*Tropical and Subtropical Agroecosystems*

# CHRONIC TOXICITY OF RAW LYON'S BEAN (*Mucuna cochinchinensis)* IN BROILERS

## [TOXICIDAD CRÓNICA DEL FRIJOL LYON (Mucuna cocnhinchinensis) POLLOS DE ENGORDA]

**S. N. Ukachukwu[1]*, V. O. Shoyinka[2] and F. C. Obioha[2]**
*[1]Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. E-mail snukachukwu@yahoo.com*
*[2]University of Nigeria, Nsukka, Enugu State, Nigeria*
**Corrresponding author*

**SUMMARY**

One hundred and fifty 3-week old broilers were subjected to long period of feeding on diets containing raw Lyon's bean (*Mucuna cochinchinensis*) with the aim to studying the toxicity of the bean on blood profile, carcass characteristics and pathological changes. Five isocaloric and isonitrogenous diets were formulated to contain 0, 2, 4, 8 and 16g/kg (that is, g *Mucuna* per kg feed) and fed to the birds for 12 weeks. Inclusion of *Mucuna* beans in broiler diets caused significant (P<0.01) reduction of RBC, PCV and Hb. On carcass characteristics, only the liver was affected by the dietary treatments. The liver weight was significantly (P<0.05) depressed at first slaughter (3rd week). Also, liver sections of birds fed *Mucuna* diets at all levels of inclusion consistently showed pathological lesions at all stages of slaughter.

**Key words:** *Mucuna cochinchinensis*, chronic toxicity, broilers, haemoglobin, packed cell volume, red blood cell.

**RESUMEN**

Ciento cincuenta pollos de engorda de 3 semanas de edad fueron empleados en una prueba de alimentación de largo plazo con dietas conteniendo *Mucuna cochinchinensis* cruda con el fin de estudiar la toxicidad de este fríjol en el perfil sanguíneo, características de la canal y cambios patológicos. Se formularon cinco dietas isocalóricas e isonitrogenadas que contenían 0, 2, 4, 8 y 16 g/kg (g *Mucuna* por kg alimento) y se alimentaron las aves por 12 semanas. La inclusión de *Mucuna* en la dieta de los pollos de engorda causo una reducción (P<0.01) de Células Rojas Sanguíneas, Volumen de paquete celular y Hemoglobina. En la canal, solo el hígado fue afectado, siendo este menor (P<0.05) al primer sacrificio (3ª semana). Cortes histológicos del hígado de aves consumiendo *Mucuna* mostraron lesiones patológicas en todo el periodo experimental.

**Palabras clave:** M*ucuna cochinchinensis*, toxicidad crónica, pollos de engorda, hemoglobina, volumen de paquete celular, célular rojas sanguíneas.

## INTRODUCTION

Many leguminous crops in Nigeria belong to the neglected or under-utilized legumes. These include jack bean, sword bean, yam bean, Mucuna beans, pigeon pea, kidney bean, lima bean, bambara nut, cowpea, among many others (Ologhobo, 1992; Anumnu, 1990; Udedibie and Nwaiwu, 1987; Oyenuga, 1968; Hutchinson and Dalziel, 1954). The common feature about all these little known legumes is their high content of various naturally occurring constituents, which affect their nutritional quality. Olomu (1995) has described these natural constituents as endogenous toxic substances because they are part of the normal feedstuff. These anti-nutritional factors include haemagglutinins, protease inhibitors (like trypsin inhibitor), cyanogens, tannins, dopamine, L-Dopa, antivitamins, lipoxygenase, nicotin, phytates, goitrogens, and serotonin (Oke *et al*., 1996; Ologhobo, 1992; Balogun and Fetuga, 1989; Udedibie and Nwaiwu, 1987; Duke, 1981; Hashim and Idrus, 1977; Piper and Tracy, 1910; Bort, 1909).

The presence of these antinutritional factors in a feedstuff confers toxicity action to such feedstuff. *Mucuna cochinchinensis,* a member of the genus *Mucuna*, has been reported to contain a good number of these factors (Carew *et al*., 2000; Del Carmen *et al*., 2000; Flores *et al*., 2000; Ukachukwu and Obioha, 2000; Ukachukwu *et al*., 1999; Ukachukwu and Obioha, 1997). Ukachukwu *et al.*(1999) reported that raw *Mucuna* extracts were not acutely toxic to broiler birds. However, they reported that the birds that received the extracts showed some other signs of toxicity, which included dizziness and diarrheic droppings. They opined that the non-acute toxicity of the raw seed extracts does not preclude the fact that raw *Mucuna* could be chronically toxic when eaten for

a long period of time. This work therefore, aims at investigating toxicity of raw *Mucuna* bean on broilers when they are exposed to such a bean for a long time.

## MATERIALS AND METHODS

Two hundred (200) unsexed Anak strain day-old broiler chicks were raised in a deep litter house on a common broiler starter diet (Pfizer Feed[Registered Trade Mark]) for 21 days. After the 21 days 150 of them were selected and randomly allocated to five dietary treatments using 30 birds per treatment in a completely randomized design (CRD) experiment. The five diets respectively contained raw *M. cochinchinensis* seeds at five levels of 0%, 0.2%, 0.4%, 0.8% and 1.6%. These translated to 0g/kg, 2g/kg, 4g/kg, 8g/kg and 16g/kg (that is, g *Mucuna* per kg feed). The feeding trial lasted for 12 weeks ($4^{th}$ – $15^{th}$ week of age). The diets were formulated to be isocaloric and isonitrogenous as follows: (1) Weeks 4 - 6 (22%CP and 2.9Mcal. ME/Kg) (Table 1), and (2) Weeks 7 – 15 (20%CP and 2.9Mcal ME/Kg) (Table 2). Throughout the entire experiment feed and water were offered *ad libitum* on daily basis.

Three birds per dietary treatment were slaughtered at intervals of 21 days. So, there were four slaughters at $3^{rd}$, $6^{th}$, $9^{th}$ and $12^{th}$ week of experimental feeding, which corresponded to $6^{th}$, $9^{th}$, $12^{th}$ and $15^{th}$ week of age. The blood of the sacrificed birds was used for haematological studies including Packed Cell Volume (PCV), Red blood cells (RBC) count and Haemoglobin (Hb) determination. Some of the organs of the sacrificed birds were used for carcass characteristics and histopathlogical studies. The organs were weighed and examined grossly and histopathologically for any lesions arising from possible toxicity due to the dietary treatments. The organs examined were liver, spleen, kidney, heart and pancreas. They were preserved in formalin. The organs were fixed in 10% formal saline for a maximum of 24h, processed and infiltrated with paraffin wax. Sections (5 microns thick) were cut, stained with haematoxylin and eosin (H and E) and examined with the light microscope for pathological lesions.

Data collected on carcass characteristics and hematological conditions were subjected to analysis of variance (ANOVA) in CRD, and the Duncan's new multiple range test (DNMRT) was applied to partition means, where necessary (Duncan, 1955; Snedecor and Cochran, 1980; Gomez and Gomez, 1985), as packaged in the MSTATC (1993) computer software.

Table 1: Composition of the treatment diets containing different levels of raw *Mucuna cochinchinensis* fed at starter phase

| Ingredients | Treatment diets | | | | |
|---|---|---|---|---|---|
| | Control | 0.20% | 0.40% | 0.80% | 1.60% |
| *M. cochinchinensis, %* | - | 0.20 | 0.40 | 0.80 | 1.60 |
| Maize, % | 51.90 | 51.82 | 51.75 | 51.56 | 51.17 |
| Wheat offal, % | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Soybean meal, % | 33.00 | 32.88 | 32.75 | 32.54 | 32.13 |
| Fish meal, % | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Bone meal, % | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Oyster shell, % | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Salt, % | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Vit./Min. Premix* , % | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Calculated: | | | | | |
| Crude protein, % | 22.00 | 22.00 | 22.00 | 22.00 | 22.00 |
| ME (Mcal/Kg) | 2.90 | 2.90 | 2.90 | 2.90 | 2.90 |

1Kg of premix contains: Vitamin A (5,000,000 I.U.), Vitamin D3 (1,000,000 I.U.), Vitamin E (16,000mg), Vitamin K3 (800mg), Vitamin B1 (1,200mg), Vitamin B2 (22,000mg), Niacin (22,000mg), Calcium pantothenate (4,600mg), Vitamin B6 (2,000mg), Vitamin B12 (10mg), Folic acid (400mg), Biotin (32mg), Choline chloride (200,000mg), Manganese (48,000mg), Iron (40,000mg), Zinc (32,000mg), Copper (3,400mg), Iodine (600mg), Cobalt (120mg), Selenium (48mg), Anti-oxidant (48,000mg).

Table 2: Composition of the treatment-diets containing different levels of raw *Mucuna cochinchinensis* fed from 7th – 15th week of age

| Ingredients | Treatment diets | | | | |
|---|---|---|---|---|---|
| | Control | 0.20% | 0.40% | 0.80% | 1.60% |
| *M. cochinchinensis, %* | - | 0.20 | 0.40 | 0.80 | 1.60 |
| Maize, % | 55.65 | 55.57 | 55.50 | 55.31 | 54.92 |
| Wheat offal, % | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Soybean meal, % | 27.25 | 27.13 | 27.00 | 26.79 | 26.38 |
| Fish meal, % | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Bone meal, % | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Oyster shell, % | 1.50 | 1.50 | 1.50 | 1.50 | 1.50 |
| Salt, % | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Vit./Min. Premix* , % | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Calculated: | | | | | |
| Crude protein, % | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| ME (Mcal/Kg) | 2.90 | 2.90 | 2.90 | 2.90 | 2.90 |

1 Kg of premix contains: Vitamin A (5,000,000 I.U.), Vitamin D3 (1,000,000 I.U.), Vitamin E (16,000mg), Vitamin K3 (800mg), Vitamin B1 (1,200mg), Vitamin B2 (22,000mg), Niacin (22,000mg), Calcium pantothenate (4,600mg), Vitamin B6 (2,000mg), Vitamin B12 (10mg), Folic acid (400mg), Biotin (32mg), Choline chloride (200,000mg), Manganese (48,000mg), Iron (40,000mg), Zinc (32,000mg), Copper (3,400mg), Iodine (600mg), Cobalt (120mg), Selenium (48mg), Anti-oxidant (48,000mg).

## RESULTS AND DISCUSSION

### Carcass characteristics (Tables 3a-d)

Dressed weight percentages of birds were not significantly affected (P>0.05) by the inclusion levels at any of the slaughter stages. Also there were no significant (P>0.05) differences among the levels of inclusion at all the slaughter stages in the percent weights of most of the organs investigated. It was only in the liver that significant (P<0.05) differences were observed among treatment levels at first slaughter. The 16,000ppm diet depressed percentage weight of liver when compared with the 0ppm diet. The other inclusion levels did not produce any significant depression. Also, there were no significant depressions at subsequent slaughters.

The non-significant (P>0.05) dressed weight percentages of birds suggest that the inclusion of *M. cochinchinensis* beans did not affect relative meat yield of birds at any of the slaughter stages. The non-significant (P>0.05) differences in the organs investigated could also mean that none of the organs was a direct target organ of the toxic factors contained in the bean. It could also suggest that the inclusion levels of the beans in the diets of the broilers (even the 16,000ppm) did not produce the various toxic factors at high enough levels to cause morphological changes of the organs. The significant (P<0.05) differences observed in the liver leads to a suspicion that the liver might be a target organ of the toxic factors contained in the beans. This is expected since the liver is the primary organ responsible for metabolism of any toxic elements that have been absorbed into blood circulation. If complete detoxification of the toxic factor(s) takes place in this organ, they could get to other organs in less toxic or virulent form. Thus, they would place so less a demand on the functionality of these organs that their morphological integrity would not be interfered with. One of the toxic factors found to be contained in the *M. cochinchinensis* bean is haemagglutinin (Ukachukwu and Obioha, 1997) and liver is a target organ of this toxic component (Ikegwuonu and Bassir, 1976; Stead *et al*., 1966; Salgakar and Sohonie, 1965). The non-significant (P>0.05) depression of liver at slaughters 2 - 4 suggests that some inactivation of haemagglutinin by pepsin may have occurred (Liener and Rose, 1953), but that all the haemagglutinins could not be inactivated (Goddard and Mendel, 1929).

### Histopathological changes

Pathologic changes were observed only in the liver sections of broilers the selected from diets containing *Mucuna* beans. The lesions were similar at all levels and at every slaughter. A typical lesion is therefore, shown in plate 1. This reveals that diets containing raw *Mucuna* beans caused wild area of periportal necrosis with some mononuclear cell infiltration, while the centrilobular areas showed vacuolation and degeneration of hepatocytes. These observations contrasted with liver sections of broilers on the control (no mucuna) diet, which were devoid of histopathological changes (Plate 2). The severity of the lesions in the portal areas in all groups that fed on

diets containing *Mucuna* is related to its anatomical role as the focus of blood supply to the lobule through the hepatic portal vein from the gastro-intestinal, and hepatic artery from the aorta. Consequently, ingested toxic materials getting into the liver have contact first with hepatocytes in these areas. In line with the important function of the liver as an organ of detoxification, hepatocytes in the periportal areas suffer most from toxic insults. In this situation, toxic substances present in the *Mucuna* beans (especially haemagglutinins) must have been responsible for the histopathological changes found in the liver sections. The known deleterious effects of haemagglutinins include zonal necrosis of liver (Salgakar and Sohonie, 1965) and complete damage of the liver (Ikegwuonu and Bassir, 1976; Stead *et al.,* 1966).

Table 3. Effect of prolonged feeding of *Mucuna cochinchinensis* on the carcass characteristics of broiler chicks

| | TREATMENT | | | | | |
|---|---|---|---|---|---|---|
| Organ[#] | 0% | 0.20% | 0.40% | 0.80% | 1.60% | SEM |
| **a) First slaughter after 3 weeks of experimental feeding** | | | | | | |
| Dressed, % | 49.43(57.70) | 51.10 (59.21) | 49.98(58.61) | 49.03(56.98) | 50.66(59.78) | 1.88[ns] |
| Kidney,,% | 6.19 (1.14) | 5.67 (0.98) | 5.74 (0.99) | 5.85 (1.03) | 5.68 (0.98) | 0.18[ns] |
| Spleen, % | 2.30 (0.16) | 2.38 (0.17) | 2.19 (0.15) | 2.66 (0.22) | 2.23 (0.15) | 0.19[ns] |
| Liver, % | 11.01 (3.64[a]) | 10.52 (3.30[ab]) | 9.74 (3.28[ab]) | 10.40 (2.83[ab]) | 9.16 (2.52[b]) | 0.35* |
| Pancreas, % | 3.59 (0.39) | 3.48 (3.37) | 3.40 (0.35) | 3.74 (0.43) | 3.45 (0.37) | 0.26[ns] |
| Heart, % | 4.44 (0.60) | 4.53 (0.63) | 4.74 (0.68) | 4.69 (0.67) | 4.10 (0.51) | 0.21[ns] |
| Lungs, % | 5.27 (0.88) | 4.97 (0.75) | 4.42 (0.60) | 4.63 (0.65) | 4.76 (0.69) | 0.31[ns] |
| **b) Second slaughter after 6 weeks of experimental feeding** | | | | | | |
| Dressed, % | 55.62(68.10) | 54.60(66.46) | 54.48(66.25) | 54.31(65.99) | 55.02(67.06) | 0.90[ns] |
| Kidney, % | 5.20 (0.82) | 5.11(0.79) | 5.54 (0.95) | 4.74 (0.69) | 5.28 (0.85) | 0.27[ns] |
| Spleen, % | 2.42 (0.18) | 1.92 (0.11) | 2.18 (0.15) | 2.73 (0.23) | 2.58 (0.20) | 0.25[ns] |
| Liver, % | 8.45 (2.74) | 8.38 (2.27) | 9.46 (2.25) | 8.65 (2.16) | 8.65 (2.14) | 0.44[ns] |
| Pancreas, % | 2.94 (0.26) | 2.05 (0.28) | 2.95 (0.27) | 3.07 (0.29) | 3.03 (0.28) | 0.10[ns] |
| Heart, % | 4.10 (0.51) | 3.99 (0.49) | 4.12 (0.52) | 3.87 (0.46) | 3.83 (0.45) | 0.22[ns] |
| Lungs, % | 4.57 (0.64) | 4.58 (0.64) | 4.29 (0.56) | 4.16 (0.53) | 4.64 (0.66) | 0.16[ns] |
| **c) Third slaughter after 9 weeks of experimental feeding** | | | | | | |
| Dressed, % | 56.71(69.31) | 56.67(69.81) | 55.82(68.43) | 54.41(66.11) | 56.41(69.35) | 0.55[ns] |
| Kidney, % | 4.90 (0.73) | 5.07 (0.79) | 5.13 (0.80) | 4.84 (0.71) | 4.69 (0.67) | 0.18[ns] |
| Spleen, % | 2.19 (0.15) | 2.14 (0.14) | 2.26 (0.16) | 2.43 (0.18) | 1.81 (0.10) | 0.15[ns] |
| Liver, % | 8.40 (2.34) | 8.56 (2.24) | 8.51 (2.20) | 8.85 (2.13) | 8.26 (2.07) | 0.34[ns] |
| Pancreas, % | 2.77 (0.24) | 2.72 (0.23) | 2.98 (0.27) | 2.81 (0.24) | 2.90 (0.26) | 0.21[ns] |
| Heart, % | 3.90 (0.46) | 3.80 (0.44) | 3.87 (0.46) | 3.92 (0.47) | 3.92 (0.47) | 0.18[ns] |
| Lungs, % | 4.63 (0.66) | 4.21 (0.54) | 4.81 (0.70) | 4.31 (0.57) | 4.26 (0.55) | 0.47[ns] |
| **d) Fourth slaughter after 12 weeks of experimental feeding** | | | | | | |
| Dressed, % | 54.88(66.85) | 55.49(67.85) | 54.67(66.52) | 55.25(67.52) | 56.99(70.29) | 1.29[ns] |
| Kidney, % | 5.09 (1.10) | 4.73 (0.70) | 4.71 (0.70) | 4.59 (0.60) | 4.79 (0.70) | 0.24[ns] |
| Spleen, % | 2.40 (0.18) | 3.39 (0.41) | 2.72 (0.23) | 2.07 (0.13) | 2.12 (0.14) | 0.48[ns] |
| Liver, % | 8.52 (2.18) | 8.39 (2.12) | 8.10 (2.00) | 7.33 (1.73) | 7.54 (1.63) | 0.37[ns] |
| Pancreas, % | 2.96 (0.27) | 2.87 (0.25) | 2.94 (0.27) | 2.45 (0.18) | 2.43 (0.18) | 0.19[ns] |
| Heart, % | 3.62 (0.40) | 3.90 (0.46) | 3.78 (0.44) | 3.96 (0.48) | 4.01 (0.49) | 0.20[ns] |
| Lungs, % | 4.13 (0.52) | 4.23 (0.55) | 4.90 (0.76) | 4.64 (0.67) | 3.94 (0.48) | 0.22[ns] |

[*] Means on the same row followed by the same superscript are significantly the same at * ($P<0.05$) or ** ($P<0.01$)

[#] All expressed as percentage of liveweight of chicks

Note: Figures in parentheses are the untransformed or original figures while the ones outside the parentheses are the transformed figures using the Arc Sine Transformation method.

**Hematological conditions (Table 4a-d)**

At first slaughter only the 16g/kg diet caused significant ($P<0.01$) reduction of red blood cells (RBC). At subsequent slaughters inclusions of *M. cochinchinensis* beans even at 2g/kg caused significant ($P<0.01$) reductions of both RBC and packed cell volume (PCV) of blood. They also caused reduction in the quantity of hemoglobin (Hb) though the reduction was significant ($P<0.01$) only at the second slaughter.

The hematological picture suggests that haemagglutinin could be implicated. The raw *M.*

*cochinchinensis* has earlier been found to have hemagglutinating activity of up to 4267 HU/g (Ukachukwu and Obioha, 1997). Ologhobo *et al.* (1993) reported localization of haemagglutinin in a base soluble protein fraction of lima bean. They fed the base soluble protein fraction to broilers and observed consistent reduction of RBC and Hb in the birds. They concluded that this suggests the direct involvement of haemagglutinins.

Table 4: Chromic toxicity effect of raw *Mucuna cochinchinensis* on the haematological conditions of broilers

| Parameter | TREATMENT 0% | 0.20% | 0.40% | 0.80% | 1.60% | SEM |
|---|---|---|---|---|---|---|
| **a) First slaughter after 3 weeks of experimental feeding** | | | | | | |
| PCV, % | 35.66 (34) | 36.42 (35) | 34.64 (32) | 34.84 (33) | 35.44 (34) | $1.47^{ns}$ |
| Hb, g/100ml | 11.33 | 11.77 | 10.77 10.90 | 11.17 | $0.81^{ns}$ | |
| RBC ($x10^3$) | $243^a$ | $227^a$ | $227^a$ | $224^a$ | $120^b$ | 7.20** |
| **b) Second slaughter after 6 weeks of experimental feeding** | | | | | | |
| PCV, % | 40.78 ($42.70^a$) | 34.85 ($32.70^b$) | 34.65 ($32.3^b$) | 34.24 ($31.70^b$) | 33.21 ($30.00^b$) | $0.74^{ns}$ |
| Hb, g/100ml | $14.2^a$ | $10.87^b$ | $10.40^b$ $10.20^b$ | $9.97^b$ | 0.39** | |
| RBC ($x10^3$) | $296^a$ | $227^b$ | $219^b$ $217^b$ | $152^c$ | 7.67** | |
| **c) Third slaughter after 9 weeks of experimental feeding** | | | | | | |
| PCV, % | 39.43 ($40^a$) | 36.25 ($35^{ab}$) | 35.26 ($33^b$) | 35.06 ($33^b$) | 35.45 ($32^b$) | 0.72** |
| Hb, g/100ml | 12.30 | 11.67 | 11.10 11.07 | 10.63 | $0.54^{ns}$ | |
| RBC ($x10^3$) | $298^a$ | $258^b$ | $239^{bc}$ $230^c$ | $222^c$ | 5.75** | |
| **d) Fourth slaughter after 12 weeks of experimental feeding** | | | | | | |
| PCV, % | 39.43 ($40^a$) | 36.67 ($36^b$) | 35.46 ($34^{bc}$) | 35.06 ($33^{bc}$) | 33.41 ($30^c$) | 0.52** |
| Hb, g/100ml | 12.60 | 11.83 | 11.40 11.20 | 10.30 | $0.42^{ns}$ | |
| RBC ($x10^3$) | $296^a$ | $227^b$ | $219^b$ $217^b$ | $152^c$ | 7.67** | |

* Means on the same row followed by the same superscript are significantly the same at * ($P<0.05$) or ** ($P<0.01$)

Note: Figures in parentheses are the untransformed or original figures while the ones outside the parentheses are the transformed figures using the Arc Sine Transformation method.

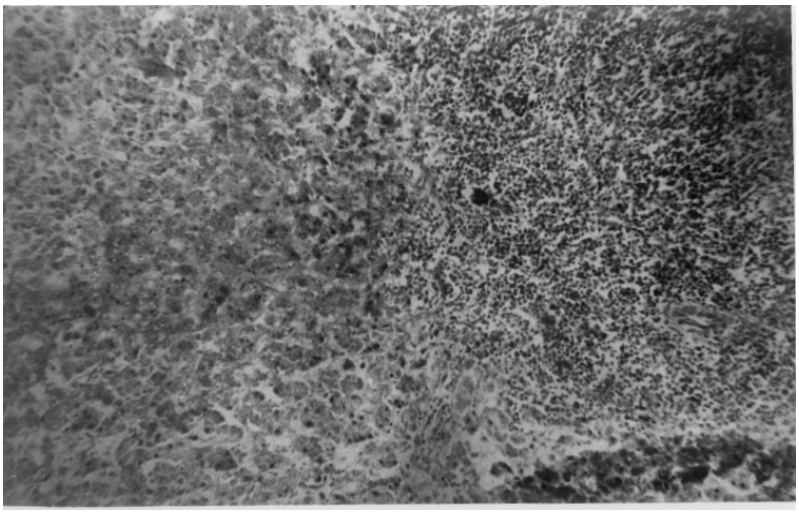

Plate 1: Liver section of broiler fed diet containing raw *Mucuna* (RMD). Note wild area of periportal hepatocytes necrosis (right) and centrilobular zone of hepatocytes degeneration (left). H and E stain, x320.

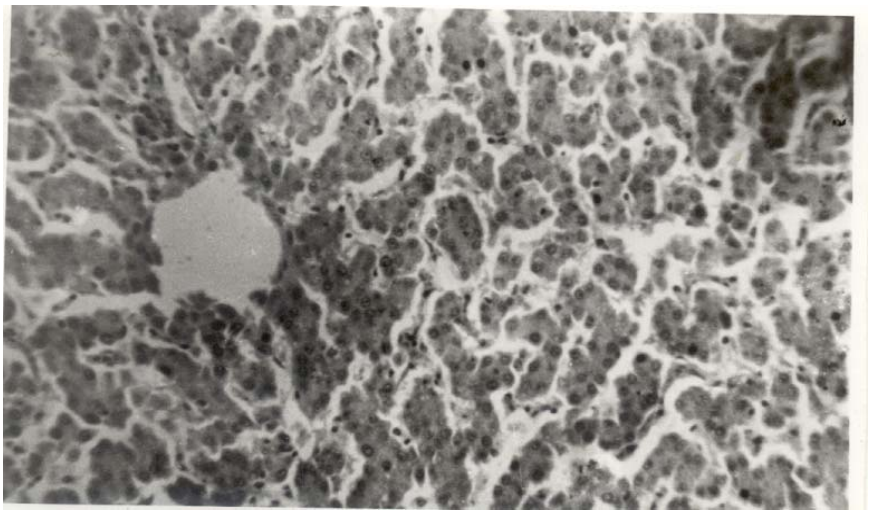

Plate 2: Liver section of broiler fed diet containing no *Mucuna* (NMD).
Note normal lobular architecture, hepatocytes and sinusoids. H and E stain, x320.

**ACKNOWLEDGEMENT**

The authors acknowledge the International Foundation for Science for funding the research.

**REFERENCES**

Anumnu, A.I. 1990. Isolation, characterization and toxicity studies of *Mucuna flagellipes* Hemagglutinin. MSc Thesis. University of Nigeria, Nsukka.

Arnold, J. B., Summers, J. D. and Bilanski, W. K. 1971. Nutritional Value of Heat Treated Whole *Soybean*s. Canadian Journal of Animal Science 51:57-65.

Balogun, A. M. and Fetuga, B. L. 1989. Anti-nutritional components in some lesser-known leguminous crop seeds in Nigeria. Biological Wastes. 28: 303-308.

Borchers, R.; L. D. Mange; S.O. Nelson and L. E. Stetson. 1972. Rapid improvement of raw soyabeans by dielectric heating. Journal of Food Science 37:333.

Bort, K. S. 1909. The Florida Velvet bean and its history, U. S. Dept. Agric., Bur. Pl. Ind. Bull. 14 (3): 25-32.

Carew, L. B., Valverde, M. T., Zakrzewska, E. I. and Alster, F. A. 2002. Raw velvet beans (*Mucuna pruriens)* and L-Dopa have differing effects on organ growth and blood chemistry when fed to chickens. In Milton Flores B., M. Eilitta, R. Myhrman, L. B. Carew and R. J. Carsky (Eds.). Proceeding of International Workshop on Food and Feed from *Mucuna*: Current Uses and the Way Forward. Held in Tegucigalpa, Hondiras, April 26-29, 2000. CIDICCO, Honduras. 272-287.

Church, D. C. and Pond, W. G. 1974. Basic Animal Nutrition and Feeding. O & B Books, U. S. A.

Del Carmen, J., Gernat, A. G., Myhrnan, R. and Carew, L. B. 2002. Evaluation of raw and heated velvet beans (*Mucuna pruriens)* as feed ingredients for broilers. In Milton Flores B., M. Eilitta, R. Myhrman, L. B. Carew and R. J. Carsky (Eds.). Proceeding of International Workshop on Food and Feed from *Mucuna*: Current Uses and the Way Forward. Held in Tegucigalpa, Hondiras, April 26-29, 2000. CIDICCO, Honduras. 258-271.

Duke J. A 1981 Handbook of legumes of world economic importance Plenum Press, New York. pp. 170 - 173.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11: 1-42.

Flores, L., Esnaola, M. A. and Myhrman, R. 2002. Growth of pigs fed diets with *Mucuna* bean flour (*Mucuna pruriens*) compared to soyabean meal. In Milton Flores B., M. Eilitta, R. Myhrman, L. B. Carew and R. J. Carsky (Eds.). Proceeding of International Workshop on Food and Feed from *Mucuna*: Current

Uses and the Way Forward. Held in Tegucigalpa, Hondiras, April 26-29, 2000. CIDICCO, Honduras. 288-303.

Goddard, V. R. and Mendel, L. B. 1929. Journal of Biochemistry, 82: 447-463. As cited by Liener, I. E. (1974). In Journal of Agricultural and Food Chemistry. 22:17-22.

Gomez, K. A. and A. A. Gomez 1985. Statistical Procedure for Agricultural Research (2nd Edition). John Wiley and Sons. New York.

Gustafson, M. A., Jr., C. J. Flegal and P.J. Schaible 1971. The effects of microwave heating on the properties of raw unextracted soyabeans for utilization by the chick. Poultry Science. 50:35

Hashim, Z. and Idrus, A. Z. 1977. Utilization of Lyon's bean (*Mucuna cochinchinensis)* as feeding stuff. Proc. on Feedingstuff for livestock in South-East Asia pp. 154 - 157.

Hutchinson, J. and Dalziel, J. M. 1954. Flora of West Tropical Africa. Crowns Agents for Overseas Government and Administrations, London. p. 562

IFSP 1988. Integrated farming Systems Programme. Soyabean Recipes. Institute of Agricultural Research and Training, Moor Plantation, Ibadan.

Ikegwuonu, I. E. and Bassir, O. 1976. Effects of Phytohemagglutinins fromimmature legume seeds on the function and enzyme activities of the liver and on the histopathological changes of some organs of the rat. Toxicology and Applied Pharmacology. 40: 217 - 226.

Liener, I. E.and Rose, J. E. 1953. Soyin, a toxic protein from the Soyban. III Immunochemical properties. Proc. Soc. Exp. Biol. Med., 83:539.

Lloyd, L. E.; McDonald, B. E. and Crampton, E. W. 1978. Fundamentals of Nutrition. (2nd ed.). W. H. Freeman and Company, San Francisco.

MSTAT-C 1993. Software program for the design, management, and analysis of agronomic research experiments. Michigan State University, USA.

Nelson, A. I., Steinberg, M. P. and Wei, L. S. 1978. Development of Whole Soyaban food for Home Use: Rationale, Concept and Examples. International *Soybean* Programme (INTSOY), College of Agriculture, University of Illionis, 113 Mumford Hall. Urban, Illionis. 61801, U. S. A.

Oke, D. B., Fetuga, B. L. and Tewe, O. O. 1996. Effect of autoclaving on the anti-nutritional factors of cowpea varieties. Nigerian Journal of Animal Production. 23(1): 33-38

Ologhobo, A. D. 1992. Nutritive values of some tropical (West African) legumes for poultry. Journal of Applied Animal Research. 2: 93-104.

Ologhobo, A. D., Apata, D. F., Oyejide, A. and Akinpelu, R. O. 1993. Toxicity of raw lima beans (*Phaseolus lunatus*) and lima beans fractions for growing chicks. British Poultry Science. 34: 505-522.

Ologhobo, A. D., Apata, D. F., Oyejide, A. and Akinpelu, R. O. 1993. A comparison of protein fractions prepared from lima beans (Phaseolus lunatus) in starter diets for broiler chicks. Journal of Applied Animal Research. 4 : 13-30.

Olomu, J. M. 1995. Monogastric Animal Nutrition: Principles and Practice. JACHEM Publishers, Benin City, Nigeria.

Oyenuga, V. A. 1968. Nigeria's Food and Feedings Stuffs. Ibadan University Press, Ibadan University Press, Ibadan. Pp. 62-63.

Piper, C. V. and Tracy S. M. 1910. The Florida velvet bean and related plants. US Dep. Agric. Bur. Pl. Sci. Bull 179: 1-26.

Raghavan, G. S.; Vijaya, J.; Harper, M.and Kienholz, E. W. 1974. Nutritive value of salt bed roasted soyabeans for broiler chicks. Poultry Science. 53:547-553.

Salgakar, R. S. and Sohonie, K. 1965. Hemagglutinins of Fieldbean, (*Dolichos lablab):* Part II - Effect of feeding field bean hemagglutinin A on rat growth. Indian Journal of Biochemistry. 2:197.

Snedecor, G. W. and W. G. Cochran. 1980. Statitical Methods (7th Edition). The Iowa State University Press, Ames., Iowa, U. S. A..

Stead, R. H., De Muelenaere, H. J. h. and Quicke, G. V. 1966. Trypsin inhibition, hemagglutination and Intraperitoneal toxicity of *Phaseolus vulagaris* and *Glycine max.* Arch. Biochem Biophys. 113: 703-708.

Steel, R. G. D. and Torrie, J. H. 1980. Principles and procedures of statistics: A biometrical approach.2nd Edition. McGraw-Hill Book Company, Inc. New York.

Udedibie, A. B. I.; Esonu , B. O.; Unachukwu, C. and Iwuoha, N.C. 1996. Two-stage cooking as a method of improving the nutritive value of jackbean (*Canavalia ensiformis*) for broilers. Nigerian Journal of Animal Production. 23: 107-110.

Udedibie, A. B. I. And Nwaiwu, J. 1987. The potential of Jackbean (*C. ensiformis*) as animal feed. Nigerian Agricultural Journal. *23: 130-143.*

Ukachukwu, S. N. and Obioha, F. C. 1997. Chemical evaluation of *Mucuna cochinchinensis* as alternative protein feedstuff. Journal Applied Chemistry and Agricultural Research. 4: 33-38.

Ukachukwu, S. N. and Obioha, F. C. 2000. Effect of time duration of thermal treatments on the nutritive value of *Mucuna cochinchinensis*. Global Journal of Pure and Applied Science. 6(1):11-15.

Ukachukwu, S. N., Obioha, F. C. and Amechi, N.(1999. Toxicity of raw *Mucuna cochinchinensis* extracts on broiler chicks. Journal of Sustainable Agriculture and Environment 1:123-126.

Ukachukwu, S.N. 2000. Chemical and nutritional evaluation of *Mucuna cochinchinensis* (Lyon's Bean) as an alternative protein ingredient in broiler diets (Ph.D. Thesis, Univ. of Nigeria, Nsukka).

Waldroup, P.W. and Hazen, K.R. 1978 An evaluation of roasted, extruded and raw unextracted soyabeans in the diet of laying hens. Nutrition Reports International. 18:99.

*Submitted 6 November 2002 – Accepted 11 March, 2003*