



Research Article

An Evaluation of the Protein Digestibility of Flours and Derived Protein Rich Product of Three Varieties of *Mucuna Pruriens* (L.) From Rats (*Rattus Norvegicus*) Males in Growth

Maoudombaye Théopihile¹, Mahamat Seid Ali^{1*}, Gomoung Doloum², Ngatchic Metsagang Therese Josiane³, Ndoutamia G.¹

¹Faculty of Science and Technology, University of Doba, Chad

²Faculty of Science and Technology, University of Sarh, Chad

³Department of Food Science and Nutrition, Higher National School of Agro-Industrial Sciences, Ngaoundéré, Cameroon

Abstract

The objective of the present study is to evaluate the proteinaceous digestibility of crude flours and derived protein rich product of three varieties of *Mucuna pruriens* of the male albino rats in growth. 48 rats have been taken randomly split up into 8 groups where 6 each according to their formulated feedings; those foods are: foods without protein (RSP), foods with casein (RC), food with the black macuna derived protein rich product (RMNc), food with the scratch macuna derived protein rich product (RMRc), food with the white macuna derived protein rich product (RMBc), food with the black macuna crude flours (RMNf), food with the scratch macuna crude flours (RMRf) et food with the white macuna crude flours (RMBf). All those foods content the same quantity of azote excepted foods without protein. Rats have been isolated in the semi metabolic cages which allow gathering the remaining of the foods supplied and the faeces to determine the parameter values of consumption. The experiment has taken 28 days. The apparent and reel protein digestibilities obtained in each food are respectively : RC (76,63±0,36% ; 95,86±0,06%), RMNc (71,20±0,77% ; 91,60±0,99%), RMRc (73,68±0,23% ; 93,49±0,85%), RMBc (71,16±0,59% ; 92,03±0,70%), RMNf (33,25±1,91% ; 53,88±1,70%), RMRf (31,3±2,40% ; 52,12±2,22%) and RMBf (31,12±4,00% ; 51,92±3,8%). The results show that derived protein rich product have ameliorated the protein digestibility and could be the alternative for the use of seeds of *Mucuna pruriens* to feed human beings and animals.

Keywords: crude flours; derived protein rich product; *Mucuna pruriens*; protein digestibility; male rates in growth.

Introduction

In sub-Saharan Africa, the problem of protein malnutrition is recurrent because the diet of populations is characterized by protein deficiency, the consequences of which occur in

infants (Deen *et al.*, 2003). Animal proteins are inaccessible to the rural poor (Mezajoug *et al.*, 2010). On the other hand, food sources of protein of vegetable origin are available and accessible. Legumes are considered to be the major source

Article may be cited as:

M. Théopihile *et al.* (2017) Int. J. Appl. Sci. Biotechnol. Vol 5(3): 284-292. DOI: <http://dx.doi.org/10.3126/ijasbt.v5i3.18119>

^{1*}Corresponding author

Mahamat Seid Ali,
Faculty of Science and Technology, University of Moundou, Chad
Email: seidaligarga@gmail.com

Peer reviewed under authority of IJASBT

© 2017 International Journal of Applied Sciences and Biotechnology



This is an open access article & it is licensed under a Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>)

of dietary protein among plants (Baudoin and Maquet, 1999). Legume seeds, like those of *Mucuna pruriens*, are a rich source of quality proteins for humans and animals but have limited digestibility due to the antinutrients they contain (Gurumoorthi et al., 2003; Siddhuraju et al., 2005).

Indeed, *Mucuna pruriens* presents agronomic, medicinal and nutritional potential, but is very little used. The nutritional values determined for *Mucuna* seeds are comparable to those for conventional legumes (Pugalenthi et al., 2005). Protein values are generally between 22 and 35%. These values are higher than those found in conventional legumes such as *Pisum sativum* (22%), *Phaseolus vulgaris* (21%), *Cicer arietinum* (19%) and *Lens culinaris* (21%) (de Almeida Costa et al., 2006). However, it has been noted that when consumed without proper treatment, *Mucuna* seeds have adverse effects in humans and birds (Josephine and Janardhanan, 1992; Vijayakumari et al., 1996; Dossa et al., 1998/1999; Del Carmen et al., 1999). Among the toxic and anti-nutritional factors identified in these seeds are tannins, trypsin inhibitors, anticoagulants and L-dopa (Bell and Janzen, 1971; Daxenbichler et al., 1971; Ravindran and Ravindran, 1988). Traditional treatments such as cooking, fermentation or germination improve the protein digestibility of seeds by decreasing the levels of some anti-nutrients (Bishnoi et al., 1994; Chau and Cheung, 1997). In addition, methods for the production of isolates, concentrates and curds in seeds of certain legumes are an effective way to improve the nutritional quality of proteins as they reduce the toxic and anti-nutritional factors of proteins (Maoudombaye et al., 2012). The objective of this work is to evaluate the protein digestibility of raw meal and curds of three varieties of *Mucuna pruriens* (L.) in male rats (*Rattus norvegicus*).

Biological Materials

Plant material

The plant material used consists of seeds of *Mucuna pruriens*, a legume little known and very rare on the Chadian market. Three varieties were used in this study: black, white and striped varieties (Fig. 1). The seeds were provided by the Chadian Institute of Agricultural Research for Development (ITRAD).

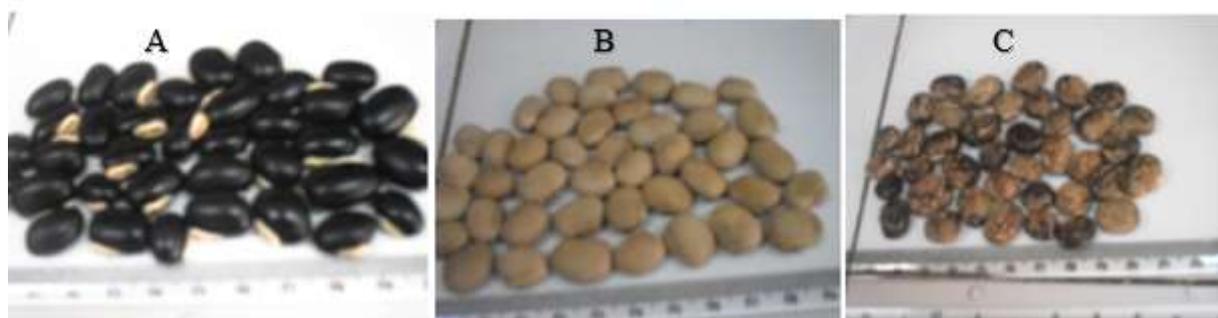


Fig. 1: Seeds of the three varieties of *Mucuna pruriens* used. [A.- *M. pruriens* var. *utilis* ; B.- *M. pruriens* var. *cochinchinensis* ; C.- *M. pruriens* var. *pruriens*].

The animal material

For many years, nutritionists have adopted a particular rat strain, isolated by the Washington Wistar Institute as an experimental model (Adrian et al., 1991). The most obvious advantage of the rat is its omnivorous character and especially the sensitivity of its response to nutritional conditions. By simply monitoring its daily intake within a few days, it is possible to predict the nutritional quality of the component studied (Adrian et al., 1991; Giami et al., 2005). The animals are male albino rats of the Wistar breed, growing between 87 and 116 g.

Production of *Mucuna Pruriens* Flours and Derived Protein Rich Product

The seeds of the three varieties (white, striped and black) of *Mucuna pruriens* were soaked separately in distilled water in a 1/10 (w / v) ratio for 24 h at 35 °C. They were squeezed and then dried for 48 h in an oven (Towson & Mercer, England) ventilated at 40 ± 5 °C. The dried seeds were husked using a cereal mill (SAMAP brand) and manually wound to remove the seed coats. They were then crushed in the same mill and then sieved using a sieve of mesh 0.5 mm in diameter. The flours thus obtained were stored at 4 °C. in plastic bags for the production of curds, the nutrition of the rats during the experiment and the determination of the physico-chemical characteristics.

The derived protein rich product are produced according to the procedure described in (Ngatchic et al., 2005). Proteins coagulate in the presence of acids and heat. The principle of this process is to produce *Mucuna* milk from the flour and to curdle it in the presence of hot citric acid. 500 g of *mucuna* flour were dissolved in 2500 ml of distilled water (1/5 weight / volume ratio). The solution obtained was stirred with an electric stirrer (TECHNICON stirrer motor, England) equipped with an autotransformer (DIDALAB, France) set at 130 rpm for 3h and then centrifuged using a Centrifuge (DL-6000B) for 10 min at 4000 rpm to collect the supernatant. The pellet was recycled once under the same extraction conditions. The supernatant obtained is *mucuna* milk.

This milk was poured into a pot and then acidified with citric acid at a rate of 0.325 g / 100 ml. The whole was boiled on a hot plate at 97.5 °C. for 10 min. The solution was then poured into a pressing cloth and then pressed for 10 min. The compact mass obtained is the mucuna The derived protein rich product.

After pressing, the mucuna curd was removed and dried in a ventilated electric dryer at 40 ± 2 °C for 48h. It was finally ground and sieved to a particle size of 0.5 mm and then the powder conserved as in the case of flours at 4 °C. in plastic bags for the physicochemical characterization and nutrition of the animals during the experiment.

Determination of the Protein Content of Flour and Faeces

The protein content was determined using the Kjeldahl method (AFNOR, 1982) for mineralization and the method of (Devani et al., 1989) for the determination of nitrogen. The crude protein content was obtained by multiplying the nitrogen content by the conventional factor 6.25 (Séraphin et al., 2015).

Formulation of Diets for In Vivo Digestibility

The in vivo digestibility of proteins evaluates the nutritional quality of a protein from the analysis of the results of the measurement of the nitrogen retained and of the growth of the rats. The quality of dietary proteins was assessed by the balance sheet method, which examined the measurement of ingested nitrogen and that lost in faeces (Mezajoug et al., 2010). The digestibility tests are carried out on animals placed individually in cages specially adapted to collect faeces, which are analyzed physico-chemically at the end of experimentation (Mezajoug et al., 2010).

The basic rule is that all rations are iso-nitrogenated (ie, they have the same nitrogen content) and the only variable between the positive control (containing casein), the negative control (containing protein), And experimental rations, is the nature of proteins. *The protein content of food is maintained at 10%* (Giami et al., 2005). The rations were formulated according to (Bonafou et al. , 2007)[26]. In total, eight diets were prepared as follows:

- A protein-free regimen representing the negative control (RSP);
- A positive control protein diet having casein (RC) as a protein source;
- Three protein diets from raw meal of the three varieties of Mucuna which are raw mucuna flour (RMNf), raw mucuna flour (RMRf) and raw mucuna flour (RMBf);
- Three protein diets from the curd flours of the three varieties of mucuna which are black derived protein rich product mucuna (CWM), curdled mucuna (RMRc) and white curd mucuna (RMBc).

Conduct of the Experiment

The rats are weighed and randomized into 8 groups of 6 rats each, a total of 48 rats. They are each kept in semi metabolic cages (Giami et al., 2005).

During the experimental period, the foods were weighed and given to the rats in the form of cosettes once every two days in the morning in a fixed time interval (8 to 10h). The water is served in baby bottles at will and replaced every other day. Before distributing new foods, the remains of the foods offered to the animals were picked up and weighed. The difference between the quantities of feed served and the leftovers determined the amount consumed per animal (Adrian et al., 1998). The animals were weighed every other day at the same time interval. The last weighing took place at the end of the experiment. The feces of the last two days of the experiment were collected and their nitrogen content was determined for the evaluation of protein digestibility (Adrian et al., 1991). The variation in body mass and the amount of food consumed during the experimental period were used to estimate the protein efficiency coefficient (PEC). The loss of mass presented by the group of rats subjected to the protein-free diet was used to calculate the net protein efficiency coefficient (FNEC) (Mezajoug et al., 2010).

Evaluation of Nutritional Value Parameters of Diets

The weight gain (GP), expressed in g, is defined as the difference between the final weight and the initial weight of the animal. The weight gain per day was obtained by dividing the total weight gain by the number of days of the experiment.

GP (g) = Final weight - initial weight

$$GP/j \text{ (g)} = \frac{\text{Final weight} - \text{initial weight}}{\text{Number of days}}$$

The total quantities of food consumed (QTAC) represent the total quantities of food ingested during the experimental period. Its expression in g / d is obtained by dividing the amount of QTAC (g) by the number of days of the experiment.

QTAC (g) = Total quantity of food ingested during the experimental period.

$$QTAC \text{ (g/j)} = \frac{\text{Total amount of food ingested}}{\text{Number of days}}$$

Total Ingested Protein (TPI) (g) represents the amount of dietary protein ingested during the experimental period.

PTI (g) = QTAC(g) x Percentage of dietary protein

$$PTI \text{ (g/j)} = \frac{QTAC \text{ (g)} \times \text{percentage of dietary protein}}{\text{Number of days}}$$

The consumption index (ICONS) is calculated from the following formula:

$$\text{ICONS} = \frac{\text{Amount of food consumed (g)}}{\text{Total live weight (g)}}$$

The protein efficiency coefficient (PEC) is obtained by comparing the weight gain (g) to the PTI (g).

$$\text{CEP} = \frac{\text{Growth of the test group (g)}}{\text{Total protein ingested (g)}}$$

$$\text{CEPN (g)} = \frac{\text{Growth of test group + weight loss of rats fed diet without protein}}{\text{Protein ingested by the test group}}$$

Protein Digestibility In-Vivo

Protein digestibility in vivo is determined by apparent digestibility (DA) and actual digestibility (DR).

$$\text{DA} = \frac{\text{Nitrogen ingested} - \text{Fecal nitrogen}}{\text{Fecal nitrogen}} \times 100$$

$$\text{DR (\%)} = \frac{[I - (F - \text{FPP})]}{I} \times 100 \text{ (Young and Pellett, 1982).}$$

I = protein ingested by a subject subjected to diet with protein

F = protein excreted by feces of a subject subjected to diet with protein

FPP = protein excreted by feces of a subject subjected to the protein-free diet

Data Analysis

The data obtained were expressed as mean \pm SD. The Statgraphics 5.0 software (Manugistics, Rockville, Maryland, USA, 1997) was used for ANOVA and the DUNCAN multiple comparison test for significant differences. Statistical significance was defined for $p < 0.05$.

Results and Discussions

The amounts of food and nitrogen ingested as well as nitrogen excreted were measured in male albino rats subjected to a 28-day experiment. Rat weight measurements were also performed. These results are reflected in Fig. 2 to 5. Table 1 summarizes the mean values of the Consumption Indices (ICONS), Protein Efficiency Coefficients (PECs) and Calculated Net Protein Efficiency Ratios (FNECs), while In Table 2, apparent and actual protein digestibilities are recorded.

Amount of Food Ingested Per Diet

The results obtained show that the highest intake per day is the casein diet (29.06 ± 0.45 g) and the lowest value at the protein-free diet (21.90 ± 0.95 g). The results obtained show, moreover, that there is no significant difference between the values of the NMR regimes (27.39 ± 0.33 g), C-NMR (27.73 ± 0.30 g), NMR (27.09 ± 0.45 g) and RMBf (26.86 ± 0.3 g) on the one hand and between those of the NMR regimes (27.39 ± 0.33 g), RMBc (26.79 ± 0.60 g), Nmr (27.09 ± 0.45 g), RMBf (26.86 ± 0.3 g) and RMRf (26.88 ± 0.50 g) on the other hand (Fig. 2). On the other hand, the values of the regimes NMR, RMBC, NMR, RMRf and RMBf differ significantly from CPR at the threshold of $p < 0.05$. The high level of consumption observed in the batch of rats subjected to the casein diet is due to the palatability of the presence of this protein in the food. Maga (1981) reported that basic amino acids and glutamic acid help to improve the flavor and palatability of foods rich in it. On the other hand, the low consumption rate of the batch of rats subjected to the protein-free diet would be due to the total absence of protein which would decrease the palatability. The results obtained are much greater than those of [31], which obtained the mean consumption of 17.8 ± 1.7 g and 8.8 ± 2.1 g respectively for the casein diet and the protein-free diet.

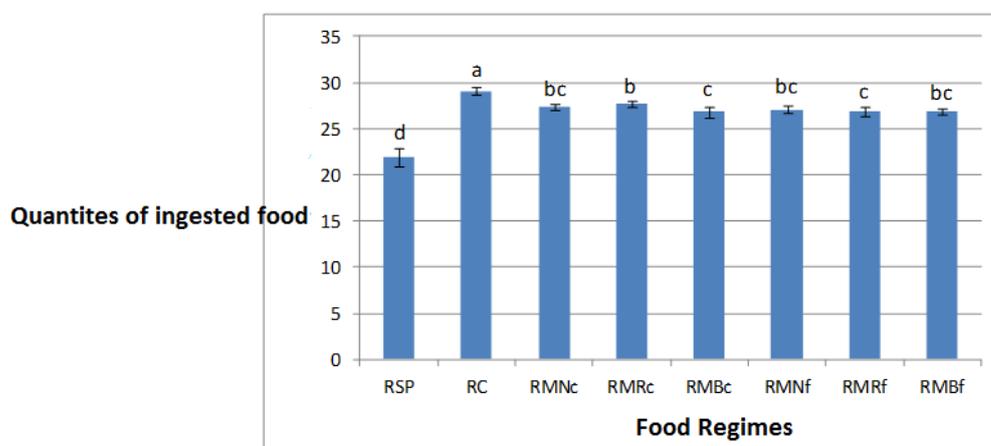


Fig. 2: Average quantities of food ingested during the experiment

Amount of Nitrogen Ingested Per Diet

The results of the analyzes yield values of 0.46 ± 0.01 g of nitrogen ingested for the batch of rats subjected to the casein (RC) regimen and 0.00 ± 0.00 g for the group of rats consuming the food Without protein. Nitrogen intake increases with the amount of food consumed for each diet (Mezajoug *et al.*, 2010). After ingestion of a meal, nitrogen of exogenous origin represents between 50 and 70% of the nitrogen flux at the jejunal level (Baglieri *et al.*, 1994; Mahé *et al.*, 1996; Gaudichon *et al.*, 1996; Gausseres *et al.*, 1996). The nonprotein fraction of exogenous nitrogen is slightly higher than that of endogenous nitrogen, as it varies between 40 and 80% depending on the type of meal and the time (Baglieri *et al.* 1994). The levels of ingested nitrogen obtained from the different curd diets were significantly different: 0.43 ± 0.00 g for cMMR, 0.44 ± 0.00 g for CMA and 0.42 ± 0.00 g for RMBc. At the level of flours, the levels of NMR (0.43 ± 0.00 g) and FMRR (0.43 ± 0.00 g) were significantly different from each other and different from that of RMBf (0.42 ± 0.00 g) (Fig. 3). The results of casein diet and protein-free diet confirm their respective intake. In general, the quantities of nitrogen ingested are appreciable for all experimental diets except for the protein-free diet.

Fecal nitrogen test results yielded a maximum amount of excreted nitrogen for FMRR (0.29 ± 0.01 g) and a minimum value for the batch of rats subjected to the protein-free diet (0.089 ± 0.00 G). The fecal nitrogen values of the clotted

groups are significantly identical with each other, as well as for the crude flour diets (Fig. 4). The values of the curds are close to those of the casein, which attests that the proteins of the curds have been well digested. On the other hand, the faecal nitrogen levels of raw meals are very high: 0.29 ± 0.00 g for (RMBf) and for (RMRf) and 0.28 ± 0.00 g (NMR). The maximum fecal nitrogen excreted by the groups of rats subjected to raw meal was due to the high content of raw fiber foods and the antinutrients which would have complexed the proteins thus preventing their digestion. The fibers of the different regimes were increased by the incorporation of 5% cellulose. Increased dietary fiber content increases fecal nitrogen excretion following an increase in microbial nitrogen (Zhu *et al.*, 1990). The protein fraction of endogenous nitrogen mainly consists of salivary amylases, pepsin, pancreatic proteases (trypsin, chymotrypsin, elastase, carboxypeptidases) and lipases (Baglieri *et al.*, 1994; Mahé *et al.*, 1996; Gaudichon *et al.*, 1996; Gausseres *et al.*, 1996). Moreover, because of their high water retention capacity, the fibers exert a "barrier" effect which would impede the digestion and reabsorption of digestive secretions and explain the higher endogenous losses observed in their presence (Mahé *et al.*, 1997). All this explains the rate of 0.089 ± 0.00 g for the diet without protein and that of fecal nitrogen excreted (0.10 ± 0.00 g) by the casein-fed animals because they lack fiber (Mezajoug *et al.*, 2010).

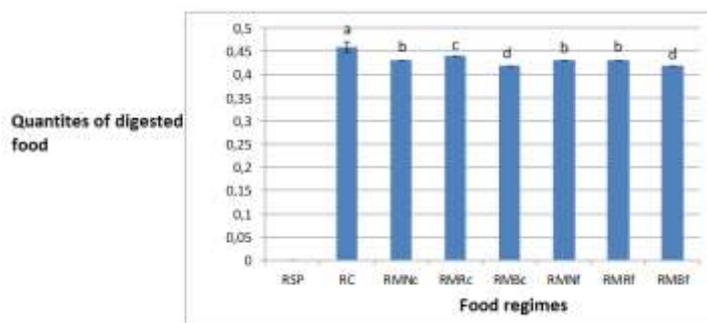


Fig. 3: Average quantities of nitrogen ingested during the experiment

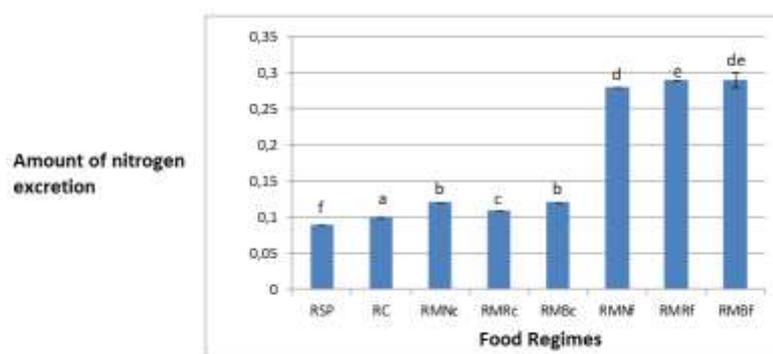


Fig.4: Average quantities of nitrogen excreted during the experiment

Weight Gain of Animals

Evaluation of animal weights yielded results ranging from 11.55 ± 0.30 g for casein-fed rats to -8.6 ± 0.84 g for NMR-fed rats. The weight gains of NMR (10.78 ± 0.10 g) and C-RMR (11.28 ± 0.52 g) were identical to each other and significantly differed from RMBc (10.13 ± 0.45 g) at the threshold of P <0.05. There was no significant difference between cMRc and casein group (Fig. 5). These results show that the proteins of the curds are assimilated to the same title as the reference protein which is casein. In the case of crude flours, the weight losses of NMR (-8.6 ± 0.84 g) with RMRf (-7.94 ± 0.13 g) and RMBf (-8.01 ± 0.25 g) Between them. The weight losses of RMRf, RMBf and protein-free diet are identical to the threshold of p <0.05. The weight loss of the animals would be attributed to the poor protein digestibility of the raw meal on the one hand and to the total absence of it in the ration on the other hand. The results obtained are lower than those of (Bonafou et al., 2007) which reported a gain of 24.22 ± 9.580 g for the casein diet and a loss of -12.26 ± 5.200 g for the protein-free diet.

Consumption Index (ICONS)

The Consumption Index (ICONS) is the ratio of the amount of food ingested to the weight gain of the animal. It reflects overall food efficiency and figures the yield of the ration. The lowest result reflects better production (Mezajoug et

al., 2010). Under normal feeding conditions, the value of the consumption index is between 1.9 and 2.1; Or an average value of 2. The value 2 means that the animal consumed 2 kg of food to produce 1 kg of live weight (www.avicultureamaroc.com). A negative result is a sign of misuse of the food (Maoudombaye et al., 2012).

Table 1 shows the consumption indices ranging from 2.64 ± 0.09 for RMBc to -3.38 ± 0.07 for RMRf. From this table, it appears that the best production returns to the CMA RMR (2.46 ± 0.11) which has the lowest index. The cMNA consumption indices (2.55 ± 0.05) and cMRc (2.46 ± 0.11) were statistically identical to each other and that of casein and differed from that of RMBc (2.64 ± 0, 09). In general, the indexes of consumption of curds reflect a good protein efficiency because they have allowed weight gain comparable to that of casein. In contrast, the RMRf (-3.38 ± 0.07) and RMBf (-3.35 ± 0.10) consumption indices for the raw meals were significantly different from each other and different from that for NMR (-3.17 ± 0.24 g) at the threshold of p <0.05. These negative cues indicate poor digestibility of protein diets that resulted in weight loss of rats. However, ICONS alone can not predict the effectiveness of a protein as the amount consumed does not always correspond to the assimilated quantity (Bonafou et al., 2007).

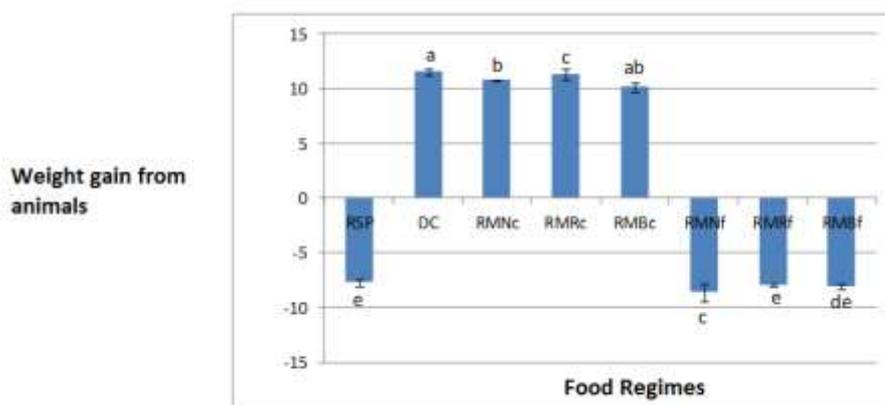


Fig. 5: Weight variations of rats according to diet

Table 1: Changes in protein and net efficiency ratios and dietary consumption indices

| Parameters | Witness | Mucunaderived protein rich product | | | Mucuna raw meal | | |
|--------------|------------------------|-------------------------------------|-------------------------|------------------------|-------------------------|-------------------------|-------------------------|
| | casein | black | banded | white | black | banded | white |
| Icons | 2,51±0,05 ^a | 2,55±0,05 ^b ^a | 2,46±0,11 ^a | 2,64±0,09 ^b | -3,17±0,24 ^c | -3,38±0,07 ^d | -3,35±0,10 ^d |
| CEP | 4,08±0,11 ^a | 3,93±0,06 ^{bc} | 4,06±0,18 ^{ba} | 3,78±0,13 ^c | -3,16±0,23 ^d | -2,95±0,06 ^d | -2,98±0,09 ^d |
| CEPN | 6,73±0,03 ^a | 6,67±0,05 ^{ab} | 6,66±0,04 ^{ab} | 6,56±0,11 ^b | -0,11±0,00 ^c | -0,11±0,00 ^c | -0,11±0,00 ^c |

Means followed by a different letter are significantly different (p <0.05)

ICONS = Consumption index; CEP = protein coefficient of efficacy; CEPN = net protein efficiency coefficient.

Table 2 : Variations of apparent and real digestibility according to diets

| Parameters | Witness | Mucunaderived protein rich product | | | Mucuna raw meal | | |
|------------|-------------------------|------------------------------------|--------------------------|-------------------------|--------------------------|-------------------------|-------------------------|
| | casein | black | banded | white | black | banded | white |
| DA (%°) | 76,63±0,36 ^a | 71,20±0,77 ^b | 73,68±0,23 ^b | 71,16±0,59 ^b | 33,25±1,91 ^c | 31,3±2,40 ^c | 31,12±4,00 ^c |
| DR (%) | 95,86±0,06 ^a | 91,60±0,99 ^b | 93,49±0,85 ^{ba} | 92,03±0,70 ^b | 53,881±1,70 ^c | 52,12±2,22 ^c | 51,92±3,8 ^c |

Means followed by a different letter are significantly different (p <0.05)

DA = apparent digestibility; DR = Real digestibility

Coefficients of Protein Efficiency (CEP) and Net (FNEC)

The protein efficiency coefficient (PEC) is a parameter for measuring the growth of animals. CEP is the ratio of animal weight gain on the amount of protein ingested. According to Friedman (Friedman et al., 1996), proteins with a PEC less than 1.5 are of low protein quality, those with a PEC between 1.5 and 2 are of intermediate quality, when greater than 2, the proteins are good quality. Based on this classification, protein of curds; 3.93 ± 0.06% (C NMR), 4.06 ± 0.18% (CPR) and 3.78 ± 0.13% (RMBc); Are of good nutritional quality such as casein (4.08 ± 0.11%). However, a low CEP value does not always indicate a low ability of the protein to grow. The calculation of the FNEC is more appropriate and more accurate (Friedman et al., 1996).

The results in Table 1 show that CEP levels of 4.08 ± 0.11% for Casein at -3.16 ± 0.23% for MNf. The CWR CPR (4.06 ± 0.18%) was significantly identical to that of casein and that of cMR (3.93 ± 0.06%). There was no difference between the cMNA of C-NMR (3.93 ± 0.06%) and that of RMBc (3.78 ± 0.13%). In contrast, RMBc (3.78 ± 0.13%) differed significantly from CMA (4.06 ± 0.18%) and casein (4.08 ± 0.11%). The CEPs of raw meal are identical to each other at the threshold of p <0.05. Similar CEPs of curds (3.18 ± 1.24%) and casein (3.27 ± 0.61%) were reported in the rats by (Bonafou *et al.*, 2007; Mezajoug *et al.*, 2010).

The efficiency of a protein for growth can be estimated by calculating the net protein efficiency coefficient (FNEC) which takes into account the weight loss of the animal fed to the staple food (Cheftel *et al.*, 1985). This is the ratio of animal weight gain added to the weight loss of the protein-free group divided by the amount of protein ingested by the animal. The CEPN values of the curds are significantly equal to each other. There was no significant difference between the value of casein CEPN (6.73 ± 0.03) and that of cMNA (6.67 ± 0.05) and MRC (6.66 ± 0.04). FNEC levels of raw meals, all negative, are statistically identical at the p <0.05 threshold. The values of the curds obtained are higher than those of rapeseed (4.59) and soybean (2.74) reported by Friedman (Friedman et al., 1996). This demonstrates the good nutritional quality of mucuna curds. Mezajoug

(Mezajoug *et al.*, 2010) reported a value of 5.89 ± 0.50 for casein.

The digestibility of a food is defined as the ability of a food to be transformed into chemicals capable of passing through the doorway, while the digestibility of a protein is the capacity of the digestive tract to effectively absorb the food, Nitrogen intake [38]. The apparent digestibilities obtained ranged from 76.63 ± 0.36% for the batch of rats subjected to the casein diet to 31.12 ± 4.00% for rats consuming foods based on crude mucuna flours black. The apparent digestibility values of rats fed with curds did not differ significantly from each other but were slightly lower than that of casein (Table 2). The apparent digestibility rates of the crude flour diets, which are very low compared with those of the curds, are significantly identical to the p <0.05 threshold.

On the other hand, the actual digestibility rates range from 95.86 ± 0.06% for RC to 51.92 ± 3.8% for RMBf. The actual digestibility value of cMRc (93.49 ± 0.85%) was significantly identical to that of RC (95.86 ± 0.06%) but differed from that of cMR (91.60 ± 0.99%) In addition, RMBc (92.03 ± 0.70%) which are equal to each other. The actual digestibilities of crude flours, NMR (53.881 ± 1.70%), RMRf (52.12 ± 2.22%) and RMBf (51.92 ± 3.8%) are all identical to one another at the threshold of p <0.05. The digestibilities of the curds are included in the animal protein digestibility ranges of 95 to 98% and vegetable proteins of 75 to 95% reported. On the other hand, the low digestibility rates of the raw meal diets relativize their low nutritional quality (maoudombaye *et al.*, 2012).

Conclusion

From this work, the curd production process not only concentrated proteins but reduced the levels of mucuna to antinutrients that complexed the proteins preventing their proper use. Nutrition tests carried out on the young growing male rats showed that the curds favored good growth of the rats compared to those fed with casein. The digestibility rates in these rats showed that the curds were not toxic and showed good nutritional quality of proteins. On the other hand, animals fed raw meal during the same tests lost weight. Mucuna raw meals showed a poor nutritional quality of proteins which resulted in substantial loss of animal weight. In view of these results, the curds of *Mucuna*

pruriens appear globally as a potential source of protein that can be used in human food, such as soya derived protein rich product.

References

- Adrian J, Potus J, Annie P (1998) Introduction à l'analyse nutritionnelle des denrées alimentaires: Méthodes biologiques sur l'animal. Technique et documentation Lavoisier, Paris (France), 1998. 254p
- Adrian J, Rabache M and Frangne R (1991) Techniques d'analyse nutritionnelle. In: *Principes de techniques d'analyse*. Ed. Lavoisier TEC & DOC Paris, 451-478
- AFNOR (1982) Association Française de Normalisation (A.F.NOR). Recueil de normes françaises des céréales
- Baglieri A, Mahe S, Zidi S, Huneau JF, Thuillier F, Marteau P, Tome D (1994) Gastro-jejunal digestion of soya-bean-milk protein in humans. *British Journal of Nutrition* **72**(4): 519-532. DOI : [10.1079/BJN19940056](https://doi.org/10.1079/BJN19940056)
- Baudoin JP and Maquet A (1999) Improvement of protein and amino acid contents in seeds of food legumes. A case study in Phaseolus. *Biotechnologie, Agronomie, Société et Environnement* **3**(4):220-224.
- Baudoin JP, Maquet A (1999) Improvement of protein and amino acid contents in seeds of food legumes. A case study in Phaseolus. *Biotechnologie, Agronomie, Société et Environnement*. **3**(4): 220-224.
- Bell EA and Janzen DH (1971) Medical and ecological considerations of L-dopa and 5-HTP in seeds. *Nature*. **229**(5280): 136-137. DOI : [10.1038/229136a0](https://doi.org/10.1038/229136a0)
- Bishnoi S, Khetarpaul N and Yadav RK. (1994) Effect of domestic processing and cooking methods on phytic acid and polyphenol contents of pea cultivars (*Pisum sativum*). *Plant Foods for Human Nutrition (Formerly Qualitas Plantarum)*. **45**(4): 381-388. DOI : [10.1007/BF01088088](https://doi.org/10.1007/BF01088088)
- Bouafou KG, Kouamé KG and Offoumou AM (2007) Bilan azoté chez le rat en croissance de la farine d'asticots séchés. *Tropicultura* **25**(2): 70-74.
- Chau CF and Cheung PK (1997) Effect of various processing methods on antinutrients and in vitro digestibility of protein and starch of two Chinese indigenous legume seeds. *Journal of Agricultural and Food Chemistry*. **45**(12): 4773-4776. DOI : [10.1021/jf970504p](https://doi.org/10.1021/jf970504p)
- Cheftel JC, Cuq JL and Paris DL (1985) Technique and documentation-Lavoisier, pp. 1- 295.
- Daxenbichler ME, VanEtten CH, Hallinan EA, Earle FR, Barclay AS (1971) Seeds as sources of L-DOPA. *Journal of medicinal chemistry* **14**(5): 463-465. DOI : [10.1021/jm00287a030](https://doi.org/10.1021/jm00287a030)
- de Almeida Costa GE, da Silva Queiroz-Monici K, Reis SM, de Oliveira AC. (2006) Chemical composition, dietary fibre and resistant starch contents of raw and cooked pea, common bean, chickpea and lentil legumes. *Food chemistry*. **94**(3): 327-330. DOI : [10.1016/j.foodchem.2004.11.020](https://doi.org/10.1016/j.foodchem.2004.11.020)
- Deen LJ, Funk M, Guevara CV, Saloojee H, James Y, Doe YJ, Palmer Aand Weber WM. (2003) Bulletin of the World Health Organization **81**: 237-243. DOI :
- Del Carmen J, Gernat AG, Myhrman R and Carew LB (1999) Evaluation of raw and heated velvet beans (*Mucuna pruriens*) as feed ingredients for broilers. *Poultry Science*. **78**(6): 866-872. DOI : [10.1093/ps/78.6.866](https://doi.org/10.1093/ps/78.6.866)
- Devani MB, Schishoo CJ and Suhagia BN (1989). Spectrophotometrical method for microdetermination of Nitrogen Kjeldhal digest. *J. Assoc. Off. Anal Chem* **72**(6): 953-956.
- Dossa CS, Mensah GA, Dossa AD and Adoun C (1998/1999) Influence de divers traitements physico-chimiques de graines de *Mucuna pruriens* sur leur composition chimique en nutriments. *Tropicultura* **16-17**: 141-146.
- et produits céréaliers. 1ère édition, A.F.NOR (Ed.), Paris, France
- Friedman M. Nutritional value of proteins from different food sources. A review. *Journal of Agricultural and Food Chemistry*. 1996 Jan 18;44(1):6-29. DOI : [10.1021/jf9400167](https://doi.org/10.1021/jf9400167)
- Gaudichon C, Mahe S, Luengo C, Laurent C, Meaugeais P, Krempf M and Tome D (1996) A 15N-leucine-dilution method to measure endogenous contribution to luminal nitrogen in the human upper jejunum. *European journal of clinical nutrition*. **50**(4): 261-268.
- Gausserès N, Mahé S, Benamouzig R, Luengo C, Drouet H, Rautureau J, Tomé D. (1996) The gastro-ileal digestion of 15 N-labelled pea nitrogen in adult humans. *British Journal of Nutrition*. **76**(1):75-85. DOI : [10.1079/BJN19960010](https://doi.org/10.1079/BJN19960010)
- Giami SY (2005) Compositional and nutritional properties of selected newly developed lines of cowpea (*Vigna unguiculata* L. Walp). *Journal of Food Composition and Analysis*. **18**(7): 665-763. DOI : [10.1016/j.jfca.2004.06.007](https://doi.org/10.1016/j.jfca.2004.06.007)
- Gurumoorthi P, Senthil Kumar S, Vadivel V and Janardhanan K. (2003) Studies on agrobotanical charecters of different accessions of velvet bean collected from western ghats, south India. *Tropical and subtropical Agroecosystems* **2**(3): 105-115.
- Josephine RM and Janardhanan K. (1992) Studies on chemical composition and antinutritional factors in three germplasm seed materials of the tribal pulse, *Mucuna pruriens* (L.) DC. *Food chemistry* **43**(1):13-18. DOI : [10.1016/0308-8146\(92\)90235-T](https://doi.org/10.1016/0308-8146(92)90235-T)
- Maga JA (1981) Mushroom flavor. *Journal of Agricultural and Food Chemistry*. **29**(1):1-4. DOI : [10.1021/jf00103a001](https://doi.org/10.1021/jf00103a001)
- Mahe S, Roos N, Benamouzig R, Davin L, Luengo C, Gagnon L, Gausserges N, Rautureau J and Tomé D. (1996) Gastrojejunal kinetics and the digestion of [15N] beta-lactoglobulin and casein in humans: the influence of the nature and quantity of the protein. *The American journal of clinical nutrition* **63**(4):546-552.
- Mahe S, Tome D, Dumontier AM and Desjeux JF. (1989) Absorption of intact morphiceptin by

- diisopropylfluorophosphate-treated rabbit ileum. Peptides. 10(1): 45-52. DOI : [10.1016/0196-9781\(89\)90074-0](https://doi.org/10.1016/0196-9781(89)90074-0)
- Maoudombaye. Master memory. University of Ngaoundere (2012), 83 p.
- Mezajoug KLB (2010) Doctorate of INPL and Doctorate Ph.D from the University of Ngaoundéré. National Polytechnic Institute of Lorraine 226 p.
- Ngatchic JT, Sokeng SD, Njintang NY, Maoundombaye T, Oben J and Mbofung CM (2013) Evaluation of some selected blood parameters and histopathology of liver and kidney of rats fed protein-substituted mucuna flour and derived protein rich product. *Food and chemical toxicology*. **57**: 46-53. DOI : [10.1016/j.fct.2013.02.045](https://doi.org/10.1016/j.fct.2013.02.045)
- Pugalenth M, Vadivel V and Siddhuraju P (2005) Alternative food/feed perspectives of an underutilized legume *Mucuna pruriens* var. utilis—a review. *Plant foods for human nutrition* **60**(4): 201. DOI : [10.1007/s11130-005-8620-4](https://doi.org/10.1007/s11130-005-8620-4)
- Ravindran V and Ravindran G (1988) Nutritional and anti-nutritional characteristics of mucuna (*Mucuna utilis*) bean seeds. *Journal of the Science of Food and Agriculture* **46**(1): 71-79. DOI : [10.1002/jsfa.2740460108](https://doi.org/10.1002/jsfa.2740460108)
- Séraphin DK, Youssouf KK, Doudjo S, Emmanuel AN, Benjamin YK, Dago G (2015) Caracterisation Biochimique Et Fonctionnelle Des Graines De Sept Cultivars De Voandzou [*Vigna Subterranea* (L.) Verdc. Fabaceae] Cultives En Côte D'ivoire. *European Scientific Journal* **11**(27).
- Vijayakumari K, Siddhuraju P, Janardhanan K (1996) Effect of different post-harvest treatments on antinutritional factors in seeds of the tribal pulse, *Mucuna pruriens* (L.) DC. *International journal of food sciences and nutrition* **47**(3): 263-272. DOI : [10.3109/09637489609012587](https://doi.org/10.3109/09637489609012587)
- Walker AF. 1982 Physiological effects of legumes in the human diet: a review. *Journal of plant foods*.
- Young VR and Pellett PL (1991) Protein evaluation, amino acid scoring and the food and drug administration's proposed food labeling regulations. *The Journal of nutrition*. **121**(1):145-50.
- Zhu JQ, Fowler VR and Fuller MF. (1990) Digestion of unmolassed sugar-beet pulp in young growing pigs and implications for the growth-supporting values of fermented energy. *Animal Science*. **50**(3): 531-539. DOI : [10.1017/S000335610000502X](https://doi.org/10.1017/S000335610000502X)