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EFFECTS OF DIATOMACEOUS EARTH ON THE PROXIMATE COMPOSITION OF STORED COWPEA VARIETY (*IT96D-610K*)

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Abstract

A study was carried out to determine the effect of a raw diatomaceous earth (DE) obtained fromBularafa community in Yobe State, Nigeria on the proximate composition of stored cowpea variety (IT96D-610K). Twelve small scale prototype silos made of two different structures (wooden and galvanised mild steel (GMS)) were constructed and used in the storage of the cowpea for a 4-month period. 7000g of cowpea at 9.88% moisture content admixed withdiatomaceous earth havingtwo different particle sizes(0.075mm and 0.090mm) and three different concentrations(0.1g, 0.05g and 0g of DE/100g of cowpea)in varying combinations were loaded into each silo. The sample admixed with zero concentration of diatomaceous earth served as the control in each of the wooden and galvanised steel structures respectively. Temperature, relative humidity and moisture content within the storage structures were monitored. Proximate compositionsuch as ash, crude protein, fat, crude fibre, carbohydrate alongside moisture content were also measured.Significant differences ($p<0.05$) was observed between the control sample and treated samples.The values of moisture content, ash content and crude fibre increased while crude protein, fat and carbohydrate decreased with increased storage period. At the last month of storage, wooden silo recorded a higher temperature value (28.88˚C) compared to the galvanised steel (GMS) silo which showed (22.30˚C). An increase in moisture content was observed in both silos with wooden silos showing a higher percentage rise in both control and treated samples. At the end of the fourth month the average moisture content, ash content, crude protein, fat, crude fibre and carbohydrate content of control and treated samples were(10.57% and 13.39%), (4.12% and 4.16%), (22.75% and 22.69%),(1.95% and 1.90%),(2.21% and 2.23%) and (57.75% and 55.63%) in the GMS and wooden silos respectively.Cowpea admixed with diatomaceous earth stored in GMS silo showed the best nutritional quality. Hence of all the storage materials, storage time, particle size and concentration of DE used galvanised mild steel (GMS), 0.075mm particle size and 0.05g of DE/100g of cowpea for the first four weeks of storage were seen to be the best. These proved to be the best method of storage for cowpea as the procedure retained its proximate composition. The increased crude fibre level in the treated samples is a major indicator for good health.

1.0 Introduction

According to Mrema and FAO (2011) [1], grains can be grouped into three areas which include pulses, cereals and oil seeds. Cowpea (*VignaUnguiculata*) is a pulsed grain, leguminous plant that bears seeds in pods.The crop is a major pulse grain whose origin is unknown and was domesticated in Southern Africa and later discovered in East and West Africa [2]. Though [3] stated that most likely cowpea originated from Nigeria where wild and bushy varieties are populous in the forest zone areas. Nigeria leads other West African countries such as Senegal and Mali as the highest producer of cowpea in the region. Cowpea remains a means of sustenance for an African population of over 200 million people [4]. Cowpea is widely consumed because of its richness in protein content and its cheapness amongst the poor modern and rural population especially in Nigeria. This cheapness makes it an alternative source to animal protein in poor communities. Cowpea is also rich in nutrients such as carbohydrates, fats and oil, crude fibre, ash and abounds in supply of minerals and vitamins. It is low in fat and high in fibre content respectively. Amongst other legumes the crop is considered to be the most cultivated, distributed and marketable food product in the country [5]. A common insect pest of cowpea found in tropical areas is cowpea weevil (*CallosobruchusMaculataus*). This weevil is a field to store pest as it attacks the cowpea pods from the farmland, during harvest and eventually its eggs get stuck to the harvesting equipment, storage structures or even on the grain itself. According to [6]poor harvest and storage facilities have been attributed majorly to postharvest losses in grains, roots and other fruit crops in Nigeria. It was further stated that anestimate of 2.4 billion tonnes ($US320M) was lost annually to these food losses.[7] stated that close to 80% of cowpea produced by farmers in smallholder farms employed on-farm method in storage. Persisting poor methods and unfavourable conditions of storage cause high quantitative and qualitative losses in storage of cowpea which farmers still face in Nigeria presently. Traditional storage structures such as cribs and granaries made of mud, wood, straws and grass are still being used by small holder farmers in storage of their harvested produce. Yet due to changes in climate conditions and lack of funds it is difficult for farmers to upgrade and maintain these facilities in some cases leading to waste during glut, and attack of their produce by insect pests. Modern storage structures such as silosare located in several states across the country serving as grain reserves. The only challenge is maintenance and accessibility to farmers and the high cost of individual purchase. The use of triple layer storage (PICS) bags, open weave sacks, zero fly bags are used in storage of grains in modern days. The use of conventional insecticides such as actellic dust, phostoxin (aluminium phosphide) tablets have been recommended for cowpea storage in Nigeria in stated and required quantities. These insecticides has been of importance in storage but its misuse has posed a lot of health risks and hazards to humans during consumption of the product. This has called for the possible use of natural plant materials and botanicals in the storage of cowpea as an alternative to insecticides in combating stored grains products [8]; [9]; [10]. Neem kernel powder, powders of Eucalyptus,guavaandlemon grassleavesas well as orange and grape peels have been recorded to adequately control insect pests in stored produce. African black pepper (*piper guineese*) has shown repellent and insecticidal properties, preventing insect pest multiplication in stored grains. Inert dusts have been used in developing countries in control of insect pests in stored food products over the years. Many of these mineral dusts which include bentonite clays, zeolites, aluminium oxide and kaolin show insecticidal properties of which diatomaceous earth DE is considered to be very effective. Diatomaceous earth is rich in an active ingredient of Silica dioxide (SiO_2) constituting about 80.98% of its composition. Commercialised version of these natural organic compound obtained from the petrified remains of the diatoms found in fresh water areas has been in use in developed countries such as US. This commercialised form includes Permaguard, ProtectIt, and Silicosec amongst others. They also contain percentage bait that aids in attracting insects when used as grain protectant in stored food commodities.Fresh deposits of diatomaceous earth have been discovered in Northern Nigerian communities (Bularafa, Abakire) in Yobe andBorno state. Despite the improved method in storage of cowpea and other grains such as in bags, the problem of insect's pest still persists hence the recent use of diatomaceous earth in treating of grains before storage as a grain protectant. Hence the aim of this study is to determine the effects of diatomaceous earth on the proximate composition of stored cowpea.

2.0 Materials and methods

The materials and the method used in this studyare explained below:

2.0.1 Wooden and galvanised mild steel (GMS) prototype silo development and construction

The silos constructed in this study were chosen based on the affordability and accessibility of materials to farmers in the rural area of Kwara state. The two material types (Wooden and GMS) chosen was also based on the need to determine the effects of diatomaceous earth on cowpea stored within each prototype silo. The prototype household silo structure wasshallow, cylindrically shaped with the upper end having a conical frustum. It had a height of 0.48m and a base diameter of 0.24m. The same parameters such as shape and internal dimensions were used in the construction of both wooden and galvanised mild steel silos. The total capacity of each prototype silo was 12kg and was loaded three quartered full for the experiment. The storage silos were designed for indoor storage and the experiment was set up at the store house of the Department of Agricultural and Biosystems Engineering, University of Ilorin, Kwara State.

2.1 Diatomaceous Earth (DE)

Crude Diatomaceous earth of fresh water origin was obtained from Bularafa community in Yobe state, Nigeria. The organic compound was oven dried at 40°C to 4.5% moisture content [11]. A laboratory mortar and pestle was used to ground the DE to powder. The ground DE was sieved using a U.S standard 200 sieve (0.075mm openings) and 100 sieve (0.090mm openings) and kept in airtight Ziploc bags for a day prior to being admixed with the cowpea seeds for the experiment. The Bularafa diatomaceous earth was applied at three different dose rates of (0.1gper 100g cowpea, 0.05g per 100g cowpea, 0g per 100g cowpea) for each particle size stated above.

2.2 Cowpea Samples

Freshly harvested cowpea seeds (*VignaUnguiculata*) variety *IT96D¬610K* threshed and clean were obtained from International Institute of Tropical Agriculture (IITA) in Ibadan, Oyo State. Two bags each weighing 50kg were purchased.Samples were taken randomly in replicates from each bag and an average moisture content of 9.88% was recorded. The seeds were stored in drums in a hermetic system of storage. The lot was then disinfested with phostoxin tablets for four days prior to the setting up of the experiment after which aeration took place before storage.

2.3 Bioassays

84000g of clean cowpea seeds were measured on a weighing scale(Hanna) and divided into twelve equal portions making a portion to be 7000g each. 21g ofDE was obtained after passing through 0.075mm openings and 21g of DE was also sieved out through 0.090mm openings. 7g of DE with particle size opening 0.075mm was admixed thoroughly with two equal portions of the cowpea and stored in both galvanised mild steel (GMS) and wooden silos. 3.5g of DE with particle size opening of 0.075mm was also admixed thoroughly with two equal portions of the cowpea and stored in another two different wooden and galvanised mild steel silos respectively. The same procedure was repeated for the 0.090mm particle size opening using both 3.5 and 7g of DE concentration admixed thoroughly with cowpea stored in the wooden and GMS silos respectively. Control experiment was set without the use of diatomaceous earth (DE) in both wooden and GMS silosrespectively.The experiment was carried out for a period of 16 weeks (4 months period).An EMC moisture meter (USDA-ARS) was used to determine on-spot the temperature, relative humidity and moisture content representative of the samples inside each of the prototype silos. 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 Acuritethermo hygrometer averaged on a weekly basis and recorded.

2.4 Proximate Analysis

Samples were taken weekly from each of the prototype silos for proximate analysis. Analysis was carried out in five replicates giving a total of 60 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 proximate composition of stored cowpea determined includes carbohydrate, crude protein, fats, crude fibre, and ash contents. Moisture content was also determined in the laboratory using the oven-dried method. These were determined in the laboratory using [12] nutritional guidelines.

2.5 Data Analysis

Data obtained from the experiments were subjected to statistical analysis of variance (ANOVA) using SPSS 16.0 Essential Regression Software Package. The effect of different particle sizes and concentration of diatomaceous earth (DE) and storage structure types on the proximate composition of stored cowpea was determined using ANOVA at $p<0.05$ and the level of significant means were further evaluated using New Duncan's Multiple Range Test (NDMRT). The Analysis of variance test showed the effect of the measured parameters on the nutritional composition of stored cowpea and the NDMRT 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 randomised block design.

3.0 Results and discussion

The initial moisture content of cowpea prior to storage was 9.88%.Storage of treated cowpea in wooden structure recorded the highest moisture content of 13.74% followed by the control (with no DE added) with a moisture content of 12.10%. The least moisture content of 10.57% was recorded in the galvanized mild steel (GMS) storage material at the end of the fourth month. The result showed that moisture content of stored cowpea in wooden silos (13.74%) was significantly higher by (10.57%) compared to cowpea stored in galvanized mild steel (GMS) silos (keeping other factors constant) at the end of the fourth month. It was inferred from this study that stored cowpea retain or acquire more moisture content when stored in wooden materials than galvanized mild steel materials. Though according to [11] wooden silo is more effective at temperature control than metal silo under tropical conditions. This difference could be attributed to moisture permeation based on the wood specie used and the weather conditions (increase in relative humidity). When this occurs diatomaceous earth being hygroscopic in nature absorbs moisture easily. This could be a possible reason for the rise in moisture content in cowpea treated with DE in wooden storage materials.Also when wood species surface are not smooth, the presence of cracks and splits may develop in storage creating room for moisture permeation and problem of insect pests.[13]recorded reduced efficacy of diatomaceous earth in storage of grains due to higher grain moisture content because the mode of action of diatomaceous earth is due to desiccation. [14]also attributed rise in moisture content of stored cowpea to reaction by enzymes in the cowpea tissue and the respiratory activities of the cowpea favored by the storage media or material.

Concentration had significant on the moisture content in both treated and control samples. Also cowpea treated with 0.1g/100g of DE had higher moisture content (12.21%), but not so much different from those treated with 0.05g/100g of DE and 0.0g/100g no DE (control) having (12.16%) and (12.10%) moisture content as they had almost same effect on stored cowpea.Particle size also does not seem to significantly alter the proximate component of the stored cowpea. Cowpea treated with 0.090mm particle size of DE had moisture content of 0.08% higher than cowpea treated with 0.075mm particle size during storage.Storage period also had significant effect on the moisture content of stored cowpea throughout storage till the end 13.39%.Moisture content, ash content and crude fibre of stored cowpea significantly increased with longer storage time. This supports findings by [15] on increase in moisture content and crude fibre contents observed in maize stored in metal silo for an8-month period**.** Cowpea stored in GMS materials (58.35%) had significantly higher carbohydrate contents than cowpea stored in wooden materials (55.18%).Crude protein, fat and carbohydrate significantly decreased with higher storage period vice versa. However, crude protein, fat, and carbohydrate increased with decreasing levels of concentration and their corresponding values (22.81%, 1.97%, and 56.81%) was at maximum in the control samples where (no DEor zero concentration of DE) was added. It has been postulated that doubling the exposure time of DE dusts has greater benefits than increasing the amount of concentration. This is because the latter does not necessarily increase the rate of insect mortality as DE dusts kill insect by physical means thereby needing long exposure periods.Only moisture content andcarbohydrate content was slightly increased when treated with particle size of 0.075mm of diatomaceous earth during storage.Particle size also did not significantly alter the proximate component of the stored cowpea.

There was a rise of (0.8%) in the ash content of the stored cowpea across the total sixteen weeks of storage. The two particle sizes of diatomaceous earth used had no significant effect on the ash content in both the wooden and GMS storage structure respectively. This means that both storage structures and particle size of diatomaceous earth used had the same effect in the ash content during storage. An0.15% increase in ash content was observed when 0.1g concentration of DE was used. A slight increase of 0.02% was also observed in the ash content of the control having zero (no) DE concentration.

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% in crude protein content was noticed between the initial crude protein content and the control having (zero concentration) of DE. [15]recorded a decrease in protein content of maize stored in metal storage structure for an 8-month period. The effect of wooden and GMS materials was the same on the crude protein content decreasing during storage. [14] also recorded decrease in protein content after sixteen weeks of cowpea storage. This buttressed findings by [16] who stated that protein degenerates with time as a result of the effect of microbes. Also, a general decrease was observed in the fat content from the initial storage at 2.02% to 1.90% after the end of the study. A decrease of 0.06% in fat content was recorded during storage when 0.075mm and 0.090mm particle size of diatomaceous earth was used. When 0.1g/100g of DE concentration was used there was a significant decrease of 0.20% in the fat content. The same amount of decrease wasalso recorded for cowpea stored with 0.05g/100g of DE. The same findings was recorded by [15] on decrease in the oil content of stored maize generally across reinforced concrete and galvanized steel silos. The control sample showed a decrease of 0.05% and retained the fatcontent of cowpea more as compared to the treated samples. This correlates with [14] that stated that non-conducive environment in storage of cowpea such as the use of plastic containers prevented microbial activities which leads to deterioration of the fat contents. There was a significant decrease in the carbohydrate content of the stored cowpea as affected by storage period, storage structures, particle size and concentration of DE. Storage structures had different effects on the carbohydrate contents of the cowpea stored in them. The metal storage structure retained a higher carbohydrate content of 58.35% as compared to the wooden storage structure with 55.18%. Cowpea treated and stored in the metal storage structures retained the highest carbohydrate content followed by the control with 56.81% retainability. Cowpea stored in wooden storage structure recorded the least carbohydrate content of 55.18% at the 16th week of storage. These findings on decreasing carbohydrate content during storage were consistent with those reported by [17] and [15]. They stated that prolonged storage was partially associated with increased population of storage fungi that uses starch as a source of energy. An increase of 0.04% in crude fibre content of stored cowpea was observed throughout the 16 weeks of study. This increase was observed after the first month of study till the end of the experiment. The (control) DE having zero concentration, 0g/100g) showed a negligible increase of 0.01% in the crude fibre content throughout the period of storage. The crude fibre content of the stored cowpea in the storage structures showed an increase in its value. Both wooden and metal storage structures had same effect on the crude fibre content. [18]reported an increase in crude fibre contents of infested cowpea seeds treated with moringa seeds oil. The findings were based on the fact that cowpea weevil *Callosobruchus Maculataus* makes out a hole from the grain endosperm with only the seed coat left which is primarily made of fibre.

4.0 Conclusion

The study focused on effects of diatomaceous earth on the proximate compositions of stored cowpea variety (IT96D-610K). The following conclusions were drawn:

1. The Nutritional composition of the stored cowpea showed an increase in the value of Moisture content, Ash content, and Crude Fibre content as the storage period increased except for Crude protein, Fats and Oil and Carbohydrate which exhibited a different pattern by decreasing with increased storage period.
2. Of all the storage structure, storage time, particle size and concentration of DE used galvanised mild steel (GMS) silo treated with 0.075mm particle size and 0.05g of DE/100g of cowpea stored for four weeks were seen to be the best in keeping moisture content low.

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