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An ASABE Meeting Presentation
DOI: https://doi.org/10.13031/aim.201800802
Paper Number: 1800802

VARIATIONS IN NUTRIENT COMPOSITION OF STORED COWPEA IT96D-610K IN WOODEN AND STEEL STRUCTURES

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Written for presentation at the
2018 ASABE Annual International Meeting
Sponsored by ASABE
Detroit, Michigan
July 29-August 1, 2018

ABSTRACT. *Grain quality and quantity reduction during storage is a global challenge that must be addressed in order to ensure food security. With grains comprising a high percentage amongst food crops consumed over the world, it remains a nutritious and healthy food source for all population types. Cowpea grains remain an inexpensive and rich source of protein needed for tissue development and crude fiber that aids digestibility in humans. Hence there is a need to store and retain these nutritional parameters during storage till consumption. This paper investigates diatomaceous earth (DE) effects on the nutrient composition (crude protein and crude fiber) of stored cowpea variety (IT96D-610K) in wooden and galvanized mild steel structures. Twenty-eight thousand grams of cowpea at a moisture content of 9.8% was admixed with 21g of ground crude diatomaceous earth having a particle size of 0.075mm. Six small scale prototype structures made of two different materials (wooden and galvanized mild steel (GMS)) were developed and used in the storage of the cowpea for a 16-week period under room temperature. Effects of storage time and storage structures on nutritional parameters such as crude protein and crude fiber were determined. Significant differences ($p<0.05$) was observed between the control sample and the treated samples. A general decrease in the crude protein content of 0.19% was observed throughout the period of sixteen weeks' storage. A significant reduction of 0.07% was seen in crude protein content between the initial crude protein content and the control having (zero concentration) of DE. Crude protein decreased with increased storage period in both storage structures (wooden and galvanized mild steel (GMS)) with GMS being most effective in storage. The (control) DE having zero concentration, (0g/100g) showed a negligible increase of 0.01% in the crude fiber content throughout the period of storage. The crude fiber content of the stored cowpea in the storage structures showed an increase of 0.03% in its value. Both wooden and GMS storage structures had same effect on the crude fiber content at the end of storage.*

Keywords. *Cowpeas, storage, structures, nutrition, composition, diatomaceous earth.*

Introduction

Cowpea production on a global scale in 2010 was 5.5 million metric tons with Africa producing 94% of this value (CGIAR, 2015). Nigeria being the world largest producer and consumption of cowpea accounts for 58% of its production in Africa and 61% globally (IITA, 2015). An estimate of over 200 million people in Africa depend on cowpea as a source of food (Chege, 2004). In Nigeria, cowpea serves as a cheap source of animal protein rich in both soluble and insoluble dietary fibre. The high demand for good, quality cowpea is as a result of continuous increase in cost of animal protein sources and deficit in local production in Nigeria. Approximately 2.4 billion tons of food annually (costing about US$320million) was linked with poor harvest and storage facilities primarily in cereal grains and pulses of which cowpea was greatly affected (Adejumo and Raji, 2007). This deficit is due to the lack of well-designed storage methods, ineffective storage facilities and postharvest management of grains which also contributes largely to food insecurity in Nigeria.

In retaining the qualitative and quantitative value of this rich and nutritious grain to meet consumer satisfaction and seed viability, certain factors are of utmost importance. These factors are external (insects and fungi) and natural (temperature and moisture). Cowpea weevil, *Callosobruchus Maculataus* is the primary pest of stored cowpea causing losses from the farm before and during harvesting and also in storage. High temperature and moisture values also aid the development of fungi during storage of cowpea leading to mold development, grain discoloration, spoilage and ultimately nutrient loss. The use of chemicals and insecticides in treatment of grains has been able to address to some extent the insect mortality thereby preserving grains for a longer period. The major challenge with these is the serious health risks posed to humans when dosages of these compounds are administered than required. Poor storage methods lead to loss of macronutrient in grains, wastage, and reduces seed viability for the next planting season. Cowpea when not stored under proper conditions loses nutrients just like any other grain.

Recent alternative storage technology has introduced the use of triple layer bags that aids hermetic storage in many countries in Africa. Others include the treating of grains with botanicals (African black pepper, Neem powder, and Moringa seeds), natural organic compounds (diatomaceous earth) which over time have been observed to contribute to long term storage. The use of modern steel bins and silos are also improved storage facilities helping in grain storage. The challenge still remains that of affordability. Many of the farmers in rural areas in Ilorin, Nigeria still use traditional methods of storage which have not yielded much results, hence the need to sell off harvest at a very low cost to avoid glut. Diatomaceous earth used in grain treatment records high insect mortality rate in storage over 3, 6, 9 and even up to 12 months. The effect when treated with maize and stored in bags for over 12 months' records efficacy of this compound in maintaining its quality and quantity.

Hence this paper aims to determine the effect of treating cowpea with diatomaceous earth in local structures (galvanized mild steel) and wooden structures still employed in some remote areas in remote areas who find it unable to afford modern facilities. Also, is to investigate the effectiveness of the diatomaceous earth in reducing weevil development in cowpea yet preserving the nutritional composition (crude protein and crude fiber) of the stored cowpea.

Materials and Methods

Study Area

The research was carried out at a storage room at the Department of Agricultural and Biosystems Engineering in Ilorin, Kwara state, Northern Nigeria. The study investigated the variation in the nutritional contents of cowpea treated with diatomaceous earth stored in wooden and galvanized mild steel prototype storage structures. Storage was done for a period of four months between May and September 2016.

Freshly harvested cowpea seeds variety IT96D-610K were purchased from the International Institute of Tropical Agriculture (IITA), Oyo state in Nigeria and evaluated for moisture, protein and fibre. Initial values of data were recorded prior to treatment and storage. The cowpea was purchased in bags and stored in plastic drums to keep it air-tight. The seeds were disinfested with phostoxin tablets for four (4) days prior to when the experiment was set up. The cowpea seeds were aerated after disinfestation for complete removal of the gas odor before experiment was set up.

Crude Bularafa Diatomaceous Earth

Crude Bularafa diatomaceous earth (DE) of fresh water origin was obtained from Bularafa community in Yobe state, Northern Nigeria. This organic compound was oven dried at 40^0C to 4.5% moisture content (Arnaud *et. al*., 2005) and ground to dust by means of a laboratory mortar and pestle. It was sieved using a U.S. standard 200 sieve (0.075mm openings) and kept air-tight in plastic (Ziploc) bags prior to being admixed with cowpea seeds. The sieved diatomaceous earth was then admixed with the cowpea seeds and stored in prototype storage structures fabricated for the purpose of this experiment. Another portion of the cowpea not treated with diatomaceous earth was used as the control also stored in both wooden and galvanized mild steel storage structures respectively. The ground bularafa diatomaceous earth was applied to the cowpea seeds at a dose rate of 0.1g/100g, 0.05g/100g and 0g of DE/100g of cowpea (control with (zero concentration of diatomaceous earth)) respectively in both storage structures.

Design and storage

Prototype storage structures made of wood and galvanized mild steel with a maximum capacity of 12kg each for stored cowpea was developed and fabricated. The structures were made from cheap and readily available materials for small scale farmers in Ilorin. The construction was done at a local fabrication workshop in the area. The structures were cylindrical in shape with the top designed as a conical shape inclined at an angle of 30^0 as shown in Figure 1.

Figure 1. Wooden and Galvanised mild steel(GMS) storage structures

The roof, wall and floor of the storage structures were made of each material (wood and galvanized mild steel). The floor level was raised above the natural ground level and the storage structures rested on a wooden platform supported at the edges. This was done to prevent taking up of moisture from concrete flooring. An opening was located on the wall to provide for discharge of the cowpea grains by gravity while a window on the roof of the structure served as the entry point for loading of grains and taking of weekly samples. The structures were designed to prevent air leakage and water leakage by sealing all leaks with adhesives. The prototypes were designed for indoor storage in a well-ventilated room to control both temperature and relative humidity. The prototype structures designed were for portability, required little space and ease of cleaning and maintenance.

Bioassays

28000g of clean cowpea seeds were measured on a weighing scale (Hanna) and divided into four equal portions making a portion to be 7000g each. 21g of DE was obtained after passing through 0.075mm sieve openings. 14g of DE with particle size opening 0.075mm was equally divided into two separate portions. Each portion of 7g was each admixed thoroughly and separately with two different portions of the cowpea and stored in both galvanized mild steel (GMS) and wooden structures. 7g of DE with particle size opening of 0.075mm was equally divided into two separate portions as well. Each portion of 3.5g of DE was each admixed thoroughly and separately with the remaining two equal portions of the cowpea and stored in wooden and galvanized mild steel structures respectively. Fourteen thousand grams of cowpea was divided into two equal portions and was not treated with diatomaceous earth i.e. zero concentration of DE. 7000g of cowpea was stored in both wooden and GMS respectively. This served as the control for the experiment. The experiment was carried out for a period of 16 weeks (4 months period). The ambient temperature and relative humidity data of the storage room environment was obtained using a Pro V2 Weather data logger (Onset Hobo – U23-003) and Acurite thermohygrometer averaged on a weekly basis and recorded. The structures were labelled based on the treatments as shown in the key below.
M1- Wooden Structure, M2- Galvanised mild steel structure, Particle Size (P1-0.075mm), Concentration (C1-0.1g of DE/100g of cowpea, C2-0.05g of DE/100g of cowpea, C3-No concentration of DE is added(control).

Proximate Analysis

Seven grams of cowpea samples were taken weekly from each of the storage structures for proximate analysis. Analysis was carried out in five replicates giving a total of 30 runs. Samples were taken at the top, middle and bottom of the silos with the use of a grain probe (IL 1-800-284-5779) from the upper part of the storage structure. The samples were taken and immediately stored in sealed bags and taken to the laboratory for analysis. The nutritional composition of stored cowpea determined includes crude protein and crude fibre contents. Moisture content was also determined in the laboratory using the oven-dried method. These were determined in the laboratory using AOAC (2002) nutritional guidelines.

Data Analysis

The data obtained from the experiments were subjected to statistical analysis of variance (ANOVA) using SPSS 16.0

Essential Regression Software Package. The effects of concentration of diatomaceous earth (DE) (0.1g/100g of DE and 0.05g/100g of DE), storage period and storage structure types on the nutritional composition of stored cowpea was determined using ANOVA at $p<0.05$ in Table 1. Furthermore, the level of significant means was further evaluated using New Duncan's Multiple Range Test (NDMRT) as shown in Table 2.

Results and Discussion

The Analysis of variance test- Individual factor effect in Table 1 showed the effect of the measured parameters on the nutritional composition of stored cowpea and the NDMRT in Table 2 showed the different mean values of nutritional composition across the particle sizes and concentration of diatomaceous earth, period of storage and storage structure types. The experimental design was a completely randomized block design.

Table 1: Analysis of Variance Test - Individual Factor Effect

Source	Dependent Variable	Sums of Square	df	Mean Square	F	Sig.
Time	MC	1672.653	16.000	104.541	136700.000	0.000*
	CP	3.632	16.000	0.227	912.583	0.000*
	CF	0.166	16.000	0.010	96.535	0.000*
Structure	MC	2555.693	1.000	2555.693	3341000.000	0.000*
	CP	0.001	1.000	0.001	2.915	0.388
	CF	0.001	1.000	0.001	5.975	0.150
Concentration	MC	2.349	2.000	1.174	1535.000	0.000*
	CP	0.388	2.000	0.194	779.985	0.000*
	CF	0.069	2.000	0.035	320.986	0.000*

Table 2: Multiple Comparisons Using New Duncan Multiple Range Test

Variable	Structures	Moisture Content	Crude Protein	Crude Fibre
Structure	Wooden	13.74a	22.78a	2.22a
	GMS	10.57b	22.78a	2.22a
Particle Size	0.075mm	12.12a	22.78a	2.21a
Concentration	0.1g/100g	12.21a	22.67a	2.22a
	0.05g/100g	12.16a	22.77b	2.32b
	0.0/g100g	12.10a	22.81c	2.20c
Time	Initial	9.88a	22.88a	2.19a
	Week four	10.52b	22.84a	2.21b
	Week eight	12.12c	22.80a	2.21b
	week twelve	13.17d	22.78b	2.22b
	Week sixteen	13.39e	22.69c	2.23b

Means with same alphabet under the same column for each parameter are not significantly different from each other at $P<0.05$

Temperature and relative humidity changes during storage

The clean cowpea seeds analyzed before storage had an initial moisture content of 9.88%. Crude protein and fibre contents recorded values of 22.88% and 2.19% respectively. The ambient temperature and relative humidity of the stored room environment throughout the 4-month period May, 2016 to September, 2016 are shown in Figure 2. The climate in Kwara state is Tropical continental, while Ilorin is the humid tropic type characterized by wet and dry seasons (Jimoh and Nwaokenye, 2011). The study period was during the wet season.

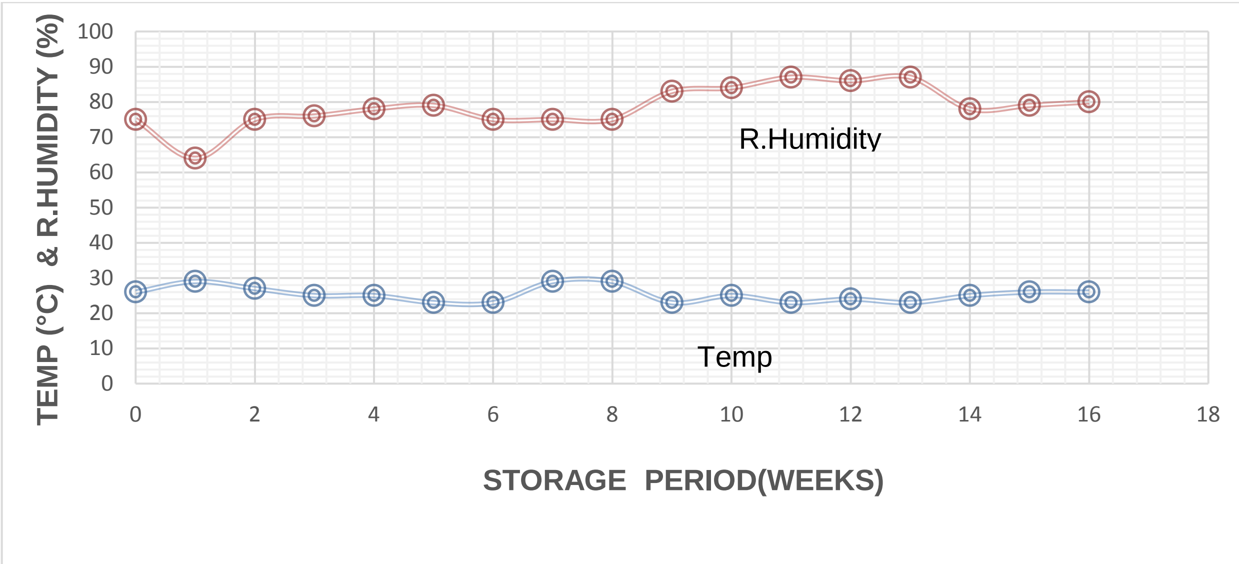

Figure 2: Ambient Temperature and Relative Humidity of Storage Environment

The ambient temperature of the stored room environment shown in Figure 2 changed throughout the period of storage which caused corresponding changes in the temperature and relative humidity within the storage structures. The decrease in ambient temperature can be attributed to changes in weather condition (wet season) of the area where the study was being carried out between May and September over the study period. Alabadan (2006) recorded a decrease in ambient temperature during the rainy season during storage of maize in wooden silos. An average temperature of 25˚C and relative humidity of 78.5˚C was recorded throughout the storage period. (Chattah *et al*., 2016) recorded a mean ambient temperature value of 38.07°C during storage of wheat in designed storage bins whereas relative humidity had an average value of 73.46% throughout the storage period of 12 months. This range of values for both temperature and relative humidity has been recorded to enhance the development of insect pests which cause loss of nutrients and deterioration in grain quality. (Ileleji *et al*., 2007) reported that the development and growth of pest insects that attack grains take place between 25-350 C. However, much of the grain quality deterioration and contamination have been associated with inadequate storage methods (Gourama and Bullerman, 1995).

Moisture content changes in storage

Moisture content was observed to increase significantly in all treated and control samples throughout the 16 weeks of storage in Figure 3. This rise in moisture could be attributed to an increase in the relative humidity of the storage environment. The least value of moisture content (10.34%) retained at the end of storage is seen in DE treated sample in GMS structure and subsequently followed by (11.01%) in control sample (untreated) without DE in the GMS structure as well. This finding buttress result from Masum et al., (2010) where moisture content value was lowest in jute seeds stored in tin container over a two-month period. The ability of the GMS structure to keep the stored cowpea airtight as compared to wooden structure results in a lower moisture content value after storage. This was followed by a value of (11.27%) moisture content in GMS structure having cowpea admixed with 0.05g of cowpea/100g of DE. The highest value of moisture content (16.0 %) at the end of storage was observed in the treated sample in the wooden structure at the end of storage. This value was observed to be close to that recorded in the control sample (untreated) with (15.38%) moisture content in the wooden structure. Wooden structure was seen to be more permeable to an increase in the moisture content of the environment. Furthermore, DE used in treatment of stored cowpea is a hygroscopic material that absorbs water from the environment hence a rise in the moisture content of treated cowpea. (Aremu *et al*., 2015) also ascribed the increase in moisture content to respiratory activities of the cowpea favored by the storage media. Wooden structure with cowpea admixed with 0.05g of DE/100g of cowpea also followed this trend with a value of (15.0%) being recorded. Generally, it can be inferred that GMS structures kept the moisture content of both treated and untreated samples at a minimum value throughout storage as compared to wooden structures which did not and recorded higher values.

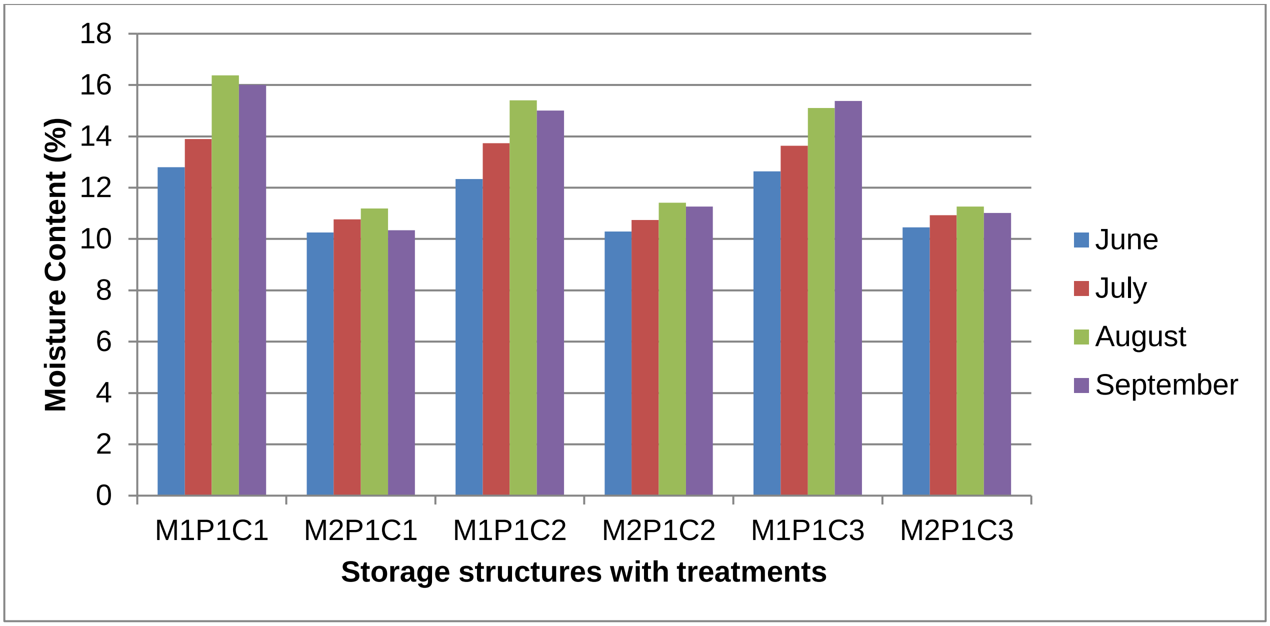

Figure 3: Moisture content changes throughout storage period across storage structures

Crude protein content changes in storage

A significant decrease in the crude protein content was recorded in all the structures both wooden and GMS. The untreated samples without DE (diatomaceous earth) showed a decrease in the crude protein content as well but retained it better as compared to the treated samples. At the end of the storage period as illustrate in Figure 4, crude protein content of untreated cowpea in wooden structure was 22.75% while that of GMS was 22.74%.

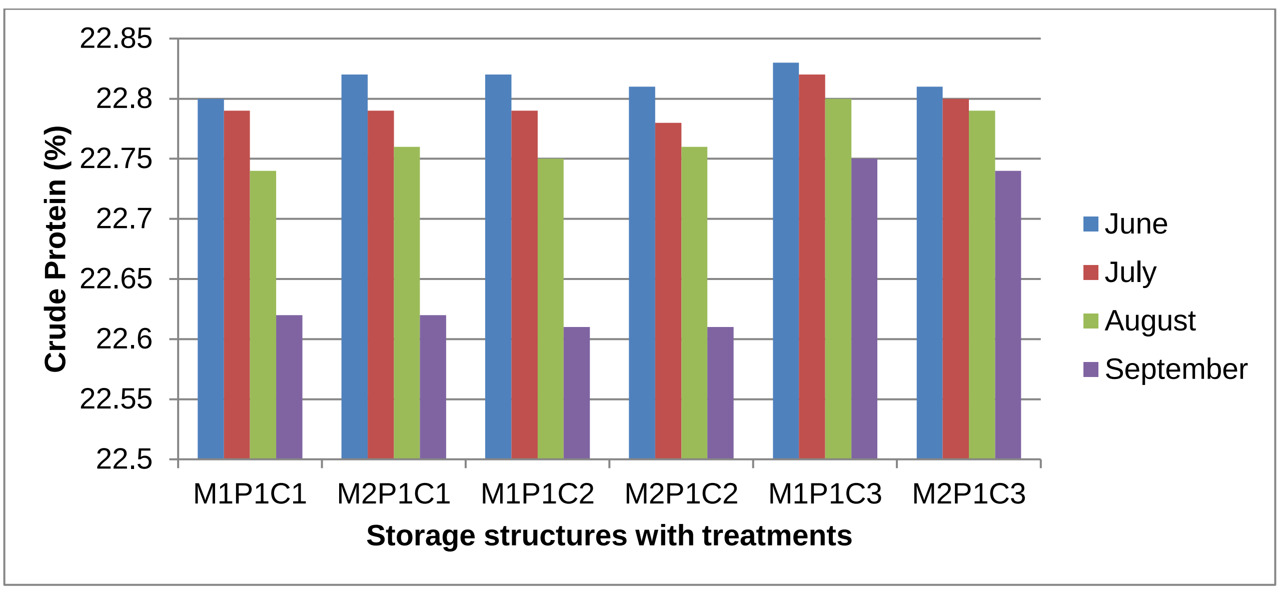

Figure 4: Crude protein content changes throughout storage period across storage structures

Treated samples in both structures showed a consistent decline in the crude protein content throughout the storage period. The least value was recorded in wooden structure treated with 0.075mm particle size and 0.05g of DE/100g of cowpea. In treated samples stored in both structures, the most significant decrease in crude protein content value was observed between the third and fourth (last) month of storage. (Hellevang, 2000) stated that protein deteriorates as an outcome of the influence of microbes. Higher temperatures above 27^{0}C (Goldstein, 2002) in storage has been recorded to result to a rise in the action of enzymes and microorganisms in storage. This further leads to reduced quality causing chemical changes in the composition of grains stored in structures (Bankole *et al*., 2013). (Rehman *et al*., 2002) stated that after six months of maize storage a significant decrease in protein content up to 20.4% was recorded. Also, (Omobowale *et al*., 2015) recorded a decrease in protein content of maize storage in metal structure over an 8-month period.

Concentration of diatomaceous earth is seen to have effect on the crude fibre contents of stored cowpea in wooden and GMS structures. An increase in the crude fiber contents is seen in the treated samples with GMS structures recording the highest values after 16weeks of storage.

Crude fiber content changes in storage

When cowpea was treated with 0.075mm particle size and 0.05g of DE/100g of cowpea, crude fibre content recorded was 2.25% in GMS structure. Figure 5 shows a sharp increase in cowpea samples treated with 0.075mm particle and 0.05g of DE/100g of cowpea stored in wooden structures, having a final value of 2.24% as well.

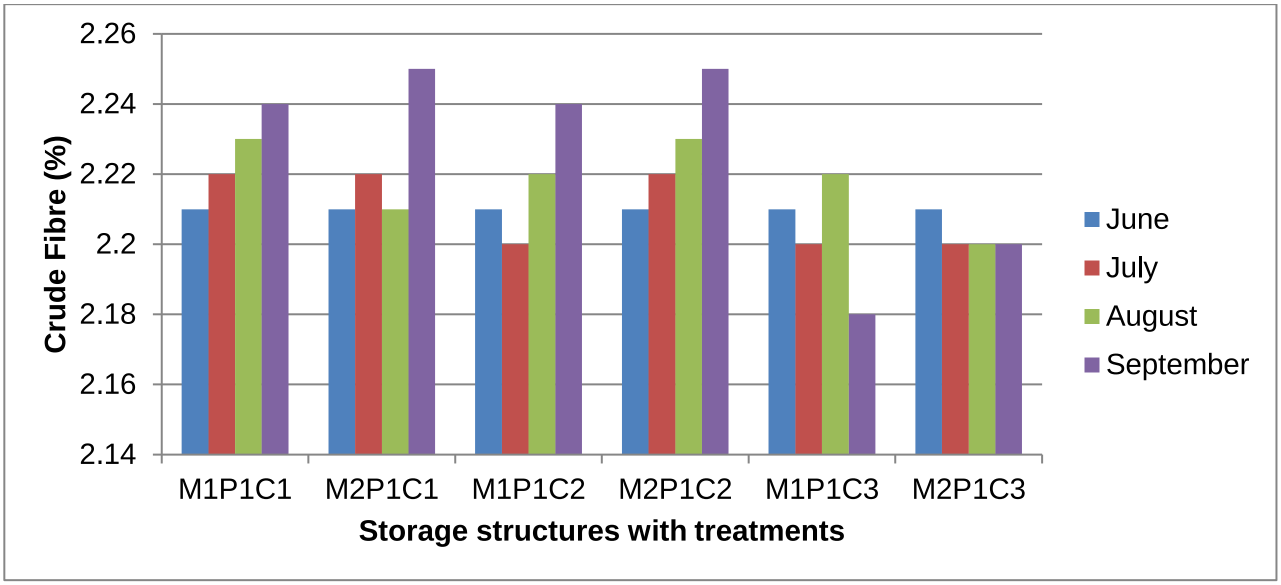

Figure 5: Crude fibre content changes throughout storage period across storage structures

Untreated samples (control) in wooden and GMS structures respectively recorded final values of 2.18 and 2.20% at the end of the storage period. A steady value (2.20%) for crude fibre contents in untreated samples in GMS was observed from second month of storage till the end of the experiment. Crude fibre content of the stored cowpea was not significantly altered as shown in the result of the analysis. (Ilesanmi *et al*., 2016) stated an increase in the crude fibre contents of infested cowpea seeds treated with moringa seeds oil. The findings revealed that cowpea weevil *(Callosobruchus Maculataus)* makes a hole out of the grain endosperm with only the seed coat left which is primarily made of fibre.

Conclusions and Recommendation

Galvanised mild steel (GMS) structure was best in keeping the moisture content of both treated (11.27%) and untreated (10.34%) cowpea samples to a minimum in storage. GMS structure also retained the crude protein and fibre contents of the stored cowpea for both treated and untreated samples better as compared to wooden structures.

It was observed that when wooden structure is employed in storage of grains, special attention should be given to the type of material and joints during construction. Joint failure occurs when not firmly fabricated an allows for movement of air into the storage environment leading to an increase in moisture and passage of insect pests. The presence of cracks also contributes to the passage of moisture thereby reducing the efficacy of the diatomaceous earth ultimately leading to nutrient loss. It is highly recommended that different wood species be researched on and experiment carried out on the storagibility and effect of these species on the nutritional composition of stored cowpea.

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