Nutritional effects of drinking *Terminalia littoralis* Seem. decoction

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ABSTRACT

Aims: The nutritional effects of drinking *Terminalia littoralis* Seem. decoction, used in ethno-medicine as prophylactic agent against sickle cell crisis, was studied.

Study design: Cross-sectional study.

Place and Duration of Study: Department of Biochemistry, Federal University of Technology, Owerri, Nigeria, between January 2012 and March 2012.

Methodology: Preparation and analysis of the decoction for pH, concentration, minerals, moisture, crude protein, crude ash, crude fat, total carbohydrates, energy and amino acid contents. The protein quality and the presence of some phytochemicals and vitamins were also evaluated. A feeding study using the decoction as the only source of fluid for albino rats of the Wistar strain for 35 days and the blood analysed for haemoglobin concentration, packed cell volume, mean corpuscular haemoglobin concentration and number of white blood cells.

Results: The decoction had a pH of 5.95±0.01 and a concentration of 1.7 g/ 100 ml. Preliminary screening showed that it contained tannins, saponins, flavonoids, thiocyanates, cardiotonic glycosides, cyanogenic glycosides, vitamin C, β-carotene, free amino acids,

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monosaccharides and 4-hydroxybenzoic acid. Its mineral contents (mg/ L) were K^+ (12.800±0.004), Na^+ (21.000±0.001), Ca^{2+} (33.600±0.002), Mg^{2+} (10.400±0.002), Zn^{2+} (21.200±0.004) and Fe^{2+} (15.200±0.002). It had a protein level of 4.55±0.42 % with 50.19±0.08 % essential amino acid content. It had a high protein quality; with Computed-Protein Efficiency Ratio-1 (C-PER-1) of 1.83; C-PER-2 of 1.83 and C-PER-3 of 0.70. Met and Cys were the limiting amino acids.

Conclusion: Drinking the decoction significantly ($p<0.05$) increased growth rate, nutrient adequacy, digestion and assimilation of feeds. It did not however affect ($p>0.05$) the weights of the organs and the haematological parameters studied.

Keywords: Decoction, effects, folk medicine, rat model, nutritional, Terminalia littoralis

1. INTRODUCTION

Terminalia littoralis Seem. is a member of the Combretaceae family (Oliver-Bever, 1986) whose most popular member is *T. catappa*. The fruit is a drupe and its exocarp of the fruit is edible (tasting slightly acidic), fleshy, green (unripe) and yellow (when ripe). The kernel is also edible. Its fruits and leaves are smaller than those of *T. catappa* (Thomson and Evans, 2006). *T. littoralis*, just like *T. catappa*, is an ornamental tree and known as the umbrella tree in Nigeria. Plant parts of some members of the *Terminalia* species have been reported to have medicinal values. Researchers have shown that the aqueous tree bark extract of *T. arguna* exhibited hypocholesterolemic effect (Ram *et al*., 1997). Leaf extracts of *T. catappa* were reported to be antidiabetic (Nagappa *et al*., 2003; Ahmed *et al*., 2005), antioxidant and hepatoprotective (Lin *et al*., 1997; Chen *et al*., 2000; Kinoshita *et al*., 2007) and antisickling (Mgbemena and Ohiri, 1999; Moody *et al*., 2003). The fallen dry leaf decoction of *T. catappa* was reported to inhibit the polymerization of sickle-cell trait haemoglobin (Ibegbulem *et al*., 2010) and reduce serum LDL-cholesterol levels (Ibegbulem *et al*., 2011) effects. The fallen dry leaf decoction of *T. littoralis* had also been reported to

inhibit the polymerization of sickle-cell trait haemoglobin (Ibegbulem, 2009). The nuts of *T. catappa* also form part of the local feedstock for tropical aquaria in Nigeria, contributing useful amounts of essential nutrients to the diet of man (Christian and Ukhun, 2006). The leaves contain several flavonoids, tannins, saponins, triterpinoid and phytosterols which make them useful in different traditional medicines for various purposes (Ahmed *et al*., 2005). The defatted seed-based diet of *T. catappa* was found to have caused depression in growth rate, enlargement of rat tissues with adverse effects on carcasses of rats because of the inability of the rats to utilize the feed mass due to heat-stable antinutrients (like phytates, oxalates and condensed tannins) that may have been present in the diet (Muhammad and Oloyede, 2004). When the leaves of *T. catappa* were used as sole feed for goats, they caused negative effects on haematological and biochemical indices with a reduction of feed intake by 25.39 per cent (Enilolorunda *et al*., 2003). The different parts of *T. littoralis* are used to treat eye complaints, thrush and rheumatism in Samoa (Jackson, 2003). Infusions and decoctions of *T. littoralis* are frequently administered in ethno-medicine as prophylaxis against sickle-cell crisis (personal communications).

Decoctions are characterized by their quick absorption, favourable therapeutic outcomes and few toxic side effects. They are mostly made into oral preparations (Yi, 2001). Infusions and decoctions made from plants have been used as popular medicines in several underdeveloped and developing countries as alternative treatments for various conditions (Pepato *et al*., 2001). Such medicines aid in the development of healthcare by increasing health coverage to the people (Elujoba *et al*., 2005); thus, economically empowering herbalists and conserving funds for those who can prepare them at home. Sofowora (2002) reported that many herbal preparations used in traditional medicine are decoctions in the pharmaceutical sense. Oral administration is the most popular route of administering such preparations. Zakrzewski (1991) posited that the advantage of this route is that the drug can mix with food, acid, gastric enzymes and bacteria which can alter its toxicity either by influencing absorption or by modifying the compound.

While literatures are awash with the therapeutic applications of most traditional medicines, reports on the nutritional effects of drinking ethno-medicines are scarce. This paper presents the nutritional effects of drinking *T. littoralis* Seem. decoction which is used as prophylactic agent against sickle-cell crisis.

2. MATERIAL AND EXPERIMENTAL DETAILS

2.1 PREPARATION OF DECOCTION

Fallen dry leaves of *Terminalia littoralis* Seem. (pink mesocarp fruited) were picked from under their trees situated at the Nekede Village, Owerri, Imo State. The leaves were authenticated by Dr. F.N. Mbagwu, a plant taxonomist, of the Department of Plant Science and Biotechnology, Imo State University, Owerri, Nigeria. The herbarium number is: IMSUH 127. The leaves were cleaned of debris, washed in tap water, mopped dry of water then chopped into bits. A quantity (100.0 g) of the chopped leaves was put in an aluminum pot and 4.6 litres of distilled water poured in. This was brought to boil and allowed to simmer for 20 minutes. The decoction produced was filtered off the leaves using a muslin cloth.

2.2 ANALYSIS OF DECOCTION

Qualitative tests for the presence of tannins, saponins, flavonoids, β-carotene and cardiotonic glycosides were carried out using to the methods of Evans (2002). Test for the presence of vitamin C, phytosterols and free amino acids and monosaccharides were carried out using the methods of Plummer (1971). Test for the presence of thiocyanates was carried out by modifying the alkaline picrate paper method of Haque and Bradbury (1999). The modification made was that the resulting orange/ brick-red coloured paper strip was not washed in distilled water and the colour intensity measured spectrophotometrically at 510 nm. Test for the presence of cyanogenic glycosides was done using the method of AOAC (1990). The presence of 4-hydroxybenzoic acid was detected using the methods of ASEAN (2005).

Proximate analysis for its moisture, crude ash, crude fat, crude protein and total carbohydrate contents were estimated using the methods of AOAC (1990). Energy content was calculated as described by Wardlaw and Kessel (2002). Mineral analysis for its potassium, sodium, calcium, magnesium, zinc and iron contents were carried out using the methods of Allen *et al*. (1983) and AOAC (1990). The determination of its pH and concentration were estimated using the methods of AOAC (1990).

The determination of the amino acid compositions of the decoction and their subsequent quantification were carried out using the Technicon Sequential Multi-sample (TSM) amino acid analyzer (model DNA 0209) ion-exchange-based chromatographic methods as described by Spackman *et al*. (1958). Defattening of the decoction had earlier been done by making equivolume mixture of the decoction and chloroform/ methanol (2:1) then discarding the chloroform layer. Moisture in the decoction was evaporated using a rotary evaporator (model RE52CS, made in China) at 50^{o}C. The amino acid compositions were expressed in g/ 100 g protein.

2.3 RESOLUTION OF Gln AND Asn CONTENTS

The amide side-chain in Asn and Gln are often hydrolysed in the chemical procedure used for the determination of the amino acids of proteins and their Asp and Glu residues add to the Asp and Glu contents (Nelson and Cox, 2008; Schutz, 2011). The average percentage occurrence of Glu, Gln, Asp and Asn in 1150 proteins of known amino acid sequences are 6.3, 4.2, 5.3 qnd 4.3, respectively (Nelson and Cox, 2008). Hence, the ratio of 6.3/4.2 for Glu and Gln, respectively, and 5.3/ 4.3 for Asp and Asn, respectively, were used to resolve their contents from Glx and Asx contents.

2.4 ESTIMATION OF PROTEIN QUALITY

The protein quality of the decoction was estimated by calculating the Total Essential Amino Acid (TEAA) excluding Trp content, Total Non-Essential Amino Acid (TNEAA), Total Neutral Amino Acid (TNAA), Total Acidic Amino Acid (TAAA), Total Basic Amino Acid

(TBAA), Total Sulphur-Containing Amino Acid (TSCAA), Total Branched-Chain Amino Acid (TBCAA) and Total Aromatic Amino Acid (TArAA) excluding Trp content. The percentage occurrences of these parameters and some AAs in their proteins and ratios of some of these parameters were also evaluated. The Computed-Protein Efficiency Ratios (C-PERs) of the decoction was estimated using the three regression equations reported by Alsmeyer *et al*. (1974) and Amadou *et al*. (2010) which show variations in PER values with amounts of the amino acids:

C-PER-1 = - 0.684 + 0.456 (Leu) – 0.047 (Pro)

C-PER-2 = - 0.468 + 0.454 (Leu) – 0.105 (Tyr)

C-PER-3 = - 1.816 + 0.435 (Met) + 0.780 (Leu) + 0.211 (His) – 0.944 (Tyr).

The EAA scores of the decoction was calculated as the ratio of the actual amount (mg) of each EAA per g of the protein to the required amount (mg) of that EAA per g of a reference protein as described by FAO/WHO (1973) and Wardlaw and Kessel (2002) using the FAO/WHO/UNU (1981) provisional amino acid scoring pattern.

2.5 BIOASSAY AND BLOOD ANALYSIS

A total of thirty - two weanling albino rats (*Rattus norvegicus*) (both sexes) of the Wistar strain were used for the animal feeding study. They were purchased from the animal colony of the Department of Biochemistry, University of Port Harcourt, Port Harcourt, Nigeria, and were aged between seven (7) and eight (8) weeks. They weighed between 42 and 75 g. The rats were allotted to 4 groups of 8 rats each (2 groups for males and 2 groups for females). The groups, of the respective sex, were equalized as nearly as possible on weight basis. Each rat was housed in a wire-screened cage with provisions for feed and fluid. Acclimatization of the rats to their new environment lasted for 4 days. All the rats were maintained under the same conditions of light and dark cycles (circadian rhythm) and ambient room temperature.

The decoction was administered to the test rats (of the respective sex) in place of water. Tap water served as the only source of fluid for the control group. All the rats ate

grower's mash (guinea feed) (produced by Bendel Feed and Flour Mill Limited, Sapele, Nigeria) as the only source of solid feed, *ad libitum*. The duration of administration was for 35 days. The animals were treated humanely in accordance with the internationally accepted principles for laboratory animal use and care as encapsulated in NIH (1985).

At the end of the experiment, each rat was re-weighed before being anaesthetized with chloroform ($CHCl_3$) vapour. Incisions were then made into their cardiac and thoracic cavities and blood specimens collected by cardiac puncture using a 5 ml hypodermic syringe and the blood deposited in EDTA- containing sequestering bottles. The organs (heart, kidneys, liver and spleen) were excised and dropped into 10% formolsaline solutions. The respective organ was mopped dry of the solution and the weight measured using an analytical balance. The haemoglobin (Hb) concentration of the uncoagulated blood was estimated using the methods of Bain and Bates (2002). The packed cell volume (PCV), mean corpuscular haemoglobin concentration (MCHC) and white blood cell (WBC) count were estimated using the methods of Baker *et al*. (2001).

The growth rate of the rat was calculated as the ratio of the weight gained by the experimental animal to the number of days (35) of the experiment. Total feed and fluid consumptions for the period of the experiment were noted and daily feed and fluid intakes calculated. Feed efficiency ratio was calculated as the ratio of the growth rate to that of the daily feed intake. The feed conversion ratio was calculated as the ratio of the daily feed intake to that of the growth rate.

2.6 STATISTICAL ANALYSIS

Data generated were evaluated by the use of the student's t-test of significance and the analysis of variance (ANOVA). Values were declared significant at $p \leq 0.05$.

3. RESULTS AND DISCUSSION

The decoction contained tannins, saponins, flavonoids, phytosterols, thiocyanates, cyanogenic glycosides, cardiotonic glycosides, vitamin C, β-carotene, free amino acids, monosaccharides and 4-hydroxybenzoic acid. The tannins, saponins and flavonoids are anti-oxidants (Evans, 2002). Phytosterols competitively inhibit uptake of dietary cholesterol (Garrett and Grisham, 1999). Thiocyanates are detoxification products of cyanogenic glycosides (FSANZ, 2005; Bradbury, 2006) and exhibit antisickling activities by carbamoylating the N-terminal amino acids of haemoglobin, thereby shifting the oxygen dissociation curve to the left (Chang *et al*., 1983). Cardiotonic glycosides can increase or decrease beats of a failing heart (Evans, 2002). Vitamin C and β-carotene (a pro-vitamin) are also anti-oxidants while amino acids and monosaccharides are nutrients (Wardlaw and Kessel, 2002). The 4-hydroxybenzoic acid is also an antisickling agent (Moody *et al*., 2003). These indicated that the decoction bore nutrients and therapeutic agents. The quantitative determinations for the concentrations of the phytochemical, vitamin and pro-vitamin are suggested for further studies.

The proximate compositions of the decoction showed that it was a low-energy water based medicine (Table 1).

TABLE 1: Proximate composition (%) and energy content of the decoction*

Moisture content	Crude ash	Crude protein	Crude fat	Total carbohydrate	Energy content (kcal/ 100 ml)
90.80±0.10	1.69±0.04	4.55±0.42	2.49±0.47	0.49±0.20	42.57±0.14

*Values are mean ± SD of triplicate determinations.

TABLE 2: Mineral contents (mg/ L) of the decoction*

K^+	Na^+	Ca^{2+}	Mg^{2+}	Zn^{2+}	Fe^{2+}
12.800±0.004	21.000±0.001	33.600±0.002	10.400±0.002	21.200±0.004	15.200±0.002

*Values are mean ± SD of triplicate determinations.

The most ($p<0.05$) abundant mineral evaluated in the decoction was Ca^{2+} (Table 2). The physiological importance of the minerals shall not be over emphasized here. While the mineral contents were higher than those reported for one tablespoon full of different vegetable oils and one and half cups of regular Cola beverage, its calcium content was equal to the 33.0 mg they reported for one and half cups of orange juice (Wardlaw and Kessel, 2002).

TABLE 3: Amino acid profile of decoction (g/100g protein)*

Essential amino acid		Non-essential amino acid	
His	1.30±0.03^{e}	Asp	3.85±0.02^{b}
Ile	3.11±0.09^{c}	Asn	3.12±0.02^{c}
Leu	5.65±0.28^{a}	Arg	4.40±0.04^{a}
Lys	3.08±0.04^{c}	Ser	2.10±0.17^{d}
Met	0.58±0.07^{g}	Gly	3.00±0.07^{c}
Phe	4.56±0.07^{b}	Pro	1.31±0.03^{e}
Thr	1.59±0.03^{f}	Cys	0.56±0.08^{f}
Trp	ND	Ala	2.21±0.30^{d}
Val	4.63±0.08^{b}	Glu	3.78±0.04^{b}
Tyr	2.56±0.07^{d}	Gln	2.52±0.03^{d}

*Values are mean ± SD of duplicate determinations.

ND = not determined.

Values on the same column with the same superscript letter are not significantly different ($p > 0.05$).

The amino acid profile of the decoction (Table 3) showed that it contained all the essential amino acids (EAAs) and non-essential amino acids (NEAAs). The most ($p<0.05$) abundant essential amino acid and non-essential amino acid were Leu and Arg, respectively. The sulphur-containing amino acids were the least occurring in the two amino acid groups presented in Table 1. Its Gly and Pro contents were 5.57±0.01 and 2.43±0.00

%, respectively. This appears to suggest that its proteins were soluble globular proteins. Globular proteins are soluble and have low Gly and Pro contents while fibrous proteins have high Gly (33%) and Pro (13%) contents (Schultz, 2011).

TABLE 4: Total amino acids and amino acid groups of decoction*

Total amino acids and amino acid groups	Value (g/ 100 g protein)	% Occurrence in TAA
Total amino acids (TAAs)‡	53.91±1.31	100.00±0.00
Total essential amino acids (TEAAs)	27.06±0.62	50.19±0.08
Total non-essential amino acids (TNEAAs)	26.84±0.69	49.79±0.08
Total basic amino acids (TBAAs)	7.48±0.00	13.87±0.00
Total acidic amino acids (TAAAs)	8.93±0.02	16.56±0.35
TBAA + TAAA	16.41±0.22	30.44±0.12
Total neutral amino acids (TNAAs)	37.50±0.42	69.56±0.35
Total branched-chain amino acids (TBCAAs)	13.39±0.45	24.83±0.23
Total aromatic amino acids (TArAAs)	7.12±0.14	13.21±0.06
Total sulphur-containing amino acids (TSCAA)	1.14±0.15	2.11±0.26

*Based on Table 3

‡Excluding Trp

The TEAA constituted more than 50 % of the TAA (Tables 3 and 4). This was significantly ($p<0.05$) higher than the TNEAA contents. The decoction also contained more ($p<0.05$) acidic protein species because the TAAA content was significantly ($p<0.05$) higher than the TBAA content; with TBAA/ TAAA ratio of 0.84±0.00. The TBCAA contents appear to suggest that more than 20 % of its TAA may supply energy to the body. Nelson and Cox (2008) posited that branched-chain amino acids, like Leu, Ile and Val, make good sources of energy. The TArAA contents suggest that more than 35 % of the Phe may be spared by Tyr. Depletion of the Phe stock may disrupt protein synthesis, since it is an EAA. The EAAs operate on the all-or-none basis (Wardlaw and Kessel, 2002). The TSAA content of the

decoction is made up of 49.12 % Cys. This was more than the Cys contents of animal foods but lower than the over 50 % Cys contents expected of plants foods (Adeyeye *et al*., 2010).

The values of the Computed-Protein Efficiency Ratios (C-PERs) were C-PER-1 (1.83±0.03), C-PER-2 (1.83±0.02) and C-PER-3 (0.70±0.01). The C-PER-1 and C-PER-2 values compared favourably with the values of 2.0 and above of high protein sources reported by Wardlaw and Kessel (2002). This showed that the biological value of the decoction was high for a plant protein source; hence suggesting that the ability of the body tissues to retain the proteins would be high. Plant proteins are known to have incomplete amino acid spectra and are mostly of low protein efficiency ratios (Wardlaw and Kessel, 2002). The C-PER-3 value may have been low because of the low Met content of the decoction. Alsmeyer *et al*. (1974) posited that changes in the amounts of these amino acids have value in predicting changes in PER, but may not have a direct relation to it (the PER).

TABLE 5: Essential amino acid scores of the decoction relative to FAO/WHO/UNU (1981) provisional amino acid scoring pattern*

	Essential amino acid						
Description	Ile	Leu	Lys	Met + Cys	Phe + Tyr	Thr	Val
Decoction	0.78±0.02	0.81±0.04	0.56±0.01	0.33±0.05	1.19±0.03	0.40±0.01	0.93±0.02
Standard (mg/g protein)‡	40	70	55	35	60	40	50

*Values are mean ± SD duplicate determinations.

‡FAO/WHO/UNU (1981) provisional amino acid scoring pattern; excluding Trp

Though the decoction was not intended for use as a nutritional supplement, the essential amino acid scores are presented in Table 5. This appears to suggest that the limiting amino acids in the decoction were Met and Cys. Their deficiencies can be corrected by consuming 1/0.33 or 3.03 g of the decoction's protein; their requirements for cellular activities in humans can be met by drinking 66.59 ml of the decoction per day, when its protein content of 4.55±0.42 % (Table 1) is considered. This is possible because it is less than one-quarter of a 250 ml capacity cup.

TABLE 6: Effects of decoctions on fluid intake, growth rate, feed consumed and feed efficiency ratio of test rat‡

	Fluid intake (ml/ day)		Growth rate (g/ day)		Feed consumed (g/ day)		Feed efficiency ratio	
Group	M	F	M	F	M	F	M	F
Test (8)	12.82±0.37*	12.80±0.23*	1.79±0.32*	1.74±0.21*	9.68±0.18	9.65±0.24	0.18±0.03*	0.18±0.00*
Control (8)	11.57±0.17	11.46±0.22	1.21±0.27	1.09±0.38	9.59±0.56	9.66±0.48	0.13±0.01	0.11±0.01

‡Values are mean ± SD of the number of responses in parenthesis.

M = male rats; F = female rats.

*Significantly different ($p<0.05$).

The decoction was administered at a pH of 5.95±0.01 and a concentration of 1.7 g/ 100 ml. Fluid intakes were higher ($p<0.05$) in the test rats (Table 6). This may have been due to the palatability of the decoction and/ or the greater desire to quench thirst. Physiologically, there is a greater tendency to consume more fluid when one tries quenching thirst by drinking fluids other than water. There is also a natural tendency for the consumer to void more urine, so as to maintain the body's water balance. Rats that drank the decoction in place of water grew ($p<0.05$) more than their controls. The decoction also increased significantly ($p<0.05$) the feed efficiency ratio of the diet (Table 6). This suggested that the nutrient adequacy of their diets was improved. The feed conversion ratios (calculated as the daily feed consumed: growth rate ratio) of the test rats were 5.41±0.56 for the males and 5.55±1.14 for the females while the control rats had 7.92±2.07 and 8.86±1.26 for the male and female rats, respectively. This suggested that the decoction increased ($p<0.05$) their bodies' abilities to convert feed mass to body mass. These may be attributed to the additional nutrients contributed by the decoction. It also suggested that decocting the leaves destroyed or reduced the antinutritional factors contained in them and enhanced the utilization of nutrients in the feed, unlike a similar study by Enilolorunda *et al*. (2003) who reported a reduction in feed intake when *T. catappa* leaves were used as sole source of feed

for goats. Even though tannins are antinutrients (Muhammad and Oloyede, 2004), they are also anti-oxidants (Evans, 2002).

TABLE 7**:** Effects of the decoction on organ weights (g) of test rat*

	Kidney		Spleen		Heart		Liver	
Group	M	F	M	F	M	F	M	F
Test (8)	0.955±0.11	0.941±0.13	0.439±0.10	0.464±0.09	0.397±0.08	0.397±0.06	5.096±0.63	4.573±0.27
Control (8)	0.900±0.06	0.833±0.11	0.410±0.06	0.332±0.09	0.345±0.03	0.332±0.05	4.100±0.27	4.040±0.72

*Values are mean ± SD of the number of responses in parenthesis.

M – male rats; F = female rats.

TABLE 8**:** Effects of the decoctions on haematological parameter of test rat*

	Hb (g/ dl)		PCV (%)		MCHC(g/dl)		WBC(number/L)	
Group	M	F	M	F	M	F	M	F
Test (8)	9.50±1.70	9.45±2.50	33.00±4.08	29.75±3.86	0.28	0.32	4712.50±197.38	4200±1065.36
Control (8)	8.98±0.46	8.05±1.00	34.50±1.73	31.75±6.24	0.26	0.25	4175.00±1074.32	5000±1802.31

*Values are mean ± SD of the number of responses in parenthesis.

M – male rats; F = female rats.

When the decoction was drunk in place of water for 35 days, it did not significantly ($p>0.05$) increase the weights of organs evaluated (Table 7). This appeared to suggest that though the organs tended to be hypertrophic due to the possible neutralization of noxious stimuli from the decoction by cells or one of their organelles (Cotran *et al*., 1999), such tendencies were however not significant ($p>0.05$). Hypertrophy is an adaptive or compensatory mechanism due to increased stress (Schoen, 1999). It may also be due to the adaptation of the cells or their organelles to new steady-states. Weight changes of these tissues are useful measures of their pathological conditions (Duchen *et al*., 1984).

The decoction did not also significantly ($p>0.05$) increase or decrease the respective haematological parameters studied (Table 8). This meant that it did not cause any haematological challenge. A similar finding by Ram *et al.* (1997) reported that the aqueous tree bark extract of a sister species, *T. arguna*, did not adversely affect the haematological indices of their test rats.

From the foregoing, it appeared that the decoction was nutritious and harmless.

4. CONCLUSION

The decoction contained therapeutic agents and nutrients. It had a high protein quality and when administered to rats as the only source of fluid, increased the growth rate, nutrient adequacy and digestion of feed, without affecting the organs and haematological indices.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

Adeyeye, E.I., Kenni, A.M. (2008). The relationship in the amino acid of the whole body, flesh and exoskeleton of common West African fresh water male crab *Sudananautes africanus africanus*. Pakistan Journal of Nutr, 7 (6), 748-752.

Ahmed, S.M., Vrushabendra, S.B.M., Dhanapal, P.G., Chandrashekara, V.M. (2005). Anti-diabetic activity of *Terminalia catappa* Linn. leaf extracts in alloxan-induced diabetic rats. Iranian Journal of Pharmacology and Ther, 4, 36-39.

Allen, S.E., Parinson, J.A., Quarmry, C. (1983). Chemical Analysis of Ecological Materials. Blackwell, Oxford.

Alsmeyer, R.H., Cunningham, A.E., Happich, M.I. (1974). Equations to predict PER from amino acid analysis. Food Technol, 28, 34-38.

Amadou, I., Kamara, M.T., Tidjani, A., Foh, M.B.K., Guo-Wei, L. (2010). Physicochemical and nutritional analysis of fermented soybean protein meal by *Lactobacillus plantarum* Lp6. World Journal of Dairy and Food Sci, 5(2), 114-118.

ASEAN (2005). Identification and Determination of 2-Phenoxy-Ethanol, Methyl, Ethyl, Propyl, and Butyl 4-Hydroxybenzoate in Cosmetic Products by TLC and HPLC. Association of Southeast Asian Nations (ASEAN). http://www.aseansec.org/MRA-Cosmetic/Doc-4.pdf. Retrieved 2/ 12/ 2007.

AOAC (1990). Official Methods of Analysis, fifteenth ed. Association of Official Analytical Chemists, Virginia.

Bain, B., Bates, I. (2002). Basic haematological techniques. In Lewis, S.M., Bain, B.J., Bates, I. (Eds.), Dacie and Lewis Practical Haematology, ninth ed. Churchill Livingstone, London, pp. 19-46.

Baker, F.J., Silverton, R.E., Pallister, C.J. (2001). Baker and Silverton's Introduction to Medical Laboratory Technology, seventh ed. Sam-Adex Printers, Ibadan.

Bradbury, J.H. (2007). Kits to determine cyanide in cassava, thiocynates in urine and to remove cyanide from cassava flour. Cassava Cyanide Disease Network, 7, 3-4.

Chang, H., Ewert, S.M., Bookchin, R.M., Nagel, R.L. (1983). Comparative evaluation of fifteen anti-sickling agents. Blood, 61 (4), 693-704.

Chen, P.S., Li, J.H., Liu, T.Y., Lin, T.C. (2000). *Terminalia catappa* and its major tannin component, punicalagin, are effective against bleomycin-induced gentotoxicity in Chinese hamster ovary cells. Cancer Lett, 152, 115-122

Christian, A., Ukhun, M.E. (2006). Nutritional potential of the nut of tropical almond (*Terminalia catappa* L.). Pakistan Journal of Nutr, 5 (4), 334-336.

Cotran, R.S., Kumar, V., Collins, T. (1999). Robbins Pathologic Basis of Disease, sixth ed. W.B. Saunders, Philadelphia.

Duchen, L.W., Corselliue, J.A., Adams, J.H. (1984). Greenfield's Neuropathology, fourth ed. Edward Arnold, England.

Elujoba, A.A., Odeleye, O.M., Ogunyemi, C.M. (2005). Traditional medicine development for medical and dental primary health care delivery systems in Africa. African Journal of Traditional, Complementary and Alternative Med, 2 (1), 46-61.

Enilolorunda, O.O., Aduyemi, A.O. (2003). Comparisms of nutritional potentials of *Terminalia catappa* and *Acalypha wilkesiana* leaves as sole feed for goats. Moor Journal of Agriculture Res, 4 (2), 242-245.

Evans, W.C. (2002). Trease and Evans Pharmacognosy, fifteenth ed. W.B. Saunders, Edinburgh.

FAO/WHO (1973). Energy and Protein Requirements. Geneva: Technical Report Series No. 522, WHO.

FAO/WHO/UNU (1981). Amino Acid Scoring Patterns. Joint FAO/WHO/UNU Expert consultation on energy and protein requirements, Provisional Agenda Item 3.2.3. Food and Agriculture Organization/World Health Organization /United Nations University ESN: FAO/WHO/UNU EPR/81/31. Food and Agriculture Organization of the United Nations, Rome.

FSANZ (2005). Cyanogenic Glycosides in Cassava and Bamboo Shoots: A Human Risk Assessment. Food Standard Australia New Zealand, Canberra.

Garret, R.H., Grisham, C.M. (1999). Biochemistry, second ed. Brooks/Cole-Thomson, California.

Haque, R., Bradbury, J.H. (1999). Simple kit method for determination of thiocyanate in urine. Clinical Chem, 45, 1459 – 1464.

Ibegbulem, C.O. (2009). Antisickling potentials and biochemical effects of *Raphia hookeri* sap and *Terminalia* species leaf decoctions in Wistar rats. Unpublished Ph.D Dissertation. University of Calabar, Nigeria.

Ibegbulem, C.O., Eyong, E.U., Essien, E.U. (2010). Antipolymerization effect of *Terminalia catappa* decoction on sickle cell trait haemoglobin. Nigerian Journal of Biochemistry and Molecular Biol, 25(2): 40-45.

Ibegbulem, C.O., Eyong, E.U., Essien, E.U, (2011). Biochemical effects of drinking *Terminalia catappa* Linn. decoction in Wistar rats. African Journal of Biochemistry Res, 5(8): 237-243.

Jackson, K.L. (2003). Traditional medicinal plants of Samoa. http://www.dittmar.dusnet.de/english/ ewisspfl7.html. Retrieved 11/ 06/ 2008.

Kinoshita, S., Inoue, Y., Nakama, S., Ichiba, T., Aniya, Y. (2007). Antioxidant and hepatoprotective actions of medicinal herb, *Terminalia catappa* L. from Okinawa Island and its tannin corilagin. Phytomedicine, 14 (11), 755-762.

Lin, C.C., Chen, Y.L., Jer, M.L., Ujiie, T. (1997). Evaluation of the antioxidant and hepatoprotective activity of *Terminalia catappa*. American Journal of Chinese Med, 25 (2), 153 – 162.

Mgbemene, C.N., Ohiri, F.C. (1999). Anti-sickling potential of *Terminalia catappa* leaf extract. Pharmaceautical Biol, 37 (2), 152-154.

Moody, J.O., Segun, F.I., Aderounmu, O., Omatade, O.O. (2003). Antisickling activty of *Terminalia catappa* leaves harvested at different stages of growth. Nigerian Journal of Natural Product and Med, 7, 30 – 32.

Muhammad, N.O., Oloyede, O.B. (2004). Assessment of biological value of *Terminalia catappa* seed meal-based diet in rats. Biokemistri, 16 (1), 49-55.

Nagappa, A.N., Thakurdesai, P.A., Venkat Rao, N., Singh, J. (2003). Antidiabetic activity of *Terminalia catappa Linn* fruits. Journal of Ethnopharmacol, 88, 45-50.

Nelson, D.L., Cox, M.M. (2008). Lehninger Principles of Biochemistry, fifth ed. W.H. Freeman and Company, New York.

NIH (1985). Guide for the Care and Use of Laboratory Animals. National Institutes of Health, United States of America, Publication No. 85-23.

Oliver-Bever, B. (1986). Medicinal Plants in Tropical West Africa. Cambridge University Press, Cambridge.

Pepato, M.T.I., Folgado, V.B.B., Kettelhut, I.C., Brunetti, I.L. (2001). Lack of antidiabetic effect of a *Eugenia jambolana* leaf decoction on rat streptozotocin diabetes. Brazilian Journal of Medical and Biological Res, 34, 389-395.

Plummer, D.T. (1971). An Introduction to Practical Biochemistry. McGraw-Hill, London.

Ram, A., Laura, P., Gupta, R., Kumar, P., Sharma, V.N. (1997). Hypocholesterolaemic effects of *Terminalia arguna* tree bark. Journal of Ethanopharmacol, 55 (3), 165-169.

Schoen, F.J. (1999). The heart, in: Cotran, R.S., Kumar, V., Collins, T. (Eds.) Robbins Pathologic Basis of Disease, sixth ed. W.B. Saunders, Philadelphia, pp. 543-599.

Schultz, R.M. (2011). Proteins I: composition and structure. In: Devlin, T. M. (Ed.), Textbook of Biochemistry with Clinical Correlations, seventh ed. John Wiley and Sons Inc., New Jersey, pp. 75-138.

Sofowora, A. (2002). Plants in African traditional medicine-an overview. In: Evans, W.C. (Ed.), Trease and Evans Pharmacognosy, fifteenth ed. W.B. Saunders, Edinburgh, pp. 488-496.

Spackman, D.H., Stein, E.H., Moore, S. (1958). Automatic recording apparatus for use in the chromatography of amino acids. Analytical Chem, 30, 1191.

Thomson, L.A., Evans, B. (2006) *Terminalia catappa* (tropical almond). http://www.agroforestry.net/tti/T.catappa-tropical- almond.pdf. Retrieved 16/ 02/ 2008.

Wardlaw, G.M., Kessel, M.W. (2002). Perspective in Nutrition, fifth ed. McGraw-Hill, Boston.

Yi, D. (2001). From ancient times to modern day: the evolution of preparing traditional Chinese medicine. http://www.houseofyiyang.com/eng/hoyy/herb/main.htm. Retrieved on 13/ 06/ 2008.

Zakrzewski, S.F. (1991). Principles of Environmental Toxicology: ACS Professional Reference Book. American Chemical Society, Washington D.C.