THE INFLUENCE OF ALLELOCHEMICALS OF PRIDE OF BARBADOS *(Caesalpina pulcherrima)* SEEDS IN NUTRITION OF SWINE

Annongu, A. A.
Faculty of Agriculture, University of Ilorin
Ilorin, Kwara State, Nigeria.
E-mail: azorann@yahoo.com

Toye A . A.
[1]Faculty of Agriculture, University of Ilorin
Ilorin, Kwara State, Nigeria.
[2]Causal Genetics Institute (CGENI), Causal Genetics Ltd., United Kingdom

Ogunbode, A. A.
Faculty of Agriculture, University of Ilorin
Ilorin, Kwara State, Nigeria.

ABSTRACT

Investigations into the influence of allelochemicals of Pride of Barbados (Caesalpina pulcherrima) seed meal (PBSM) processed by traditional and chemical methods and using weaner pigs was conducted. 20-pigs weighing an average of 3.7kg were fed diets made of a corn-soy reference diet and diets with 5, 10 15 and 20% inclusion of PBSM in a one way ANOVA using completely randomized design model. The feeding trial lasted a month while the experimental animals were offered feed and water ad libitum. Results on quantitative analysis of phenolic compounds in the virgin and treated seed samples showed that raw seed meal contained 0.708% tannins while boiled, boiled and fermented, boiled-fermented poluvinyl pyrrolidone (PVP) treated gave 0.534, 0.406 and 0.360% tannin content respectively. Treated PBSM in diets did not influence performance characteristics and 100% survival rate was recorded on both the control and test diets. Biochemical indices were ascending and descending in values due to increasing levels of dietary content of PBSM. Processing PBSM had no deleterious effects on the pigs' electrolyte balance except on K^+ which the significant difference was on the positive side. Summarily, treating PBSM as described and including in diets up to 20% level produced diets comparable in nutritional value with the conventional diet.

Keywords: *Allelochemicals, pride of barbados seeds, Caesalpina pulcherrima, nutrition, swine*

INTRODUCTION

There is need for greater utilization of the relatively neglected leguminous seeds particularly the *Caesalpina pulcherrima spp* that abound in abundance in our locality for feed formulation in order to reduce the escalating cost of monogastric animal production. The protein intake in most developing countries among which Nigeria is one, is very low due to the high cost of production of the simple stomached animals that depend on similar orthodox foodstuffs used as staple food by mankind. In order to have a fast means of protein supply in abundance, the pig industry like that of poultry must be developed. However, this panaceae has often been constrained due to the cost of feeds which accounts for 50-75% of swine production (Fetuga, Babatunde and Oyenuga, 1984). It is due to the above reasons that nutritionists are researching to discover new feeding materials to increase livestock production. Investigation on the alternative use of Pride of Barbados seeds in place of soybeans, groundnuts cakes in this study is part of such efforts.

Pride of Barbados *(Caesalpina pulcherrima)*, PB is a novel legume and like all legumes, may be an important source of plant protein, lipids, vitamins and minerals. Although the nutritional value of legumes is of great importance, intake of most like the unconventional PB seeds is not as expected (Ahmed, Hamed, Mohammed, Amro and El-fadil 2006). This is because the use of most legumes in diets for man and animals is restricted by the presence of toxic factors. Preliminary works (Ihekoronye and Ngoddy, 1985; Osagie, 1998) reported that PB seeds contain biologically active chemicals such as lectins, vanadium, oxalate, trypsin inhibitors, phytate, hydrocyanides and polyphenols. Some of these toxicants interfere with digestive processes preventing efficient utilization of legume nutrients. Mature seeds of PB are inedible due to toxins.

Only the immature fresh seeds and the extra-cotyledonous deposit are consumed by children and sometimes adults in certain parts of Nigeria (Prohp et al., 2004). Toxicity is due to the preponderance of tannins which when ingested direct, causes symptoms like nausea, vomiting and diarrhoea (Russel, Hardin, Grand and Traser, 1997). The presence of the myriad of chemicals in PB also makes it a distinctive great medicinal plant used against bacteria, fungi, Usilage maydis (Khan, Nddaalio, Nkunja, Weavers and Sawhney, 1980; Singh and Pattak, 1994). It is also used as a purgative, for fever, bronchitis and for abortion due to its garlic acid, tannins and hydrocyanic acids. Despite the presence of the numerous anti-nutrients, processing techniques involving traditional and chemical are attempted in this study to improve the nutritive value of PB seeds and render it acceptable by the pigs.

MATERIALS AND METHODS

Ripened pods of PB collected within Ilorin Metropolis between October and November had the seeds removed. The seeds weighing over 70kg were pulverized to increase the surface area then soaked and boiled for 90minutes before subjecting to industrial fermentation as described by Annongu, Meulen, Atteh and Apata (1996). Soaking and boiling prior to fermentation were to leach out soluble tannins and other phytochemicals in PB as first step in detoxification. The fermented meal, after sun-drying, was treated with polyvinyl pyrrolidone (PVP) for further chemical detoxification.

Twenty weaner pigs weighing an average of 3.7kg were used for the trial. They were housed in a pen and randomly allotted to five iso-nitrogenous, iso-caloric diets, each diet containing four pigs per dietary treatment. The experiment was in a completely randomized design involving the five treatments which represented the five diets with 0.00, 5.00, 10.00, 15.00 and 20.00% inclusion levels of the processed

Pride of barbados seed meal (PBSM). The pigs were fed twice daily at 8.00 and 16.00hours over a feeding period that lasted for one month. The composition of the experimental diets as fed basis is shown on Table 1. The animals were allowed free access to feed and water.

In the course of the feeding trial, data were recorded on performance characteristics. At the end of the experiment, blood samples were collected from replicates on all the treatments via ear vein puncture using syringe and needle. Whole blood was collected in EDTA treated bottles while samples for sera were allowed to clot then centrifuged to obtain clear sera in test tubes. Sera samples were for determination of serum biochemical parameters namely serum total protein, albumin, globulin, cholesterol and the metabolites, blood urea nitrogen and creatinine excretion. The whole blood samples were used for the analyses of electrolytes, Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), Hydrogen Carbonate (HCO_3^-), Calcium (Ca^+) and Phosphorus (P).

The raw PBSM and the experimental diets were analyzed for proximate composition for dry matter, organic matter, crude fibre, total mineral content, ether extract according to the methods described by AOAC (1990). Nitrogen was determined by the micro-kjedahl method as modified by Concon and Diane (1973) and the nitrogen content was converted to crude protein by multiplying by the factor 6.25 (Jeanette, 1987). All proximate results were expressed as percentage of sample analyzed. Quantitative determination of condensed tannins was carried out according to the procedures of El-Olemy, Al-Mutadi and Abdel-Fattach (1994) and Okwu and Iroabuchi (2004). Serum constituents were determined by the methods of Singh (1990) while mineral elements analysis was carried out thus: Na and K were determined using the standard flame emission photometer employing Sodium Cloride (NaCl) and Potasium Chloride (KCl) to prepare the standards (AOAC, 1990). P was determined colorimetrically using the spectronic 20 (Gallencamp, UK) as described by Pearson (1976) with KH_2PO_4 as the standard. Ca was determined using Atomic Absorption spectrophotometer AAS Model SP 9. Values are expressed in mmol/L. Data collected was analyzed by one way analysis of variance using the completely randomized design model, SPSS 1999 version and treatment means were compared using Duncan multiple range test at 5% level of probability (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Table 2 presents data on the effects of processing on the tannin content in PBSM. Tannin content of raw PBSM was found to be 0.708g while boiled seed meal gave 0.534g. Boiling coupled with fermentation reduced the tannic content to 0.406g while addition of PVP to the boiled and fermented PBSM further decreased the condensed tannins to 0.360g. The performance characteristics of weaner pigs fed treated PBSM in diets are shown on table 3. Group of pigs fed the control diet, 1 and the diet with the highest inclusion of PBSM, diet 5 had the highest feed consumption. There was no significant difference in weight gain of pigs offered the control and test feedstuff diets. Feed efficiency followed the trend similar to that on the weight gain since no significant difference was observed. Survival rate of 100% was recorded on both the control and diets containing the test feedstuff and no ill-effect was observed on the animals' phenotypic appearance.

Table 4 shows data on the influence of feeding treated PBSM in diets on some serum constituents in pigs. There were significant differences in all the measured parameters. The levels of serum total protein and albumin appeared to increase with increasing quantity of dietary content of PBSM, while the concentration of globulin and cholesterol showed some variations among the treatment groups. The metabolites, Blood Urea Nitrogen (BUN) and creatinine presented reverse results as recorded on total protein and albumin levels. The effect of treated PBSM in diets on blood electrolyte balance is given on table 5. There were no significant differences in levels of Sodium, Chloride, Hydrogen Carbonate, Calcium and Phosphorus except Potassium.

Quantitative analysis of tannin content in raw and treated PBSM samples showed that tannin content of raw PBSM was 0.708g. boiling and fermentation reduced the tannin level to 0.534 and 0.403g respectively. Similar results of reduction in soluble toxic chemicals were reported when test material was soaked in water for different time intervals (Ahmed, Hamed, Mohammed, Amro and El-fadil, 2006), indicating the leaching effect of water on the soluble allelochemicals. The reduction in tannin content to 0.360g following addition of the chemical PVP to the boiled-fermented PBSM demonstrated the efficacy of this chemical in detoxifying tannins. The mode of action of the artificial water soluble polymers like PVP, PVPP or PEG in binding tannins is thought to be in their content of large number of oxygen atoms which are capable of forming hydrogen bonds with the phenolic groups in tannins thereby precipitating them from solutions (Jones, 1965). This action of tannin-binding has recently renewed the interest of researchers in the application of the polymers for neutralizing the negative effects of such phenolic compounds in animal feeds and feedstuffs.

Performance data showed that daily feed intake on both the reference and test diets appeared comparable except for that on diet 4 which showed some variations. The insignificant differences in average daily weight gain and feed conversion ratio also serve to explain that the nutritive value of the control diet and diets containing treated PBSM are comparable. Similarly, the 100% survival rate recorded on the conventional and diets with treated PBSM suggest that treated test feedstuff in diets is as good as or even better than the conventional feedstuff (for instance compare feed intake and weight gain of 553.58 and 223.22 on the control diet with 580.36 and 256.25g on the diet containing 20% treated PBSM that is, diet 5).

The serum biochemical indices of total protein, albumin, globulin, cholesterol and the metabolites, BUN and serum creatinine were influenced by dietary PBSM. Serum total protein and albumin values increased with increasing levels of PBSM in diets while those of globulin and cholesterol decreased with increasing levels of the treated diet of PBSM. The higher serum total protein and albumin values obtained on some diets (3 & 4) was contrary to the observations of past works (Akinola and Abiola, 1999) who noted that serum protein and albumin values of cockerels decreased with increase in dietary melon husk due to the high dietary fibre which reduced the protein utilization in the diets fed. Results obtained in this study on serum protein and albumin were contrary to those of the reported authors above probably because the test feedstuff used in our study though high in fibre, was subjected to boiling and fermentation treatments prior to incorporation in diets which reduced the fibre level hence industrial fermentation has been shown to reduce the fibre content of fibrous feed materials (Annongu, Meulen, Atteh and Apata, 1996).

The low values recorded on serum urea and creatinine excretion on diets containing treated PBSM suggested that the test feedstuff had little or no ill-effect on the protein metabolism in the experimental animals (Eggum, Thorbek, Beames, Chuwa and Henekel, 1982). Blood cholesterol level on the diet containing the highest level of 20% treated PBSM, diet 5, was high compared with the other PBSM based diets which could be attributable to the increase in the dietary oil content of the diet since Pollmann, Damielson and Peo (1979) noted that high dietary oil leads to high serum cholesterol level in swine.

Treated dietary PBSM produced no adverse effects on the electrolyte balance of the pigs. Values of $Na,^{+}$ $Ca,^{+}$ P or $Cl,^{-}$ and HCO_3^{-} obtained on diets with PBSM were similar to the ones on the conventional diet. The significant difference recorded on potassium (K^{+}) was rather positive since group of pigs maintained on the 20% PBSM based diet contained more potassium. Result on electrolyte balance of the pigs obtained in this experiment tallied with the approximate reference or normal ranges reported by Monica (1987). It could therefore not be completely out of place to submit that the pride of Barbados seeds might be helpful for proper maintenance of electrolyte balance in the blood of the fed animals. Proper maintenance of blood electrolytes would rule out the occurrence of some disease conditions associated with electrolyte imbalance such as hyponatremia/hypernatremia; hypokalaemia/hyperkalaemia; hypochloremia/hyperchloremia; alkalosis/acidosis; hypomagnesia linked to low Ca_2^{+} level; low $K,^{+}$ diabetes and dialysis (Ganong, 1987), azotemia diseases or damage of the kidneys (Adroge and Madias, 2000; Morton and Charles, 1980; Cohn, 2000; Sheng, 2000; Nakamura et al., 1999).

CONCLUSION

Study on the influence of allelochemicals of Pride of Barbados *(Caesalpina pulcherrima)* seed meal, PBSM processed by traditional and chemical methods and using weaner pigs was conducted. Results on quantitative analysis of phenolic compounds in the virgin and treated seed samples showed that raw seed meal contained 0.708% tannins while boiled, boiled and fermented, boiled-fermented-PVP treated gave 0.534, 0.406 and 0.360% tannin content respectively. Processing PBSM had no deleterious effects on the pigs' electrolyte balance as $p > 0.05$ except on K^+ which the significant difference was on the positive side ($p < 0.05$). Therefore, processing PBSM as described in this work could detoxify it and it may for a useful alternative protein feedstuff in nutrition of monogastric animals like pigs.

Table 1: Composition of the experimental diets on as fed basis (%)

Diets Ingredients	1	2	3	4	5
Maize	55.00	52.00	50.00	48.00	45.00
Soybean meal	38.50	36.00	33.00	30.00	28.00
PBSM	0.00	5.00	10.00	15.00	20.00
PVP	0.00	0.50	0.50	0.50	0.50
Lysine	1.50	1.50	1.50	1.50	1.50
DL-methionine	1.50	1.50	1.50	1.50	1.50
Bone meal	2.00	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.20	0.20	0.20	0.20	0.20
Vit.min.premix	0.15	0.15	0.15	0.15	0.15
Antimicrobial premix	0.15	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00	100.00
Analyzed content of diets					
Dry matter	92.55	90.92	90.76	93.69	91.58
Crude protein	19.00	23.200	23.80	20.00	23.50
Ether extract	1.98	1.74	1.67	1.27	2.01
Total ash	5.63	7.63	8.43	5.65	10.99
Crude fibre	8.25	7.81	7.05	9.10	7.15
Gross energy Kcal/kg	4.36	4.33	4.32	4.34	4.30

Raw PBSM proximate composition: *Dry matter, 88.26; Crude protein, 29.10; Crude fibre, 12.05, Total ash, 4.89; Ether extract, 5.38.*

PBSM, Pride of Barbados Seed Meal.

PVP, Polyvinyl pyrrolidone

Anti-microbial premix, Furazolidone.

Source: Experimentation, 2010

Table 2: Effects of processing on tannin content in PBSM

Samples	Weight (g)
Raw PBSM	0.708
Boiled PBSM	0.534
Boiled and fermented PBSM	0.406
Boiled-fermented and PVP treated	0.360

Source: Experimentation, 2010

Table 3: Performance characteristics of weaner pigs fed the experimental diets

Diets	1	2	3	4	5	SEM
Parameters						
Mean daily feed intake (g/p/d)	553.58^{a}	517.86^{ab}	517.86^{ab}	489.29^{b}	580.36^{a*}	16.32
Mean daily weight gain (g/p/d)	223.22	258.93	228.58	229.58	256.25*NS*	24.26
Feed efficiency (F/G)	2.52	2.01	2.28	2.16	2.27*NS*	0.21
Survival rate (%)	100.00	100.00	100.00	100.00	100.00	

a-b means in rows not sharing common superscripts differed significantly (p < 0.05)

NS, no significant difference.

Table 4: Effects of feeding treated PBSM in diets on some serum constituents in pigs.

Diets	1	2	3	4	5	SEM
Parameters						
Total protein (g/l)	58.50^{b}	51.00^{b}	81.50A	62.00^{a}	56.00^{b}	5.49
Serum albumin (g/l)	27.50^{b}	39.50^{ab}	45.00^{a}	42.50^{ab}	38.00^{b}	3.85
Serum globulin (g/l)	31.00^{a}	11.50^{b}	38.50^{a}	19.50^{b}	18.00^{b}	2.42
Blood urea nitrogen (mmol/l)	4.75^{a}	2.90^{b}	3.10^{ab}	3.00^{ab}	2.55^{b}	0.46
Creatinine (mmol/l)	4.85^{a}	30.50^{b}	30.00^{b}	23.00^{b}	25.00^{b}	2.49
Cholesterol (mmol/l)	2.00^{a}	1.50^{b}	1.70^{ab}	1.75^{ab}	2.00^{a}	0.10

a-b means in rows not sharing common letters are significantly different.

Table 5: Effects of feeding dietary processed PBSM on electrolyte balance in weaner Pigs (mmol/l)

Diets Indices	1	2	3	4	5	SEM
Sodium	137.00	137.00	133.00	134.00	125.50NS	2.97
Potassium	5.05b	10.05b	10.20b	7.20b	17.95a*	1.64
Chloride	81.50	72.50	78.50	73.00	82.50 NS	3.38
Hydrogen carbonate	17.00	18.50	18.50	19.00	19.00 NS	0.96
Calcium	2.15	2.23	2.28	2.20	2.25 NS	0.07
Phosphorus	1.05	1.20	1.25	1.40	0.85 NS	0.20

a-b means in the row not sharing common superscripts differed significantly.

REFERENCES

Adroge, H. J. and **Madias, N. E.** (2000). Hyponatremia. *Northern England Journal of Medicine*, 342, 1581-1589.

Ahmed, M. B., Hamed, A. R., Mohammed, E. A., Amro, B. H. and **El-fadil, E. B.** (2006). Proximate composition, antinutritional factors and protein fractions of guar gum seeds as influenced by processing treatments. *Pakistan Journal of Nutrition*, 5, 481-484.

Akinola, S. O. and **Abiola, S. S.** (1999). Blood chemistry and carcass yield of cockerels fed melon husk diets. *Tropical Journal of Animal Science*, 2 (2), 39-44.

Annongu, A. A., Meulen U. Ter, Atteh J. O. and **Apata D. F.** (1996). Toxikologische beurteilung von nativem und industriell fermentiertem schibutter-Oekuchen fuer die Fuetterung von Broilern. *Arch. Gefluegelk.* 60 (5), 221-226.

AOAC (1990). *Official methods of analysis* (14th ed). Washington D. C.: Association of Official Analytical Chemists

Cohn, J. N. (2000). New Guidelines for Potassium Replacement in Clinical Practice. A Contemporary Review by the National Council on Potassium in Clinical Practice. *Arch. Int. Medicine*, 160, 29-36.

Concon, M. and **Diane, V. J.** (1973). *Analysis of Protein and Amino acids*. London: Oxford University Press

Eggum B. O., Thorbek L., Beames R. M., Chuwa L. and **Henekel S.** (1982). Influence of diet and microbial activity in the digestive tract on digestibility and nitrogen and energy metabolism in rats and pigs. *Poultry Journal of Nutrition*, 48: 161-165.

El-Olemy, M. M., Al-Mutadi, F. J. and **Abdel-Fattach, A. A.** (1994). Experimental phytochemistry. A Laboratory Manual. College of Pharmacy, King Saud University. Pp. 51-53.

Fetuga, B. L., Babatunde, G. M. and **Oyenuga, V. A.** (1984). Nutritional value of cereal and cassava diet for growing and fattening pigs in Nigeria. *Journal of Science, Food and Agriculture*, 24, 1515-1523.

Ganong, W. F. (1987). *Hypermagnesia*. In *Review of Medical Physiology.* USA: Prentice Hall International Inc. 253.

Ihekoronye, A. and **Ngoddy, P.** (1985). *Proteins: Food quality control*. In *Integrated Food Sciences and Technology* (3rd ed). London: Macmillian Publishers, 28, 155-193.

Jeanette, E. (1987). Sorghum Quality Laboratory Manual for Use in West Africa.

Jones, D. E. (1965). Banana tannin and its reaction with polyethylene glycol. *Nature,* 206, 299-300.

Khan, M. R., Nddaalio, G., Nkunja, M. H., Weavers, H. and **Sawhney, A. N.** (1980). Studies on the African medicinal plants part 1. Preliminary screening of medicinal plants for anti-fungal activity. *Plant Medical Suppliment,* 40, 91-92.

Monica, C. (1987). *Electrolytes.* In *Medicinal laboratory Manual for Tropical Countries. Vol. 1,* (2nd ed). *Tropical Health Technology.* Buttersworth: Heinemann, 548.

Morton, H. M. and **Charles, R. K.** (1980). *Electrolytes.* In *Fluid and Electrolyte Metabolism.* 3rd (ed). New York: McGraw-Hill Inc., 727.

Nakamura, S. H., Amlal, P. J., Schuthers, J. Galla, G.E., Shill and **Soleimani, M.** (1999). HCO3- -reabsorption in renal collecting duct of NHE-3 -deficient mouse. A compensatory Response. *American Journal of Physiology,* 276, 14-21.

Okwu, D. E. and **Iroabuchi, F.** (2004). Photochemical analysis and antimicrobial activity screening of aqueous and ethanol root extract of Uvarra chamae beans. *Journal of Chemical Society of Nigeria,* 2004, 112-113.

Osagie, A. U. (1998). *Anti-nutritional factors. In Nutritional Quality of Plant Foods*. Benin City: Ambolk Press, Nigeria, 21, 244.

Pearson, D. (1976). *Chemical analysis of foods* (7th ed.) London: Churchill, Livingstone.

Pollman, D. S., Damielson, D. M. and **Peo, E. R.** (1979). Value of high fibre diets for growing swine. *Journal of Animal Science,* 48, 6.

Prohp, T. P., Mendie, E. A., Madusha, A. O., Uzoaru, S. C., Aigbiremolen, A. and **Onyebuagu, P. C.** (2004). Cyanide contents of Pride of Barbados (Caesalpina pulcherrima) grown in different parts of Nigeria. *Journal of Medical Laboratory Science,* 13, 29-32.

Russel B. A., Hardin J. N., Grand L. and **Traser A.** (1997). Poisonous plants of North Carolina. Caesalpinia spp (Pride of Barbados). Department of Horticultural Sciences, North Carolina state University (online) *http://www.ces.nesy.edu./depths* [10/11/2006].

Sheng, H. W. (2000). *Sodium, Chloride and Potassium.* In *Biochemical and Physiological Aspects of human Nutrition* (2nd ed.). Philadelphia: W. B. Saunders company 686-710.

Singh, S. P. (1990). *A Manual of Practical Biochemistry*. Delhi: C. B. S. publishers & Distributors, 110032.

Singh, K. V. and **Pattak** (1994). Effects of leaf extract of some higher plants on spore germinationon Usilago maydis and Usilago nuda. *Fitoterapia,* 55, 318-320.

Steel, R. G. D. and **Torrie, J. H.** (1980). *Principle and Procedures of statistics* (2nd edition). New York: McGraw-Hill Book Company, USA.