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Post-Harvest Loss And Nutritional Quality Of Popcorn And Local Maize Varieties Infested And Damaged By Maize Weevil, Sitophilus zeamais Motsch (Coleoptera: Curculionidae)

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Abstract: *Post-harvest loss and nutritional quality of pop-corn and local white and yellow varieties of maize infested and damaged by maize weevils under storage periods of 3 and 12 months in market stores were investigated . Sample of 1kg of each variety was randomly sampled per bag of 50kg and used for the assessment of loss using Frass Method, and population of maize weevils per one kg sample were recorded, while 100 seeds were sampled and used for percent holed seed damage assessment . The undamaged and damaged seeds were blended for Phytochemical analysis, proximate, mineral element analyses and determination of vitamins. ANOVA and DMRT were used for data analysis. The results indicated that yellow local variety attracted more weevil population (339 &588/kg) than the white coloured local variety (58 &100 weevils/kg) in the samples of 3 &12 months of storage respectively . However, at 12 months of the storage period, weight loss and percent damage were significantly (P<0.05) higher in the white variety (98% and 99%).Weight loss in popcorn was minimal(28%) but % holed seed was 59% decreasing the market value.There was reduction in Vitamin C and A in popcorn and yellow maize while Protein ,and fat contents were significantly reduced in the white variety. Mineral elements in damaged seeds of all the maize varieties was significantly reduced at 12 months of storage .Phenol , Alkaloid,Phosphorus,Magnesium,Iron were higher in Popcorn which are traits for resistance and also nutrients required by the body .This study recommends only three momths of storage of untreated popcorn and local maize stored in bags in rural areas .*

Keywords: *Post-harvest loss, Nutritional value, Loccal maize variety, Popcorn, Mineral elements, Phytochemicals, , Sitophilus zeamais.*

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I. Introduction

Popcorn (Zea mays everta L.) is grown in many parts of the world including Nigeria (Tunku et al.,2014). . Popcorn is a good source of snack, providing 69% protein and its hull is excellent roughage comparing favourably with bran flakes or whole wheat toast. In addition, it is naturally high in dietary fibre, low in calories, fat and free sugar and sodium thus the need to increase its production due to its health benefits (Shamsudden, 1994). Maize, *Zea mays L*, is a dietary staple in sub-saharan Africa (Ogunbodede and Olakojo, 1999). It is a major food crop, feed, and industrial raw material, maize holds considerable promise as a weapon against poverty and food crisis in the west Africa sub-region (Okoruwa, 1992). As the first harvested crop in the year, maize plays a significant role in reducing hunger period (Fajemisin, 1991). It is therefore important to effectively investigate the post-harvest loss of the grains in order to ensure adequacy of food, feed, seeds, and raw material to agro-based industries.

The major constraint to utilization of maize in the tropics and sub-tropics is the attack by the maize weevil *Sitophilus zeamais* motschulsky (Akob and Ewete, 2007). Adult weevil and larvae feed on undamaged grains and frequently cause severe powdering, rendering the product unfit for human consumption.Partially damaged maize grain manifest loss in weight, poor marketability, quality deterioration and low viability (Enobakhare and law-Ogbomo, 2002). Weight losses of 3-80% in storage have been reported (Delina, 1987). Maize is often heavily infested in tropics by various vertebrates and invertebrates, pests which include rodents and insects. The most important of these being the maize weevil, *Sitophilus zeamais* (Adedire, 2002). Post-harvest losses to storage insect pest such as *S. zeamais* have been seen as an increasing important problem in Africa and other tropical countries (Markham et al., 1994). Infestation by this weevil commences in the field but most of the damages is done during storage (Demissie et al., 2008).

In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population and provides 50 % of the basic calories. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals,. Maize grains have great nutritional value as they contain 72% starch, 10% protein, 4.8 % oil, 8.5% fibre, 3.0% sugar and 1.7% ash (Chaudhary, 1983). . White, red and yellow are the three types of maize and among all, yellow variety is commonly used for animal feed. Yellow maize unlike white maize, provides carotene and xanthophylls pigment for coloration of egg yolk, poultry fat and skin. Maize is also an excellent source of linolenic acid. The seed is high in starch (65-70%), but low in protein (8.8%), fibre and minerals.

The maize weevil, *S. zeamais* Motsch and the lesser grain borer *Rhyzopertha dominica* Fab; are among the most destructive pests of stored maize world wide (Ofuya and Lale, 2001). The devastating loss of stored products to insects attack has therefore necessitated the used of various measure to control maize weevils. Methods employed in pest control include the use of botanicals, biological controls, cultural control, hermetic storage, controlled atmosphere, and chemical methods (Akinkurolere et al., 2006; Demissie et al; 2008; Abebe et al; 2009). The development of alternative control strategies such as the use of resistant maize, cultivars against *S. zeamais* has gained popularity Abebe et al., 2009). Varietals differences in the susceptibility of maize to infestation and damage by *S. zeamais* have been observed (Adesuyi, 1979, Ashamo, 2001; Abebe et al; 2009). . Also, there is a report of increased susceptibility of varieties of crops to stored product insects 2004; Bamaiyi et al, 2007).

Nevertheless, the use of less susceptible maize cultivars, in conjunction with other control methods to form an integrated pest management (IPM) program may provide a lasting system to maintain insect population in stored maize at an acceptable level in the tropics

Damaged grains have reduced nutritional values, impaired germinability, and reduced weight and market values, (Abebe et al. 2009). Losses ranging from 20 to 90% due to *S. zeamais* infestation in unprotected maize grain have been reported (Delina 1987, Giga et al., 1991).

Objective of this study was to assess the post-harvest losses and loss in nutritional composition of popcorn , local white and yellow maize varieties infested by maize weevil (*Sitophilus zeamais* motsch).

II. Materials and Methods

This study was conducted in the Biological Science Laboratory and Biochemistry laboratory, Kogi State University, , Anyigba, Nigeria.

Collection of Materials and Damage Assessment

Popcorn, white and yellow local maize seeds stored for three and twelve months were sampled from three maize stores with piles of bags in Anyigba Market, Dekina local government Area, Kogi State, Nigeria in November 2014. They were collected into polythene bags and taken to the Biological Science Laboratory. One kilogram weight of each variety in three (3) replicates were used for the assessment. In each replicate, the damage was separated from the undamaged, the number of weevils found per 1kg quantity in each variety was recorded and weight loss was equally recorded using the following procedures .The percentage of damage was determined using the following Calculation:,% Damage = (No. of holed seeds/ Total no. of seed counted) X (100/1)Weight loss was determined using the Frass Method,where the grain samples were weight and the kilogram weight of the samples were transferred into a sieve and agitated to remove residues, dust . respectively for the three varieties.

The Frass i.e dust and broken grains were weighed and the maize varieties and popcorn stored for 12 months were separated into damaged and undamaged. The damage and undamaged seeds were separately pound into powders using mortar and pestle and analyzed for proximate nutrients and mineral element composition, phytochemical constituenst in Biochemistry Laboratory, Kogi State University, Anyigba.

Statistical Analysis:

Data collected were subjected to analysis of Variance using SAS statistical package, and means were separated using FLSD at 5% level probability. DMRT was used for ranking.

Results and Discussion

The results in table 1 showed that weight loss of popcorn (yellow) was 10%, 21% for local white and 45% for local yellow varieties at 3 months of storage but at 12 months,the weight loss of popcorn variety increased to 28.4% while that of white var increased to 97.6% and local yellow to 63.3% . The percent holed seeds of popcorn was 59%, local white (99%) and local yellow (90%) at 12 months of storage. The laboratory results indicated that yellow local variety attracted more weevil population (n = 339 and 588) than the white local variety (n=58 and 100) weevils at 3 and 12 months respectively and popcorn (n=37& 84).However at 12 months of the storage period, weight loss and percent hole seeds were significantly ($P \leq 0.05$) higher in the white variety (98% and 99%) respectively than the yellow variety (63% and 90%). This high percentage in the yellow seeds may be due to higher weevil population recorded at 3 months infesting yellow variety.

The mean weight loss and percent (%) holed seeds of the popcorn and the local white variety were comparable at 3 months, and the weevil population were also comparable and significantly ($P \leq 0.05$) lower than the local yellow. However, at 12 months of storage, weight loss of popcorn was significantly ($P \leq 0.05$) lower (28.4%) compared with local yellow (63.1%) and local white (97.6%) which recorded the highest weight loss. Similarly, percent holed seed of popcorn was significantly $p \leq 0.05$ lower (59.3%) compared with local yellow (90%) and local white (99%) which recorded highest holed seed .The weevil population feeding on the popcorn (84.3) and local white (100) were comparable at 12 months and significantly ($p \leq 0.05$) lower compared with local yellow which recorded 588.6 weevils per 1kg of seed. From these results, the local white and the popcorn yellow can be stored for 3 months without treatment and sustainably stored in the local storage facilities without serious weight losses in seeds stored in bulk in the market stores for sale. While it is not advisable to store the local yellow for 3 months without treatment against the weevil or storing in air tight drums,Hermethic bags..

The results of proximate composition of nutrients are presented in table 2 and indicated significant ($P \leq 0.05$) high content of ash (2.18%) and crude fibre (2.95%) in the undamaged yellow variety compared with the white and popcorn varieties which recorded 1.70% and 1.78% respectively for ash, and 2.21% crude fibre for white, 2.57% crude fibre for popcorn.Undamaged popcorn recorded significant ($P \leq 0.05$) high crude protein 13.2% followed by yellow local variety 11.7%. The white variety recorded significant ($P \leq 0.05$), high carbohydrate 72.8%, local yellow (68.4%), The fat content in popcorn is higher 5.73%, yellow (4.60%), and white (4.39%). The moisture content of all the varieties are within a good range of 9-10.7%. Moisture content of the white and yellow damaged increased which could result to mold attack and reduce market and health value. Moisture content in white varieties significantly low compared with damaged popcorn (5.63%) and (4.49%) for yellow local maize. The crude protein of damaged white is significantly lower compared with the yellow and popcorn. . The results of proximate composition of healthy seeds and damaged seeds by weevils indicated significant ($P \leq 0.05$) reduction of crude protein and fat content in the damaged popcorn, yellow local and white local variety

The results of mineral content in the maize varieties are present in Table 3. the undamaged (healthy) yellow recorded significantly ($P \leq 0.05$) higher content of Na (66.2mg), Ca. (63.16mg) and Fe (6.25mg) compared with the white local and their contents in both yellow and white local maize (12.8mg), Ca (10.7mg), Fe (3.84mg).

The popcorn yellow variety had significant ($P \leq 0.05$) higher content of Mg (147.5mg), P (330.1mg) compared with the white Mg (108.5mg), P (300.3mg) and the yellow mg (117.5mg), P (310mg). The results showed significantly ($P \leq 0.05$) high content of Zn (10.3mg) in the white local variety compared with the undamaged (healthy) local yellow variety containing 7.34mg Zinc and popcorn yellow containing 3.13mg Zn.

All the mineral elements were significantly ($P \leq 0.05$) reduced in the damaged local maize seeds, and the damaged popcorn recorded the lowest content of Na, Ca, Fe and Zn which reduced their nutritional value. ..In this study, the slight resistance of yellow popcorn to damage by the weevil can also be attributed to higher content of phenol and the mineral elements such as iron (Fe), phosphorus (P), magnesium (Mg), calcium (Ca) than the quantity recorded in white variety which is in accordance with the report that increased phenolic and ferulic acid content contribute to the resistance of maize seeds to *Sitophilus zeamais*. (Ahamo, 2001; Arnason et al., 1994, 2004). In this study, the carbohydrate (CHO), Protein and fat level were high but after feeding on the seeds, these nutrients were decreased and this could explain susceptibility of all the varieties to *S. zeamais*. These results agree with the work done by (Singh and Mccain, 1963; Dobie, 1974) who reported that weevil infestation had positive correlation between higher sugar and starch levels with weevil number .

The results of phytochemicals are presented in the table 4. The presence of phytochemicals in these corn seeds was generally low. However, popcorn yellow variety recorded significantly ($P \leq 0.05$) higher content of flavonoid, tannin, alkaloid and phenol compared with the local white and local yellow varieties. All the phytochemicals (secondary metabolites) were reduced in the damaged seeds, the level of tannin, alkaloid and phenol in yellow local ranked next to popcorn. From the results, popcorn, yellow maize variety exhibit resistance to attack by *S. zeamais* and had lower weight loss compared with the white variety which may be explained from the concentration of saponin, alkaloid, and phenol in the popcorn and yellow local and this is in agreement with the report of Thacker, 2002 that saponin, flavonoids and tannin which are bioactive agents deterred feeding of insects.

Table 5 presents results on vitamin content in the maize varieties.Undamaged yellow maize recorded significant ($P \leq 0.05$) higher content of beta – carotene (vitamin A) 8.47 mg/5mg of maize sample and vitamin C (6.67mg/5mg) compared with popcorn (yellow colour). However, there was no significant difference ($P \geq 0.05$) in the vitamin C content in yellow local and popcorn. The vitamin A content in undamaged popcorn recorded was 5.85 mg/5mg maize sample. The vitamin A and C content in the local white variety were negligible and were not detectable.The vitamin A and C content in damaged yellow and popcorn variety was reduced as a result of feeding by *S. zeamais* for twelve (12) months in storage. The result for damaged yellow indicated 5.06 mg of vitamin C while 2.36mg of vitamin A and 3.66mg vitamin C were recorded for popcorn. The results indicated a reduction in vitamin content of the maize varieties. . Similarly, results obtained from determination of vitamins showed significant ($P\leq 0.05$), reduction of vitamin C and Beta - Carotene (Vitamin A) in the damaged popcorn and yellow local varieties. Thus the nutritional value of the popcorn and local white and yellow maize was drastically reduced and will affect the nutritional requirements for children and adults feeding on these low quality maize stored for 12 months and sold to the public after winnowing.

Table 1 Effect of storage period on percent damage and seed weight loss.

Period of damage (Months/ Infestation						
Varieties	**Weight loss**		**% damage**		**Number of weevils (n)**	
	3	12	3	12	3	12
Yellow popcorn var.	9.93^{b}	28.4^{c}	10.7^{b}	59.3^{b}	37.3^{b}	84.3^{b}
White local var.	21.3^{b}	97.6^{a}	17.3^{b}	99.3^{a}	58.3^{b}	100.0^{b}
Yellow local var.	44.7^{a}	63.3^{b}	78.00^{a}	90.0^{a}	339^{a}	588.6^{a}
L S D(0.05)	16.8	4.19	9.97	9.37	94.9	77.7

Means in column bearing the same superscript(s) do not differ significantly ($p \geq 0.05$) using DMRT test.

Table 2 Comparison of proximate composition of nutrients in damage and undamaged maize varieties store for 12 months.

Variety	**MC (%)**	**Ash(%)**	**CF (%)**	**CP (%)**	**CHO(%)**	Fat(%)
Undamaged white local maize	9.41^{C}	1.70^{b}	2.21^{C}	9.65^{c}	72.8^{a}	4.39^{C}
Undamaged yellow local maize	10.2^{b}	2.18^{a}	2.95^{a}	11.7^{b}	68.4^{b}	4.60^{b}
Undamaged yellow popcorn	10.7^{a}	1.78^{b}	2.57^{b}	13.2^{a}	66.11^{c}	5.73^{a}
L S D	0.41	0.15	0.14	0.14	0.39	0.21
Damaged white local maize	9.64^{c}	2.05^{b}	2.41^{c}	8.86^{c}	72.8	4.22^{c}
Damaged yellow local maize	10.5^{b}	2.45^{a}	3.08^{a}	11.00^{b}	68.5	4.49^{b}
Damaged yellow pop corn	10.7^{a}	1.83^{c}	2.63^{b}	12.91^{a}	66.3	5.63^{a}
L S D	0.27	0.09	0.09	0.59	0.82	0.13

Means in column bearing the same superscript(s) do not differ significantly ($p \geq 0.05$) using DMRT test.

Table 3 Comparison of mineral elements in damage and undamaged varieties stored for 12 months.

Variety	**Na (Mg/100g)**	**Ca (Mg/100g)**	**Mg (Mg/100g)**	**Fe (Mg/100g)**	**P (Mg/100g)**	Zn (Mg/100g)
Undamaged white local	64.3^{b}	58.05^{b}	108.5^{c}	5.65^{b}	300.3^{c}	10.3^{a}
Yellow local	66.2^{a}	63.16^{a}	117.5^{b}	6.25^{a}	310.1^{b}	7.34^{b}
Yellow pop corn	12.75^{c}	10.69^{c}	147.5^{a}	5.05^{a}	330.1^{a}	3.13^{c}
L S D	0.50	0.06	3.51	0.32	0.59	1.32
Damaged white local	57.5^{a}	45.0^{b}	90.0^{c}	3.25^{b}	277.5^{a}	10.039
Yellow local	58.0^{a}	54.4^{a}	102.0^{b}	3.84^{c}	292.4^{a}	5.41^{b}
Pop corn	7.07^{c}	6.95^{c}	133.9^{a}	2.83^{c}	314.9^{a}	2.64^{c}
L S D (0.05)	1.43	0.43	0.25	0.62	53.1	0.21

Means in column bearing the same superscript(s) do not differ significantly ($p \geq 0.05$) using DMRT test.

Table 4 Comparison of Phytochemicals in damage and undamaged maize varieties stored for 12 months.

Variety	**Saponin.(Mg/5g)**	**Flavonoid(Mg/5g)**	**Tannin(Mg/5g)**	**Alkaloid(Mg/5g)**	Phenol(Mg/5g)
Undamaged white maize	0.003^{b}	0.043^{a}	0.021^{b}	0.01^{c}	0.040^{b}
yellowmaize	0.004^{a}	0.01^{b}	0.029^{b}	0.020^{b}	0.060^{b}
yellow pop corn	0.002^{c}	0.06^{a}	0.059^{a}	0.030^{a}	0.11^{a}
L S D	0.0002	0.032	0.02	0.004	0.03
Damaged white maize	0.002b	0.00c	0.013^{b}	0.007^{c}	0.020^{c}
yellowmaize	0.0029^{a}	0.027^{b}	0.021^{b}	0.014^{b}	0.040^{b}
yellow pop corn	0.002^{a}	0.047^{a}	0.051^{a}	0.024^{a}	0.060^{a}
L S D	0.002	0.015	0.017	0.004	0.001

Means in column bearing the same superscript(s) do not differ significantly ($P \geq 0.05$) using DMRT test.

Table 5 Comparison of vitamins in damage and undamaged maize varieties stored for 12 months.

Variety	Vit. C (mg)	Vit. A (mg)
Undamaged White local	0.000[c] (ND)	0.00[c] (ND)
Yellow local maize	6.670[a]	8.465[a]
Popcorn	6.035[a]	5.845[b]
L S D	1.106	0.409
Damaged White local	0.000[c] (ND)	0.000[c] (ND)
Yellow local	4.920[a]	5.060[a]
Popcorn	3.655[a]	2.355
L S D	1.470	0.224

Means in column bearing the same superscript(s) do not differ significantly ($P \geq 0.05$) using DMRT test.

III. Conclussion.

The damage of 3 months stored maize was minimal and the nutritional qualities of the maize varieties were reduced at 12 months storage. The popcorn recorded lower seed weight loss than the white variety and yellow local at 12 months of storage thus, storing the seeds of popcorn for minimum of 3 months was best to retain the seed quality and nutritional quality at local conditions. The level of phytochemicals and mineral elements in the yellow popcorn contributed to the resistance to *S. zeamais* which resulted to reduced weight loss.The study recommends only 3 months storage of local maize and popcorn.The weight loss of 10-45% at 3 months and 2.84%-97.6% at 12months wrere recorded for the three varieties ranking low for popcorn and increased for yellow and white maize.

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