



Influence of Diatomaceous Earth (DE) on the Proximate Composition of Stored Maize Seeds

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Abstract

Research was carried out to evaluate the influence of diatomaceous earth (DE) on proximate composition and to determine the optimal dosage of DE for maintaining seed quality of stored maize at different levels (0.0kg DE/100 kg maize, 0.75 kg DE/100 kg maize, 1.50 kg DE/100 kg maize, 2.25 kg DE/100 kg maize and 3.0 kg DE/100 kg maize). The seeds were stored in the laboratory of College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike for 30 weeks. Proximate analyses were carried out at the Faculty of Crop Science Laboratory, University of Nigeria, Nsukka before and after storage. The first experiment (before storage) was laid out in complete randomize design while the second experiment (after storage) was laid out in 5 x 5 factorial fitted in CRD. Both experiments were replicated three times. Data collected were subjected to analysis of variance (ANOVA) and treatment means were separated using least significant difference at ($p \leq 0.05$) level of probability. The results showed that first experiment before storage did not differ among the varieties for ash, carbohydrate (CHO), protein, moisture, crude fat and fibre while the second experiment after storage showed that CHO, protein, fibre, ash, moisture and fat contents were all influenced significantly ($p \leq 0.05$) due to levels of DE, variety and their interactions. Proximate analysis of the maize stored with DE had a slight increase in carbohydrate. Crude fat and fibre increased as the levels of DE increased while protein decreased with increased level of DE. Bende white had higher values for ash, crude fat and carbohydrate while Sammaz 27 had highest amount of protein, crude fibre and moisture content. For maximum proximate composition, store with 1.5 kg DE/100 kg maize for ash content, 3.00 kg DE for crude fat and fibre and 0.75 kg DE/100 kg maize for carbohydrate. For maximum protein composition, do not preserve maize with DE.

Key words: Diatomaceous earth, proximate composition, maize, seed quality, storage period

Introduction: Maize (*Zea mays* L.) is the most widely grown cereal crop in the world and is an important crop in sustaining human life or as feed commodity, as well as significant bioethanol energy resource (kumari *et al.* 2017). It is one of the dominant cereal crops in the Guinea and Sudan savannas in northern Nigeria (Kamara *et al.*, 2020). In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2018). Its grain is a rich source of starch (72%), vitamins A and B (3 – 5%), proteins (10%), oil content (4.8%), fiber (5.8 %), sugar (3.0%) and ash (1.7%) (Khan *et al.* 2016). Safe seed storage and prevention of seeds quality and quantity losses has become a necessity to overcome shortage of seed and tackle starvation and hunger. Some studies reported that dry storage using diatomaceous earth (DE) enable farmers to

store maize and maintain quality (Befikadu, 2019). The desiccant dusts, particularly DEs, are considered as valuable alternatives to the synthetic residual insecticides as grain protectants (Kavallieratos *et al.*, 2018; Losic and Korunic, 2018).

The storage period significantly influences the proximate composition of maize, leading to changes in moisture, ash, protein, fat, fibre, and carbohydrate content. Understanding these changes is important for minimizing nutrient loss and ensuring food safety. Kumar *et al.*, 2017 noted that hygroscopic nature of DE changes the moisture content of maize during storage, potentially influencing its storability and susceptibility to mold growth while Adebayo *et al.*, 2017 stated that the abrasive properties of DE cause physical damage to maize seeds, leading to nutrient loss and changes in

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proximate composition. DE also influences the lipolytic activity of maize, potentially increasing fat acidity which affects its nutritional value (Suleiman *et al.*, 2015). Okoli *et al.*, 2018 supported the fact that storage period and DE treatment interact to influence the protein quality of maize, with implication for its nutritional value. The use of DE as a natural insecticide in storage of maize has gained attention due to its efficacy against pests and potential impact on seed quality. Hence, there is the need to evaluate the influence of DE on the proximate composition of stored maize and to determine the optimal dosage of DE for maintaining maize quality.

Materials and Methods: Maize seeds were sourced from Premier Seeds Nigeria Ltd, Kaduna State and Bende local market. Diatomaceous earth (DE) was got from Nigeria Stored Product Research Institute, Ilorin. Prior to the experiment, seeds were planted during the early planting season of 2024, harvested and stored for 30 weeks at different levels of DE (0.0kg DE/100 kg maize, 0.75 kg DE/100 kg maize, 1.50 kg DE/100 kg maize, 2.25 kg DE/100 kg maize and 3.0 kg DE/100 kg maize) in the laboratory of College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike for 30 weeks. The proximate analyses were carried out before and after storage at the Faculty of Crop Science Laboratory, University of Nigeria, Nsukka.

The moisture content, ash content, crude fats, crude protein, carbohydrate and crude fiber samples were determined using the recommended method described by the Association of Official Analytical Chemists (AOAC, 2019). To measure moisture content, a sample was placed in a pre-dried and weighed petri dish. The dish was then weighed at regular intervals until the weight remained constant, indicating the removal of all moisture. To estimate total ash, a moisture-free sample was placed in a pre-heated, cooled, and weighed crucible. The sample was first charred on a hot plate, and then incinerated in a muffle furnace at 600°C for hours. After cooling in a desiccator, the crucible was weighed. This process was repeated until the resulting ash was light-colored (white or greyish) and had a constant weight. Crude fat was determined based on the Soxhlet extraction method.

The protein content of the samples was determined by analyzing their nitrogen content using the Micro Kjeldahl Method which was calculated by multiplying the nitrogen content by a conversion factor of 6.25. For carbohydrate content, total percentage carbohydrate was determined as the difference between 100% and the sum of percentage crude protein, fat and fibre, moisture, and ash constituents of the sample. The acid-alkali digestion method was employed to determine the fibre content, which consists of insoluble vegetable matter resistant to proteolytic and diastatic enzymes, but can be broken down through microbial fermentation. The first experiment prior to storage was laid out in complete randomized design (CRD) while the second experiment after 30 weeks of storage was laid out in 5x5 factorial fitted in CRD. Both experiments were replicated three times. Data collected from all determinations were subjected to analysis of variance (ANOVA) using GENSTAT Discovery Edition 12 (GENSTAT, 2009). Significant means were separated using least significant difference at ($p \leq 0.05$) level of probability.

Results and Discussion: The initial proximate analysis before storage showed that varieties did not differ from each other (Table 1) for ash, carbohydrate (CHO), protein, moisture, crude fat and fibre while the proximate analysis after storage (Table 2 and 3) showed that CHO, protein, fibre, ash, moisture and fat contents were all influenced significantly ($p \leq 0.05$) by DE, variety and interaction.

For ash content, 2.25 kg DE (2.95 %) recorded the least ash content while 1.5 kg DE (3.89 %) recorded the highest ash content. Bende white (3.79 %) and Sammaz 27 (3.54 %) recorded higher mean values for ash content while Kapam 6 (3.00 %) recorded the lowest mean value. Kapam 6 stored at 1.50 kg DE (5.00 %) observed the maximum ash content followed by Oba 98 stored at 2.25 kg DE (4.80 %) while Kapam 6 stored at 0.75 kg and 2.25 kg DE (2.00 %), Oba super 6 stored at 2.25 kg and 3.0 kg DE (2.00 %) respectively recorded the lowest ash content. The quantity of ash content for the five varieties increased largely when compared before (1.20 – 2.30 %) and after storage ((3.00 – 3.79 %) in Tables 1 and 2. This showed that period of storage enhanced ash content positively. This supports the report of Sunmonu *et al* (2019)

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that storage period had impact on ash content of stored maize. There was a slight increase of 0.34 % and 0.69 % in ash content when 0.75 and 1.50 kg DE were used to preserve 100 kg maize respectively while those treated with 2.25 and 3.0 kg DE decreased ash content. Freo *et al.* (2011) reported that DE treated wheat increased ash content while Omobowale and Akomolafe (2021) noted that untreated cowpea had maximum ash content after storage.

Storage of maize treated with 2.25 Kg DE (Table 2) showed the maximum moisture content of 12.90 %. The lowest moisture content of 11.59 % was recorded from 0.75 kg DE treated maize. Sammaz 27 had the highest moisture content of 13.24 % followed by Oba super 6 with 12.79 %. For interaction, Sammaz 27 treated with 3.0 kg DE had the maximum moisture content (14.75 %) followed by Bende white treated with 2.25 kg DE (14.45 %) while the least was Oba 98 treated with 1.5 kg DE (9.10 %). It was deduced from this study that stored maize with DE acquired more moisture when compared to initial moisture content before storage. This could be attributable to increase in RH, DE being hygroscopic in nature absorbed moisture and increased moisture content in maize treated with DE (Sunmonu *et al.*, 2019). Maize stored at 2.25 kg DE (12.90 %) was significantly higher (3.20 %) when compared to initial moisture content before storage. Also increased moisture content of stored maize could be reaction of enzymes within the tissue of maize seed and respiratory activities of maize followed by the storage media or material (Aremu *et al.*, 2015).

Maize stored at 2.25 kg DE produced the highest percent of fat content (3.98 %) while maize stored at 0.0 kg DE produced lowest (3.57 %) (Table 2). Bende white showed optimum fat content (4.00%) while Oba 98 showed sub optimum fat content (3.42 %) for variety. Treatment combination of Kapam 6 and 2.25 kg DE showed the maximum value (4.61 %) for crude fat followed by Bende white combined with 0.75 kg DE (4.53 %) while Kapam 6 and Oba 98 combined with 0.0 kg DE showed minimum value for fat (3.05 %) content. As the level of DE increased the value for fat content also increased. Fat content recorded a general increase from initial fat (3.62 %) before storage to storage at 3.0 kg DE (3.94 %) after storage.

A significant increase of 0.18 % in fat content was observed when 0.75 kg DE was used and an increase of 0.41 % was seen when 2.25 kg DE was used storing maize. Omobowale *et al.* (2015) in cowpea had contrary opinion that a general decrease was observed in fat content from initial storage at 2.02 % to 1.90 % after the end of the study.

Oba 98 (73.88 %) and Bende white (71.58 %) recorded higher CHO than other varieties while Sammaz 27 recorded lower (69.35 %) CHO (Table 3). Seeds stored at 0.75 kg DE showed the maximum CHO (71.78 %) while seeds stored at 0.0 kg DE (control) showed the minimum CHO (70.32 %). Oba 98 stored at 0.75kg DE observed the highest value (76.11%) followed by same stored at 0.0 kg DE (74.01 %) while Sammaz 27 stored at 3.0 kg DE observed the lowest value (67.74 %) for CHO. Influence of DE increased CHO significantly at 0.75 kg DE and it gradually declined as the level of DE increased, though the lowest value obtained for DE treated maize was better than untreated maize. Oba 98 contained highest amount of CHO compared to others varieties. CHO showed significant decrease due to DE and variety on stored maize at 1.50 – 3.0 kg DE. Different levels of DE had different effect on CHO content of maize stored in them. The initial CHO prior to storage had higher CHO content of 75.45 % as compared to 0.75 kg DE of 71.78 %. Decreased CHO content during storage were also reported by Sunmonu *et al.* (2019), Omobowale *et al.* (2015) and Labuschagne *et al.* (2014). They reported that prolong storage was correlated with increased fungi population in storage that depend on starch as a source of energy.

The maximum mean protein content (Table 3) was observed from Sammaz 27 (8.99 %) followed by Oba super 6 (8.43 %) while the minimum protein (6.96 %) was observed from Bende white. Protein decreased with increased level of DE and their corresponding value (80.80, 8.20, 7.90, 7.44 and 7.72 %) was highest in control. Sammaz 27 treated with 0.0 kg DE (10.01 %) had the highest protein content while Bende white treated with 3.0 kg DE (6.24 %) had the lowest protein content. Protein content depicted continuous decline as the level of DE increased. Significant reduction of 0.11 % was observed between initial protein prior to storage and 0.00 kg DE after

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storage. Omobowale *et al.* (2015) also reported a decrease in protein content of maize stored for 8 Months in metal storage. Sunmonu *et al.* (2019) reported same decreasing protein on cowpea with DE stored on wooden and galvanized steel (GMS). Decreasing protein content after 16 weeks storage with DE was reported by Aremu *et al.* (2015).

Crude fibre ranged from 1.29 % (0.0 kg DE) to 1.59 % (3.0 kg DE) for DE and 1.19 % (Bende white) to 1.73 % (Sammaz 27) for variety (Table 3). Their interactions showed that Sammaz 27 treated with 1.50 kg DE (2.48 %) had the maximum crude fibre followed by Oba 98 treated with 0.75 kg DE (2.00 %) and Oba super 6 and Sammaz 27 treated with 3.0 kg DE (2.0 %). Fibre content increased as the levels of DE increased which was similar to the report of Ilesami and Gungula (2016) that increase in crude fibre content of infested cowpea was due to the fact that cowpea weevil makes out holes from the seeds leaving the endosperm which is made up of fibre primarily. Omobowale *et al.* (2015) also observed increased crude fibre content on cowpea stored in both wooden and metal structures.

Conclusion: Proximate analysis of the maize stored with DE had a slightly increase in carbohydrate. Crude fat and fibre content increased as the levels of DE increased while protein decreased with increased level of DE. Bende white had higher values for ash, crude fat and carbohydrate compared to other varieties. Sammaz 27 had highest amount of protein, crude fibre and moisture content from this study. For maximum proximate composition, store with 1.5 kg DE/100 kg maize for ash content, 3.00 kg DE for crude fat and fibre and 0.75 kg DE/100 kg maize for carbohydrate. For maximum protein composition, do not preserve maize with DE.

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Table 1. Initial proximate composition of maize seeds prior storage

Variety	Ash (%)	CHO (%)	Protein (%)	Fat (%)	Fibre (%)	Moisture content
Bende White	1.40	77.06	7.94	3.40	1.20	9.00
Kapam 6	1.60	75.09	8.82	3.90	2.10	8.82
Oba 98	2.00	76.42	8.38	3.20	2.00	8.00
Oba Super 6	2.30	75.48	8.18	3.60	1.80	8.64
Sammaz 27	1.20	73.05	10.25	4.00	2.50	9.00
Mean	1.70	75.42	8.71	3.62	1.92	8.69
LSD _{0.05}	ns	ns	ns	ns	ns	Ns

Table 2. Influence of diatomaceous earth and variety on ash, moisture and fat content of stored maize

Variety	Levels of Diatomaceous Earth					Mean
	0.00 kg	0.75 kg	1.50 kg	2.25 kg	3.00 kg	
Ash (%)						
Bende white	3.99	3.98	3.99	3.00	3.99	3.79
Kapam 6	3.00	2.00	5.00	2.00	3.00	3.00
Oba 98	3.00	3.00	3.00	4.80	2.01	3.16
Oba Super 6	2.99	3.99	4.49	2.00	2.00	3.09
Sammaz 27	3.01	4.73	2.99	2.99	3.99	3.54
Mean	3.20	3.54	3.89	2.95	2.99	3.31
LSD _(0.05) for variety		0.16**				
LSD _(0.05) for DE		0.16**				
LSD _(0.05) for Interaction		0.35**				
Moisture Content (%)						
Bende white	12.99	10.49	12.95	14.45	12.40	12.65
Kapam 6	11.00	11.75	13.50	13.60	11.45	12.26
Oba 98	11.48	9.25	9.10	10.45	11.53	10.36
Oba Super 6	11.00	12.99	12.99	13.99	12.99	12.79
Sammaz 27	12.98	13.50	13.00	11.99	14.75	13.24
Mean	11.89	11.59	12.31	12.90	12.62	12.26
LSD _(0.05) for variety		0.37**				
LSD _(0.05) for DE		0.37**				
LSD _(0.05) for Interaction		0.82**				

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	Crude Fats (%)					
Bende white	4.02	4.53	4.03	3.80	3.64	4.00
Kapam 6	3.05	3.05	4.02	4.61	4.43	3.83
Oba 98	3.05	3.20	3.44	3.60	3.83	3.42
Oba Super 6	4.23	4.20	4.03	3.69	3.49	3.93
Sammaz 27	3.52	3.79	4.00	4.21	4.31	3.96
Mean	3.57	3.75	3.90	3.98	3.94	3.83
LSD _(0.05) for variety		0.025**				
LSD _(0.05) for DE		0.025**				
LSD _(0.05) for Interaction		0.056**				

Table 3. Influence of diatomaceous earth and variety on CHO, protein and fibre content of stored maize

Variety	Levels of Diatomaceous Earth					Mean
	0.0 kg	0.750 kg	1.50 kg	2.25 kg	3.0 kg	
	Carbohydrate (%)					
Bende white	72.02	72.64	70.29	70.8	72.14	71.58
Kapam 6	69.46	71.5	69.88	70.16	70.56	70.31
Oba 98	74.01	76.11	73.22	72.39	73.67	73.88
Oba Super 6	67.91	69.86	72.51	70.42	71.69	70.47
Sammaz 27	68.23	68.78	70.01	72.03	67.74	69.35
Mean	70.32	71.78	71.18	71.16	71.16	71.12
LSD _(0.05) for variety		0.02**				
LSD _(0.05) for DE		0.02**				
LSD _(0.05) for Interaction		0.045**				
	Crude Protein (%)					
Bende white	7.54	7.41	7.22	6.24	6.41	6.96
Kapam 6	8.82	8.51	8.05	7.48	7.78	8.13
Oba 98	8.22	7.93	7.22	8.02	6.68	7.61
Oba Super 6	9.41	8.44	8.41	7.83	8.05	8.43
Sammaz 27	10.01	9.02	8.63	9.03	8.3	8.99
Mean	8.8	8.26	7.9	7.72	7.44	8.02
LSD _(0.05) for variety		0.02**				
LSD _(0.05) for DE		0.02**				
LSD _(0.05) for Interaction		0.05**				
	Crude Fibre (%)					
Bende white	1	1	1	1.48	1.48	1.19
Kapam 6	1.48	1	1.48	1.48	1.48	1.38

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Oba 98	1	2	1	1.48	1	1.29
Oba Super 6	1.48	1.48	1.48	1.48	2	1.58
Sammaz 27	1.48	1	2.48	1.73	2	1.73
Mean	1.29	1.29	1.49	1.53	1.59	1.44
LSD _(0.05) for variety		0.07**				
LSD _(0.05) for DE		0.07**				
LSD _(0.05) for Interaction		0.16**				