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Valorization of some minor plants of Côte d'Ivoire: Biochemical parameters and nutritional composition of the legume *Mucuna pruriens* seeds according to their maturity stage

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Abstract

The present study was aimed at investigating some biochemical properties, mineral contents and amino acid composition in seeds of *Mucuna pruriens* as a function of ripening stage. These seeds were harvested at different stages of maturation in a field carried out in the center of Côte d'Ivoire (Gbèkê Region). Seeds and pod were separated, and they were oven dried and ground to obtain the crude flour and analyzed according to standard procedures. Results showed that levels of dry matter (85.229-94.025 g.100g-1 dw), lipids (1.503-2.973 g.100g-1 dw), proteins (17.810-28.617 ± 0.296 g.100g-1 dw), fiber (6.483-7.477 g.100g-1 dw), ash (3.922 -9.231 g.100g-1 dw) and total sugars (10.338 -26.210 g.100g-1 dw) , increase significantly with the stage of maturity, while those of carbohydrates (70.282-51.703 g.100g-1 dw) and the energy value (365.893-348.037 Kcal.100g-1) decreases. Mineral analysis revealed that seeds are rich in essential minerals. Potassium (915.54- 20065.73 ug.100g-1) were the most abundant mineral, followed by magnesium (1335.33-16546.66 ug.100g-1), calcium (808.66-7739.39 ug.100g-1) and phosphorus (732.33-7440.00 ug.100g-1). The least abundant minerals were sodium (0.00-60.22 ug.100g-1), zinc (20.25-56.33 ug.100g-1), iron (41.63-475.52 ug.100g-1), copper (9.76-37.99 ug.100g-1) and manganese (0.00-5.94 ug.100g-1). For all assayed minerals, highest levels were founded in the seeds harvested 45 days after fertilization. Amino-acids profile has showed nutritionally useful amounts of essential amino acids such as histidine (18.32-40.81 mg.g-1 protein), isoleucine (30.76-66.35 mg.g-1 protein), leucine (72.47-103.51 mg.g-1 protein), lysine (27.22-57.28 mg.g-1 protein), methionine (25.51-51.74 mg.g-1 protein), threonine (10.91-37.40 mg.g-1 protein), tryptophan (29.22 -61.62 mg.g-1 protein) and valine (35.71-72.74 mg.g-1 protein). The study revealed M. pruriens seeds are rich in energetic and nutritional compounds. However, to optimize their nutritional qualities they may be harvest 35 days after the fertilization of the flowers.

Keywords: Amino Acid composition; Legume; Mineral composition; Proximate composition; *Mucuna pruriens*

1. Introduction

In sub-Saharan Africa, the food problem arises in terms of quantity and quality for more than a third of the population [1]. Fill the imbalance between population growth and food production is one of the important tasks of developing countries. The high cost of staple foods and political constraints on food imports are the main factors that aggravate the food situation in those countries [2]. Faced with this situation, it has been suggested that the valuation of food plants

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which are full of African countries is a solutions [3]. Unfortunately, a large part of this resource is under-exploited, even neglected [4].

This is the case in Côte d'Ivoire, where many food plants are gradually abandoned without their nutritional potential being assessed; nevertheless, studies of Amouzou *et al* [5] have shown that the nutritional potential of neglected plants can resolve food deficiencies and malnutrition. Those plants can serve as invaluable resources for the food and pharmaceutical industry. Among these plants with high nutritional values, legumes appear as an alternative. Those species have been envisaged as an economically viable alternative of protein sources and calories in developing countries [6]. Supplementation in legumes provides proteins, minerals and energy during additional dry seasons in developing countries [7]. Some underused wild legumes adapted to unfavorable conditions have been explored for their nutritional advantages [8].

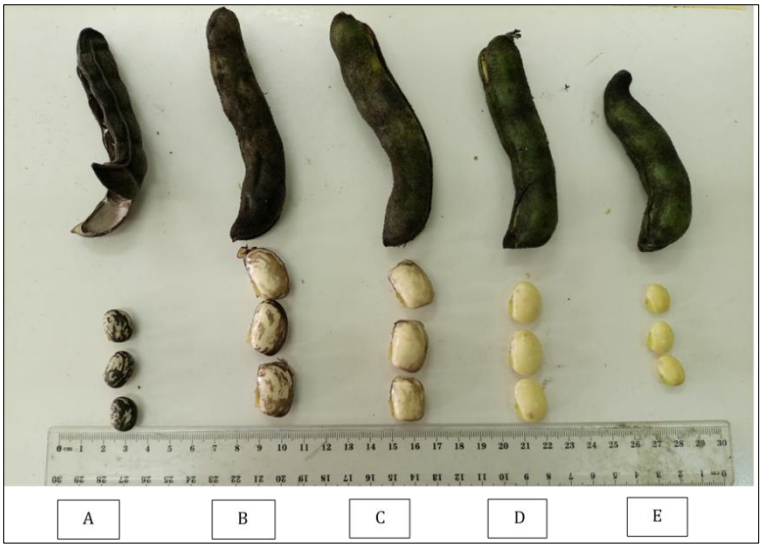
To meet the growing need for plant proteins for humans and livestock, research is underway on the possibilities of using legumes as an inexpensive source of protein [9]. Even if some of them, such as beans and groundnuts, have been taken into account in the development and intensification programs, many still remain orphans. This is the case of *Mucuna pruriens*. The plant *M. pruriens* is a heliophilous, thermophilic, fast-growing, creeping legume with many potentialities, which belongs to the family of Fabaceae consisting of approximately 650 genera and 20,000 species [10], and the second most important plant source of human and animal nutrition [11]. This plant can adapts to very diverse soils, sandy to clayey and supports a fairly high acidity [12]. Apart from its use in the fight against erosion and weeds [13] it has now appeared that it can be used in animal feed [14] due to the high protein content of its seed (20.2 to 20.9% dry matter), and the relatively high proportions of essential amino acids: 1.68% lysine and 0.27% methionine [15].

Despite, the potential of this under-utilized specie as a source of less consumed food, meager information is available on chemical composition of *M. Pruriens* produced in Côte d'Ivoire. It is with a view to enhancing this minor plant that we undertook this study. The specific objectives were to carry out a physico-chemical characterization of the seeds and to determine their nutritional values according to their stages of maturity.

2. Material and methods

2.1. Biological material

The plant material consisted of seeds and pods of *M. pruriens* (figure 1), produced during the 2019-2020 and harvested at different stages of maturation in a field carried out in the center of Côte d'Ivoire (Gbèkê Region). The seeds used to create the field were collected from a specie of the legume species *M. pruriens* (MP), in the village of Adoukoffikro in Abengourou (in the east).



A = harvested 60 days after fecundation (S5); B = harvested 45 days after fecundation (S4); C = harvested 35 days after fecundation (S3); D = harvested 25 days after fecundation (S2); E = harvested 15 days after fecundation (S1)

Figure 1 Seeds and pods of *Mucuna pruriens*

2.2. Methods

2.2.1. Experimental Plots Establishment Method

Cultivation of *Mucuna pruriens* cultivar was carried out in the open field, during the academic year of 2019 - 2020, in Bouaké. The experimental device is a block of 1150 m^2 area (25 m × 46 m), made up of 3 lines of pockets and 12 pockets per line. A total of 36 pockets for the block were sown. The pockets are separated by 3 m between them and the lines by 5 m, giving a distance of 3m x 5m (Figure 2). After germination, a simple wooden shelter about one and a half meters high was designed above the three rows of mounds, to serve as a stake. No insecticides or products were used in this field. The plot was monitored and maintained by regular weeding with a hoe.

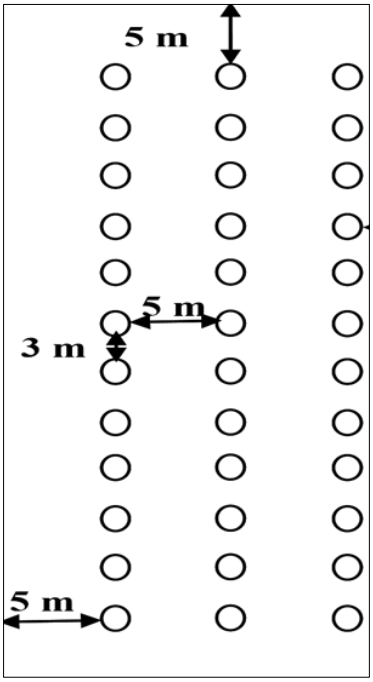


Figure 2 Experimental device of plot setting up in the field

2.2.2. Flower labeling and pod harvesting

Evolution of the flowers was followed until fecundation. A flower is said to be fertilized when the perianth falls. On this date, a tissue of variable color from one flower to another, is attached to the base of each fertilized flower. This date was noted on the flower label.

Humidity rate and pods and seeds colors evolution were followed up to the different the harvests dates, carried out at 15, 25, 35, 45 and 60 days after fertilization. Fifteen (15) days mark the beginning of seed release inside the pods and sixty (60) days, the physiological state of dried seeds inside the pods. These details made it possible to obtain the five stages of maturity. At each stage of maturity, 300 pods were harvested. A total of 1500 pods (300 pods × 5 stages of maturity) were harvested.

2.2.3. Sample Preparation

M. pruriens seeds were dried in an oven at 45°C for 48 hours. The dried samples were mechanically milled into powder with flat-hammer grinding mill and sifted through a 60-mesh screen and then stored in airtight containers for analysis [16].

2.2.4. Proximate Composition Analysis

The moisture content in each sample was determined using a hot air oven (Memmert) at a temperature of 105 °C and dried to constant weight according to method AOAC [16]. The ash content was determined by incinerating in a furnace for 5 h at 550°C [16]. Total nitrogen (N) was determined by the standard micro-Kjeldahl method [16] using a digestion apparatus (Kjeldatherm System KT 40, Gerhardt Laboratory Instruments, Bonn, Germany) and a titration system (T110-TR160-TA-TM120, Schott-Geräte GmbH, Hofheim, Germany). Crude proteins content was calculated by multiplying

percentage N by factor 6.25. Crude lipid content was assayed by extraction with petroleum ether (b.p. 40-60°C) in a Soxhlet extractor [16]. Carbohydrate content was calculated by difference. The percentage carbohydrate was calculated by using: % Carbohydrate = 100% - (% protein + % fats + % moisture + % ash + % fiber). Method described by Dubois and *al* [17] was used to determine total sugars while reducing sugars were analyzed according to the method of Bernfeld [18] using 3.5 dinitrosalycilic acids (DNS). The energy values of mushrooms were evaluated using formula described by Crisan and Sands [19].

Energy value (kcal/100g) = (2.62 × % protein) + (8.37 × % fat) + (4.2 × % carbohydrate).

All the analyses were done in triplicate

2.2.5. Mineral Composition Analysis

Minerals were determined employing AOAC [16] method. Flour was digested with a mixture of concentrated nitric acid (14.44 mol/L), sulfuric acid (18.01 mol/L) and perchloric acid (11.80 mol/L) and analyzed using an atomic absorption spectrophotometer. The total phosphorus was determined as orthophosphate by the ascorbic acid method after acid digestion and neutralization using phenolphthalein indicator and combined reagent [20].

2.2.6. Amino-acids characterization

Individual amino acids were characterized by the method of Balogun and Olatidoye [21] Amino acids were analyzed by a reverse-phase HPLC (Method L 7400, HITACHI, Japan) fitted with a Denali C18 5 micron column (4.6 x 150 mm). The flow rate was 1 ml min-1 with fluorescence detector. The cystine content of protein sample was obtained separately by the method of Liddell and Saville [22]. For the determination of tryptophan content of proteins, aliquots containing known amounts of proteins were dispersed into glass ampoules together with 1 ml 5M NaOH. The ampoules were flame sealed and incubated at 110°C for 18 hr. The tryptophan contents of the alkaline hydrolysates were determined colorimetrically using the method of Rao *et* al [23]. The contents of the different amino acids were expressed as g/100 g proteins.

2.3. Statistical Analysis

All analyses were performed in triplicates. Results are expressed as the mean ± standard deviation of several sample with Kyplot (version 2.0 beta 15, ©1997-2001, Koichi Yoshioka) statistical software. The data were statistically analyzed by one way analysis of variance (ANOVA). Means were compared by Turkey's test. Differences were considered statistically significant at $P < 0.05$.

3. Results and discussion

3.1. Proximate Composition

The biochemical composition of *M. pruriens* seeds according to their maturity stages is given in table 1. Results showed that the rates of dry matter (85.229 ± 0.008-94.025 ± 0.003 g/100g dw), lipids (1.503 ± 0.012-2.973 ± 0.012 g/100g dw), protein (17.810 ± 0.154-28.617 ± 0.296 g/100g dw), fiber (6.483-7.477±0.049 g/100g dw), ash (3.922 ± 0.013-9.231 ± 0.013 g/100g dw) and total sugars (10.338 ± 0.013 -26.210 ± 0.013 g/100g dw), increase significantly with seed maturation, while those of humidity (14.771 ± 0.008-5.975 ± 0.003 g/100g dw), energy value (365.893 ± 0.215-348.037 ± 0.186 Kcal)) and carbohydrates (70.282 ± 0.147-51.703 ± 0.300 g/100g dw) decrease during maturation. As for reducing sugars, their content increases from the 15th to the 35th day (2.255 ± 0.06-6.231 ± 0.006 g/100g dw) before decreasing (6.231 ± 0.006-5.434 ± 0.022 g/100g dw) until the 60th day. The moisture (8.28%), protein (26.25%), carbohydrate (58.04%) and energy value (357.287 Kcal/100g) levels obtained in the seeds harvested 35 days after fertilization (S3) are identical to the moisture (9.03%), protein (27.17%), carbohydrate (62.43%) and energy (406.30 Kcal/100g) found in mature seeds of *M. pruriens* by Ezeagu *et al* [24]. We could then say that the S3 stage corresponds to the stage of maturity from which we could harvest the seeds. However, our ash (6.480%), fiber (6.990%) and total sugar (22.650%) contents are much higher than the values (fiber: 3.65%; ash: 3.19% and total sugars: 2.37%) obtained by these authors. On the other hand, the lipid contents (2.23-2.97%) of this study are much lower than those of Kalidass and Mohan [25] and Ezeagu *et al* [24] who founded 6.57 – 8.80 % and 7.21% of lipids respectively in the mature seeds of *M. pruriens*. The high protein content in the seeds studied shows their importance as sources of this vital nutrient. The seeds of *M. pruriens* therefore show promise as a protein and energy supplement for human and animal foods with low protein content such as cereals [26]. The low lipid content (1.50-2.97) obtained shows that *M. pruriens* seeds cannot be considered oilseeds. The fiber composition was determine because of the recent interest in the potential role of the dietary fiber in human nutrition. The low crude fiber content obtained in the seeds (06.48-07.47 g.100 g-1) is an

advantage in terms of feeding monogastric animals [24]. The fiber content obtained in this research are lower than results (14-26 %) of Dahl *et al* [27] in *M. pruriens* seeds. The high levels of ash compared to the values of some previous studies show that the seeds of *M. pruriens* are rich in minerals, because the ashes represent the inorganic constituents. The net carbohydrate contents (46.11 to 52.53 %) in this study are significantly higher than those of peanuts and soy found by Rao *et al* [28]**,** proves that the seeds of *M. pruriens* are very energetic. This is confirmed by the high calorific values (348.037-365.893 Kcal.100g^{-1}) which are almost identical to those of *M. pruriens* founded by Kalidass and Mohan [25], and Dahl *et al* [27]**,** which are in the range of 370.71-390.29 Kcal.100g^{-1}.

Table 1 Proximate composition of seed flour of Mucuna pruriens according to the their harvested stade (g 100 g-1seed)

Parameters	Harvest time				
	S1	**S2**	**S3**	**S4**	**S5**
Dry matter	85.229 ± 0.008^{a}	88.450 ± 0.004^{b}	91.719 ± 0.047^{c}	93.339 ± 0.007^{d}	94.025 ± 0.003^{e}
Humidity	14.771 ± 0.008^{e}	11.550 ± 0.004^{d}	8.281 ± 0.047^{c}	6.661 ± 0.007^{b}	5.975 ± 0.003^{a}
Lipid	1.503 ± 0.012^{a}	1.993 ± 0.012^{b}	2.233 ± 0.012^{c}	2.653 ± 0.012^{d}	2.973 ± 0.012^{e}
Protein	17.810 ± 0.154^{a}	20.810 ± 0.154^{b}	26.250 ± 0.154^{c}	27.350 ± 0.141^{d}	28.617 ± 0.296^{e}
Carbohydrate	70.282 ± 0.147^{e}	65.643 ± 0.173^{d}	58.047 ± 0.173^{c}	54.207 ± 0.173^{b}	51.703 ± 0.300^{a}
Crude fiber	6.483 ± 0.057^{a}	6.810 ± 0.046^{b}	6.990 ± 0.030^{c}	7.300 ± 0.040^{d}	7.477 ± 0.049^{e}
Ash (%)	3.922 ± 0.013^{a}	4.743 ± 0.013^{b}	6.480 ± 0.013^{c}	8.490 ± 0.013^{d}	9.231 ± 0.013^{e}
Total sugars	10.338 ± 0.013^{a}	19.745 ± 0.013^{b}	22.650 ± 0.013^{c}	25.466 ± 0.013^{d}	26.210 ± 0.013^{e}
Reducing sugars	2.255 ± 0.061^{a}	4.719 ± 0.032^{b}	6.231 ± 0.006^{e}	5.813 ± 0.012^{d}	5.434 ± 0.022^{c}
Energetic value (Kcal)	365.893 ± 0.215^{e}	363.757 ± 0.168^{d}	357.287 ± 0.131^{c}	350.107 ± 0.150^{b}	348.037 ± 0.186^{a}

All values are means of triplicate determinations expressed on a dry weight basis ± denotes standard error. "Mean values in the following row sharing a common letter are not *statistically significant according to DMRT; S1: seeds harvested 15 days after fecundation; S2: seeds harvested 25 days after fecundation; S3: seeds harvested 35 days after fecundation; S4: seeds harvested 45 days after fecundation; S5: seeds harvested 60 days after fecundation

3.2. Mineral Composition

Table 2 summarizes the mineral contents of the seed powders. Potassium (915.54±30.64 to 20065.73±41.69 ug.100g^{-1}) was found to be the most abundant mineral, followed by magnesium (1335.33±29.87-16546.66±50.33 ug.100g^{-1}), calcium (808.66±4.45-7739.39±0.61 ug.100 g^{-1}) and phosphorus (732.33±41.88-7440.00±45.82 ug.100g^{-1}). This is in close agreement with the observation of Aremu *et al* [29] that K was the most predominate mineral in Nigerian Agricultural Products. The least abundant minerals were sodium (0.00±0.00-60.22±1.07 ug.100g^{-1}), Zinc (20.25±2.49-56.33±5.50 ug.100g^{-1}), iron (41.63±0.35-475.52±1.14 ug.100g^{-1}), cooper (9.76± 0.08-37.99±0.03 ug.100g^{-1}) and manganese (0.00±0.00-5.94±0.27 ug.100g^{-1}). The levels of all the minerals assayed were high in seeds harvested 45 days (S4) followed by those harvested 35 days (S3) after fertilization. These two stages of maturity are therefore the most suitable for harvesting seeds if we want to optimize their mineral composition. High levels of potassium, calcium and magnesium were previously founded in *M. pruriens* seeds by Daffodil and *al* [30]. Like most of food legumes, *Mucuna* seeds are a good source of minerals that could easily satisfy the dietary needs of these mineral elements in case of deficiency. The results of this research agree with those of Salunkhe *et al* [31] who showed that food legumes are a good source of minerals such as calcium, iron, copper, zinc, potassium and magnesium. The levels of potassium seem to be higher compared with recommended dietary allowance values (1550 mg) [30]. This high content of potassium can be utilized beneficially in the diets of people who take diuretic to control hypertension and suffer from excessive excretion of potassium through the body fluid [32]. Minerals serve as cofactors for many physiologic and metabolic functions [21]. Magnesium, the highest mineral component after potassium has been reported to be an activator of many enzyme systems and maintains electrical potential in nerves [33]. Calcium present at significant levels is important in blood clothing muscle contraction and in certain enzymatic metabolic processes. It's also an important mineral required for bone formation and neurological function [21].

Table 2 Mineral composition of seeds of *Mucuna pruriens* according to the their harvested stade (ug.100g^{-1} seed flour)

parameters	Harvest time				
	S1	**S2**	**S3**	**S4**	**S5**
Calcium	808.667 ± 4,452^{a}	2908.667 ± 4,452^{b}	4039.333 ± 65.432^{c}	7739.390 ± 0.615^{e}	5442,367 ± 0,635^{d}
Phosphorus	732.333 ± 41.885^{a}	2642.333 ± 41.885^{b}	4593.333 ± 25.166^{d}	7440.000 ± 45.826^{e}	3493.333 ± 45.092^{c}
Magnesium	1335.333 ± 29.872^{a}	4767.000 ± 29.309^{b}	11153.000 ± 50.269^{c}	16546.667 ± 50.332^{e}	13036.667 ± 47.258^{d}
Potassium	915.546 ± 30.645^{a}	2309.546 ± 30.645^{b}	15636.667 ± 47.258^{d}	20065.733 ± 41.697^{e}	9690.000 ± 36.056^{c}
Sodium	0.000 ± 0.000^{a}	1.365 ± 0.324^{b}	20.267 ± 0.473^{c}	60.223 ± 1.072^{e}	52.900 ± 0.361^{d}
Manganese	0.000 ± 0.000^{a}	1.006 ± 0.117^{b}	2.038 ± 0.071^{c}	5.947 ± 0.274^{e}	3.967 ± 0.503^{d}
Zinc	20.556 ± 2.498^{a}	29.156 ± 2.498^{b}	33.767 ± 1.966^{c}	56.333 ± 5.508^{e}	41.000 ± 3.606^{d}
Cooper	9.766 ± 0.085^{a}	11.266 ± 0.283^{b}	16.889 ± 0.127^{c}	37.993 ± 0.034^{e}	26.168 ± 0.198^{d}
Iron	41.634 ± 0.350^{a}	83.524 ± 0.417^{b}	109.68 ± 0.590^{c}	475.527 ± 1.144^{e}	364.737 ± 2.663^{d}

All values are means of triplicate determinations expressed on a dry weight basis ± denotes standard error. "Mean values in the following row sharing a common letter are not *statistically significant according to DMRT; S1: seeds harvested 15 days after fecundation; S2: seeds harvested 25 days after fecundation; S3: seeds harvested 35 days after fecundation; S4: seeds harvested 45 days after fecundation; S5: seeds harvested 60 days after fecundation

3.3. Seeds Amino-acids profile

Table 3 Amino acid profiles of seed proteins of *Mucuna pruriens* according to the their harvested stade (mg.g^{-1} seed protein)

Parameters	Harvest time				
	S1	**S2**	**S3**	**S4**	**S5**
Arginine	38.394 ± 0.041^{a}	40.514 ± 0.041^{b}	57.234 ± 0.041^{c}	71.274 ± 0.041^{e}	69.874 ± 0.041^{d}
Methionine	25.514 ± 0.041^{a}	32.234 ± 0.041^{b}	41.534 ± 0,041^{c}	51.744 ± 0.041^{e}	48.234 ± 0.041^{d}
Valine	35.714 ± 0.041^{a}	40.394 ± 0.041^{b}	53.474 ± 0.041^{c}	68.294 ± 0.041^{d}	72.744 ± 0.041^{e}
Alanine	49.114 ± 0.041^{a}	54.424 ± 0.041^{b}	63.764 ± 0.041^{c}	79.234 ± 0.041^{d}	81.314 ± 0.041^{e}
Tryptophan	29.224 ± 0.041^{a}	35.764 ± 0.041^{b}	44.314 ± 0.041^{c}	52.984 ± 0.041^{d}	61.624 ± 0.041^{e}
Proline	0.000 ± 0.000 ^{a}	5.894 ± 0.041^{b}	13.244 ± 0.041^{c}	25.414 ± 0.041^{d}	33.984 ± 0.041^{e}
Lysine	27.224 ± 0.041^{a}	34.754 ± 0.041^{b}	41.634 ± 0.041^{c}	55.714 ± 0.041^{d}	57.284 ± 0.041^{e}
Glutamic Acid	81.574 ± 0.041^{a}	99.224 ± 0.041^{b}	108.234 ± 0.041^{c}	122.004 ± 0.041^{d}	125.764 ± 0.041^{e}
Leucine	72.474 ± 0.041^{a}	83.434 ± 0.041^{b}	90.224 ± 0.041^{c}	103.514 ± 0.041^{e}	100.764 ± 0.041^{d}
Serine	25.674 ± 0.041^{a}	32.764 ± 0.041^{b}	38.114 ± 0.041^{c}	91.224 ± 0.041 ^{e}	57.214 ± 0.04^{d}
Tyrosine	0.000 ± 0.000 ^{a}	1.214 ± 0.041^{b}	5.034 ± 0.041^{c}	10.224 ± 0.041^{d}	18.514 ± 0.041^{e}
Cysteine	0.000 ± 0.000 ^{a}	2.334 ± 0.041^{b}	7.714 ± 0.041^{c}	13.794 ± 0.041^{e}	11.224 ± 0.041^{d}
Isoleucine	30.764 ± 0.041^{a}	42.234 ± 0.041^{b}	58.274 ± 0.041^{c}	66.354 ± 0.041^{e}	62.414 ± 0.041^{d}
Aspartic Acid	63.114 ± 0.041^{a}	79.184 ± 0.041^{b}	90.434 ± 0.041^{c}	102.514 ± 0.041^{d}	110.444 ± 0.041^{e}
Threonine	10.914 ± 0.041^{a}	17.134 ± 0.041^{b}	24.594 ± 0.041^{c}	31.764 ± 0.041^{d}	37.404 ± 0.041^{e}
Histidine	18.324 ± 0.041^{a}	20.154 ± 0.041^{b}	31.634 ± 0.041^{c}	40.814 ± 0.041^{e}	38.854 ± 0.041^{d}
Glycine	40.354 ± 0.041^{a}	51.874 ± 0.041^{b}	67.394 ± 0.041^{c}	80.764 ± 0.041^{e}	79.234 ± 0.041^{d}

All values are means of triplicate determinations expressed on a dry weight basis ± denotes standard error. "Mean values in the following row sharing a common letter are not *statistically significant according to DMRT; S1: seeds harvested 15 days after fecundation; S2: seeds harvested 25 days after fecundation; S3: seeds harvested 35 days after fecundation; S4: seeds harvested 45 days after fecundation; S5: seeds harvested 60 days after fecundation

Table 3 shows the amino acid profile of the seeds of *M. pruriens*.

The protein quality, also known as the nutritional value of a food depends on its amino acid content and on the physiological utilization of specific amino acid after ingestion, absorption and minimal obligatory rates of oxidation [34]. A total of 17 amino acids were detected. Phenylalanine, Asparagine and glutamine were not be detected. The amino acid profile confirm the nutritional potential of *M. pruriens* seeds. Glutamic acid (81.57±0.04-125.76±0.04 $mg.g^{-1}$ protein), Aspartic acid (63.11±0.04-110.44± 0.04 $mg.g^{-1}$ protein), Leucine (72.47±0.04-103.51±0.04 $mg.g^{-1}$ protein) were the major abundant amino acids in seeds. This observation is agreement with those reports of Udengwu *et al* [35] and, Balogun and Olatidoye [21] in *M. pruriens* and *M. Utilis* seeds respectively. For all the amino acids, the highest levels were observed in the seeds harvested from the 45th day (S4) after fertilization. The values of amino-acids obtained in seeds harvested at this period are substantially identical to those found in mature seeds by this previous authors. This period corresponds to the stage of maturity of the seeds and conducive to their harvest. All the essential amino acids for humans were detected in significant proportions, with the exception of phenylalanine. These include histidine (18.32±0.04-40.81±0.04 $mg.g^{-1}$ protein), isoleucine (30.76±0.04-66.35 ± 0.04 $mg.g^{-1}$ protein), leucine (72.47±0.04-103.51±0.04 $mg.g^{-1}$ protein), lysine (27.22±0.04-57.28±0.04 $mg.g^{-1}$ protein), methionine (25.51±0.04-51.74±0.04 $mg.g^{-1}$ protein), threonine (10.91±0.04-37.40± 0.04 $mg.g^{-1}$ protein), tryptophan (29.22±0.04-61.62± 0.04 $mg.g^{-1}$ protein) and valine (35.71±0.04-72.74±0.04 $mg.g^{-1}$ of protein). The high scores of essential amino acids present in these seeds implied that they have a high biological protein value. This is particularly important as there is a need for novel protein sources owning to the increasing cost of conventional sources of protein in the third world. In addition, the cereal based diets common in developing countries could receive a boost with the inclusion of these seeds in their diet.

4. Conclusion

At the end of this study it appears that the seeds of *M. pruriens* are a good sources of proteins, carbohydrates which makes them an energy food. They contain most of the essential minerals and amino acids. However, the rate of the different ones increases progressively during the maturity then to benefit from it the seeds will have to be harvested from the 35th day after fertilization of the flowers. This study reveals that the nutritional profile of mature *M. pruriens* seeds can also be explored as an alternative source of protein and nutrients to alleviate protein-energy malnutrition among economically weaker sections of populations in developing countries.

Compliance with ethical standards

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Disclosure of conflict of interest

ASA Kouakou, HK Konan, F Kané, KA Kanga, EJP Kouadio and LP Kouamé are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as constituting a conflict of interest.

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