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Effect of Pre-Treatment with Plant Powders on the Nutrient Composition of Maize Grain *Zea Mays* Infested by Weevil *Sitophilus zeamais* Motsch

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ABSTRACT: Quality deterioration in maize grain as judged by changes in proximate composition caused by *S. zeamais* after three months post infestation was determined by proximate analyses of the maize grain before and after the infestation. Fifty grammes of maize were treated with 0.5 g and 1.0 g of each plant powder (i.e. kernel of *Azadiracta indica*, bulb of *Allium sativa*, rhizome of *Zingiber officinale*, leaves of *Nicotiana tabacum* and *Ocimum basilicum* and along with conventional insecticide, Coopex). The results showed that the percentage total protein determined by the estimate of total nitrogen content did not decrease much after three months of post infestation. The percentage ash in the maize grain decreased with storage period. The percentage fibre was higher in the untreated control (7.02%), than on the treated grains (3.23%). The percentage carbohydrate however, decreased (69.85%) with increase in infestation period. The minerals content in infested grains decreased substantially due to insect feeding. The findings have indicated that all the tested materials have potentials of reducing effect of *S. zeamais* on the nutritional composition of maize grains at 1.0g of powder/50g of grains, but *A. indica* is more efficacious.

KEYWORDS: *S. zeamais*, Plant, powder, Nutritional composition

INTRODUCTION

Maize (*Zea mays* L) is an out-breeding, heterogeneous crop. It has come close to being a staple food crop in the drier parts of the forest zone, where it forms about 20 per cent of the total carbohydrate food grown (Simone *et al.,* 1994). Damage to grains may happen due to improper application of post harvest practices, such as threshing, drying or transportation (Lale, 2002). A stored product pest of maize, *Sitophilus zeamais* (Mostch.) (Coleoptera: *Curculionidae*) is particularly important because it mostly attacks the final agricultural product causing considerable losses to quality, quantity and viability (Simone *et al.,* 1994).

Once infestation is established, insect pests cause gradual and progressive damage leading to losses in weight, nutritional, organoleptic and aesthetic quality of stored grains (Lale, 2002; Denloye *et al.*, 2007). The huge post – harvest losses and quality deterioration of food grains and tubers caused by insect pests and microorganisms during storage are major problems of assuring food security in developing countries such as Nigeria, Ghana and Gambia (Akinneye *et al.*, 2006). The damage to sorghum and millet grains in storage in northern Nigeria due to this pest ranges between 4 and 10 per cent (Bamaiyi *et al.*, 2006). Obeng-ofori and Amiteye (2005) estimated that out of a total annual harvest of 250,300,300.00 tons of maize in Ghana, about 20 percent was lost to *S. zeamais*, and some cases even total losses were recorded. According to Adugna (2006), maize stored in traditional stores at 12.5 percent relative humidity for six months may lose 8 – 9 percent of its weight due to attack of *S. zeamais.*

Qualitative loss arises primarily from the alteration of the physical appearance and chemical constituents of the products with insect frass and debris, and could lead to detectable reductions in vital nutrients such as sugar, proteins, lipids minerals, vitamins, and other chemical constituents (Lale, 2002). Bamaiyi *et al.* (2006) observed that decrease in intestinal transit time of food provides less effective absorption of nutrients from the food. High fibre in the diet impairs absorption of protein, calcium, iron and zinc. Considering the economic importance of maize grain and the damage caused to it by maize weevils, the present study has been designed to assess the qualitative loss in the infested maize grain treated with different plant powders and to determine the effectiveness of the powders.

MATERIALS AND METHODS

The maize grains used in the experiments were purchased from Sokoto Central market. Grains visibly infested by weevils were separated from uninfested ones. The uninfested maize grainswere first deep frozen at low temperature (0^0C) for 10 days to kill off any prior infestations and were then conditioned for two weeks in an ambient condition (Ofuya, 1997). The sterilized maize was then used for experimental purposes.

Thirty adults *S. zeamais* were collected from the infested maize above and then reared on the uninfested maize grains under the ambient conditions for 6 weeks to obtain a new stock from which F_1 generations of adults were collected and used in the planned experiments. The stock was maintained throughout the experiment. The insect were identified using the identification key (Hills, 1999). The male has irregular pits producing rough appearance over the lateral and dorsal surfaces, the female snout is ovoid.

Kernel of *Azadiracta indica* A. juss, leaves of *Nicotiana tabacum* L. and *Ocimum basilicum* L., bulb of *Allium sativa Allium* L. and rhizome of *Zingiber officinale* were collected, identified in the Herbarium at Botany unit and tested for their insecticidal efficacy along with the conventional insecticide, Coopex (Permethrin-0.5%) against *S. zeamais.* The concentrations used were 0.5 and 1.0g/50g of maize, which were applied to 50g of maize in a labeled petridish, and replicated three times. The control was not treated with any powder. All the petridishes were shaken vigorously to ensure proper mixing after which they were infested with newly emerged adult *S. zeamais*. Five newly emerged pair of adults *S. zaemais,* collected from the mother stock were then released into each of the petridish. The petridishes were arranged in complete randomized design (CRD) and were kept in the laboratory for seven days. After seven days dead and living insect were removed from the petridishes. The Petri dishes were left undisturbed for 3 month, after which the proximate composition was assessed.

Proximate analysis

To assess the qualitative loss caused to maize grains, proximate analyses of the infested and uninfested maize were carried out using method adopted by Anitia *et al.* (2006).

Determination of moisture

Empty flask was weighed and then 2g of the sample were added in the flask. It was then dried using hot air oven at 105-110^{0}C for 24 hours and then cooled down in desiccators. The flask was weighed again. The Sample was then returned to the oven for another 24 h to ensure that the drying was complete. Both the flask and the dried sample were weighed again.

Determination of ash

This involved the incineration of each sample in a muffle furnace (Naber industrie of enbau, Bremen, Germany) at 550^{o}C for 12 hours.

Determination of Crude fat

This was achieved by exhaustively extracting the sample with diethyl ether.

Determination Crude fibre

Crude fibre was estimated from the loss in weight of the crucible and its contents on ignition after ashing, following the sequential extraction of the samples with 1.25% sulphuric acid and 1.25% sodium hydroxide.

Determination of Protein

The micro-Kjeldahl nitrogen method was used, which involved the digestion of 0.5g of sample with sulphuric acid and a catalyst followed by colorimetric determination of nitrogen. The value of nitrogen was multiplied by 6.25 to obtain percentage crude protein.

Determination of carbohydrate

The carbohydrate content was obtained by subtracting the values of moisture, total ash, lipid, crude fibre and crude protein (Anitial *et al.*, 2006).

Determination of electrolytes

Sodium, potassium, calcium, magnesium and phosphorus content were measured using an Atomic Absorption Spectrophotometer (A.A.S) after acid-digestion of the samples (Anitial *et al*., 2006).

Statistical analysis

All the samples were analyzed in triplicates. The proximate composition and mineral data were subjected to analysis of variance at 5% level of confidence, using statistical analysis system (SAS, 2003), and means that were found to be significant were separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Result of proximate analyses of the maize grains showed that *S. zeamais* caused deterioration in the quality of grains in all trials (Tables 1 – 4). There was a reduction in loss of nutritional content when the amount of powder was increased from 0.5g - 1.0g. These affect the quality of various organic compounds and mineral elements analysed.

Organic Compounds

Table 1 shows that maize treated with 0.5g of *A. indica* had lowest increase in moisture content. Maize treated with *N. tabacum* had increased moisture content followed by *O. basilicum, A. sativum* and *Z. officinale* (Table 1). The untreated infested grains had highest moisture level (9.83 - 13.3%).

Ash content of the infested grains was significantly affected when grains were treated with various powders. The loss in ash content of the grains treated with coopex was low while in the untreated, the loss was high. The loss in ash content of grains treated with 0.5g of *A. indica* was low, while maize treated with other plant powders had higher losses in their ash content, but better than control. This is in conformity with Bamaiyi *et al*., (2006). This indicates that the insect's activity (feeding and reproduction) reduced the mineral content of grains.

Lipid content reduced after three months of infestation (Table 1). This follows the same pattern as observed in the ash content (Table 1). Insect infestation affects the total fat content of grains and tends to increase the breakdown of fat into fatty acids (Jood and Kapoor, 1993). Jood *et al*. (1996) reported that insect infestation resulted in substantial reduction in the content of total lipids of the grain. There was a significant ($P < 0.05$) reduction and negatively correlated loss of lipids in grains with increased levels of insect infestation (Bamaiyi *et al*., 2006).

Fibre content of grains increased after three months of infestation, as the weevil fed on the endosperm. Maize treated with coopex had lower loss while untreated control had higher loss. Among the seed treated with plant powders *A. indica* had the lowest loss, as seen in Table 1. An increase in fibre content was also observed among the infested untreated grains. For most endosperm, *S. zeamais* hollow out the contents of grains leaving only the bran, which is largely fibre. This result agrees with Bamaiyi, *et al.* (2006) who reported that insect infestation decreased the nutritional quality of grains and increased the relative level of dietary fibre.

Powder application affects protein content. Untreated (control) had the minimum loss followed by coopex , *A. indica Z. officinale*, *N. tabacum* , *O. basilicum* and *A. sativum* treatment respectively. No much decrease was observed in total protein content; which could be attributed to the accumulation of insect frass and exuviae within the grains, which increased the total nitrogen content of the grains. Similar observations were made by Jood and Kapoor (1993), who found a progressive increase in total nitrogen, total protein, non-protein and uric acid with increased level of infestation of wheat. The insects feeding actually decreased the true protein content of grains. The endosperm component of maize grains contains 90 per cent of the seed protein, which is readily damaged by insects (Bamaiyi *et al*., 2006). The total protein content of the grains (as calculated from its nitrogen content) is not affected during storage in untreated non infested grains (Table 1).

Carbohydrate content decreased in both treated and untreated grains (Table 1). The carbohydrate content decreased with increase in storage period. Moisture content increased from 9.83 to 12.00 per cent in treated maize, while among untreated grains it increased to 13.30 per cent. This shows that higher insect infestation increases the moisture content of the grains.

Table 2 shows that the qualitative loss caused by *S. zeamais* to maize treated with 1.0g of various plant powders along with coopex and untreated control had similar trend with respect to organic compounds. Significant differences ($P<0.05$)

were observed among the maize treated with 0.5 and 1.0g/50g of maize. This signifies that increased amount of plant powders resulted in decreased losses in the nutritional compounds, and showed that *A. indica* and *N. tabacum* are the most effective among the plants tested.

Mineral Elements

Losses in mineral elements caused by *S. zeamais* to maize after three months of exposure is presented Tables 3 and 4,. The chemical analysis of treated and untreated grains showed that the weevil caused significant losses in mineral elements such as Na, K, Ca, Mg and P (Table 3). Significant decrease ($P<0.05$) in loss of the minerals was obtained when the amount of powder was increased to 1.0g (Table 4). The minerals content in infested grains decreased substantially due to insect feeding. This is in agreement with the findings of Jood and Kapoor (1993) who found that feeding by *S. zeamais* decreased the minerals and vitamin content of maize grains.

Based on these observations, it can be deduced that all the plant powders used had significant ($p<0.05$) effects on the nutritional content of the grains. The effectiveness of the tested powders can be arranged in the following descending order Coopex.> *A. indica* > *N. tabacum* > *O. basilicum* > *A. sativum* > *Z. officinale*.

In conclusion there is a need for more work on this aspect of mineral elements so as to know how this lost in mineral elements can affect nutrition.

Table 1: Effect of *S. zeamais* infestation on nutritional composition of maize treated with 0.5g of various plant powders

Treatment used	Organic Compounds					
	Moisture	Ash	Lipid	Fibre	Crude protein	Carbohydrates
Untreated uninfested control	9.83^{a}±0.17	2.10^{a}±0.07	3.50^{a} ±0.00	2.70^{a} ±0.44	7.40^{a}±0.00	74.47^{a}±0.12
Coopex	10.37^{b}±0.04	1.87^{b} ±0.16	3.00^{b} ±0.00	3.23^{b} ±0.04	7.36^{b}±0.00	74.17^{b} ±0.1
A. indica	11.07^{c}±0.07	1.33^{c} ±0.09	2.77^{c} ±0.04	4.07^{c} ±0.07	7.32^{c} ±0.01	73.45^{c} ±0.06
A. sativum	12.10^{f}±0.10	1.00^{e} ±0.00	2.40^{f}±0.00	4.7^{f} ±0.1	7.11^{f}±0.00	72.68^{f} ±0.00
N. tabacum	11.50^{d}±0.07	1.20^{d} ±0.00	2.63^{d} ±0.00	4.37^{d}±0.04	7.18^{e} ±0.01	73.12^{d}±0.10
O. basilicum	11.87^{e}±0.07	1.00^{e}±0.00	2.50^{e}±0.00	4.50^{e}±0.00	7.15^{e}±0.00	72.99^{e}±0.01
Z. officinale	12.73^{g}±0.15	0.78^{f}±0.02	2.07^{g}±0.04	5.93^{g} ±0.07	7.22^{d}±0.01	71.28^{g} ±0.15
Control	13.30^{h}±0.10	0.50^{g} ±0.00	1.93^{h} ±0.07	7.02^{h} ±0.02	7.40^{a}±0.00	69.85^{h} ±0.13
LSD	**0.2172**	**0.1051**	**0.0904**	**0.1205**	**0.0341**	**0.173**

All values are in percentages. Means in column followed by a common letter are not significantly different (p >0.05)

Table 2: Effect of *S. zeamais* infestation on nutritional composition of maize treated with 1.0g of various plant powders

Treatment used	Organic Compounds					
	Moisture	Ash	Lipid	Fibre	Crude protein	Carbohydrates
Untreated uninfested control	9.90^{a} ±0.10	2.10^{a} ±0.10	3.43^{a}±0.04	2.77^{a}±0.04	7.39^{a}±0.00	74.41^{a}±0.06
Coopex	10.43^{b}±0.04	1.80^{b} ±0.10	3.03^{b} ±0.04	3.13^{b} ±0.07	7.36^{a}±0.04	74.24^{b} ±0.1
A. indica	10.43^{b}±0.07	1.77^{b}±0.04	3.00^{b} ±0.00	3.27^{b} ±0.04	7.36^{a} ±0.00	74.17^{c}±0.07
A. sativum	11.17^{d}±0.09	1.33^{d}±0.09	2.73^{c}±0.04	4.33^{d}±0.09	7.25^{c}±0.03	73.18^{d}0.01
N. tabacum	11.00^{c}±0.00	1.53^{c}±0.04	2.80^{b}±0.10	3.97^{c}±0.04	7.32^{b}±0.04	73.38^{cd}±0.04
O. basilicum	11.07^{c}±0.07	1.50^{c}±0.00	2.77^{c}±0.07	4.10^{c} ±0.10	7.30^{b}±0.00	73.27^{cd}±0.04
Z. officinale	12.17^{e}±0.09	1.07^{e}±0.07	2.50^{d}±0.10	5.07^{e}±0.07	7.18^{d}±0.01	72.02^{e}±0.11
Control	13.40^{f}±0.10	0.50^{f} ±0.00	1.93^{e} ±0.07	6.97^{f} ±0.04	7.40^{a}±0.00	69.80^{f} ±0.1
LSD	**0.1893**	**0.0917**	**0.0788**	**0.1051**	**0.0295**	**0.1508**

All values are in percentages. Means in column followed by a common letter are not significantly different (p >0.05)

Table 3: Effect of *S. zeamais* infestation on mineral content of maize treated with 0.5g of various plant powders

	Mineral elements				
	Na	K	Ca	Mg	P
Untreated uninfested control	$52.67^{a} \pm 0.17$	$72.67^{a} \pm 0.17$	$0.90^{a} \pm 0.00$	$1.05^{a} \pm 0.00$	$2.98^{a} \pm 0.02$
Coopex	$52.33^{a} \pm 0.17$	$72.20^{a} \pm 0.15$	$0.80^{b} \pm 0.00$	$1.05^{a} \pm 0.00$	$2.97^{a} \pm 0.00$
A. indica	$47.67^{b} \pm 0.17$	$70.17^{b} \pm 0.17$	$0.80^{b} \pm 0.14$	$1.00^{b} \pm 0.00$	$2.95^{a} \pm 0.00$
A. sativum	$38.33^{e} \pm 0.83$	$57.17^{e} \pm 0.17$	$0.71^{d} \pm 0.01$	$0.93^{c} \pm 00.02$	$2.88^{c} \pm 0.00$
N. tabacum	$45.1^{c} \pm 0.1$	$65.17^{c} \pm 0.17$	$0.75^{c} \pm 0.01$	$1.00^{b} \pm 0.00$	$2.91^{b} \pm 0.002$
O. basilicum	$41.67^{d} \pm 0.8$	$60.83^{d} \pm 0.6$	$0.75^{c} \pm 0.0$	$0.97^{b} \pm 0.02$	$2.89^{c} \pm 0.003$
Z. officinale	$32.67^{f} \pm 0.17$	$47.43^{f} \pm 0.1$	$0.60^{e} \pm 0.00$	$0.85^{d} \pm 0.00$	$2.81^{d} \pm 0.00$
Control	$25.67^{g} \pm 0.7$	$42.50^{g} \pm 0.00$	$0.50^{f} \pm 0.00$	$0.80^{e} \pm 0.00$	$2.71^{e} \pm 0.01$
LSD	**07892**	**0.8002**	**0.0183**	**0.0313**	**0.0044**

All values are in mg/g Means in column followed by a common letter are not significantly different ($p > 0.05$)

Table 4: Effect of S. *zeamais* infestation on mineral content of maize treated with 1.0g of various plant powders

Treatment used	Mineral elements				
	Na	K	Ca	Mg	P
Utreated uninfested control	$52.67^{a} \pm 0.17$	$72.67^{a} \pm 0.17$	$0.90^{a} \pm 0.02$	$1.10^{a} \pm 0.00$	$2.98^{a} \pm 0.00$
Coopex	$52.40^{a} \pm 0.09$	$72.2^{a} \pm 0.17$	$0.85^{b} \pm 0.00$	$1.05^{a} \pm 0.00$	$2.966^{b} \pm 0.00$
A. indica	$52.33^{a} \pm 0.17$	$72.50^{a} \pm 0.2$	$0.85^{b} \pm 0.14$	$1.07^{a} \pm 0.00$	$2.95^{b} \pm 0.00$
A. sativum	$42.7^{d} \pm 0.17$	$62.93^{c} \pm 0.20$	$0.76^{c} \pm 0.01$	$0.97^{c} \pm 0.02$	$2.91^{d} \pm 0.00$
N. tabacum	$47.67^{b} \pm 0.17$	$67.67^{b} \pm 0.17$	$0.80^{c} \pm 0.00$	$1.00^{b} \pm 0.00$	$2.93^{c} \pm 0.003$
O. basilicum	$45.00^{c} \pm 0.00$	$67.33^{b} \pm 017$	$0.78^{c} \pm 0.17$	$1.02^{b} \pm 0.02$	$2.92^{d} \pm 0.003$
Z. officinale	$38.03^{e} \pm 0.17$	$50.10^{d} \pm 0.10$	$0.68^{d} \pm 0.002$	$0.90^{d} \pm 0.00$	$2.84^{e} \pm 0.00$
Control	$33.00^{f} \pm 0.17$	$40.00^{e} \pm 0.00$	$0.50^{e} \pm 0.00$	$0.75^{e} \pm 0.00$	$2.71^{f} \pm 0.01$
LSD	**0.7290**	**0.7392**	**0.0169**	**0.0289**	**0.0040**

All values are in mg/g Means in column followed by a common letter are not significantly different ($p > 0.05$)

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