

## Feeding losses and biochemical changes caused by *Sitophilus oryzae* L. infestation in maize varieties

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### Abstract

Food grain during storage undergoes considerable loss due to infestation by stored grain weevils. The most common among them prevalent in Bihar is *Sitophilus oryzae*. It penetrates holes in the maize and feeds upon reducing it into dusting material not only that excreta and remains of dead and decaying insects causing fowling of the food. So the food undergoes both quantitative and qualitative changes. To ascertain the losses seven replicate experiments are run with a control and the samples are weighed before and after infestation. Similarly, the loss of individual amino acids has been ascertained by carrying out paper chromatography. Different rice varieties subjected to infestation underwent different degrees of losses while in Rattan the weight loss was most pronounced (21.26%), the shaktiman1 suffered the least (0.67), Ganga 10 underwent moderate losses (14.01%). As far as loss of amino acid is concerned pre infestation Shaktiman1 had 12 amino acid and after post-infestation loss 2 amino acid of which both are non essential. Ganga 10 had 11 amino acid before infestation but after infestation it losses four amino acid out of which three is essential. Before infestation Rattan had 14 amino acid but after infestation it losses six amino acid out of which three is essential.

**Keywords:** Rice varieties, *sitophilus oryzae* paper chromatography, quantitative and qualitative losses, essential amino acids

### Introduction

Maize (*Zea mays* L.) along with wheat and rice are most important staple diet. India occupies 7<sup>th</sup> rank in maize production and contributes 2% of total maize production in world wide. Maize is rich source of protein and dietary energy contributing 30% and 60% respectively of primary source of energy in developing country (Mlynekova and Ceresnakov, 2013). The hard outer layer of corn provide a protective armour against insect infestation in filled as well as in stored condition (Paliwal *et al.*, 2000) [14]. Poor management at post-harvest storage level and pest management cause grain loss (Demissie *et al.*, 2008) [5]. Various insect pests, infest and damage the grain at storage conditions leading to quantitative and qualitative loss of grains. *Sitophilus oryzae* (The rice weevil) becoming more threat to the serious at their storage level. Increase in temperature due to global warming providing favourable condition for the development of *S. oryzae* (Kosewska *et al.*, 2023) [8]. 30-40% of grains are lost at storage level (Kumar and Kalita, 2017) [9]. Infestation causes characteristic loss of grain by changing quantity and quality and accumulation of dead insects on cereals (Nietupski *et al.*, 2021) [13]. I have found no research has been carried out regarding loss of amino acid content caused by infestation of *S. oryzae* to maize, hence this study is focussed on to find out (i) Weight loss of maize caused by *S. oryzae* infestation (ii) Loss of amino acid species in different varieties of maize due to infestation.

### Methods

Grains of three high-yielding varieties of maize, viz, Shaktiman1, Ganga 10, and Rattan, were subjected to infestation by *S. oryzae* during the rainy season of 2023. Experiments were conducted in the laboratory condition at the University Department of Zoology B. R. A. Bihar University, Muzaffarpur.

### Assessment of loss of weight

To assess the weight loss, firstly, seven replicates of one hundred grains of each variety were taken into petri dishes. Four males and eight females of *S. oryzae* were released in each of the petri dishes except for the one that acted as the control. These petridishes were covered by muslin cloth to prevent the escape of insects and were left undisturbed for two weeks under laboratory conditions at  $27\pm 3$  °C and about 70% relative humidity. The insects were removed dead insects were accounted for. The samples were then left under the same conditions for another two weeks for the emergence of the F<sub>1</sub> generation. Thereafter emergence of insects was checked every alternate day till no new emergence was recorded for three consecutive days in a row, while doing so extra precautions was taken to ensure that no grain particle was lost. Upon complete stopping of emergence, infected grains were isolated, identified by chalky spots and linear streaks. These grains were counted and then dissected upon to remove insect parts or developing stages. Again, taking extra care to ensure non-removal of the grain particles. These grains were then weighed to ascertain the weight after infestation. At the same time, the weight of the control was also taken to ascertain weight loss. If any, without insect infestation. The weight loss suffered by the control was deducted from the weight loss suffered by the experimental sample, which represented the weight loss due to insect infestation. Actual weight loss  $W = X - (CF) - Y$

Where X is the initial weight of the uninfested sample, Y is the final weight of the infested sample, and CF is the weight loss in the control, assumed to be due to moisture loss.

Percentage weight loss =  $W/X \times 100$

### Assessment of loss of amino acids

To ascertain the loss of amino acid, both uninfested and infested samples were subjected to two-dimensional chromatography. Amino acids are characterized by calculating and comparing R<sub>f</sub> values.



Fig 1: Sitophilus oryzae emerging from maize grain

**Result**

**Assessment of loss of weight**

Regarding the feeding losses suffered by maize grains of different varieties, it was found that Shaktiman 1 variety suffered the least weight loss at 0.68 per cent, whereas Rattan suffered the most at 21.25% (Table 1). The other rice variety studied was Ganga-10, which suffered a percentage weight loss of 14% and thus was in an intermediate position as far as weight loss due to *Sitophilus oryzae* infestation was concerned. Adams (1976) [1] studied weight loss caused by the development of *Sitophilus zeamais* but none of these three varieties figured in his study.

Table 1: Showing percentage weight loss in the maize variety caused by infestation of *S. oryzae*

Variety	Mean initial weight of control (gm)	Mean final weight of control (gm)	Mean difference in weight of control (gm)	Mean weight of uninfested sample(gm)	Mean weight of infested sample(gm)	Mean actual weight loss	Mean percentage weight loss
Shaktiman1	35.847	35.752	0.094	35.894	35.559	0.241	0.670
Ganga 10	37.405	37.316	0.089	37.214	31.913	5.212	14.006
Rattan	36.316	36.058	0.258	36.082	28.155	7.669	21.257

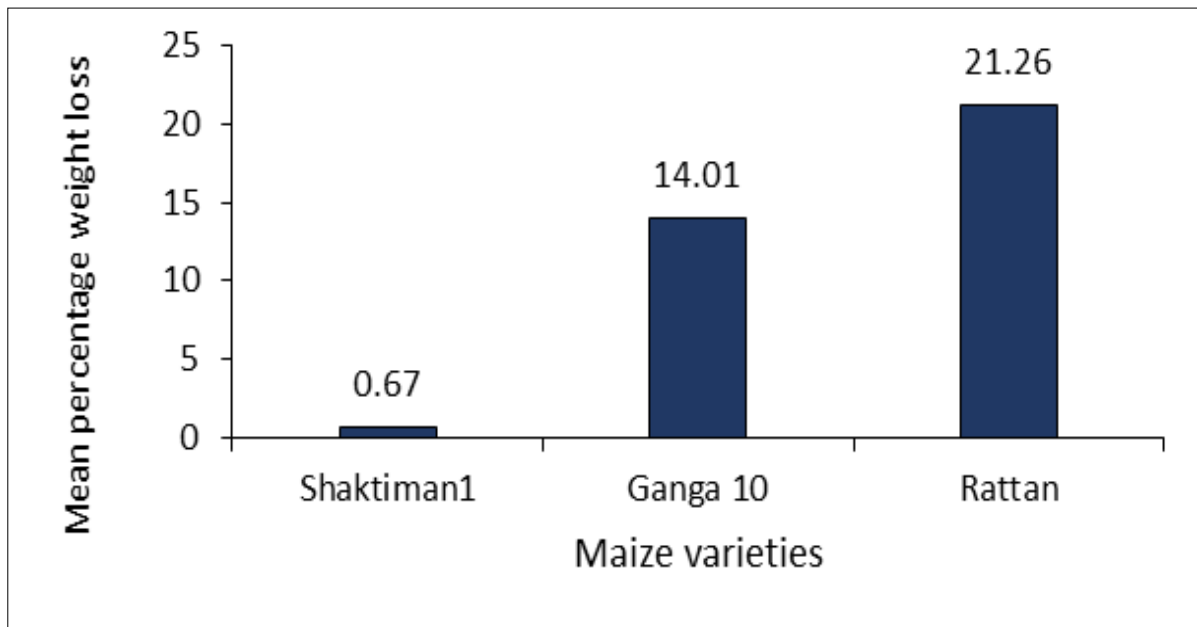


Fig 2: Weight loss per cent caused by the infestation of *S. oryzae* in different varieties of maize

**Assessment of loss of amino acids**

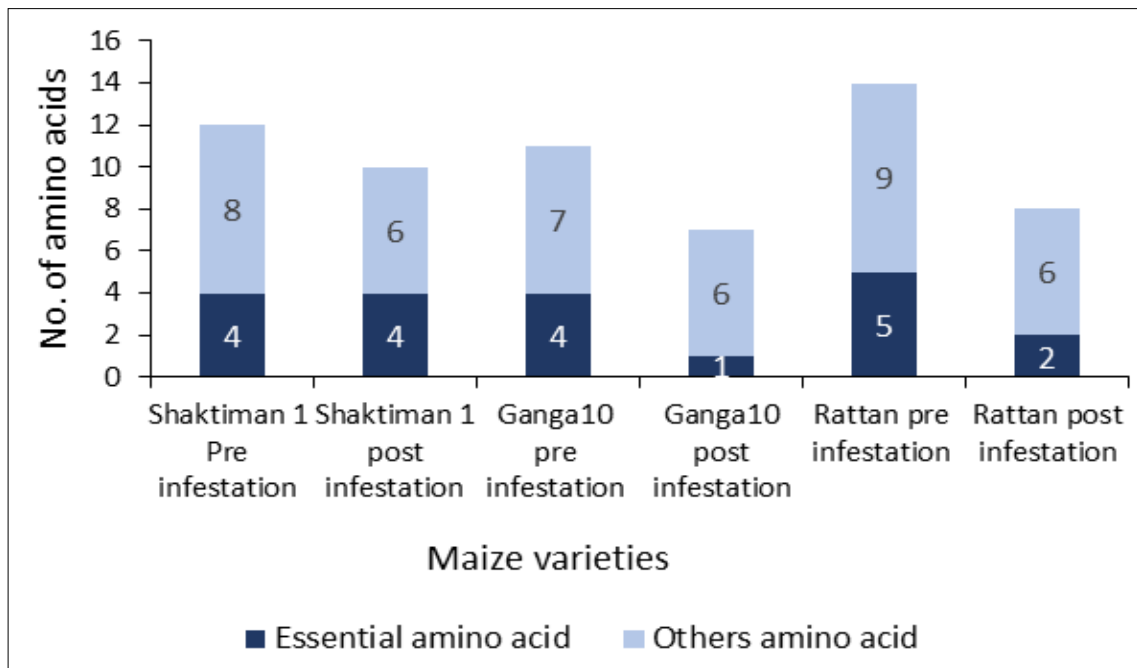
Analysis of table 2 shows that out of three varieties of maize, viz. Shaktiman 1, Ganga-10 and Rattan on which experiments were carried out, the highest number of amino acid species, fourteen were present in the Rattan variety. These included Alanine, Arginine, Aspartic Acid, Glycine, Glutamic Acid, Isoleucine, Leucine, Lysine, Phenylalanine, Proline, Serine, Threonine, Tryptophan and Tyrosine. Post-infestation analysis of the Rattan variety of maize revealed that six amino acids were lost in course of infestation. These were Aspartic acid, Isoleucine, Lysine, Phenylalanine, Threonine and Tyrosine. Out of these, four were essential amino acids. The analysis of Shaktiman 1 variety of maize revealed twelve identifiable spots corresponding to Alanine, Arginine, Aspartic Acid, Glutamic Acid, Glycine, Leucine, Lysine, Phenylalanine, Proline, Serine, Tryptophan and Tyrosine. Two amino acids Alanine and Proline were lost upon infestation by *Sitophilus oryzae*. Amino acid analysis

of another variety Ganga exhibits that it contains twelve amino acids in all. These are Alanine, Arginine, Aspartic Acid, Glutamic Acid, Glycine, Lysine, Phenylalanine, Proline, Serine, Tryptophan, Threonine and Tyrosine. In the post-infestation analysis it was found that four amino acids Aspartic Acid, Phenylalanine, Serine and Tryptophan, were missing. Among the essential amino acids, it was Phenylalanine which had been lost from all varieties of rice and maize except for the Shaktiman 1 variety of maize. Among the non-essential amino acids it was the Aspartic Acid which was missing from post-infested grains of most of the varieties, followed by Serine. The infestation of *Sitophilus oryzae*, thus, also caused the biochemical transformation of food grains, causing the loss of many amino acids including many essential ones. Furthermore, many amino acid species were lost from the grain upon infestation by *Sitophilus oryzae*, thereby making those grains less nutritious.

**Table 2:** Comparison between the amino acid composition of fresh and infested grains of the maize variety upon infestation by *S. oryzae*

SI.No	Amino acids	Rattan			Ganga 10			Shaktiman1			
		AA in fresh grains	AA in infested grains	Total no. of lost amino acids	AA in fresh grains	AA in infested grains	Total no. of lost amino acids	AA in fresh grains	AA in infested grains	Total no. of lost amino acids	
1	Alanine	+	+	6 amino acids (Aspaertic acid Isolucine Lysine Phenylalanine Threonine & Tyrosine)	+	+	4 Amino acids (Aspartic acid Phynylalanine Serine & Tryptophan)	+	-	2 Amino acids (Alanine & Hydroxy proline)	
2	Arginine	+	+		+	+		+	+		+
3	Aspaertic acid	+	-		+	-		+	+		+
4	Glutamic acid	+	+		+	+		+	+		+
5	Glycine	+	+		+	+		+	+		+
6	Isolucine*	+	-		-	-		-	-		-
7	Leucine*	+	+		-	-		-	+		+
8	Lysine*	+	-		+	+		+	+		+
9	Phenylalanine*	+	-		+	-		-	+		+
10	Proline	+	+		+	+		+	+		-
11	Serine	+	+		+	-		-	+		+
12	Threonine	+	-		+	+		+	-		-
13	Tryptophan*	+	+		+	-		-	+		+
14	Tyrosine	+	-		+	+		+	+		+

Here \*Essential amino acid and AA - Amino acid



**Fig 3:** Comparison between the number of amino acids in fresh and *S. oryzae*-infested maize varieties.

**Discussion**

Though the maize varieties studied in this work has not been subjected to the similar studies elsewhere, as per the literature available, some works have been done on other varieties of food grains and infestation by other pests but those workers have also drawn similar conclusions. The infestation of *S. oryzae* during maize storage is of common incidence. It has been widely studied by different workers and it appears that many factors including storage condition storage condition, physical and chemical features of grain and the microbiome composition exert impact on the rate of infestation and grain damage.

The amino acids of the susceptible varieties were more in number than resistant ones. The weevil *Sitophilus oryzae* appeared selective in feeding behaviour towards certain amino acids over others which may be due to the preference of larval stages residing in the grains. Kalode and Pant (1967) [7] have also supported this view. Auclair (1953) [3] has also claimed that aphid growth development and

reproduction will proceed at a much lower rate on varieties which are poor in amino acids than on varieties rich in amino acids. Peas varieties susceptible to the pea aphid generally contained a higher concentration of total amino acid than the resistant ones. David and Paul (1973) observed the preference of castor varieties for whitefly infestation and found that total free amino acid contents in the resistant types were lower than the susceptible ones.

According to Kosewska *et al.*, (2024) [8] have found that foraging increase in case of cultivars with low protein conten and high asteric acid cotent. Boniecki *et al.* (2020) [4] found that the development dynamics of *Sitophilus oryzae* L. depend mainly on temperature, seed moisture, and type of food. The chemical composition of individual cereal species may act as an attractant or deterrent to storage pests (Mebarkia *et al.*, 2010 [11]; Nawrot *et al.*, 2006) [12]. One of the most common features affecting the infestation of the grain is hardness (Ahmed *et al.*, 2020). The hardness though genetically determined may also depend upon cultural

factors such as the moisture content during the storage and infestation by another microbial agent (Dziamba *et al.* 2001)<sup>[6]</sup><sup>[9]</sup>, since hardness also depends upon the protein content, the protein richness may lead to higher infestation. Carbohydrates are also important factors in attracting the weevils towards the grain. Water-soluble carbohydrates potentially affect the attractiveness of grains as food for storage pests (Li *et al.*, 2021)<sup>[10]</sup>. According to Majd-Marani *et al.* (2023), the content of phenols and lipids in the food eaten by insects may also significantly impact development. Feeding activity of *S. oryzae* tends to increase in plant cultivars with low levels of antioxidant activity. Fewer insects emerge in cultivars having a higher antioxidant activity (Majd-Marani *et al.* 2023). So it appears that a general physical and biochemical trait profoundly affects the attractiveness of food and the ability of insects to thrive upon it.

**Conflict of Interest:** The authors declare that there is no conflict of interest regarding the publication of this article.

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### References

1. Adam S, Schulten GGM. Loss caused by insects and microorganisms. *Journal of Stored Products Research*,1978;15:1057.
2. Ali AG, Ali MHM, Saad OS, Mahmoud ZN, Nasr DH, Elamin SM, *et al.* Recent Research Advances in Biology, 2020, 2
3. Auclair JL, Maltais JB, Cartier JJ. Factors in resistance to pea aphid - *Acyrtosiphon pisum*. *Canadian Entomologist*,1957;89(10):457-469.
4. Boniecki P, Koszela K, Świerczyński K, Skwarcz J, Zaborowicz M, Przybył J. Neural visual detection of grain weevil (*Sitophilus granarius* L.). *Agriculture*,2020;10(1):25.
5. Demissie G, Tefera T, Abraham T. Efficacy of silicosec, filter cake and wood ash against the maize weevil, *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae) on three maize genotypes. *Journal of Stored Products Research*,2008;44:227-231.
6. Dziamba J, Dżiki D, Laskowski J. The influence of nitrogen fertilisation on selected properties of wheat grain. *Engineering for Rural Development*,2001;10:121-127.
7. Kalode MD, Pant WC. Studies on the amino acid, nitrogen, sugar and moisture content of maize and sorghum varieties and their relation to *Chilo zonellus* (Swin) resistance. *Indian Journal of Entomology*,1967;29(2):139-144.
8. Kosewska O, Przemieniecki SW, Nietupski M. The effect of antibiotics on bacteriome of *Sitophilus oryzae* and *Rhyzopertha dominica* as a factor determining the success of foraging: A chance for antibiotic therapy in grain stores. *Applied Sciences*,2023;13(3):1576.
9. Kumar D, Kalita P. Reducing postharvest losses during storage of grain crops to strengthen food security in developing countries. *Foods*,2017;6(1):1-22.
10. Li M, Geng L, Xie S, Wu D, Ye L, Zhang G. Genome wide association study on total starch, amylose and amylopectin in barley grain reveals novel putative alleles. *International Journal of Molecular Sciences*,2021;22(2):553.
11. Mebarkia A, Rahbé Y, Guechi A, Bouras A, Makhlof M. Susceptibility of twelve soft wheat varieties (*Triticum aestivum*) to *Sitophilus granarius* (L.) (Coleoptera: Curculionidae). *Agriculture and Biology Journal of North America*,2010;1(4):571-578.
12. Nawrot J, Warchalewski JR, Piasecka-Kwiatkowska D, Niewiada A, Gawlak M, Grundas ST, *et al.* The effect of some biochemical and technological properties of wheat grain on granary weevil (*Sitophilus granarius* L.) (Coleoptera: Curculionidae) development. In: *Proceedings of the 9th International Working Conference on Stored Product Protection*,2006:400-407.
13. Nietupski M, Ciepiewska D, Fornal L. Effect of the chemical protein diversity of selected wheat grain cultivars on the development of storage pests. *Progress in Plant Protection*,2006;46(2):420-423.
14. Paliwal RL, Granados G, Lafitte HR, Violic AD, Marathe JP. Tropical maize: improvement and production. *FAO Plant Production and Protection Series*,2000:28:374.