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NUTRITIONAL COMPOSITION OF *PHASEOLUS VULGARIS* (PURPLE BEAN) SOLD AT THE KORHOGO MARKET (NORTHERN CÔTE D'IVOIRE)

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ABSTRACT

In Africa, beans are consumed as a starchy staple food. However scientific reports on the nutritional potential of *Phaseolus vulgaris* (purple beans) are rare. In order to contribute to their wider use and valorization in Côte d'Ivoire, this plant has attracted our attention. The physicochemical and nutritive properties were investigated and the results obtained were as follow : moisture (75,19%), crude proteins (10.33%), crude fibres (27.59%), ash (5.45%), carbohydrates (38.73%), crude lipids (1.77%) and food energy (178.28 kcal/100 g). The mineral elements contents were high with remarkable amount of K (609.87 mg/100 g), Ca (237.20 mg/100 g), Mg (176.39 mg/100 g), P (145.40 mg/100 g), Na (9.90 mg/100 g), Fe (59.25 mg/100 g) and Zn (33.65 mg/100 g). The Ca/P ratio was from 1.63. These purple bean also contained appreciable levels of polyphenols (572.25 mg/100 g), flavonoids (15.33 mg/100 g) and tannins (162.02 mg/100 g). All these results suggest that the studied purple bean if consume in sufficient amount would contribute greatly to the nutritional requirement and to the food security of Ivorian population.

Keywords: Purple Bean, Proximate Composition, Nutritive Potential, Polyphénol.

1 INTRODUCTION

Bean, is a legume crop ranked among the major world crops [1]. Originating from America [2], this plant is cultivated on a large scale in several countries including Morocco (61%) and Kenya (19%) [3 ; 4]. A highly nutritious food, beans are a source of starch, protein and fiber [5 ; 6]. In addition to its nutritional importance, it constitutes a plant with great agronomic such as biological nitrogen fixation [7 ; 8]. This is favorable for crop rotations and associations for agriculture on farming in drylands [9 ; 10]. In addition, it is of interest to smallholder farmers wishing to increase economic returns.

In Côte d'Ivoire, beans are consumed in several forms: seeds and fruits or vegetables [11 ; 12]. Much appreciated, the latter still called green bean or eats everything, fits best in the search for a light diet [13]. For this purpose, two varieties of this bean are mainly found on the Ivorian market. These are the Contender or local varieties and the Cora or Burkinabé variety. These varieties are produced on small areas of cultivation, which makes Ivorian bean production low. To remedy this deficit, the country is forced to import beans from high production countries such as France, Kenya, Burkina Faso etc [11]. However, in the market of Korhogo (capital of the savannah region) we notice a variety of purple beans that is marketed and consumed by a certain number of people. This bean is sold at 25 CFA per heap (an average of fifteen pods) and then at 200 CFA per kilogram on the local market allowing it to fit perfectly into a village economy thus reflecting its interest for the population. Despite this low cost (compared to green beans), this little-known variety is neglected. This leads to huge economic losses despite all the efforts made by the peasants. It would therefore be a good idea to carry out an in-depth study that would lead to the demonstration of the nutritional quality of this bean and contribute to its valorization. Indeed, beyond the crop benefits associated with legumes in general, purple beans may exhibit variability in their biochemical composition. This is why a study has been carried out to identify the nutritional potential. This includes determining lipids, proteins, etc.

2 MATERIAL

2.1 Biological material

Biological material consists of immature bean pods of purple variety purchased on the market of Korhogo, north of Côte d'Ivoire. 250 g purple bean were washed with distilled water, drained at ambient temperature and oven-dried (Memmert, Germany) at 60°C for 72 h [14]. The 80 g purple bean dried obtained were ground with a laboratory crusher (Culatti, France) equipped with a 10 µm mesh sieve. The 58,56 g powdered obtained were stored in polythene bags at 4°C until further analyses.

2.1.1 Chemical

All solvents (n-hexane, ethanol and methanol) were purchased from Merck. Standards used (glucose, gallic acid, tannic acid, quercetin) and reagents (vanillin, Folin-Ciocalteu) were purchased from Sigma-Aldrich. All chemicals used in the study were of analytical grade.

3 METHODS

3.1 Nutritive analysis

Physicochemical analysis: Moisture, ash, proteins and lipids were determined using [15] official methods. The moisture content was determined by the difference of weight before and after drying fresh sample (10 g) in an oven (Memmert, Germany) at 105°C until constant weight. Ash fraction was determined by the incineration of dry matter sample (5 g) in a muffle furnace (Pyrolabo, France) at 550°C for 12 h. The percentage residue weight was expressed as ash content. Proteins were determined through the Kjeldhal method and the lipid content was determined by Soxhlet extraction using hexane as solvent. For crude fibre [16], 2 g of dried powdered sample were digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with hot water and dried in an oven (Memmert, Germany) at 100°C until constant weight. The dried residue was then incinerated and weighed for the determination of crude fibres content. Carbohydrates and calorific value were calculated using the following formulas [17]: Carbohydrates = $100 - (\% \text{ moisture} + \% \text{ proteins} + \% \text{ lipids} + \% \text{ ash})$. Calorific value: $(\% \text{ proteins} \times 2.44) + (\% \text{ carbohydrates} \times 3.57) + (\% \text{ lipids} \times 8.37)$. The results of ash, fibre, protein, lipid and carbohydrate contents were expressed on dry matter basis. The mineral content was estimated by incineration of flour sample (5 g) in a muffle furnace (Pyrolabo, France). The ash obtained was dissolved in 5 ml of mixture of chloride acid and nitric acid (HCl/HNO₃) and analyzed using the atomic absorption spectrophotometer (AAS model, SP9).

3.2 Antioxidant properties

Polyphenols content: Polyphenols content was determined using the method reported by [18]. A quantity (1 g) of dried powdered sample was soaked in 10 mL of methanol 70% (w/v) and centrifuged at 1000 rpm for 10 min. An aliquot (1 mL) of supernatant was oxidized with 1 mL of Folin-Ciocalteu's reagent and neutralized by 1 mL of 20% (w/v) sodium carbonate. The reaction mixture was incubated for 30 min at ambient temperature and absorbance was measured at 745 nm by using a spectrophotometer (PG Instruments, England). The polyphenols content was obtained using a calibration curve of gallic acid (1 mg/mL) as standard.

Flavonoids content: The total flavonoids content was evaluated using the method reported by [19]. 0.5 mL of the methanolic extract was mixed with 0.5 mL methanol, 0.5 mL of AlCl₃ (10%, w/v), 0.5 mL of potassium acetate (1 M) and 2 mL of distilled water. The mixture was allowed to incubate at ambient temperature for 30 min. Thereafter, the

absorbance was measured at 415 nm by using a spectrophotometer (PG Instruments, England). The total flavonoids were determined using a calibration curve of quercetin (0.1 mg/mL) as standard. **Anti-nutritional properties**

Tannins content: Tannins of samples were quantified according to [20]. For this, 1 mL of the methanolic extract was mixed with 5 mL of vanillin reagent and the mixture was allowed to incubate at ambient temperature for 30 min. Thereafter, the absorbance was read at 500 nm by using a spectrophotometer (PG Instruments, England). Tannins content of samples was estimated using a calibration curve of tannic acid (2 mg/mL) as standard.

Oxalates content: Oxalates content was performed using a titration method [21]. One (1) g of dried powdered sample was weighed into 100 mL conical flask. A quantity of 75 mL of sulphuric acid (3 M) was added and stirred for 1 h with a magnetic stirrer. The mixture was filtered and 25 mL of the filtrate was titrated while hot against KMnO₄ solution (0.05 M) to the end point.

Phytates content: Phytates contents were determined using the Wade's reagent colorimetric method [22]. A quantity (1 g) of dried powdered sample was mixed with 20 mL of hydrochloric acid (0.65 N) and stirred for 12 h with a magnetic. The mixture was centrifuged at 12000 rpm for 40 min. An aliquot (0.5 mL) of supernatant was added with 3 mL of Wade's reagent. The reaction mixture was incubated for 15 min and absorbance was measured at 490 nm by using a spectrophotometer (PG Instruments, England). Phytates content was estimated using a calibration curve of sodium phytate (10 mg/mL) as standard.

3.3 Statistical analysis

All the analyses were performed in triplicate and data were analyzed using EXCEL 2013 and STATISTICA 7.1 (StatSoft). Differences between means were evaluated by Duncan's test. Statistical significant difference was stated at $p < 0.05$.

4 RESULTS

The proximate composition of the purple bean is shown in Table 1.

The bean sample studied had a moisture content of $75.19\% \pm 0.25$. The ash content was $5.45\% \pm 0.04$. As for protein content, it was approximately $10.33\% \pm 0.14$. The purple bean studied had a lipid content of $1.77\% \pm 0.04$. The carbohydrate content of the bean sample studied was estimated at $38.73\% \pm 35$. The fibre content was found to average $27.59\% \pm 0.08$. The energy value of the purple bean was 178.28 ± 0.21 .

Table 1: Proximate composition of the purple bean

Parameters	Amount
Rendement (%)	23.42 ± 0.65^h
Moisture (%)	75.19 ± 0.25^b
Ash (%)	5.45 ± 0.04^f
Proteins (%)	10.33 ± 0.14^e
Lipids (%)	1.77 ± 0.04^g
Carbohydrates (%)	38.73 ± 35^c
Fibers (%)	27.59 ± 0.08^d
Calorific energy (Kcal/100g)	178.28 ± 0.21^a

Data are represented as Means $\pm$ SD ($n = 3$). Means in the column with no common letter differ significantly ($p < 0.05$) for each parameters.

The graph shows the levels of polyphenols, flavonoids, tannins, oxalates and phytates in the bean under study (Figure 1). The levels of polyphenols, flavonoids and tannins are estimated at

572.65 mg/100 g, 15.33 mg/100 g and 162.02 mg/100 g respectively. The levels of antinutrients were 442.65 mg/100 g for oxalates and 68.89 mg/100 g for phytates.

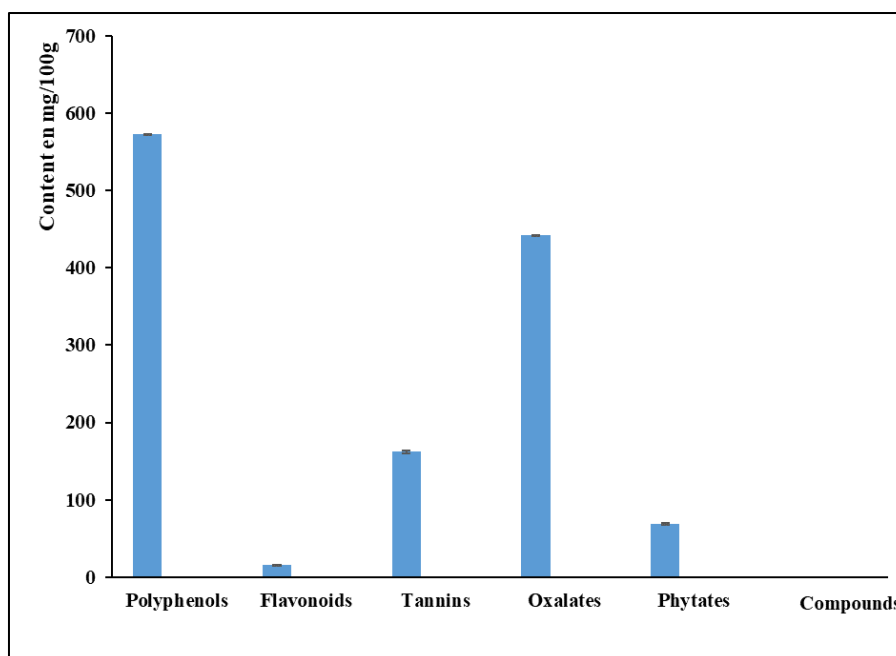


Figure 1: Phytochemical and antinutrient compounds in purple

The mineral content values for purple beans are shown in Table 2. The variety analysed in this study contained the following amounts of calcium (237.20 mg/100 g), potassium (609.87 mg/100 g), phosphorus (145.40 mg/100 g), magnesium (176.39 mg/100 g), sodium (9.90 mg/100 g), iron (59.25 mg/100 g) and zinc (33.65 mg/100 g). The ratios of Ca/P ; Na/K ; oxalate/Ca ; phytate/Ca and phytate/Fe were found to be 1.63; 0.016; 1.86; 0.29 and 1.16, respectively.

Table 2 : Mineral composition of purple bean (mg/100g)

Mineral compounds	Amount (mg/100g)
Calcium (mg)	237.20 ± 0.65 ^b
Magnesium (mg)	176.39 ± 1.22 ^c
Potassium (mg)	609.87 ± 1.23 ^a
Phosphore (mg)	145.40 ± 0.82 ^d
Sodium (mg)	9.90 ± 0.61 ^s
Fer (mg)	59.25 ± 0.19 ^e
Zinc (mg)	33.65 ± 0.92 ^f
Ca/P	1.63
Na/K	0.016
[Oxalates]/Ca	1.86
[Phytates]/Ca	0.29
[Phytates]/Fe	1.16

Data are represented as Means ± SD (n = 3). Means in the column with no common letter differ significantly (p<0.05) for each parameters.

5 DISCUSSION

The physicochemical parameters generally differ significantly (p < 0.05). The relatively low moisture content obtained in this study differs from that reported by [23] (89.3%). This difference could be explained by the harvest period, the storage method, as well as respiration and other metabolic processes linked to senescence [24 ;25]. This moisture loss could be advantageous, as it allows for a higher dry matter concentration. Given its relatively high ash content, the

purple bean can be considered a significant source of minerals. This value is comparable to those obtained for cereals and tubers (2–10%) [26]. The protein content of purple beans is lower than that reported by [27], who observed levels ranging from 22 to 29% in white and purple bean seeds. This low value could be explained by the early harvesting of our beans. The purple bean studied is characterised by a relatively high fibre content compared with the values (12.57% and 15.40%) determined by [28] for kplala and dah leaves studied in Cameroon. This high fibre content could be explained by the fact that our beans, harvested at an early stage, are consumed with their pods. Given the daily fibre requirements, estimated at between 25 and 30 g [29], consuming 100 g of the bean studied would meet these requirements. Indeed, fibre is important for the body as it acts within the digestive tract by facilitating intestinal transit and also prevents the absorption of excess cholesterol [30]. The low fat content found in this study supports the conclusions of [13], who demonstrated that beans are low in fat. Furthermore, a diet providing 1–2% of its caloric energy in the form of fat is considered sufficient for humans, as excessive fat intake leads to cardiovascular disorders such as atherosclerosis, cancer and ageing [31]. Consequently, consumption of the beans studied could be beneficial for people suffering from obesity. The carbohydrate content (38.73%) determined in this study is low. This value is well below that reported by [32], who recorded a content of 60% in dried beans. This could be explained by harvesting at an early stage of maturity, as the starch content increases during ripening. This would account for the low energy value. Thus, the calorific value would correspond to their low fat content and relatively high moisture content [33]. The polyphenol content is higher than that reported by [34] for white beans (143 mg/100 g) and black-eyed beans (140 mg/100 g) in Algeria. The high levels of polyphenols, flavonoids and tannins could be explained by heat treatment, which leads to a concentration of these compounds, as well as by the varieties grown [35 ; 36]. Indeed, polyphenols, flavonoids and tannins also possess antioxidant activity, which contributes to their medicinal properties [37]. A high intake of these beans could therefore reduce cellular oxidative stress, which has been implicated in the pathogenesis of various neurodegenerative diseases, including Alzheimer's disease, Parkinson's disease and amyotrophic lateral sclerosis [38 ; 39]. The selected purple bean contains antinutrients such as oxalates and phytates. The oxalate levels observed are the lowest (0.6–15.1%) compared with those reported in certain edible leafy vegetables [40]. The toxicity of oxalates to humans has been estimated at 2–5 g/day, and consumption of a diet rich in these antinutrients can lead to kidney disease [41]. Phytates are the primary form of phosphorus storage and are particularly abundant in cereals and pulses [42]. These antinutrients chelate divalent cations such as calcium, magnesium, zinc and iron, thereby reducing their bioavailability [43]. Furthermore, the antinutrients present in these purple beans can be easily removed by soaking, boiling or frying [44]. Given the recommended dietary allowances for minerals – calcium (1,000 mg/day); phosphorus (800 mg/day) ; magnesium (400 mg/day) and iron (8 mg/day) – this purple bean could make a substantial contribution to improving human nutrition [45]. Furthermore, a Ca/P ratio greater than 1 may be beneficial for the consumption of the purple bean studied, as a diet is considered good if the Ca/P ratio is > 1 and poor if it is < 0.5 [46]. Thus, consumption of purple beans would likely reduce diseases linked to high blood pressure, as their Na/K ratio is less than 1 [45]. As for magnesium, this mineral is known to prevent cardiomyopathy, muscle degeneration, growth retardation, immune dysfunction, congenital malformations and haemorrhagic disorders [47]. The iron content of purple beans exceeded the recommended dietary allowances for men (1.37 mg/day) and women (2.94 mg/day) [48]. Iron plays numerous biochemical roles and acts as an important catalytic centre in many enzymes, such as cytochrome oxidase. Thus, purple beans could be recommended in diets aimed at reducing anaemia, which affects over a million people worldwide [49]. In order to predict the bioavailability of calcium and iron, the ratios of antinutrients to nutrients were calculated. The calculated [oxalate]/[Ca] and [phytate]/[Ca] ratios were below the critical threshold of 2.5 known to reduce calcium bioavailability [50]. It was also observed that the calculated [phytate]/[Fe] ratios were above the critical threshold of 0.4. This implies that phytates could impair the bioavailability of iron [51]. However, the [phytates]/[Fe] ratio could be reduced after processing such as soaking or boiling [44].

6 CONCLUSION

From the results above, the purple bean could serve as a supplementary diet, supplying the body with nutrients such as fibres, proteins, and minerals. The presence of secondary metabolites (polyphenols, flavonoids, tannins) in appreciable amounts contribute to their medicinal value. The purple bean also contains some anti-nutritional factors such as oxalates and phytates which are required to be removed to improve their nutritional quality. Hence, the studied purple bean could contribute to the alleviation of protein-energy malnutrition and micronutrient deficiencies if they are consumed in sufficient amount.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

All authors have read and approved the final version of the article. The authors declare that there are no conflicts of interest related to this study and the use of the data.

AUTHOR CONTRIBUTIONS

Noelle Kodjo collected biological material, analyzed the samples in the laboratory, analyzed the data, and wrote the article. Sylvie Assoi participated in the collection of biological material, laboratory analyses, and the writing of the article. Mandoué Bamba contributed to data analysis and the writing of the article. Bio Bamba is the scientific supervisor of the study and thoroughly revised the article.

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