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RESEARCH ARTICLE

NUTRITIONAL VALUE OF SOME LEGUMINOUS BEANS (SOYBEANS, COWPEAS, LIMA BEANS AND PIGEON PEAS) COMMONLY CONSUMED IN CÔTE D'IVOIRE

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ABSTRACT

The present study was carried out on soybeans (*Glycine max*), cowpeas (*Vignaunguiculata*), lima beans (*Phaseoluslunatus*) and pigeon peas (*Cajanuscajan*) in order to promote their consumption in Africa by determining their nutritional values. For this purpose, a physico-chemical analysis of each whish was performed reveal that the powders of soyabeans, cowpeas, lima beans and pigeon peas are richer in proteins (pigeon peas : 15.98 ± 0.23% and soyabeans : 30.77 ± 0.83%) and the fibers (lima beans : 20 , 62 ± 0.21% and soyabeans : 29.45 ± 0.07%). They have low water contents (cowpeas: 7.65 ± 0.18% and lima beans: 10.93 ± 0.03%). The ash content varied from (cowpeas: 3.86 ± 0.06%. Tosoyabeans: 5.23 ± 0.06%). Regarding the lipid contents of the seeds, they were between (lima beans: 1.16 ± 0.15% and soyabeans: 19, 86 ± 0.15%) while the carbohydrate content is between soyabeans: 32.90 ± 2.11% and pigeon peas: 55.59 ± 0.08%). The energy value varied between cowpeas 228.41 ± 1.81 andsoyabeans: 358.85 ± 5.07 Kcal per 100 g of powders. As for the phytochemical composition, the content of phenolic compounds is the highest and it varies from (lima beans: 29.76 ± 0.24 mg / 100 g of DM tosoyabeans: 114.26 ± 0.09 mg / 100 g of DM). Likewose the values of the antinutritional factors are respectively (pigeon peas: 7.51 ± 0.48 mg / 100 g of DM and soyabeans: 17.25 ± 1.15 mg / 100 g of DM) and (pigeon peas: 53.18 ± 1.18 mg / 100g and lima beans: 84.52 ± 1.08 mg / 100g DM) All leguminous beans are rich in potassium (pigeon peas: 23.57 ± 0.57% and cowpeas : 27.78 ± 0.89%) and phosphorus (lima beans: 5.07 ± 0.06% and soyabeans: 8.63 ± 0.28 %). The results show that all the leguminous beans studied represent a potential source of lipids and proteins in the diet of Ivorians.

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INTRODUCTION

Leguminous beans are a group of dicotyledonous flowering plants (angiosperms) whose fruit is a pod (Harborne, 1994). They come in different shapes and colors, their dimensions vary from small to big trees; most are annual. The fruit is the most characteristic feature of this family (Aykroyd and Doughty 1964). Leguminous beans crops mainly provide carbohydrates and proteins, but also a variety of other elements (lipids, fibers, minerals, vitamins) for human and animal nutrition. Leguminous beans are an important source of vegetable protein for human consumption (Kellouche&Soltani, 2005). In addition to their role in the nitrogen cycle, the production of leguminous beans interacts with other biochemical cycles such as those relating to phosphorus or xenobiotics.

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The presence of legumes in agricultural production systems contributes to increasing the functional diversity of agro-ecosystems, which is beneficial to the biodiversity of agricultural landscapes and territories. They thus contribute in several ways to the balance of agro-ecological systems (Peoples *et al.,* 2009; Duc and Bursti., 2010). A great diversity of legumes exists in the different regions in the world, with almost 1,004,088 tons produced in 2016.

That's why Food and Agriculture Organization of the United Nations (FAO) has proclaimed the year 2016 as leguminous beans the year of leguminous beans The objective of this work is to carry out the biochemical analysis of four legumes (soybeans, lima beans, cowpeas and pigeon peas), in order to promote their consumption in Côte d 'Ivory because these leguminous beans are supposed to help reduce malnutrition and prevent metabolic diseases in the rural population.

MATERIAL AND METHODS

Material: Plant material is composed of four leguminous beans species (soybeans, pigeon pea, cowpea and lima bean). They were bought in different markets of Côte d'Ivoire (Bondoukou, Bongouanou)and at the market of adjamé in the district of Abidjan.

Methods : The dry samples were separately sorted, winnowed, washed three times with tap water and rinsed with distilled water. They were then dried in an oven at 50 ° C for 48 hours before being crushed using an IKA (Germany)stainless steel mill. The powders obtained are sieved with a 0.5 mm sieve. The residues obtained are crushed again until exhaustion. The fine flours are kept in pots and stored in the refrigerator at 4 ° C for the various analyzes. The humidity, crude proteins, lipids and ash levels were determined according to AOAC methods (1975). The water content of the samples was determined by differential weighing of a 10 g sample before and after passage in the oven at 105 ° C for 2 h. The protein content was determined according to the Kjeldahl method, using 1 g of leguminous beans powder. The conversion factor considered is 6.25. The lipids content d was determined by extracting 5 g of leguminous beans powder in a soxhlet apparatus for 5 hours using hexane. The ashes were determined by incineration of 1 g of leguminous beans in a muffle furnace (Maker, 5 EL STATOP-2MG, France), maintained at 550 ° C for 6 hours. The crude fiber content of leguminous beans was determined by the method of Van Soest (1963). Digestible carbohydrates (DC) and energy value were determined based on dry matter (DM) by calculation (FAO, 1998), as following:

DC (% DM) = 100- (protein (% DM) + fat (% DM) + fiber (% DM) + ash (% DM)

Energy (kcal / 100 g DM) = 2.44 X protein (% DM) + 8.37 X lipids (% DM) X 3.57 X carbohydrates (% DM)

The quantification of reducing sugars was carried out according to the method of Bernfeld (1955). The total sugar content was determined by the phenol sulfuric method described by Dubois *et al* (1956). The composition of the minerals is determined using a scanning electron microscope coupled to an energy scattering spectrometer (Zeiss supra 40 VP, Germany). Two grams of sample were taken, burned on a benzene spout and placed in the oven at 750 ° C. After six hours, the sample was removed and cooled in a desiccator. Ten milligrams of ash residue was collected. Polyphenols were determined by the method of Singleton *et al* (1999). The flavonoid content was determined according to the method of Meda *et al* (2005). The tanins were determined by the method of Bainbridge *et al* (1996). The phytates were quantified according to the method of Latta and Eskin (1980). The oxalates were quantified according to the method of Day and Underwood (1986).

Statistical analyses : The anlyses were performed in triplicate and the data expressed as an average ± standard deviation. Analysis of variance (ANOVA) followed by Newman-keuls test, the 5%level, was used to compare the means, followed by the standard deviation (STATISTCA 7.1 software). Twomeans are significantly different if the probability resulting from the statistical tests is less than or equal to 0.05 ($P \leq 0.05$). Otherwise, these differences are not significant ($P > 0.05$). The letters a, b, c, d, e, .in super script follow the means from the Newman-Keuls test in the tables. Means with different letters and the same line are significantly different ($P \leq 0.05$).

RESULTS AND DISCUSSION

Biochemical composition : The biochemical composition of leguminous beans is summarized in Table I. The values are expressed relative to the dry matter (DM) except for the values of humidity. The humiditycontent of the powder of the various leguminous beans varied from 7.65 to 10.93% fresh matter. Cowpea had the lowest content (7.65% FM) compared to soybeans, pigeon peas and lima beans. Similar values for the moisture content of voandzou flour have been reported by Amarteifio *et al.* (2010); Okonkwo and Opara (2010); Anhwangé and Atoo (2015). Generally, leguminous beans seeds are known for their low humidity. This allows a good and long shelf life. A high moisture content decreases the storage time and impacts the quality of the seeds (Anhwange and Atoo, 2015). Leguminous beans have ash contents between 3.86% (cowpea) and 5.23% (soy) DM The ash contents are statistically different from each other. These values are higher than those reported by Mazahid *et al*. (2013) who obtained average contents of 3.25% with voandzou seeds originating in Sudan. The same is true for Amartiefio et al. (2010) and Abiodum *et al*. (2011) who reported contents between 3.57 g / 100 g and 4.85 g / 100 g of dry matter for seeds originating in Namibia, Swaziland and Nigeria. According to Amarteifio *et al*. (2006), this slight difference between ash contents could be explained by the texture and the composition of the soils which would have an effect on the mineral absorption of the plants and the varietal differences (Osorio-Diaz *et al*. 2002; Rosin *et al.*2002).

The crude protein values are between 15.98 ± 0.23% and 30.77 ± 0.83%. Soybeans have the highest rate (30.77% DM) compared to other leguminous beans. The results obtained are substantially equal to the values reported by Amartiefio *et al*. (2002) and Amartiefio *et al.* (2010). These authors obtained respectively 15.1; 17.5; 21.2 grams of proteins per 100 grams of dry matter. Work on soybeans in Burkina Faso has already reported proteins values of 31.04% (Hama-Ba et al. 2017). This difference would be due to the genotypes and the environmental conditions under which these seeds were cultivated (Salunkhie *et al*., 1985; Aremu *et al,* 2005). Given the proteins content, the seeds of legumes, could be used to alleviate the problems of protein-energy malnutrition (Aberoumand, 2008).Use of these seeds in animal nutrition could reduce the cost of modern farming which is highly dependent on imported soybean meal. .Indeed, the use of seedsroasted or raw voandzou in chicken farming by Ironkwe and Esonu (2012) have given encouraging results. Concerning the lipids contents of the seeds, they vary from 1.16% for the lima bean to 19.86% for the soybeans which is the richest. As for cowpea and pigeon pea, their lipids values are statistically identical. The results obtained differ from the values obtained by Amarteifio and Moholo(1998); Alajaji and El-Adawy (2006) and Boateng, *et al*., (2013). These authors have shown that the seeds of leguminous beans, with the exception of soybeans and peanuts which are oilseed leguminous beans, generally contain little fat. These low lipids contents of these seeds can be recommended for a hypolipidemia diet. Regarding carbohydrates, the contents vary from 32.90 for soybeans and 55.5% of M S for pigeon pea.

Table 1. biochemical composition of leguminous beans

Parameters	Leguminousbeans			
	soybeans	lima beans	cowpea	pigeon pea
Humidity (%)	8.97±0,21[b]	10.93±0,03[d]	7.65±0,18[a]	10.30±0,28[c]
Ashe(%DM)	5.23±0,06[c]	4±0,0[b]	3.86±0,06[a]	4.03±0,11[b]
Proteins(%DM)	30.77±0,83[d]	20.91±0,10[c]	17.33±0,25[b]	15.98±0,23[a]
Lipid (%DM)	19.86±0,15[b]	1.16±0,15[a]	1.93±0,15[c]	1.96±0,23[c]
Fiber (%DM)	29.45±0,07[c]	20.62±0,21[a]	29.26±0,30[c]	22.1±0,58[b]
Carbohydrate(%DM)	32.90±2,11[a]	53.29±0,24[c]	47.60±0,54[b]	55.59±0,082[d]
Starch(%DM)	16.41±1,12[b]	16.12±1,45[b]	22.66±0,99[c]	12.81±3,64[a]
VE(kcal/100gDM)	358.85±5,07[d]	251.06±0,51[b]	228.41±1,81[a]	253.96±1,21[c]

ANOVA followed by the Newman-Keulsmultiple comparison test at the 5% threshold. On the same line, the means followed by different letters are significantly different ($p \leq 0.05$).The means are taken from three samples per leguminous beans

Table 2. Mineral composition of the leguminous beans

	Leguminousbeans			
Parameters	soybeans	lima beans	cowpea	pigeon pea
P	8.63±0,28[d]	5.07±0,06[a]	6.57±0,37[c]	5,74±0,49[b]
Ca	4.84±0,14[d]	0.85±0,11[a]	3.04±0,27[c]	1.21±0,2[b]
Mg	1.77±0,31[b]	2.6±0,16[c]	1.62±0,13[a]	3.19±0,28[d]
K	27.02±0,96[c]	25.39±0,37[b]	27.78±0,89[d]	23.57±0,57[a]

ANOVA followed by the Newman-Keuls multiple comparison test at the 5% threshold. On the same line, the means followed by different letters are significantly different ($p \leq 0.05$).The means are taken from three samples per leguminous beans

Table 3. Phytochemical composition of leguminous beans

Parameters (mg/100g DM)	Leguminousbeans			
	Soybeans	Limabean	Cowpea	Pigeon pea
Polyphenol	114.26±0,93[d]	29.76±0,24[a]	65.84±0,24[c]	65.15±0,58[b]
Flavonoid	1.61±0,20[a]	2.39±0,27[b]	2.19±0,17[c]	3.64±0,18[c]
Tannin	19.23±0,08[c]	7.78±0,09[a]	11.52±0,19[b]	19.30±1,22[c]

ANOVA followed by the Newman-Keuls multiple comparison test at the 5% threshold. On the same line, the means followed by different letters are significantly different ($p \leq 0.05$).The means are taken from three samples per leguminous beans.

Table 4. Anti-nutritional substances of leguminous beans

Parameters (mg/100g DM)	Leguminousbeans			
	Soybeans	Limabean	Cowpea	Pigeon pea
Phytates	17.25±1,15[c]	12.81±0,20[b]	7.61±0,89[a]	7.51±0,48[a]
Oxalates	64.17±1,01[b]	84.52±1,09[d]	79.38±1,18[c]	53.18±1,09[a]

ANOVA followed by the Newman-Keuls multiple comparison test at the 5% threshold. On the same line, the means followed by different letters are significantly different ($p \leq 0.05$).The means are taken from three samples per leguminous beans.

Figure 1.Différents leguminousbeans (A) lima beans; (B) Soybeans ; (C) Pigeon peas; (D) cowpeas

A significant difference (P ≤0.05) is observed between the different leguminous beans. The seeds of the leguminous beans studied are, on the whole, made up of more than 30% of carbohydrates. These levels are lower than those reported by Piyarat, (2007), Yusuf *et al*. (2008), Boateng *et al*., (2013) and Mazahib, (2013). The levels reported by these authors are between 54.51 and 65% DM. These observed differences between the results can be attributed to the varietal properties and the environmental conditions of their cultivation (Aremu *et al*, 2006; Boateng *et al*., 2013). Total carbohydrates constitute the majority fraction of seeds in which they represent 24 to 68% of the dry matter. This fraction is predominated by starch and the content is between 12.81% DM for pigeon pea and 22.66% DM for cowpea. These rates are lower than those obtained by Huang *et al*, (2007); Adebooye and Singh (2008) who found rates between 44.1 and 49.6% DM in cowpea varieties in Algeria. The fiber contents of leguminous beans range from 20.62% to 29.45%, respectively for lima beans and soybeans. These values are lower than those obtained on soybean varieties (74 to 78%) in Spain Redondo et al, (2007) and higher than the results of work carried out on leguminous beans (15.61% and 15.68%) in Burkina Faso by Hama-Ba *et al*, (2017). The Institute of Medicine Food and Nutrition Board recommends eating foods high in fiber. In fact, fibers could reduce the risks linked to cardiovascular disease and cancer. The energy value of most leguminous beans per 100g is between 251.06 and 358.85 Kcal respectively for lima beans and soybeans. This energy is necessary for all metabolic processes. The energy of leguminous beans comes from the supply of proteins, fats and carbohydrates (Ofuya *et al.,* 2005).

Mineral composition: The results of the analyses of the mineral composition of the leguminous beans are presented in Table II. The present study shows that the leguminous beans consumed in Côte d'Ivoire are rich in major mineral elements. They contain minerals such as phosphorus, calcium, magnesium and potassium, in sufficient proportions to meet the needs of people. According to the results obtained, the seeds have significant potassium contents (23.57 to 27.78 mg / 100g) respectively for pigeon pea and cowpea. These contents are different from each other (p ≤ 0.05). The phosphorus contents vary from 5.07 mg / 100 g (lima bean) to 8.63 mg / 100g (soy). Pigeon pea and cowpea have respective phosphorus contents of 5.74 mg / 100g and 6.54 mg / 100g. These values are higher than those reported by Ezeagu *et al.,* (2003), Agbede and Aletor (2005) and Tuleun *et al*., (2008) who found values ranging from (0.36 to 0.67 mg / 100g) on varieties of seeds of Mucuna spp. Soybeans and cowpeas have significant calcium contents, respectively 4.84 mg / 100g and 3.04 mg / 100g while pigeon pea and lima bean have contents of 1.21 to 0.85 mg / 100g. These values are lower compared to those of cereals (calcium contents: between 14.50 mg% DM and 15.50 mg % DM) (Ralijery, 2009). For the magnesium values, they vary from 1.62 to 3.19 mg / 100g for cowpea and pigeon pea. In most leguminous beans, potassium is the most abundant mineral in seeds *Mucunaspp* (Ezeagu *et al*., 2003); the levels of calcium, phosphorus, and magnesium are also satisfactory (Agbede and Aletor, 2005; Tuleun *et al*., 2008).

Phytochemical composition: The results of the analyses of the phytochemical composition of leguminous beans are summarized in Table III. The leguminous beans in this study are very rich in secondary metabolites such as polyphenols, flavonoids and tannins. The polyphenol contents vary from 29.76 to 114.26 mg / g DM. The soybean has the highest content (p ≤ 0.05). These results are lower than those reported by Yagoub and Abdalla (2007) and Bel Mbaiogaou *et al*., (2013). The total polyphenol contents reported by these authors ranged from 94 to 217 mg / g DM. Flavonoids concentrations are between 1.61 and 3.64 mg / g DM respectively for soybeans and pigeon pea. The tannins content is between 7.78 mg / g DM and 19.30 mg / g DM. These values are higher than those found by (Ezeagu *et al*., 2003 and Tuleun *et al*., 2008) on some varieties of. *Mucuna spp*.
These authors obtained values repented varying from 0.12 to 1.66 mg / g DM.

Anti-nutritional substances : The results of the analyses in anti-nutritional substances of leguminous beans are summarized in Table IV. Despite the important levels of nutrientsin leguminous beans, mineral elements and secondary metabolites, these plants contain anti-nutritional factors such as phytates and oxalates. These substances are known for their ability to reduce the bioavailability of nutrients (Lestienne, 2004). Phytates are present in the samples with contents between 7.51mg / g DM (pigeon pea) and 17.25mg/g DM (soy), These values are higher than those obtained by Andriamasinandraina, (2012) on leguminous beans (6.20 mg / g DM and 15.9 mg / g DM) and lower than those of Lestienne, (2004) whose value is 21mg / g DM. Oxalate values arebetween 53.18 and 84.52 mg / g DM respectively for pigeon pea and lima beans. A significant difference (P <0.05) is observed between the different leguminous beans.

CONCLUSION

Analysis of the biochemical composition of leguminous beans consumed in Côte d'Ivoire reveals that these seeds contain a wide variety of nutrients, minerals and phytochemicals. They also contain anti-nutritive substances such as phytates and oxalates which affect the nutritional quality of these leguminous beans by reducing the bioavailability of proteins and certain minerals. However, these legumes have a low water and lipids contents, with considerable energy value. Consuming these leguminous beans can therefore help improve the nutrition and health of rural people.

CONFLICT OF INTEREST: There is not any conflict of interest in this study all authors.

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