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SUSCEPTIBILITY OF STORED QUALITY PROTEIN MAIZE VARIETIES TO *SITOPHILUS ZEAMAIS* MOTSCH. (COLEOPTERA: CURCULIONIDAE): ASSESSMENT OF HARDNESS AND PROTEIN CONTENTS

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ABSTRACT

Effects of *Sitophilus zeamais* (Motsch.) infestation on protein contents was evaluated on ten maize varieties, comprising nine Quality Protein Maize (QPM) varieties and one non-QPM which served as a check. One hundred grammes of each maize variety were infested with ten pairs of newly emerged *S. zeamais* in separate Kilner jars. The protein contents of the maize varieties were measured before and after *S. zeamais* infestation to determine the amount of losses incurred as a result of feeding by *S. zeamais.* The result showed that at 45 days after infestation with *S. zeamais*, FLINT-Q was the most susceptible variety with the highest mean number of F_1 progeny (24.63) while SAMMAZ 17 (12.63) had the least amongst the QPM varieties. At 90 days after *S. zeamais* infestation, DENT-Q (51.63) had the highest mean number of F_2 progeny whereas SAMMAZ 17 (19.25) had the least. Maximum losses in albumin/globulin proteins were observed in DENT-Q (59.68 %) which decreased from an initial value of 0.62 % to 0.25 %. The maximum reduction in the amount of zein protein was observed in DENT-Q (55.36 %) which decreased from an initial value of 0.56 % to 0.25 %. The greatest reduction in glutelin protein was in the variety SAMMAZ 19 (59.26 %) which decreased drastically from 0.81 % to 0.33 % after 12 weeks of storage. Minimum reductions in zein (22.22 %) and glutelin (43.85 %) proteins amongst the QPM varieties were observed in SAMMAZ 17. The results of test of grain hardness showed that SAMMAZ 17 appeared to be relatively harder than all the other QPM varieties. It can therefore be concluded that SAMMAZ 17 with relatively hard kernel is the most tolerant variety to *S. zeamais* infestation which can be stored for 90 days with minimum insect infestation and reduction in protein contents.

Keywords: *Sitophilus zeamais*, Protein Contents, Stored Quality Protein Maize Varieties

INTRODUCTION

Maize (*Zea mays* L.) also known as corn belongs to the family Poaceae. Maize is one of the major staple food crops in West and Central Africa. These sub-regions have the greatest potential such as adequate moisture, abundant sunshine and relatively fertile soils for maize production (Badu-Apraku *et al.,* 2006). The expansion of farm area devoted to maize resulted in increased production from 2.4 million metric tonnes in 1961 to 10.6 million metric tonnes in 2005 (FAO, 2006). It was estimated that over 40 milllion metric tonnes of maize are produced in sub-saharan Africa annually (FAO Statistics, 2010). Maize has been of great importance in providing food for man, feed for livestock and raw materials for some agro-based industries. The nutritional quality of maize is determined by the amino acid makeup of its protein. Normal (non-QPM) maize cultivars commonly grown and consumed are deficient in two essential amino acids, Lysine and Tryptophan. As a result, malnutrition due to inadequate protein intake is therefore widespread (Bjarnason and Vasal, 1992). Quality Protein Maize (QPM) confers the presence of high lysine and

tryptophan, thus the use of QPM varieties helps to reduce nutritional related diseases and death among young children, pregnant and lactating mothers, the sickly and many low income families especially in developing countries including Nigeria (Bressani, 1992).Many varieties of the same grain species appear to be less suitable than others for insect development, and are often described as being "resistant" (less susceptible) to insect attack. Varietal resistance to storage insects is a potential means of reducing post-harvest losses of maize crop. Post-harvest losses due to storage insect pests such as the maize weevil, *Sitophilus zeamais* have been recognized as an increasingly important problem in Africa. Infestation by this weevil commences in the field (Demissie *et al.,* 2008), but most damage is done during storage. Damaged grains have reduced nutritional values, reduced weight and market values. Heavy infestation caused by the maize weevil (*S. zeamais*) can cause weight losses of as much as 30-40 % (Casey, 1994) thereby contributing to food insecurity and low farm incomes in African countries. Kelvin (2002) reported a relationship between seed hardness and thickness, both in the pericarp and the whole kernel by noting that maize with thick and hard pericarp was very hard to penetrate by the weevils. Bergvinson (2004) also revealed that maize with thicker husks or a harder kernel was insect resistant. For *Sitophilus oryzae,* grain hardness has been reported also as the main resistance parameter (Bamaiyi *et al.,* 2007). Dobie (1976) observed increased maize susceptibility to infestation after removal of the pericarp. Chemical analysis of insect infested cereal grains has revealed substantial losses of nutrients like carbohydrates, vitamins and minerals, increase total protein, non-protein nitrogen and uric acid, but the true protein content of the infested grains decreased (Jood *et al.*, 1992). Maize is rich in carbohydrate but has little amount of proteins. The damage by storage pests will inevitably tend to reduce the protein content of the grains. A good knowledge of varietal resistance to maize weevils would therefore help to maintain an acceptably low insect population in stored maize grains, minimize the level of insect pest damage and extend the period that maize can be stored safely even without the use of insecticides. This work therefore determined the effects of *S. zeamais* infestation on the different protein constituents of the QPM varieties.

MATERIALS AND METHODS

Culture of *Sitophilus zeamais* Motsch.

Unsexed *S. zeamais* adults were collected from already infested maize grains from the Storage Entomology Laboratory of Crop Protection Department, Ahmadu Bello University Zaria, Nigeria. The research was carried out during the wet season (June-August, 2013). Two hundred and fifty grammes of maize grains were infested with 50 unsexed adult *S. zeamais* in a Kilner jar. The Kilner jar was covered with muslin cloth to allow ventilation and to prevent escape of the weevils. The jar was kept on the table in the laboratory at room temperature (21-25 ^{0}C) and relative humidity (60 %). Two weeks after oviposition (egg laying), the adult weevils were sieved out and discarded. After 45 days, newly emerged F_1 generations of *S. zeamais* were used to infest the maize grains in the experiment.

Preparation of Maize Varieties

Ten (10) maize varieties, comprising nine Quality Protein Maize (QPM) varieties (SAMMAZ 14, SAMMAZ 17, SAMMAZ 19, SAMMAZ 32, SAMMAZ 33, SAMMAZ 36, SAMMAZ 37, FLINT-Q and DENT-Q) and one non-QPM variety (SAMMAZ 20) which served as check were obtained from the Institute for Agricultural Research (I.A.R), Ahmadu Bello University, Zaria. Each maize variety was fumigated using one tablet of aluminium phosphide (phostoxin) in an air tight drum for 96 hours (4 days) to disinfest any previous infestation by insect pests and thereafter spread on laboratory table for 48 hours to ensure the dissipation of fumigant effect.

Infestation and Weevil Emergence in Maize Varieties

One hundred grammes of each maize variety was weighed using Mettler balance and placed in a Kilner jar. Ten pairs of newly emerged *S. zeamais* were introduced into each of the Kilner jars using an aspirator. The Kilner jars were covered with muslin cloth to provide ventilation and prevent the weevils from escaping. This was

repeated four times for each variety of maize. All Kilner jars were labeled and arranged in a Completely Randomized Design (CRD) and allowed to stand for 12 weeks in the laboratory.

Two weeks after oviposition, the adult weevils in all Kilner jars were sieved out in order to eliminate mixing with F_1 generation and the maize samples were returned to their respective kilner jars. All Kilner jars were examined 35 days after infestation so as to determine the F_1 progeny emergence, which were sieved out, counted and discarded. Sieving and counting the F_1 progeny continued up to the 45^{th} day when most F_1 progenies would have emerged. The numbers of F_2 progenies in all Kilner jars were counted 35 to 45 days after F_1 emergence.

Determination of Damage and Weight Loss in Maize Varieties

At the end of 12 weeks, percentage damage was determined for each maize variety. Emergent holes on the grains were used as an indicator of damage. One hundred grains were obtained at random and sorted into holed (damaged) and whole (undamaged) and the following formula was used for calculating the percentage damage (Golob and Webley, 1980):

$$\%\,\text{Damage} = \frac{\text{Number of damaged grains}}{\text{Total number of sampled grains}} \times 100$$

The percentage weight loss of each maize variety was determined using the count and weight method of Gwinner *et al*. (1996). The 100 grains used for the damage assessment were again used. The damaged and undamaged grains separated out were weighed and recorded appropriately. The results obtained were used to compute the percentage weight loss using the formula:

$$\%\,\text{Weight loss} = \frac{(Wu \times Nd) - (Wd \times Nu)}{Wu \times (Nd + Nu)} \times 100$$

Where: Wu= Weight of undamaged grains
Nu= Number of undamaged grains
Wd= Weight of damaged grains
Nd= Number of damaged grains

Determination of Kernel Hardness and Protein Contents

Kernel hardness test was determined based on the method in Dobie (1974). Ten grammes of each maize variety was weighed and ground in a manually operated Maskiner mill. The flour obtained was sieved using a 30 µ aperture sieve for 15 seconds in each case. The fractions of the maize passing through and retained by the sieve were weighed and recorded as 'filtrate' and 'residue' respectively (Dobie, 1974). This was repeated four times for each variety of maize. To determine grain hardness, maize varieties that produced more filtrate and fewer residues were considered soft. Those that produced less filtrate and more residues and were considered hard. Those with equal filtrate and residues were considered moderately hard.

Protein contents of the maize varieties were determined before the maize weevils were introduced. The same process was repeated after the termination of the experiment. This was done to determine the amount of protein loss due to feeding by *S. zeamais* and the following formula was used:

$$\%\,\text{Protein loss} = \frac{\text{Protein content before infestation} - \text{Protein content after infestation}}{\text{Protein content before infestation}} \times 100$$

For all the maize varieties, albumin, globulin, prolamin (zein) and glutelin contents were determined.

Protein Extraction and Determination

A random sample of whole maize grains before infestation and damaged grains without larva after infestation were taken as representative of each maize variety. Each sample was ground at 0.5 mm setting of a cyclone mill. The samples were placed in an envelope made with filter paper, defatted with hexane in a Soxhlet-type continuous extractor for six hours and air dried (CIMMYT, 2004). Maize grain proteins were sequentially extracted and fractionated into three fractions (Landry and Moureaux, 1970). Extraction buffers for the three fractions were 0.5M NaCl solution for albumin and globulin, 70 % ethanol and 2 % 2-Mercapto Ethanol (ME) for zein and 1 % Sodium Dodecyl Sulphate (SDS) and 2 % 2-ME for glutelin. Albumin and globulin proteins (fraction I) were first extracted by weighing 500 mg of maize flour into test tubes (1:5; flour-solvent). 2.5 ml 0.5M NaCl solution was added and the tubes placed into oscillatory water bath to shake the samples for 1 hour at 4 ^{0}C. Zein protein (fraction

II) was obtained by adding 2.5 ml mixture of 70 % ethanol and 2 % 2-Mercapto Ethanol to residues that were obtained from fraction I. Glutelin protein (fraction III) was obtained by adding 2.5 ml mixture of 1 % Sodium Dodecyl Sulphate (SDS) and 2 % 2-Mercapto Ethanol solution to residues that were obtained from fraction II. These were put into oscillatory water bath to shake the samples for 1 hour at 22 ^{0}C (fractions II and III). Mixtures of the samples and extraction buffers were centrifuged at 10,000 x g for 10 minutes at 25 ^{0}C for each fraction. Supernatants (extracts) of each fraction were decanted using micropipette into empty tubes. The pellets (residues) were treated again with the same volume of the different extraction buffers and the extraction was repeated for a second time for each fraction. All the supernatants of the same fraction from the same sample were pooled together and their concentration was measured. The protein concentration of fractions I, II and III were determined for each maize variety as described by Bradford (1976). One hundred micro litre (100 µl) of the samples were pipetted into test tubes and 1 ml of Bradford assay reagent was added. The contents of the test tubes were mixed either by inversion and were incubated for five minutes at room temperature. The absorbance of the samples at 595 nm was measured using a spectrophotometer (Jenway 6405 UV/Vis) in 1 ml cuvette which was adjusted with a reagent blank prepared from 100 µl of distilled water and 1 ml of Bradford assay reagent. The protein concentrations of the samples were obtained from a standard curve equation using Bovine Serum Albumin (BSA) as the standard.

Statistical Analysis

Data obtained for progeny emergence, percentage damage, percentage weight loss, kernel hardness, albumin/globulin, prolamin (zein) and glutelin contents of the maize grains were subjected to Analysis of variance (ANOVA) to determine the differences due to the treatments and not due to chance. Where there were significant differences, SNK was used to compare the means (SAS, 2003).

RESULTS

The highest mean number of *S. zeamais* F_1 progeny (24.63) at 45 days after infestation and F_2 progeny (51.63) at 90 days after infestation were observed in FLINT-Q and DENT-Q respectively while the least mean number of F_1 (10.63) and F_2 (15.25) progeny were observed in SAMMAZ 20 (check). The mean number of F_1 emerged progeny of FLINT-Q (24.63) was significantly different from that of SAMMAZ 20 (10.63). There was no significant difference in emerged F_1 progeny observed amongst FLINT-Q, DENT-Q, SAMMAZ 33 and SAMMAZ 32 but these were significantly different ($p<0.05$) from SAMMAZ 17 and SAMMAZ 20. The mean number of F_2 emerged progeny of *S. zeamais* in DENT-Q and FLINT-Q was significantly different from the other varieties except SAMMAZ 33. Mean F_2 progeny from the check, SAMMAZ 20 was significantly different from SAMMAZ 36, SAMMAZ 37, SAMMAZ 33, SAMMAZ 32, DENT-Q and FLINT-Q but was not significantly different from SAMMAZ 17, SAMMAZ 14 and SAMMAZ 19 (Table 1). The mean percentage damage of the maize varieties ranged from 6.00 in to 36.50 (Table 2). The highest mean number of damaged grains with emergent holes was observed in FLINT-Q (36.50) followed by DENT-Q (34.88) whereas the least mean number of damaged grains with emergent holes was observed in SAMMAZ 20 (6.00), followed by SAMMAZ 17 (8.38). The mean percentage weight loss of the maize varieties ranged from 0.40 to 7.78 (Table 2). The highest weight loss among the varieties therefore was observed in FLINT-Q (7.78), followed by DENT-Q (7.59) while the least weight loss was observed in SAMMAZ 20 (0.40), followed by SAMMAZ 17 (0.86). The results of grain hardness tests showed that the residue of SAMMAZ 17 (5.05 g) was significantly higher ($p<0.05$) than all the QPM varieties. The residues of DENT-Q (3.20 g) and FLINT-Q (3.20 g) were not significantly different from each other but these were significantly different from the other QPM varieties. The QPM varieties residues compared with the check, SAMMAZ 20 (5.23 g) were found to be significantly lower ($p<0.05$) from the check except SAMMAZ 17 (5.05 g). SAMMAZ 20 and SAMMAZ 17 appeared to be harder than all

the other varieties (Table 3). The mean percentage protein of the three fractions obtained before infestation indicated that albumin and globulin (fraction I) proteins of DENT-Q, FLINT-Q and SAMMAZ 37 had no significant difference between them. DENT-Q (0.62) and FLINT-Q (0.62) had the highest percentage amount of albumin and globulin proteins whereas SAMMAZ 36 (0.45) had the least amongst the QPM varieties (Table 4). However, the check SAMMAZ 20 (0.26) which was significantly different ($p<0.05$) from all the QPM varieties had the least percentage of albumin and globulin proteins. The prolamin/zein (fraction II) protein of SAMMAZ 17, SAMMAZ 14 and SAMMAZ 19 had no significant difference amongst each other but SAMMAZ 17 (0.72 %) was observed to have the highest percentage amount of zein protein. On the other hand, FLINT-Q (0.50 %) which was not significantly different from SAMMAZ 36, SAMMAZ 32, SAMMAZ 33, SAMMAZ 37 and DENT-Q had the least. The check, SAMMAZ 20 (1.08 %) was found to have the highest percentage of zein protein when compared with the QPM varieties and was significantly different ($p<0.05$) from the QPM varieties. The highest and least percentage amount of glutelin (fraction III) protein amongst the QPM varieties was observed in SAMMAZ 19 (0.81) and SAMMAZ 17 (0.57) respectively. Both SAMMAZ 19 and SAMMAZ 17 were found to be significantly different from each other. The check, SAMMAZ 20 (0.53 %) when compared with the QPM varieties showed significant difference from them and had the least percentage amount of glutelin protein (Table 4). Maximum losses in albumin and globulin (fraction I) proteins as a result of infestation caused by *S. zeamais* were observed in DENT-Q (59.68 %). This variety decreased from an initial value of 0.62 % to 0.25 % but the minimum loss amongst the QPM varieties was found in SAMMAZ 19 (46.00 %) which reduced from an initial value of 0.50 % to 0.27 %. A maximum reduction in zein (fraction II) protein was found in DENT-Q (55.36 %) which decreased from an initial value of 0.56 % to 0.25 %. The minimum reduction in this fraction amongst the QPM varieties was found in SAMMAZ 17 (22.22 %) which reduced from an initial value of 0.72 % to 0.56 %. The highest loss in glutelin (fraction III) protein was in the variety SAMMAZ 19 (59.26 %) which decreased drastically from 0.81 % to 0.33 % within 12 weeks of storage. The decrease was comparatively less in SAMMAZ 17 (43.85 %) compared amongst the QPM varieties. This variety decreased from an initial value of 0.57 % to 0.32 %.

Table 1: Mean Progeny Emergence of *S. zeamais* in Maize Varieties

Maize Variety	Mean Progeny Emergence	
	F_1 (At 45 DAI)	F_2 (At 90 DAI)
FLINT-Q	24.63^{a}	50.25^{a}
DENT-Q	22.88^{a}	51.63^{a}
SAMMAZ 33	20.25^{ab}	45.13^{ab}
SAMMAZ 32	19.13^{ab}	34.88^{bc}
SAMMAZ 36	17.75^{bc}	33.75^{bcd}
SAMMAZ 37	17.25^{bc}	31.00^{bcd}
SAMMAZ 19	16.25^{bcd}	29.63^{cde}
SAMMAZ 14	15.13^{bcd}	28.88^{cde}
SAMMAZ 17	12.63^{cd}	19.25^{de}
SAMMAZ 20 (check)	10.63^{d}	15.25^{e}
S.E ±	2.10	5.35
CV (%)	33.67	44.57

Means followed by the same letter (s) in a column are not significantly different at $p<0.05$
DAI = Days after Infestation

Table 2: Percentage Damage and Weight Loss in Maize Varieties Infested with *S. zeamais*

Variety	Damage (%)	Weight loss (%)
FLINT-Q	36.50[a]	7.78[a]
DENT-Q	34.88[a]	7.59[a]
SAMMAZ 33	28.63[b]	5.03[b]
SAMMAZ 32	28.50[b]	5.00[b]
SAMMAZ 36	26.75[b]	4.38[b]
SAMMAZ 37	25.13[b]	4.24[b]
SAMMAZ 19	14.38[c]	3.49[b]
SAMMAZ 14	10.63[cd]	2.80[b]
SAMMAZ 17	8.38[cd]	0.86[c]
SAMMAZ 20 (check)	6.00[d]	0.40[c]
S.E ±	1.87	0.60

Means with the same letter (s) along a column are not significantly different at $p<0.05$

Table 3: Relative Kernel Hardness of Quality Protein Maize Varieties

	Kernel Hardness		
Variety	Filtrate (g)	Residue (g)	Category
FLINT-Q	5.75[a]	3.20[d]	Soft
DENT-Q	5.60[ab]	3.20[d]	Soft
SAMMAZ 33	5.45[b]	4.20[c]	Soft
SAMMAZ 32	5.50[b]	4.20[c]	Soft
SAMMAZ 36	5.40[bc]	4.33[c]	Soft
SAMMAZ 37	5.23[cd]	4.35[c]	Soft
SAMMAZ 19	5.20[cd]	4.40[bc]	Soft
SAMMAZ 14	5.08[d]	4.58[b]	Soft
SAMMAZ 17	4.68[e]	5.05[a]	Hard
SAMMAZ 20 (check)	4.25[f]	5.23[a]	Hard
S.E ±	0.07	0.08	
CV (%)	3.42	3.43	

Means followed by the same letter (s) in a column are not significantly different at $p<0.05$

Table 4: Protein Fractions of Maize Kernels before and after *S. zeamais* Infestation

	Protein fraction (%)								
	Albumin+ Globulin			Zein			Glutelin		
Variety	BI	AI	L (%)	BI	AI	L (%)	BI	AI	L (%)
FLINT-Q	0.62^{a}	0.27^{ab}	56.45^{ab}	0.50^{e}	0.23^{f}	54.00^{a}	0.79^{b}	0.37^{a}	53.16^{b}
DENT-Q	0.62^{a}	0.25^{ab}	59.68^{a}	0.56^{de}	0.25^{ef}	55.36^{a}	0.79^{b}	0.37^{a}	53.16^{b}
SAMMAZ 33	0.51^{cd}	0.24^{b}	52.94^{ab}	0.56^{de}	0.26^{ef}	53.57^{a}	0.76^{d}	0.35^{abc}	53.95^{b}
SAMMAZ 32	0.53^{bcd}	0.25^{ab}	52.83^{ab}	0.60^{cd}	0.27^{de}	55.00^{a}	0.76^{d}	0.35^{abc}	53.95^{b}
SAMMAZ 36	0.45^{e}	0.24^{b}	46.67^{b}	0.60^{cd}	0.28^{de}	53.33^{a}	0.77^{c}	0.36^{ab}	53.25^{b}
SAMMAZ 37	0.59^{a}	0.27^{ab}	54.24^{ab}	0.51^{de}	0.23^{f}	54.90^{a}	0.79^{b}	0.37^{a}	53.16^{b}
SAMMAZ 19	0.50^{d}	0.27^{ab}	46.00^{b}	0.67^{bc}	0.30^{cd}	55.22^{a}	0.81^{a}	0.33^{bc}	59.26^{a}
SAMMAZ 14	0.55^{b}	0.26^{ab}	52.73^{ab}	0.69^{bc}	0.32^{c}	53.62^{a}	0.74^{e}	0.33^{bc}	55.41^{ab}
SAMMAZ 17	0.54^{bc}	0.28^{a}	48.15^{b}	0.72^{b}	0.56^{b}	22.22^{b}	0.57^{f}	0.32^{c}	43.85^{c}
SAMMAZ 20	0.26^{f}	0.17^{c}	34.62^{c}	1.08^{a}	0.94^{a}	12.96^{b}	0.53^{g}	0.38^{a}	28.30^{d}
S.E ±	0.01	0.01	3.92	0.03	0.01	3.88	0.003	0.01	1.83
CV (%)	7.55	18.14	21.45	11.89	12.06	23.62	1.18	10.75	10.25

Means followed by the same letter (s) in a column are not significantly different at $p<0.05$
BI = Before Infestation AI = After Infestation
L (%) = Percentage Amount of each Protein Loss

DISCUSSION

Amongst the different QPM varieties, it was observed that SAMMAZ 17 had the least damage and number of adult insects; therefore it is relatively less susceptible to *S. zeamais* attack. FLINT-Q and DENT-Q varieties had the greatest percentage damage because more number of F_1 and F_2 progeny of *S. zeamais* was found in them. This agrees with the report of Abraham (1991) which indicated that the extent of damage during storage depends upon the number of emerging adult weevils during each generation and the duration of each life cycle and grains that had more adult maize weevil emergence were more seriously damaged. SAMMAZ 17 was the only QPM variety identified as having hard kernel probably making it less susceptible to attack by *S. zeamais* compared to the other varieties. The other QPM varieties were found to have soft kernels, thus making the grains more susceptible to storage insect pests. The result obtained agrees with Garcia-Lara *et al.* (2004) that reported *S. zeamais* resistance was controlled by kernel hardness. The result is also in agreement with the findings of Bamaiyi *et al.* (2007) that reported grain hardness has been the main *S. oryzae* resistance parameter. Similarly, Kelvin (2002) also reported a relationship between seed hardness and thickness, both in the pericarp and the whole kernel by noting that maize with thick and hard pericarp was very difficult to penetrate by the weevils. The result of protein fractionation studies showed that, the QPM varieties before infestation had more albumin/globulin (fraction I) and glutelin (fraction III) proteins than the check (non-QPM) variety. This is because the QPM varieties are known to provide higher amount of two essential amino acids; tryptophan and lysine. Similarly, albumin, globulin and glutelin proteins which are collectively called non-zeins also provide higher amount of these two essential amino acids; tryptophan and lysine (FAO, 1992) but the check, (non-QPM) variety have very low concentration of these amino acids. This is in line with the work of

Gentinetta *et al*. (1975) and Ortega and Bates (1983), who demonstrated QPM genotypes were higher in fraction III protein. The prolamin/zein (fraction II) protein of the check (non-QPM) was more than that of the QPM varieties. This may be because the prolamin/zein protein is very low in the two essential amino acids, tryptophan and lysine. Similarly, the normal (non-QPM) maize cultivars commonly grown and consumed are also very low in the essential amino acids, tryptophan and lysine whereas Quality Protein Maize (QPM) confers the presence of high lysine and tryptophan. Amongst the Quality Protein Maize (QPM) varieties evaluated in this work, only SAMMAZ 17 had relatively hard kernel (corneous endosperm) possibly making it less susceptible to *Sitophilus zeamais* attack. SAMMAZ 17 supported few *S. zeamais* and thus suffered less damage (8.38 %) and weight loss (0.86 %) as a result of feeding by *S. zeamais*. The other QPM varieties evaluated had softer floury endosperms suggesting that they were more susceptible to attack by *S. zeamais*. The minimum losses in zein (22.22 %) and glutelin (43.85 %) proteins were also found in SAMMAZ 17. It can therefore be concluded that SAMMAZ 17 variety with relatively hard kernel is the most tolerant variety to *Sitophilus zeamais* infestation which can be stored for 90 days with minimum insect infestation and reduction in protein contents. Based on the findings of this study, it is recommended that since QPM are more nutritious compared to the non-QPM varieties, breeders should develop more of the QPM varieties with hard kernels to obtain longer storage periods.

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