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Physical and biochemical characteristics of the Seeds white variety of Phaseolus lunatus (L.) consumed in south-east of Côte d'Ivoire during maturation

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ABSTRACT: In order to contribute to their wider utilization and valorization, seeds of white variety of Phaseolus lunatus (L.) consumed in southeast of Côte d'Ivoire have drawn our attention. Four different harvest periods of pod were used in the study. The first harvest is green, the second harvest (more green than yellow), the third harvest is more yellow than green and the last one is drown. The Physical and biochemical characteristics and biochemical of the white variety of Phaseolus lunatus (L.) were investigated. The results show that the major components increased from Stage1 to Stage 4 (crude proteins: 19.30 ± 0.32 to 25.06 ± 0.13 %; lipids: 1.01 ± 0.01 to 1.40 ± 0.02 %; fibers: 4.89 ± 0.30 to 5.13 ± 0.12 %; vitamin B6:1471 ± 1.47 to 1500 ± 2.16 % and vitamin C: 2.30 ± 0.40 to 5.81 ± 0.25 mg/100g). Carbohydrates (71.36 ± 0.60 to 64.16 ± 0.15 %) and calorific (310.71± 1.93 to 300.79 ± 0.59 Kcal/100g) value decreased during maturation. The investigated seed samples contained minerals such as P, K, Ca, Mg and Fe in abundance. Potassium (720.20 ± 1.05 to 1109.30 ± 0.81 mg/100g) is the most abundant mineral in the seed. The ratios of Na/K ranged from 0.04 to 0.05 % and Ca/P from 1.15 to 1.31 %. It may be concluded that physiological maturity was attained around 52 days after pollinisation (DAP) and mature pods may be harvested for consumption as vegetable between 45 and 52 (DAP) for good nutrients and quality.
Keywords: Physiological maturity; Pollinisation; dry weight; Immature; Mature; harvest periods.

INTRODUCTION

Seeds vegetables, especially pulses and beans are important source of proteins in our daily diet (Kellouche and Soltani, 2005). A significant part of human population relies on vegetables as staple food for subsistence, particularly in combination with cereals, tubers and racine. They are unique foods because of their rich nutrient content including starch, proteins dietary fibers, oligosaccharides, phytochemicals and minerals (Borade et al., 1984). Their nutritional contents contribute to many health benefits to humans (Young, 1991 and Burbano al., 1999).

Lima beans (Phaseolus lunatus) belong to the Fabaceae family, is also know by various names such as butter beans. Lima beans is mainly grown in Peru and later introduced to Europe and African countries (Ezeagu and Ibegbu, 2010). In Africa, about 120.000 to 200.000 hectares is devoted to Lima bean cultivation in the subhumid areas indicating the need for its maximum utilization (Nwokolo, 1996). It is of major importance in the African lowland tropics as well as in many other tropical areas where it requires moist climate and well drained aerated soil. Its seeds have high protein (235 g/kg) and carbohydrate contents (595 g/kg), low fat (16.5 g/kg) and fiber levels (50 g/kg), high levels of minerals such as K, Zn, Ca and Fe, and low levels of Na and P (Oshodi and Aletor, 1993).

Lima bean has been shown to compare favourably with soybean in terms of its protein potentials content (Luse, 1979). Many authors have showed the importance of Lima beans for relieving protein malnutrition in the humid tropicals areas. It serves as a popular and useful condiment in soup preparation and sometimes as a major protein compoment of diets (Ologhobo and Fetuga, 1983).

The seed vegetables are an annual herbaceous plant whith epigeal germination and are self-pollinated and propagated from seeds. Lima beans are twining vines herbaceous bushes, perennial in nature, but usually grown as annual, even in the tropics. It is a nutritious food stuff which cultivated primarily for immature vegetables or mature dry seeds (Lyman et al., 1985).

Stage of maturity at harvest is one of the most important factors that can influence the quality of seeds (Demir et al., 2008). Harvesting too early may result in low yield and quality, because of the partial development of essential structures of seeds (Keller and Kollmann, 1999; Elias and Copeland, 200; Ekpong and Sukprakarn, 2008; Wang, et al., 2008). Seeds harvested at early were immature and poorly developed and as such are poor stores compared to seed harvested at physiological maturity (Mahesha et al., 2001). Kumar et al. (2002) reported that seed yield and quality are largely depends on the stage of maturity. As such, harvesting of seeds at right stage of maturity is most important since harvesting either at early or late stage results in lower yields with poor quality seeds. Therefore, successful seed production depends on detection and implication of optimal time of harvesting. This time is a pre requisite for the production of maximum high quality seeds (Demir and Balkaya, 2005). Maximum seed quality may be achieved at the end of seed filling period (Tekrony and Egli, 1997) or slightly after this phase (Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009). Knowledge of seed development is essential to successful seed production and crop improvement. A better understanding of optimum harvesting time for Phaseolus lunatus (L.) seed contributes to improve quality and quantity of seed produced. This research was carried out to investigate the changes in seed quality of white beans rapeseed cultivars at different stages of development and maturity in order to determine the appropriate time for harvest and quality improvement.

MATERIALS AND METHODS

Experimental site, plant material and cropping practice

Lima beans used for this research work were brought from Tomasset, Azaguié, Côte d'Ivoire. The experimental device has been sown on a plot of 46 m x 10 m. A plot of 46 m x 10 m composed of twelve holes constitutes. The holes of the plot were separated to 5 m x 3 m. After the appearance of the first leaves of about two meters guardians were assigned to each plant. Seedlings were rejected after the emergence of way to keep only the strongest plant.

A herbicide treatment (Kallach 360°) to prevent the rapid development of herbs was done the next day after planting and three insecticide treatments (Kallach 360°) were made to reduce the impact of the first insects instead of that all the plants have started to climb the guardians. The second at the beginning of the male flower and finally the third at the formation of the first pods. A regular weeding is done to avoid any competition between the weeds and the interest of plant.

Pods were harvested at four stages of maturity for the variety: 32 days after pods set (DAP), at 38 days after pods set (DAP), at 45 days after pods set (DAP), at 52 days after pods (DAP). The seed were extracted from each pod, washed and oven-dried (Memmert, Germany) at 60 °C for 72 h (Chinma and Igyor, 2007). The dried powdered samples obtained were stored in polythene bags at 4°C until for analysis.

Colour and weight determination of pods and seeds during maturation

Pod and seed of phaseolus lunatus (L.) was measured using the CIE (Commission Internationale de l'Eclairage) L,*a* and b* colour system. The CieLab coordinates (L,*a*, b*) were directly read with a spectrophotocolorimeter MS/Y-2500 (Hunterlab, In., Reston, VA, USA), calibrated with a white tile. Color values were recorded as L* (Lightness) – the vertical co-ordinate runs from L* = 0 (black) through grey to L* = 100 (white); a*(-a, greenness, +a, redness) – the horizontal co-ordinate, that runs from -a* (green) through grey to +a* (red) and b* (-b, blueness, +b, yellowness) – another horizontal co-ordinate, that runs from -b* (blue) through grey to +b* (yellow) (Papadakis et al., 2000; Al-Said et al., 2009). The measurements were repeated on four different pods and seeds randomly selected locations at the surface of each sample. The weight of pod and seed was measured using an electronic balance (Mettler, Toledo, Switzerland, ± 0.01 g).

Proximate analysis

The moisture content of seed samples were determined by ISTA (1976). Ten grams (10g) seed samples each of Phaseolus lunatus (L.) were taken into moisture cup and put into a pre-heated over at temperature of 105° C during 24 h. The experiment was made in triplicate. After cooling, the weight of the container with its cover and contents were weighed. The seed samples were cooled in desiccators and weighed. The seed moisture content was determined by dry weight basis and was calculated by the following formula:

{(M2-M3) / (M2-M1)} x 100

Where, M1 is the weight in gram of the container and its cover, M2 is the weight in gram of the container, its cover and its contents before drying, and M3 is the weight in gram of the container, its cover and contents after drying.

Crude protein determination by Kjeldahl method (AOAC, 1990).

One gram (1g) of dried powdered sample were transferred in temperature resistant glass flask, was heated at 400 °C during 4 h in the presence of a pinch of the mixture of catalyst (Selenium + potassium

sulphate (K2 SO4)) and 20 ml of sulphuric acid (H2 SO4) 95-97 %. 60 ml of distilled water are added to the mineralisât obtained. To this volume, were added 50 ml of soda (40 %, p/v) before being carried to boiling in a distiller of the type LEGALLAISR. The ammonia which got clear was trapped in a dosing mud containing 10 ml of the acido-basic mixture (4 %, p/v) indicating mixed (methyl Red + green of bromocrésol) at pH 4,4 - 5,8.Proportioning was carried out by a sulphuric solution décimolaire of acid. Crude protein content was calculated by multiplying the nitrogen content by a factor of 6.25.

Crude fat

The crude fat was determined by continuous extraction in a soxhlet apparatus for 8 h using hexane as solvent (AOAC, 1990). Five grams (5g) of dried powdered sample was introduced into a cartridge of WHATMAN. 200 ml of hexane were added in a balloon of extraction weighed with vacuum. The balloon containing the hexane (M1) was deposited on the heating cap (110 °C) during 8 h. After extraction, the balloon was withdrawn from the device of SOXHLET and put at the drying oven with 130 °C during 1h for the total evaporation of solvent. After evaporation, the balloon was reweighed (M2). The lipid content (TL) was given by the following equation:

$$TL\ (\%) = \frac{(M_2 - M_1)}{5\ g} \times 100$$

Total Ash

The total ash content was determined by heating 10 g of the dried sample in a silica dish by incinerating in a furnace at 550 °C for 8 h (AOAC, 1990).

Total and reducing sugars determination

One (1) gram of flour was weighed in a tube to centrifugate. Ten (10) ml of ethanol (80%, v/v) were added. The mixture was homogenized and centrifuged with 3000 trs/min during 20 minutes. The supernatant collected was preserved in erlenmeyer of 50 ml. The ethanol contained in this mixture was evaporated with the sand bath during 10 min. The supernatant collected was used for the dosage of sugars ethanosolubles.

Total sugars determination

The method described by Dubois et al. (1956) was used for the total sugar content determination. The ethanosoluble extract (150 µL) was put in a test tube. To this volume, are added 1 ml of phenol (5%, p/v) and 1 ml of concentrated sulphuric acid (97%).The reading of the optical density was carried out to 490 Nm with spectrophotometer (JASCO V530) against a witness containing 150 µL distilled water instead of the ethanosoluble extract. The optical density was converted into quantity of total sugars thanks to the curved standard obtained starting from a solution of glucose (2 mg/mL).

Reducing sugar

The reducing sugar content was determined according to the method of Bernfeld. (1955). using 3.5 dinitrosalysilic acid. 1 ml of extract was put in a test tube. To this volume, are added 300 µl of DNS (acid 3.5 dinitrosalicylic). The mixture was carried to the bath Marie boiling during 5 mn. After cooling during 5 min on the straw mattress, 2 ml of distilled water were added to the reactional medium. The reading of the optical density was carried out at 540 Nm with spectrophotometer (JASCO V530) against a witness containing 150 µL of distilled water and 300 µL of DNS. The optical density was converted into quantity of total sugars thanks to the curved standard obtained starting from a solution of glucose (2 mg/mL).

Crude fiber

Crude fiber content was determined according to the gravimetric method of Van Soeest (1963). About 2 ± 0.01 g of dried powdered sample was digested with 0.25 M sulphuric acid and 0.3 M sodium hydroxide solution. The insoluble residue obtained was washed with distilled water and dried in oven (Memmert, Germany) at 100°C until.

Carbohydrates and calorific

value were calculated using the following formulas by Müller and Tobin (1980).

Carbohydrates

[100 - (% proteins + % lipids + % ash + % crude fibre)]

The energy value of the seed (kJ) was estimated by multiplying the percentages of crude protein, crude lipid and NFE by the factors 2.4, 8.37 and 2.4 respectively (FAO, 2002).

Calorific value

[% proteins x 2.4 + % lipids x 8.37 + % carbohydrates x 3.57]

Vitamin C détermination

Vitamin C was determined by titration using the method described by (Pongraz et al., 1971). About 10 g of ground fresh seed of Phaseolus lunatus (L.) were soaked for 10 min in 40 mL methaphosphoric acid-acetic (2 %, w/v). The mixture was centrifuged at 3000 rpm for 20 min and the supernatant obtained was diluted and adjusted with 50 mL of bi-distilled water. 10 mL of the mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L.

Vitamin B détermination

All fresh seed of Phaseolus lunatus (L.) were washed and dried weighed 50 mg and cut into small pieces and extracted with 0.1 NHCl on water bath at suitable temperature and time period. All extracts were filtered through 0.40 micron filter and taken into 100 mL volumetric flash and volume was add up for mobile phase. Stock of standard (Sigma Aldrich Analytical grade Reagent) prepared by dissolving 0.01 g of each standard in 100 mL of mobile phase followed by successive dilutions. HPLC equipped with UV detector and supelco discovery C- 18 column (25 cm in length and 0.45 internal diameter) was used for analysis. Mobile phase was 50 mL MK_2HPO_4 and MeOH (70:30) at 1 mL/min flow rate and 10 µL of each sample/standard was injected and monitored at UV 254 nm (Fatim et al., 2013).

Mineral analysis

Minerals were analyzed by the method reported by (Oshodi, 1992). The ash obtained from 1g of sample was dissolved in 10% HCl, filtered with filter paper and made up to standard volume with dionised water. Flame photometry method reported by AOAC (1990) was used to determine sodium and potassium contents of the sample. Calcium, Fe, Mg, Zn and Cu were determined using Atomic Absorption Spectrophotometer (AAS). Phosphorus was estimated colorimetrically (UV-visible spectrophotometer, Model DR 2800/United States).

Statistical analysis

The analysis of variance (ANOVA) was used to determine the differences between treatments. When a difference was observed, the multiple range test of Newman-Keuls at 5% was performed to separate treatment means. Statistical tests were performed using the STATISTICA software version 7.1

RESULTS AND DISCUSSION

Physical and Nutritive Properties

Colour of Pods and seeds of Phaseolus lunatus (L.) at different maturity stages is resumed in Table 1. Colour is a primary indicator of maturity or ripeness, and is derived from the pigments found in the product (Shewfelt, 1987). Lightness (L-value) was not modified significantly in the pod except in seed beans (Table 1). Seeds Lightness (L-value) increase from (51.82 ± 0.17) to (59.29 ± 0.49). However, mean values of greenness (a-value) and yellowness (b-value) decreased very slightly in the pod and seed. The colour values during maturation were lighter for seed and drown dark for pod.

Therefore, the change in seed and pod colour could be a dependable indicator of physiological maturity of Phaseolus lunatus. Visual indicators of physiological maturity have been suggested for other Umbelliferae such as seed color in carrot (Rubatzky et al., 1999) and eryngo (Ekpong and Sukprakarn, 2006). Differences in pod and seed colour also lead to differences in the amounts of color pigments in the pod and seed coat. The loss of the green colors of seed, along with change in seed texture are considered as practical and rapid field indicators for seed harvest, which relate to seed dry weight and moisture content (Demir, 1994; Elias and Copeland, 2001).

Pods and seeds weight decrease during maturation. Pod weight ranged from 11.91 ± 0.40 to 5.41± 0.20 g. Seed weight ranged from 1.38 ± 0.10 to 1.04 ±0.06 g (Figure1).

The proximate composition

The moisture, carbohydrate and energy in seed of the white beans (Phaseolus lunatus) cultivars decreased during maturation (Table 2). The decrease in seed moisture from 70.37 ± 0.29 to 29.68 ± 0.75 g/100g at early developmental stages was a result of the increase in dry matter. This lost of moisture was also observed by Egli (1997) during similar studies with Anethum graveolens L. The decrease of moisture in the

present study, as maturity advanced is probably due to the utilization of water in various metabolic activities and removal of water by desiccation caused by environment (Sreeramulu et al., 1992).

The carbohydrate decreased from 71.36 ± 0.60 to 64.09 ± 0.15 g/100g during maturation. The decrease in carbohydrate content of seeds of phaseolus lunatus (L.) can be attributed to the transformation of starch into soluble sugars under the action of phosphorylase enzyme during maturation (Germain and Linden, 1981). It appears that the carbohydrates content in the seed of white bean of phaseolus lunatus (L.) was comparable than the range of carbohydrates (59.44 – 72.06 %) content of vigna species (Chinnamadasamy and Veerabahu, 2012) because of their low fat content when compared with Arachis hypogaea and Glycine max, which have less carbohydrate content at 26.1 % and 20.9 % respectively (Rao et al., 1989). The high carbohydrate contents in the seed of bean of Phaseolus lunatus (L.) enable this vegetable to act as a good source of calories which would be antimarasmus, especially for infant nutrition (Vedivel and Janardhanan, 2000).

No significant differences were noted among the values of energy in seed from stage 1 to stage 4. The food energy value was calculated to be 310.71 to 300.79 kcal (1300.88-1259.34kj) based on crude protein, crude lipid and NFE. The caloric value was due to its low fat content and decreasing of carbohydrate content. The range in calorific values was comparable to energy values of cowpea, green gram, horse gram, moth beans and peas (Rao et al., 1989) which are in the range of 1318–1394 KJ 100 g-1 DM.

Generally, crude proteins, vitamin C and lipids increased significantly ($P < 0.05$) in seed of Phaseolus lunatus (L.) during maturation. Crude proteins ranged from 19.30 ± 0.32 to 25.06 ± 0.13. The Phaseolus lunatus (L.) was found to be higher (25.06 %) amount of crude protein when compared to certain vegetables such as Cicer arietinum (20.70 %), Vigna mungo (23.60 %) and Vigna radiata (24.50 %) as reported by Bravo et al. (1999). To meet the protein demands in developing countries where animal protein is grossly inadequate, considerable attention is being paid to less consumed protein sources, especially in legumes which are considered as protein tablets (Salunkhe, 1982). The crude proteins levels of the studied samples suggest its usefulness as alternative source of protein. The proteins have as a role, the replacement of cells died in the adults, a good growth of nourrissons and children, a good development of the foetus among pregnant women and a good secretion of the mother's milk during breast feeding (Cheer et al., 1999).

Changes in lipid content (1.01 ± 0.01 - 1.40 ± 0.02 g/100 g) during seed development were observed in (table 4). Crude fat content of white bean was comparable to the range of 1.3-2.3 g/100 g reported for some lima bean varieties (Bello-Perez et al., 2007; Granito et al., 2007; Apata and Ologhobo, 1994) and a range of 0.66-1.27 g/100 g reported for several other food grains (Barampama and Simard, 1993). Lipids are an important component of diet and serve a number of functions in the human body. Lipids are a concentrated source of energy and supplies per unit weight more than twice the energy furnished by either proteins or carbohydrates (Pious and Veerabahu, 2012).

As observed in table 2, ascorbic acid content significantly varied among samples harvested during different stages and it ranged from 2.30 mg/100g at stage 1 to 5.81 mg/100g at stage 4. According to the results of Korus (2010b), vitamin C levels in the kale leaves ranged from 77 to 133 mg 100 g^{-1} and they depend on the variety and degree of plant maturity. Singh et al. (2007) stated that vitamin C content ranged from 9.66 to 52.90 mg 100 g^{-1} and that the harvesting stage of the samples might be another important source of variation. Podsedek (2007) gave that climatic conditions might also alter vitamin C level. According to Maorun et al. (2009), ascorbic acid content varied significantly during maturation and showed a growing trend as maturity advances. Lee and Kader (2000) reported that maturity is among the major factors that define the compositional quality of fruits and vegetables.

The total fibers ranged from 4.89 ± 0.30 to 5.13 ± 0.12. The presence of fibers in the diet is necessary for digestion and for elimination of wastes. The contraction of muscular walls of the digestive tract is stimulated by fibers, thus counteracting constipation (Rao et al., 1989). The total fibers level of presently investigated was compared to certains legumes like cowpea and kidney bean (Singh et al., 2000), different varieties of Vigna mungo (Tresina et al., 2010); Co9, Co11 and Co12 varieties of Lablab purpureus (Kala et al., 2010a).

The ash content of seeds vegetables of white bean increased during maturation and ranged from 3.37 ± 0.17 to 4.16 ± 0.07. The ash content of investigated white beans (above 4 %) would be important to the extent that it contains the nutritionally important mineral elements. Similar values were reported in Cassia obtusifolia (Vijayakumari et al., 1993); species of Vigna (Kalidass and Mohan, 2012b); species of Vigna (Kalidass and Mahapatra, 2014).

The concentrations of thiamine (B1), riboflavin (B2), Pyridoxine (B6) and Folate (B9) are presented in Table 3. Thiamine (B1) and riboflavin (B2) varied significantly ($P<0.05$) at different stages. Pyridoxine (B6) and Folate (B9) was not varied significantly ($P<0.05$) at different stages (Pyridoxine (B6) was found higher than thiamine (B1), riboflavin (B2) and Folate (B9). It ranged from 1471 ± 1.47 µg/100g at stage 1 to 1500 ± 2.16 µg/100g at stage 4. Vitamin content also depends on the stage of maturity of fruits and vegetables, as to reap, the crop before maturity is a common practice of farmers to get economical benefits, while some studies have also suggested the HPLC methods less compatible for vitamin finding than other essays (Toma et al., 1979) so

comparison of vitamin determination methods is recommended. Vitamins are one of the indispensable organic components of vegetables and fruits nutrients. In this study we have selected only water soluble B complex (B1, B2, B6, B9) vitamins which are considered necessary for cellular metabolism especially carbohydrates metabolism. The higher Pyridoxine (B6) content in the white seed of Phaseolus lunatus (L**)** may be recommended for consumption because the daily permissible range for adults is up to 1000µg/day (Alexander et al., 1984).

Mineral composition

Changes in mineral element contents in Phaseolus lunatus (L.) at the investigated fruit development stages are shown in Table 4. Previous studies reported sodium, potassium, iron and copper increased during maturation. Sodium, potassium, iron and copper increased at stage 1 to stage 4 during maturation. Minerals ranged from (38.68 ± 0.16 – 60.81 ± 0.34 mg/100g); (720.20 ± 1.05 – 1109.30 ± 0.81 mg/100g), (6.80 ± 0.15 – 10.33 ± 0.17 mg/100g) and (1.87 ± 0.04 – 2.4 ± 0.05 mg/100g), respectively. Similar result was also observed by Al-maiman and Ahmad (2002) who reported that these minerals were found in fruit aril during development. Phosphorus, magnesium and calcium decreased during maturation. This cultivar analyzed in this investigation contained relatively high amounts from Phosphorus (459.85 ± 1.18 – 259.25 ± 1.08 mg/100g); magnesium (156.05 ± 0.36 – 140.60 ± 0.53 mg/100g) and calcium (530.32 ± 0.58 – 340.50 ± 0.51 mg/100g). Changes in the mineral profile of beans can be explained by different factors, including genotypic variability in absorption of minerals from soil (Vadivel and Janardhanan, 2001), effect of fertilizers on metallic composition of plants (Sadiq and Hussain, 1994), and levels of soil salinity (Carbonell-Barrchina et al., 1998).

The iron contents of the studied seed vegetables were higher than recommend dietary allowance for males (1.37 mg/day) and females (2.94 mg/day) (Siddhuraju et al., 2001). According to Geisler and Power (2005), iron plays numerous biochemical roles in the body, including oxygen blinding in hemoglobin and acting as an important catalytic center in many enzymes as the cytochrome oxidase. Thus the white cultivar of Phaseolus lunatus (L.) of this study could be recommend in diets for reducing anemia which affects more than one million people worldwide (Trowbridge and Martorell, 2002).

The ratios of sodium to potassium (Na/K) and calcium to phosphorus (Ca/P) are also shown in Table 4. Na/K ratio in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one is recommended. Na/K ratio of white bean increased during maturation ranged from 0.04 to 0.05. Hence, in the present study, white seed of Phaseolus lunatus (L.) would probably reduce high blood pressure disease because they had Na/K less than one. Food is considered ‘good’ if the Ca/P ratio is above 1 and ‘poor’ if it is 1. Ca/P ratio of white bean increased during maturation ranged from 1.15 to 1.3. It appears that the Ca/P ratio of white seed was comparable about the ratio Ca/P of M. pruriens var utilis white seeds (Adeyeye and Fagbohun, 2005). The Ca/P ratio in the present study indicated that seed of white beans would serve as good sources of minerals for bone formation.

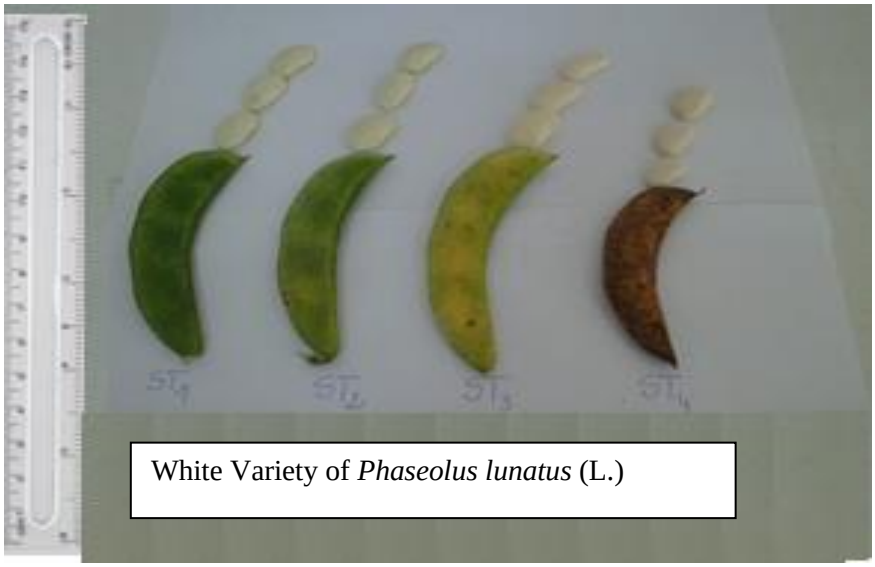

Figure 1. Stages of Pod development after pollinisation in relation dry matter accumulation in the seed. St1= (green pod), St2 (pod more green than yellow), St3 (pod more yellow than green) and St4 (drown pod)

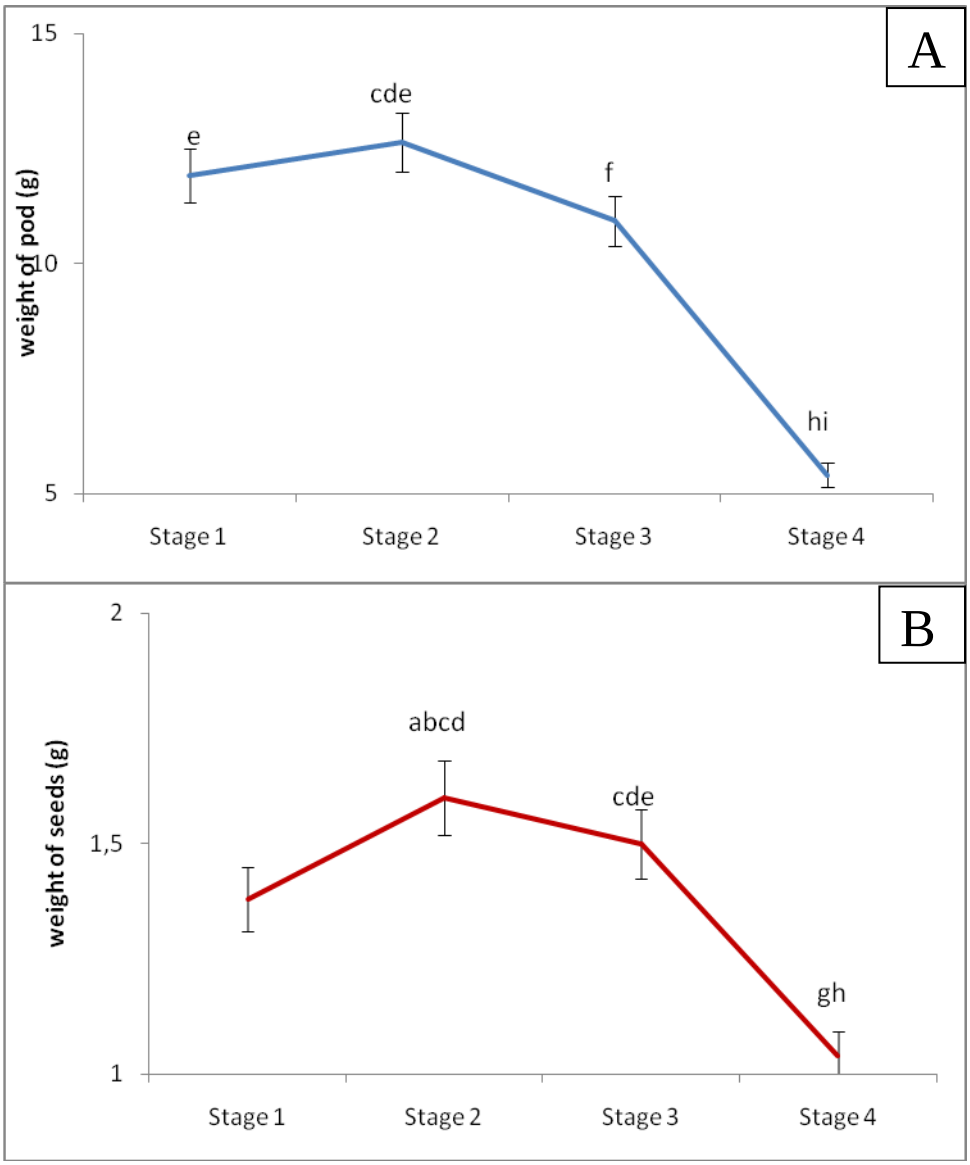

Figure 2. Weight of pods (A) and seeds (B) of phaseolus lunatus (L.) during maturation Stage1 (32 days); Stage2 (38 days); Stage 3(45 days) and Stage 4 (52 days) after pollinisation

Table 1. Physical variables of white bean of Phaseolus lunatus (L.) consumed in Southeast of Côte d'Ivoire during maturation

	Stage1(32)	Stage2 (38)	Stage3 (45)	Stage4 (52)
L*gs	37.47 ± 0.88^{ef}	42.32 ± 1.62^{bc}	45.48 ± 0.56^{a}	37.31 ± 0.69^{ef}
L*gr	51.82 ± 0.17^{g}	52.36 ± 0.47^{g}	54.51 ±0.57^{d}	59.29 ± 0.49^{a}
a*gs	-10.02 ± 0.18^{gh}	-8.60 ± 0.29^{e}	-3.90 ± 0.25^{f}	+2.32 ± 0.13^{f}
a*gr	-9.20 ± 0.21^{a}	-7.26 ± 0.20^{b}	-7.20 ± 0.43^{b}	-6.60 ± 0.41^{b}
b*gs	19.52 ± 0.47^{fg}	24.12 ± 0.55^{bc}	29.26 ± 0.36^{a}	20.66 ± 0.49^{df}
b*gr	16.77 ± 0.29^{e}	16.1± 0.29^{de}	16.00 ± 0.47^{de}	15.10 ± 0.28^{ad}
H*gs	27.58 ± 0.16^{i}	19.61 ± 0.10^{h}	07.61 ± 0.14^{e}	6.41 ± 0.14^{f}
H*gr	28.66 ± 0.36c	24.27 ± 0.27g	24.37 ± 0.50g	23.84 ± 0.19fg
C*gs	22.02 ± 0.38^{e}	25.61 ± 0.39^{cd}	29.60 ± 0.43^{a}	20.80 ± 0.21^{fg}
C*gr	19.12 ± 0.22a	17.66 ± 0.24h	17.50 ± 0.10h	16,68 ± 0.23f

Table 2. Proximate composition of white bean of Phaseolus lunatus (L.) consumed in Southeast of Côte d'Ivoire during maturation (g/100g dry weight basis)

	Stage 1(32)	Stage 2 (38)	Stage 3 (45)	Stage 4 (52)
Moisture (%)	70.37 ± 0.29^{d}	65.31 ± 0.65^{b}	55.36 ± 0.63^{g}	29.68 ± 0.75^{c}
Proteins (%)	19.30 ± 0.32^{di}	20.56 ± 0.26^{ch}	23.69 ± 0.20^{b}	25.06 ± 0.13^{a}
Lipids (%)	1.01 ± 0.01^{g}	1.22 ± 0.01^{def}	1.34 ± 0.02^{de}	1.40 ± 0.02^{d}
Total sugars (%)	1.75 ± 0.01^{f}	2.22 ± 0.09^{e}	2.78 ± 0.04^{g}	3.24 ± 0.25^{c}
Carbohydrates (%)	71.36 ± 0.60^{e}	67.15 ± 0.57^{b}	65.16 ± 0.30^{c}	64.09 ± 0.15^{c}
Fibers (%)	4.89 ± 0.30^{b}	4.90 ± 0.10^{b}	05.00 ± 0.17^{b}	05.13 ± 0.12^{ba}
Reducing sugars (%)	0.50 ± 0.01^{e}	0.44 ± 0.02^{h}	0.36 ± 0,01^{c}	0.23 ± 0.01^{d}
Ash (%)	3.37 ± 0.17^{f}	4.52 ± 0.17^{e}	4.58 ± 0.22^{e}	4.16 ± 0.07^{cde}
VitaminC (mg/100g)	2.30 ± 0.40^{c}	3.58 ± 0.22^{b}	4.73 ± 0.25^{f}	5.81± 0.25^{eg}
Energy (Kcal/100g)	310.71 ± 1.93^{de}	306.42 ± 0.63^{a}	302.55± 0.81^{b}	300.79 ± 0.59^{b}

Table 3. B- vitamin contents in seed vegetables of white bean of Phaseolus lunatus (L.) consumedin Southeast of Côte d'Ivoire during maturation (µg/100 g dry weight basis)

Cultivar		B1	B2	B3	B6	B9
CB	St1 (32)	160.15 ± 1.66^{g}	130.05 ± 2.19^{l}	ND	1471.00 ± 1.47^{f}	500.67 ± 2.42^{b}
	St2 (38)	170.00 ± 1.55^{f}	145.05 ± 0.52^{k}	ND	1500.00 ± 2.48^{h}	500.37 ± 1.10^{b}
	St3 (45)	180.27 ± 0.52^{i}	170.07 ± 0.83^{j}	ND	1500.00 ± 2.54^{h}	500.00 ± 3.24^{b}
	St4 (52)	210.80 ± 1.11^{d}	189.90 ± 0.84^{i}	ND	1500.00 ± 2.16^{h}	499.37 ± 0.56^{b}

Table 4. Mineral composition of white bean of Phaseolus lunatus (L.) consumed in South-east of Côte d'Ivoire during maturation (mg/100 g dry weight basis)

minéraux (mg/100g)	Stage1(32)	Stage2 (38)	Stage3 (45)	Stage4 (52)
Na	38.68 ± 0.16^{j}	39.49 ± 0.23^{j}	53.79 ± 0.05^{g}	60.81 ± 0.34^{f}
K	724.20 ± 1.05^{l}	899.16 ± 1.04^{k}	981.43 ± 1.62^{i}	1109.30 ± 0.81^{f}
P	459.85 ± 1.18^{b}	399.63 ± 0.75^{f}	330.69 ± 0.30^{h}	259.25 ± 1.08^{j}
Mg	156.05 ± 0.36^{f}	150.67 ± 0.32^{b}	147.75 ± 0.50^{e}	140.60 ± 0.53^{g}
Fe	6.80 ± 0.15^{fg}	7.47 ± 0.07^{eg}	7.55 ± 0.13^{eg}	10.33 ± 0.17^{bd}
Cu	1.87 ± 0.04^{d}	2.05 ± 0.03^{d}	1.90 ± 0.05^{d}	2.40 ± 0,05^{a}
Ca	530.32 ± 0.58^{g}	480.80 ± 1.48^{h}	401.33 ± 1.23^{d}	340.50 ± 0.51^{e}
Zn	0.97 ± 0.01^{c}	1.23 ± 0.03^{b}	0.53 ± 0.303^{d}	0,3 ± 0,01^{e}
Na/K	0.05	0.04	0.05	0.05
Ca/P	1.15	1.20	1.21	1.31

Data are represented as Means ±SD (n=3). Means in the column with no common letter differsignificantly ($P < 0.05$) for each seed vegetable. St1 (green pod), St2 (pod more green than yellow), St3 (pod more yellow than green) and St4 (drown pod).

CONCLUSION

The white bean of Phaseolus lunatus is a relatively good source of vitamin C, crude proteins and minerals. The better quality of seeds in terms of significantly higher dry matter accumulation than those harvested at 45 or 52 days after pollinisation (DAP). From the result above, the seed of white bean could serve

as a supplementary diet for the Ivorian population, supplying the body. Hence, the studied seed vegetables could contribute to the alleviation of protein-energy malnutrition and micronutrient deficiencies if they are consume in sufficient amount. However, it is necessary to consider other aspects such as the effects of processing on the chemical and nutritive value of these seed vegetables.

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