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The Editor-in-Chief,
FJST, Federal University Lafia
Email: fjst@fulafia.edu.ng

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FULafia Journal of Science and Technology (FJST) Vol. 1, No. 1, 2015

I am particularly pleased to write this Inaugural editorial for the first issue of FULafia Journal of Science and Technology (FJST). The inception of this project was in August, 18th 2015, when the Vice-Chancellor, Prof. Ekanem Ikpi Braide, inaugurated the Editorial Boards of the two TETFUND supported Journals in the Federal University Lafia.

It is a fact that the widespread availability of exciting new research information contributes directly to how researchers approach a wider range of questions about the problems confronting society. FJST provides a unique scientific forum that will capitalize on the wealth of new information in Science and Technology (S&T) to facilitate its dissemination in our global scientific community. As a new Journal, FJST will focus on basic and applied research in all aspects of S&T and will publish original, high quality, peer-reviewed papers including research articles, short communications and situation reports that will provide comprehensive coverage on all aspects of S&T.

In this first issue, FJST invited research-based articles from several prominent scholars and researchers in S&T. Fifteen articles are selected for publication in this first volume; a second volume will follow shortly. To enable the dissemination of work published in our Journal, FJST is entirely free from publication fees. There are no submission fees and no page or other publication charges. Author(s) will be entitled to one hard copy and can purchase additional copies subsequently. Subscription will be available for individuals and Institutions by sending email to the Editor. Upon acceptance, articles are published in hard copies and on the Journal's website and will be available as an open source Journal. The Open Access model will make the work published in FJST more extensively accessible to international scientists.

To ensure the quality of the science, there is in place an outstanding Editorial Board and Advisers as well as an accredited panel of Reviewers who are responsible for rapid peer review process of all articles. We are committed to high developing and improving standards of operation and to this end, an online manuscript management system will soon be in place.

FJST is supported by TETFUND and the Editorial Board on behalf of the University Management is grateful to TETFUND for this contribution in the development of education in our emerging University and in Nigeria as a whole.

I am enormously honored to be a part of this exciting innovative effort and I am confident that it will become a highly respected and trusted resource of leading knowledge in S&T. It is our conviction that the information presented in this publication will be a motivation in advancing S&T to solve our development problems and we eagerly look forward to seeing your research in our Journal.

Prof. E.H. Kwon-Ndung
Editor-in-Chief

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BREAKING OF DORMANCY AND SPROUTING OF SOME POTATO (*Solanum Tuberosum* L.) VARIETIES UNDER DIFFERENT STORAGE CONDITIONS AND DURATIONS IN JOS, PLATEAU STATE, NIGERIA.

¹Deshi, K. E., ²Odiaka, N. I., ³Obasi, M. O., ⁴Kalu, B. A. and ⁵Ifenkwe, O.P.

*

^{1,5}Department of Plant Science and Technology, Faculty of Natural Sciences,
University of Jos, Plateau State, Nigeria

^{2,3,4}Department of Crop Production, College of Agronomy, University of Agriculture,
Makurdi, Benue State, Nigeria

*Corresponding Author's E-mail: kdeshi@yahoo.com

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ABSTRACT

A study was carried out at the National Root Crops Research Institute, Potato program (NRCRI) Kuru, Jos Plateau State, Nigeria (Longitude 08°04'47"E, Latitude 09°04'41"N and 1,239 metres above sea level (msl) during the 2010-2011, 2011-2012 and 2012-2013 seasons to investigate "The Breaking of Dormancy and sprouting of some Potato (*Solanum tuberosum* L.) varieties under Different Storage Conditions and Durations in Jos, Plateau State, Nigeria". Five potato varieties: Nicola, Bertita, Diamant, BR63-18 and Roslin Ruaka were stored for three periods: 12, 24 and 32 weeks in three types of stores, the Room temperature Store, Diffused light store (DLS) and Air conditioned store. The experimental design used was completely randomized design in factorial combination of 5 potato varieties, 3 storage conditions and 3 storage durations. There were 45 treatment combinations replicated 3 times. Weekly temperatures and Relative humidity were recorded in each type of store. The result showed that the number of days to breaking of Dormancy tubers varied with variety. In all the seasons, Nicola took the longest number of days to break dormancy (102.67, 121.33 and 119.00 days in seasons 1, 2 and 3 respectively) while, BR63-18 was the earliest to break dormancy except in season 3 where Diamant was the first to break dormancy. Storage under Air condition took the longest number of days to break dormancy in all the seasons (85.67, 97.07 and 102.20 days in seasons 1, 2 and 3 respectively) while the Room temperature store was the earliest to break dormancy (67.66, 85.40 and 78.87 days in seasons 1, 2 and 3 respectively). The number of sprouted tubers varied with variety. Nicola resulted in the highest number of sprouted tubers in seasons 1 and 3 (35.56 and 33.85 respectively) while BR63-18 was highest in season 2. Storage under air condition resulted in highest number of sprouted tubers in seasons 1 and 3 (33.44 and 35.80 respectively). The number of sprouted tubers increased from 12 to 24 weeks and declined at 32 weeks in seasons 1 and 3. Seed tuber storage for 32 weeks resulted in significantly lower number of sprouted tubers in all the seasons. There was significant interaction of variety X store type, variety X storage duration and store type X storage duration with respect to number of sprouted tubers. The interaction may be attributed to genetic composition of the varieties and environmental conditions of the storage.

Keywords: *Potato, storage conditions, storage durations, dormancy break and sprouting*

INTRODUCTION

During the physiological development of potato, a potato tuber can remain dormant for several months.

At this stage, no measurable sprout growth occurs, even when tubers are placed under ideal conditions for sprout growth (darkness, temperature of about 15 - 20°C and relative humidity of about 90% (Wiersema, 1985; Reust, 1986). Dormancy period has been defined as the period when sprout growth is inhibited for any reason including the rest period, while rest period is the period during which no measurable sprout growth occurs even when the tubers are stored under conditions ideal for sprouting (Reust, 1987; Hartmans and Van Loon, 1987). Dormancy could be measured from the date of tuber initiation, that is, when the stolon tips starts to swell (Burton 1963, 1989) or the period between harvesting and the time when at normal temperatures the eyes begin to sprout in earnest (Beaukema and Van Der Zaag, 1990) or the period from dehauling to the time when 80% of the tubers shows sprouts of at least 2mm long (Carli *et al.* (2010).

Dormancy is deemed to have ended when the buds on the tuber, which has been stored from harvest onwards under conditions optimal for sprouting, are seen to be sprouting, that is, the dormant period ends when sprout growth starts (Wiersema, 1985 and Daniels-Lake and Prangel, 2007).

The potato is a major root crop in the Jos Plateau of Nigeria and it has a potential for two or more cropping per year if adequate well sprouted tubers are available. Although this potential exists, the production still lags behind demand (Zaag, 1986; Ifenkwe, 1989) and low productivity is caused amongst other factors by the lack of adequate seed supply for prospective potato farmers especially during the dry season (Ifenkwe, 1986), which is closely linked to tuber dormancy problem. Long dormancy is desirable for ware or table potatoes which are to be stored for long period but with seed potatoes, short dormancy is desirable (Van Ittersum and Scholte, 1992) to ensure early planting of the next cropping. The interval between the rain-fed crop and the early dry season crop is short (2-3 months) and the availability of well sprouted tubers for planting is a major problem. On the other hand, if seed tubers harvested during a rain fed cropping are to be planted in the next rain fed cropping (8-9 months) of seed storage, long dormancy then becomes desirable feature. By far, one of the most serious problems that need to be tackled is that of potato storage, in the traditional potato production system in Nigeria, no specific stores are designed for potato storage; farmers use any available space in their houses often without proper ventilation and lighting (Ene *et al.*, 1986). Only farmers who can grow two crops of potato in a year can have seed regularly, seed tubers are scarce during the wet season planting when many more farmers are able to grow potato.

This current research effort was aimed at studying the breaking of dormancy and sprouting of some potato

varieties under different storage conditions and durations. A favourable effect in terms of breaking dormancy at a low cost will increase seed tuber available for short period of storage (double cropping in a year) or prolonging the period of dormancy at a low cost will increase seed tuber availability for prolong storage (from one rain fed cropping to the next rain fed cropping).

MATERIALS AND METHODS

The study consisted of two stages: multiplication of seed tuber in the field aimed at generating sufficient tubers for storage and storage of seed tubers. Five potato varieties viz: Nicola, Bertita, Diamant, BR 63-18 and Roslin-Ruaka were obtained and multiplied at the National Root Crops Research Institute (NRCRI) Kuru, Jos Plateau State, Nigeria (09° 44' N, 08° 47' E; 1,239m above sea level) during the 2010-2011, 2011-2012 and 2012-2013 seasons. In storage, a completely randomized design in factorial combination of 5 potato varieties, 3 storage conditions and 3 durations were used. There were 45 treatment combinations replicated 3 times. Each treatment was represented by 40 seed tubers.

Storage conditions

Three types of stores were used: Diffused Light Store (DLS), Air conditioned store (cooled store) and room temperature store (Control). The Diffused light store (DLS) is a store structure based on the model developed by Nwokocha and Ifenkwe (1991) was constructed in 2010 with little modification (while Nwokocha and Ifenkwe used mud blocks to keep the cost of construction as low as possible, compressed bricks were used). This will enable the use of the store for other purposes after this research. The structure consisted of double walls made of compressed bricks with inlet vents at the floor level and outlet vents on top of walls opposite the inlet vents. Plain and glazed glasses were fitted for illumination (Inside and outside walls respectively). The top was sealed off with mud decking and then overlaid with thatched. The space between the double walls was packed with Acha (*Digitaria exilis*) straw to enhance insulation. The shutters for the doors and the vents were made of foam covered on both sides with 6mm plywood. The doors one on each wall opened in opposite directions. Cooling in this store is aided by cool night air and the inlet vents are covered with wire nets to ward off insects and rodents into the store. The vents were opened in the night and closed in the early hours of the morning allowing cool night air to be trapped in the store and the insulation retains cool air through the day (Nwokocha and Ifenkwe, 1991).

Air conditioned store (ACS)

This store consisted of a building made of compressed bricks and decked with mud. The windows were insulated with six inch foam. It was

artificially lighted with low energy bulbs and the store was cooled with an air condition (1.5 horse power split unit air condition). Air condition was used because of the source of electricity-Nigerian electricity supply company (NESCO) is steady and reliable.

Room temperature store (control)

The store received some light through the windows. This served as the control representing local farmers' potato storage practice. The conditions in the storage includes: temperature, relative humidity, and light. Thermo-hydrometers (Humidity and temperature data loggers were installed in each store room and was used to measure the temperature and relative humidity in each store on 6 hour period. Mean minimum and maximum temperature for each day was therefore calculated for each season and weekly mean was then calculated.

Storage durations (Periods)

Each store had tubers of each variety stored for the same period. The tubers were stored for 12, 24 and 32 weeks in each type of store and then taken to the field for planting. Seed storage for 32 weeks was from rain fed harvest to rain fed planting (prolonged storage). Beukema and Van Der Zaag (1990) reported that in principle seed should be at least 3 months old before it is planted again and not older than 5-11 months (depending on the storage method and storage temperature).

Storage practices

The harvested tubers from seed multiplication were properly screened by physical examination to remove any diseased or damaged tubers. This was followed by seed selection (sizes of 30-40 mm grade) of each variety. The tubers were kept in an open room for two weeks for curing before storage. Mean weight of tubers for each variety were taken before storage. Tuber storage started at 3 weeks after harvest (August 26th, 2010; September 8th, 2011 and September 7th, 2012 in seasons 1, 2 and 3 respectively).

Observations and measurements were done fortnightly. 10 sampled tubers were examined at each given time and the storage observations included: Number of days from harvest to breaking of dormancy and number of sprouted tubers.

The storage data was subjected to analysis of variance (ANOVA) and the means were separated using least significant difference (LSD) using the mini tab software.

RESULTS

Days to breaking of dormancy

The main effects of variety and store type with respect to mean number of days after harvest to dormancy break (80% of tubers peeping) were

significant ($P < 0.05$) (Table 1). In season 1, variety BR 63-18 took the shortest number of days from harvest to break dormancy (50.56). This was followed by Roslin Ruaka that broke dormancy in 63.00 days. In season 2, BR63-18 was also the earliest to break dormancy in 75.44 days, although it was similar to Diamant and Roslin Ruaka which broke dormancy in 77.00 and 77.78 days, while in season 3 Diamant was the earliest to break dormancy in 66.89 days, although it was similar to BR63-18 which broke dormancy in 70.00 days. In all the 3 seasons, Nicola took the longest number of days to break dormancy (102.67, 121.33 and 119.00 days during seasons 1, 2 and 3 respectively) (Table 1).

Tubers stored in Room temperature store were the earliest to break dormancy in 67.67, 85.40 and 78.87 days during seasons 1, 2 and 3 respectively. While storage in Air conditioned store took longest to break dormancy in 85.87, 97.07 and 102.20 days during seasons 1, 2 and 3 respectively (Table 1).

The interaction of variety and store type on mean number of days after harvest to dormancy break was significant ($P < 0.05$) (Table 2). During season 1, in the Room temperature store, BR 63-18 took the shortest number of days to break dormancy (49.00 days) which did not vary significantly ($P < 0.05$) from Roslin-Ruaka that took 51.33 days. In the DLS, BR 63-18 was the earliest to break dormancy (44.33 days) this was followed by Diamant and Roslin-Ruaka that broke dormancy in 63.00 days. In the ACS, BR 63-18 was still the earliest to break dormancy (58.33 days). This was followed by Roslin-Ruaka that took 74.67 days to break dormancy, which did not significantly ($P < 0.05$) differ from Diamant that broke dormancy in 79.33 days (Table 2).

During season 2, in the RTS, BR 63-18 and Roslin Ruaka were the earliest to break dormancy in 70.00 days; this was followed by Diamant which broke dormancy in 77.00 days. In the DLS, Diamant was the earliest to break dormancy in 67.67 days; this was followed by BR 63-18 which broke dormancy in 77.00 days. In the ACS, BR 63-18 was the earliest to break dormancy (81.67 days) although it was similar to Diamant and Roslin Ruaka that took 86.33 days to break dormancy (Table 2).

In the Room temperature store during season 3, Nicola and Bertita took significantly longer number of days to break dormancy (105.00 days) while Diamant, BR 63-18 and Roslin took a similar number of days to break dormancy (60.67, 63.00 and 60.67 respectively). In the Diffused light store, the different varieties significantly varied in number of days to break dormancy. Nicola took the longest (119.00 days) followed by Bertita (95.67 days) while Diamant took the shortest number of days (63.00). In the ACS, Nicola and Bertita took a longer number of days to break dormancy (133.00 and 128.33 days respectively), this was followed by Roslin Ruaka that took 91 days to break dormancy while Diamant and BR 63-18 took a

similar number of days (77.00 and 81.67 days respectively) (Table 2).

Number of sprouted tubers

The main effects of variety, store type and storage duration on mean number of sprouted tubers were significant ($P < 0.05$) (Table 3). During season 1, the variety Nicola recorded a significantly ($P < 0.05$) higher mean number of sprouted tubers (35.56) than the other varieties. It is closely followed by the varieties, BR 63-18 and Bertita which had similar mean number of sprouted tubers (30.22 and 28.56 respectively).

However, the variety Roslin Ruaka had the least number of sprouted tubers (14.22). In season 2, Variety BR 63-18 resulted in significantly ($P < 0.05$) higher mean number of sprouted tubers (25.52). This was followed by Diamant with 23.52 sprouted tubers, while Roslin Ruaka, Nicola and Bertita had similar mean number of sprouted tubers (Table 3). In season 3, Nicola resulted in the highest mean number of sprouted tubers (33.85), although this was similar to Bertita and BR 63-18. Roslin Ruaka resulted in the lowest mean number of sprouted tubers (32.04) although it was similar to Bertita, Diamant and BR 63-18 (Table 3).

The different store types were significantly ($P < 0.05$) affected the sprouting of tubers. During season 1, storage of tubers in Air conditioned store resulted in significantly ($P < 0.05$) higher mean number of sprouted tubers (33.44), while storage in Room temperature and Diffused light stores resulted in similar mean number of sprouted tubers (22.13 and 21.36 respectively). In season 2, Storage of seed tubers in diffused light store resulted in highest number of sprouted tubers (31.92). This was followed by storage under RTS with 24.38 tubers that were sprouted while the Air condition store had the lowest number of sprouted tubers (10.89) (Table 3). However, in season 3, the ACS resulted in the highest mean number of sprouted tubers (35.80). This was followed by DLS which resulted in 32.43 sprouted tubers. The RTS resulted in the lowest number of sprouted tubers (30.49).

The different storage durations had significant effect on number of sprouted tubers. In season 1, storage of tubers for 12 and 24 weeks resulted in similar mean number of sprouted tubers (28.89 and 29.18 respectively), while storage for 32 weeks resulted in significantly lower mean number of sprouted tubers (18.85) (Table 3). In season 2, storage of seed for 12 weeks resulted in the highest mean number of sprouted tubers (32.48). This was followed by storage for 24 weeks with 20.03 tubers that were sprouted, while storage for 32 weeks resulted in significantly ($P < 0.05$) lower mean number of sprouted tubers (14.67) (Table 3). However in season 3, Storage of tubers for 24 weeks resulted in significantly higher mean number of sprouted tubers

(37.16). This was followed by storage for 12 weeks with mean number of sprouted tubers of 33.90, while 32 weeks of storage resulted significantly ($P < 0.05$) lower number of sprouted tubers (27.66) (Table 3).

There was significant ($P < 0.05$) interaction between variety and store type in all the 3 seasons. During season 1, the variety Nicola had a significantly higher mean number of sprouted tubers (35.56 and 36.44) in the room temperature store and in the diffused light store respectively. In the air conditioned store however, the variety, BR 63-18 had the highest mean number of sprouted tubers (39.70) (Table 4). In season 2, Nicola and BR 63-18 gave the highest mean number of sprouted tubers (31.33 and 32.00 respectively) in the RTS. In the DLS Roslin Ruaka and Diamant gave the highest number of sprouted tubers (34.44 and 34.22 respectively). In the ACS all the varieties resulted in similar mean number of sprouted tubers except Nicola which had significantly ($P < 0.05$) lower number of sprouted tubers (3.11) (Table 4). However in season 3, Nicola resulted in the highest mean number of sprouted tubers (37.44) in the RTS. In the DLS, Bertita resulted in the highest number of sprouted tubers (35.02) although this was similar to Nicola and BR 63-18. In the ACS, Diamant resulted in the highest number of sprouted tubers 39.89, although it was similar with BR 63-18 and Roslin Ruaka (Table 4).

There was significant interaction of variety and storage duration on mean number of sprouted tubers in all the seasons. In season 1, at 12 weeks of storage, the variety, BR 63-18 recorded the highest mean number of sprouted tubers (36.15). At 24 weeks of storage, the varieties, Nicola and BR 63-18 had similar mean number of sprouted tubers (37.22 and 35.26 respectively). At 32 weeks of storage, the variety Nicola resulted in significantly higher mean number of sprouted tubers (36.00) (Table 5).

At 12 WOS during season 2, all the varieties resulted in similar number of sprouted tubers except Nicola which had significantly ($P < 0.05$) lower number of sprouted tubers (11.33). At 24 WOS, Nicola resulted in highest number of sprouted tubers (26.56) although this was similar with BR 63-18 which had 24.78 sprouted tubers. At 32 WOS Nicola resulted in significantly ($P < 0.05$) higher mean number of sprouted tubers (24.78) (Table 5). However in season 3, Nicola resulted in the lowest mean number of sprouted tubers (23.78) at 12 WOS. At 24 WOS, Roslin-Ruaka resulted in the lowest number of sprouted tubers (35.67). At 32 WOS, Diamant and Roslin Ruaka had similar and lowest mean number of sprouted tubers (21.11) (Table 5).

Interaction of store type and store duration on mean number of sprouted tubers was significant ($P < 0.05$) in all the seasons. In season 1, at 12 weeks of storage, the diffused light store resulted in the lowest mean number of sprouted tubers (25.90) and this was significantly different from other types of storages. At

24 weeks of storage, the room temperature and diffused light stores resulted in similar mean numbers of sprouted tubers (27.04 and 25.69 respectively). At 32 weeks of storage, the room temperature store resulted in the lowest mean number of sprouted tubers (10.70) (Table 6). In season 2, at 12 WOS, all the store types resulted in similar mean number of sprouted tubers. At 24 WOS, DLS resulted in highest number of sprouted tubers (37.03). The ACS had no sprouted tubers because the store was razed down by fire. Same pattern was repeated in 32 WOS (Table 6). However, at 12 WOS during season 3, RTS resulted in the highest number of sprouted tubers (37.56). At 24 and 32 WOS, ACS resulted in highest mean number of sprouted tubers (39.33 and 38.79 respectively) (Table 6).

DISCUSSION

Breaking of dormancy

The potato varieties used in this study differed in mean number of days to breaking of dormancy in all the three seasons. Variety Nicola took the longest number of days to break dormancy in all the 3 seasons (102.67, 121.33 and 119.00 days in seasons 1, 2 and 3 respectively) and BR 63-18 was the earliest to break dormancy in seasons 1 and 2 (50.56 and 75.44 days respectively) while in season 3, Diamant was the earliest to break dormancy in 66.90 days and other varieties were in between. That may be attributed to their genetic composition. Carli *et al.* (2010) reported that dormancy is a varietal character and they characterised potato varieties into 3 categories based on dormancy periods: short dormancy, medium dormancy and long dormancy. Van Ittersum (1992) reported that dormancy of tubers of potato varies among genotypes. Beukema and Van der Zaag (1990) reported that varieties differ markedly in length of dormancy. Huaman and Spoonar (2002) found a very wide range in the length of the dormant period in cultivated potato and its wild species.

The number of days to breaking of dormancy varied with variety and store type in all the seasons. Generally tubers stored in Room temperature store were the earliest to break dormancy followed by tubers stored in Diffused light store while the air conditioned store took longest to break dormancy in all the 3 seasons. Genetic variability of tubers and environmental conditions especially temperature may be responsible for variation in Number of days to dormancy. Temperature affects physiological age of potato seed tubers, the higher the temperature, the faster the seed tubers age, thus the seed tubers in the Room temperature store broke dormancy early, while the low temperature in Air condition store may be responsible for the long dormancy observed (Appendix a, b and c shows temperature and relative humidity in the different store types during seasons

1, 2 and 3 respectively). Storage temperature had been reported as an important factor influencing the length of dormancy period (Beukema and Van der Zaag, 1990). Jo Frazier *et al.* (2004) found the length of dormancy to differ by cultivars and storage conditions, while Carli *et al.* (2010) reported dormancy period to be influenced by variety, environment and management conditions. They found tubers stored at low temperature (cold storage at 2-4°C) to have longer period of dormancy than those stored at high temperatures (18-20°C).

It is worth noting that the seed tubers generally took a longer number of days to break dormancy in season 2 than in seasons 1 and 3. This may be attributed to the lower storage temperatures observed in season 2, compared to seasons 1 and 3 (Appendix a, b and c). It has been reported that conditions under which seed tubers are produced in the field affect the dormancy period e.g. high temperature, low soil moisture and low soil fertility during tuber growth accelerate physiological development and reduce the dormancy period (Wiersema, 1985; Carli *et al.*, 2013). Burton (1963) found a longer dormancy period after a cold wet season. This also suggests that the temperature during seed multiplication in the field during season 2 may have been lower than that of seasons 1 and 3.

Number of sprouted tubers

The mean number of sprouted tubers was significantly ($P < 0.05$) affected by variety in all the 3 seasons. While Nicola resulted in highest number of sprouted tubers in seasons 1 and 3, BR 63-18 had the highest number of sprouted tubers in season 2. This variation may be as a result of differences in the genetic composition of the varieties used. Most varieties have been reported to vary markedly in length of dormancy (Van der Zaag, 1992) and sprouting (Hay and Porter, 2006). The main effect of store type was significant ($P < 0.05$). Air conditioned store resulted in highest number of sprouted tubers in seasons 1 and 3 while DLS was highest in season 2 (being that air conditioned store was razed down by fire after the first storage period in season 2). The environmental conditions such as temperature and Relative humidity in the different store types were different (Appendix a, b and c), which may be the reason for the observed differences.

The number of sprouted tubers varied with variety and store type. Room temperature resulted in lowest number of sprouted tubers in all the seasons while the Air conditioned store resulted in the highest number of sprouted tubers in seasons 1 and 3. Since it has been reported that storage at higher temperature results in early break of dormancy and sprouting (Burton, 1989), while lower storage temperature lengthen the period of dormancy (Brandt *et al.*, 2003), one would have expected that the room temperature

store which had the highest maximum temperature in all the three seasons (31.57°C, 27.84°C and 29.73°C in seasons 1, 2 and 3 respectively), will have higher number of sprouted tubers but that is not the case, the air conditioned store rather had highest number of sprouted tubers. A lot of tubers in room temperature and diffused light store were lost due to tuber rot than in the air conditioned store. The higher number of sprouted tubers in the Air conditioned store may have been due to cooling which reduced the activities of the microorganisms causing rot. Struik and Wiersema (1999) reported that temperature has an effect on the growth of disease causing agents (bacteria or fungi). Kibar (2012) observed that an increase or decreased in potato storage temperature can be used to minimized disease development. At temperatures above 10°C the growth of disease organisms increases dramatically, while, by reducing holding temperature, many storage disease problems can be minimized.

The significant ($P < 0.05$) interaction of variety and storage duration in mean number of sprouted tubers may be attributed their genetic variability and physiological age. Struik and Wiersema (1999) reported that tubers may have the same chronological age but their physiological age (pattern of sprout development) may differ. Generally it is expected that as tubers break dormancy, sprouting will increase with time. In this study one would expect that all the

tubers be sprouted (40 out of 40 tubers stored per treatment) by 24 and 32 weeks of storage, but the number of sprouted tubers was lower than expected. The reduction in number of sprouted tubers may be because some tubers got rotted during storage and as the period of storage increases, more tubers are lost to rot. This loss of tubers depends on the variety. Seed tuber storage for 12 weeks and 24 weeks resulted in higher number of sprouted tubers in all the seasons, while there is significant ($P < 0.05$) drop in number of sprouted tubers at 32 weeks of storage in all the three seasons. The drop at 32 weeks may be due to extra rotting which occurred because of prolonged storage.

The number of sprouted tubers varied with storage duration and store type. This interaction may be attributed to the storage conditions and physiological age of the tubers. Pavlister (2004) reported that sprouting behaviour of tubers is greatly influenced by storage conditions and length of storage period.

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Table 1: Effect of Variety as Affected by Store Type on Mean Number of Days to Break

(80% of Tubers Peeping) of Dormancy during three seasons (2010 – 2011, 2011-2012 and 2012-2013) in Jos

Treatment	Number of days from harvest to dormancy break		
	Season 1	Season2	Season3
Variety			
Nicola	102.67	121.33	119.00
Bertita	98.00	98.00	109.67
Diamant	68.44	77.00	66.89
BR63-18	50.56	75.44	70.00
Roslin-Ruaka	63.00	77.78	74.67
LS	**	**	**
LSD _{0.05}	4.54	3.81	5.32
Storage type			
Room temperature (RT)	67.67c	85.40b	78.87c
Diffused light store (DLS)	76.07b	87.27b	83.07b
Air conditioned store (ACS)	85.87a	97.07a	102.20a
LS	**	**	**
LSD _{0.05}	4.39	2.97	3.47
Interaction			
Variety x store type	*	*	*

Table 2: Interaction of Variety and Store Type on Mean Number of Days after Harvest to Break (80% of Tubers Peeping) of Dormancy

Treatments	Season 1 Store types			Season 2 Store types			Season 3 Store types		
	RTS	DLS	ACS	RTS	DLS	ACS	RTS	DLS	ACS
Variety									
Nicola	91.00	105.00	112.00	119.00	119.00	126.00	105.00	119.00	133.00
Bertita	84.00	105.00	105.00	91.00	98.00	105.00	105.00	95.67	128.33
Diamant	63.00	63.00	79.33	77.00	67.67	86.33	60.67	63.00	77.00
BR63-18	49.00	44.33	58.33	70.00	74.67	81.67	63.00	65.33	81.67
RoslinRuaka	51.33	63.00	74.67	70.00	77.00	86.33	60.67	72.33	91.00
LSD _{0.05}		8.85			6.31			7.82	
RTS. Room temperature store									
DLS. Diffused light store									
ACS. Air condition store									

Table 3:

Effect of Variety as Affected by Store Type and Storage Duration on mean Number of Sprouted Tubers during three Seasons (2010-2011, 2011-2012 and 2012-2013) in Jos

Treatment	Mean number of sprouted tubers		
	Season 1	Season 2	Season 3
Variety			
Nicola	35.56	20.89	33.85
Bertita	28.56	20.68	32.71
Diamant	19.65	23.52	32.19
BR63-18	30.22	25.52	33.74
Roslin-Ruaka	14.22	21.37	32.04
LS	**	**	**
LSD _{0.05}	1.68	1.20	1.56
Storage type			
Room temperature store	22.13	24.38	30.49
Diffused light store	21.36	31.92	32.43
Air conditioned store	33.44	10.89	35.80
LS	**	**	**
LSD _{0.05}	0.84	1.05	1.06
Storage Duration (weeks)			
12	28.89	32.48	33.90
24	29.18	20.03	37.16
32	18.85	14.67	27.66
LS	**	**	**
LSD _{0.05}	0.82	1.11	1.08
Interaction			
Variety x Storage type	**	**	**
Variety x Storage duration	**	**	**
Storage type x Storage duration	**	**	**

Table 4: Interaction of Variety and Store Type on Mean Number of Sprouted Tubers

Treatment	Season 1			Season 2			Season 3		
	Storage type			Storage type			Storage type		
	RTS	DLS	ACS	RTS	DLS	ACS	RTS	DLS	ACS
Variety									
Nicola	35.56	36.44	34.67	31.33	28.22	3.11	37.44	33.78	30.33
Bertita	25.24	24.36	36.09	18.67	31.47	11.91	31.11	35.02	32.00
Diamant	15.85	11.26	31.85	23.00	34.22	13.33	26.78	29.89	39.89
BR63-18	25.33	25.63	39.70	32.00	31.22	13.33	29.11	33.11	39.00
RoslinRuaka	8.67	9.11	24.89	16.89	34.44	12.78	28.00	30.33	37.78
LSD _{0.05}		2.13			2.17			2.36	

RTS. Room temperature store
DLS. Diffused light store
ACS. Air condition store

Table 5: Interaction of variety and storage duration on mean number of sprouted tubers.

Treatment	Season 1			Season 2			Season 3		
	Storage duration			Storage duration			Storage duration		
	12	24	32	12	24	32	12	24	32
Variety									
Nicola	33.44	37.22	36.00	11.33	26.56	24.78	23.78	39.11	38.67
Bertita	33.96	33.42	18.31	37.87	14.04	10.13	30.04	36.80	31.29
Diamant	24.15	23.11	11.70	37.89	19.00	13.67	38.44	37.00	21.11
BR63-18	36.15	35.26	19.26	37.78	24.78	14.00	38.89	37.22	25.11
RoslinRuaka	16.78	16.89	9.00	37.56	15.78	10.78	38.33	35.67	21.11
LSD _{0.05}		2.13			2.27			2.41	

Table 6: Interaction of store type and storage duration on mean number of sprouted tubers

Treatment	Season1			Season 2			Season 3		
	Storage Duration			Storage Duration			Storage Duration		
	12	24	32	12	24	32	12	24	32
Store type									
RTS	28.64	27.04	10.70	32.21	23.07	17.82	37.56	35.13	18.77
DLS	25.90	25.69	12.49	32.56	37.03	26.16	34.85	37.01	25.41
ACS	32.14	34.81	33.37	32.68	-	-	29.28	39.33	38.79
LSD _{0.05}		1.40			1.85			1.83	



GROWTH INHIBITION OF ROT FUNGI BY COMPETITIVE GROWTH OF *TRICHODERMA VIRIDE*

Terna, T.P.

Department of Botany, Federal University Lafia, PMB 146, Lafia, Nasarawa State, Nigeria.

E-mail: ternapaul@yahoo.com

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ABSTRACT

A study was carried out *in vitro* to evaluate the antagonistic growth potential of a *Trichoderma viride* strain in the biological control of some common post-harvest and storage rot fungi of food crops. The experiment was set up in Completely Randomized Design (CRD) with three treatments and two replicates. Data obtained were analyzed by Analysis of Variance (ANOVA) at 5% level of probability using SPSS software version seventeen. 5mm diameter agar discs of 2-7 days old cultures of antagonist and rot fungi obtained using a sterile 5mm diameter cork borer were cultured simultaneously in dual cultures on Potato Dextrose Agar (PDA) in 8.5mm diameter petri dishes and incubated for a total duration of 9 days at 28°C. Radial growth inhibition of rot fungi increased steadily from the 1st to the 9th day of post-inoculation. Radial growth of *Aspergillus flavus* was inhibited the most (42.94%), followed by *Aspergillus niger* (30.88%) and lastly *Fusarium oxysporum* (30.65%). In pairing with *A. flavus*, massive sporulation of *T. viride* on growth surface of rot fungus was accompanied with extensive degradation of mycelia of *A. flavus* by *T. viride* after 9 days post-inoculation. Zones of mycelia growth inhibition were observed in dual cultures of *T. viride* with *A. flavus* and *F. oxysporum*. Differences in growth inhibition of rot fungi by *T. viride* were significant ($P < 0.05$) except between pairing with *A. niger* and *F. oxysporum*. The *T. viride* strain used in the study exhibited significant biocontrol potential through competitive growth against the test fungi and could be applied in biocontrol of rot fungi in storage as a means of enhancing shelf life as well as preserving the market value of harvested farm produce.

Key words: *T. viride*, Biocontrol, rot fungi, dual culture

INTRODUCTION

Trichoderma species are a group of ascomycetic fungi present in nearly all types of temperate and tropical soils. They are often isolated from decaying plant materials and in the rhizospheres of most plants (Schuster and Schmoll, 2010). Since Weindling's first report of the use of *Trichoderma* spp. as biocontrol agent for controlling plant disease in 1934, several studies have shown that *Trichoderma* spp. are the most effective biological control agents for managing plant diseases (Tsvetkov *et al.*, 2014). Biological control mechanisms employed by *Trichoderma* species in the control of other pathogenic fungi include; mycoparasitism, competition, bio fertilization, induction of host defence mechanisms and antibiosis (Benitez *et al.*, 2004; McIntyre *et al.*, 2004; Howell and Puckhaber, 2005).

The present study was aimed at evaluating the competitive competence of a soil strain of *T. viride* in the biocontrol of some post-harvest rot fungi in the study area.

MATERIALS AND METHODS

i). Source and identification of isolates

Rot Fungi

Fungi causing Post-harvest rot of Banana, namely; *A. niger* and *A. flavus*, used in the study were generously donated by a fellow researcher, Mr. Tivkaa Amande of the Department of Microbiology, University of Uyo, Nigeria. *F. oxysporum* was isolated from actively decaying plant and other organic waste in Bodija Market, Ibadan.

Trichoderma viride

Trichoderma viride was isolated from soil samples obtained from the demonstration farm of the Institute for Agricultural Research and Technology (IAR&T) Ibadan, Nigeria, using the serial dilution Figure technique on Potato Dextrose Agar (PDA), at concentration 10^{-6} . Fungal identification was carried out through Morphological and microscopic examination of purified isolates of *Trichoderma viride*, with the aid of identification keys of Rifai (1969) and the compendium of soil fungi (1980).

ii). Preservation of fungal cultures

Purified cultures of rot fungi and *T. viride* were maintained on PDA slants at 28°C pending their use in dual culture assays.

iii). Dual culture tests

The method described by Kukuc and Kivanc (2003) was used. 5mm diameter Mycelia plugs obtained from actively growing regions of 2-7 days old cultures of *T. viride* and rot fungi were obtained using a sterile cork borer, and simultaneously Figured 2.5cm apart on 8.5mm diameter petri dishes containing solidified PDA. Dual cultures were incubated for a total period of 9 days in which radial growths of test fungi were measured every 48hrs. Percentage radial growth inhibition was determined as follows:

$$PRGI = (PC - P)/PC \times 100$$

Where, PRGI = Percentage Radial Growth Inhibition of rot fungi

Pc = Radial growth of rot fungi in control Figure

P = Radial growth of rot fungi in dual culture with *T. viride*

iv). Experimental Design

The experiment was set up in Completely Randomized Design (CRD) with two treatment replicates.

v). Data Analysis

All data collected were subjected to Analysis of Variance (ANOVA) and the Least Significant Difference (LSD) determined at 5% level of probability, using SPSS software version 17.

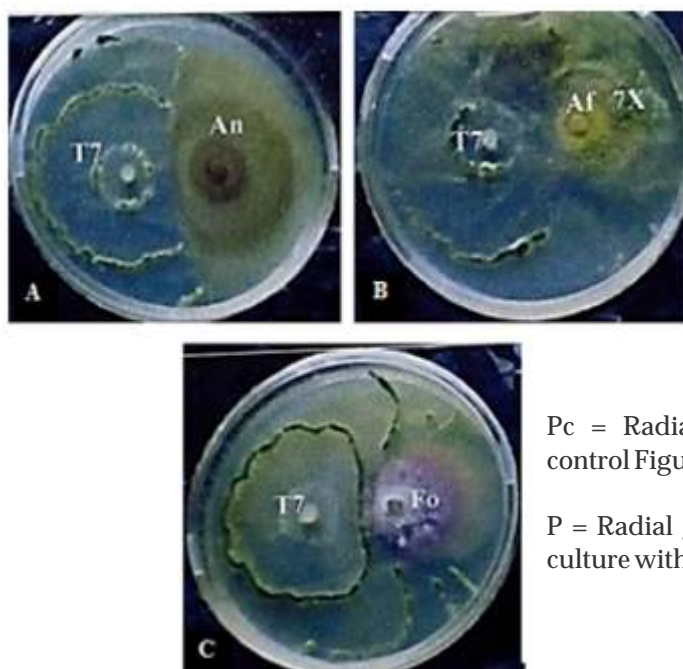
RESULTS

Table 1: Growth inhibition of rot fungi by *T. viride* in dual culture

Rot fungi	% Radial Growth Reduction by <i>T. viride</i>				
	Day 1	Day 3	Day 5	Day 7	Day 9
<i>A. niger</i>	-16.92	7.23	17.80	26.33	30.88
<i>A. flavus</i>	9.38	18.71	41.96	40.99	42.94
<i>F. oxysporum</i>	-25.81	-1.37	7.02	20.27	30.65
LSD					12.06

Growth inhibition of all rot fungi by *T. viride* (Table 1) increased steadily from the 1st day of pairing to the 9th day. The highest inhibition of all rot fungi was observed after 9 days of pairing in dual cultures. *A. flavus* was inhibited the most (42.94%), and differed significantly ($P < 0.05$) from *A. niger* (30.88%) and *F. oxysporum* (30.65%). In pairing with *A. flavus*, massive sporulation of antagonist was also observed on

mycelial growth of the rot fungus after 9 days of pairing in dual culture (Figure 1b). Massive degradation of mycelia of *A. flavus* by *T. viride* was also observed (Figure 1B). Faint zones of mycelia growth inhibition were observed after 9 days in pairing of *T. viride* with *A. flavus* and *F. oxysporum* (Figure 1b and 1c).



Pc = Radial growth of rot fungi in control Figure

P = Radial growth of rot fungi in dual culture with *T. viride*

Figure 1. Growth of *T. viride* and rot fungi in dual cultures.

T7 = *T. viride*
 An = *A. niger*
 Af = *A. flavus*
 Fo = *F. oxysporum*
 7x = Spores of *T. viride*

DISCUSSION

The *Trichoderma viride* strain used in the study inhibited radial growths of *A. niger*, *A. flavus* and *F. oxysporum* in dual cultures. Growth inhibition of the rot fungi by *T. viride* progressed steadily from the 1st day of pairing through to the 9th day. Antagonism by *Trichoderma* requires a progressive build-up of toxins and other factors that function synergistically in reducing the growth of pathogenic fungi. In a similar work by Shafiquzzaman *et al.* (2009), it was reported that growth inhibition of *G. boninense* by *T. harzianum* increased from 47.86% on the 9th day to 72.06% 14 days after pairing in dual culture.

Massive sporulation of *T. viride* on rot fungi was observed in the presence of significant degradation of rot fungi mycelia. These features are indications of the mycoparasitic nature of the *T. viride* strain used in the study. In a previous study, Terna *et al.* (2013) also reported significant biocontrol activity of lytic enzyme induced culture filtrates of the *T. viride* strain used in this study. *Trichoderma* controls other fungal pathogens via a mycoparasitic process in which its mycelia grows towards the pathogenic fungi, coils around them and secret enzymes that degrade pathogens' cell walls (Vinale *et al.*, 2008). They also penetrate and destroy some of the fungal resting structures, thereby reducing their inoculum potential (Howell, 2005).

F. oxysporum was the least inhibited by the antagonist. A similar observation was reported by Sivan and Chet (1989) in which it was suggested that higher resistance of *F. oxysporum* to lysis by *Trichoderma* species could be as a result of the high protein content of their cell walls.

CONCLUSION AND RECOMMENDATIONS

The *Trichoderma viride* strain used in the study exhibited potent competitive ability and could be further explored *in vivo* for biological control of post-harvest rots especially those produced by *A. niger*, *A. flavus* and *F. oxysporum*.

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INSECTICIDAL EFFECTS OF THE ETHANOLIC EXTRACT OF *PSEUDOCEDRELAKOTSCHYI* AGAINST *DERMESTES MACULATUS* (COLEOPTERA: DERMESTIDAE) ON TREATED DRIED CATFISH (*CLARIAS GARIEPINUS*).

¹Yakubu, D.P., ²Dawet, A*, ³Allan, A.I. and ⁴Nwibari, B.M.W.

Department of Zoology, Faculty of Natural Sciences, University of Jos, Jos, Nigeria.

*Corresponding Author's E-mail: thonydawet@gmail.com

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ABSTRACT

This research work was carried out to assess the insecticidal properties of the ethanol extract of *Pseudocedrela kotschy* in the control of *Dermestes maculatus* infesting dried fish (*Clarias gariepinus*) in storage. Ethanol extract of *P.kotschy* was administered in different concentrations to dried fish infested with larvae and adult stages of *D.maculatus*. 96gram of dried fish sample was divided into 12 groups of 8g each and each group was subdivided into three (3) replicates of 2.7g of dried fish in each treatment. For the bioassay test, groups 1-6 were infested with 10 larvae of *D. maculatus* each and treated with 0.1, 0.5, 1.5, 3.0, 6.0, and 9.0g of plant extract respectively. Groups 7 and 8 were infested with 10 adult *D.maculatus* and treated with 3.0 and 9.0g of plant extract respectively. Groups 9 and 10 were infested with 10 larvae and adult *D.maculatus* respectively and treated with 9.0g of standard insecticide each. Groups 11 and 12 were infested with 10 larvae and adult *D. maculatus* respectively but not treated with either the plant extract or pestox (standard insecticide) but as controls. The set-up was monitored daily for seven days. In the groups treated with the plant extract, the highest mortality rate was observed in smoked fish treated with 0.1g (2.23%) plant extract while the mortality rate of 1.1 % each was recorded in smoked fish treated with 1.5g and 9.0g plant extracts, compared 4.44 % recorded in the untreated (control). The extract had no significant ($P>0.05$) effect on the mortality of the insects. The groups treated with 9 gpestox (standard insecticide) recorded the highest mortality 25 (27. 78 %) compared to the groups treated with the plant extract. The ethanol stem bark extract of *P.kotschy* reduced the activities of *D.maculatus* larvae and adults.

Keywords: Insecticidal effects, *P.kotschy*, *D. maculatus*, Dried fish.

INTRODUCTION

Fish is very rich in essential amino acids, vitamins and minerals (FAO, 2004). Fish is also very important in terms of employment and income generation, poverty alleviation, foreign exchange earnings, and provision of raw materials for the animal feed industry. Nigerians are high fish consumers with a total annual consumption figure of 1.2 million metric tons (FDF, 2005). Dried (smoked or sundried) fish is a highly relished item of many traditional dishes in Nigeria as food and condiment that greatly enriches the flavour of various dishes. It is one of the major sources of proteins and essential minerals in the tropics (Odeyemi *et al.*, 2000).

Smoked fish is one of the most widely distributed and the cheapest sources of protein and micro-nutrients in Nigeria. However, it is usually infested by insect pests, such as *D. maculatus* and *Necrobiarufipes*. Osuji (1974) reported that about 71.5% of dried fish infestation in most of the producing areas was caused by *D. maculatus*. However, the general use of such chemicals to protect stored fish has been hampered by reports of health hazards and high cost of purchase. Adeyemi *et al.* (2000) reported that fish treated with chemical insecticides adversely affect consumers, causing blurred vision, dizziness and vomiting. In addition, Amusan and Okorie (2002) reported that dermestid larvae and adults, unlike many other beetles, are less susceptible to synthesized insecticides that normally attack pests of stored products. Therefore, attention is currently being focused on the use of natural preservation materials that are cheap, easily accessible and that have long term protecting ability. In this regard, a host of plant materials are presently considered as a promising alternative to synthetic insecticides in the control of pests of crops and animals (Saxena, 1989; Onifade and Alabi, 1998). Plant derived materials are more readily biodegradable. Some are less toxic to mammals, may be more selective in action, and may retard the development of resistance.

The main advantage is that such insecticides may be easily accessed by the farmers and small scale industries. Studies have indicated that several plant products such as leaf, bark, seed powder or oil extracts of plants when mixed with stored grains reduce oviposition rate, suppress adult emergence of bruchids, and also reduced seed damage rate (Onu and Aliyu, 1995; Keita *et al.*, 2001; Tapondjou *et al.*, 2002). Several natural products, including oils derived from plant materials, have been tested as protectants of dried fish from insect pest infestation. The fruit oil of *Piper guineense* (Family: Piperaceae) was found to be effective as protectant of dried fish against larval and adult stages of *D. maculatus* (Amusan and Okorie, 2002). The kernel oil of neem *Azadirachta indica* (A. Juss). (Family: Meliaceae) caused high mortalities in both the larvae and adults

of *D. maculatus* in dried fish and suppressed oviposition and adult emergence (Onu and Baba, 2003).

There has been an increasing search for edible, cheap, and safe plant materials that will not contaminate food products in acting as grain protectants in small storage systems (Arannilewa, 2002). It is on this basis that the present study was carried out to investigate the insecticidal property of *P. Kotschyi* against the insect pest of dried fish (*D. maculatus*).

MATERIALS AND METHODS

Collection and Extraction of Plant Materials

This was carried out in a similar method as described by (Dawet *et al.*, 2011). *Pseudocedrel lakotschyi* stem bark was collected from Bwai in Mangu Local Government Area, Plateau State, Nigeria. The stem bark of *P. kotschyi* was collected and dried in the open air under shade for 7 days and pulverized using mortar and pestle. The pulverized stem bark (458g) was soaked in 800 ml absolute ethanol for 72 hours and filtered. The filtrate was then dehydrated in a hot oven at 50°C and the residue was stored at 4°C until use.

Collection and Maintenance of Experimental Insects

Dermestes maculatus were obtained from infested smoked *Clarias gariepinus* from Katako Market in Jos, Plateau State, Nigeria. The beetles were identified based on morphological characters described by Borro and Delong (1964). The identified insects or beetles were kept in a plastic container covered with muslin cloth along with dried fish.

Collection of Dried Fish

Dried *Clarias gariepinus* were purchased from Katako Market, Jos, Plateau State, Nigeria. The fish were cut into pieces to check for any hidden insect and also for ease of feeding during the experiment.

Formulation and Administration of Plant Extract (Bioassay)

These were carried out in the Undergraduate Research Laboratory, Department of Zoology, University of Jos, Jos, Nigeria. The crude extract was pulverized in a crucible after dehydration, into fine powdery particles and weighed on a sensitive weighing balance. The required amount of the residue which varies according to the dose was mixed with the dried fish. 96gram of dried fish sample was divided into 12 groups of 8g each and each group was subdivided into three (3) replicates of 2.7g of dried fish in each plastic container of 17 cm wide and 12 cm high and covered with muslin cloth to prevent the movement of insects and enhance proper aeration. Group 1-6 were infested with 10 larvae of *D. maculatus* each and treated with 0.1, 0.5, 1.5, 3.0, 6.0, and 9.0g of plant extract respectively. Groups 7 and 8

were infested with 10 adult *D. maculatus* and treated with 3.0 and 9.0g of plant extract respectively. Groups 9 and 10 were infested with 10 larvae and adult *D. maculatus* respectively and treated with 9.0g of pestox (standard insecticide) each. Groups 11 and 12 were not treated with either the plant extract or standard insecticide but infected with 10 larvae and adult *D. maculatus* respectively as controls. The set-up was observed every twenty four hours for one week during which the mortality was recorded.

Determination of the

Mortality of *Dermestes maculatus*

The mortality of test organisms was observed and recorded every twenty four hours. Larvae and adult *D. maculatus* were considered dead when no response was observed after probing them on their antennae, ventral part or the lateral side with a forcep under a hand lens or dissecting microscope. Death larvae and adult *D. maculatus* were isolated and stored in separate containers as soon as the mortality was observed and recorded.

Data Analysis

One way analysis of variance (ANOVA) was used to determine the significant effect of the plant extract on the mortality of the insects.

RESULTS AND DISCUSSION

The effect of *P. kotschy* stem bark extracts on the larvae *D. maculatus* is showed in Tables 1 and 2. In the groups treated with the plant extract, the highest mortality rate was observed in dried fish treated with 0.1g (2.23%) plant extract and least mortality rate in smoked fish treated with 1.5g and 9.0g (1.1%) plant extracts respectively, compared to the untreated (control) with mortality rate of 4.44%. The groups treated with the 9 g pestox (standard insecticide) recorded the highest mortality 25 (27.78 %) compared to the untreated group.

Tables 3 and 4 showed the effect of *P. kotschy* stem bark extract on adult mortality. In groups treated with the plant extract, the highest mortality 8 (8.89 %) was observed in smoked fish treated with 9.0g while the least mortality 3 (3.33 %) was recorded in group treated with 3.0g crude ethanolic extract of *P. kotschy* compared to 8 (8.89 %) recorded in the untreated (control). Groups treated with 9 g of the pestox (standard insecticide) recorded 30 (3.34 %) mortality to the untreated control. The statistical analysis shows that the plant extract had no significant ($P>0.05$) effect on *D. maculatus* larvae and adults.

The low mortality recorded in this study is at variance with (Don-Pedro, 1985) who reported 50 % mortality of adult *Callosobruchus maculatus* and *D. maculatus* in cowpea grains and fish chips mixed with

5.62 g and 14.29 g respectively. Similarly, Don-pedro (1989) reported that application of oils (groundnut, traditional coconut, industrial coconut, palm, and shark liver oil) against *D. maculatus* on dried trout (*Salmo gairdneri*) significantly reduced the development of progeny of *D. maculatus* only at dosages of 56ml/kg. The variation in the result of this study could probably be due to the insect resistance to the plant extract used in this study. Results of this study indicate that larvae mortality did not increase with increase in the concentrations of the ethanol extract of *P. kotschy*.

Contrary to Osuji (1975) who reported that salting of fish gives protection against *D. maculatus*, partly because larval development is prolonged and larval mortality increased with increase in salt content. The increase in mortality of *D. maculatus* adults with increase in concentration of *P. kotschy* plant extract reported in this study is consistent with Abdullahi *et al.* (2010) [who report that the effects of the spice powder of *Piper guineense* on the mortality of adult *D. maculatus* was higher in dried fish treated with higher dosage of the pepper which recorded 100% mortality of the beetle within 2 days of treatment. Mortality caused by *P. kotschy* extract on larvae and adult *D. maculatus* could probably be attributed to several mechanisms which could include blockage of spiracle of the insects, and thus impairing respiration, leading to the death of the insects (Adeyemi *et al.*, 2000; Owoade, 2008). Mortality observed in the untreated control could probably be due to physiological factors other factors than plant extract.

CONCLUSION

The ethanol stem bark extract of *P. kotschy* reduced the activities of both larvae and adult beetles in feeding and movement during the 7 days exposure suggesting that the plant possesses potential insecticidal properties although low mortality of *D. maculatus* larvae and adults were recorded at varying concentrations.

Other methods of formulation can also be exploited or could be in combination with other plant materials to test the combined effects of the botanicals in controlling the hide beetles. More plant materials should be exploited so as to have different alternatives to chemically synthesized pesticides in order to eradicate or reduce to the barest minimum, the detrimental effects or health hazards imposed by the use of chemical to safeguards human health and ensures a safe environment. Further research should be carried out on the insecticidal activity of *P. kotschy* and the effects of the extract on the nutritional values of the food products.

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Table 1: Mortality of *Dermestes maculatus* Larvae in Dried Fish Treated with Ethanol Extract of *Pseudocedrela kotschy* and Pestox (Standard Insecticide)

CONC. (g)	No. of Pest in each replica te	Weight of fish (g)	Mortality																						
			Day 1			Day 2			Day 3			Day 4			Day 5			Day 6			Day 7			TOTAL	
			Replicates			Replicates			Replicates			Replicates			Replicates			Replicates			Replicates				
			R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃		
0.1 (P.E)	10	8.0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
0.5 (P.E)	10	8.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5 (P.E)	10	8.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
3.0 (P.E)	10	8.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.0 (P.E)	10	8.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.0 (P.E)	10	8.0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
9.0 (C.P)	10	8.0	0	0	0	0	0	0	1	2	0	1	1	0	0	2	2	2	1	6	4	2	1		25
0.0 (C)	10	8.0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	4

R1 = Replicate one, R2 = Replicate two, R3 = Replicate three, P.E = Plant extract, C.P = Chemical pesticide, C = control

Table 2: Mean Mortality of *Dermestes maculatus* Larvae in Dried Fish Treated with Ethanol Extract of *Pseudocedrela kotschy* and Pestox (Standard Insecticide)

	JNC. (g)	No of Plastic	Pest in each Container		Weight of fish (g)	Mean mortality (%)							
			R ₁	R ₂		R ₃	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	1 (P.E)	10	10	10	8.0	0±0.00(0)	0±0.00(0)	0±0.00(0)	0±0.00 (0)	0.67±0.3(2.20)	0±0.0(0)	0±0.00(0)	2(2.20)
2	0.5 (P.E)	10	10	10	8.0	0±0.00(0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0
3	1.5 (P.E)	10	10	10	8.0	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0.3±0.35(1.10)	0±0.00 (0)	1 (1.10)
4	3.0 (P.E)	10	10	10	8.0	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0
5	6.0 (P.E)	10	10	10	8.0	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0
6	9.0 (P.E)	10	10	10	8.0	0.3±0.35(1.10)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0
9	9.0 (C.P)	10	10	10	8.0	0±0.00 (0)	0±0.00 (0)	1±0.5(3.33)	0.67±0.33(2.20)	1.3±0.66(4.44)	3±1.50(10)	2.3±1.17(7.78)	25(28)
11	0.0 (C)	10	10	10	8.0	0±0.00 (0)	0±0.00 (0)	0±0.00 (0)	0.67±0.3(2.22)	0.33±0.35(1.10)	0.3±0.35(1.10)	0±0.00 (0)	4(4.44)

R1 = Replicate one, R2 = Replicate two, R3 = Replicate three, P.E = Plant extract, C.P = Chemical pesticide, C = control

Table 3: Mortality of Adults *Dermestes maculatus* in Dried Fish Treated with Ethanol Extract of *Pseudocedrela kotschy* and Pestox (Standard Insecticide)

CONC. (g)	No. of Pest in each replica te	Weight of fish (g)	Mortality																						
			Day 1			Day 2			Day 3			Day 4			Day 5			Day 6			Day 7			TOTAL	
			Replicates			Replicates			Replicates			Replicates			Replicates			Replicates			Replicates				
			R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃	R ₁	R ₂	R ₃		
3.0 (P.E)	10	8.0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	3
9.0 (P.E)	10	8.0	0	0	0	0	2	0	0	0	0	1	1	0	0	1	0	0	3	0	0	0	0	0	8
9.0 (C.P)	10	8.0	1	1	0	3	4	5	0	2	3	3	1	1	1	0	1	0	1	0	2	1	0	30	
0.0 (C)	10	8.0	1	1	0	0	1	0	0	0	0	2	0	0	0	0	0	2	0	0	1	0	0	8	

R1 = Replicate one, R2 = Replicate two, R3 = Replicate three, P.E = Plant extract, CP = Chemical pesticide, C = Control

Table 4: Mean Mortality of Adult *Dermestes maculatus* in Dried Fish Treated with Ethanol Extract of *Pseudocedrela kotschy* and Pestox (Standard Insecticide)

	CONC. (g)	NO Plastic	of Pest in each container		Weight of fish (g)	Mean mortality (%)							
		R ₁	R ₂	R ₃		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total (%)
8	3.0(P.E)	10	10	10	8.0	0±0.00(0)	0±0.00(0)	0±0.00(0)	0.67±0.3(2.23)	0.33±0.35(1.10)	0±0.00(0)	0±0.00(0)	3(3.33)
	9.0(P.E)	10	10	10	8.0	0±0.00(0)	0.67±0.3(2.22)	0±0.00(0)	0.67±0.3(2.22)	0.33±0.35(1.10)	1±0.35(3.33)	0±0.00(0)	8(8.89)
10	9.0(C.P)	10	10	10	8.0	0.67±0.3(2.20)	4±0.87(13.33)	1.67±0.67(5.56)	1.67±0.67(5.56)	0.67±0.3(2.22)	0.3±0.35(1.10)	1±0.35(3.33)	30(33)
12	0.0 (C)	10	10	10	8.0	0.67±0.3(2.20)	0.3±0.35(1.10)	0±0.00(0%)	0.67±0.3(2.22)	0±0.00(0)	0.67±0.3(2.20)	0.33±0.35(1.10)	8(8.89)

R1 = Replicate one, R2 = Replicate two, R3 = Replicate three, P.E = Plant extract, C.P = Chemical pesticide, C = control.



MEAT QUALITY IMPROVEMENT AND HERITABILITY OF BODY WEIGHT AND CHEMICAL COMPOSITION OF BREAST MEAT IN JAPANESE QUAIL (*Coturnix coturnix japonica*)

¹Kaye J. *, ²Akpa G.N., ³Adeyinka I.A. and ⁴Nwagu B.I.

¹Department of Animal Production, University of Jos

²Department of Animal Science, Ahmadu Bello University, Zaria

³National Animal Production Research Institute, Ahmadu Bello University, Shika- Zaria

*Corresponding Author's E- mail: jokaye2003@gmail.com

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ABSTRACT

The study was conducted to investigate the effect of sex, age, generation on meat quality of 752 Japanese quail. Determined also were realized h^2 of body weight, body length and chemical compositions of the birds. Data obtained were subjected to analyses of variance and realized heritability calculated as appropriate for the following: To quantify changes in breast meat quality with respect to age and sex, body measurements with respect to sex, age and generations selected and to determine the realized h^2 of body dimension, body weight and chemical composition in Japanese quail. The result shows that the sex of birds were affected by pH20mins, pH24hr Cooking loss, colour (P and pectoral major water holding capacity and lightness colour (P. The advanced in age significantly affects the pH20mins, pectoral major water holding capacity, cooking loss breast muscles, lightness, redness, yellowness, chroma, hue and drip loss, pectoral major water absorbing capacity. Age, sex and generation significantly affect body length and some economic traits and sex of the birds except pelvic circumference and breast length in sex of Japanese quail. The realized h^2 for body weight at day 56, breast length and body length at day 35 ranges from moderate to high (0.24 – 0.71). The realized h^2 for chemical composition of the Japanese quail are low NFE (0.01), ash (0.04). The possibility depends on the genetic variability of body weight and body composition. The low, moderate to high realized h^2 is an indication that the traits are affected by additive genetic effects in the case of low h^2 and also for moderate to high h^2 the traits are affected by non additive genetic effects and environmental factors.

Key words: Japanese quail, meat quality, body measurement, generations, realized h^2

INTRODUCTION

The major poultry meat quality attributes are appearance, texture, juiciness, flavour and functionally. With increasing trends in further processing, meat functionality has increased in relative importance, especially because of its key role in determining the sensory quality of complex ready-to-eat products (Fletcher, 2002). Meat pH is one of the major contributing factors to poultry meat colour. Variation in pH significantly affected the storage and processing quality of poultry meat by modifying its water holding capacity and properties. Low pH meat is characterized by low water-holding capacity and poor quality and is usually referred to as pale, soft and exudative (PSE) meat (Barbut, 1997). High pH meat, known as dry, firm and dark (DFD), presents poor storage quality due to faster rate of off-odor production and accelerated microbial growth (Allen *et al.*, 1997).

Selection of meat-type quails focused not only on increased growth performance but also on improved carcass quality of the Japanese quail meat. In particular, the emphasis has been on better body composition, with higher breast meat yield and lower abdominal fat. This focus responds to the consumer desire for healthier meat, and to the evolution of the meat through a rising demand for portioned and processed products (Barton, 1994; LeBival-Duval, *et al.*, 1999). The profitability of quail production is therefore largely determined by the possibility of increasing the proportion of prime parts in the carcass determined, genetically (Debut, *et al.*, 2003).

Galobart and Moran (2004) and Musa *et al.* (2006) stated that there was rapid decrease in pH at early postmortem when carcass temperatures are still elevated as a result of pale, soft and exudative-like meat. Other similar investigation on meat quality was conducted (Pikul *et al.*, 1987; Knust and Pingel, 1992 and Witkiewicz, 2000).

Akram *et al.* (2013) stated that as quail advances in age body length, drumstick length and shank length increases. Nsosoet *al.* (2008) stated the body length and shank length to increase significantly up to 45 days of age. The analysis of body dimensions in poultry bird at different ages showed that their body length, drumstick length, shank length, breast length increases with advance in age (Kozaczyrski, 1999).

Body composition can be significantly improved by selection, as shown by the high level of the heritability of the amount of meat, ranging from 0.40 and 0.65 in the studies of Vereijken (1992), Jego *et al.* (1995), and Le Bihan-Duval *et al.* (1998). Many researches on selection to improved quail meat has been successful, but the impact on meat quality, and especially on storage and processing quality, remains to be clarified. Therefore, the research was geared towards determining meat quality improvement and heritability of body weight and chemical composition of breast meat in Japanese quail. The effect of sex, age

and generation on meat quality in Japanese quail was the focus of this study.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the Poultry Unit of Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Samaru-Zaria. Zaria is within Northern Guinea Savannah zone of Nigeria, latitude 11° 12'N and longitude 7° 33'E at an altitude of 610M above sea level. The climate is relatively dry, with mean annual rainfall of 700-1400mm, occurring between the Month of April and September. The dry season begins around the middle of October, with dry cold weather that ends in February. This is followed by relative hot, dry weather from March to April, when the rain begins. The mean minimum and maximum daily temperature is about 14° and 24°C during the cool season and 19° and 36°C during the hot season. The relative humidity varies between 19% in the dry season and between 63% and 80% in the wet season as stated by Akpa *et al.* (2002).

Mating Plan

Artificial selection was carried out on the birds at day 35, 42, 49 and 56 after weighing all the birds. Those with the highest weight were chosen for breeding consisting of 28 males and 84 females. The selected birds were mated in a constructed cage at the ratio of 1 male to 3 females (1:3) in constructed caged of 10cm x 10cm x 10cm to determine the BW, carcass weight, Body Length traits, minerals and chemical composition of meat. For the study that utilized mating ratio 1:3, all the birds were wing banded in accordance with the families and 1500 fertile eggs were hatched.

Management of Fertile Egg

Eggs were collected daily after the birds had reached maturity. Eggs were identified by their sire families (28), stored at room temperature lower than 20°C and 65% relative humidity (RH) for a week, and then disinfected with tetra hydroxyl (TH4) mixed with 1 liter of water for spraying on egg surface. Pedigreed eggs were set in the setting trays, depending on their sire families and arranged in a forced draft incubator with temperature of 37.5°C and 65% RH. Eggs were turned automatically every three hours. At the end of the 14th day of incubation, eggs were transferred into pedigree hatching baskets and moved into the hatcher where the temperature was 37.5°C and RH was 70%.

Incubation and Hatching of Fertile Eggs

Pre-incubation of the fertile egg collected was made by storing them at a temperature of 15°C. Fumigation was done 12 hours before placing them in the incubator. When eggs were set in the incubator, temperature requirement was put at 37.5 °C with humidity of 60% and turning of eggs was at an angle of 45° for 4-6 times a day and the chicks were hatched

at day 18 of incubation.

Experimental Birds and their Management

The research Japanese quails were purchased at 21 days of age, from National Veterinary Research Institute (NVRI), Vom, Plateau State. The management of the young chicks included the provision of supplementary heat for 4 weeks at least 24 hours lighting, and thereafter 13 to 16 hours light and 6 to 8 hours dark cycle. Indoor air temperature for the chicks was 36 °C. Birds were allowed ad libitum access to food and water. They were fed with starter and grower diet containing 24% crude protein (CP) and 2904ME, Kcals/kg between 1-35 days of age. Thereafter a breeder diet containing 23% CP and 2800, Kcals/kg ME was fed. The same diets were provided to birds on the selection process across various generations. The minerals and vitamins were adequately supply to cover the requirements according to NRC (1994).

Data collection

Three generations namely base population, G_1 and G_2 . The following data were collected on each generation:

Body length

Six hundred and seventy-two birds were used to study the body length (cm) traits of the birds. The birds were sexed at day 21 at which point they were feathered.

Live Body Length Measurement (cm)

The same six hundred and seventy two birds used for live body weight measurement and live body length traits measurement were taken on the birds. The measurements were taken after sexing at day 21 (point when birds were feathered).

Pelvis circumference (cm): measured by using vernier caliper across the pelvis, Breast Length (cm): Obtained by using a tailors tape, measured from the back bone to the last cervical vertebra round the body, Shank Length (cm): Obtained by using a tailors tape from the hock joint to the base of the 3 toes, Drumstick +Thigh length (cm): Determined by using the tailors tape from the pelvis joint down through the thigh drumstick to the hock joint before shank, Wing length (cm): Determined by placing tailors tape across from the tip to the point of attachment of wing to the body of the bird Breast circumference (cm): Vernier caliper was used to determine the circumference of the breast, corrected to the nearest 0.01mm.

Quail Meat Proximate Composition:

Three samples from the birds slaughtered for body weight measurement were taken from female and male birds collected from breast portion weekly at day 35, 42, 49, 56 for G_0 , G_1 , G_2 to determine moisture, protein, fat, ash, and NFE contents. They were determined in accordance with the standards of

AOAC methods (AOAC, 2000). Protein determination involved a Kjeldahl assay ($N \times 6.25$). Fat was determined by extracting samples in a soxhlet apparatus using petroleum ether as a solvent. Moisture was quantified by oven-drying 10g samples at 100°C over night. Ash was determined after incineration in a furnace at 550°C and carbohydrate content was calculated by computing the difference.

Rate and the Intensity of the Muscle Acidification during Post mortem:

Physical and chemical traits from the left side of the breast sample was taken from the 10 male and 10 female birds at day 35, 42, 49 and 56 to determine breast muscle pH_{20min} ($_{20min}$) post slaughter and pH_{24hour} ($_{24hr}$) post slaughter. At the 24th *post mortem* hour, hydrophilic properties of meat were also determined as – water holding capacity (WHC) and water absorption capacity (WAC) and colour characteristics of the meat were determined:

The breast muscles pH was determined with ten female and ten male birds were slaughtered at day 35, 42, 49 and 56 after a 6-hour fasting period. After slaughter, evisceration and defeathering, $_{20min}$ and $_{24hr}$ values were measured with a pH meter, equipped with glass electrode and a temperature probe. The pH of a solution was taken the negative logarithm of the hydrogen ion activity determined in breast portion of meat using standard buffer solutions. They were prepared with carbon-dioxide-free water and stored in bottles of chemically resistant glass. The apparatus was calibrated with standard buffer solutions to check the linearity of the response of the electrode at different pH values and to detect a faulty glass electrode. The standardization of the apparatus was calibrated with two standard buffer solutions. After the apparatus has been calibrated, the electrodes and the cups were thoroughly washed. The cup were fill with a portion of the solution tested and preliminary values were obtain before getting the actual value of the pH subsequently for each sample of day 35,42,49 and 56 for the two sexes.

Water Holding Capacity (WHC) was determined with ten samples of approximate size of 2.0 1.0 0.5 cm meat were obtained from the pectoral muscles. They were weighed with a precision of 0.001 g, and put in tubes containing 15 ml saline. Samples were left for 24 hours at about 2-40 °C. After 24 h, meat pieces were removed from the tubes, carefully dried on a filter paper and again weighed on the same scales.

The WHC of meat was calculated as:

$$WHC = (b-a) \times \frac{10}{a}$$

Where: a – weight of the piece of meat prior to analysis (g), b - weight of the piece of meat after a 24-stay in physiological saline (g).

The Water Absorbing Capacity (WAC) of meat was determined in saline. Two samples of approximate size of 2.0 1.0 0.5 cm meat were obtained from the pectoral muscles. They were weighed with a precision of 0.001 g, and put in tubes containing 15 ml saline. Samples were left for 24 h at about 2-40 . After 24 h, meat pieces were removed from the tubes, carefully dried on a filter paper and again weighed on the same scales.

The WAC of meat was calculated as:

$$WAC = (b - a) \times 10 / a \quad (b-a) \times \frac{10}{a}$$

Where, a - weight of the piece of meat prior to analysis, g; b - weight of the piece of meat after a 24hr - stay in physiological saline, g.

The muscles colour was determined by taken a sample of sliced meat from the posterior part of the breast muscle was obtained from 10 female and 10 male Japanese quail after slaughter to determine the colour of muscles set-up a spectrophotometer produced by X-Rite incorporated. The values of L*, a* and b* colorimetric coordinates were determined on scale (Riegel *et al.*,2003): L* corresponds to Lightness, a* corresponds to Redness, b* corresponds to yellowness, On the basis of a* and b* values were calculated as follows:

$$\text{Chroma ()} = (a^{*2} + b^{*2})^{0.5}$$

Hue angle (h°), that specifies the site of cross point of coordinates a* and b*: $h^{\circ} = \text{tg}^{-1} (b^{*}/a^{*})$

Estimation of Genetic Parameters

Realized heritability

The realized heritability (h^2) for traits were obtained for each generation by the formula ($h^2 = R/S$) that is the ratio of selection response to total selection differential. The response to selection (R) was determined as the deviation of the selected progeny mean from the mean of the parent generation (Falconer, 1970). The selection differential (S) was estimated as the difference between the mean of the selected population and the overall population. Significant differences among means were separated by the Duncan's multiple range test (Duncan, 1955).

Statistical analysis

Statistical analysis was done by the aid of SAS software (SAS, 2004) according to the following Statistical models:

$$Y_{ijkl} = \mu + G_i + H_j + s_k + GH_{ij} + GS_{jk} + e_{ijkl}$$

Where: Y_{ijkl} = the observation of $ijkl^{\text{th}}$ bird, μ = overall mean, G_i = effect of i^{th} generation ($i = 0, 1, 2$), H_j = effect of j^{th} age ($j = 35, 42, 49, 56$ day), s_k = effect of k^{th} sex ($k = \text{male and female}$), e_{ijkl} = random error.

Significant differences between means were ranked by using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Table 1 shows the least square means of breast meat quality of Japanese quail as influenced by age and sex. The result for the breast meat differed significantly ($P < 0.05$) in age and sex, except pectoralis major water holding capacity, lightness (L*) which differed significantly ($P < 0.01$) in sex and % drip loss, pectoral major water absorbing capacity which are not significant also in sex. The % drip loss and pectoralis major water absorbing capacity differed significantly ($P < 0.01$) for age of Japanese quail.

The sex of the birds that shows that female traits improved more than the males in $P^{\text{H}}_{20 \text{ mins}}$, pectoralis major water absorbing capacity, lightness (L*), yellowness (b*). While males are more than females in $P^{\text{H}}_{24 \text{ min}}$, cooking loss breast muscle, Redness, chroma. As birds advances in age there was decline in $P^{\text{H}}_{20 \text{ mins}}$, pectoral major water holding capacity, lightness (L*), Chroma, Hue. The $P^{\text{H}}_{24 \text{ mins}}$, % drop loss, Pectoral major, water absorbing capacity, Lightness (L*), Redness (a*) yellowness (b*) shows intermittent increased and decreased.

The least square means for body length and some economic traits affects the sex and generations of Japanese quail at day 56 is shown in Table 2. The result indicated that body length and body weight differed significantly ($P < 0.05$) in sex and generation of birds, except body weight 56 which differed significantly ($P < 0.01$) in sex, while non significant difference was observed for pelvic and breast circumference. The females have higher body length and body weight increase than the males except body length at day 35. There was improvement in generation selected (G_s) than G_1 and G_2 , but G_2 has higher value increase than G_1 .

The realized heritability of body dimension at day 35, 42, 49 56; body weight at day 56 and various body parts dimension at day 56 of Japanese quail is shown in table 4. The result indicated that realized h^2 for the traits are from moderate to high. The responses to selection in mean and percentage values for response to selection are lower than selection differential.

Table 5 show the realized heritability of chemical composition of Japanese quail and the result indicated that h^2 values were low for ash and nitrogen free extract while crude protein, oil were moderate and dry matter was high. The response to selection mean and percentages were lower than the selection differential.

Table 1: Least square means of breast meat quality of Japanese quail as influenced by age and sex

Characteristic s	N	Sex		LoS	Slaughter age (d)				LoS
		Males	Females		D ₂₅	D ₄₂	D ₄₉	D ₅₆	
pH _{20min}	10	6.1±0.22 ^a	6.3±0.15 ^a	*	6.5±0.18 ^a	6.5±0.20 ^a	6.05±0.19 ^b	6.0±0.12 ^b	*
pH _{24hours}	10	5.9±0.11 ^a	5.8±0.01 ^a	*	5.9±0.03 ^a	5.8±0.02 ^a	5.8±0.01 ^b	5.3±0.05 ^b	*
% Drip loss	10	0.8±0.01 ^a	0.8±0.04 ^a	Ns	4.0±0.02 ^d	0.8±0.02 ^a	0.7±0.03 ^b	0.6±0.005 ^c	**
pectoralismajor, water holding capacity	10	17.7±0.62 ^b	20.3±0.41 ^a	**	17.9±0.41 ^c	18.7±0.43 ^b	19.7±0.45 ^a	19.8±0.0.46 ^a	*
Pectoralis major, water absorbing capacity	10	23.4±0.62 ^a	23.4±1.75 ^a	Ns	27.2±1.75 ^a	23.7±1.91 ^b	22.8±1.11 ^b	19.9±1.89 ^c	**
Cooking loss, breast muscle	10	31.1±2.47 ^a	27.3±0.85 ^b	*	25.4±0.85 ^d	26.6±1.56 ^b	30.1±1.56 ^c	34.9±0.78 ^a	*
Lightness(L [*])	10	42.9±0.52 ^c	44.4±0.83 ^a	**	44.8±0.93 ^a	43.7±0.85 ^b	43.5±0.03 ^b	42.7±0.56 ^d	*
Redness(a [*])	10	10.8±0.41 ^a	10.7±0.40 ^a	*	10.1±0.41 ^a	10.4±0.40 ^a	11.0±0.48 ^b	11.4±0.25 ^b	*
Yellowness(b [*])	10	11.0±0.20 ^a	11.4±0.32 ^a	*	11.1±0.32 ^a	11.3±0.36 ^a	11.1±0.31 ^a	11.3±0.61 ^a	*
Chroma(C ^o)	10	15.2±0.46 ^a	14.9±0.36 ^b	*	14.4±0.17 ^d	15.5±0.57 ^b	15.5±0.42 ^c	15.7±0.46 ^a	*
Hue(h ^o)	10	0.7±0.17 ^a	0.7±0.59 ^a	Ns	0.6±0.06 ^c	0.7±0.05 ^b	0.8±0.02 ^a	0.8±0.03 ^a	*

Means for each character within sex generations and age with different superscripts differ*=(P<0.05),**=(P<0.01); G₀= Base population; G₁=Generation one, G₂=Generation two, pH_{20min} = pH value after 20min postmortem; pH_{24hr} = pH value after 24hr postmortem

Table 2: Least square means for some parts of body dimension in Japanese quail of different generations and sex

Traits	N	Sex			Generation				
		Males	Females	LoS	G ₁	G ₂	G ₂	LoS	
		M±SE	M±SE		M±SE	M±SE	M±SE		
Body length ₃₅ (cm)	56	14.1±0.37 ^a	14.0±0.67 ^b	*	15.1±0.32 ^a	13.7±0.53 ^c	14.2±0.81 ^a	*	
Body length ₄₂ (cm)	56	9.1±0.32 ^b	9.6±0.27 ^a	*	9.9±0.42 ^a	9.5±0.45 ^c	9.7±0.24 ^a	*	
Body length ₄₉ (cm)	56	10.6±0.34 ^b	10.9±0.26 ^a	*	10.1±0.31 ^b	10.2±0.42 ^c	10.8±0.22 ^a	*	
Body length ₅₆ (cm)	56	10.2±0.21 ^b	12.7±0.16 ^a	*	13.9±0.16 ^b	10.7±0.54 ^b	11.6±0.32 ^a	*	
Body Weight 56(g)	56	207.3±2.76 ^b	235.8±2.3 ^a	**	244.5±2.12 ^b	228.1±2.94 ^c	232.1±2.52 ^a	*	
DAY 56:									
Pelvic <u>circumf</u> (cm)	56	3.2±0.08 ^a	3.2±0.07 ^a	Ns	3.5±0.82 ^b	2.8±0.28 ^c	3.2±0.08 ^a	*	
Breast Length (cm)	56	7.2±0.29 ^a	7.2±0.28 ^b	*	7.9±0.31 ^b	7.2±0.18 ^b	7.6±0.23 ^a	*	
Shank Length (cm)	56	3.1±0.14 ^a	3.2±0.30 ^b	*	3.4±0.07 ^b	2.9±0.08 ^c	3.1±0.08 ^a	*	
Drumstick Length (cm)	56	5.3±0.14 ^a	5.6±0.15 ^a	*	5.8±0.12 ^b	4.1±0.22 ^c	4.6±0.14 ^a	*	
Wing Length (cm)	56	8.6±0.03 ^a	8.3±0.02 ^b	*	8.7±0.06 ^b	8.2±0.04 ^b	8.4±0.07 ^a	*	
Breast <u>circumf</u> (mm)	56	3.1±0.05 ^a	3.1±0.02 ^a	Ns	3.9±0.01 ^b	3.1±0.22 ^c	3.3±0.02 ^a	*	

Means within each row for the sexes and generations columns with different superscripts differ* = (P < 0.05), ** = (P < 0.01); NS = not significant, LS = Level of significance, G₀ = Base population; G₁ = Generation one; G₂ = Generation two.

Table 3: Realized heritability of body dimension of Japanese quail

Traits	Response to Selection		Selection Differential		Realized h ²
	Mean	%	Mean	%	
Body length35(cm)	0.5	3.52	1.4	9.27	0.36
Body length42(cm)	1.0	6.45	1.4	3.77	0.71
Body length49(cm)	0.6	4.05	0.9	5.96	0.67
Body length56(cm)	0.4	2.56	0.7	4.40	0.57
Body Weight 56(g)	4.0	1.72	16.4	6.71	0.24
DAY 56:					
Pelvic circumference (cm)	0.4	20.00	0.7	20.00	0.57
Breast Length (cm)	0.4	5.26	0.7	8.86	0.57
Shank Length (cm)	0.2	20.00	0.5	14.71	0.40
Thigh Length (cm)	0.5	13.89	0.7	18.42	0.71
Wing Length (cm)	0.2	2.38	0.5	5.75	0.40
Breast circumference (mm)	0.2	6.06	0.8	20.51	0.25

Table 4: Realized heritability of chemical composition of Japanese quail

Traits	Response to Selection		Selection Differential		Realized h^2
	Mean	%	Mean	%	
Dry matter	7.55	8.43	9.14	10.02	0.83
Crude protein	4.21	16.10	15.68	41.68	0.27
Oil	3.93	12.52	11.93	30.29	0.33
Ash	1.29	17.00	2.74	30.31	0.04
Nitrogen free extract	0.06	0.14	9.65	18.39	0.01

The breast meat quality was influenced by age and sex of Japanese quails significantly as shown in table 2. The sex of birds were affected by $P^{H_{20mins}}$, $P^{H_{24hrs}}$ cooking loss, breast muscle, Redness, Yellowness and Chroma colour ($P < 0.05$) and pectoral major water holding capacity and lightness colour ($P < 0.01$). The rapid decrease in pH early postmortem when carcass temperatures are still elevated as a result of pale, soft and exudative – like meat. This is similar to study of Galobart and Moran (2004) and Musa *et al.* (2006). The possibility of genetically improving carcass quality by selection depends on the genetic variability of body weight and body composition.

The advanced in age significantly affects the $P^{H_{20min}}$, pectoral major water holding capacity, cooking loss breast muscles, lightness, redness, yellowness, chroma, hue ($P < 0.05$) and of drip loss, pectoral major water absorbing capacity ($P < 0.01$). As birds advances in age, water holding capacity, pH, drip loss, pectoral major water holding capacity, pectoral major water absorbing capacity, cooking loss, colour as usually determine in breast muscle are very important culinary value and technological properties of the quail meat. Other similar investigation on quality is conducted (Pikul *et al.*, 1987; Knust and Pingel, 1992; Witkiewicz, 2000).

Age, sex and generation significantly affect body length and some economic traits and sex of the birds except pelvic circumference and breast length in sex of Japanese quail as shown in table 2. Similar findings were reported by Akram *et al.* (2013) that as the birds advance in age body length, drumstick length and shank length increases. Nsoso *et al.* (2008) further strengthened the body length and shank length increased significantly up to 45 days of age. The analysis of body dimensions in poultry bird at different ages showed that their body length, drumstick length, shank length, breast length increases with advance in age (Kozaczyrski, 1999). The increased in the body length, pelvic circumference, breast length, shank length, drum stick + thigh length, wing length and breast length might be considered normal because age is a major determinant of growth and physiological development (Sonaiya *et al.*, 1986 and Ojedapo *et al.*, 2012).

The realized heritability of body length at day 35, 42, 49, 56 body weight at 56, body parts dimensions at day 56 were shown in table 3. The realized h^2 for

body weight at day 56, breast length and body length at day 35 were moderate 0.24, 0.25, 0.36, respectively. While the remaining traits shows high realized h^2 (0.40 – 0.71). There is dearth information on h^2 of body weight at day 45 was reported by Caron *et al.* (1990) while h^2 values were reported by Ahuja *et al.* (1983); Sato *et al.* (1986); Elfiky (1991); Sharaf (1992) and Solima (1992). The moderate to high h^2 observed in this study indicated that traits were affected by non additive genetic effect and environmental factors; therefore the remedy to the situation is by continuous selection. The realized h^2 of chemical composition of Japanese quail in table 5 indicated that nitrogen free extract (0.01), ash (0.04) are low in h^2 , that indicates that they are affects while crude protein (0.27) and oil (0.33) h^2 are moderate and dry matter h^2 are high, due to non genetic effect and environmental factors. Therefore continuous selection should be done to achieve better result. There are dearth researches on the h^2 on chemical composition of Japanese quail.

CONCLUSION

Japanese quail sex is affected by $P^{H_{20mins}}$, $P^{H_{24hr}}$ Cooking loss, pectoral major water holding capacity and lightness colour. The advanced in age affects the $P^{H_{20mins}}$, pectoral major water holding capacity, cooking loss breast muscles, lightness, redness, yellowness, chroma, hue, drip loss and pectoral major water absorbing capacity. Age, sex and generation significantly affect body length, economic traits and sex of the birds. The realized h^2 for body weight at day 56, breast length and body length at day 35 ranges from moderate to high (0.24 – 0.71). The realized h^2 for chemical composition of the Japanese quail are low NFE (0.01), ash (0.04). The moderate to high heritability indicates that response to selection for high body weight could be rapid therefore selection for high body weight can be achieved for body weight at day 56, breast length and body length at day 35 can while low h^2 shows that response was a slow process therefore selection to improve on the traits may occur gradual because of additive genetic effects.

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RESPONSE OF WEANER RABBITS TO GRADED LEVEL OF OFFAL BASED DIETS OF TIGER NUT(*Cyperus esculentus*)

Alu, S. E.

Department of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi,
P.M.B.135, Shabu-Lafia Campus, Nasarawa State, Nigeria.

Corresponding Author's E-mail:seafarms2000@yahoo.com.

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ABSTRACT

Twenty crosses of Californian x New Zealand breed of weaner rabbits averaging 4 to 6 weeks old of mix sexes were used to investigate the growth and haematological traits of rabbits fed on tiger nut offal (TNO) based diets in a 35- day experiment. They were randomly allotted to 5 treatment groups and replicated 4 times. Each replicate had 1 rabbit that was housed individually in a cage and were fed twice daily (7.00am and 4.00pm) and had access to drinking water at all times. Feeding troughs and drinkers were provided in each cage and a known quantity of feed was supplied daily. Five diets were compounded to be iso-nitrogenous (18% CP) and iso-caloric (2700 ME kcal/kg) and TNO was included in the diets at 0, 5, 10, 15 and 20%, respectively. Growth was observed and measured in the course of the feeding trial and the results showed non-significance ($P>0.05$) in feed intake (68.11-75.66 g/rabbit/day), body weight gain (5.39-8.40 g/rabbit/day), feed conversion ratio (6.64-7.82) and protein efficiency ratio (11.59-13.38); other parameter included feed cost per kg and mortality. Blood samples from rabbit treatments revealed that there was no variation ($P>0.05$) in packed cells volume (26.25-34.00 %), haemoglobin (9.30-10.10 g/dl), red blood cells (2.23-2.93 $\times 10^{12}$) and white blood cells (6.00-7.75 $\times 10^7$). Mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, neutrophils and leucocytes were also not affected by the graded levels of TNO. Serum biochemistry analyses also showed that there was no variation ($P>0.05$) in the serum glucose (3.65-5.75 mol/l), cholesterol (2.80-5.00 mmol/l), total protein (48.50-52.50 g/dl), albumin (24.00-43.50 g/dl), creatinine (44.50-66.00 μ /l) and triglyceraldehyde (0.25-0.80 mmol/l). Similarly, serum enzymes, alkaline phosphatase, aspartate transaminase and alanine transaminase were not affected ($P>0.05$) by the inclusion of TNO in the diets. All the electrolytes analyzed, phosphate, calcium, sodium, chloride and bicarbonate were not influenced ($P>0.05$) by the treatments. The inclusion of TNO in the diet of rabbits did not affect their health status, nutrient bioavailability, and utilization as well as growth rate therefore; farmers can incorporate up to 20% of TNO in the diets of rabbits without causing any deleterious effect.

Keywords: *Weaner rabbits, haematology, growth rate, Tiger nut offal*

INTRODUCTION

Animal protein is a very important requirement in human diet, for the supply of all needed essentials amino acids the body cannot synthesize. In Nigeria, like many other developing countries of the world, there is inadequate dietary animal protein in terms of quality and quantity. This is contrary to the situation in many developed countries that have well developed animal production industries that meet the demand for dietary animal supply. Larger percentage of human population live on cereals and not root crops which are deficient in essential amino acid needed for growth and development. Tewe (1997) reported that animal protein consumption in Nigeria was 4.82g/caput/day as against the required minimum of 35g recommended by the FAO (2002). World Bank Assisted National Agricultural Research Strategy Plan (1999-2010) has projected animal protein supply of 5.322g/caput/day, for the estimated 159million population in 2010.

The problem of malnutrition in Nigeria is mainly attributing to low intake of animal protein both in quantity and quality. The livestock sub-sector of the Nigerian economy is not fulfilling its primary role of satisfying the protein requirement of the nation. This implies that livestock production has to improve radically if the ever increasing demands for animal products in the diets of people in the developing countries are to be met. The shortage and high price of animal protein have been aggravated by the high cost of conventional feed ingredients. The current high cost of commercial feeds is well known and that feed account for 60-80% of production cost of monogastric animals in developing countries compare to about 50-60% in developed countries. The level of cereal and oil seed production and processing, the ravage of drought and the competition from direct human consumption have all contributed to the high cost of grains which in turn has lead to folding up of many poultry farms, and general decline in livestock production.

The nutritionist has the long time challenge for research into least cost rations in order to sustain the farmers in production (Alu, 2015).

The scenario pointed to above has therefore forced animal nutritionists to expand the raw materials base for livestock feeds formulation to include an ever increasing range of agro-industrial by products into animal feeds which hold tremendous potentials for alleviating the short supply and high cost of feed. The use of non-conventional feedstuff as substitutes for grains and other feedstuff have been the most active area of animal nutrition research in the tropical world; one of such non-conventional agro-by-products that have the potential of reducing the cost of staple grains is Tiger nut offal.

Tiger nut was reported as noxious, invasive and injurious weed in the tropical and temperate

zones; they are edible tubers with a slightly sweet, nutty flavour. The nuts have excellent nutritional qualities with a fat composition similar to olive oil. The nuts are also very rich in mineral content especially phosphorus and potassium (Eteshola and Oraedu, 1996) which makes it a suitable ingredient for feeding poultry. The objective of the study is therefore; to investigate the response of weaner rabbits fed graded levels of Tiger nut offal based diets.

MATERIALS AND METHODS

Study area

The experiment was carried out at the Nutrition and Biochemistry laboratory of Animal Science Department, Nasarawa State University, Keffi, Shabu-Lafia Campus. It is located in the Guinea Savanna zone of Nigeria. It is found on latitude 08035'N and longitude 08033'E. The mean monthly maximum and minimum temperatures were 35.060C and 20.160C respectively at the time of the experiment while the mean monthly relative humidity and rainfall were 74.67% and 168.90mm respectively (Nigerian meteorological Agency, 2008).

Source of Tiger nut offal and other feed ingredients

Tiger nut offal (TNO) was sourced from local drink vendors within Lafia metropolis, Nasarawa state, Nigeria. It was sun dried and used to compound the experimental diets. Other feed ingredients included maize, full fat soybean, common salt methionine, vitamins-mineral premix, palm oil rice offal, groundnut cake, lysine and bone meal.

Chemical analyses

The proximate analysis of TNO and experimental diets were done at Faculty of Agriculture, Nasarawa State University, Keffi using the procedure outlined by AOAC (1990). Nitrogen free extract (NFE) was calculated using the formula: $NFE (\%) = 100 - (\%CP + \%CF + \%EF + \%ASH + \text{Moisture})$.

Management of the rabbits and experimental design

Twenty weaner crosses of Californian x New Zealand breeds of rabbits of mix sexes averaging 4 to 6 weeks old were randomly allotted to 5 treatment groups and replicated 4 times. Each replicate had 1 rabbit that were housed individually in a cage. Anti stress and worming drugs were administered to the animals before the commencement of the experiment to reduce the stress that may arise from transportation and handling as well as possible presence of endo and ecto parasites.

The rabbits were fed twice daily (7.00am and 4.00pm) and had access to drinking water at all times. The experiment lasted for a period of 35 days after an initial adjustment period of 7 days.

Experimental diets

Five iso-nitrogenous (about 18% CP) and iso-caloric (2779 kcal/kg, ME) diets were compounded to contain 0, 5, 10, 15 and 20 % levels of TNO in treatments T₁, T₂, T₃, T₄ and T₅, respectively such that T₁ served as the control diet. The percentage composition of TNO and experimental diet are presented in Tables 1 and 2.

DATA COLLECTION

Collection of blood

At the end of the 6th week 2 rabbits per treatments were randomly selected, a 2 ml sterilized disposable syringe and needle was used to collect blood sample from the heart according to the methods outlined by Schalm *et al.* (1972).

Haematological studies

A portion of the blood samples were emptied into sample bottles containing EDTA to prevent clotting and used for the hematological analysis. The parameters analyzed included packed cell volume, red blood cell, white blood cell, hemoglobin, mean cell haemoglobin, mean cell haemoglobin concentration and mean cell volume.

Serum biochemical studies

Another portion of the blood samples were emptied into sample bottles without EDTA and used to analyze for serum biochemistry. The parameters analyzed included total protein, triacylglyceride, glucose, cholesterol, albumin, creatinine and globulin.

Enzyme

Blood sample were being collected in sample bottles without anti-coagulant to allow for clotting for serum enzyme analysis according to the methods outlined by Schalm *et al.* (1972). The enzymes analyzed included glutamine transaminase, aspartate transaminase, alanine transaminase, alkaline phosphatase, were analyzed.

Electrolytes

Blood samples collected in separate sample bottles without anti-coagulant to allow for clotting were used for serum electrolyte analysis according to the method outlined by Feteris (1965). Parameters analyzed included calcium, phosphate, sodium, potassium, chloride and bicarbonate.

Statistical analysis

Data obtained were subjected to One Way Analysis of Variance (ANOVA) and where significance differences ($P \leq 0.05$) were observed, means were separated using Duncan's Multiple Range Test as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Table 3 summarizes the effect of graded levels of TNO meal-based diets on growth performance of weaner rabbits. There was no

significant variation ($P > 0.05$) in feed intake (68.11-75.66 g/rabbit/day), body weight gain (5.39-8.40 g/rabbit/day), feed conversion ratio (6.64-7.82) and protein efficiency ratio (11.59-13.38) of weaner rabbits; the non-significant difference recorded could be attributed to the nutritional adequacy and safety of the test ingredients. The values recorded in this study fell within the normal ranges for rabbits as earlier reported by Lebas (1980) and Dalikeh *et al.* (2012). Dalikeh *et al.* (2012) reported lower values of 40.22 to 44.60g/rabbit/d for feed intake as compared to the ones recorded in the present study.

Table 4 shows the effect of graded levels of TNO meal-based diets on the haematological constituents of weaner rabbits. The values recorded were not significantly affected ($P \geq 0.05$) by different dietary treatments. Packed cells volume (26.25-34.00 %), haemoglobin (9.30-10.10 g/dl), red blood cells (2.23-2.93 X10¹²) and while blood cells (6.00-7.75 X10⁷) and other haematological variables evaluated were not affected by the various levels of inclusion of TNO in the diets. The non significant difference suggests the wellness of the animals throughout the period of the experiment as normal haematological parameters of an animal are direct indication of absence of disease (Olafedehan, 2010).

The effect of graded levels of TNO on the serum biochemical variables of weaner rabbits is presented in Table 5. The results show that there was no variation ($P > 0.05$) in the glucose (3.65-5.75 mol/l), cholesterol (2.80-5.00 mmol/l), total protein (48.50-52.50 g/dl), albumin (24.00-43.50 g/dl), creatinine (44.50-66.00 μ /l) and triglyceraldehyde (0.25-0.80 mmol/l) however, the values recorded in the present study were close to those reported previously (Dalikeh *et al.*, 2012) when they fed eggshell meal to weaner rabbits.

The values of the serum electrolytes (Table 5) analyzed were not significantly ($P > 0.05$) affected by different dietary treatments which could be related to the nutritional adequacy and safety of the test ingredients (Olabanji *et al.*, 2007). An electrolyte imbalance exists when the serum concentration of an electrolyte is either too high or too low; stability of the electrolytes balance depends on adequate intake of water and the electrolytes, and on homeostatic mechanisms within the body that regulate the absorption, distribution and excretion of water and its dissolved particles. The results of serum electrolytes level in the present study imply that the rabbits were healthy.

The values of the serum enzymes (Table 5) indices analyzed were not significantly ($P > 0.05$) affected by different dietary treatments. This observation could be related to the nutritional adequacy and safety of the test ingredients (Alu, 2015); the serum enzymes obtained for all the treatments groups were within the normal range as earlier reported by Lebas (1980).

Table 1: Proximate composition and energy value of Tiger nut offal

Nutrients	(%)
Caloric value (ME, kcal/g)	522.6
Crude protein	8.50
Crude fibre	5.50
Ether extract	2.12
Moisture (%)	6.77
Total Carbohydrate	65.50
Total Ash	1.86
NFE	64.00

Table 2: Percent gross composition of the experimental diets for weaner rabbits

Ingredients	T ₁ (0%)	T ₂ (5%)	T ₃ (10%)	T ₄ (15%)	T ₅ (20%)
TNO	0%	5%	10%	15%	20%
Premix	0.25	0.25	0.25	0.25	0.25
NaCl	1.00	0.25	0.25	0.25	0.25
Bone ash	1.35	1.50	1.00	1.00	1.00
Palm oil	2.00	4.00	4.00	4.00	5.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
GNC	22.00	14.50	13.65	17.50	18.00
Rice offal	29.90	16.00	14.00	7.00	-
Maize bran	-	20.50	15.00	5.00	2.00
FFSB	8.00	12.50	16.00	15.00	17.00
Maize	35.00	25.00	25.35	34.50	36.00
Total	100	100	100	100	100
Energy (kcal/kg, ME)	2795.74	2779.93	2710.60	2706.59	2711.12
CP (%)	18.46	18.02	18.08	18.15	18.00
CF (%)	5.84	5.92	5.26	3.71	2.72
Ca (%)	0.21	0.88	0.70	0.70	0.77
P (%)	0.83	0.52	0.50	0.42	0.31

*Premix, the vitamins and mineral premix supplied the following per 100kg of diet. Vitamin A 15,000 I.U, vitamin D₃ 300,000 I.U, vitamin E 3,00 I.U, vitamin K 2.50mg, thiamin, (B₁) 200mg, riboflavin (B₂) 600mg, pyridoxine (B₆) 600mg, niacin 40.0mg, vitamin B₁₂ 2mg, panthothenic acid 10.0mg, folic acid 100mg, biotin 8mg, choline chloride 50g, antioxidant 12.5g, manganese 96g, zinc 6g, iron 24g, copper 0.6g, iodine 0.14g, selenium 24mg, cobalt 214mg.
TNO- Tiger nut offal, GNC- Ground nut cake

Table 3: Effect of graded levels of TNO meal-based diets on growth parameters of weaner rabbits

Parameters	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM	LOS
Initial weight (g/rabbit)	725.00	775.00	787.50	787.50	775.00	57.19	NS
Final weight (g/rabbit)	1087.48	1001.12	1089.33	1108.19	1109.23	69.78	NS
Weight gain (g/rabbit/d)	8.48	5.39	7.07	7.65	7.95	0.34	NS
Feed intake (g/rabbit/d)	69.44	70.77	68.11	75.66	72.08	1.29	NS
Feed conversion ratio	6.64	7.09	7.60	7.82	6.84	0.69	NS
Protein efficiency ratio	12.59	12.72	13.38	12.61	11.59	1.22	NS
Feed cost/kg (N/kg)	78.24	99.70	104.91	76.36	104.63	-	-
Mortality (%)	0	25	0	0	50	-	-

SEM-Standard Error of Mean NS- Not Significantly different ($P>0.05$), LOS-Level of significance

Table 4: Effects of graded levels of TNO meal-based diets on the haematological parameters of weaner rabbits.

Parameters	T ₁ (0%)	T ₂ (5%)	T ₃ (10%)	T ₄ (15%)	T ₅ (20%)	SEM	LOS
PCV (%)	29.50	29.50	30.50	26.25	44.00	5.65	NS
Hb (g/dl)	9.95	10.10	9.95	9.30	10.05	3.14	NS
RBC (X10 ¹²)	2.91	2.93	2.75	2.23	2.91	1.66	NS
MCV (fl)	100.20	100.85	111.20	104.15	100.60	10.18	NS
WBC (X10 ⁷)	7.25	6.00	7.05	7.75	6.35	2.62	NS
MCH (p/g)	33.75	34.20	35.35	35.95	34.45	5.89	NS
MCHC (g/dl)	33.75	34.20	31.90	35.25	34.00	5.82	NS
Lymphocyte (%)	60.50	63.00	55.50	55.75	63.00	7.72	NS
Neutrophils (%)	39.50	37.00	44.50	43.00	37.00	6.34	NS

SEM= standard error of mean, LOS= level of significant, NS= not significant ($P>0.05$), LOS-Level of significance,

PVC- Packed cell volume, Hb- Haemoglobin, RBC- Red blood cells, MCV- Mean corpuscular volume, WBC- White blood cells, MCH- Mean corpuscular haemoglobin, MCHC- Mean corpuscular haemoglobin concentration

Table 5: Effect of graded levels of TNO meal-based diets on the serum biochemical parameters of weaner rabbits.

Parameters	T ₁ (0%)	T ₂ (5%)	T ₃ (10%)	T ₄ (15%)	T ₅ (20%)	SEM	LOS
Glucose (mol/l)	5.55	5.62	5.45	3.65	5.75	2.28	NS
Cholesterol (mmol/l)	4.90	4.20	5.00	2.80	4.70	2.07	NS
Total protein (g/dl)	52.50	49.00	50.50	48.50	48.50	7.05	NS
Albumin (g/dl)	24.00	25.00	28.50	28.50	43.50	5.07	NS
Creatinine (μ /l)	52.50	44.50	53.33	46.00	66.00	7.24	NS
TG (mmol/l)	0.75	0.80	0.80	0.25	0.25	0.75	NS
Alkaline phosphatase (μ /l)	64.00	63.50	64.00	65.50	70.00	8.08	NS
Aspartate transaminase (μ /l)	44.00	38.50	37.00	38.00	43.58	6.34	NS
Alanine transaminase (μ /l)	17.25	18.95	17.90	20.80	19.40	4.80	NS
Phosphate (%)	0.80	0.85	0.65	0.60	0.75	1.30	NS
Calcium (%)	2.60	2.25	2.50	2.65	2.20	1.56	NS
Potassium (%)	0.80	0.85	0.65	0.60	0.75	0.85	NS
Sodium (%)	3.75	4.55	5.25	1.40	2.40	1.85	NS
Chloride (%)	93.00	95.00	91.50	92.00	98.50	9.69	NS
Bicarbonate (%)	25.00	29.50	27.00	25.00	25.50	5.14	NS

SEM= standard error of mean, LOS= level of significant, NS= not significant ($P>0.05$), TG- Triglyceraldehyde, LOS-Level of significance

CONCLUSION

From the results of this study farmers can

use up to 20% of TNO as a source of energy for rabbit feeding without affecting nutrient bioavailability and utilization to the animals.

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SCREENHOUSE EVALUATION OF GROUNDNUT GENOTYPES FOR NITROGEN FIXATION AND MAIZE VARIETIES FOR NITROGEN UPTAKE EFFICIENCY

¹Usman N.I., ²Yusuf A.A., ²Abdu N., ¹Ndor E. and ¹Azagaku D. E.

¹Crop Production Technology Department, College of Agriculture, P.M.B 33, Lafia, Nasarawa State, Nigeria.

²Soil Science Department, Faculty of Agriculture / Institute for Agricultural Research, Ahmadu Bello University, P.M.B 1044, Zaria, Nigeria.

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ABSTRACT

Phosphorus is important in the symbiotic association with the bacteria rhizobium, there by fixing atmospheric nitrogen. Due to low availability of the fertility status of most savannah soils, the objectives of this research were therefore; to estimate biological nitrogen fixation by the groundnut genotypes under low and high phosphorus conditions and to determine the nitrogen uptake efficiency of some selected maize varieties. To achieve these objectives, a potted experiment was conducted in the screenhouse of the Department of Soil Science, Ahmadu Bello University Samaru, Zaria. The treatments consisted of a combination of five genotypes of groundnut namely; (Samnut 10, Samnut 11, Samnut 21, Samnut 22 and Samnut 23) and three varieties of maize (TZE, TZEE, and Obatampa). The groundnut genotypes had 60kg P₂O₅ ha⁻¹ (13.2 mgP/kg soil) and 0kg P₂O₅ ha⁻¹ (0 mgP/kg soil), the maize varieties had 75 kg P₂O₅ ha⁻¹ (16.5 mgP/ kg soil) and 0 kg P₂O₅ ha⁻¹ (0 mgP/ kg soil) levels. The treatments were repeated three times and laid down in a Completely Randomised Design. There was no significant difference in the amount of atmospheric nitrogen fixed by the groundnut genotypes. However, Phosphorus application significantly increased nitrogen fixation compared to the control, therefore 60kg P₂O₅ ha⁻¹ is concluded for higher nitrogen fixation in the soil. The effect of maize varieties in relation to nitrogen uptake efficiency was significant statistically, this result shows that the varieties that grow and develop extra early takes up more nitrogen faster than the late varieties and early varieties.

Keywords: *Screenhouse, Genotypes, Nitrogen fixation.*

INTRODUCTION

Intercropping of legumes and cereals has been an old practice in tropical agriculture. The major aim of intercropping is to make maximum use of the resources like space, light and nutrients. (Sanginga *et al.*, 2001; Schulz *et al.*, Li *et al.*, 2003b; Ndakidemi, 2006), minimizing negative effects such as competition among the components, and also to improve the crop quality and quantity (Mpairwe *et al.*, 2002). Some other benefits include water quality control through minimal use of inorganic nitrogen fertilizers that contaminate the environment (Crew and Peoples., 2004). Studies have shown that legume-cereal mixtures produce higher grain yields than either crop grown alone (Rao and Mathuva, 2000; Olufemi *et al.*, 2001; Mpairwe *et al.*, 2002; Dapaah *et al.*, 2003). The yield increases in the legume-cereal mixtures were attributed to improve nitrogen nutrition of the cereal (e.g Maize) component and also to other unknown processes (Vanlauwe *et al.*, 2001; Connolly *et al.*, 2001; Sanginga *et al.*, 2001). In Nigeria, maize yield averages about 1.4 tons per hectare and this is only about 20% of the average in Canada and other parts of the world where intensive cereal production is carried out (Afolami and Fawole, 1991; FAO, 1999). Groundnut which is also referred to as peanut, (*Arachis hypogea*) is a dehiscent legume that is harvested from below the soil. Reports on biological nitrogen fixation (BNF) by grain legumes are well documented (Giller and Cadisch, 1995; Peoples *et al.*, 2002) because of its importance as nitrogen source in agricultural ecosystems (Dakora and Keya, 1997).

Nitrogen (N) is the most limiting nutrient element for maize production (Sanginga, 2003) and it is essential for seed formation and maturity. A steady supply is needed during the early growth stage and this steady supply is provided by the action of soil microorganisms on the soil organic matter (SOM) or by application of inorganic fertilizers. It is however, a known phenomenon that savanna soils have low inherent fertility status, low water holding capacity, low organic matter, low cation exchange capacity (CEC), low total nitrogen and phosphorus, low water infiltration capacity, poor internal drainage due to poor structure (Lombin *et al.*, 1991; Jones and Wild, 1975), indicating that the soils have low productivity potential. This study was carried out to estimate biological nitrogen fixation by the groundnut genotypes under low and high phosphorus conditions as well as to determine the nitrogen uptake efficiency in some selected maize varieties.

MATERIALS AND METHOD

The experiment was conducted in the screen house of the Department of Soil Science screen house, Faculty of Agriculture/Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria. Located at Latitude 10°11'N, Longitude 7°38'E with an altitude of 686m asl. Sand was collected from a nearby

river and sieved through a 2mm sieve. Three kilogram each of air-dried soil was weighed in 48 plastic pots of 18cm in diameter and 16cm deep. The sand sample was analysed for total nitrogen using Kjeldahl digestion method as described by Bremner and Mulvaney (1982).

The treatments consists of a combination of five genotypes of groundnut (Samnut 10, Samnut 11, Samnut 21, Samnut 22, Samnut 23) and a reference maize crop of three genotypes namely TZE, TZEE, and Obatampa, which are classified as early maturing, extra early maturing and late maturing respectively, to match the combination of the selected groundnut genotype Samnut 10 and Samnut 11, which is classified as late maturing (ICRISAT, 2007) , (IAR, 1990) and Samnut 21 and Samnut 22, which were classified as early maturing, and Samnut 23, which is classified as extra early maturing were used (ICRISAT, 2007). The crops were planted in the pots with the groundnut genotypes receiving 0 and 13.2 mg P₂O₅ kg⁻¹ soil while the maize genotypes received 0 and 16.5 mg P₂O₅ kg⁻¹. These gave a total of 16 treatments which were repeated three times in a Completely Randomised Design

Data collected from some of the post-harvest materials were used to calculate the phosphorus use efficiency (PUE), shoot N uptake, root N uptake, shoot P uptake, root P uptake, total N uptake, total P uptake and nitrogen fixed using N difference method.

These are shown in the formulae below:

Shoot N uptake = Shoot dry weight x Nitrogen concentration.

Root N uptake = Root dry weight x Nitrogen concentration.

Total N uptake = Shoot N uptake + Root N uptake.

Nitrogen Fixed = Total N uptake of groundnut genotype x Total N uptake of maize Genotype x. (Hardason and Damro, 1987).

Where x = Samnut 10, Samnut 11 and Obatampa = Late maturity.

x = Samnut 21, Samnut 22 and TZE = Medium maturity.

x = Samnut 23 and TZEE = Extra Early maturity.

These formulae were used in calculating the above mentioned parameters from the plant sample and other materials obtained from the harvest of the groundnut plants to be collected. All data collected were subjected to Analysis by standard ANOVA procedures for a complete randomised design for test of significance using SAS systems (SAS, 1999), treatment means were compared using the least significant difference test at 5% level of probability.

RESULTS AND DISCUSSION

The effect of groundnut genotypes and P levels on shoot N uptake are all shown in Table 1. The shoot N uptake of a plant is its ability to take up available nitrogen from the soil to its shoot (Hardason

and Damro, 1987). The effect of groundnut genotypes on shoot N uptake was not significant statistically, which implies that the groundnut genotypes had the same level of N uptake in their shoot. The shoot N uptake in relation to P rate was statistically significant, this implies that 13.2 mgP/kg soil had higher level of N in the shoot of the plant than 0 mgP/kg soil respectively. Yayock and Yusuf, (1979) reported that for every 120kg of pod produced 75 kg N, 7 kg P, 42 kg K, 15 kg Ca, 6 kg Mg and 6 kg S would have been taken up by the crop, this is because of the interactive effect of N and P in which the interaction enhances the uptake of both nutrients, therefore higher uptake of shoot N (Malcolm and Mart, 1986). The interaction between the groundnut genotypes and the P rates

interaction enhances the uptake of both nutrients, therefore the higher uptake of total N (Malcolm and Mart, 1986). The interaction between the groundnut genotypes and P rates was not significant statistically.

Nitrogen fixation

The effect of groundnut genotypes and P levels on nitrogen fixation is shown in Table 1. The effect of the groundnut genotypes in relation to N fixed was not significant statistically. This is due to the genotypic characteristics of the genotype being the same in terms of N fixation. The application of 13.2 mgP/kg soil gave the highest amount of N fixed. This observation corroborates the findings of Bellido *et al.*, (2001). They applied 0, 50, and 80 kgP/ha on

Table 1: Effect of genotypes and P levels on groundnut shoot N uptake, root N uptake, total N uptake and nitrogen fixed

Treatment	Shoot N uptake (g)	total N uptake (g)	nitrogen fixed (g)
Genotypes (G)			
Samnut 10	20.40a	22.00a	17.54a
Samnut 11	35.49a	37.27a	19.86a
Samnut 21	18.12a	19.84a	11.96a
Samnut 22	16.44a	17.04a	16.03a
Samnut 23	21.12a	21.60a	15.40a
SE	31.01 ^{NS}	32.62 ^{NS}	9.57 ^{NS}
Phosphorus (P) Level mg/kg soil			
0	13.37b	14.77b	6.97b
13.2	31.26a	32.33a	25.34a
SE	12.46*	13.05*	3.83*
G X P Interaction			
SE	62.02	65.25	19.14
Significance	NS	NS	NS

*Means followed by dissimilar letters within the same treatment in a column are significantly different at 5% level of probability.

NS = Not significant at 5% level of probability.

were statistically not significant.

Total N uptake

The effect of groundnut genotypes and P levels on total N uptake is shown in Table 1. The total N uptake of a plant is the sum total of the root N uptake and the shoot N uptake (Hardason and Damro, 1987), the effect of total N uptake and the groundnut genotypes was not significant statistically. This implies that the total N uptake level by each groundnut genotype was the same statistically. The effect of P levels on total N uptake was significant statistically. Application of 13.2 mgP/kg soil had a higher total N uptake than 0 mgP/kg soil because of the interactive effect of N and P in which the

cowpea crop and found out that the application levels of 50, 80 kgP/ha had a higher levels of atmospheric N fixation. This is because groundnut is a heavy P feeder and it requires P for most of its physiological and metabolic processes that helps enhance its growth and development, therefore the application of P at 13.2 mgP/kg soil is necessary for increased atmospheric nitrogen fixation within the genotypes selected. The interaction between the P rates and groundnut genotypes in relation to N fixed was not significant statistically.

Nitrogen uptake efficiency

The effect of maize varieties in relation to nitrogen uptake efficiency was significant statistically (Table

2) with Tzee having the highest mean, while Tze and Obatampa had the same mean statistically. This due to the inherent characteristics of the varieties being different, e.g Tzee is the extra early variety, Tze is the early variety and obatampa is the late variety, this result show that varieties that grow and develop extra early takes up more nitrogen faster than late varieties and early varieties. This work corresponds to the work of Lemcoff and Loomis (1994A) which states that a steady supply of nitrogen is needed during the early growth stage and this steady supply is provided by the action of soil microorganisms on the soil organic matter (SOM) or by application of inorganic fertilizers. Therefore this shows that if maize requires nitrogen at a steady supply at an early stage of development, then the extra early varieties will require nitrogen at a higher rate, hence this work shows Tze having a higher nitrogen uptake efficiency. Therefore early and late varieties of maize like Tze and Obatampa can be sown in regions where there are

moderate to low plant nutrient, e.g. Northern guinea savannah region of Nigeria, or Derived savannah region of Nigeria. Tze variety of maize which is the extra early variety can be planted in areas of Nigeria where there is less rainfall, very low plant available nutrient, example; the Sudan savannah region in Nigeria because most of the soil in that region have been leached away and it is also sandy, hence less fertile. The result also shows that p application was not significant to nitrogen uptake efficiency (Table 2). This is because nitrogen is the most limiting nutrient element for maize production (Sanginga, 2003). Therefore the effect of p is hence not significant. The interaction of maize varieties and p level was also not statistically significant (Table 5).

Table 2. Effect of varieties and P levels on nitrogen uptake efficiency of maize

Treatment	Nitrogen uptake efficiency
Varieties (V)	
Tze	5.65b
Tzee	10.24a
Obatampa	4.98b
SE	1.62*
Phosphorus (P) Level mg/kg soil	
0	6.57a
16.5	7.35a
SE	1.34 ^{NS}
V X P Interaction	
SE	2.31
Significance	NS

*Means followed by dissimilar letters within the same treatment in a column are significantly different at 5% level of probability.

NS = Not significant at 5% level of probability.

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THERMAL PROCESSING METHODS AND THEIR INFLUENCE ON NUTRIENTS AND ANTI-NUTRIENTS COMPOSITION OF FLAMBOYANT SEEDS *DELONIX REGIA*

¹Alu, S. E. *, ²Ari, M. M. and ³Ogah, D. M.

^{1,2,3}Dept. of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi, P.M.B.135, Shabu-Lafia campus, Nasarawa State, Nigeria.

*Corresponding Author's E-mail: seafarms2000@yahoo.com

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ABSTRACT

The effect of different thermal processing methods on nutrients and anti-nutrients composition of *Delonix regia* (DR) seeds was investigated. The raw seeds were sorted to ensure homogeneity of product; raw samples were collected, crushed and tagged T1. At boiling point (100°C), another sample of the seeds was poured into tower aluminum pot containing 25 litres of water; samples were taken after 40 minutes of boiling and tagged T2. The third sample (T3) was toasted using open pan for 40 minutes and crushed. Each sample of the treatments was replicated 3 times; the prepared samples were then taken for analyses. The results showed that cooking produced better ($P < 0.05$) crude protein value of 35.49% while crude fibre was reduced significantly ($P < 0.05$) compared to the raw; the concentration of lysine (0.39%) and tryptophan (0.73%) were significantly ($P < 0.05$) higher when toasted compared to the other treatment methods. Similarly, ash content was significantly ($P < 0.05$) higher in raw (7.99%) and cooked (7.64%) compared to the toasted seeds. Cooking and toasting significantly ($P < 0.05$) reduced acid detergent fibre, acid detergent lignin and cellulose. Cooking also significantly ($P < 0.05$) increased trypsin inhibitor activity, TIA (12.06 mg/100g) but reduced phytate (0.11 vs. 0.14 mg/100g) for T2 and T3, respectively. In view of the findings of this study, cooking and or toasting DR seeds can serve as an alternative protein source for most monogastric animals considering its rich nutrient composition.

Keywords: *Thermal processing methods, nutrients, anti-nutrients, Delonix regia*

INTRODUCTION

Food and Agriculture Organization (1991) identified population pressure rising at 3.3% annually, poor food security and poor management of natural resources as the bane of African food crisis. Hence, the food demands of Africans have been estimated to be growing at an alarming rate of 3.5% annually. Consequently, the problem of inadequate animal protein intake is a challenge that calls for a two approach which are the intensification of research on short-generation interval animals like rabbits, poultry and other monogastric animals that have high reproductive efficiency and the increasing use of non-conventional feeds for animal feeding.

In order to ameliorate the food crisis situation, it has become imperative therefore, that animal nutritionists turn their attention to identification and exploitation of legumes especially those indigenous to the tropics. Among the thousand known legumes, only few have been extensively promoted and used for animal feeding.

Delonix regia (DR), otherwise known as “flame of the forest”, is one of those underutilized legumes; tones of these seeds are wasted every year since they are neither consumed by any animal nor utilized for any medical purpose. Like most legumes, DR seeds contain anti nutrients such as phytic acid, cyanide, trypsin inhibitors, oxalate and haemagglutinins which unless removed or reduced by processing are capable of exerting deleterious effects when ingested by animals.

Heat treatments generally inactivate protein inhibitors, volatile and off-flavor compounds. A better understanding of the effects of different processing methods on the nutritive value may lead to a wider use of this legume in the food industry. The objective of this study was to investigate the effect of different thermal processing methods on nutrients and anti-nutrient composition of DR seeds.

MATERIALS AND METHODS

Study area

The experiment was carried out at the Nutrition and Biochemistry laboratory of Animal Science Department, Nasarawa State University, Keffi, Shabu-Lafia Campus. It is located in the Guinea Savanna zone of Nigeria. It is found on latitude 08°35'N and longitude 08°33'E. The mean monthly maximum and minimum temperatures were 35.06°C and 20.16°C respectively at the time of the experiment while the mean monthly relative humidity and rainfall were 74.67% and 168.90mm respectively (NIMET, 2008).

Procurement and thermal treatment of *Delonix regia* seeds

Mature pods were collected from different locations from within Ombi II community of Lafia

town during the dry season. The pods were split manually using hard sticks and stones to release the seeds and cleaned to ensure homogeneity of product. Raw samples were crushed and tagged T1; at boiling point (100°C) another sample of the seeds were poured into tower aluminum pot containing 25litres of water. Samples were taken after 40 minutes of boiling and tagged T2. The third sample (T3) was toasted using open pan for 40 minutes and crushed. Each sample of the treatments was replicated 3 times; the prepared samples were then taken for analyses.

Analytical procedures

The proximate composition of each sample from the three thermally treated seeds was determined according to AOAC (1990) methods while the fibre fractions were determined according to the methods outlined by VanSoest and Robertson (1985). Phytic acid determination was done according to the modified method described by Wheeler and Ferrel (1971) and Steward (1974) while trypsin inhibitor activity was determined according to the methods described by Gupta and Deodhar (1975) and Hammerstrand *et al.* (1981). The methods share the same principles of determining trypsin inhibitors in soybeans products based on the tryptic hydrolysis of synthetic substrate, benzoyl-DL-arginine-nitroanilide (BAPA). The Spectrophotometric method of Brunner (1984) was used for saponin analysis; tannin and oxalate were determined using the methods outlined by Swain (1979).

Experimental design and statistical analysis

The experimental design used for this trial was the Completely Randomized Design (CRD). Data obtained for each parameter were subjected to One Way Analysis of Variance (ANOVA) and where significant differences ($P < 0.05$) occurred, the means were separated using Least Significant Difference (LSD) as described by (Aeangwanich *et al.*, 2004).

RESULTS AND DISCUSSION

The result of the effect of cooking and toasting on proximate, fibre fractions and inorganic matter composition of DRS is presented in Table 1. There was significant reduction ($P < 0.05$) in the crude protein values; seeds in T2 had the highest crude protein (35.49%) while T1 (29.97%) had the least value. Similarly, there was significant reduction ($P < 0.05$) in the crude fibre level across the treatments; cooked seeds, T2 had the least CF (10.28%) compared to those of T3 (11.91%) and T1 (13.57%). There was significant reduction ($P < 0.05$) in ash content as toasted seeds had the lowest value (7.15%) compared to the raw (T1) and cooked (T2) seeds. There was no variation ($P > 0.05$) in the values obtained for crude fat and nitrogen free extract. All the inorganic matters analyzed were not affected ($P > 0.05$) by the different thermal processing methods. The significant increase in the crude protein value could be attributed to the

fact that cooking which is a gradual heating process releases the protein in the seed better than that of toasting. The values obtained in the present study for raw seeds were higher than the earlier reports of Ega and Kaga (1994) of 7.01% while Abdullahi and Abdullahi (2005) reported values as high as 61.8 %. Egena et al. (2008) reported a crude protein content of 18.40 % while Biobaku (1994) reported a value of 14.59%. Fatufe (2009) reported a value of 36.92% crude protein; these differences show that DRS have a wide variety of protein compositions.

Cooking reduced significantly the crude fibre value of DRS compared to toasting methods. The values obtained in the present study were consistent with the earlier findings of Egena *et al.*, (2008) and Fatufe (2009). The authors reported values of 17 and 11.39%, respectively. Ega and Kaga (1994) reported a crude fibre value of 3.97% in raw seed nuts and 4.75% in fermented seed nuts. The crude fat contents which were not significantly affected by the processing methods fell within the normal range and were slightly lower than previous reports. Crude fat of raw DRS ranged between 5.01% (Ega and Kaga, 1994) and 9.50% (Egena *et al.*, 2008). Other investigations revealed 7.6% (Abdullahi and Abdullahi, 2005), 7.89% (Biobaku, 1994) and 4.17% (Fatufe, 2009).

Toasting significantly reduced the ash content of DRS; the values reported in the present study agree with the 5.30 and 15.60% earlier reported by Biobaku *et al.* (2003) and Abdullahi and Abdullahi (2005), respectively. Other values included 8.60% (Egena *et al.*, 2008) and 8.38% (Ega and Kaga, 2001). Ega and Kaga (1994) reported 5.57% ash content in raw seed nuts and 6.09% in fermented seed nuts.

The result of the effect of different processing methods on fibre fractions shows that ADF (20.92vs. 18.18 and 18.99%) and ADL (7.89vs. 6.69 and 7.40%) significantly reduced ($P<0.05$) compared to the raw seeds. Seeds in treatment T2 had the least ADL while those of T2 and T3 had the least values for ADL and cellulose. There was no variation ($P>0.05$) in the value of NDF and hemicellulose due to either cooking or toasting. There is evidence that pre-digestion or any attempt to initiate the hydrolysis of feed components often enhances their digestibility and utilization. One of such techniques is thermal treatments (Bio-Ingredients Ltd, 2004). The values obtained in the present study are in consonance with the earlier reports of Abdullahi and Abdullahi (2005) and Biobaku (1994).

Table 2 summarizes the effect of different thermal processing methods on the amino acids and vitamin concentration of DRS. There was significant ($P<0.05$) increase in the values obtained for lysine (0.39 %) and tryptophan (0.73 %) due to toasting compared to those of raw and cooked seeds. Similarly, the values obtained for vitamin A (544.11 mg/100g) was significantly higher ($P<0.05$) than those of other treatment methods however, reverse was the case for

vitamins B1 and C. The trend observed is consistent with the earlier assertion of Alu (2015), the author noted that vitamins, particularly water-soluble are heat-labile and may be completely lost at certain temperatures.

The result of the effect of cooking and toasting on anti-nutritional factors of DRS is presented in Table 3. The result shows that there was significant reduction ($P<0.05$) in the TIA as toasted seed had the least value (21.17mg/100g) compared to those of the raw (19.10mg/100g) and cooked (25.06mg/100g). Similarly, toasting and cooking significantly reduced ($P<0.05$) phytate concentration. Cooked and toasted seeds had the least values (0.11 and 0.14mg/100g) respectively. There was no significant variation ($P>0.05$) in the values obtained for oxalate, saponin and tannin although the values tended to reduce due to the processing methods. The reduction in TIA is an indication of their high nutritive value; the highest level of trypsin inhibitors was found in the raw seeds followed by the cooked seeds. Abdullahi and Abdullahi (2005) reported a reduction in TIA content by 9.62% in DRS boiled for 60minutes. This finding agrees with Vdal Vilverde *et al.* (1994) who found that heat treatments partially or completely inactivate TIA in legumes. This result was similar to those observed by Collins and Sanders (1976) and Rahma *et al.* (1987). The various treatments caused a decrease in phytic acid, the numerical decrease ($P>0.05$) in phytic acid content being best observed in the cooked seeds. This is probably due to the combination of the cooking and sun drying; cooking and sun drying cause greater reduction on phytic acid (Egena *et al.*, 2008). Again, this is similar to the findings of Abdullahi and Abdullahi (2005) who reported a 7.55% decrease in phytic acid with boiling for less than 1 hour.

The non significant variation in the values obtained for oxalate, saponin and tannin is an indication of their low levels in the seeds. The values obtained are close to the ones earlier reported by Abdullahi and Abdullahi (2005).

Table 1. Effect of processing methods on proximate, fibre fractions and inorganic matter of *Delonix regia* seeds (%)

Parameters	T1	T2	T3	SEM	LOS
Proximate composition					
Crude protein	29.97 ^c	35.49 ^a	32.88 ^b	0.30	*
Crude fibre	13.57 ^a	10.28 ^c	11.91 ^b	0.18	*
Crude fat	2.60	3.08	2.60	0.16	NS
Ash	7.99 ^a	7.64 ^a	7.15 ^b	0.07	*
NFE	36.97	36.37	36.59	0.57	NS
Fibre fractions					
Neutral detergent fibre	41.62	37.51	38.50	0.84	NS
Acid detergent fibre	20.92 ^a	18.18 ^c	18.99 ^b	0.07	*
Acid detergent lignin	7.89 ^a	6.69 ^b	7.40 ^b	0.02	*
Cellulose	13.03 ^a	11.50 ^b	11.59 ^b	0.03	*
Hemicelluloses	20.71	19.33	19.51	0.77	NS
Minerals					
Calcium	0.49	0.30	0.40	0.035	NS
Phosphorus	0.42	0.26	0.31	0.038	NS
Magnesium	0.54	0.42	0.47	0.038	NS
Potassium	0.92	0.71	0.82	0.060	NS
Sodium	0.10	0.09	0.09	0.003	NS

NS-No significant difference ($p>0.05$), a, b, c- means on the same row bearing different superscript differ significantly ($P<0.05$), *- significantly different ($P<0.05$), SEM- standard error of means, LOS – Level of significance.

Table 2. Effects of processing methods on some essential amino acids and vitamins of *Delonix regia* seeds

Parameters	T1	T2	T3	SEM	LOS
Amino acids (%)					
Methionine	2.80	2.84	2.88	0.50	NS
Lysine	0.30 ^c	0.33 ^b	0.39 ^a	0.01	*
Tryptophan	0.67 ^c	0.70 ^b	0.73 ^a	0.01	*
Vitamins (mg/100g)					
A	483.88 ^b	504.97 ^b	544.11 ^a	1.57	*
B ₁	30.54 ^a	23.08 ^b	13.50 ^c	0.10	*
C	6.81 ^a	5.61 ^b	3.60 ^c	0.18	*

NS-No significant difference ($p>0.05$), a, b, c- means on the same row bearing different superscript differ significantly ($P<0.05$), *- significantly different ($P<0.05$), SEM- standard error of means, LOS – Level of significance

Table 3: Effect of processing methods on anti-nutritional factors of *Delonix regia* seeds (mg/100g)

Parameter	T1	T2	T3	SEM	LOS
Trypsin inhibitor activity	19.10 ^c	12.06 ^a	11.17 ^b	0.070	*
Phytate	0.16 ^a	0.11 ^b	0.14 ^{ab}	0.003	*
Oxalate	0.06	0.04	0.05	0.040	NS
Saponin	0.31	0.11	0.16	0.010	NS
Tannin	0.09	0.08	0.04	0.010	NS

NS-No significant difference ($p>0.05$), a, b, c- means on the same row bearing different superscript differ significantly ($P<0.05$), *- significantly different ($P<0.05$), SEM- standard error of means, LOS – Level of significance

CONCLUSION

Toasted or cooked *Delonix regia* seeds can also serve as a close substitute for soybeans due to the similarities in their nutrient and amino acids composition. The major anti-nutritional factors identified in the seeds are tannin, phytic acid, trypsin inhibitors and saponin, which are known to impair feed utilization

by animals. Cooking or toasting for 40 minutes has reduced the concentration of all the anti-nutrients and improved some of the nutrient content of the seed. Other processing methods to further reduce the anti-nutritional factors and perhaps completely eliminate them should be investigated.

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INTEGRATED SEDIMENTOLOGICAL AND PETROPHYSICAL CHARACTERISTICS OF THE EOCENE NANKA FORMATION AT OGBUNIKE AREA, SOUTHEAST, NIGERIA.

¹ODEM.A.* and ²AKAEGBOBII.M.

Department of Geology, University of Ibadan, Nigeria.

*Corresponding Author's E-mail: melodyagadalive@gmail.com

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ABSTRACT

The Eocene Nanka Formation at Ogbunike type locality was studied to ascertain the lithostratigraphy, petrophysical properties and depositional environment. Petrophysical properties of reservoir rocks are influenced by current velocity, degree of current variance and grain size parameters. These properties are partly controlled by facies characteristics which in turn are related to depositional environment. Field mapping utilizing bearing and pacing, and spot sampling based on lithologic variation was adopted along six lithologic profiles. Measurement of azimuths and dips of cross beds were taken for paleocurrent analysis. A total of 18 representative samples were collected for granulometric, thin section and heavy mineral petrographic analyses. Detailed sedimentology field study and lithologic description revealed the section to be 14.78m thick (vertical thickness) with a lateral extent of about 82m consisting of ironstone/sandstone, pyritic grayish shales, interstratified claystone/mudstone and heterolite. Azimuths of NE-SW and NW-SE directions described the paleocurrents of the formation with dominant polar-unimodal orientation, high vector strength (mean of 14.18°) and low variance ranging from 248.5 to 368.9. The sediments are bimodal to polymodal suggesting different parent sources, predominantly positively skewed, leptokurtic and dominantly moderately sorted suggesting fair porosity, fair permeability, heterogeneous reservoir unit, moderate energy of transportation medium and fluvial environment. Heavy minerals found indicated mixed provenance and mineralogical maturity. The study revealed that the sediments are ferruginous, texturally sub-mature to mature, mineralogically super mature, fine to medium grained, moderately sorted and deposited in a near-shore fluvial environment under a moderate energy condition. The sediments are characterized by fair permeability and effective porosity, heterogeneous to slightly homogeneous reservoir unit.

Keywords: Grain size, Depositional Environment, Provenance, Porosity, Permeability, Reservoir.

INTRODUCTION

The Anaambra Basin was formed following the Santonian tectonic pulse on a sub-basin formed by the differential subsidence of the fault block in the southern Benue Trough. It was a deltaic complex filled with a lithostratigraphic unit akin to those of the Cenozoic Niger Delta (Nwajide and Reijers, 1996). Petrophysical properties of reservoir rocks which include porosity, permeability, etc., are influenced by current velocity, degree of current variance, grain size, sorting, etc. These properties are partly controlled by facies characteristics which in turn are related to depositional environment. Outcrop models both increase the knowledge of reservoir heterogeneity and provide the foundation for which the rest of the subsurface reservoir and simulation models can be built (Reynolds *et al.*, 1998; Schatzinger and Tomutsa, 1999; Grammer *et al.*, 2004). Effort in this direction has lent credence to an integrated evaluation of the sedimentological and petrophysical characteristics of the Ogbunike sandstone (Eocene Nanka Formation).

Location and Accessibility

The study area lies within Longitude 6°51'55"E and Latitude 6°10'48"N and falls within Ameki Formation of the Anambra Basin (fig.1). The exposure is about 14.78m thick (vertical thickness) and a lateral extent of about 82m.

The outcrop is accessible by good road network, located in Ogbunike area on the left flank of the Onitsha bound Onitsha – Enugu express way, near toll gate, Anambra State, Southeast, Nigeria.



Figure 1. Geological map of Anambra State showing location of study area with photograph inserted (Modified after Nigerian Geological Survey Agency, 2006).

GEOLOGIC BACKGROUND

The Anambra Basin is a Cretaceous/Tertiary basin, which is the structural link between the Lower Benue Trough and the Tertiary Niger Delta Basin. Anambra Basin consist of the Mamu Formation, Ajali sandstone, Nsukka Formation, Imo Formation, Ameki Group and Ogwashi-Asaba (Nwajide, 2013). The Ameki Group consists of the Nanka Sand, Nsugbe Formation, and Ameki Formation (Nwajide, 1979), which are laterally equivalent. The age of the formation has been considered to be either early Eocene (Reyment, 1965) or early middle Eocene (Adegoke, 1969). The depositional environment has been interpreted as estuarine, lagoonal, and open marine, based on the faunal content. White (1926) interpreted an estuarine environment because of the presence of fish species of known estuarine affinity. Adegoke (1969), however, indicated that the fish were probably washed into the Ameki Sea from inland waters, and preferred an open marine depositional environment. Nwajide (1979) suggested environments that ranged from nearshore (barrier ridge-lagoonal complex) to intertidal and subtidal zones of the shelf environments, whereas Fayose and Ola (1990) suggested that the sediments were deposited in marine waters between the depths of 10 m and 100 m.

Acra *et al.* , (2013) and Oboh *et al.*, (2005) opined that the univariate, bivariate, multivariate, pebble morphometry and sedimentary structures of the Paleocene – Eocene sediments in the Anambra Basin indicate that the sandstones were deposited in a variety of depositional settings such as fluvial, lagoonal, tidal and shallow marine environments and the sediments are derived from two sources namely the basement area and the preexisting sedimentary terrain which exist east and northeast. The stratigraphic architecture shows various facies associations such as the tidally influenced channels, braided fluvial channels, flood plains and fluvial channels. The sands are medium-coarse grained mainly moderately sorted, subrounded, negatively to positively skewed and leptokurtic in distribution. They suggested a four facies model – fluvial channels, braided fluvial channels, tidally influenced channels and flood plain deposits all being deposited at varying environments based on high, moderate or low energy fluctuation and the dominant system either fluvial or tidal incursions, a coarsening upwards sequence, flaser and lenticular bedding, herringbone structures, tidal bundles, clay draped reactivation surfaces, bimodal -bipolar paleocurrent distribution and the trace fossil Ophiomorpha and Skolithos.

LOCAL GEOLOGIC SETTING

From detailed sedimentologic field mapping exercise, the studied section (figure 2) is about 14.78m thick and made up of ironstone/sandstone, shale, sandstone/siltstone, interstratified calcareous clay/mudstone and heterolithic sandstone lithologies from the base. The shales are dark – grey in colour, fissile, and clayey in some places. The sandstone intervals are parallel to wavy laminated, fine to medium grained, yellowish to pinkish brown and dark colour, occasionally highly compacted/cemented and friable. The heterolithic sandstone is medium to coarse grained, white to pinkish brown with degree of ferruginization and parallel to wavy lamination. The main characteristic sedimentary structures are flaser bedding, planar/troughs cross beddings with intervening mud drapes. There is also presence of reactivation surface and iron stains at various intervals. The fossil assemblage's present include skololithus, ophiomorpha, with bioturbations at various intervals. A total of six (6) lithologic profiles were logged.

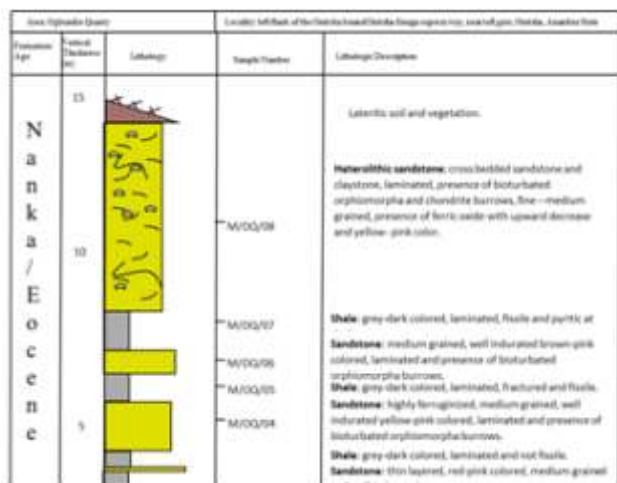


Figure 2. Lithologic log of the studied section

MATERIALS AND METHODS

Field Approach

The exercise was limited to surface geological studies utilizing bearing and pacing method. The field study entailed carrying out detailed geological mapping of the rock types in the study area. Field observations including grain texture, colour and mineralogical composition, measurements of dips and azimuth of cross-beddings, in-situ measurements of length and breadth of ichnofossils, thickness and lateral extent of beds, taking photographs of important sedimentary structures and logging of exposed vertical sections were done. Measurements of dips and strikes (azimuths) of the cross-beds were taken from the foreset planes for palaeocurrent analysis. Spot sampling method was adopted along lithologic profiles for sample collection. The outcrop was trenched at each sample collection point in order to obtain fresh samples. Samples collected were labeled with reference to locality from the base to the top. Separate sample bags were used for each sample to avoid contamination.

Laboratory Approach

The laboratory works carried out include heavy mineral separation, granulometric, heavy mineral separation and paleocurrent analyses. A total of eighteen fresh samples were collected from Ogbunike quarry for laboratory analyses.

Paleocurrent Analysis

Paleocurrent data measured from the foreset planes of cross-bedded sand facies in the field were synthesized for calculation of the mean vector azimuths (MVA), variance and vector strength using Steinmetz (1962) method.

Granulometric Analysis

The grain size distributions of nine representative samples were mechanically determined in Sedimentology Laboratory/Grain Size of the Geology Department, University of Ibadan, Ibadan, Nigeria. Pulverized and quartered fraction was sieved using Durham Geo-Slope shaker for 20 minutes agitation of 100g sample component. Standard sieve set in the order of mesh sizes 1/2? were used. The fraction of each mesh size was weighed for statistical analysis based on the procedure of Folks and Ward (1957).

The results of the statistical data obtained from sizes distribution was used to deduce the mode of transportation and depositional environment of the sandstone. Sieve data plotted on semi-log sheet were used to determine the 50th percentile or median

diameter (? 50), mean, sorting, skewness and kurtosis. These parameters were then substituted into the empirical formula proposed by Krumbrien and Monk (1942) to estimate permeability of the reservoir intervals.

Heavy Mineral Separation

Eight samples were subjected to heavy minerals petrographic analysis in the Geochemistry and Petrographic Laboratories of the Department of Geology, University of Ibadan. Each sample was treated with dilute hydrochloric acid (HCl) and acetone (CH₃COOH) to remove carbonate clay or iron oxide coating and clean the grains which was accompanied by drying in an oven. 5g of each treated sample was taken and put in a separate funnel containing bromoform. Gravity settling technique was adopted for the separation of the heavy minerals. The separated heavy minerals were mounted on glass slide for each sample using Canada balsam.

Examination and identification of the heavy minerals was carried out using a petrographic microscope on the basis of their optical properties. The number, size and shape of the different opaque and non-opaque minerals were noted and their percentages also estimated. The maturity index or ZTR index was calculated using Hubert (1962).

RESULTS AND DISCUSSION

PALEOCURRENT ANALYSIS

The paleocurrent distribution of the outcropping units shows a dominant polar-unimodal orientation or pattern with vector strength (mean of 14.18o) of high dispersion. The primary mode is in the Northeast direction approximately and the secondary mode in the southwest direction. These unimodalpaleocurrent patterns indicate a fluvial environment. The rose diagrams (Figure 3) also suggest Northwest and Southwest provenance for the sediments. Azimuths of NE-SW and NW-SE directions described the paleocurrents of the formation. Table 1 shows the summary of the paleocurrent parameters of the Ogbunike sandstone. Table 2 also shows paleocurrent results and their environmental implications.

The variance ranges from 248.5 to 368.9 indicating a fluvial environment. The low variance also suggests high vector strength, lower permeability and effective porosities, poor reservoir sediment sorting and higher reservoir heterogeneity (Figure 4).

Azimuth A	Dip D	Sine A	Cos A	Cos D	(A1-A)	(A1-A) ²
75	9	0.97	0.26	0.99	-3.61	13.042
103	22	0.97	-0.23	0.93	24.39	594.81
70	24	0.94	0.34	0.91	-8.61	74.16
100	20	0.99	-0.17	0.94	21.39	457.48
97	24	0.99	-0.12	0.91	18.39	338.14
97	24	0.99	-0.12	0.91	18.39	338.14
92	17	1.00	-0.04	0.96	13.39	179.26
82	15	0.99	0.14	0.97	3.39	11.48
94	12	1.00	-0.07	0.98	15.39	236.81
91	16	1.00	-0.02	0.96	12.39	153.48
102	18	1.00	-0.22	0.95	23.39	547.03
96	18	1.00	-0.11	0.95	17.39	302.37
104	22	0.97	-0.25	1.00	25.39	644.59
66	20	0.91	0.41	0.94	-12.61	159.05
112	22	0.41	-0.38	0.93	33.39	1114.81
Total		14.10	2.84			5164.64

Cross Bed A

Cross Bed B

Azimuth A	Dip D	SINE A	COS A	COS D	(A1-A)	(A1-A) ²
75	27	0.97	0.26	0.89	-6.48	41.93
54	21	0.81	0.59	0.93	-27.48	754.88
67	18	0.92	0.39	0.95	-14.48	209.52
81	20	0.99	0.16	0.94	-0.48	0.23
80	16	0.99	0.17	0.96	-1.48	2.18
84	17	1.00	0.11	0.96	2.53	6.38
82	20	0.99	0.14	0.94	0.53	0.28
66	22	0.91	0.41	0.93	-15.48	239.49
94	28	1.00	-0.07	0.88	12.53	156.87
118	24	0.88	-0.47	0.91	36.53	1334.07
108	12	0.95	-0.31	0.98	26.53	703.57
84	19	1.00	0.11	0.95	2.53	6.375
79	16	0.98	0.19	0.96	-2.48	6.126
86	20	1.00	0.07	0.94	4.53	20.475
66	32	0.91	0.41	0.85	-15.48	239.45
Total		14.29	2.14			3721.83

Table 1. Paleocurrent results for the study location (Ogbunike).

Azimuth A	Dip D	Sine A	Cos A	Cos D	(A1-A)	(A1-A) ²
70	22	0.94	0.34	0.93	-4.92	24.12
76	20	0.97	0.24	0.94	1.08	1.17
56	22	0.84	0.56	0.93	-18.92	357.92
64	24	0.90	0.44	0.92	-10.92	119.22
84	28	1.00	0.11	0.88	9.08	82.47
76	28	0.97	0.24	0.88	1.08	1.17
74	28	0.96	0.28	0.88	-0.92	0.84
106	30	0.96	-0.28	0.87	31.08	966.05
66	30	0.91	0.47	0.87	-8.92	79.54
100	22	0.99	-0.17	0.93	25.08	629.07
98	20	0.99	-0.14	0.94	23.08	532.75
84	20	1.00	0.11	0.94	9.08	82.47
92	26	1.00	-0.04	0.90	17.08	291.77
90	22	1.00	0.00	0.93	15.08	227.45
84	20	1.00	0.11	0.95	9.08	82.47
Total		14.40	3.88			3478.55

Cross Bed C

Table 2. Paleocurrent results for the study location and their environmental implications.

Locality	Outcrop	Formation	Pattern	MVA	Variance	Vector Strength	Environment
Ogbunike	Cross Bed A	Nanka	Unimodal	244.4	265.9	13.9°	Fluvial
Ogbunike	Cross Bed B	Nanka	Unimodal	235.8	368.9	13.8°	Fluvial
Ogbunike	Cross Bed C	Nanka	Unimodal	224.8	248.5	14.8°	Fluvial

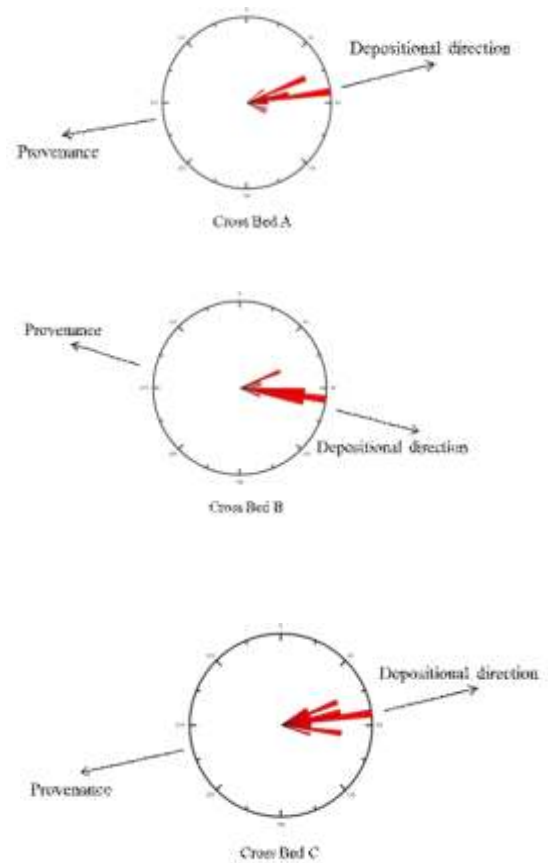


Fig.3. Rosette diagram showing provenance and depositional direction of cross beds A, B and C.

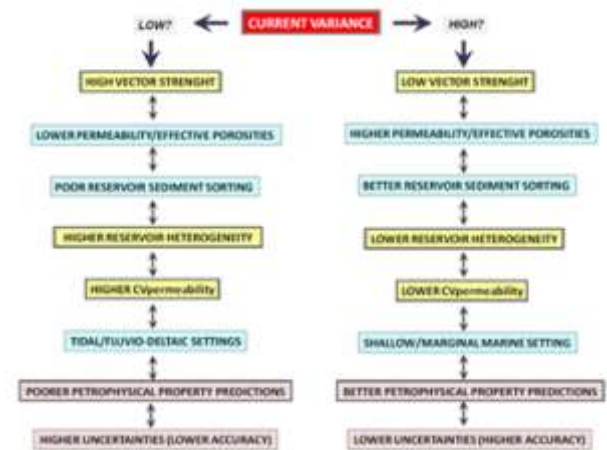


Figure 4. Flow chart for 'quick-look' reservoir evaluation given the paleocurrent data (After Obi et al, 2013).

GRANULOMETRIC ANALYSIS

Statistical size frequency parameters such as graphic mean, sorting, skewness and kurtosis were obtained from the plots using designated percentile values (Table 3). The ternary plots of sand, mud and gravel, and sand, silt and mud shows that the sediments are predominantly sands. Plots of particle size against class weight shows that the sediments are unimodal to polymodal. These suggest that the sediments were derived from different parent sources. The graphic mean of the distribution of sediment under investigation ranges from 1.4 to 2.3.

Table 3. Statistical parameters for Ogbunike sandstone

Sample	Mean (Mz)	Sorting	Skewness	Kurtosis	Mean	Sorting	Skewness	Kurtosis
MOQ16	2.14	1.29	-0.36	1.05	Fine Sand	Poorly Sorted	Coarse Skewed	Very Leptokurtic
MOQ17	1.40	1.30	-0.10	1.04	Medium Sand	Poorly Sorted	Symmetric al	Mesokurtic
MOQ18	2.27	0.86	-0.05	1.26	Fine Sand	Moderately Sorted	Symmetric al	Leptokurtic
MOQ06	1.05	0.75	0.19	1.33	Medium Sand	Moderately Sorted	Fine Skewed	Leptokurtic
MOQ14	1.41	0.80	-0.08	1.19	Medium Sand	Moderately Sorted	Symmetric al	Leptokurtic
MOQ12	2.06	1.05	0.23	0.58	Medium Sand	Poorly Sorted	Fine Skewed	Very Platykurtic
MOQ02	1.40	1.00	-0.01	1.33	Medium Sand	Poorly Sorted	Symmetric al	Leptokurtic
MOQ04	1.94	0.67	-0.11	1.26	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic
MOQ10	1.05	0.75	0.19	1.33	Medium Sand	Moderately Sorted	Fine Skewed	Leptokurtic

This shows that 77.78% of the sediments are medium grained while 22.22% are fine grained suggesting a moderate to low energy of transportation medium (Folk and Ward, 1957). The sorting values range from 0.7 to 1.3 indicating that 55.56% of the samples are moderately sorted while 44.44% are poorly sorted. This implies fluvial origin. Skewness values range from -0.3 to +0.3 indicating 44.44% are symmetrical, 22.22% are coarsely skewed and 33.33% are coarsely skewed. This implies that 55.56% of the sediments are positively skewed suggesting fluvial origin. Bivariate plots of skewness versus sorting (figure 5a) and mean grain size versus sorting (figure 5b) also indicate that the environment of deposition is fluvial (Friedman 1967, Moiola and Weiser 1968).

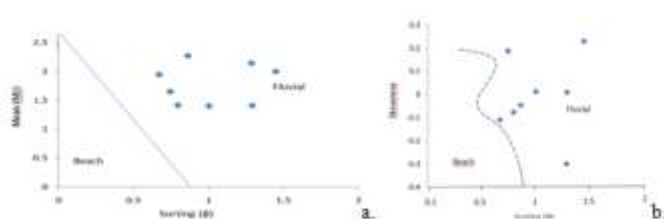


Figure 5. Graphs of Mean against Sorting (a) (After Miola and Waizer, 1977)

Skewness against Sorting (b) for the studied section (After Friedman, 1961).

Porosity

According to Teoh (2007), sedimentological studies have shown that porosity increases with increasing sorting. Increasing sorting also correlates with increasing permeability (Krumbein and Monk, 1942). A well-sorted reservoir sand contain grains that are about the same size and shape, while poorly sorted sands contain grains with different size and shape. The finer grains of the matrix block both the pores and throat passages within the framework for poorly sorted sediment but well-sorted sediment will have better porosity and permeability (Teoh, 2007). From the grain size data, the poor to moderate sorting of the samples suggest a poor to fair porosity for the sediment.

Reservoir Quality

The quality of the Ogbunike sandstone reservoir was studied using the coefficient of variance analysis. Essentially, the Cv represents the degree of variance of the statistical parameter. Distributions with $Cv < 1$ are considered low variance, while those with $Cv > 1$ are considered high variance. According to Acra *et al*, 2014; $Cv < 0.5$ is homogeneous or good sorting, $Cv > 0.5$ is heterogeneous or poor sorting, $Cv > 1$ is very heterogeneous or very poor sorting. From the results (Table 4), the samples sorting ranges from heterogeneous (1.0) to homogeneous (0.4). The plot of coefficient of variance against mean grain size (figure 6) place the samples to be moderately sorted in more than a half of the sampled area. Hence the porosity is fair and the reservoir is heterogeneous on the average.

Table 4. Sorting and coefficient of variance of the Ogbunike sandstone.

Samples	Mean (Mz)	Sorting	Cv
MOQ16	2.14	1.29	0.60
MOQ17	1.40	1.30	0.92
MOQ18	2.27	0.86	0.38
MOQ06	1.05	0.75	0.45
MOQ14	1.41	0.80	0.57
MOQ12	2.06	1.05	0.73
MOQ02	1.40	1.00	0.72
MOQ04	2.06	0.67	0.35
MOQ10	1.05	0.75	0.45

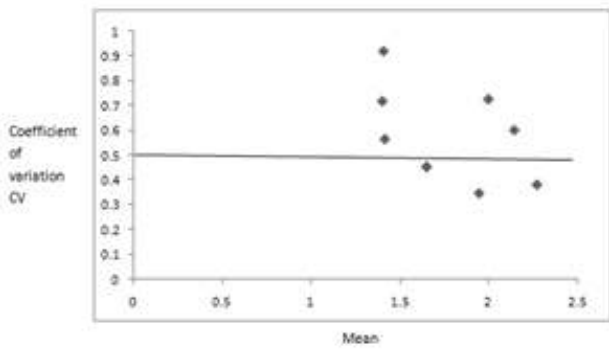


Figure 6. Coefficient of variance against mean grain size (Acra *et al*, 214).

Permeability

Permeability increases with increase in sorting of sediments (Krumbein and Monk, 1942). Qualitative description based on permeability values (North, 1985) adopted in this study is shown in table 3. From the empirical permeability data (table 4), the permeability of the sediments range from 0.727 to 3.736 suggesting poor to fair permeability based on permeability values of North, 1985.

Table 4. Qualitative description of permeability rocks in the study area obtained by use of empirical formula (after Krumbein and Monk, 1942).

Sample	Sorting	D50(um)	D50(mm)	K (mD)
M/OQ/16	1.287	192.5	1.925	0.998
M/OQ/17	1.292	375.5	3.755	3.736
M/OQ/08	0.864	202.6	2.026	0.727
M/OQ/06	0.746	331.7	3.317	1.683
M/OQ/14	0.797	367.8	3.678	2.774
M/OQ/12	1.448	322.0	3.220	3.079
M/OQ/02	1.004	379.3	3.793	2.962
M/OQ/04	0.672	256.5	2.565	0.907
M/OQ/10	0.746	331.7	3.317	1.683

HEAVY MINERAL ANALYSIS

From the analysis data (Table 5), the opaque minerals predominates the non-opaque. The opaque minerals constitute 73.90% while the non-opaque constitutes 26.10% on the average. The average ZTR% index is 52.87% with Tourmaline as the least abundant of ultra-stable minerals. This value indicates mature mineralogy of the sediments (Hubert, 1962). Figures 7 and 8 shows the abundance of the heavy minerals and ternary plot of ZTR respectively. The abundance of tourmaline and zircon in the heavy mineral suite suggest prolonged abrasion, chemical alteration and reworking of minerals from older sediments. The presence of garnet suggest plutonic source, epidote suggest metamorphic or hydrothermal source and apatite suggest basic to acid plutonic source. These suggest plutonic, metamorphic and older sediments sources for the sediments (provenance). These sources could be the younger granites (plutonic), Oban massif (metamorphic) and older sediments of the Benue Trough.

Table 5. Modal estimation of heavy mineral distribution.

Sample No.	Zircon (Z)	Tourmaline (T)	Rutile (R)	Staurolite (S)	Sillimanite (Si)	Garnet (G)	Apatite (A)	Epidote (E)	Opaque (Op)	Non- Opaque	ZTR Index (%)
M/OQ/0											
2	6	4	12	12	2	1	-	1	88	38	57.9
M/OQ/0											
4	4	3	7	11	1	2	-	2	76	30	46.7
M/OQ/0											
6	6	4	7	10	1	1	1	1	95	31	54.8
M/OQ/0											
8	7	4	5	10	1	2	1	1	114	31	51.6
M/OQ/1											
2	5	6	9	9	1	2	1	2	75	34	58.8
M/OQ/1											
4	4	3	7	11	1	2	1	2	75	30	46.7
M/OQ/1											
6	6	4	7	11	1	1	1	1	95	31	54.8
M/OQ/1											
7	7	4	5	10	1	2	1	1	114	31	51.6
Total	45	32	59	84	9	13	6	11	725	256	423
%									73.9	26.1	52.8

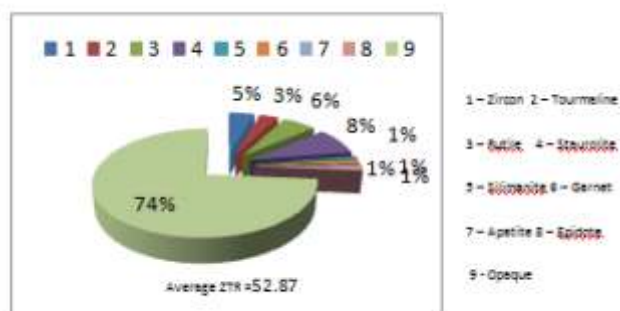


Figure 7. Abundance of heavy minerals in Ogbunike sandstone

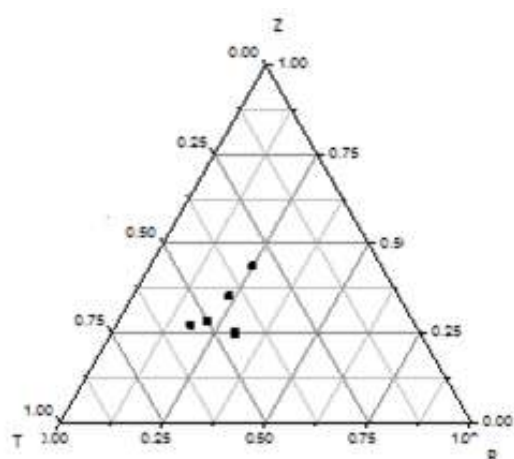


Figure 8. Ternary plot of average ZTR index.

CONCLUSION

The integrated sedimentology field study and inorganic geochemical analyses of the Eocene Nanka Formation at Ogbunike type locality, reveals that the outcrop consist of ironstone/sandstone, shale, sandstone, interstratified calcareous clay/mudstone and heterolithic sandstone sediments which are medium to fine grained. The outcrop is laterally extensive (about 82m) with a vertical thickness of about 14.78m.

The paleocurrent analysis shows a dominant polar-unimodal orientation or pattern with vector strength (mean of 14.18o) of high dispersion. The primary mode is in the Northeast direction approximately and the secondary mode in the southwest direction which shows the types of cross bedding that occurs in the study area. These results agree with the N-S regional paleocurrent trend

established for the Anambra basin and in the study area. These unimodal paleocurrent patterns are diagnostic of fluvial environment. The rose diagrams also suggest Northwest and Southwest provenance for the sediments. Azimuths of NE-SW and NW-SE directions described the paleocurrents of the formation. The variance is low and ranges from 248.5 to 368.9 and this indicates a fluvial environment. The low variance also suggests high vector strength, lower permeability and effective porosities, poor reservoir sediment sorting and higher reservoir heterogeneity.

Granulometric analysis identified the sediments to be bimodal to polymodal suggesting different parent sources, poorly to moderately sorted, predominantly positively skewed and leptokurtic. These suggest fluvial depositional environment and moderate to low energy of transportation medium. The poor to moderate sorting suggest poor to fair porosity, poor to fair permeability and a heterogeneous reservoir unit.

The heavy mineral suite using ZTR index supports the mineralogical maturity. This also suggests plutonic, metamorphic and recycled older sediments source origins (provenance) for the sediments.

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ALLEVIATING WATER SHORTAGES IN UNIVERSITY OF ILORIN TEACHING HOSPITAL, KWARA STATE, NIGERIA.

¹Mokuolu, O. A*, ²Sojobi, A. and ³Ayansola, M. A.

¹Department of Water Resources and Environmental Engineering,
Faculty of Engineering and Technology, University of Ilorin, Ilorin, Kwara State, Nigeria.

²Department of Civil Engineering, Landmark University, Omuaran, Kwara State, Nigeria

*Corresponding Author's Email: olubunmimokuolu@yahoo.com or
mokuolu.aa@unilorin.edu.ng.

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ABSTRACT

Adequate water supply is a necessity to life and an essential infrastructure in a major tertiary Hospital. This study looks into the current situation and future solution to the shortage of water experienced in the University of Ilorin, Kwara State, Nigeria. Total water demand was 332m³/d. considering immediate future expansion; water demand was put at 400 m³/d. Source of water was borehole yielding about 115 m³/d when working at maximum capacity, total of 20m³ water was supplied by 2 water tankers per day revealing a shortfall of 197 m³/d. Possible solutions were examined using Linsley adapted method: Surface water or river intake, direct supply from existing sources and construction of dams. Their various merits and de-merits were examined and the most appropriate to meet current and future demand was selected for intervention. Construction of additional boreholes, adequate maintenance and monitoring were recommended.

Keywords: *Water shortage, Hospital, Ilorin, Water demand, Borehole*

INTRODUCTION

Adequate and sustainable water supply system is a necessity for a tertiary hospital. Water always seeks to find its lowest level, in so doing, may remain on the surface in form of streams, rivers or lakes, it may also find its way underground by soaking through the soil and settling at whatever level the subterranean strata dictates. Therefore Sources are either through ground water or surface water. The elements that make up a modern water supply system include the source of supply, storage facilities, transmission to treatment facilities, treatment facilities, transmission from treatment and intermediate storage facilities to distribution facilities (Linsley *et al.*, 1992). Safe transmission serves the ultimate purpose of conveying the water to the consumer. In spite of the importance of adequate water supply to humans, access to potable water supply in Nigerian cities lag behind demand.

Although Nigeria is blessed with abundant water resources, considering total run-off of 600million m³/d or 5700L/C/d from Nigeria's Basins (Martins, 2001). Governments at all levels (federal, state and local) have not been able to successfully harness these resources to ensure a sustainable and equitable access to safe, adequate, improved and affordable water supply and sanitation to the population (Ohwo and Abotutu, 2014). This situation has been confirmed by studies of different cities in Nigeria and Ilorin capital of Kwara state in particular with a population of 606,533 in 1996 with a growth rate of 2.83% and in 777,667 in 2007 comprising three local governments (Ilorin East, Ilorin South and Ilorin West). This figure shows that the growth rate is about 2.82%, which follows the growth rate as proposed by NPC (2006) (Ayanshola, *et al.*, 2013). The provision of water supply and services in Nigeria has been traditionally regarded as a social responsibility of the Government; Findings from a city in Kwara as reported by Sule and Okeola 2010, only 8% households got water supply at least five days a week, 34% only get water once a week and 21% do not get water at all. Looking at the water problem in the area, it was obvious that an overwhelming majority depend on a secondary source of water supply.

About 54% of the households depend on well water while 35% rely on borehole and 7% on a water vendor. Also 98% of the households have storage facility within the household as services are not regular. In this regard 50% make use of plastic/metallic drums while 20% utilize jerry cans for this purpose. Reports from other cities in Nigeria equally echoed similar situations as obtained in Lagos and Warri-Effurun metropolis, Ibadan, Newi, and Yenagoa (Ohwo and Abotutu, 2014). Area of study is a well patronized tertiary Hospital located in Ilorin, Kwara State where amenity like water supply is expected to be high however as experienced in other parts of the City and reported by WHO, 2015 that in

low- and middle-income countries, 38% of health care facilities lack any water source, water shortage was a serious challenge in the Hospital. This study looked into possible means of overcoming the problem in terms of present and future water demand with the aim of proffering solution to current and ultimate water demand of the Hospital.

MATERIALS AND METHODS

This study used quantitative analysis to estimate current and future water demand of a Healthcare facility located within basement complex geographical location in Ilorin Kwara state capital. Ilorin lies between latitudes 8°25'N and 8°32'N longitudes 4°30'E and 4°41'E (Mokuolu *et al.*, 2014; Ayanshola, *et al.*, 2013). It is a major Hospital with 600 bed capacity and providing emergency, medical, surgical, radiology, obstetrics/ gynecology and child health services. It is a medical health institution which also trains medical students while offering health care services. The Hospital has over three thousand employees which include various professionals like Doctors, Nurses, Laboratory Scientists, Pharmacists, Engineers, Physiotherapists and Imaging Scientists. Others are: social workers, Nutritionists, Caterers, Accountants, Administrators, etc. The hospital renders health care services to an average of one thousand patients per day.

The study approach was grouped into three main parts:

- The determination of current and future demand; The baseline study was by direct observation/ key informant interview and quantitative analysis
- The appraisal of all possible means to meet these needs.
- The selection of the most feasible and sustainable approaches for satisfying the anticipated requirements while considering the methods of Engineering economy to accurately determine the optimum solution.

RESULTS AND DISCUSSION

Existing Water Supply Situation (*baseline study*)

The main Source of water was the borehole.

- 10 (ten) boreholes were on ground, 8 (Eight) of them were reticulated
- Water yield/output of boreholes unknown
- Physical, Chemical and Biological characteristics of water (water quality) was yet to be established

Existing water distribution

The Hospital had 2 over head tanks (45,000L each), 1 underground (300,000L capacity), 1 surface (45,000L capacity). Water was being pumped directly to overhead tanks from 4 boreholes, surface tank received supply from 2 boreholes while the underground received supply from 1 borehole. The

remaining 1 number borehole was connected direct to the pipe network. Pipe sizes range from 25mm to 100mm diameter. There was no record of water distribution system design.

Water Shortage

Qualitative data through In Depth Interview (IDI) showed there were occasions when the boreholes develop technical problems (pumps or pumping panel) or Electricity Supply failures. Through IDI and direct observations, there were complains of water shortage by the hospital community.

Water Demand

The demand for water varies from ward to ward, to residential quarters to Administrative departments. Hospital water demand according to WHO

Table 1. Water use and quantities

Use	Quantity (L/day)
Hospital with laundry facility	220
Outpatient	5
Office staff	30
Staff accommodation	220

Table 2. Water use according to facility

Facility	Population	Water use (L/day)
Wards and clinics	505	111,100
Residential quarters	272	59,840
Hospital staff	3188	95,640
Other staff	500	15,000
Out patients	1190	5950
Others (wetting flowers, washing drains etc)		15,000
Total demand		292,530
Add 10% waste/ losses		332,000 (approx.)

Based on assumption, considering immediate future expansion, water demand is put at 400.000L/d or 400m³/d

Solutions to water shortage

Sources of Supply:

Possible sources of water supply can be found in any of the following (adapted from Linsley et al., 1992):

- Construction of boreholes
- Surface water or river intake
- Direct supply from existing sources
- Construction of dams.

Construction of Boreholes

Main source of water supply currently was the borehole. According to Jimoh, 2010, Geohydrological and resistivity studies in basement complex which Ilorin lies is low (ranging from 7200L/d to 14,400L/d).

Following this investigation study, 8 boreholes current in use can yield max of (8 x 14,400)L/d amounting to 115,200L/d (115.2m³/d) when in full operation, additional 20,000L/d was supplied by two water tankers owned by the Hospital which brings water from other sources, meaning a shortfall of about 196,800L/d (196.8m³/d).

Surface Water or River Intake

The only source, considering this option is river Oyun which runs through the Hospital. It has an annual flow of over 80 million m³ (source: KWWC) whereas annual water demand of the Hospital was 146,000m³. It was observed that the river runs dry during the dry season therefore this option need not be given any serious consideration.

Supplies from Existing Sources

Raw water is available for Ilorin community at Agba, Asa and Sobi dam. Total possible yield from the three dams is 135,000m³/day.

Breakdown is as follows:

Asa dam yield: 112,500m³/d

Agba dam yield: 13,500m³/d

Sobi dam yield: 9000m³/d

Total yield= 135,000m³/d

(Source: Kwara State water corporation (KWWC))

Requirement for Ilorin Community is about 180,000m³/d. Two options can be considered using this source for water supply.

Option 1

The Kwara State government had planned a 25,000 m³ water reservoir at Oke Ose to supply the Hospital and its environs.

Advantage

When completed and commissioned, this option will meet the hospital demand.

Disadvantages

- When there is a breakdown at Asa water works, no water can be obtained from the urban system.
- Complete dependent on state government supply

Option 2

Direct supply of raw water from existing supply: The raw water is to be directed to a treatment plant which can be located at the water works area of the hospital. The water is then treated and pumped into existing water line.

Advantage

How much water to be treated and when can easily be decided.

Disadvantages

- When there is a breakdown at Asa dam waterworks, no water can be obtained for treatment and supply to the Hospital.
- Expensive in terms of capital cost.

Construction of Dams

The main river Oyun is dammed by the University of Ilorin for her community use. One of the tributaries of this river runs through the Hospital. The

yield of this tributary is not yet determined at the time of writing since investigations on run-off has not been carried out.

Water is an essential infrastructure in healthcare facility and necessity for human existence. Nigeria is blessed with abundant water resources, but largely untapped Government at all levels (federal, state and local) have not been able to successfully harness these resources to ensure a sustainable and equitable access to safe, adequate, improved and affordable water supply (Helladendu, 2012). The ultimate source of all natural potable water on the earth is rain, Nigeria's groundwater potential is estimated at 106 x10⁹m³ (Martins 2001; Adah and Abok 2013). Use of borehole water is a well known and accepted as a source of water supply in Nigeria (Sule and Okeola 2010; Ohwo and Abotutu, 2014). The quality of water produced by the hospital borehole was not ascertained however report by Yusuf et al., 2012 indicated that quality analysis of boreholes sample in Kwara state were suitable for human consumption.

CONCLUSION

This study has established that the source of

water to this tertiary health facility was inadequate to meet the demand. There is an urgent need for the Management to take a decision to supplement the shortfall.

Adequate treated water could be obtained from Kwara State Government supply to meet the Hospital's current and immediate future expansion needs but this cannot be totally dependable as this will involve going beyond the hospital boundary to meet her necessary need. Construction of additional ten boreholes to augment the existing ten boreholes in addition to on-going efforts on urban supply will alleviate the current shortage.

In addition the following recommendations are made:

- 1) That wastages be reduced to near zero by changing faulty taps, damaged pipelines, faulty water closets.etc
- 2) Construction of ten boreholes to augment the current ten numbers.
- 3) A good relationship with the Kwara State Government/ KWWC.
- 4) Further studies on Oyun River for possibility of a dam.

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SEASONAL VARIABILITY OF SOME METEOROLOGICAL PARAMETERS WITH RESPECT TO SOLAR ACTIVITY OVER SOME STATIONS IN NIGERIA.

¹Falaiye, O. A.*, ²Ijila, P.O. and ³Abimbola, O.J.

¹Department of Physics, University of Ilorin, P.M.B.1515, Ilorin.

²Department of Physics, Adeyemi College of Education, Ondo.

³Department of Physics, Federal University, Lafia, P.M.B. 146, Lafia.

*Corresponding Author'E-mail: sesantayo2001@yahoo.com

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ABSTRACT

In this study we investigated the effects of solar activity on periodic variability of some meteorological parameters for three meteorological stations in Nigeria, from 1980 to 2010. Maximum and minimum temperature, rainfall, relative humidity, evaporation, sunshine duration, solar radiation and windspeed data were used as climate parameters and sunspot numbers data as solar activity indicator. Time series plots of the climatic/meteorological parameters and sunspot numbers were made for each station in order to observe their trend of variations with respect to solar activity effects on the various climatic parameters. The correlation coefficients between the various meteorological variables and solar indices at each station were obtained and given for the considered locations. Results obtained showed that above 95% level of statistically significant correlations exist between sunspot numbers and some climatic parameters for all the locations considered.

Keywords: Meteorological, climate, solar indices, sunspot.

INTRODUCTION

The sun is by far the most important driving force of the climate system. However, only little is known about how variable this force is acting on different time scales ranging from minutes to millennia and how the climate system reacts to changes in this forcing. Changes of the global insolation can be related to the nuclear fusion in the core of the Sun, the energy transport through the radiative zone and the convection zone, the emission of radiation from the photosphere, and the distance between Sun and Earth (Beer et al., 2000). Earth's climate has changed often in the past; most of these changes occur gradually over thousands if not millions of years. The rise of agriculture and human civilization corresponds climatically to earth leaving the ice age about 1000 years ago. The present era called the Holocene, is characterized by relative mild global temperature and year-round ice-cover restricted to high elevation and Polar Regions (Moldwin, 2008).

Climate change has for long remained an object of keen intensive research. The climate of our own earth is rooted in the troposphere, a region which is the lowest layer of the Earth's atmosphere starting at the surface going up to between 7km at the poles and 17 km at the equator with some variation due to weather factors. Attempts have been made to establish a coupling effect among the various layers of Earth's atmosphere (Labitzke and Van Loon, 1988; Rabiou et al. 2005). Impact of solar activity on Earth's terrestrial environment is propagated from the hemisphere via interplanetary medium to the lower atmosphere which has troposphere at its lower end. Solar activity affects the dynamics of the troposphere

and influence the weather of the Earth. Understanding the solar terrestrial interaction, including climatology and weather, starts within the context of Earth's connection to Sun's activity (Tobiska et al., 2000). It is warmer presently in many parts of the world than at any time during the past 1000 years, with possibilities of warmest years than the previous centuries occurring within the next few decades, this change occurring within the next few decades. This change in temperature usually lead to lower ozone levels near the earth surface and significant increase in smog problems in the cities where the release of carbon dioxide is greater (Obioha, 2008). There is therefore a need for proper understanding of the Sun-Earth connection as an external forcing of the Earth's climate; Rabiou (2004). The complexity of climate change in Nigeria makes it imperative for the understanding and evaluation of the various meteorological parameters and processes that forces them, so that we can take action when necessary to curb possible negative effects we might have control over. It will also assist the government to respond to early warning as a result of better preparedness. The cumulative effect will be seen in better and improved socio-economic activities.

Site Description

The study sites, in Nigeria, include the following stations, Ilorin, Ikeja, and Maiduguri, representing the various climatic belts in the country. Ikeja represents the coastal influence, Ilorin represents the savannah belt as well as the central point of the country and Maiduguri represents the extreme North East (see Figure 1). These locations all lies in the trajectory-path of the North Easterly wind bringing in the harmattan dust across the country from the Bodele

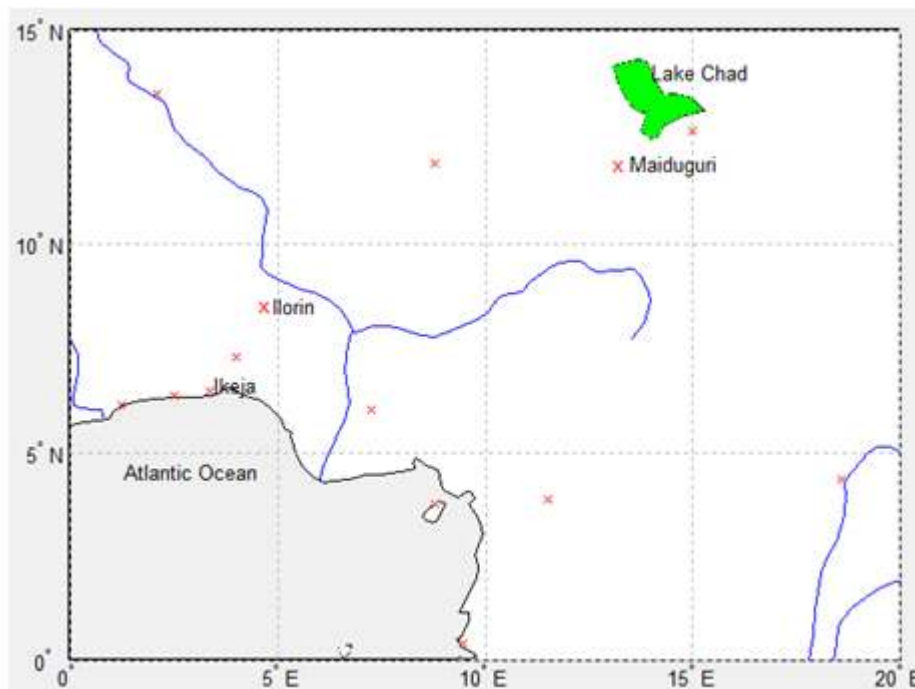


Figure 1: Geographical Locations of the study Sites in Nigeria

Table 1: The Geographical Coordinates of the Stations Used in this Study.

S/N	Stations(site)	State	Latitude($^{\circ}$ N)	Longitude($^{\circ}$ E)	Elevation(m asl)
1	Ikeja	Lagos	06.58	03.33	39.4
2	Ilorin	Kwara	08.48	04.58	307.4
3	Maiduguri	Borno	11.85	13.08	353.8

depression to the Atlantic.

METHODS

The monthly mean meteorological data for the period of Jan, 1980 to Dec, 2010 for eight meteorological parameters: Maximum Temperature, Minimum Temperature, Wind speed, Sunshine duration, Solar Radiation, Evaporation, Rainfall, Relative Humidity and Average Temperature were obtained from the Nigeria Meteorological Agency, Oshodi-Lagos. Also the solar indices data were obtained from NGDC, Boulder, Colorado through the website (<http://www.pmodwrc.ch/pmod.php?topic=tsi/composite/SolarConstant>) for the three synoptic meteorological stations covering the same period.

Time series plots (Fig.1 -3) of some meteorological parameters and sunspot numbers were made for each station to enable us study their trend of variations. Secondly, the correlation analyses were employed to determine the solar activity effect on the climatic parameters variation. Table 2 shows how the solar indices: sunspot numbers (Rs) varies with each of the eight climatic parameters at Ilorin, Ikeja and Maiduguri stations. The correlation coefficients and their statistical significant levels for the sunspot numbers and the eight climatic parameters are indicated in table 1 and discussed.

RESULTS AND DISCUSSIONS

Seasonal Variation of Meteorological Variables with Respect to Sunspot Number from 1980 to 2010

In Figures 1.0(a,b,c,d,e,f,g,h) to 3.0(a,b,c,d,e,f,g,h), the sunspot numbers(blue colour) has been compared with time series of meteorological data(green colour) in order to extend the examination of the assumed association between climate and solar variability.

Figures 1.0(a,b,c,d,e,f,g,h) to 3.0(a,b,c,d,e,f,g,h) demonstrates a strong co-variation between the meteorological parameters and sunspot numbers in the stations for the period 1980 to 2010. The green curve illustrates the different meteorological parameters which are generally varying in a systematic manner with a periodicity of similar to, but not exactly in phase with the variation of the magnitude of the sunspot number. The two time series

had several features in common. Most noteworthy is the prominent minimum at a time, the steep rise to a maximum in another time, and a brief drop during another time and followed by a final rise.

However, the graph showed the following disparities: For Maximum Temperature, there is a strong co-variation between sunspot number and maximum temperature at Ilorin and Ikeja while for all stations Minimum Temperature has similar variation with sunspot number.

Also for Evaporation Pitche, Ilorin and Maiduguri have similar curve pattern with sunspot number curve while only Ilorin have the co-variations of relative humidity with sunspot number.

Solar Radiation in Ilorin, Ikeja and Maiduguri demonstrate similar pattern with sunspot number, Wind Speed at Ikeja and Maiduguri have a strong co-variation with sunspot number, Sunshine Hour also demonstrate the same pattern with sunspot number at Ikeja and Maiduguri.

Correlations between Sunspot numbers and the climatic parameters

As seen on Table 2, the correlations between sunspot numbers and climatic parameters are not statistically significant in all the stations, except in some stations that will be stated: In Ikeja, there is a positive significant correlation between the sunspot numbers and both the wind speed and the minimum temperature. It can be inferred that the proximity of the water bodies in Ikeja influence wind pattern in such a way that some significant positive correlation between sunspot numbers and wind speed is detectable. The influence of rivers and influence of the neighboring oceans that helps in lowering the minimum temperature and this is responsible for the significant correlation between sunspot number and the wind speed and minimum temperature. Also there is a negative significant correlation between the sunspot number and both the relative humidity and rainfall.

In Ilorin, there is a positive significant correlation between the sunspot numbers and the wind speed. It can be inferred that the high amount of radiation in the region is therefore linked in such a way that some significant positive correlation between

sunspot numbers and wind speed is detectable. Also there is a negative insignificant correlation between the sunspot number and other climatic parameters.

In Maiduguri, there is a positive significant correlation between the sunspot numbers and wind speed. It can be inferred that the due to the vegetation, it is therefore linked in such a way that significant positive correlation between sunspot numbers and wind speed is detectable. There is also negative insignificant correlation between the sunspot and some of the climatic parameters due to vegetation of the area.

CONCLUSIONS

It can be generally stated that sunspot numbers has positive correlation with minimum temperature in the stations, and negative correlation

with maximum temperature. It also has some negative correlation with rainfall in some parts of the stations. Some parts of the regions on the other hand indicate slight positive correlation between sunspot numbers and rainfall.

Results show that above 95% level of statistically significant correlations exist between sunspot numbers and both minimum temperature and relative humidity in Ikeja, between sunspot numbers and wind speed in Ilorin, Ikeja and Maiduguri stations.

This implies that sunspot numbers have direct influences on some climatic parameters in Nigeria. This can also be ascertained from the seeming trends in the climatic parameters – sunspot numbers profiles.

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SEASONAL VARIATION OF METEOROLOGICAL VARIABLES W.R.T SUNSPOT NUMBER FROM 1980 TO 2010:

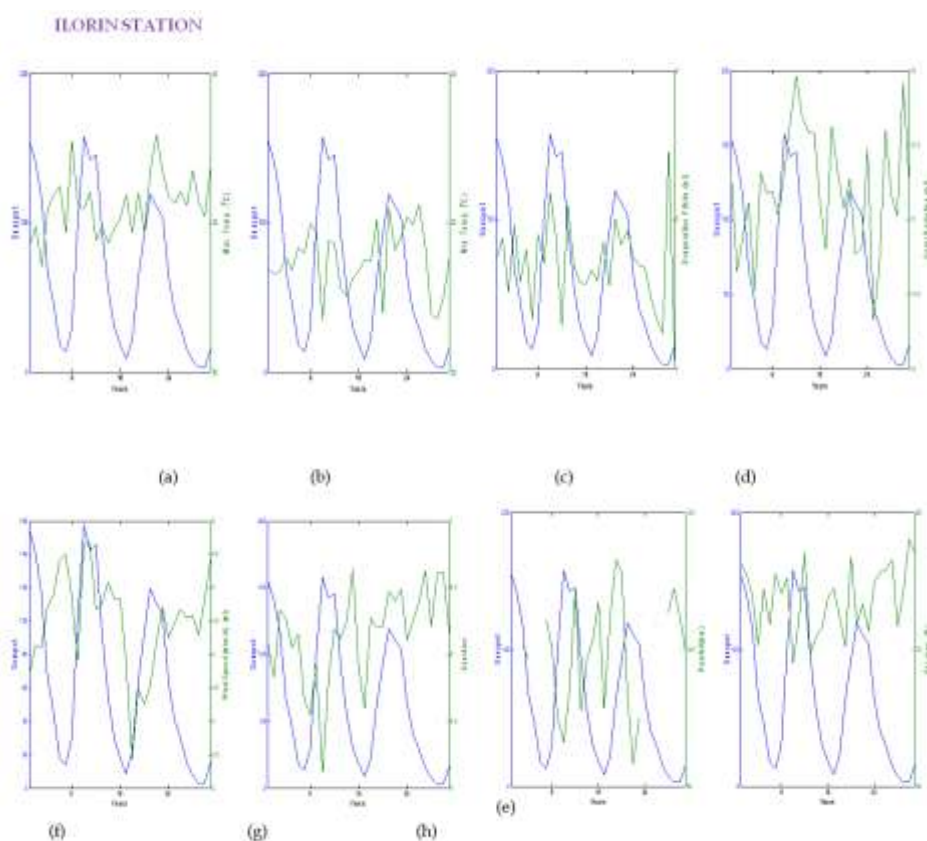


Figure 1.0(a): Seasonal variation of maximum temperature at Ilorin w.r.t sunspot number from 1980 to 2010. (b, c, d, e, f, g, h), same as (a) but for Minimum temperature, Evaporation, Solar radiation, Wind Speed, Sunshine Hour, Rainfall and Relative Humidity.

IKEJA STATION

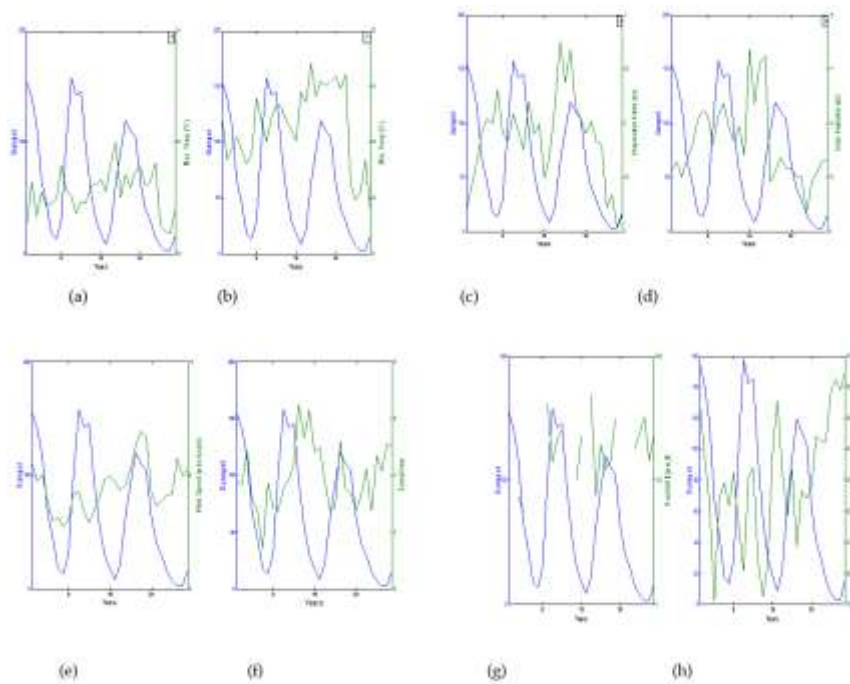


Figure 2.0(a): Seasonal variation of maximum temperature at Ikeja w.r.t sunspot number from 1980 to 2010. (b, c, d, e, f, g, h), same as (a) but for Minimum temperature, Evaporation, Solar radiation, Wind Speed, Sunshine Hour, Rainfall and Relative Humidity.

MAIDUGURI STATION

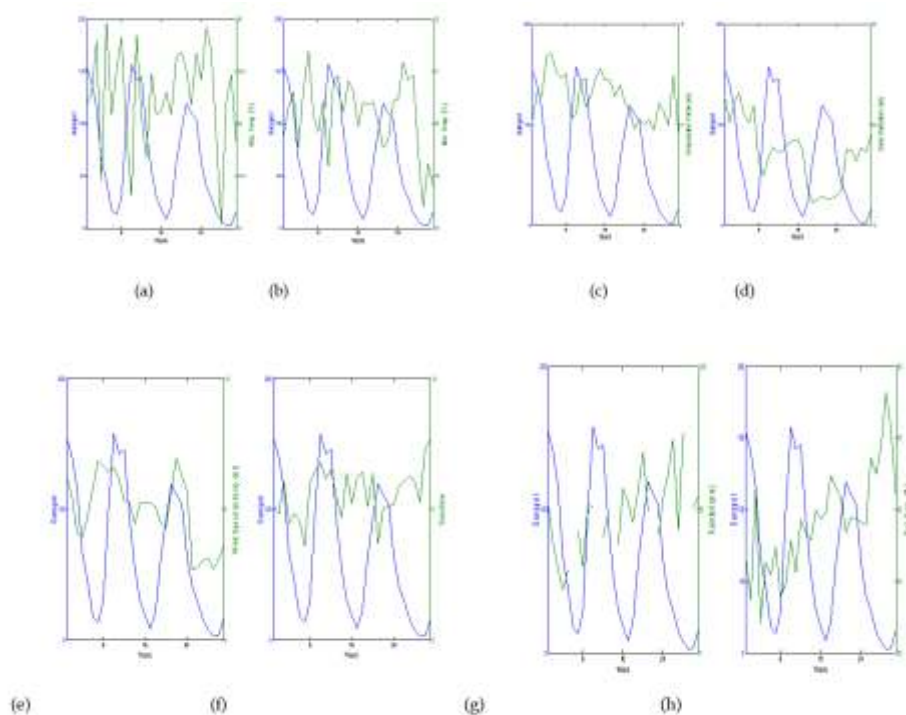


Figure 3.0(a): Seasonal variation of maximum temperature at Maiduguri w.r.t sunspot number from 1980 to 2010. (b, c, d, e, f, g, h), same as (a) but for Minimum temperature, Evaporation, Solar radiation, Wind Speed, Sunshine Hour, Rainfall and Relative Humidity.

Table 2.0: Correlations between Sunspot numbers and the climatic parameters
(Correlation variables with score of 0.1 and above indicates significant correlation among the parameter of study)

CLIMATIC PARAMETERS	ILORIN	IKEJA	MAIDUGURI
Maximum Temperature	-0.0315	-0.0238	-0.0223
Minimum Temperature	0.0048	0.1469	0.0079
Relative Humidity	-0.0219	-0.1136	-0.0528
Rainfall	-0.0237	-0.1283	-0.0252
Wind speed	0.1705	0.1705	0.3386
Evaporation	0.0562	0.0626	-0.0893
Solar Radiation	-0.0135	-0.0408	-0.0375
Sunshine Hour	0.0085	0.0085	-0.0251

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RADIO PROPAGATION MODELING OF JOS SUBURBS AT 900MHZ USING AN ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM

¹Deme, A. C. *, ²Usman, A. U. and ³Choji, D. N.

¹ICT Directorate, University of Jos, Jos-Nigeria

²Department of Electrical and Electronics Engineering, Federal University of Technology, P.M.B. 65, Minna, Nigeria

³Department of Computer Science, University of Jos, Nigeria.

*Corresponding Author: E-mail: demeabraham@gmail.com, demeab@unijos.edu.ng

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ABSTRACT

This study investigates radio propagation modeling of the suburbs of Jos, Nigeria, at an operating frequency of 900MHz, using an Adaptive Neuro-Fuzzy Inference System (ANFIS) Technique. Path loss values computed based on received power measurements obtained from Base Transceiver Stations situated across the suburbs of the city were used to train, validate and test the ANFIS model for capacity to predict path loss. Results indicated that the ANFIS model with a Root Mean Square Error (RMSE) value of 4.74dB offers an improvement in prediction accuracy over the COST 231 Hata model, which has an RMSE value of 5.90dB.

INTRODUCTION

Transmission between the base station and the mobile station is usually accompanied by some power loss, and this loss is known as path loss and it depends particularly on the carrier frequency, antenna height and distance (Ashis, 2012). There is a variety of models used by researchers and radio engineers to predict path loss across a particular terrain. A model that suits a given terrain (or environment) may not necessarily be suitable to another. Hence, radio engineers and researcher have been evolving new techniques for accurate prediction of path loss.

For the purpose of path loss prediction, a wide range of radio propagation models have been used globally. Some of these models include empirical and deterministic models. Empirical models are path loss prediction models that are based on observations and measurements alone. Unfortunately, these empirical models though easier to implement, are less sensitive to the environment's physical and geometrical structures and not so accurate while the deterministic models which though are more accurate are computationally inefficient and require more detailed site-specific information which is often difficult to come by (Abhayawardhana et al. 2005).

An Adaptive Neuro-Fuzzy Inference System (ANFIS) is an intelligent computation technique that is highly efficient in handling complex non-linear problems. Because artificial intelligence is adaptive and relies on observed data rather than on an analytical model of the system, the resulting scheme is robust, efficient and capable of reflecting changes in the wireless signal behavior and hence they mitigate the error in wireless signal prediction (Alotaibi et al., 2008).

Alotaibi et al. (2008) used ANFIS as wireless signal predictor on a private mobile network-terrestrial trunked radio (TETRA) network, where it was shown to outperform some empirical models and to be marginally better than RBF-NN predictor. Also, ANFIS was used by Turkan et al. (2010) to predict path loss based on data obtained in the 900 MHz band in Harbiye region of Istanbul, Turkey. ANFIS prediction error was shown to be less than that obtained using Bertoni-Walfish model. Faihan et al. (2007) developed a robust ANFIS based prediction model for the city of Riyadh city – Saudi Arabia. ANFIS prediction error was shown to be less than that obtained using Bertoni-Walfish model (Walfisch and Bertoni, 1998).

This study investigated the applicability of an ANFIS based predictor for path loss prediction across the suburbs of Jos, Nigeria. The ANFIS predictor is developed and trained on measured data obtained from Base Stations situated within the terrain. The prediction accuracy of the ANFIS predictor is compared with that of the empirical COST 231 Hata based on root mean square error (RMSE) and the

square of multiple correlations, R-square (R^2).

ADAPTIVE NEURO-FUZZY INFERENCE SYSTEMS

An ANFIS is a combination of an Artificial Neural Network (ANN) and a Fuzzy Inference System (FIS) to form an intelligent adaptive system capable of solving complex non-linear problems. ANNs are quite useful in modeling systems where there is no mathematical relationship between input and output patterns. This stems from the fact that, as systems that mimic the human brain, ANNs can be trained using input patterns and target output, and then used to predict a result given new set of inputs. Based on the concepts of fuzzy set theory, fuzzy if-then rules, and fuzzy reasoning, FIS is a computational network capable of modeling human knowledge and reasoning.

ANFIS was first proposed by Jang (1993) to combine the learning ability of ANNs with the ability of fuzzy systems to interpret imprecise information (Abraham et al., 2013). ANFIS is based on the first-order Takagi-Sugeno-Kang (TSK) model. A brief ANFIS architecture as described in (Abraham et al., 2013) is as follows: Figure 1 shows an example of such fuzzy inference system with two inputs, x and y and one output which is a function of the inputs. For the TSK inference system, the rule is constructed as follows:

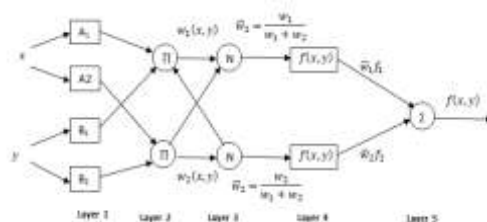


Figure 1: The Architecture of an Adaptive Neuro-Fuzzy Inference System

If x is A_i and y is B_j , THEN $f_i = p_i x + q_i y + r_i$

Where A_i and B_j are linguistic labels in the input spaces x and y respectively and f_i is a local function which depends on x and y .

Layer 1 is the fuzzification layer which generates membership grades for each linguistic label for any input value; these values are defined by membership functions. The common membership functions are the bell and triangular functions depicted in Figure 2. The bell function used in this work is described by the three parameters, a , b and c in equation (1).

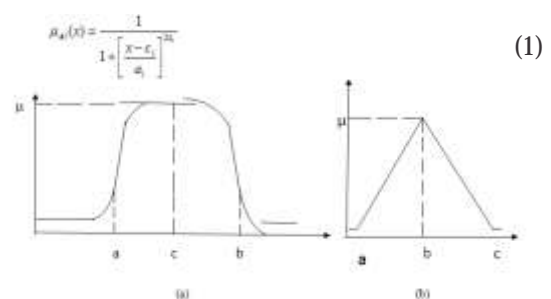


Figure 2: (a) bell and (b) triangular membership functions

Layer 2 is the application of the fuzzy operator and the output of every node in this layer is the product of all the incoming signals into the node as given by equation (2).

$$w_i = \mu_{A_i}(x_i) \times \mu_{B_i}(y_i) \quad (2)$$

Layer 3 produces an output which is the so-called normalized firing strength of each rule according to equation (3):

$$\bar{w}_i = \frac{w_i}{\sum_{j=1}^2 w_j} \quad (3)$$

Layer 4 is a layer of adaptive nodes each with a node function described by equation (4):

$$\bar{w}_i f_i = \bar{w}_i (p_i x + q_i y + r_i) \quad (4)$$

where, p_i , q_i and r_i are called consequent parameters and the least-squares method is used to identify their optimal values.

Layer 5 is the defuzzification layer, that generates a crisp output given by equation (5).

$$f(x, y) = \frac{\sum_i \bar{w}_i f_i}{\sum_i \bar{w}_i} \quad (5)$$

where, $\bar{w}_i f_i$ is the output of node i in layer 4 denoting the consequent part of rule i .

In the training algorithm suggested by Jang (1993), ANFIS uses a hybrid learning algorithm which is a combination of gradient descent and the least-squares approximation method in order to train the network. Gradient descent back-propagation algorithm is used for training the premise parameters and least-squares approximation is used for training the consequent parameters. The optimal consequent parameters are estimated in the forward pass, while the premise parameters remain fixed. In the backward pass, premise parameters are tuned, while the consequent parameters remain fixed.

THE COST 231 HATA MODEL

The COST 231 Hata (Purnima, 2010) Model is an extension of the Hata Model, which is also an extension of the Okumura Model. It was formulated to suit the European environments taking into consideration a wide range of frequencies (500MHz to 200MHz). The COST 231 Hata Model is one of the most widely used radio propagation models because of suitability for urban, semi-urban, suburban and rural areas. The COST 231 Hata Model is given by (Purnima, 2010).

$$L = 46.5 + 33.9 \log f - 13.82 \log h_b - a(h_b) + (44.9 - 6.55 \log h_b) \log d \quad (6)$$

Where,

- L = Median path loss in Decibels (dB)
- $C=0$ for medium cities and suburban areas

- $C=3$ for metropolitan areas
 - f = Frequency of Transmission in Megahertz (MHz) (500MHz to 200MHz)
 - h_b = Base Station Antenna effective height in Meters (30m to 100m)
 - d = Link distance in Kilometers (km) (up to 20kilometers)
 - h_r = Mobile Station Antenna effective height in Meters (m) (1 to 10metres)
 - $a(h_r)$ = Mobile station Antenna height correction factor as described in the Hata Model for Urban Areas.
 - For urban areas, $a(h_r) = 3.20(\log 10(11.75h_r))^2 - 4.97$, for $f > 400$ MHz
- For sub-urban and rural areas, $a(h_r) = (1.1 \log(f) - 0.7)h_r - 1.56 \log(f) - 0.8$

PERFORMANCE EVALUATION INDICES

The statistical indices that form the bases for performance evaluation are based on Root Mean Squared Error (RMSE) and the square of multiple correlations, (R^2).

The RMSE is given by (Olasunkanmi *et al.*, 2014)

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (M_i - P_i)^2}{N}} \quad (7)$$

Where,

M – Measured Path Loss

P – Predicted Path Loss

N – Number of paired values

The square of multiple correlations is given by (Abraham *et al.*, 2013)

$$R^2 = 1 - \frac{\sum_{i=1}^N (y_i - \bar{y})^2}{\sum_{i=1}^N (y_i - \hat{y}_i)^2} \quad (8)$$

Where y_i is the measured path loss, \bar{y} is the mean of the measured path loss. R^2 can take on any value between 0 and 1, but can be negative for models without a constant, which indicates that the model is not appropriate for the data. A value closer to 1 indicates that a greater proportion of variance is accounted for by the model.

MATERIALS AND METHODS

Measurements were taken from 8 different Base Stations of the mobile network service provider (Mobile Telecommunications Network (MTN), Nigeria), situated within the Jos suburbs. The instrument used was a Cellular Mobile Network Analyser (SAGEM OT 290) capable of measuring signal strength in decibel milliwatts (dBm). Readings were taken within the 900MHz frequency band at intervals of 0.2 kilometer, after an initial separation of 0.05kilometer away from the Base Station.

The mobile network parameters obtained from the service provider include the following:

- i) Mean Transmitter Height, $H_T = 34$ meters
- ii) Mean Effective Isotropically

Radiated Power, EIRP = 47dBm

- iii) Transmitting Frequency, f_c =
900MHz

Creating the ANFIS Model Predictor

According to Alotaibi et al (2008), creating an ANFIS network involves specifying the number of network inputs, the number of fuzzy membership function (MF) per each input, the type of fuzzy MF, and the number of epochs. In this paper, the type of the MF chosen is the bell-shaped function, and the number of fuzzy MF per each input is 2 and the number of iterations is 30.

Path Loss Prediction using the ANFIS Model

The techniques adopted in this study include the following:

- a) Splitting Base Station Data into 60% Training, 10% Validation and 30% Testing

This basically involves analyzing each base station separately by randomly splitting path loss data obtained from it into 60% training, 10% validation and 30% training. The essence of validation is to further refine the network construction. This technique simultaneously carries out a performance comparison of the ANFIS based models with the COST 231 Hata model on each base station.

- b) Training with one Base Station data set and testing with a set from another

This is a test for generalization as described in (Abraham et al., 2014). The technique involves randomly training with data set from one Base Station and then testing with a data set from another Base Station. By implication, a given data set can both be used for training and testing.

RESULTS AND DISCUSSION

As stated in the previous section, the first comparative technique involves analyzing each base station data separately, by randomly splitting the data into 60% training, 10% validation and 30% training. Figures 3 to 6 show prediction comparisons of the ANFIS-based model with the COST 231 Hata model relative to the test output. It can be observed from Figures 3, 5 and 6 that the ANFIS based model exhibits a closer prediction, while Figure 2 shows that the COST 231 Hata outperforms the ANFIS model.

MODEL	STAT.	BST1	BST2	BST3	BST4	BST5	BST6	BST7	BST8	GEOM. MEAN
ANFIS	RMSE(dB)	1.06	7.78	4.98	5.05	3.35	4.18	5.53	5.85	4.18
	R ²	0.99	0.11	0.78	0.73	0.92	0.78	0.69	0.56	0.80
COST 231 Hata	RMSE(dB)	4.89	6.32	6.03	6.62	6.52	5.32	6.08	5.42	5.87
	R ²	0.27	-0.75	-0.04	-0.41	0.06	-0.06	-0.13	-0.14	-0.10

Table 1: Splitting data into 60% training, 10% validation and 30% testing

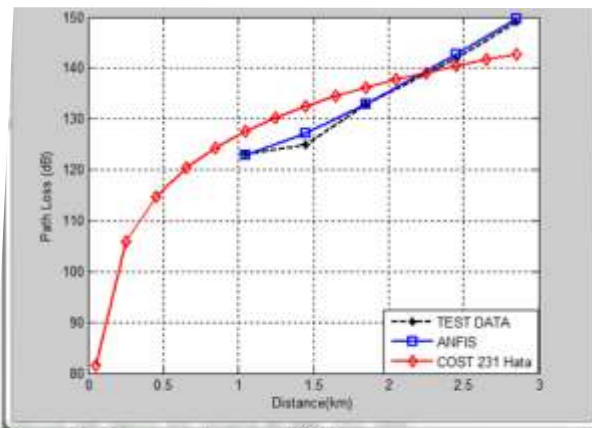


Figure 3 : Comparison on BST1

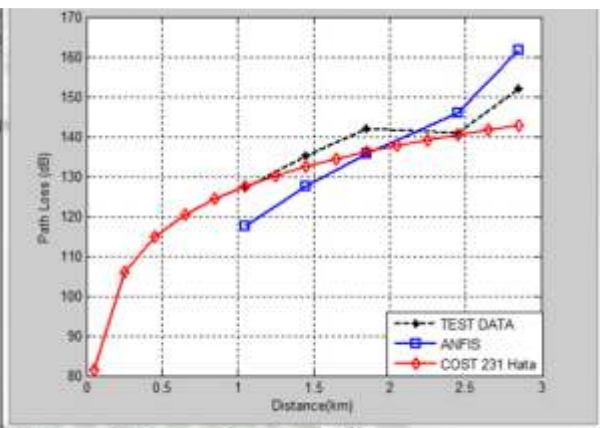


Figure 4 : Comparison on BST2

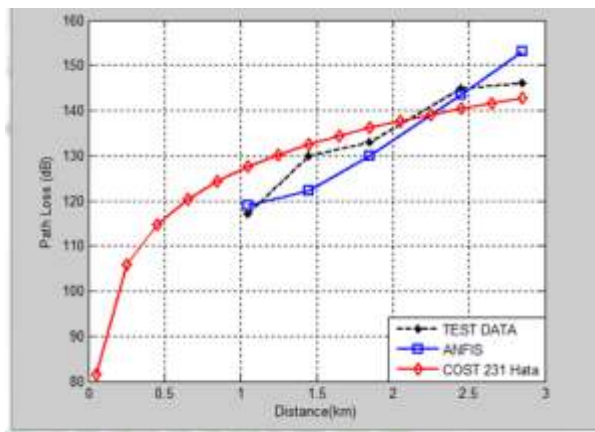


Figure 5 : Comparison on BST3

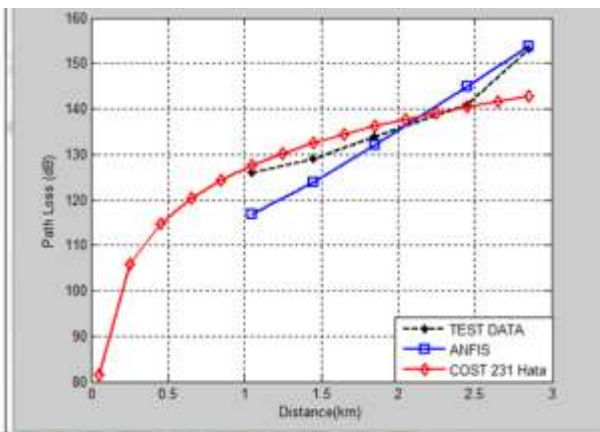


Figure 6 : Comparison on BST4

The performance statistics of the two models across all the Base Stations are presented in Table 1, which shows that the ANFIS model outperforms the COST 231 Hata counterpart on all but Base Stations 2 and 8. Geometric mean values show that the ANFIS model with an RMSE value of 4.18dB and R^2 of 0.6 is more accurate than the COST 231 Hata counterpart, which has an RMSE value of 5.87dB and a very poor R^2 value of -0.10.

The sample graphical comparisons shown in Figures 7 to 10 are based on the second comparative technique. It can be observed that the ANFIS model exhibits a slightly closer prediction than the COST 231 Hata model as far as all the Figures are concerned. Results in Table 2 show that the ANFIS model gives a better prediction on all train/test pairings with the exception of BST6/BST2. Mean performance shows that there is a slight convergence in performance, with the ANFIS model just fractionally more accurate by about 0.56dB.

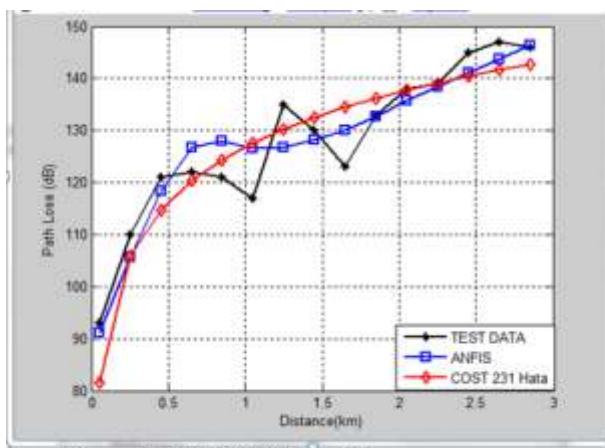


Figure 7: BST3/BST6 Pairing

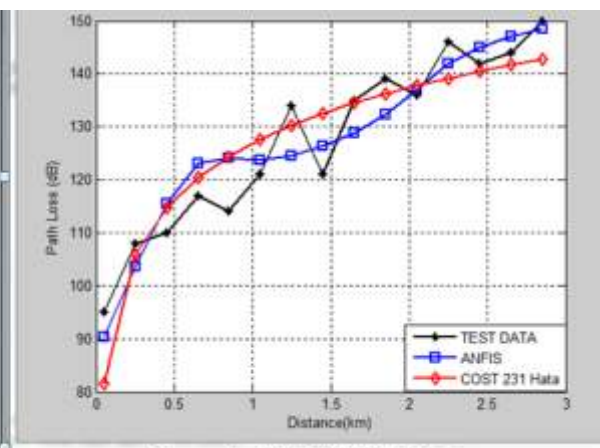


Figure 8: BST5/BST1 Pairing

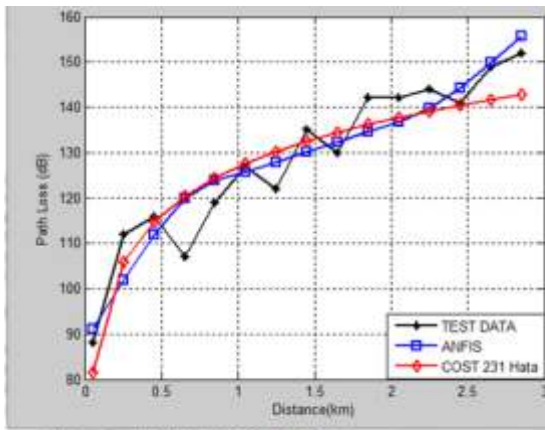


Figure 9: BST2/BST8 Pairing

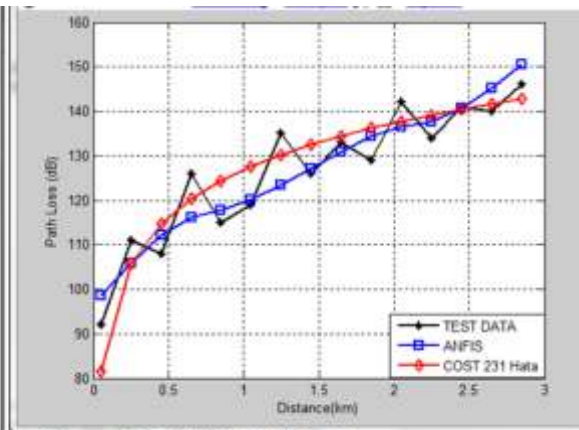


Figure 10: BST7/BST4 Pairing

MODEL	STAT.	BST3 /BST6	BST5 /BST1	BST2 /BST8	BST7 /BST4	BST6 /BST2	BST8 /BST5	GEOM. MEAN
ANFIS	RMSE(dB)	4.82	5.52	5.81	5.50	6.08	4.62	5.37
	R ²	0.89	0.88	0.89	0.86	0.83	0.9	0.87
COST 231 Hata	RMSE(dB)	6.03	6.52	6.32	6.08	5.33	5.42	5.93
	R ²	0.82	0.83	0.87	0.82	0.87	0.86	0.84

Table 2: Training with one Base Station data set and testing with a set from another

Finally, a combined performance evaluation based on the two comparative techniques shows that on the geometric mean, the ANFIS model with an RMSE value of 4.74dB offers an improvement over the COST 231 Hata model, which has an RMSE value of 5.9dB. Moreover, the ANFIS model's superior R² value of 0.72 indicates that it has higher correlation with the test data, compared with the COST 231 Hata model's R² value of 0.29.

CONCLUSION

This study has successfully demonstrated the applicability of an Adaptive Neuro-Fuzzy Inference System technique for path loss prediction across the

suburbs of the city of Jos, Nigeria. Prediction results based on the two comparative techniques implemented show that the ANFIS model with an acceptable RMSE value of 4.74dB is more accurate than the commonly used empirical COST 231 Hata model, which has an RMSE value of 5.9dB. Hence, the ANFIS model is recommended for path loss prediction across the area under investigation.

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DESIGNING AN OFFSET POISSON-GAMMA MIXTURE REGRESSION MODEL

¹Mbe, E. Nja*, ²E.C. Nduka and ³P.U. Ogoke

¹ Department of Mathematics, Federal University Lafia, Nasarawa State, Nigeria

² Department of Mathematics & Statistics, University of Port-Harcourt, Rivers State, Nigeria

³ Department of Mathematics & Statistics, University of Port-Harcourt, Rivers State, Nigeria

*Corresponding E-mail: mbe_nja@yahoo.com

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ABSTRACT

The problem of over-dispersion often encountered by Poisson distribution is what gave rise to the development of the Poisson-Gamma mixture distribution. This distribution is a mixture of a family of Poisson distributions with Gamma mixing weights. The log likelihood function of the Poisson-Gamma mixture distribution has been exponentiated in order to extract the canonical link of the mixture distribution. This link function is re-expressed as a sum of the loglinear link and an offset. By implication, modeling for the Poisson-Gamma mixture model amounts to modeling for the Poisson loglinear model and adding the offset term to the result. This model can be used to model HIV/AIDS infection rate for multiple sex partners. It is theoretically shown that the mixture distribution reduces to the Poisson distribution and that in large samples, the Poisson-Gamma mixture is approximated by the Poisson distribution.

KEYWORDS: *Over-dispersion, Poisson distribution, Gamma mixing weights, Loglinear*

INTRODUCTION

The need to use a Poisson-Gamma mixture distribution arises when the Poisson distribution exhibits over-dispersion. For the Poisson model, the mean and the variance are equal. If the variance of a Poisson model exceeds its mean, over-dispersion is said to occur. Over-dispersion is indicated if Pearson dispersion is greater than 1 Hibe, (2007). The problem with over-dispersion, common to most Poisson models is that it renders the parameter estimates biased. Where over-dispersion is a concern, the alternative models are:

- (1) Quasi-Poisson
- (2) Negative Binomial regression

MATERIALS AND METHODS

In this paper, we shall consider only the Negative Binomial regression as an alternative to the over-dispersed Poisson model. In designing an offset Poisson-Gamma mixture model, it is logical to use the order listed below:

- (i) Poisson distribution
- (ii) Gamma distribution
- (iii) Poisson-Gamma distribution (Negative Binomial distribution)
- (iv) Offset Poisson-Gamma mixture regression model

RESULTS AND DISCUSSION

THE POISSON REGRESSION

The Poisson regression is derived from the poisson probability mass function given Johnson, (2004), Freund, (1992) as

$$P(X = x) = \lambda^x e^{-\lambda} / x! \text{ and (Hilbe 2007) as}$$

$$f(x_i; \lambda_i) = e^{-t_i \lambda_i} (t_i \lambda_i)^{x_i} / x_i!,$$

$$x = 0, 1, 2, \dots, \lambda > 0 \dots\dots\dots (1)$$

where x_i is the count response, λ_i is the predicted count or rate parameter, t_i is the area or time in which counts enter the model

(1) reduces to

$$f(x_i, \lambda_i) = e^{-\lambda_i} (\lambda_i)^{x_i} / x_i!$$

where λ_i applies to individual counts devoid of time or size considerations, t_i is set equal to 1. When time or size or space is a concern, $t_i > 1$ and the resulting model is called offset Poisson model.

$$f = P(X = x) = \lambda^x e^{-\lambda} / x! \dots\dots\dots (3)$$

is the probability of observing any specific count y

The Likelihood function is

$$L(\mu_i, y_i) = \sum_{i=1}^n \{y_i \ln(\mu_i) - \mu_i - \ln(y_i!)\} \dots\dots\dots (4)$$

where μ_i is the predicted count.

(3) is used when the Poisson model is estimated by a Generalized Linear Model.

When estimation employs a full maximum likelihood update, we use

$$\mu_i = \exp(x_i, \beta)$$

and equation (4) becomes Hilbe, (2007)

$$L(\beta; y_i) = \sum \{y_i(x_i, \beta) - \exp(x_i, \beta) - \ln(y_i!)\} \dots\dots\dots (5)$$

From (iii)

$$\exp \log f = \exp\{-\mu + x \log \mu - \log x!\}$$

Thus the canonical link is

$$\theta = \log(\mu) = X' \beta \dots\dots\dots (6)$$

Equation (6) is called the log-linear model.

If time or space or size is a concern and we use a rate as $\frac{\mu}{t}$ instead of μ (6) becomes

$$\log(\mu/t) = X' \beta - \log(t) \dots\dots\dots (7)$$

where $\log(t)$ is called an offset. Equation (7) is then termed an offset Poisson regression model.

GAMMA DISTRIBUTION

This distribution models the waiting time between Poisson distributed events. The probability of waiting time until the n th poisson(λ) event is a gamma probability density expressed as

$$P(x) = \frac{\lambda(\lambda x)^{n-1}}{(n-1)!} e^{-\lambda x}$$

where λ is the rate at which time changes.

If $X \sim \text{Gamma}(K; \theta)$ the pdf becomes

$$P(x) = x^{k-1} e^{-x/\theta} / \Gamma(x) \theta^k$$

for $x > 0, k, \theta > 0$

k = Shape parameter = no of occurrences of an event

θ = Scale parameter

By letting $\alpha = k$ (shape parameter) and $\beta = 1/\theta$ (rate parameter)

The pdf when $X \sim \Gamma(\alpha, \beta)$ becomes $(x, \alpha, \beta) = \beta^\alpha x^{\alpha-1} e^{-\beta x} / \Gamma(\alpha)$ for $x \geq 0$ & $\alpha, \beta > 0$

$$= X^{\alpha-1} e^{-\beta x} / \beta^\alpha \Gamma(\alpha), \text{ for } x > 0, \alpha > 0, \beta > 0$$

$$\text{If } \beta = 1/\alpha$$

α = Poisson rate parameter

$g(x, \alpha, \beta) = 0$ elsewhere

$$g(x, \alpha, \beta) = \log X^{\alpha-1} e^{-\alpha/\beta} - \log \beta^\alpha \int_0^x y^{\alpha-1} e^{-y} dy$$

$$g(x, \alpha, \beta) = \exp\{\log f(x, \alpha, \beta)\}$$

$$= \exp\left\{-\frac{1}{\beta} X - \alpha \log \beta + \log \Gamma(\alpha) + (\alpha - 1) \log x\right\}$$

The canonical link

$$\theta = -1/\beta$$

$$-1/\beta = E(X) = X'\beta$$

$$\text{But } \beta = 1/\alpha$$

$$\Rightarrow -\frac{1}{\beta} = -\alpha$$

$$\text{but } -1/\beta = \alpha'\beta$$

$$-\alpha = \alpha'\beta$$

Thus Gamma regression for rates yields an offset Gamma regression as

$$\alpha/t = \alpha'\beta$$

$$-\alpha = t\alpha'\beta$$

t = time or size or shape.

POISSON-GAMMA MIXTURE DISTRIBUTION

The variance of the Poisson-Gamma mixture distribution differs from that of Poisson by $\mu^2 k$, the extra component arising from mixing the Poisson distribution with a gamma distribution. Thus this variance is given as

$$\text{var}(X) = \mu + \mu^2 k$$

The mean, $E(X) = \mu$ (same as poisson)

The distribution is also termed, Negative Binomial. This is because the negative binomial distribution is a mixture of a family of poisson distributions with gamma mixing weights. In this case, the poisson parameter is a random variable distributed as gamma. The negative binomial distribution with r number of failures, k number of successes and having the probability of success p is given as

$$f(k; r; p) = P(X = k) = \binom{k-1}{r-1} (1-p)^r p^{k-r}, \quad k = r, r+1, \dots$$

By letting $p \rightarrow 0$ or $r \rightarrow \infty$, the Negative Binomial tends to the poisson distribution, where the stopping parameter $r \rightarrow 0$ in a Negative Binomial distribution and the probability of success in each trial $p \rightarrow 0$, the mean parameter λ , is kept constant.

The parameter p becomes

$$p = \lambda/(\lambda + r), \quad \Rightarrow \lambda = rp/(1-p)$$

Under this parameterization,

$$\begin{aligned} \text{The pmf} = f(k; r; p) &= \frac{\Gamma(K+V)}{\Gamma(K)\Gamma(V)} p^K (1-p)^V \\ &= \frac{\lambda^K}{K!} \frac{\Gamma(r+K)}{\Gamma(r)\Gamma(K)} \frac{1}{(1+\lambda/r)^r} \dots \dots \dots (9) \end{aligned}$$

Where k is the number of successes in a sequence of independently and identically distributed Bernoulli trials. r is the number of failures.

$$\lim_{r \rightarrow \infty} f(k; r; p) = \frac{\lambda^K}{K!} e^{-\lambda}$$

λ = expected value or mean

Thus the poisson distribution is a limiting Negative Binomial distribution. The Poisson-Gamma mixture

pmf, $f(k; r; p)$ can be shown to be equal to that of the negative binomial as follows:

$$\begin{aligned} f(k; r; p) &= \int_0^1 f_{\text{poisson}}(\lambda) \cdot f_{\text{gamma}}(r, 1-p/p)(\lambda) d\lambda \\ &= \int_0^1 \frac{\lambda^K}{K!} e^{-\lambda} \lambda^{r-1} e^{-\lambda(1-p)/p} \left/ \left(\frac{p}{1-p} \right)^r \Gamma(r) \right. d\lambda \\ &= (1-p)^r p^{-r} / K! \Gamma(r) \int_0^1 \lambda^{r+K-1} e^{-\lambda/p} d\lambda \\ &= (1-p)^r / K! \Gamma(r) p^{r+K} \Gamma(r+K) \\ &= \Gamma(r+K) / K! \Gamma(r) p^K (1-p)^r \end{aligned}$$

Hence the Negative Binomial distribution is also the poisson-Gamma mixture distribution.

Under the parameterization $k\alpha, E(Y) = \mu = k\alpha$

$$\text{var}(Y) = K\alpha + K\alpha^2 = \mu + \mu^2/K$$

The probability mass function $P(Y = y; \alpha; k)$ becomes

$$P(Y = X; \alpha; K) = \frac{(X+K-1)!}{X! (K-1)!} \frac{\alpha^K}{(1+\alpha)^{K+X}}, \quad X = 0, 1, 2, \dots$$

by which we obtain the log likelihood as

$$l = X \log \left\{ \frac{\alpha}{(1+\alpha)} \right\} - K \log(1+\alpha) + \log \left(\frac{X-1}{K-1} \right)$$

The canonical link function is

$$\eta = \log(\alpha/(1+\alpha)) = \log(\mu/(\mu+k)) \dots \dots \dots (10)$$

Thus the generalized linear regression model arising from (10) is

$$\log(\mu/(\mu+k)) = \alpha + X'\beta$$

for a fixed k

Using another parameterization with

$$f(x; k; p) = \binom{x-1}{k-1} p^k (1-p)^{x-k} \quad x = k, k+1, k+2, \dots$$

where p = probability of success

k = no of successes before r th failure

$$\log f = k \log \left(\frac{x-1}{k-1} \right) + k \log(p/(1-p)) + x \log(1-p)$$

$$\exp f = \exp \left\{ x \log(-p) + k \log \left(\frac{p}{1-p} \right) + \log \left(\frac{x-1}{k-1} \right) \right\}$$

Canonical link, $g(p) = \log(1-p)$

$$= \log q$$

$$= X\beta$$

The offset model is achieved as

$$\log(q/t) = \log(q) - \log(t) = X\beta$$

$$\Rightarrow \log(q) = X\beta + \log(t)$$

q = probability that a person mates with an infected person

$$t = 1/2 \text{ month}$$

ESTIMATION IN POISSON-GAMMA MIXTURE MODEL

The poisson-Gamma mixture (Negative Binomial) x is a non-negative discrete random variable with probability mass function

$$P(X = x) = \begin{cases} \left(\frac{r}{r+m} \right)^r \frac{\Gamma(r+k)}{k! \Gamma(r)} \left(\frac{r}{r+m} \right)^k, & m, r > 0, x = 0, 1, 2, \dots \\ 0, & \text{elsewhere} \end{cases}$$

m = mean = location parameter

r = dispersion parameter = heterogeneity

The variance $\sigma^2 = m + m^2/r$

when r is known, the Negative binomial distribution with parameter m becomes a member of the exponential family.

\bar{x} = is a minimum variance unbiased estimator for m Al-Khasawneh, (2010).

For the two-parameter poisson-Gamma mixture distribution, both m and r are unknown. This situation is more practical.

ESTIMATION OF THE DISPERSION PARAMETER r

Both the method of the moments and maximum likelihood method individually impose constraints on the estimation of the dispersion parameter. Al-Khasawneh, (2010) combines both the method of moments and maximum quasi-likelihood estimation in a variety of ways using appropriate weights.

Method of moments

This is done by solving simultaneously, the following equations:

$$\hat{m} = \bar{x} \quad (11)$$

$$s^2 = m + m^2/r \quad (12)$$

$$\text{Thus } \hat{r} = \bar{x}^2 / s^2 - \bar{x} \quad (13)$$

From (13) it is obvious that if the sample variance s^2 equals the sample mean, \hat{r} cannot be determined.

$$\hat{r}_{MLE} = \bar{x}$$

\hat{r}_{MLE} is solution to

$$n \ln(1 + \bar{x}/r) = n_1(1/r) + n_2(1/r + 1/r + 1) + n_3(1/r + 1/r + 1 + 1/r + 2) + \dots \quad (14)$$

Where n is the size, n_1 is the number of ones in the sample, n_2 is the number of twos in the sample and so on.

Equation (15) can be written as

$$\sum \sum \frac{1}{r + i} + n \ln r / r + \bar{x} = 0 \quad (15)$$

Equation (15) is solved by *IWLS* or Newton-Raphson method to obtain \hat{r}_{MLE} .

\hat{r}_{MLE} exist only for over-dispersed samples Levin and Reeds, (1977)

The re-parameterization of $\alpha = 1/r$ was suggested by Piegorsch, (1990) and Anraku and Yanagimoto (1990), where α was estimated by Maximum Likelihood.

Piegorsch, (1990) obtained $\hat{\alpha}_{MLE}$ as follows:

$$P(X=x) = \begin{cases} \frac{\Gamma(x + \alpha^{-1})}{x! \Gamma(\alpha^{-1})} \left(\frac{\alpha m}{1 + \alpha m} \right)^x (1 + \alpha m)^{-1/\alpha}, & m, \alpha > 0, x = 0, 1, 2, \dots \\ 0 & \text{elsewhere} \end{cases} \quad (16)$$

$$\frac{\partial l}{\partial m} = \sum_{i=1}^n \left(\frac{X_i}{m} - 1 + \frac{\alpha X_i}{1 + \alpha m} \right) = 0 \quad (17)$$

$$\frac{\partial l}{\partial \alpha} = \sum_{i=1}^n \left[\sum_{v=0}^{X_i-1} \frac{1}{\alpha(1 + \alpha v)} - \frac{n}{\alpha} \log(1 + \alpha m) + m \alpha \left(\frac{\bar{x} + \alpha^{-1}}{1 + \alpha m} \right) \right] = 0 \quad (18)$$

$$m_{MLE} = \bar{y}$$

Solving (18) at $m = \hat{m}$ yields $\hat{\alpha}_{MLE}$

THE OFFSET POISSON-GAMMA MIXTURE MODEL

The canonical link function of the Poisson-Gamma mixture regression model can be expressed as

$$\eta = \log(1 - p) \quad (19)$$

Where $p = m/m + r$ is the probability of success in each trial

$$\text{or } \eta = \log \left(\frac{m}{m + r} \right) \quad (20)$$

where m is $E(X)$ = mean.

Equation (19) derives from a probability mass function defined as

$$f(k; r; p) = \frac{\Gamma(r + k)}{k! \Gamma(r)} p^k (1 - p)^r$$

while (20) is derived from a *pmf* version of the Poisson-Gamma model expressed as

$$f(x; \alpha; k) = \frac{(X + K - 1)!}{X! (K - 1)!} \frac{\alpha^K}{(1 + \alpha)^{X+K}}, \quad X = 0, 1, 2, \dots$$

where $E(X) = m = K\alpha$ = mean

$$\text{Var}(X) = K\alpha + K\alpha^2 = m + m^2/K$$

It can be shown that expression (19) & (20) are equivalent. Using equation (20), a generalized linear model having the Poisson-Gamma mixture model is expressed as

$$\eta = \log(m/m + r) = X\beta$$

Note that $m/m + r = p$

$$\Rightarrow \log(m) - \log(m + r) = X\beta$$

$$\log(m) = X\beta + \log(m + r) \quad (21)$$

$\log(m + r)$ is an off-set for the Poisson-Gamma mixture regression model.

Under the condition that $m + k = 1$, the Poisson-Gamma mixture model (21) reduces to a Poisson (m) loglinear model.

$$\hat{\beta}_{MQLE} = (X'WX)^{-1}X'WZ$$

Where W is a diagonal weight matrix with Poisson weights.

$$w = m/\phi, \quad \phi > 1 \quad (\phi \text{ is over-dispersion parameter})$$

$\hat{\beta}$ estimates are Maximum Quasi Likelihood Estimates (MQLE).

Over-dispersion occurs when the observed variance is larger than the expected variance. Under the assumption that the logistic model is correct $D \sim \psi_{n-p}^2$. Collet (2003)

Thus Collet, (2003) $D > n - p = E(\psi_{n-p}^2)$ can indicate over-dispersion, even though the condition $D > n - p$ can be caused by other reasons such as wrong link function, existence of large outliers, etc.

Illustration for an HIV/AIDS study

We assume a community where multiple sex partners live. Let the meeting with a non-HIV/AIDS member of a community by a multiple sex partner be counted as a success and the meeting with a HIV/AIDS member be counted as a failure.

Let p represent the proportion of non-HIV/AIDS.
 Let k = no of times a multiple sex member of the community meets non-HIV/AIDS members before meeting with the r th infected person.
 Then r = no of times the multiple members meets with infected persons.
 k is likely to be higher for higher populations.
 $\therefore k$ is a function of the population (size). r is also going to be higher with higher populations.
 Let $\alpha = 1/r$, then α is a measure of Poisson over-dispersion. Recall that for the Poisson-Gamma mixture distribution, $\text{var}(X) = m + m^2/r = m + \alpha m^2$ thus as $r \rightarrow \infty$, over-dispersion $\rightarrow 0$ and the Poisson-Gamma mixture distribution tends to the Poisson distribution.

Thus in large populations the Poisson-Gamma mixture distribution will be approximated by the Poisson distribution.

CONCLUSION

The offset Poisson-Gamma mixture model has been formulated to show that the Poisson-Gamma mixture link is actually the sum of the Poisson loglinear link and an offset.

Thus modeling a Poisson-Gamma mixture regression model amounts to modeling a Poisson loglinear model and thereafter adding the offset term. It is also shown in this study that by using the fact that the Poisson overdispersion measure is a reciprocal of the number of failures, increasing the sample size reduces Poisson overdispersion.

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EXAMINATION MANAGEMENT PORTAL FOR TERTIARY INSTITUTIONS: A CASE STUDY OF FEDERAL UNIVERSITY LAFIA

Agushaka J.O.^{*}, Ezugwu A.E., Ofem P.O., Adetula E.O., Eke C.I. & Yakmut D.I.
Department of Computer Science, Faculty of Science, Federal University Lafia

^{*} Corresponding Author's E-mail: agushaka@yahoo.com

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ABSTRACT

A study was carried out on the analysis, design and implementation of a Web-based examination management system in Federal University Lafia. A step by step data flow diagram was created as a guide for application developers towards building a more flexible student information system for the university. Using the design, enhanced and intelligent computer software for result computation, integrated with a dedicated database for storing processed results and other relevant records was developed to simplify the University grading system and overcome the short-comings of existing examination packages. An empirical evaluation and comparison of the system with other similar systems shows that it will equally expedite the processing of students' records, semester results and transcripts at various levels and offer a faster, secured management and access to students' results On-line. This system is more efficient and provides substantial benefits for both the University management and students as observed in its implementation.

Keywords: *Examination Management System, Computer Software and Computation.*

INTRODUCTION

Paper examinations still remain the primary means by which student learning in both undergraduate and postgraduate curricula are assessed, as they have unique advantages that may never be replaced in the nearest future. However, paper examinations are laborious to grade, tally, and record. They are also difficult to keep, especially after they are returned to the students. Often, electronic examination is considered a suitable alternative (grading, returning exams, etc). Despite this, more challenges still exist when administering electronic exams, including ensuring that everybody has a secure computer for the examination. Hence, the prevalence of paper examination is expected to continue for quite some time. However, examinations, results and the personal information about students are the key elements of an electronic student information management system. Given the various needs of the different categories of students in a university setting, each student record will need to be processed from time to time in order to meet those needs and the needs of other people outside the university who rely on such records. Some institutions still rely on manual systems for the archiving of students records thereby making its processing and retrieval cumbersome. According to Arekete and Osinowo (2009), student records in other cases are available in semi-electronic or computerized forms which still have the aforementioned inherent difficulties. These electronic formats are unfriendly because they require further cumbersome transformation processes in order to produce the much needed reports. In this current digital era, time is always of essence. There is therefore need to create systems that are seen to be efficient, flexible, reliable and able to produce accurate information as at when required.

Student Information Management Systems (SIMSs) have gone through tremendous changes with respect to technology. According to USDEOPEP (2009), since the early 1990s, the Web has become the technological infrastructure that has enabled the deployment of innovative SIMSs for tertiary institutions. Idogho *et al.*, (2011) reported the creation of an “interactive intranet portal for effective management in tertiary institution”. Their work addressed problems that emanate from the processing of student results, payment of fees and management of library resources. They identified services that are relevant to the institution and sought to harmonize them into a single platform. However, their work discussed only two of such services which include result processing and library resource

management. Also in Youh (2010), a “client server distributed database for student result processing” was also reported. Their work focused on allowing various academic units to maintain and control their data. They placed emphasis on the benefits of leveraging a distributed architecture as opposed to centralized database architecture. In another related study, Ayodele and Ezugwu (2010) reported the “design and implementation of student's information system for tertiary institutions using neural networks: an open source approach”. Just like the previous researches, their work focused on the collection and storage of student records and a prompt processing of results and student transcripts and the end result being the availability of students result online.

This study compared the other similar systems and aims to expedite the processing of students' records, semester results and transcripts as well as offering a faster more secured access to results online.

MATERIALS AND METHODS

The best suitable alternative solution to resolving the stated problem is the creation of an Internet based application. The internet has become a melting pot for the business community, with web application as the key mechanism for success and growth. The choice of adopting web application lies solemnly on some of its important qualities and attributes among which include remote distributive nature (processing occurs at different physical locations), reliability, availability, interoperability and security.

SYSTEM DESIGN METHODOLOGY

Schedule Feasibility

Time evaluation is the most important consideration in the development of project. The time schedule that is required for the development of this project is very important since more development time affects machine time and cost that can cause delay in the development of other systems. A reliable Exam Management System can be developed in the considerable amount of time if scheduled feasibility is properly documented and followed in the cause of the design work. The figures covered in this section are the initial information gathering, which were later projected for a better design model of the proposed system implementation.

System Data Flow Models

The aim of designing a data flow diagram at the early stage of the system planning and implementation is to enable the developer have a wider perspective about the information and functional domain of the overall system functionalities. In the cause of this design process, the data flow diagram is usually

refined to achieve a greater level of detailed information that encompasses the running application to be developed by the software designer. The Web-based Exam Management System data flow diagram is splinted into three levels; ranging from level 0 to level 3 as shown in Figures 1, 2, 3 and 4. The input entities involve Admin (exam officer and MIS staff), Instructors and Students, while the input data objects include: students' profile, course information and examination records. The labelled lines and arrows represent data type hierarchies

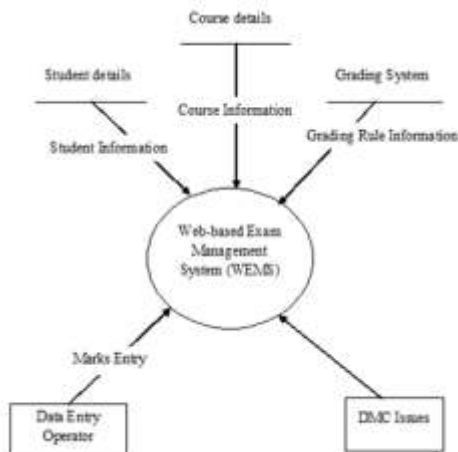


Figure 1: Proposed Exam Management System DFD Level 0

The figure above serves as the core or heart from which we build a fully functional system, with diverse functionalities. Our focus is to develop examination processing engine that will be deployed or migrated across universities, polytechnics and colleges of education. The running of such system should be platform independent and customizable to the taste of end users.

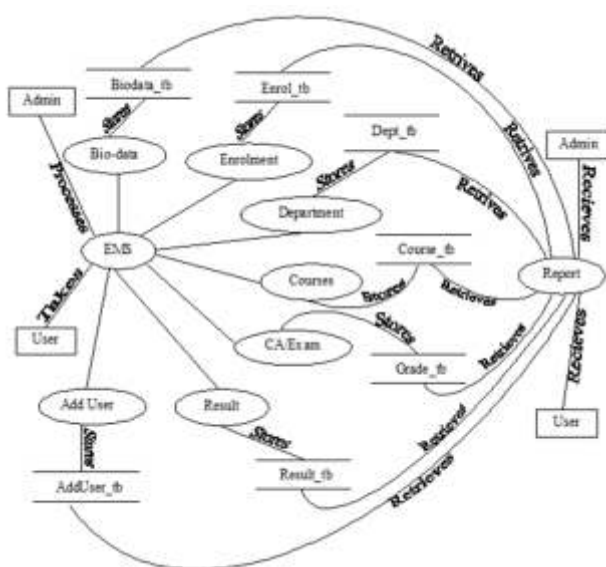


Figure 2: Exam Management System DFD Level 1

The system user comprises both the administrators,

instructors and students interface/module, and each of these users will have different degree or level of right of assessments, depending on their respective roles. We will subsequently provide a detailed description of the running system.

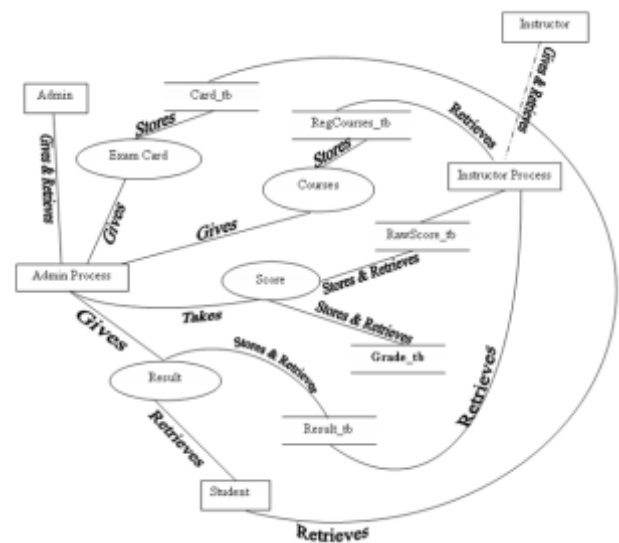


Figure 3: Proposed Exam Management System DFD Level 2

In Figure 3, Examination Card denote a printed or hardcopy identification card containing the list of all courses registered by a student, and on it is also attached the bearer passport photograph. This might differ for some institutions, but WEMS offers a provision for generating examination identification card automatically for individual students.

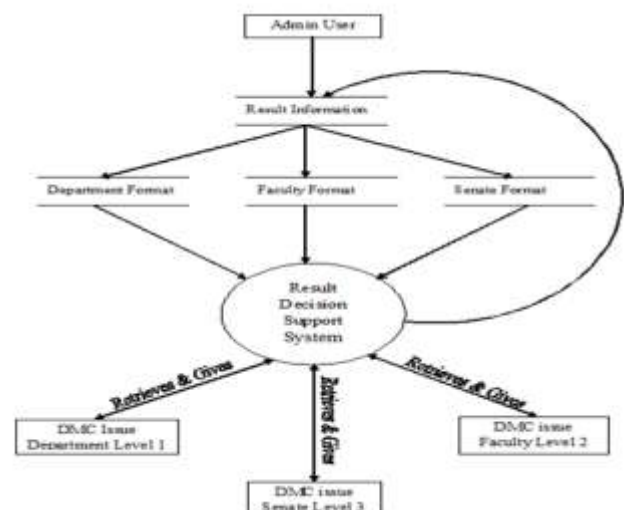


Figure 4: Proposed Examination Management System DFD Level 3

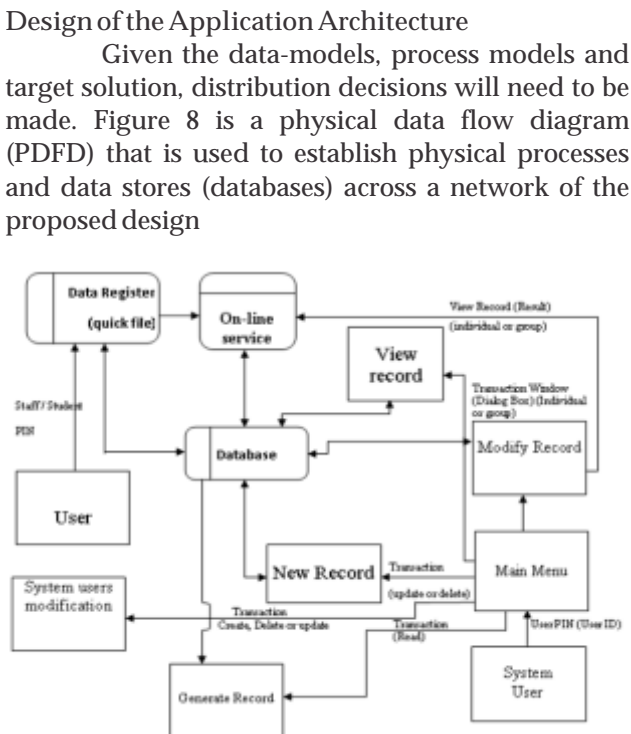
The above entity relationship diagram shows the connection between students, courses and instructors. A connection is established between students, course and instructor because the three are

Figure 7: The System Design Task for the Software Project Development Life Cycle



related. This relationship can further be understood by having knowledge of the role of students, courses, and instructors within the context of the proposed system to be implemented. We choose to define a set of object/relationship pairs that defines the relevant relationships. For example, a student registers a course, receives lectures for the course, at the end, he or she takes an examination.

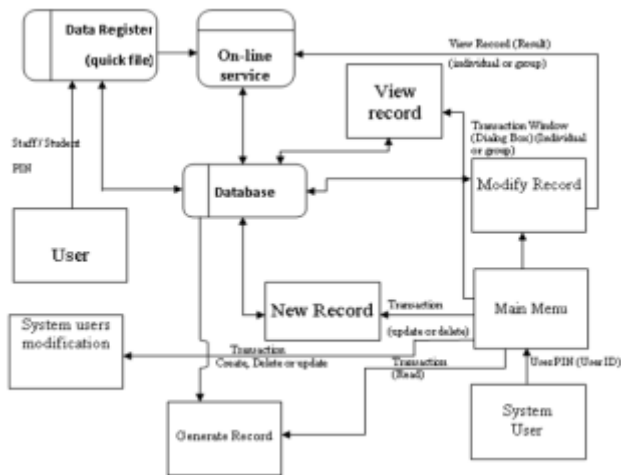
Fig. 7 is a task diagram depicting the work (= tasks) that should be performed to complete the design phase.



Design of the Database(s)

The resulting database schemas shown in Table 1, will serve as container where data are stored as records in tables on the server side database. It consists of a user table (login), Bio-data table, enrolment table, course table, grade table, department table etc. Each table contains a setup information data whose details are provided in the data tables that are shown on the next page:

Table 1: Sample course table from a database.



Data Table

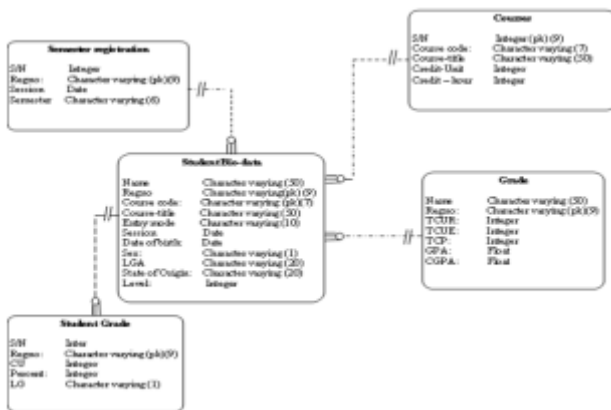


Figure 9: Physical Database Schema

System Design

From the Data Flow Diagram (DFD) depicted earlier on, the next step is the definition of the modules and their relationship to one another in a form called a structured chart, using a data dictionary and other structured tools. The design specifications that get generated at the end of this phase are technical in nature and contain:

- User interfaces
- Databases and data structures
- Algorithms and program structures
- Equipment and other facilities required
- Manual procedures that will be part of the implemented system.

Mathematical Model

The most important aspect of the new system is the grading module (mark information management system); the required parameters are basically the semester registration, course registration, assignment, and examination raw scores. The course credit unit registered is denoted by CC. The semester is broken into two; first and second semester and likewise those courses taken at the respective periods for first semester are usually denoted by odd number course codes, (MATH101, COSC201, STAT305, etc) while those for second

semester are given even number course codes (MATH104, COSC206, STAT304, etc.) respectively. A student is expected to register for a minimum of 48 credit unit in 100 levels. Thus, the total number of credit unit expected at the end of the first year is given by:

$$\sum_{i=1}^N CC_i \leq 24 \quad (1)$$

For first semester cumulative

$$\sum_{i=1}^N CC_i \leq 24 \quad (2)$$

Second semester cumulative

$$\sum_{i=1}^N CC_i + \sum_{j=1}^N CC_j \leq 48 \quad (3)$$

Where $i, j = 1, 2, 3, \dots, N$ and N represents the total number of courses registered by a student per semester.

The credit unit point and grade point average are then computed based on the above perimeter as follows:

$$TCP = \sum_{i=1}^N CG_i \times CC_i \quad (4)$$

$$GPA = \frac{\sum_{i=1}^N CG_i \times CC_i}{\sum_{i=1}^N CC_i} \quad (5)$$

Where CC_i the course's credits, N is the total number of courses; CG_i is the course grade point of the course credit system evaluation policy.

The mathematical models which yield equations (4) and (5) will be used in the mark information management module, to compute grades. Subsequently, the processed marks information will be made available for transcript processing and semester result generation.

RESULTS AND DISCUSSION

The technological approach for the development of the new system is based on WAMP Server (Apache, MySQL, and PHP) open source solution Adewale (2006). The web server has what seems to be a simple straightforward job. It sits there over a network, running on top of the client's machine listening to requests that somebody on the web might make, and it responds to those requests and serves out the appropriate web pages. In reality, it is a bit more complicated than that, and because of the web that runs twenty four hours a day, seven days a week, the stability of the web server is a major issue. PHP and MySQL are popular pair for building dynamic web applications. PHP is the most widely supported and used web scripting language, and an excellent tool for

building web database applications (Williams and Lane, 2004). MySQL is a client/server database that consists of a multithreaded SQL server that supports different back ends, several different client programs and libraries, administrative tools, and a wide range of programming interfaces Connolly & Begg (2002). It can hold up to 60,000 database tables with approximately 5 billion records).

The new system is built around a three-tier architecture model, fourth-tier could also be considered as a suitable alternative, depending on the availability of hardware/preference (see figure 10). At the base of the application is the database tier, consisting of the relational database management system that manages the data that users create, query and delete. This database tier is implemented using MySQL database server. Built on top of the database tier is the middle tier, which contains most of the application logics that have been developed using PHP as the scripting engine. This middleware works closely with the web server to interpret the request made from the World Wide Web, process this requests, interact with other programs on the server to fulfil the request, and then indicate to the web server exactly what to serve to the client browser. At the user end is the client tier, usually, a browser software (Internet Explorer, Mozilla Firefox, Opera or Safari) that interact with the application.



Figure 10: Three-tier architecture model

System Requirements

Table 2: System Requirements

Hardware Requirements		
Processor	R	DiskSpace
PentiumIII, PentiumIVorHigher	512MborHigher	250
SoftwareReq		
OperatingSystem	Da	
Win-2007, Win-XP, Linux or any other higherversion	MyS	
ServerRequi		
Server Platform	Br	
Apache WAMP Server	Internet Explorer, Firefox	
WAP Server	I	
NetworkReq		
Connectivity with University Campus		

System Description

We describe in brief some key roles being performed by the administrative officer, system users and students.

Admin: This module enables the administrator to carry out some administrative task such as addition of new students, enrolments, record modification, computation of result, system update and some basic system maintenance. There can be more than one administrator at a time, whose basic function is to manage the system.

Users: This component of the system carries out the interface or modules for all the users that access the system which includes instructors, student affairs and students. They can always access the system with a common web browser via the internet or local area network connectivity. Each user has an own interface which is always active on the client side of the system. Their respective role is further explained:

- Instructors interface:** This is an interface where all the instructors can manage their own courses and exams. The instructors are assigned the tasks of grading students and submitting their continuous assessments and exams raw scores to the administrative officer in charge of result processing to handle. This module also provides the instructors with the opportunity of knowing the total number of students that registered for their courses.
- Student interface:** With this interface the students can perform three operations. First, they can use it to print their examination cards online, and second, preview or print out their semester results. Lastly, they can use the interface to report complaints regarding detected faults to the administrative officer in charge of processing.

Creating Student Profile: The bio-data of students are usually to be created during the first semester registration or at the beginning of the course and are not needed to be re-entered again for the rest of the semester a student has. The bio-data captures the basic students' information as required by the school authority which is needed for generating reports and other particulars that are required by other bodies who are involved within the academic cycles. As long as a student is already registered in the university portal, the system automatically imports some of the necessary profile needs such as a student's registration number, department etc, since some of these information are not given at the departmental level.

Student Enrolment: The students' enrolment is a repetitive process for every semester. The user is required to enrol students based on their registration

status in the university on-line portal, which might include full time/part time, admission category, and exam details. Most importantly, it is at this level of functionality that the user selects the courses registered by the students.

The enrolment steps might include the following, depending on department choice:

- i. Session for which students are to be enrolled
- ii. Faculty/Department from which the course is taken
- iii. Course status (i.e. core, elective or cognate)
- iv. Exam date
- v. Courses under which students are to be enrolled
- vi. Semester
- vii. Admission category
- viii. Registration number

The examination management system flowchart shown in Figure 11 describes the activities diagram that takes place in the WEMS System. The various interactive scenarios that take place upon successful system login are also presented in chapter five of this in the form of screen shots.

a. The system first checks the user name and password of the system user. If they are not valid, the login interface is re-presented again with a specific login error messages. If the username and password of the user are correct, then the interface presented to the user is based on the user type and access right. The admin user will have a different user interface presented to him as regards what other users will have. When an instructor logon with instructors credential, a different interface is presented and this looks different from that of a student.

b. Student Registration: Figure 14 presents an interactive user friendly form to the admin officer in charge of students' registration in every semester to enter the necessary students' data into the system database.

c. Course Registration: Students are expected to carry out their registration process online. They can login into the system using their registration numbers and a pin code given to them by the departmental examination officer as pass mark. After a successful login, they can select the appropriate course for that particular semester. There are rooms for course registration preview, but modifications of courses registered are not allowed not until after the course registration weeks are over.

d. Generate Exam Card: The system will automatically generate examination cards for students, based on their registration status. The

examination identification card will be systematically dispatched to the web portal and made available for student to download in the cause of their examination time table release.

e. Recording of Exam/CA: It is usually the work of the lecturers to make available their CA/Exam raw score by submitting it into the exam database via the mark-sheet interface meant for that purpose. The processed scores are later retrieved by the exam/admin officer who is in charge of result processing.

f. Process Result: Result processing is performed automatically by the system based on the set conditions inbuilt in the examination package. The system processes result by means of computing the overall grade obtained by students for every course he or she has registered and sat for during the semester. Also among the computed result options include GPA and CGPA. Once the processing is done, it is auto sent to the result database and stored for future report generation.

g. Generate Result: Results are generated in form of reports by querying, and this is often based on request. Students can only access their individual's result online via the university web portal in the form of semester result with their registration numbers, of which they can print out their results for documentation.



Figure 11: Examination Engine Activity Diagram



Figure 12: Online Registration Activity Diagram

The system process assumes that every student should have performed the initial central registration and such registration being validated by MIS as required by the school authority. The departments enrol the students based on retrieved information from MIS central database. Figure 12 does not fall into the range of activities executed by WEMS, but rather it is shown to clarify the initial requirements among various stages that are involved in the process tasks.

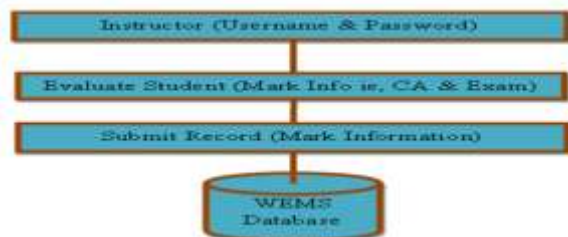


Figure 13: Result Entry Activity Diagram

This activity diagram presented in Figure 13 depicts a module that enables the Instructor to enter students' mark information into WEMS database. The record that is submitted by the instructor will serve as data input which is required by the administrative officer for further processing of the students' final results.



Figure 14: Departmental Course Report Activity Diagram

The departmental administrative officer can use the interface presented in Fig. 4.5 to produce lists of all students that registered for a particular course from within and outside the department.

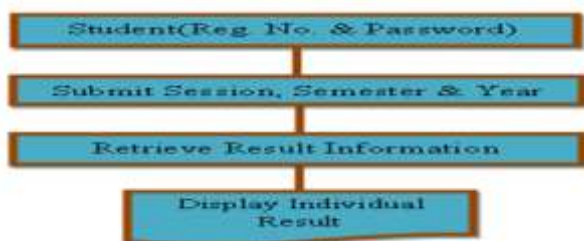


Figure 15: Online Result Checking activity diagram

This presents an activity diagram for students to check their results via online interface that is provided for such purposes. The system first requires the user to provide his/her registration number and password for authentication, after which access is granted or

denied. For every successful login, the student sends queries (i.e., session, semester and year via a dropdown combo box). The system displays the students' page with the following information, students' personal data, and all courses and grades information that are obtained by the students for that session.

CONCLUSION

This model has presented a multitier academic management software models for managing students' academic records' in tertiary institutions. The implementation of the proposed system in Federal University Lafia was a success and this could be attributed to the initial models presented for the Web-based Examination System Package. The various detailed data flow and entity relationship diagrams assisted in the development of a mathematical model for WEMS result computation engine which has been implemented on a four-tier architectural model for a Web-based dynamic application, designed using the WAMP technology (Web server, Apache, MySQL and PHP), an open source solution. Because of the sensitive nature of the system, a role-based model access mechanism has been built into the new system to further boost security of the system. The Web-based Exam software serves a dual purposes; It serves as a stand alone student registration software and at the same time dedicated for remote computing/processing of students results from different departments of the university. It also has the features that will enable the user to enter data from any remote location, thereby facilitating the enrolment process for students academic records. WEMS, when integrated into the university portal, will present end users with an interface whereby students can automatically generate and print out their examination cards, check results and also print transcripts remotely.

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ON THE COMBINATORIAL PROPERTIES OF NILPOTENT AND IDEMPOTENT CONJUGACY CLASSES OF THE INJECTIVE ORDER- DECREASING TRANSFORMATION SEMIGROUP

1

¹Ugbene, I. J. * and ²Mbah, M. A.

¹Department of Mathematics, Federal University of Petroleum Resources, Effurum, Delta State

²Department of Mathematics, Federal University, Lafia, P.M.B. 146 Nasarawa State.

*Corresponding Author's Email: ugbene.ifeanyi@fupre.edu.ng

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ABSTRACT

The elements of the injective order-decreasing transformation semigroup using path structure (Circuits and Proper paths) introduced by Stephen Lipscomb is presented. The elements were grouped according to their conjugacy class, the nilpotents and the idempotents were identified and the nilpotent and idempotent conjugacy class chain decompositions studied. Some observations were made and their order enumerated. Formulae were found for their order and combinatorial properties

Keywords: *Combinatorial properties, Nilpotent conjugacy classes, Idempotent conjugacy classes, Injective Order-decreasing Transformation semigroup*

INTRODUCTION

Semigroup of injective order-decreasing transformations, a subsemigroup of the symmetric inverse semigroup (I_n) was introduced by (Umar, 1992) and defined as thus:

Let α be a transformation In_{I_n} is said to be of order-decreasing if $(\forall x \in \text{dom } \alpha) x\alpha \leq x$. The order of the injective order-decreasing transformations (ID_n) corresponds to sequence A000110: 1, 2, 5, 15, 52, 203, 877, 4140 ... of the online Encyclopedia of integer sequences (OEIS). A formula for its order is given as $B_{n+1} = \sum_{k=0}^n \binom{n}{k} B_k$ where B_k is the k-th Bell's number. It is well known that an element $x \in I_n$ is nilpotent ($x^n = 0$) for some $n > 0$. A property of nilpotent element among others is $x\alpha \neq x \forall x \in \text{dom } \alpha$.

In this paper, we are adopted the path notations invented by (Lipscomb, 1996) for I_n which he defined as follows: Let $\mathbb{N} = x_1, x_2, \dots, x_m$ and $\alpha \in I_n$ have domain $\text{dom } \alpha = x_1, x_2, \dots, x_m$ and if $x_1\alpha = x_2, x_2\alpha = x_3, x_{m-1}\alpha = x_m, x_m = y$.

Then α is a path. Having a circuit or a proper path depends on the value of y . If $y = x_1$ then $\alpha = (x_1, x_2, \dots, x_m)$ is a circuit of length m . If $y \neq x_1$ then $\alpha = (x_1, x_2, \dots, x_m, y]$ is a proper path of length $(m+1)$.

Various text or papers have slightly different path notations as can be seen in (Munn, 1957) where he used the notations "links" and "cycles" for proper paths and circuits respectively. He would write $(12)(345) \in I_5$ as $(12)[345]$ where (12) is the cycle while $[345]$ is the link. (Gomes and Howie, 1987) denoted a primitive nilpotent as " $|1, 2, \dots, m|$ " while (Sullivan, 1987) in his study of semigroups generated by nilpotent transformations denoted a proper path of length $(m+1)$ as m -chains $[1, 2, \dots, m+1]$ and a circuit of length m as m -cycles $(1, 2, \dots, m)$.

Let G be a group. An element $x \in G$ is said to be conjugate to an element $y \in G$ if there exists $g \in G$ such that $y = g^{-1}xg$. Since conjugation is important to group theory, it was only quite natural to have extended it to some certain classes of semigroups.

Theorem 1

Let $x, y \in I_n$. Then the following holds:

- x is conjugate to y if and only if they have the same path structure
- x is nilpotent if and only if its path structure are joins of only proper paths.
- x is idempotent if and only if all the paths in its path structure is of length one

Proof:

a. Let $a = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 3 & 1 & 5 & 6 & - \end{pmatrix} \in I_6 = (123)(456)$

and

$$b = \begin{pmatrix} 1 & 2 & 3 & 4 & 5 & 6 \\ 2 & 3 & - & 5 & 6 & 4 \end{pmatrix} \in I_6 = (123](456).$$

a and b has a circuit of length 3 and a proper 3-path and hence falls in the same conjugacy class. Also we can find a permutation g in permutation group such that $y = g^{-1}xg$ or $gy = xg$ by matching the paths in a vertical order

$$\begin{aligned} a &= (123)(456) \\ b &= (456)(123] \end{aligned}$$

from where we can deduce $g = (14)(25)(36)$

b. Let φ be a proper path and σ a circuit. A circuit is an extension of a permutation and permutation group has no nilpotent, therefore $x = \varphi\sigma \Rightarrow x^n \neq 0$. Hence x is nilpotent if its path structure are only proper paths.

c. Assuming φ or σ has length 2, $x\alpha \neq x \forall x \in \text{dom } \alpha$.

This implies that $x\alpha^2 \neq x\alpha$.

The definition of Conjugacy in arbitrary semigroup seems not to be unique as can be seen in (Kudryavtseva and Mazorchuk, 2009) where they compared three approaches of Conjugacy on semigroups. (Dauns, 1989) gave a definition for monoid and (Lallement, 1979) for free semigroups.

MONOGENIC SUBSEMIGROUP

Let S be a semigroup and let $a \in S$, then the monogenic subsemigroup $\langle a \rangle$ consists of all elements of S that can be expressed as positive integral powers of a . Here we say that a is a generating set of S . In this paper, we only consider the finite monogenic subsemigroup. If repetitions occur in the positive powers of a , then we have that $a^m = a^m + a^r = a^t$ where m is called the index, r the period and $m < t$. We have that the powers $a, a^2, \dots, a^m, \dots, a^{t-1}$ are distinct and therefore order of $a = m + r - 1$. Below is a monogenic subsemigroup generated by

$$a = (12](34567)(8) \in I_8$$

$$a = (12](34567)(8); a^2 = (1](2](35746)(8);$$

$$a^3 = (1](2](36475)(8); a^4 = (1](2](37654)(8);$$

$$a^5 = (1](2](3)(4)(5)(6)(7)(8); a^6 = (1](2](34567)(8);$$

$$a^7 = (1](2](35746)(8)$$

From the illustration above, we can see that $a^2 = a^2 + a^5 = a^7$. It is worthy to note that the term 'Monogenic' was introduced by (Howie, 1995) as against the term 'cyclic' used by (Clifford and Preston, 1961) and (Lipscomb, 1996). Howie claimed that it did not merit the name 'cyclic' because it is not always cyclic as in the case of a singleton generator.

Theorem 2

Let $x \in I_n$. Then the following holds

- The index of x is the maximum of lengths of all the proper paths in it. The index is one if no proper

path exist in \mathcal{X} .

b. The period of \mathcal{X} is the lowest common multiple of all the lengths of the circuits in \mathcal{X} .

Proof: See (Lipscomb, 1996) pp 13.

MATERIALS AND METHODS

The conjugacy classes of $\alpha \in ID_n$ were arranged according to the fix of α denoted as $f(\alpha)$ and defined by $f(\alpha) = |F(\alpha)| = |\{x \in X_n : x\alpha = x\}|$ for any number of ID_n . The nilpotent conjugacy classes are marked as $(*)$, while the idempotent conjugacy classes are marked as $(@)$. The Index and period of each conjugacy class was also found. Some illustrations are given below

Table 1: Conjugacy classes of ID_1

$f(\alpha)$	Conjugacy classes	Index	Period
0	$(1)^*$	1	1
1	$(1)^@$	1	1

Table 2: Conjugacy classes of ID_2

$f(\alpha)$	Conjugacy classes	Index	Period
0	$(1)(2)^*$	1	1
	$(21)^*$	2	1
1	$(1)(2)^@$	1	1
2	$(1)(2)^@$	1	1

Table 3: Conjugacy classes of ID_3

$f(\alpha)$	Conjugacy classes	Index	Period
0	$(1)(2)(3)^*$	1	1
	$(21)(3)^*$	2	1
	$(321)^*$	3	1
1	$(1)(2)(3)^@$	1	1
	$(1)(32)$	2	1
2	$(1)(2)(3)^@$	1	1
3	$(1)(2)(3)^@$	1	1

Table 4: Conjugacy classes of ID_4

$f(\alpha)$	Conjugacy classes	Index	Period
0	$(1)(2)(3)(4)^*$	1	1
	$(21)(3)(4)^*$	2	1
	$(21)(43)^*$	2	1
	$(321)(4)^*$	3	1
	$(4321)^*$	4	1
1	$(1)(2)(3)(4)^@$	1	1
	$(1)(32)(4)$	2	1
	$(1)(432)$	3	1
2	$(1)(2)(3)(4)^@$	1	1
	$(1)(2)(43)$	2	1
3	$(1)(2)(3)(4)^@$	1	1
4	$(1)(2)(3)(4)^@$	1	1

RESULTS AND DISCUSSION

We observed some combinatorial relations between numbers associated with the nilpotent and idempotent conjugacy classes of ID_n . We define the following numbers:

N_n = the cardinality of nilpotent conjugacy classes of ID_n .

E_n = the cardinality of idempotent conjugacy classes of ID_n .

M_n = the total number of chains in the nilpotent conjugacy class chain decomposition of ID_n .

L_n = the total number of chains in the idempotent conjugacy class chain decomposition of ID_n .

Table 5: Table of combinatorial relations

n	N_n	E_n	M_n	L_n
1	1	2	1	2
2	2	3	3	4
3	3	4	5	6
4	5	5	7	8
5	7	6	9	10
6	11	7	11	12
7	15	8	13	14
8	22	9	15	16
9	30	10	17	18
10	42	11	19	20

The following results are products of Table 5 above.

Lemma 1: Let $\alpha \in ID_n$, the nilpotent conjugacy classes of ID_n is given as $|E_n| = n + 1$.

Proof: For each idempotent rank of $n = 0, 1, \dots, n$ in ID_n , there exist at least one idempotent element. Also idempotent elements of a particular rank fall under a conjugacy class. Thus we have $n + 1$ idempotent conjugacy classes

Lemma 3: The total number of chains in the nilpotent conjugacy class chain decomposition of ID_n is

$$M_n = 2n - 1.$$

Proof: Let α be a nilpotent transformation in ID_n with domain $X_n = 1, 2, \dots, n$.

The number of images $(x\alpha) < X_n$ in any n of ID_n . Therefore number of total nilpotent conjugacy class chain decomposition of n will be

(n) empty maps + $(n - 1)$ maps of other combinations of chain decomposition of n . Hence $M_n = 2n - 1$

Lemma 4: The total number of chains in the idempotent conjugacy class chain decomposition of ID_n is $L_n = 2n$

Proof: From Theorem 1.1 we have that \mathcal{X} is idempotent if and only if all the paths in its path structure is of length one. It implies that it is either a

circuit of length one or a proper 1-path of n .
Generally, there are two kinds of path in n ways.
Therefore $L_n = 2n$

structure of length one.

CONCLUSION

The sequence of $N_n = 1, 2, 3, 5, 7, 11, 15, 22, 30, 45, \dots$ where $n = 1, 2, \dots$ is the partitions of a positive integer A000041 of the Online Encyclopedia of Integer Sequences (OEIS). Also the idempotent and nilpotent conjugacy classes for ID_n as well as the total number of chains in the idempotent conjugacy class chain decomposition of ID_n has been shown and hence satisfies the part

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PROPORTIONAL EFFECT OF OUTLIERS ON OVER-DISPERSION

¹Akeyede, I^{*}, ²Saleh, I. M. and ³Babalola, O. A.

¹Department of Mathematics, Federal University Lafia, P.M. B 146, Lafia, Nigeria.

²Department of Mathematics, Federal University Lafia, P.M. B 146, Lafia, Nigeria.

³National Population Commission, Osogbo, Osun State

^{*}Corresponding Author: E-mail: imamakeyede@gmail.com

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ABSTRACT

The impact of outlier on analysis of time series data in causing over-dispersion was examined. The problem of over-dispersion is central to all General Linear Models (GLM's) having discrete responses. If the estimated dispersion after fitting is not near the expected values, then the data may be over dispersed. One of the causes of over-dispersion is outlier. Outlier is a data which is unusual with respect to the group of data in which it is found. In this paper, data were simulated based on poisson model using SPSS and first analysed to see whether the estimated parameters is unbiased of the fixed parameters. Thereafter, two different values of outliers, 10's and 20's were introduced to different percentages of the generated data and then analysed using the STATA package to observe the effect of the outliers being introduced on the data for small, moderate and large samples. The data simulated were replicated 300 times for all categories. The averages of the results were computed. The results showed that the higher the percentage of outliers the more the over-dispersion occurs in the models and the larger the sample size the less the over-dispersion.

Keywords: Outliers, Over-Dispersion, Simulation,

INTRODUCTION

An outlier is an observation that lies outside the overall pattern of a distribution (Moore and McCabe, 1999). A convenient definition of an outlier is a point which falls more than 1.5 times the interquartile range above the third quartile or below the first quartile. It can also occur when comparing the relationship between two set of data. According to Oxford Dictionary of Statistics (2008), outlier is an observation that is very different to other observations in a set of data. It is a data value which is unusual with respect to the group of data in which it is found. It may be a single isolated value far away from all others, or a value which does not follow the general pattern of the rest. Usually the presences of outliers indicate some sort of problem. This can be a case which does not fit the model under study or an error measurement. Outliers are often easy to spot in histograms. Since the most common cause of outlier is recording error, it is sensible to search for outliers by means of summary statistics and plots of the data before conducting any detailed statistical modeling or analysis. If there is only a single outlier present, then an effective test is the Dixon test. For data from a normal distribution, the test statistic of the Grubbs test, suggested by Grubbs (1969), could be used. The Rosner test for multiple outliers relies on ordering the n observation in terms of their distance from the overall mean. Certain statistical estimators are able to deal with statistical outliers and are robust while others cannot deal with them. A typical example is the case of median, that can deal with outliers well, since it would not matter whether the extreme point is far away or near the other data points, as long as the central value is unchanged. The mean on the other hand, is affected by outliers as it increases or decreases in value depending on the position of the outlier. According to Hardin and Hilbe (2007), presence of outliers in data set may rise to apparent over-dispersion. Over-dispersion is a phenomenon that occurs with data fitted using the binomial, poisson or negative binomial distribution. If the estimated dispersion after fitting is not near the assumed values, then the data may be overdispersed, the value is greater than the expected value. It is underdispersed, if the value is less than expected. It is generally caused by positive correlation between responses or by excess variation between response probabilities or counts. It also arises when there are violations in the distributional assumptions of the data (Breslow, 1990). The problem with over-dispersion is that it may cause underestimation of standard errors of the estimated coefficient vector. A variable may appear to be a significant predictor when in fact it is not. Usman

and Oyejola (2013) emphasized that apparent over-dispersion may arise from any of the following:

- (i) The model omits important explanatory predictors
- (ii) The data contain outliers.
- (iii) The data contain excess zero.
- (iv) The model fails to include enough interaction terms.
- (v) A predictor needs to be transformed (to the log or some other scale).

The assumed linear relationship between the response and the link function and predictor is misspecified. (Hardin & Hilbe 2007) A model may be overdispersed if the value of the Pearson (or χ^2) statistics divided by the degree of freedom is greater than 1.0. The quotient of either is called the dispersion. Small amounts of over-dispersion are of little concern; however, if the dispersion statistics is greater than 1.25 for moderate size models, then a correction may be warranted. Models with large numbers of observations may be overdispersed with a dispersion statistics of 1.05 (Hilbe 2007). This study therefore examined the effect of proportion of outliers and sample size in causing over-dispersion to set of data

MATERIALS AND METHODS

Proportional impact of outliers were studied by creating simulated data set for small, moderate and large samples which were taken to be 20, 50 and 100 respectively. For each sample size, we introduced 1, 2 and 3 different sets of outliers out of each of the values 20, 50 and 100 of the response y_i following the idea of Usman and Oyejola (2013). These were replicated 300 times. For instance, the numbers of values of outliers introduced in each sample represent 5, 10 and 15 percent of the observations for the sample size of 20. The values of y_i simulated range from 0 to 9.

Two sets of outliers were introduced into generated data. In the first set we added 10 to the first, first and second, and first, second and third respective values of y_i randomly in the different data generated. While in the second set, we added 20 the same way. Each constructed data set entails a specific cause of the over-dispersion observed in the display of the model output stated as follows;

Constant (β_0) = 0.9 and $\beta_1 = 0.2$, $\beta_2 = -0.5$, $\beta_3 = 0.6$ are coefficients of the predictors. $t = 0, 1, \dots$, and $i = 1, 2, \dots, 300$

Results Output of Sample Size of 20 without Outliers using Stata Codes

```
glmy1 x11 x21 x31, family(Poisson) link(identity)
nolognonrtolerance i=1, ..., 300
```

A sample output of the above code is given as linear models. No. of obs = 20

Optimization: ML	Residual df = 16
Deviance = 15.967703	Scale parameter = 1
Pearson = 14.876987	(1/df) Deviance = 0.997981
Variance function: V(u) = u	(1/df) Pearson = 0.929811
Link function: g(u) = u	[Poisson]
	[Identity]
Log likelihood = -30.63208	AIC = 2.6256856
	BIC = -57.9049

OIM						
y_i	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
x_{1i}	0.2053205	0.0283715	1.8968	0.51	0.249713	0.3609276
x_{2i}	-0.5042415	0.0338103	-1.5563	0.10	-0.670508	0.537975
x_{3i}	0.6024644	0.0304156	3.3466	0.23	0.342851	0.4620779
Cons	1.0000265	0.0300299	3.5087	0.03	0.947569	1.06528404

The data simulated for 300 replications were computed and the average of the outputs were computed and presented in the table 1-6. However, we would expect that the parameter estimates would equal the values we assigned them and that the Pearson dispersion statistics, defined as the Pearson statistics divided by the model degree of freedom, would less than 1.0. Note the Pearson dispersion statistics in the above model is 0.90798 with parameter estimates approximating the values we specified. Furthermore, a value of outlier was introduced in the generated data above, in this case we added 10 to the first data. The codes used in the STATA to generate the responses with an outlier introduced on the same set of predictors yield the output is given below.

Results Output of Sample Size of 20 with an Outlier '10' using Stata Codes

geny_i = y

replacey_i = y_i + 10 in 1/1

glm y_i x_{1i} x_{2i} x_{3i}, family(Poisson) link(identity) nolognonrtolerance=1, ..., 300

A sample output of the above code is given as linear models. No. of obs = 20

Optimization : ML	Residual df = 16
Deviance = 21.936224	Scale parameter = 1
Pearson = 32.374656	(1/df) Deviance = 1.371014
	(1/df) Pearson = 2.023416
	AIC = 2.805261
Log likelihood = -38.630618	BIC = -5514.594

OIM						
y\Coef.	Std. Err.	z	P> z	[95% Conf. Interval]		
x1	3427364	.0334277	10.25	0.001	2772193	.4082534
x2	-5451369	.0453168	-12.03	0.003	-.6339563	-.4563175
x3	3167947	.030732	10.31	0.000	.2565612	.3770283
cons	1.124692	.0344106	32.68	0.001	1.057248	1.192135

From the above result, the parameter estimates are significantly different from the parameters fixed for the model having a response y_i , i.e. y with the first responses having 10 added to the value y . the Pearson dispersion statistics, however, has doubled to a value of 2.0234. The AIC and BIC Statistics are also inflated. Given a small number of observations, a value of

2.0234 indicates a serious over-dispersion, of course, we understand that the source of the over-dispersion result from the 10-outlier. Adding another 10's counts to the observations we already made to the first observations produce multiple over-dispersion (see table 1-6 for the results). More so another value of outlier was introduced in the generated data. In this case, we added 20 to the first data. The codes used in the STATA to generate the responses with an outlier introduced on the same set of predictors yield the output given below.

Results Output of Sample Size of 20 with an Outlier '20' using Stata Codes

geny_i = y

replacey_i = y_i + 20 in 1/1

glm y_i x_{1i} x_{2i} x_{3i}, family(Poisson) link(identity) nolognonrtolerance=1, ..., 300

A sample output of the above code is given as linear models. No. of obs = 20

Optimization : ML	Residual df = 16
	Scale parameter = 1
Deviance = 37.79224	(1/df) Deviance = 2.362015
Pearson = 58.03245	(1/df) Pearson = 3.627025
	AIC = 5.002345
Log likelihood = -38.4567137	BIC = -11.0712

OIM						
yiCoef	Std. Err.	z	P> z	[95% Conf. Interval]		
x1	.3754891	.0245773	11.21	0.007	.3012568	.78956321
x2	-.7896587	.0675321	-10.53	0.010	-.7231562	-.6853217
x3	.4517123	.0564325	12.45	0.000	.0457852	.5876543
cons	2.154321	.0312543	13.69	0.023	1.453278	1.786549

When another value of outlier was introduced in the generated data, i.e 10 added to the first data. The Pearson index increased to 3.627025 which is seriously overdispersed. Also there is a change in the parameter estimates and the AIC and BIC criteria increase to 5.002345 and -11.0712 respectively. The effect of 10% of the observation constituted outlier is remarkable.

RESULTS AND DISCUSSION

ANALYSIS WITH VALUE OF 10'S ADDED TO SOME PERCENTAGE OF RESPONSE

The analysis of data when 10 was added to the first, first and second, and first, second and third data could be seen clearly in the table 1-6. The data were simulated for each three sample size under consideration and analysed. Then a value of 10 was introduced to 5%, 10% and 15% of 20, 50 and 100 observations and they were analysed using the Stata code. Each set of simulations were replicated 300 times, the average of the results were taken and displayed in table 1-3 as follows.

Table 1: Proportional Effect of Outliers in Analysis for Data Set of Sample Size 20

Percentage Index	Pearson Likelihood	Log-	AIC	BIC	B ₁	B ₂	B ₃	Constant
0%	0.9298	-30.6322	8052-57.9050	2053-0.5042	0.6025		1	
5%	1.5673	-36.9933	2997-23.6720	3126-0.7654	0.4136	1.3218		
10%	2.3426	-37.8923	6712-21.7650	4312-0.7112	0.4678	1.5432		
15%	2.5630	-39.8974	2314-19.8650	45210.7856	0.5632	1.6754		

Table 2: Proportional Effect of Outliers in Analysis for Data Set of Sample Size 50

Percentage Index	Pearson Likelihood	Log-	AIC	BIC	B ₁	B ₂	B ₃	Constant
0%	0.9006	-21.7662	3312-77.125	0.2103	-0.5002	0.6125	1.0012	
5%	1.5632	-36.8763	1007-53.6740	3451-0.6734	0.4237	1.1432		
10%	2.4321	-42.6743	6588-34.7780	4654-0.6987	0.4891	1.5651		
15%	2.6126	-49.9884	0654-23.7650	4897	0.8675	0.5467	1.7733	

Table 3: Proportional Effect of Outliers in Analysis for Data Set of Sample Size 100

Percentage Index	Pearson Likelihood	Log-	AIC	BIC	B ₁	B ₂	B ₃	Constant
0%	0.8731	-20.9876	23001-82.1350	2189	-0.4982	0.6521	1.0066	
5%	1.5632	-34.9025	30992-54.0020	3500	-0.6434	0.4743	1.2318	
10%	2.6003	-41.7778	36172-35.7980	4672	-0.6532	0.4998	1.5832	
15%	2.6715	-42.1723	7145-25.087	0.4951	0.7864	0.5632	1.9865	

Tables 1-3 show the effect of percentage of outliers introduced when compared with those with 0% outlier. It was observed that the Pearson's index increases with percentage increase in the number of outliers, hence, over-dispersion occurred as all values of the index are greater than 1.0 for all categories of percentage of outlier introduced and sample sizes. Also from the results all the parameters estimates are significantly different from the fixed parameters. The increase in AIC and BIC information criteria when percentage of outliers increase indicate worse model from smaller to higher number of outliers. It was also observed that the parameters' estimates, Pearson Index and Log-Likelihood increased while AIC and

BIC decreased when sample size was increased for different percentage of outliers introduced.

ANALYSIS WITH VALUE OF 20'S ADDED TO SOME PERCENTAGE OF RESPONSE

The data were simulated for each three sample sizes under consideration and analysed. Then a value of 20 was introduced to 5%, 10% and 15% of 20, 50 and 100 observations and they were analysed using the Stata code. Each set of data was replicated 300 times for different percentage of outliers. The average values of the estimated parameters Pearson index, Log-Likelihood and the Information criteria were taken and presented in table 3-6 as follows.

Table 4: Proportional Effect of Outliers in Analysis of Data Set with Sample Size 20

Percentage Index	Pearson Likelihood	Log-	AIC	BIC	B ₁	B ₂	B ₃	Constant
0%	0.92981	-30.6322	8052.57	9050.20	53.05	420.60	251.00	0000
5%	3.0239	-37.9814	0078-12.89	70.2328	-0.9667	0.4321	1.3254	
10%	3.9876	-50.8985	2245-7.87	690.3897	-0.9007	0.4369	1.3367	
15%	5.8976	-51.7896	8965-2.89	650.1567	-0.8976	0.5156	2.8976	

Table 5: Proportional Effect of Outliers in Analysis for Data Set of Sample Size 50

Percentage Index	Pearson Likelihood	Log-	AIC	BIC	B ₁	B ₂	B ₃	Constant
0%	0.9006	-21.766	2.3312	-77.1250	2.2103	-0.5002	0.6125	1.0012
5%	3.4321	-91.0454	0.156-79.98	80.4116	-0.7654	-0.5678	1.339	
10%	3.9876	-123.685	2245-20.89	80.3814	-0.7896	0.5987	1.9876	
15%	5.1065	-151.676	1897-21.77	70.4292	-0.7998	0.6002	2.8764	

Table 6: Proportional Effect of Outliers in Analysis for Data Set of Sample Size 100

Percentage Index	Pearson Likelihood	Log-	AIC	BIC	B ₁	B ₂	B ₃	Constant
0%	0.9236	-121.76	2.1267	-89.7680	2.2007	-0.5112	0.6115	1.0102
5%	0.9256	-255.923	0.651-67.98	70.2145	-0.5432	0.6752	1.0795	
10%	0.9285	-187.903	1236-55.76	90.2276	-0.5478	0.6786	1.2435	
15%	1.8931	-176.443	6751-43.78	60.2258	0.2258	0.6895	2.2367	

Tables 3-6 show the effect of percentage of outliers introduced when compared with those with 0% outlier. In this case, outlier 20 was added to 5%, 10 and 15% of data simulated. It was observed that, the Pearson's index increases with percentage increase in the number of outliers, hence, over-dispersion occurred as all values of the index are greater than 1.0 for all categories of percentage of outlier introduced and sample sizes. Also from the results all the parameters estimates are significantly different from the fixed parameters. The increase in AIC and BIC information criteria when percentage of outliers increase indicate worse model from smaller to higher number of outliers.

CONCLUSION

Tables 1-6 show the effect of percentage of outliers introduced when compare with those with 0% outlier. It was observed that the Pearson's index increases with increase in the number of outliers, hence, over-dispersion occurred as all values of the index are greater than 1.0 for all categories of percentage of outliers introduced. Also from the results all the parameters' estimates are significantly different from the model. The increase in AIC and BIC information criteria respectively, when percentage of outliers increase, indicate worse model from smaller to higher number of outliers. It was also observed

that, the parameters' estimates, Pearson Index and Log-Likelihood increased while AIC and BIC decreased when sample size was increased for different percentage of outliers introduced. Therefore, the outlier has little effect on the model with increase in the sample size and indeed there is little over-dispersion.

The study concluded that the higher the number of outliers in a set of data the higher the over-dispersion especially at smaller sample sizes. However if the sample size increases with the same number of outliers there will be little over-dispersion. It is therefore recommended that if outliers are present in a data set the sample size should be increased.

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STRUCTURAL AND OPTOELECTRONIC PROPERTIES OF ZnS NANOPARTICLES EXPOSED TO ORGANIC AND INORGANIC CAPPING AGENTS

¹Kalu, O.^{*}, ²Amah, A. N. and ³Mbah, M. A.

¹Department of Physics, Material Science Division, Federal University, Lafia, P.M.B. 146 Nasarawa State.

²Department of Physics, Material Science Section, University of Agriculture, Makurdi, P.M.B. 2737, Benue State.

³Department of Mathematics, Federal University, Lafia, P.M.B. 146 Nasarawa State.

*Corresponding Author's Email: kalu.onyekachi@fulafia.edu.ng; konyekachi@gmail.com

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ABSTRACT

ZnS nanoparticles capped with Sodium Carboxyl-methyl Cellulose (CMC-organic) and Tetraethylorthosilicate (TEOS-inorganic) as capping agents were synthesized by chemical co-precipitation and sol-gel technique respectively. Structural, morphological and optical studies of the synthesized nanoparticles were carried out using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), UV-Vis spectroscopy and Fourier transform infrared spectroscopy (FTIR). Studies of the capped ZnS nanoparticles revealed zinc blende structure. Particle sizes calculated from Williamson-Hall (W-H) analysis of Uniform Deformation Model (UDM) were 2.57nm (ZnS:CMC) and 1.58nm (ZnS:SiO₂). The average strain values calculated from the model indicated that ZnS:SiO₂ has 10.3×10^{-3} while ZnS:CMC has 5.5×10^{-3} . All samples had smooth surfaces due to passivation of the capping agents. Optical absorption studies shows a blue shift of the absorption edge with band gap values of 5.00eV and 3.73eV for ZnS:CMC and ZnS:SiO₂ which are higher than the bulk value of 3.60eV of ZnS nanoparticles due to quantum confinement effect. The vibrational modes associated with OH-stretching at 3484.25cm^{-1} and the carboxylic group -COOH at 1703.02cm^{-1} confirms the presence of capping agent from the Fourier transform infrared spectroscopy measurement.

Keywords: ZnS, Capping agents, Chemical route, Sol-gel, Nanoparticle sizes, Strain and Optoelectronic

INTRODUCTION

Semiconductor nanoparticles as an advance research material for most dynamic area of scientific research have significant fundamental and commercial interest. ZnS as an important group II–VI semiconductor compound with average wide band gap energy of 3.6 eV has shown excellent properties in luminescence, photochemistry and low toxicity compared to other semiconductors (Amah *et al.*, 2012). This is because of the wide range of its application in areas such as phosphors, optics, electronics, solar cells, catalyst and sensors, hence the need for intensive investigation in order to understand the workability of the device in the above aforementioned applications (Ravi, 2011; Ahemen *et al.*, 2013).

Nanoparticles generally are zero dimensional structures which are size dependent. As they approach the nanoscale regime, quantization and domination of atoms at the surface becomes significant due to the large surface area of the nanoparticles. Therefore during synthesis or preparation of nanoparticles the choice of capping agent in engineering of size and surface structure is of both theoretical and practical importance due to the inherent mechanical, chemical, electrical, optical, magnetic, electro-optical and magneto-optical properties that are substantially different from those observe for their corresponding bulk (Gnanam and Rajendran, 2011).

These capping agents which is either organic or inorganic during synthesis determines the material to be synthesized, since they are responsible for the stability on the surface of the nanoparticles through covalent or ionic interaction as well as isolation of individual nanoparticles under ambient conditions (Kalu *et al.*, 2013).

Organic capping agent's which are polymeric in nature consist of molecules that bind to the surface of the particles with a network of hydroxyl head group and an alky tail chain. They restrict the growth of the nanometric size of the particles by stabilizing the nuclei and larger nanoparticles against aggregation, as well as accurate control of size and surface structure (Sperling and Parak, 2012).

Inorganic capping agents has been observed to be wide band gap semiconductors, whose primary aim is the elimination of surface related defect states at the particle surface during synthesis and the confinement of charge carriers to the core material. This usually results to increase quantum yield and luminescence efficiency. They also decrease polydispersity which enhances colloid stability at control growth rate. The lowering of density of trap states in surface passivated samples has been attributed to the effect capping agent, hence its application in luminescent semiconductors (Reiss *et al.*, 2002).

Also capped zinc sulfide nanoparticles with varying emission spectra and decay times have been reported due to passivation of the nanocrystal's

surface which plays important role in the optical properties and the controlling of dispersed particle sizes (Kalu *et al.*, 2013).

Widening of a semiconductor band gap stemming from quantum size effect can be obtained when the semiconductor particle size reaches or become less than the Bohr radius. Therefore to prepare such nanoparticles at engineered size and surface structure requires limiting their growth at the beginning of their formation when capped (Kalu *et al.*, 2013; Pawar *et al.*, 2010.).

The variation of particle size is a crystal distortion due to the confinement caused by capping. The strain-induced broadening stemming from such distortions depends largely on the lattice parameters and the diffraction angle which can be evaluated. Lattice strain is therefore a measure of the distribution of the lattice constants arising from crystal imperfections (Mote *et al.*, 2012). Crystallite size and lattice strain affect the Bragg peak in different ways. Such as increase in width of the peak, the intensity of the peak and shift peak to a position accordingly.

(Kumar and Rao, 2013).

This research investigated the effect of organic and inorganic capping agents on the particle sizes of ZnS nanoparticles and analyzed the associated strain induced due to peak broadening using Williamson-Hall Model.

MATERIALS AND METHOD

The ZnS nanoparticles were prepared from analytical grade of zinc sulphate hepta-hydrate ($\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$), sodium sulphide nona-hydrate ($\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$), toluene, ethanol, deionized water, Sodium carboxymethyl cellulose (CMC) and tetraethylorthosilicate (TEOS).

The synthesis process was carried out by mixing 0.2M of CMC solution (1 % wt/wt in deionized water) with 50 ml of (4.39g) of $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ under stirring for 25min. This was followed by adding (drop-wise) 50 ml of (4.80g) of $\text{Na}_2\text{S} \cdot 9\text{H}_2\text{O}$ using a pipette to the Zn^{2+} /CMC precursor solution at room temperature under continuous stirring. Continuous stirring was uninterrupted until the last drop of the S^{2-} precursor solution was added for another 25min to allow for complete mixing of the reactants and formation of a white precipitate. The precipitate was then centrifuged at 3500 revolution per minute (rpm) for 20min to obtain a white precipitate which was washed several times with toluene/ethanol mixed solution. The white precipitate was filtered and then dried at 100°C in a vacuum oven for 4 hours. The dried sample (ZnS:CMC) was grinded in an agate mortar and pestle to obtain a fine powder for characterization. Note that before drying, part of the washed precipitate was taken out and re-dispersed into ethanol for optical measurements. The above procedure was repeated using tetraethylorthosilicate (TEOS) as an inorganic capping agent with little modification during synthesis for the sample (ZnS:SiO₂).

Characterization of the synthesized nanoparticles (ZnS, ZnS:CMC and ZnS:SiO₂) was carried out using X-ray Diffraction (PANalytic X-ray Diffraction machine at Engineering Materials Development Institute Akure, Nigeria) with Cu K α radiation ($\lambda = 0.154056$ nm), Scanning electron microscope (Carl-Zeiss MA 10 series machine at Sheda Science and Technology Complex Abuja, Nigeria) for the morphologies of the synthesized samples deposited on a carbon-coated grid for examination. Optical absorption spectra of the nanoparticles samples dispersed in ethanol were recorded at room temperature using a UV-Visible spectroscopy (JENWAY 6405 at Federal University Lafia, Nasarawa State Nigeria) and Fourier Transform Infrared spectroscopy between the range of $400 - 4000\text{cm}^{-1}$ were recorded (Shimadzu-IR 8400s at the National Research Institute of Chemical Technology, Zaria, Kaduna State, Nigeria) to verify the presence of capping agents.

RESULTS AND DISCUSSION

The result presented in Fig.1 shows that the XRD pattern of the samples ZnS, ZnS:CMC and ZnS:SiO₂ nanoparticle has a zinc blende (cubic) crystal structure respectively.

The spectrum as deployed in Fig.1 shows that the diffraction peaks at about 2θ values were

$$32.07^\circ, 51.96^\circ, 60.54^\circ (\text{ZnS}), 27.0^\circ, 51.72^\circ, 59.86^\circ (\text{ZnS:CMC}) \text{ and } 26.25^\circ, 49.08^\circ, 58.54^\circ (\text{ZnS:SiO}_2)$$

whose corresponding diffraction planes are (111), (220) and (311). It is clear from Fig.1 that there are three major diffraction peaks. The highest intensity reflection peak is at about 27.0° for capped samples (ZnS:CMC, ZnS:SiO₂) with two other small intensity peaks at $51.72^\circ, 59.86^\circ$ and $49.08^\circ, 58.54^\circ$ respectively indicating that [111] is the preferred direction and at 32.07° for the uncapped sample (ZnS). The broadening of the XRD peak confirms the formation of the ZnS nanocrystals at particle sizes regime of 7.61nm, 2.57nm and 1.58nm for ZnS, ZnS-CMC and ZnS-SiO₂ respectively as calculated from the full-width half-maximum (FWHMs) for specific diffraction peaks using the Williamson-Hall (W-H) analysis of Uniform Deformation Model (UDM) (Mote *et al.*, 2012). However the nature of XRD pattern for the ZnS-SiO₂ sample may be associated with Ostwald ripening and phase transformations occurring concurrently during the poly-condensation reactions followed by gel transforms into a solid mass.

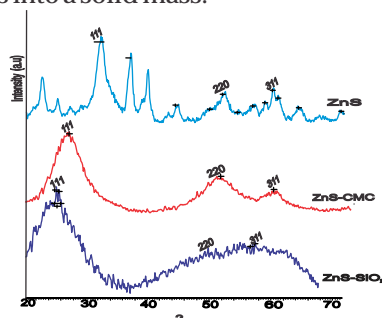


Fig.1. XRD pattern for (a) ZnS (b) ZnS:CMC and (c) ZnS:SiO₂ nanoparticles

The information concerning the strain and the particle size were obtained from the full width at half maximum (FWHMs) of the three diffraction peaks. The FWHMs (β) can be expressed as a linear combination of the contributions from the strain (ϵ) and particle size (D) nm of the Scherrer's equation which are components for the formation of Williams Hall analysis for particle size and lattice strain with the following relation shown below

$$\beta_{hkl} = \frac{k\lambda}{D \cos \theta} + 4\epsilon \tan \theta \quad \dots\dots\dots (1)$$

$$\beta_{hkl} \cos \theta = \frac{k\lambda}{D} + 4\epsilon \sin \theta \quad \dots\dots\dots (2)$$

Equation (1) represents the Uniform Deformation Model (UDM) of Williamson-Hall equation for strain analysis whose plot separates the contribution due to strain (ϵ) and crystallite size (D) towards the line broadening.

The result in Fig.2 below represent the plot of $\beta_{hkl} \cos \theta$ versus $4 \sin \theta$ whose amount of strain is the slope of the linear fit and calculated crystallite size from the intercept on $\beta_{hkl} \cos \theta$ axis.

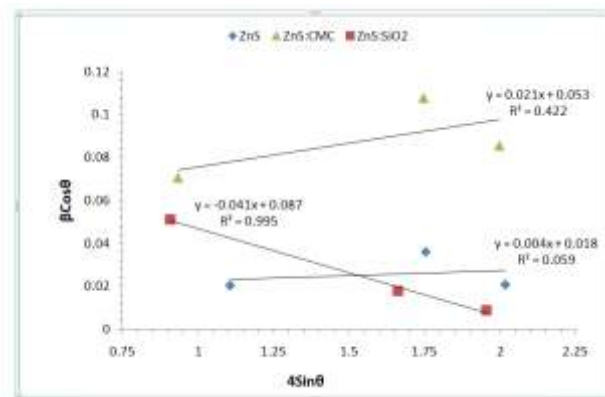


Fig.2. Williamson-Hall plots of powdered XRD data of ZnS, ZnS:CMC and ZnS:SiO₂

Table 1. Lattice parameter, structure, energy band gap, particle sizes and the strain values

Sample	2θ	hkl	d_{hkl} Å	Lattice Constant Å	Structure	Energy band gap (eV)	Williamson-Hall method (UDM) Particle Size (nm)	Strain (ϵ)
ZnS	32.07	111	2.7886	4.8299	cubic	3.60	7.61	0.0011
	51.96	220	1.7384	4.9735				
	60.54	311	1.5281	5.0681				
ZnS:CMC	27.00	111	3.3002	5.7161	cubic	3.73	2.57	0.0055
	51.72	220	1.7662	4.9955				
	59.86	311	1.5439	5.1205				
ZnS:SiO ₂	26.25	111	3.3925	5.8759	cubic	5.00	1.58	0.0105
	49.08	220	1.8547	5.2458				
	58.54	311	1.5755	5.2253				

The results presented in Table 1, show that the particles sizes obtained using Williamson-Hall Uniform Deformation Model (UDM) confirmed changes in particle sizes due to capping effect. Also the calculated values of the strain induced on the nanoparticles were directly proportional to the energy band gap and inversely proportional to the nanoparticle sizes. In comparison, it is observed that ZnS:SiO₂ has the smallest particle size, high induced strain and the largest energy band gap which indicates an excellent combination for tuning optoelectronic properties.

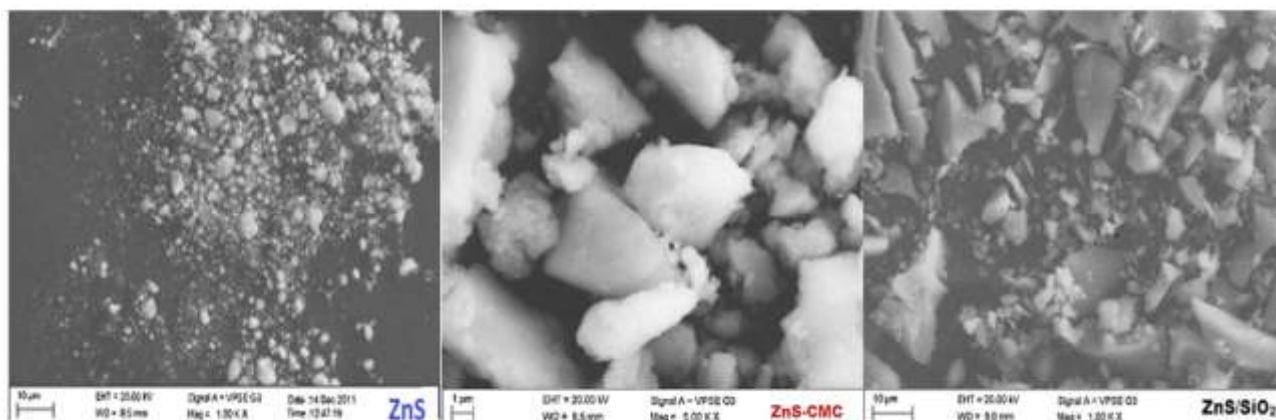


Fig.3. SEM micrograph of ZnS, ZnS:CMC and ZnS:SiO₂

The results in Fig.3 shows the SEM micrographs of the organic and inorganic capped ZnS nanoparticles synthesized in this work. The morphology of the nanoparticles depends on the capping agent used such that the ZnS sample has a rough surface texture while that of ZnS:CMC and ZnS:SiO₂ revealed smooth surfaces confirming the presence of capping agent.

The optical absorption spectra of the synthesized nanoparticles samples (ZnS, ZnS:CMC and ZnS:SiO₂) using the measurement from UV-vis spectroscopy are shown in Fig. 4a, with the absorption wavelengths ranging from 220-308nm. It was observed that at the same concentration of the capping agents the sample peak of (ZnS:SiO₂) shifted towards a low value 220nm wavelength(nm) compared to other sample.

The plot of the square of the absorption coefficient $(\alpha h\nu)^2$ versus energy $(h\nu)$ for determining the energy band gap for all samples are presented in Fig.4b. The energy band gaps of the samples were estimated by extrapolating the straight-line portion of the spectrum to a zero absorption coefficient using the Tauc's relation of (equation 3) for direct band gap semiconductor (Ahemen *et al*, 2013).

$$(\alpha h\nu)^2 = (h\nu - E_g) \dots\dots\dots (3)$$

The observed blue shift in the absorption edge is a reflection of the band gap increase owing to quantum confinement effect which can be associated to decrease in particle sizes at nanosize regime. The obtained optical band gap corresponding to the absorption edge for ZnS, ZnS:CMC and ZnS:SiO₂ samples were 3.60eV, 3.73eV and 5.00eV respectively as shown in Fig. 4(b). The band gap values of 0.13eV and 1.40eV were suggested to be as a result of blue shifted for ZnS:CMC and ZnS:SiO₂ samples as compared to the uncapped ZnS sample of energy band gap blue shifted at of 0.00eV (Murali-Krishna *et al.*, 2010). These results also indicate that at the same molar concentration, the capping ligands determine the actual value of electronic and optical properties of the nanoparticles.

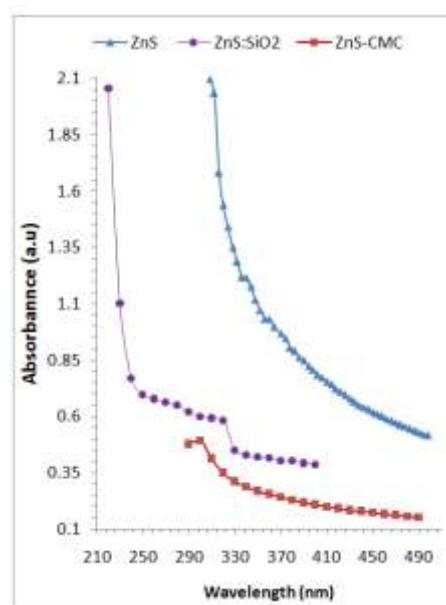


Fig. 4a: Optical Absorbance of ZnS, ZnS:CMC, ZnS:SiO₂ nanoparticles

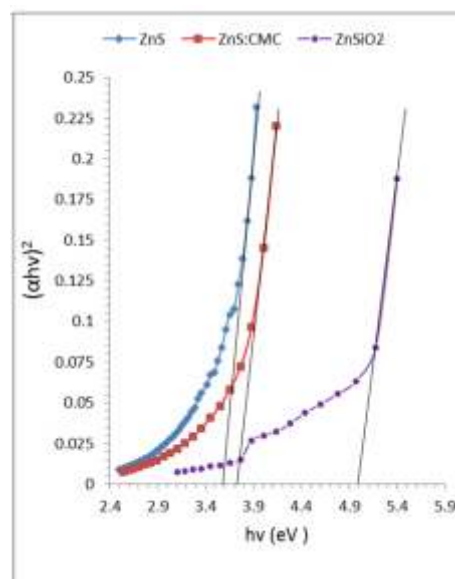


Fig.4b: Energy band-gap for ZnS, ZnS:CMC and ZnS:SiO₂

The characteristic absorption peak of the capping agent from FTIR confirmed the effective surface passivation of the nanoparticle in figures 5(a-b) for the capped samples only.

The result in Fig.5a reveals the spectra of capped ZnS:CMC with an associated band belonging to carboxylic groups shifted to a higher wavenumber of 1615.44cm^{-1} for C=O stretching and 1474.63cm^{-1} for C-O stretching. This may be linked to their strong interaction with the Zn^{2+} ions forming a Zn-CMC

complex during the in situ precipitation process. Fig.5b depicts the spectra of ZnS:SiO₂ nanoparticles with bending vibration mode at 1678.13cm^{-1} indicating C=O stretching and C-H out of plane bending at 942.26cm^{-1} . The peak at 1383.01cm^{-1} may be due to -Si-C₆H₅ stretching.

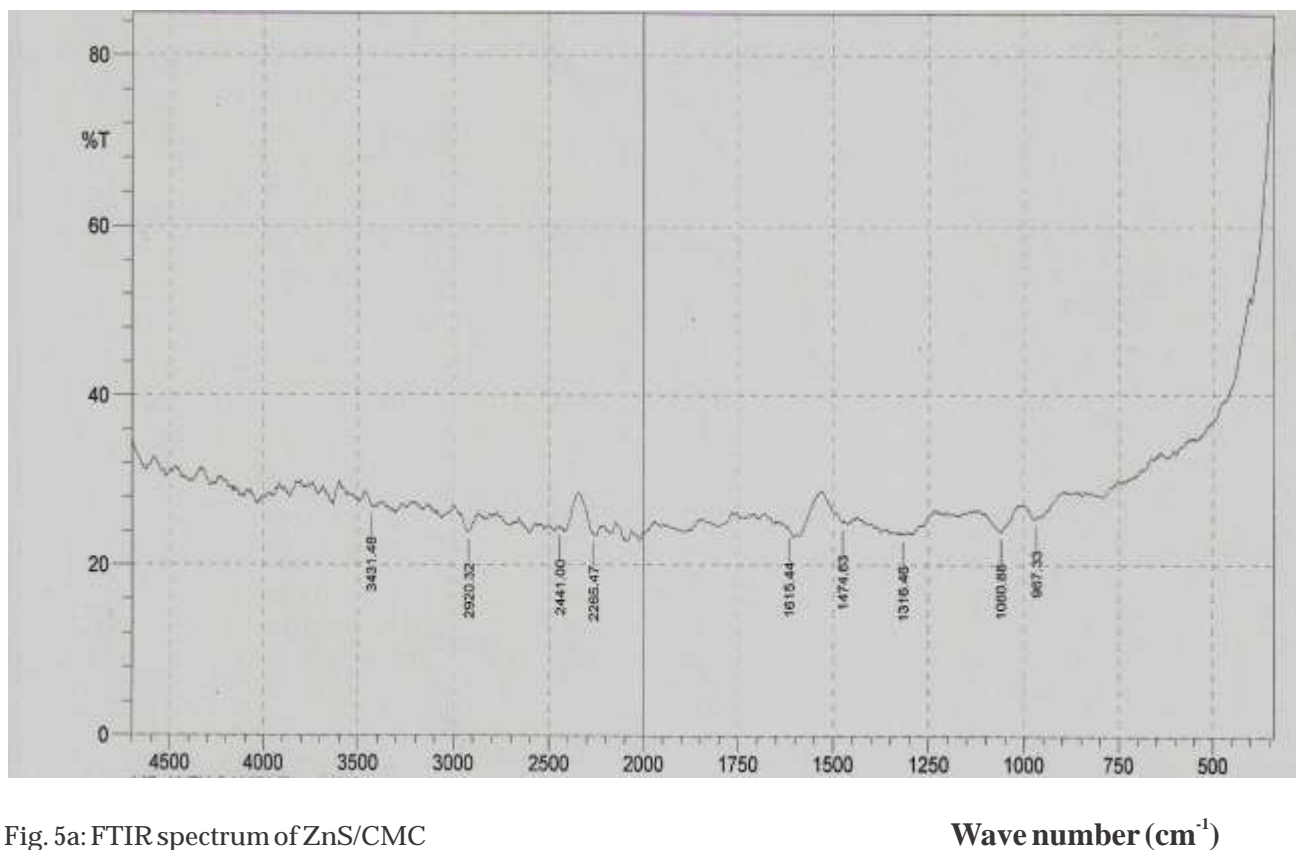


Fig. 5a: FTIR spectrum of ZnS/CMC

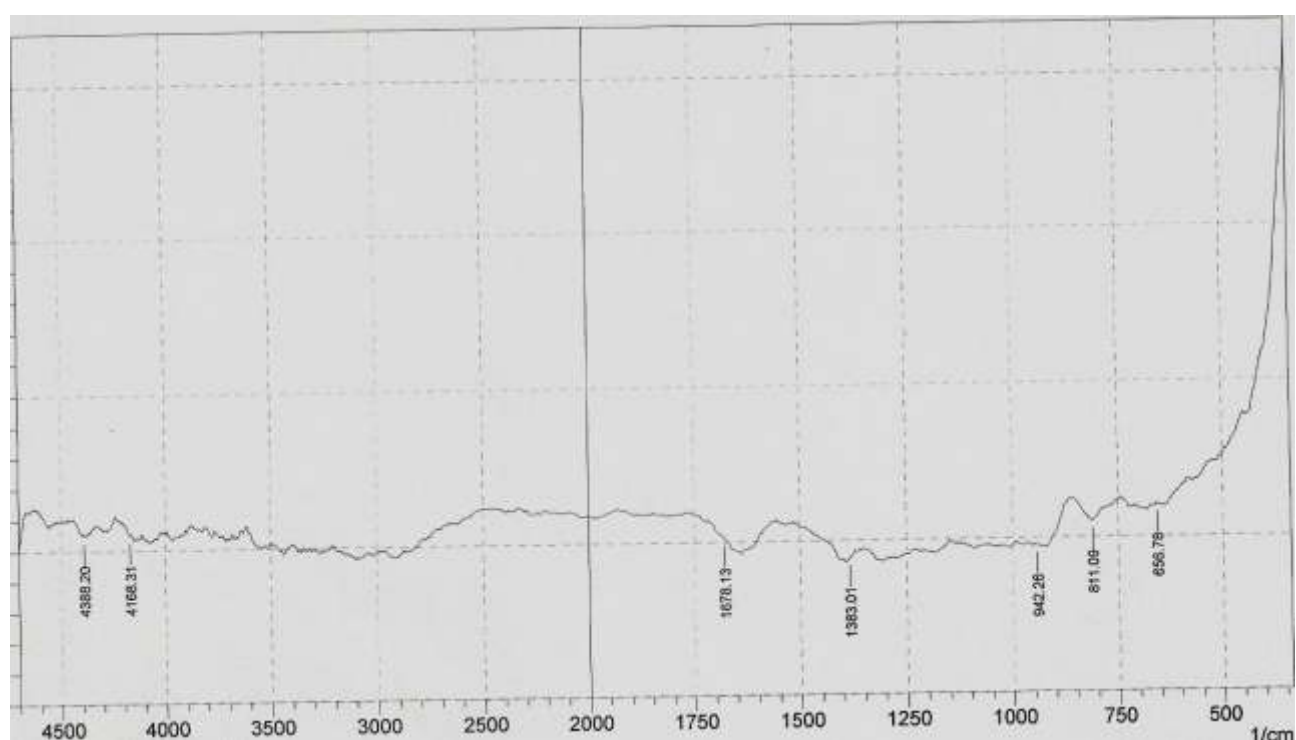


Fig.5b FTIR spectrum of ZnS:SiO₂

Wave number (cm^{-1})

CONCLUSION

The studies have revealed that organic and inorganic capping agents prevented particle agglomeration through its adsorption on the surface of nanoparticles. The particle sizes calculated from Uniform Deformation Model (UDM) are in range of 1.58nm to 2.57nm for the capped samples to that of 7.61nm for uncapped ZnS. The obtained energy band gaps shows a blue shift of 0.13eV to 1.40eV as compared to the absorption energy of the bulk ZnS. This suggests the importance of capping agents in determining the actual value of electronic and optical properties of nanoparticles during nucleation and limiting the growth of the ZnS particles. In addition the values of crystallite sizes obtained are in good agreement with the values obtained for the energy band gap indicating the presence quantum

confinement. In comparison it can be noted that the high strain value caused decrease in particle sizes evaluated which confirms the presence and good effect of capping agents.

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