging to the food patrimony of the region of Valencia [8]. These technological valorizations of the sweet pea seeds represent significant advantage for the economy of both production areas and Spain and other advanced countries [9]. The seeds harvested from various countries are exported to Europe and mainly in Spain [10].

Many studies were performed about the food interest of the sweet pea seeds. They resulted in significant amounts of proteins, fats and sugars with relative lower glycemic index. The seeds are therefore recommended in diets for people with metabolic disorders such as cardiovascular diseases and diabetes [11,12]. Besides, the unsaturated fatty acids of the oil extracted from the grains were with high proportion of omega 3 [6,13]. According to Belewu and Abodunrin [14], the consumption of this oil allows droping of the low density lipoproteins content (LDL) and increases that of the high density lipoproteins (HDL). This physiological characteristic has contribution in decreasing the risk of occurrence of cardiovascular diseases. The seeds oil also provides significant contents of vitamin E and other components favorable to the biological membranes such as the skin, and for the immune system as an antioxidant [15].

The main studies about the sweet pea seeds in Côte d'Ivoire were primarily related to agronomical parameters, especially the production yield [16,17]. There are not rather attempts relating to their valorization technology. However, the processing of these natural foods with quite sociocultural and nutritional interests could result in successful recipes for consumers, and thus represent effective ways in addressing the poverty for populations in many areas. This study aimed at determining the nutritive composition and the sensory acceptability of sweet pea seed milk consumed in Côte d'Ivoire.

2. MATERIALS AND METHODS

2.1 Raw Material

The study material was the milk processed from fresh sweet pea seeds sold commercially. The samples were collected between January and May 2015. Fresh seeds were purchased from markets in the communes of Adjamé, Yopougon, and Abobo, located at the Centre, North-Western and North-Eastern of Abidjan, respectively.

2.2 Sampling

Fresh sweet pea seeds were purchased from sedentary traders in 9 communal markets located in Adjamé, Yopougon and Abobo; 3 markets from each commune. For each market, the sweet seeds were bought from 9 various saleswomen at mean amount of 10 kg per woman, leading to overall quantity of 810 kg of seeds gathered and conveyed to laboratory for further investigations. Thus, a pool of 50 kg of sweet pea seeds was deducted after homogeneous mixture of the overall samples collected. Then, the seeds were sorted, washed and disinfected with hypochloride solution. Then, they were soaked for 72 h in a bath of distilled water for complete rehydration. After soaking, the seeds were crushed with a Heavy Duty Blender. The resulted batter was divided into 2 batches. The first half was filtered on a nylon cloth as in traditional processing. The second batch was subjected to a tangential microfiltration. Both treatments led to milky and thick solutions as presented at Fig. 1. The resulted sweet pea milks were preserved at 4°C in refrigerator till analyses.

2.3 Assessment of the Nutritive Components of the Milk

2.3.1 Determination of main biochemical parameters

The biochemical components were determined using standard methods by AOAC [18]. Thus, the ash content determination consisted in total incineration of 5 g of sweet pea milk at 550°C in an oven (PYROLABO, France) for 8 h. For crude fibers, 2 g of milk sample of sweet pea seeds were taken, and then put into an extraction solution prepared with 0.25 M sulfuric acid and 0.31 M sodium hydroxide, and intermittently boiled. After suction filtration, the insoluble residue was washed with hot water, oven-dried at 105ºC for 8 h then incinerated. The final residue led to the estimation of the crude fibers amount. The fibers, either soluble or insoluble, were quantified according to gravimetric enzymatic method [19]. The proteins contents were valued with the Kjeldahl total nitrogen method basis. The lipids contents were measured after extraction using hexane solvent and Soxhlet device. The total carbohydrates contents and total caloric energy value were estimated using following formulas [20]:

Total carbohydrates content (%) = 100 – (% moisture + % proteins + % lipids + % ash)

Total caloric energy (%) = (% proteins x 4) + (% carbohydrates x 4) + (% lipids x 9)

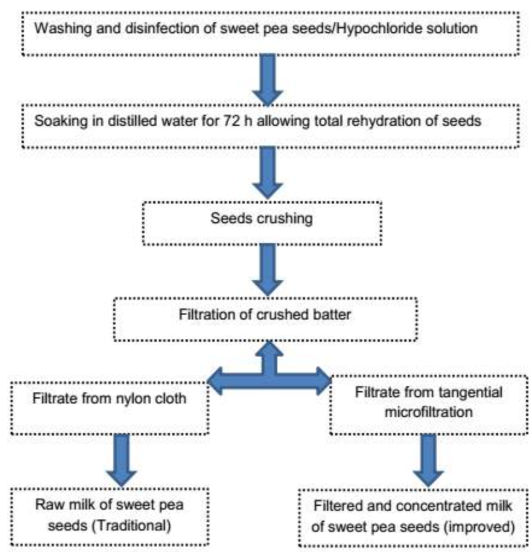

Fig. 1. Flow chart for processing of sweet pea milk

Starch content was also determined using iodine method of Jarvis and Walker [21], and the total soluble carbohydrates measured out with method of Dubois et al. [22] using phenol and sulfuric acid. Then, the reducing sugars were deduced according to the method of Bernfeld et al. [23] with 3, 5-dinitrosallicyclic acid reagent basis. Before their quantification, soluble carbohydrates were extracted with ethanol, zinc acetate and oxalic acid [24]. The results of proteins, lipids, ashes, fibers, starch, total glucides, and total soluble and reducing carbohydrates contents were expressed on the dry matter basis.

2.3.2 Evaluation of oligosaccharides in the carbohydrates from the sweet pea milk

The main carbohydrates elements from sweet pea milks were identified using a High Performance liquid Ionic chromatography (HPIC) equipped with a DX600 unit (Dionex corp., Sunnyvale, CA) and a pulsed amperometric detector (Dionex ED50). Samples of sweet pea milk have undergone a 1/1,000 dilution with ultrapure water (deionized). Then, they were filtered upon a micropore membrane (0.45-micron diameter) before injection on a 4 x 250 mm Dionex column (Carbocarp MA-1 model). The elution of the sugars was enhanced with a sodium hydroxide (NaOH) gradient, consisting in successive practicing of 0.8 M NaOH for 10 min, 0.6 M NaOH for 30 min and 0.8 M NaOH for 10 min once more, at programme of 0.4 mL/min. An external mixture of standard carbohydrates compounds purchased from Sigma-corporation (Sigma Aldrich, USA) and taken at concentrations above their limit of quantification, was injected within 8 sets of sweet pea seeds samples, and also eluted. This accounted with drift coefficient and correction of the raw results before calculating the content of each carbohydrate molecule from the samples. The resulted chromatograms were analyzed with Chromoleon software version 6.11 (Dionex, USA). Each sample was analyzed in duplicate and the average of carbohydrate content was expressed in g/kg.

2.3.3 Fatty acid composition of fats from the sweet pea milk

The various fatty acids of the sweet pea milk were highlighted according to AFNOR method [25]. This determination was achieved with a Gas Phase Chromatography device (Finnigan Focus GC System, Restek, France) coupled with a flame ionization detector, an injector and a digital integrator. The process was preceded by the fatty acids' extraction from triglycerides and their conversion into methyl esters forms using chloroform-methanol solvents mixture. This operation used a silica capillary column (CP 88:60 Sil x 25 mm, Waters, USA) with helium as gas carrier at a programme of 20 mL/min. The column temperature was maintained at 100℃ while the temperature of the injector and detector were both at 220℃. The calibration was performed thanks to an internal standard of methyl palmitate esters and the percentage of each fatty acid was obtained using the integrator (Azur Software: Thermo Electron Corporation, GC).

2.3.4 Estimation of daily nutrient intake of the sweet pea milk

The daily intake from each nutrient was estimated accounting the content and the mean consumption of sweet pea milk. Values were calculated with the amount of 31.1 g or 31.1 mL of overall milk consumed per day by a 70 kg adult person in Côte d'Ivoire [26,27].

$$EDI = Cn * Qc$$

With: EDI, estimated daily intake of the nutrient (g/day; Cn, concentration of nutrient; Qc, daily consumption of milk (31.1 g).

2.4 Sensory Evaluation of the Sweet Pea Milk

The sensory analysis consisted in tasting of both raw and filtered sweet pea milks compared to milk processed from soya bean bought from a supermarket and used as control. Thus, hedonic acceptance and descriptive sensory tests were performed. The tasting sessions were carried out in the laboratory of Biochemistry and Food Sciences from Felix Houphouët-Boigny University of Abidjan. Each analysis was performed with 15 mL of milk samples filled in glasses. Responses were given by scores within a 9 points rating scale where 1 expressed the lack of sensation and 9 expressed the full feeling.

2.4.1 Hedonic appreciation

The hedonic analysis was carried out by a group of 30 persons including both male and female genders and recruited according to their availability and their awareness of the sweet pea seeds. The panelists were invited to translate the level of their acceptance of the appearance, flavour, aroma and texture of the milk samples filled with anonymous codes, by providing values from 1 to 9 [28], for respective extreme desagreability and extreme pleasure.

2.4.2 Descriptive sensory analysis

Sensory description consisted in expressing the intensity of some properties perceived from the milk. The experiments were performed by a group of 10 panelists trained beforehand for the identification of four descriptors, namely appearance, flavour, aroma and texture of the milk and their perception degree (Table 1). The jury was selected according to the availability, the health, the motivation for participating in the study, and the sensory aptitude, especially for the sight, smell, and taste. For the evaluation of the milk, panelists were invited to taste samples anonymized with codes (A, B and C) and filled into various orders of presentation as shown in Table 2, then to fit the rating scale by indicating the value for the intensity perceived. The values varied also from 1, when the sensory parameter is not perceived, to 10 when it is extremely felt.

2.5 Statistical Analysis

The statistical treatment was performed at 5% significance level. The statistical analysis of the nutritive parameters consisted in a Student T test comparing the milk raw milk of sweet pea seeds and the milk resulting from the tangential microfiltration. From the sensory descriptive tests, a one-way Analysis Of Variance (ANOVA) according to the type of milk was carried out and means were compared with the Student Newman Keuls statistical post-hoc test. Then, multivariate analyses, specifically Principal Component Analysis and Ascending Hierarchical Clustering, were drawn for structuring variability between sensory parameters and milk samples. For the acceptance tests, a Chi square (X^2) non-parametric test of comparison of proportions was implemented.

Table 1. Descriptors for sensory analysis of the sweet pea milk

Parameter	Meaning	Rating scale for evaluation	
		Minimum (any)	Maximum (extreme)
Appearance	White	0	9
Flavour	Sweet	0	9
Aroma	Fruit aroma	0	9
Texture	Fluidity	0	9

Table 2. Fitting of various samples of milk A, B and C* to panelists for descriptive tasting

Order of individuals	Order of fitting
1	ABC
2	ACB
3	BAC
4	BCA
5	CBA
6	CAB
7	ABC
8	ACB
9	BAC
10	BCA

A, Raw milk of sweet pea seeds; B, Soya milk; C, Filtered milk of sweet pea seeds

3. RESULTS AND DISCUSSION

3.1 Nutritive Components of the Sweet Pea Milk

Results from the nutritive parameters show quite difference between the raw milk obtained with simily traditional extraction from the sweet pea seeds and the concentrated milk after tangential microfiltration as highlighted by the significance p_{-value} (p<.001) of the statistical student t test from overall parameters in Table 3. Indeed, the raw milk contains more ash (1.04%) compared to the filtered milk (0.29%). Before filtration, the sweet pea milk also contains more proteins and records greater fat and carbohydrates contents than thereafter, with respective means of 4.97%, 15.30% and 25.06% against 1.37%, 4.23% and 6.93%. Moreover, the microfiltration of the sweet pea milk results in droping of the amounts of fibers (4.57%), total soluble carbohydrates (3.23%), and reducing sugars (0.42%) compared to respective values of 16.51%, 11.69% and 1.51% found in the unfiltered raw milk. Such changes of the nutrients result in rather droping of the total caloric energy value of the milk to 71.35 kcal/100 g against 257.89 kcal/100 g provided before filtration. From overall macromolecules parameters, the carbohydrates are more represented (p<.001) in both raw and filtered sweet pea milks, with respective content of 25.06% and 6.93% (Table 3).

3.1.1 Main carbohydrates components of the sweet pea milk

Starch is the most overriding carbohydrate in the milk (p<.001) processed from sweet pea seeds. It is found in the raw milk with content of 147 g/kg which is superior (p<.001) to the mean of 40.67 g/kg resulting from the filtered milk. This carbohydrate is followed by sucrose with similar distribution consisting in 88.55 g/kg before the milk's filtration and 24.50 g/kg from the filtered milk. Other oligosaccharides, namely maltose, xylose, glucose, fructose and lactose, are also measured. But they are with relative lower contents oscillating between 0.17 and 3.01 g/kg (Table 4).

3.1.2 Fatty acids composition of the sweet pea milk

Excepted of Arachidic, Behenic, margaric, and palmitoleic acids, Table 5 shows statistically similar contents (p>.05) in each saturated or unsaturated fatty acid either the sweet pea milk is considered before filtration or thereafter. With overall amounts of 19.375% and 18.797% in respective raw milk and filtered milk, the saturated fatty acids are mainly constituted of palmitic acid, with invariable contents in both milks (14.21% and 14.36%, respectively).

Besides, the major fatty acids (more than 80%) are unsaturated, with rather great contents superior to 66% of monounsaturated components, and more than 13% for the polyunsaturations, unvarying from both raw and filtered milks. The monounsaturated fatty acids are with more oleic acid contents in raw milk and filtered milk (65.29% and 66.34%, respectively), whereas the linoleic acid represents almost the overall (13.21% and 14.30%, respectively) polyunsaturated fatty acids (Table 5).

3.1.3 Estimated nutrients intakes from consumption of sweet pea milk

The estimated daily consumption of 31.1 g of milk provides more nutrients intakes ($p<.001$) from the raw milk compared to the filtered milk. The raw milk allows daily mean intakes of 1.54 g of proteins, 4.76 g of lipids, 5.13 g of fibers, and 7.79 g of carbohydrates and provides total caloric energy of 80.20 kcal whereas the micro filtered sweet pea milk records lower values of 0.43 g, 1.32 g, 1.42 g, 2.16 g, and 22.19 kcal for respective nutrients (Table 6).

3.2 Sensory Characteristics of the Sweet Pea Milk

3.2.1 Sensory acceptance of the milk

Table 7 shows various appreciations from the milk samples tasted by panelists.

From the raw sweet pea milk, more than 70% panelists do not appreciate neither the flavour nor the appearance and the aroma. These parameters record respective percentages of 56.67%, 66.67% and 30% full rejection from the panelists. Oppositely, the texture is accepted by 70% persons including 36.67% full acceptance.

Table 3. Values of the main nutritive traits of the milk processed from sweet pea seeds

Parameters	Contents from RMSPS	Contents from FMSPS	t_{-value}	p_{-value}
Proteins content (%)	4.970±0.065^{aC}	1.375±0.058^{bD}	71.914	<0.001
Fats content (%)	15.301±0.684^{aB}	4.233±0.035^{bC}	27.978	<0.001
Total fibers content (%)	16.506±1.347^{aB}	4.567±0.206^{bB}	15.171	<0.001
Total carbohydrates content (%)	25.060±0.592^{aA}	6.933±0.257^{bA}	48.671	<0.001
f_{-value}	308.25	551.23		
p_{-value}	<0.001	<0.001		
Reducing sugars content (%)	1.512±0.122^{a}	0.418±0.002^{b}	15.471	<0.001
Total soluble carbohydrates content (%)	11.687±1.395^{a}	3.233±0.050^{b}	10.492	<0.001
Ash content (%)	1.036±0.03^{a}	0.287±0.092^{b}	14.155	<0.001
Caloric energy value (kcal/100 g)	257.892±2.631^{a}	71.350±1.559^{b}	105.636	<0.001

From the same parameter, values with different lowercase letter are statistically different at 5% significance; f_{-value}, value of the statistical Ficher test; t_{-value}, value of the statistical Student t-test; p_{-value}, probability value of the statistical test. RMSPS, raw milk of sweet pea seeds; FMSPS, filtered milk of sweet pea seeds

Table 4. Contents of carbohydrates components from the sweet pea milk

Carbohydrates components	Contents (g/kg)		t_{-value}	p_{-value}
	RMSPS	FMSPS		
Maltose	3.012±0.116^{aC}	0.833±0.093^{bC}	25.292	<0.001
Sucrose	88.554±0.484^{aB}	24.500±0.016^{bB}	151.714	<0.001
Glucose	1.807±0.003^{aD}	0.500±0.016^{bC}	136.002	<0.001
Fructose	0.964±0.007^{aE}	0.267±0.020^{bC}	55.869	<0.001
Lactose	0.602±0.006^{aE}	0.167±0.006^{bC}	90.663	<0.001
Xylose	0.602±0.005^{aE}	0.167±0.007^{bC}	92.164	<0.001
Starch	146.988±0.211^{aA}	40.667±1.268^{bA}	14.308	<0.001
f_{-value}	251677	2944.02		
p_{-value}	<0.001	<0.001		

Table 5. Fatty acids components from the sweet pea milk

Fatty acids	Contents from RMSPS (%)	Contents from FMSPS (%)	t_{-value}	p_{-value}
Palmitic acid C16:0	14.210±1.904[aB]	14.356±0.690[aB]	-0.20	0.85
Stearic acid C18:0	3.856±0.268[aC]	3.542±0.179[aC]	1.69	0.170
Arachidic acid C20:0	0.670±0.069[aD]	0.465±0.012[bD]	5.10	**0.007**
Behenic acid C22:0	0.360±0.037[aD]	0.234±0.060[aD]	3.08	**0.034**
Lignoceric acid C24:0	0.156±0.020[aD]	0.133±0.010[aD]	1.78	0.150
Margaric acid C17:0	0.123±0.011[aD]	0.067±0.002[aD]	8.37	**0.001**
Total Saturated fatty acids	**19.375**	**18.797**		
Oleic acid C18:1n9 cis	66.340±2.625[aA]	65.287±2.000[aA]	0.55	0.610
Palmitoleic acid C16:1	0.420±0.023[bD]	0.765±0.100[aD]	-5.82	**0.004**
Eicosenoïc acid C20:1	0.313±0.017[aD]	0.425±0.101[aD]	-1.90	0.130
Erucic acid C22:1n9	0.013±0.004[aD]	0.012±0.001[aD]	0.48	0.660
Nervonic acid C24:1	0.013±0.004[aD]	0.012±0.001[aD]	0.48	0.660
Total Monounsaturated fatty acids	**67.097**	**66.501**		
Linoleic acid C18: 2n6Cis	13.210±0.819[aB]	14.298±2.000[aB]	-0.87	0.430
Linolenic acid C18:3n3	0.302±0.012[aD]	0.389±0.200[aD]	-0.75	0.490
Total Polyunsaturated fatty acids	**13.512**	**14.687**		
Total unsaturated fatty acids	**80.609**	**81.188**		
f_{-value}	1160.68	1485.19		
p_{-value}	<0.001	<0.001		

From the same line/column, values with different lowercase/uppercase letters are statistically different at 5% significance; f_{-value}, value of the statistical Ficher test; t_{-value}, value of the statistical Student t-test; p_{-value}, probability value of the statistical test. RMSPS, raw milk of sweet pea seeds; FMSPS, filtered milk of sweet pea seeds

Table 6. Estimated daily nutrients intakes resulting from consumption of 31.1 g of sweet pea milk

Nutritive traits	Nutrients intakes from the sweet pea milk		t-value	p-value
	RMSPS	FMSPS		
Proteins (g/day)	1,55±0.02[a]	0,43±0.02[b]	71,914	<0.001
Lipids (g/day)	4,76±0.21[a]	1,32±0.01[b]	27,978	<0.001
Fibers (g/day)	5,13±0.42[a]	1,42±0.06[b]	15,171	<0.001
Carbohydrates (g/day)	7,79±0.18[a]	2,16±0.08[b]	48,671	<0.001
Caloric energy value (Kcal/day)	80,2±0.82[a]	22,19±0.48[b]	105,636	<0.001

From the same line, values with different lowercase letters are statistically different at 5% significance; f_{-value}, value of the statistical Ficher test; t_{-value}, value of the statistical Student t-test; p_{-value}, probability value of the statistical test. RMSPS, raw milk of sweet pea seeds; FMSPS, filtered milk of sweet pea seeds

Regarding the filtered milk, the appearance, the flavour and the aroma are rather more appreciated than the raw unfiltered milk. Percentages of 56.66% and 90% tasters accept the milk's respective appearance and aroma, and 46.67% of them accept the flavour. However, 40%, 43.34% and 3.33% persons find these parameters unpleasant. This milk also provides a pleasant texture accounting 63.34% positive opinions against 20% of rejection.

Compared to milks of the sweet pea seeds, the control soya milk is generally pleasant for appearance and texture with respective rate of 80% and 74% acceptance. But, the flavour and the aroma of the soya milk do not differentiate the levels of acceptance (P>.05) and record respective rates of 30% and 40% panelists expressing displeasure when 50% accept them (Table 7).

3.2.2 Sensory characteristics of the milk

Fig. 2 indicates the sensory profile of the milks studied. These milks are statistically differentiated by the appearance, the flavour, and the aroma (p<.001), while the texture is invariably felt (p=.08).

Table 7. Percentages of panelists for acceptance of the appearance, the flavour, the aroma, and the texture felt from the milk

Analysis parameters			Rejection				Middle		Acceptance			Statistics	
Levels of rating scale			1	2	3	4	5	6	7	8	9	X^2	P
df							8						
Theorical distribution (%)			11.10	11.10	11.10	11.10	11.10	11.10	11.10	11.10	11.10		
Experimental responses	A	Appearance (%)	56.67	23.33	6.67	0.00	0.00	1.00	3.33	0.00	0.00	75.67	<0.001
		Flavour (%)	66.67	6.67	10.00	10.00	3.33	3.33	0.00	0.00	0.00	97.3	<0.001
		Aroma (%)	30	16.67	23.33	6.67	6.67	10	6.67	0.00	0.00	22.82	0.004
		Texture (%)	3.33	13.33	3.33	3.33	6.67	0.00	6.67	26.67	36.67	33.63	<0.001
	B	Appearance (%)	0.00	0.00	0.00	3.33	16.67	10	10	30	30	31.83	<0.001
		Flavour (%)	0.00	10	13.33	6.67	20	23.33	16.67	6.67	3.33	13.21	0.105
		Aroma (%)	6.67	3.33	20	10	10	10	13.33	23.33	3.33	10.21	0.25
		Texture (%)	0.00	6.67	0.00	13.33	6.67	3.33	26.67	26.67	16.67	23.42	0.003
	C	Appearance (%)	0.00	0.00	6.67	23.33	13.33	13.33	10	23.33	10	15.62	0.048
		Flavour (%)	0.00	0.00	26.67	16.67	10	16.67	16.67	13.33	0.00	19.22	0.013
		Aroma (%)	0.00	0.00	0.00	3.33	6.67	16.67	26.67	26.67	20	28.23	0.025
		Texture (%)	0.00	6.67	3.33	10	16.67	6.67	30	16.67	10	17.42	0.026

P, value of probability test at 5%; x^2, value of the proportion comparison test; df, degree of freedom.
A, B and C: Respective raw milk of sweet pea seeds, soya milk and filtered milk of sweet pea seeds

The filtered sweet pea milk and the control soya milk are more fitted with the white appearance (8.60/10 and 9.12/10, respectively) than the raw sweet pea mil (1.89/10). Regarding the fruity aroma, filtered sweet pea milk and soya milk result in identical mean rating of 8.73/10 and 7.14/10, respectively, which are and higher than the value of xxx recorded from the raw sweet pea milk.

The unfiltered sweet pea milk also provides lower sweet flavour (1.19/10), whereas both filtered sweet pea milk and soya milk account higher rating of 8.06/10 and 7.09/10, respectively.

On the other hand, the fluidity texture is felt with statistical similar rating from the raw sweet pea milk, the filtered sweet pea milk, and the soya milk, ranging between 7.38/10 and 9.4/10 (Fig. 2).

Otherwise, the principal components analysis shows significant correlation of the four sensory parameters assessed with two principal factors (F1 and F2), which are therefore considered for the structuring of the variability (Table 8). Thus, the projection of the sensory parameters and tasted milk samples on the F1-F2 factorial draw reveals two groups of samples. Most of the samples of filtered sweet pea milk and soya milk (in green ring) are correlated with great indexes of white appearance, fruity aroma, and sweet flavour and some of them (4 individuals) provide major fluidity texture (Figs. 3 and 4). Oppositely, the raw sweet pea milk samples (in red ring) record mitigated feeling index from the overall sensory parameters. Such a structuring is confirmed by the dendrogramme performed in Fig. 5 and gathering filtered sweet pea milk and soya milk.

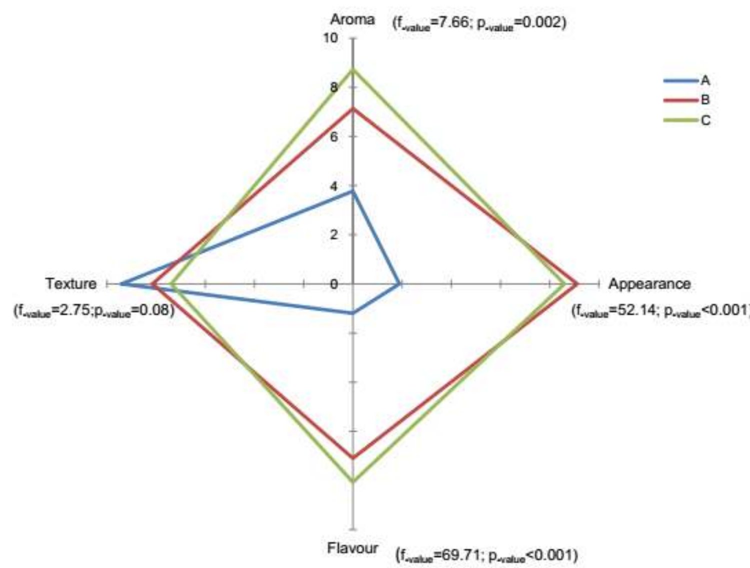

Fig. 2. Sensory profile of raw milk of sweet pea (A), soya milk (B) and filtered sweet pea milk (C)

Table 8. Eigen values and correlations matrix of the main components with the sensory parameters of the milk samples submitted to principal component analysis

Principal components	F1	F2	F3	F4
Eigen values	2.76	0.81	0.31	0.11
Variance (%)	69.06	20.28	7.83	2.83
Cumulated variance (%)	69.06	89.34	97.17	100
Appearance	**-0.916**	-0.187	0.285	-0.211
Flavour	**-0.951**	-0.028	0.171	0.256
Aroma	**-0.843**	-0.308	-0.441	-0.027
Texture	0.555	**-0.825**	0.094	0.049

Bold values are significant at 5% statistical level

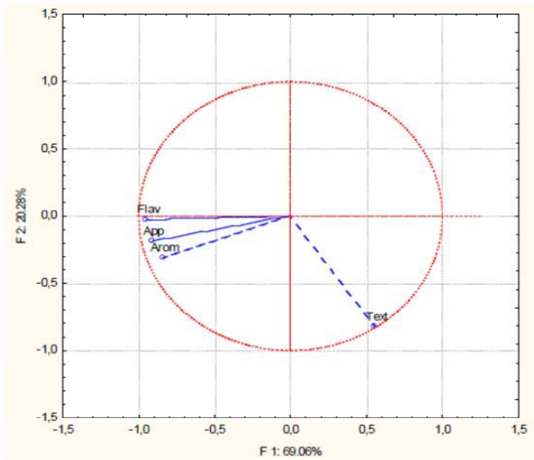

Fig. 3. Correlations between the sensory parameters of the studied milks and the F1-F2 factorial draw of the principal components analysis

Flav, sweet flavour; App, white appearance; Arom, fruity aroma; Text, fluidity texture

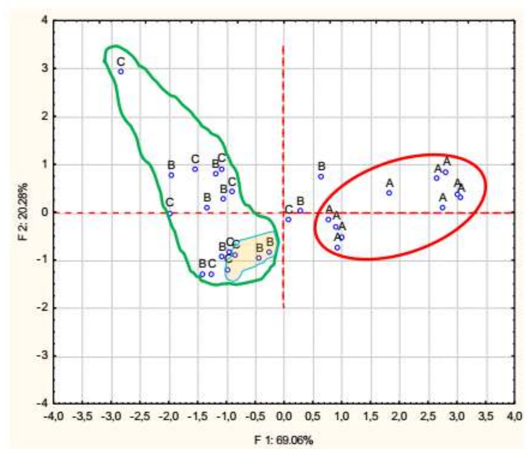

Fig. 4. Projection of the milk samples in the F1-f2 factorial draw of the principal component analysis

A, Raw milk of sweet pea seeds; B, Control soya milk; C, Filtered milk of sweet pea seeds

4. DISCUSSION

Carbohydrates are the most represented nutrients of the milk deriving from the sweet pea seeds, with mean percentage 25% in the raw milk and 7% in the filtered milk. The carbohydrates contents found in this study are close with the statement of Sanchez et al. [29]. They are primarily constituted of starch and food fibres. The raw milk is thus more starchy food compared to other widely consumed drinks such as cow milk and palm saps [25,30]. Former studies showed that the sweet pea milk is appreciated for its significant nutrients contents, particularly in starch, fibers, and saccharides [11]. It also records advantage in lower lactose content, accounting the sweet pea milk as a valuable food for people with intolerance for this disaccharide. The nutritive interest of the raw sweet pea milk is also supported by the considerable ash content, proof for important presence of mineral elements. These minerals could consist in calcium, potassium, and magnesium, according to reports of Sanchez et al. [29]. Besides, a significant amount of vegetable proteins are found, especially from the unfiltered milk, with a content of 4.97%.

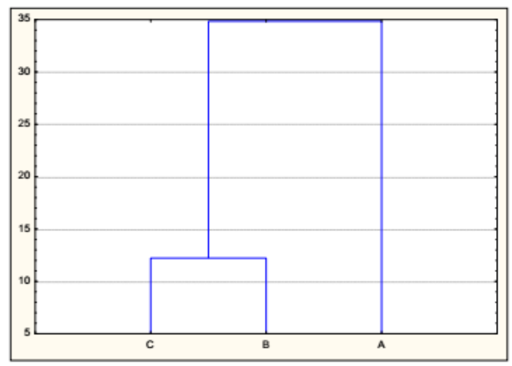

Fig. 5. Clustering dendogramme of the milk samples performed with the unweighted pair group method with arithmetic means (UPGMA)

A, Raw milk of sweet pea seeds; B, Control soya milk; C, Filtered milk of sweet pea seeds

During the tangential microfiltration of the raw sweet pea milk, several chemical elements could be retained upon the filter. Such a mechanism was hypothesized by Konan et al. [30] for the filtration of the coconut sap. It results in significant reduction of their contents, as got from the carbohydrates, fats, fibers, ashes and proteins components of the micro filtrate. According to Bosch et al. [31], the proteins found in sweet pea could have more essential amino acids than the standard values enacted by the FAO/WHO for covering the needs of adult populations. The sweet pea milks are with highly unsaturated fatty acids profile, accounting more than 67% monounsaturated fatty acids including beyond 65% oleic acid. The greater presence of unsaturations is rather valorizing for the sweet pea milk. Indeed, it could support the dropping in contents of the low density lipoproteins (LDL-cholesterol) and triglycerides thanks to the significant contribution in oleic acid [25].

The estimated daily intakes of the different nutrients, with the consumption of the cow milk basis, represent a quite index for valorizing the sweet pea milk. The results showed that the raw sweet pea milk is more suitable than the filtered sweet pea milk for providing higher nutrients intakes. However, regarding their nutritive interest, these milks are usable for addressing malnutrition by participating in fitting the populations' nutrients needs with energetic, structural and functional properties.

From the sensory appreciation of the milks, there was a significant rejection of the raw sweet pea milk by panelists. This refusal is unfortunately correlated with higher nutrients contents found from the biochemical analysis. Therefore, the main nutrients which consist of biochemical molecular complexes having biological and functional properties do not necessarily induce significant organoleptic pleasure. Thus, the microfiltration allows modification in the biochemical composition which results in quite improvement of the pleasure accounted from the sweet pea milk. So, the sensory profile of the raw sweet pea milk differs from the data provided by the filtered milk which is itself close to the soya milk. The soya milk and the filtered sweet pea milk could enclose similarities in their composition. The assumption is so probable that the sweet pea milk is often considered as alternative food for the soya milk by referring to the biochemical composition and the nutritive value [25,32].

5. CONCLUSION

The goal of this study was to highlight the sustainable valorization of the milk processed from the sweet pea seeds consumed in Côte d'Ivoire. Based on the outcomes, sweet pea milk is good source of caloric energy thanks to the great carbohydrates content associated to the significant contents in lipids and proteins and the interesting composition in biofunctional fatty acids. From the sensory tests, the filtered milk of sweet pea seeds could fit more valorization for consumers thanks to better organoleptic characteristics. Such a technology is necessary for adding value to sweet pea milk in order to increase its consumption and profitability.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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