

Original Research Article

Assessment of biochemical properties from seeds and oil deriving with sweet pea (*Cyperus esculentus* L.) in Côte d'Ivoire

ABSTRACT

Aims: To assess chemical and nutritive traits in seeds and seed oil from the sweet pea marketed in Abidjan and consumed in Côte d'Ivoire.

Study design: Pool of sweet pea seeds samples gathered from communal markets in District of Abidjan. Biochemical parameters investigated, and sweet oil extracted and characterized for its main properties.

Place and Duration of Study: Laboratory of Biochemistry and Food Sciences, Department of Biochemistry, Biosciences Unit, between January and May 2015.

Methodology: Nine communal wholesale markets were considered in three communes of the District of Abidjan, three markets each commune. A pool of 5 kg of the overall sweet pea seeds samples was constituted. Then, biochemical parameters (moisture, proteins, lipids, ash, glucides, caloric value, and carbohydrates components) of the seeds samples were evaluated with official standard methods. The oil extracted from the sweet pea seeds was characterized for main properties: oil chemical quality (oil density, iodine, and peroxide and saponification indexes, acid value) and biochemical parameters (saturated and unsaturated fatty acids).

Results: The sweet pea seeds are with high contents of glucides (41.60 ± 0.36 %), lipids (25.40 ± 0.09 %), and fibers (27.40 ± 0.02 %) and provide 8.25 ± 0.01 % of proteins. The most abundant glucides are starch (24.44 ± 0.40 g/100 g) and sucrose (14.7 ± 0.01 %). The oil resulting from sweet pea seeds is richer in insaturations, with iodine index of 130.9 ± 0.88 g of I_2 /100 g and unsaturated fatty acid content of 78.73%. This oil also reveals acceptable quality, with acid value of 1.18 ± 0.05 mg KOH/g, peroxide index of 2.80 ± 0.43 mEq O_2 /kg, and contains secondary phytonutrients gathered within 0.96 ± 0.012 % of unsaponifiable compounds.

Conclusion: Thanks to the significant nutritive properties of the raw sweet pea seeds, and then the quality of their oil, especially the rather presence of unsaturated fatty acids, valorization of sweet pea seeds in foodstuffs could increase the profitability of this culture.

Key words: Sweet pea seeds-nutritive compounds-oil quality-fatty acids.

1. INTRODUCTION

The sweet pea (*Cyperus esculentus* L.) is a hardy and rhizomatous herbaceous in the plant systematic family of Cyperaceae. It accounts with common names of tuberous pea, ground kernel or striped nuts, and is originating from the Mediterranean basin [1; 2]. With about 2,450 ha of acreages for 9,000 tons in 2012, Spain is the first producer of sweet pea seeds in the world, resulting in 3.3 billion euros of net incomes [3]. The sweet pea has been introduced in Africa by Arabs and is more cultivated in the Maghreb countries. It is also met in many countries of Western Africa [4] where Niger remains the top producer with 38,000 tons/year before Burkina Faso and Mali [5]. In Côte d'Ivoire, the sweet pea, locally named "tchongon" in Malinké language, is cultivated in the savannah and the crops are primarily exported for Spain [5]. Indeed, the sweet pea seeds are raw material for the preparation of "horchata de chufa", a typical milk of the Valencia region in Spain [6]. This drink deals with a significant interest for the general economy of the sweet pea seeds, from the production areas to the European continent [7]. The seeds are also used for oil production and the sweet pea seeds oil is richer in polyunsaturated fatty acids. Moreover, the fresh sweet pea seeds are regularly consumed by nurses and men for respective lactagenous and aphrodisiac properties [8; 9]. In Africa, the sweet pea seeds are still used as food sets in several countries (Ghana, Togo and Senegal) especially in harshen seasons [10].

Several attempts were implemented upon the nutritive value of the sweet pea seeds cultivated in various countries. They show high percentages of proteins, fat content and low glycemic index carbohydrates.

Such characters allowed promotion of the sweet pea in the food dietaries for people concerned with chronical pathologies related to diabetes and cardiovascular diseases [11; 12]. However, the oil deriving from the sweet pea seeds is richer in omega-3 fatty acids [13; 9]. So, it's accounted with the reduction of the low density lipoproteins (LDL) and the rising of the high density lipoproteins (HDL), leading to reduction of the risk in occurrence of cardiovascular diseases [14]. It is also richer in vitamin E and antioxidants evidencing positive effects for the cellular membranes, the immune systems and the anti-radicalizing mechanisms [15].

In Côte d'Ivoire, the main studies about the sweet pea seeds are primarily related to the agronomic parameters [16; 17]. In the general strategies to address nutrients deficiencies and regarding with the valorizations policies of the foodstuffs with social, cultural and nutritional interests, the sweet pea seeds could be considered as a bracing or a health food. This study was implemented to determine the nutritive characters of the seeds and the oil of the sweet pea sold in Côte d'Ivoire.

2. MATERIAL AND METHODS

2-1 Plant material

The plant material was constituted of fresh sweet pea seeds collected between January and May 2015 from several markets of the District of Abidjan, in Côte d'Ivoire. Specifically, the markets of Adjamé, Yopougon and Abobo respectively located at the center, the North-Western and the North-Eastern of Abidjan were considered.

2-2 Sampling

The sweet pea seeds were purchased from sedentary traders in 3 markets located in the communes of Adjamé, Yopougon and Abobo; 3 markets/commune. For each market, the sweet seeds were bought from 9 various female retailers at a rate of 10 kg per woman, leading to a total weight of 810 kg of seeds gathered and conveyed to laboratory for further investigations. Thus, a pool of 5 kg of sweet pea seeds was deducted after homogeneous mixture of the overall samples collected. This final amount was dried into an oven (Memmert, Germany) at 50°C for 72 h. Then, the dried seeds were ground using a Heavy Duty machine. The crushed seeds were sealed and kept into a desiccator till analyses.

2-3 Assessment of nutritive compounds

Proximate components were analyzed using standard AOAC methods [18]. Thus, the sweet pea seeds moisture was deduced after further oven-drying (Memmert, Germany) at 105°C. The ash content has resulted from incineration of 5 g of dried sweet pea seeds sample at 550°C in another oven (PYROLABO, France) to constant mass. For crude fibers, 2 g of crushed sweet pea seeds samples were taken, then put into an extraction solution prepared with 0.25 M sulfuric acid and 0.31 M sodium hydroxide, undergoing intermittent boiling. After suction filtration, the insoluble residue was washed with hot water, oven-dried at 105°C 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 resulted from extraction with solvent (hexane) and a Soxhlet device. The total glucides content and total caloric energy value were estimated using following formulas [20]:

$$- \text{Total glucides content (\%)} = 100 - (\% \text{ moisture} + \% \text{ proteins} + \% \text{ lipids} + \% \text{ ash}) \quad (1)$$

$$- \text{Total caloric energy (\%)} = (\% \text{ proteins} \times 4) + (\% \text{ carbohydrates} \times 4) + (\% \text{ lipids} \times 9) \quad (2)$$

Starch content was also determined using iodine method of Jarvis and Walker [21]; and the total soluble carbohydrates measured out with the method of Dubois et al. [22] using phenol and sulfuric acid. Then, the reducing sugars were deducted from the method of Bernfeld et al. [23] with 3, 5-dinitrosalicylic acid reagent basis. Prior to 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 weight basis.

2-4 Oligosaccharides of the sweet pea seeds carbohydrates

The main simple carbohydrates components of the sweet pea seeds 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). Prior to analysis, samples of crushed sweet pea seeds 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 (Carbocarb 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 a rate 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/mL.

2-5 Characterization of the sweet pea seeds oil

2-5-1 Relative density

A 30 g of test sample from sweet pea seeds oil was solidified into a freezer. Then, the resulted butter was put into a test-tube containing 300 mL of water. After stabilization of the water's level in the test tube, the final volume has been displayed. The experiment was carried out in triplicate, and the relative density of the butter is expressed as follows:

$$\text{Relative oil Density} = W / (V2 - V1) \quad (3)$$

With: W, the oil weight; V1 and V2, the respective water volumes before and after addition of the butter.

2-5-2 Chemical parameters

Acid, peroxide, iodine, saponification and unsaponifiable parameters were determined from the dried sweet pea seeds oil using respective AFNOR standard methods of NF EN ISO 660 [25], NF T 60-220 [26], NF ISO 3961 [27], NF T 60-206 [28] and NF T 60-205 [29].

2-5-3 Fatty acid composition

The various fatty acids of the sweet pea seeds oil were highlighted according to AFNOR method [30]. 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 processing was preceded by the extraction of the fatty acids from triglycerides using chloroform solvent, followed by the conversion of the fatty acids into methyl esters using methanol. 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 °C while the temperature of the injector and detector were both at 220 °C. The calibration was made using 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).

2-6 Statistical analysis

The outcome data were recorded with Excel program and then statistically treated using STATISTICA software (STATISTICA version 7.1). From each parameter assessed, the averages were calculated, and the homogeneity of the results was estimated according to the standard deviation and relative standard deviation.

3. RESULTS AND DISCUSSION

3-1 Proximate nutritive components of the sweet pea seeds



The outcomes resulted from the biochemical parameters are recorded in **table I**. The mean moisture content of the studied sweet pea seeds is 5.29%. These seeds are also with averages of 8.25% of proteins content and 25.40% of fat content. Besides, they have more glucides content, with mean of 41.60%. Within glucides, mean contents of 27.40% and 24.40 g/100 g are respectively provided for fibers and starch, so as 19.40% of total ethanolsoluble carbohydrates including 2.51% of reducing carbohydrates. From the energy-sources nutrients, the caloric energy value deriving with the sweet pea seeds is of 428.10 kcal/100 g. In addition, these seeds contain a mean percentage of 1.72% in ash.

Table I: Main nutritive traits of the sweet pea seeds.

Parameters	Contents	RSD* (%)
Moisture (%)	5.29 ± 0.03	0.57
Ash (%)	1.72 ± 0.36	20.93
Proteins (%)	8.25 ± 0.01	0.12
Fat (%)	25.40 ± 0.09	0.35
Total fibers (%)	27.40 ± 0.02	0.07
Total glucides (%)	41.60 ± 0.36	0.86
Total Caloric energy value (kcal/100 g)	428.10 ± 2.29	0.53
Starch content (g/100 g)	24.4 ± 0.04	0.16
Total ethanolsoluble carbohydrates (%)	19.40 ± 0.11	0.57
Reducing carbohydrates (%)	2.51 ± 0.04	1.59

* RSD: relative standard deviation

3-2 Mono and oligosaccharides of the sweet pea seeds

The Table II highlights the main contents of the proximate simple carbohydrates accounting with the glucides in the sweet pea seeds. Thus, a great presence of sucrose is recorded, with a mean content of 14.7 g/100 g. These seeds also contain free residues of maltose, glucose and fructose in respective percentages of 0.50, 0.30 and 0.16 g/100 g.

Table II: Contents of the main simple carbohydrates components of the sweet pea seeds.

Carbohydrates elements	Contents (g/100 g)	RSD* (%)
Maltose	0.5 ± 0.005	1
Sucrose	14.7 ± 0.01	0.07
Glucose	0.3 ± 0.001	0.33
Fructose	0.16 ± 0.0028	1.75

Lactose	<LOQ	-
Xylose	<LOQ	-

* RSD: relative standard deviation; LOQ: limit of quantification

3-3 Biochemical quality of the sweet pea seeds oil

3-3-1 Chemical parameters

The main traits of the oil deriving with the dried seeds of the sweet pea are showed in table III. The oil has a relative density of 0.93. It provides an acid value of 4.18 mg KOH/g, an iodine index of 130.9 g I₂/100 g, a peroxide index of 15.80 mEq O₂/kg, a saponification index of 250.5 mg KOH/g and a mean percentage of 0.96% for the total unsaponifiable components.

Table III: Values of the biochemical traits of the oil deriving from the sweet pea seeds

Parameters	Values	RSD* (%)
Relative Density	0.930 ± 0.008	0.86
Acid value (mg KOH/g)	1.180 ± 0.048	4.07
Iodine index (g I ₂ /100 g)	130.9 ± 0.880	0.67
Peroxide index (mEq O ₂ /kg)	2.80 ± 0.426	15.21
Saponification index (mg KOH/g)	250.5 ± 0.504	0.2
Unsaponifiable content (%)	0.963 ± 0.012	1.25

* RSD: relative standard deviation

3-3-2 Fatty acids of the sweet pea seeds oil

The sweet pea seeds oil is richer in unsaturated fatty acids (78.71%) than in saturated acids 21.21%), as shown in Table IV. The saturated fatty acids of this oil are mainly consisting of palmitic and stearic acids in respective percentages of 15.02% and 4.72%. Regarding with the unsaturated fatty acids, a higher presence of mono-insaturations (65.65%) is revealed in table IV. They are primarily consisted of oleic acid with mean content of 65.04%. Poly-unsaturated components gather 13.05% of the total fatty acids and are with most significant presence of linoleic acid (12.83%) and 0.22% of linolenic acid (table IV).

Table IV: Fatty acids composition of the oil deriving from the sweet pea seeds

Fatty acids	Contents (%)	RSD* (%)
Saturated fatty acids	21.21±0.052	0.25
Palmitic acid C16:0	15.02 ±0.016	0.11
Stearic acid C18:0	4.72 ±0.008	0.17
Arachidonic acid C20:0	0.77 ±0.004	0.52
Behenic acid C22:0	0.43 ±0.008	1.86
Lignoceric acid C24:0	0.150 ±0.008	5.33

Margaric acid C17:0	0.12 ±0.008	6.67
Unsaturated Fatty Acids	78.71	
Mono-unsaturated fatty acids	65.66 ± 0.071	0.11
Oleic acid C18:1n9 cis	65.04 ±0.028	0.04
Palmitoleic acid C16:1	0.306 ±0.012	3.92
Eicosanoic acid C20:1	0.296 ±0.012	4.05
Erucic acid C22:1n9	0.01 ±0.018	180.00
Nervonic acid C24:1	0.01 ±0.0001	1.00
Poly-unsaturated fatty acids	13.05± 0.22	1.69
Linoleic acid C18:2n6Cis	12.83 ±0.214	1.67
Linolenic acid C18:3n3	0.22 ±0.008	3.64

* RSD: relative standard deviation

DISCUSSION

With a mean content of 41.61%, the glucides appear the principal nutritive components in the sweet pea seeds. Such an observation was mentioned by Sanchez et al. [31] which reported 43% of glucides in the same food raw material. Other authors also confirmed the great glucide nature of these seeds, from about 44% [32]. The glucides components inner the sweet pea seeds are mainly consisting in food fibers (27.40%) and starch (24.44 g/100 g). With these contents, the studied seeds are obviously richer in starch than many tubers such as potatoes which contain 18.17 g/100 g of starch [33]. Moreover, according to Adejuyitan et al. [34], significant intakes in starch and food fibers account with pre-biotic properties for intestinal microbe's flora. The consumption of sweet pea seeds could contribute in prevention and treatment of pathologies like colon cancer. It could also reveal effective actions against cardiac, thrombosis and blood concerns related with obesity, diabetes and coronary disease risks, regarding with the conclusion of Chukwuma et al. [35]. In fact, Alegría-Torán [32] hypothesized on a probable high content of essential amino acid in the sweet pea seeds, specifically in arginine, supporting the production of insulin, which hormone is with a positive action in dropping of the blood glucose content.

The study showed 8.25% of proteins in the sweet pea seeds, corroborating the 8% reported by Kordylas [36]. That states on the lower proteins contents of the sweet pea seeds than the cowpea beans, one of the protein leguminous plants with 25% and 27% of proteins [37]. Nevertheless, Anderson et al. [38] and Borges et al. [39] emphasized the digestive enzyme characters of many proteins, particularly for catalase, lipase and amylase, accounting for a significant asset in the consumption of this food resource against gastro-intestinal and food digestion disorders, intestinal gases and digestive diarrheas. It is also duly right to state according to Bosch et al. [40] that proteins from sweet pea seeds could have better composition in essential amino acids above the indications of the FAO/WHO for satisfying the needs from adult people.

The sweet pea seeds have a significant fat content (25.40 %), agreeing with values of 22.8 to 32.8 g/100 g found in other attempts upon the same raw material [41; 42; 43]. Thus, these seeds seem better food lipid sources than many tubers such as potato and cassava whose consumption allows respective intakes of 2.5 and 5 mg/kg of body weight [44]. However, they remain less fatty than several other seeds such as nuts kernels and hazelnuts with respective 43.36% and 65.20% of lipids [45]. The main unsaturated fatty acids of the oil deriving with dried sweet pea seeds are oleic acid (65.04%) and linoleic acid (12.83%).omega 9 and 6 fatty acids endorse the sweet pea seeds oil into the group of fats recording obvious nutritive and healthy properties [46]. These oils involve in the reduction of the LDL cholesterol

and triglycerides, whereas they induce increasing in the rate of blood HDL cholesterol or “good cholesterol”, limiting the cardiovascular diseases risks.

With the assessed macronutrients basis, the seeds studied are characterized by a high caloric energy value of 428.10 kcal/100 g. Still, a quite more caloric energy value of 524.6 kcal/100g has been found by Oderinde [47] from the same seeds. This author also reported 1.86% of ash in the sweet pea seeds, close to the 1.72% resulted from the current study and forecasting a significant presence of minerals such as sodium, calcium, potassium, magnesium and zinc in the sweet pea seeds. In addition, a presence of secondary phytonutrients could be related with the 0.96% of unsaponifiable components recorded. Yeboah et al. [48] stated on 986.49 mg/g of total unsaponifiable content in sweet pea seeds, including sterols, polyphenols, saponins and carotenes.

4. CONCLUSION

This work was a contribution for valorization of the sweet pea seeds in Cote d'Ivoire. Quite more than a tuber grain, the sweet pea seed shows nutritive characteristics closing with many nuts and kernels. It's a good source of caloric energy thanks to the high contents in fat, glucides and proteins. It's also an excellent source of food fibers. The sweet pea seeds oil is mainly consisted of unsaturated fatty acids such as oleic and linoleic acids, but records significant proportions of saturated fatty acids, specifically palmitic and stearic acids. Thus, the sweet pea seeds could point for excellent sources of food nutrients to address the nutritional concerns for populations.

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