CAF2020 Paper No. P-7-6-60

Sharma UC, Satya S, Hariprasad P (2021) Effect of *Callosobruchus maculatus* infestation on nutritional parameters of urad (Vigna mungo) beans. Pp. 223-228. In: Jayas DS, Jian F (eds) Proceedings of the 11th International Conference on Controlled Atmosphere and Fumigation in Stored Products (CAF2020), CAF Permanent Committee Secretariat, Winnipeg, Canada.

Effect of *Callosobruchus maculatus* infestation on nutritional parameters of *urad (Vigna mungo)* beans

Umesh Chandra Sharma*, Santosh Satya, P Hariprasad

Centre for Rural Development and Technology,
Indian Institute of Technology, Hauzkhas, New Delhi 110016, India.
*Corresponding author's e-mail: ume.iitr@gmail.com

Abstract

Urad *(Vigna mungo)* belongs to family *Leguminosae* and is an excellent source of protein in common Indian diet. In view of specific crop cycle of legumes, proper storage is an important aspect of postharvest management. The cowpea weevil, *Callosobruchus maculatus* (F.), is one of the most important storage insect pests of grain legumes. Infestation by *C. maculatus* may cause the qualitative and quantitative loss to stored legumes. Hence present investigation aimed to study the effect of infestation on nutritional parameters of stored *Urad* beans. Infested (50% damaged grains) and un-infested *Urad* samples were analysed for various nutritional parameters such as carbohydrate, fat, protein, ash, and amino acid content. Results revealed that carbohydrate and crude fat, decreased by 4.04% and 40.38%, respectively; while on other hand there was an increase in ash content (9.21%) and crude protein (9.01%) due to pest infestation. Also, amino acid profile of infested *Urad* beans changed. Significant decrease (ranging from 6.81 to 61.39%) in level of several Amino acids such as Serine, Lysine, Methionine, Isoleucine, Valine, Arginine and Cysteine was noted. However, significant enhancement (ranging from 1.10 to 79.87%) was seen in level of Histidine, Glutamic acid, Aspartic acid, and Alanine. Insect infestation therefore, in addition to quantitative loss had consequences for human nutrition.

Keywords: Urad, *Vigna mungo*, Insect infestation, *Callosobruchus maculatus,* Amino acid profile

Introduction

Food legumes belong to the family *Leguminosae,* also known as *Fabaceae*. Grain legumes are used as pulse (whole/split dal) and are an excellent source of protein (22-24%), carbohydrate, and a fairly good source of thiamine, niacin, calcium, and iron. Pulses are the leading supplement of protein in a typical Indian diet. Among all legumes, *V. mungo* (local name Urad*)* is India's important pulse crop as it contains higher protein content than other pulse crops. The crude protein of raw seeds of *V. mungo* is 23.6% (Bravo et al., 1999). India is the largest producer and consumer of Urad in the world. Legumes are less remunerative and high-risk crops than cereals due to their susceptibility towards insect pest infestation during crop growth as well as storage. India is the largest producer (25% of global production), the consumer (27% of global consumption), and the importer (14% of global) of pulses. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, and

Karnataka are the top five legume-producing states in India (Mohanthy et al., 2015). Despite being top pulse-producing country, India still has to depend on other countries to meet domestic demands (Mangaraj et al., 2013). Before consumption, crops undergo different stages of postharvest operations. Good postharvest management is the key to reducing the postharvest losses thus contributing to food and nutritional security (Stathers et al., 2013; Sheahan and Barrett, 2017). It has been noted that significant losses occur during storage and milling. The major organisms infesting storage grains are insects, fungi, bacteria, and rodents. Among all, insect damage in stored grains alone may amount to 10-15% which is controlled by using several chemical pesticides such as malathion, chlorpyrifos and aluminum phosphide. These chemical pesticides are hazardous for the environment and human health (Satya et al., 2016).

Coleopteran insects of the family Bruchidae (also commonly known as pulse weevils/beetles) are the main insects associated with legumes (Sales et al*.,* 2000). Some pulse bruchids are *Callosobruchus maculatus* (F.), *C. chinensis* (L.), *C. analis* (F.), *C. rhodesianus* (Pic)*, C. phaseoli* (G.), and *C. dolichosi* (G.). These insects multiply at a rapid rate under suitable environmental conditions such as high humidity and temperature (Ahmed et al., 2003). Among these *C. maculatus* is ubiquitous and reported very harmful for stored pulses. Literature survey reveals that a lot of the research work has focused on quantitative losses, expressed as weight loss (De Lima, 1979; Boxall, 1986), whereas very little work on measuring the effect of insect-mediated postharvest losses on quality has been done (Hodges, 2013; Affognon et al., 2015). Losses in the quality of stored legumes not only negatively affect the market value but also impact household nutrition. In view of the above, present investigation was focused on effect of *C. maculatus* infestation on nutritive value of stored *V. mungo.*

Materials and methods

Insects rearing

Callosobruchus maculatus culture was obtained from Division of Entomology, IARI (Indian Agriculture Research Institute, New Delhi) and maintained in the Laboratory. It was done in a Biological Oxygen Demand (BOD) incubator at a temperature of 27±2°C (12:12 h day:night light cycle) and 65±5% RH. Initially, 20 pairs of freshly emerged adults were placed in a Polyethylene Terephthalate (PET) jar containing *V. mungo* grains (500 g). The jars were covered with muslin cloth and remained sealed to allow mating and oviposition. Then, initial stock culture was removed, and each jar's remaining content (grains and freshly laid eggs) was kept for further multiplication. The newly emerged beetles were used for experimental tests.

Setting up grain storage bioassay jars and sampling

Polyethylene Terephthalate (PET) jars (1000 mL) were washed and air dried. These jars were filled with 500 g organic urad (from 'Navdhanya Organic' Hauzkhas in Delhi). Two treatments (in triplicate) were used: 1) control (with no insects); 2) *C. maculatus* infested with 20 unsexed 0–3 d old adults. Attempting experiments with a single female was deemed to be an unacceptable risk of early mortality, so minimum two females were required to ensure infestation occurred. After the addition of insects (if any), jars were sealed with a muslin cloth and tighten with a rubber band. All these jars were placed in the BOD incubator at a temperature of 27±2°C (12:12 h day:night light cycle) and 65±5% RH.

The relevant subset of jars (three replicates for each type) was removed from the chamber, opened, and deteriorated sample (~50% damage) was taken out and analysed for the various parameters (proximate analysis and amino acid content).

Analysis of samples
Total nitrogen was determined by using a CHNS analyser (Vario ELIII, Elementar, Germany), and protein content was calculated as (Khalil & Manan, 1990):

Total Protein (%) = 100 × 6.25 × Total nitrogen
Where; 6.25 is the conversion factor.

The other constituents, the ash, moisture, and crude fat, were determined by standard methods (AOAC, 2000). The total carbohydrate content was obtained by the difference method:

Total Carbohydrate (%) = 100 – (Crude Protein + Crude Fat + Ash + Moisture)
Where; the crude protein, crude fat, ash, and moisture are in percentage.

The amino acid contents of the samples were determined using the HPLC method (ITC Labs, Panchkula, Haryana).

Data analysis
All experiments were performed in triplicates, and values were represented as mean. Data were analysed using Microsoft excel-2010.

Results and discussion

Proximate Analysis
The chemical analysis results (Table 1) revealed that carbohydrate and crude fat decreased by 4.04% and 40.38%, respectively. On the other hand, there was a slight increase in ash content (9.21%) and crude protein (9.01%) of the samples with infestation. The increase and decrease in values of the nutrients were found to be statistically significant. Figure 1 shows the graphical representation of change in nutritional composition of infested samples. Our findings agree with the result obtained by Etokakpan et al. (1982) which showed an increase in ash, crude protein, and crude fibre content of cowpea with insect infestation. Results of Bamaiyi et al. (2006) also showed the decrease in fat and carbohydrate content with infestation in stored cowpeas.

A general increase was seen in the percentage of total protein with the infestation. It might be due to the accumulation of insect frass and exuviae inside the grains, which increases the total nitrogen content of the grains. The insects' feeding decreased the actual protein content of grains.

An increase in total nitrogen, nonprotein nitrogen, total protein, and uric acid with increased levels of pest infestation, mainly 10%, 25%, and 50%, affect the nutritional quality of stored wheat at different levels (Jood et al., 1993, 1996; Soris et al., 2010). *Callosobruchus maculatus* feeds inside the grains, leaving the outer covering, which is mostly fibre, and raising the ash content (Bamaiyi et al., 2006). This result agrees with FAO (1984), which shows a decrease in the nutritional value of grains due to an increase in dietary fibre levels in infested grains. Increased dietary fibre intake lowers intestinal transit time, significantly reducing the rate of digested food absorption.

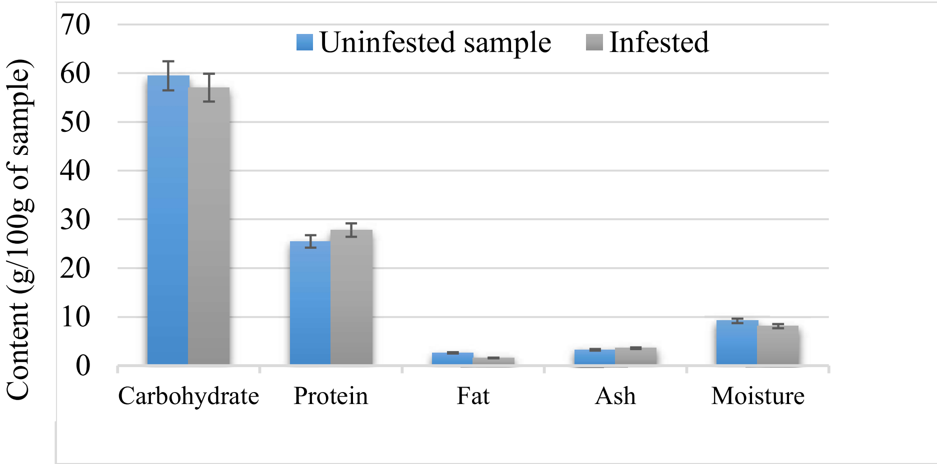

Fig.1 Comparison of nutritional composition of infested and uninfested Urad grain

Table 1. Proximate composition of infested and uninfested Urad (*V. mungo)* (mean ± SD)

Parameters	Uninfested Urad (g/100g)	Infested Urad *(g/100g)*	Percentage Change (%)
Carbohydrate	59.45±0.20	57.05±0.24	-4.04%
Protein	25.50±0.60	27.80±0.60	9.01%
Fat	2.60±0.03	1.55±0.05	-40.38%
Ash	3.25±0.03	3.55±0.04	9.21%
Moisture	9.20±0.07	8.10±0.07	-11.95%

Amino acid profile

Amino acids are the main nutritional constituents of legumes and act as essential components in the human body's specific metabolic processes. Their deficiency can adversely affect various functions of the human body.

Amino acid composition of infested and uninfested samples is presented in Table 2. It clearly shows the change in amino acid pattern. There was a significant decrease (ranging from 6.81 to 61.39%) in serine, lysine, methionine, isoleucine, valine, arginine, and cysteine. Sulphur containing amino acids (i.e., methionine and cysteine) are very limiting in Urad, and infestation caused a decrease in the level of these limiting amino acids. Our findings agree with research work of Etokakpan et al. (1982), which showed decrease in lysine, histidine, glutamic acid, valine, leucine, and methionine in infested cowpea. A decrease in amino acid content could be due to pests using them for physiological needs or due to change in physical conditions. However, significant enhancement (ranging from 1.10 to 79.87%) was seen in the level of histidine, glutamic acid, aspartic acid, and alanine.

Table 2. Amino acid profile of infested and uninfested Urad (V. mungo) samples

Amino Acid	Uninfested Sample(mg/100g)	Infested Sample(mg/100g)	Percentage change (%)
Arginine	876.32	715.48	-18.35
Cysteine	105.67	99.15	-6.17
Isoleucine	131.722	98.84	-24.96
Leucine	171.46	159.78	-6.81
Lysine	595.81	343.78	-42.3
Methionine	95.85	65.7	-31.45
Histidine	212.07	214.47	1.1
Tryptophan	206.19	160.88	-21.97
Serine	1988.90	767.88	-61.39
Valine	1964.66	1557.1	-20.74
Alanine	103.22	140.37	35.99
Glutamic acid	3518.41	3639.34	3.43
Glycine	5167.34	4573.37	-11.49
Aspartic Acid	11413.67	20532.82	79.87

Overall, present preliminary investigation clearly revealed that insect infestation reduced the nutritional and aesthetic value of stored Urad *(V. mungo)*, further decreasing its market value. This was mainly due to a change in amino acid profile and a change in certain nutritional parameters of stored legume due to infestation. So, there is need to develop effective methodology, based on design of storage bins along with eco-friendly pest control measures for storage of legumes, to reduce the nutritional and storage losses.

Acknowledgements

One of the authors, Mr. Umesh Chandra Sharma, is grateful for MHRD fellowship by IIT Delhi (India).

References

Affognon H, Mutungi C, Sanginga P, Borgemeister C (2015) Unpacking postharvest losses in sub-Saharan Africa: A meta-analysis. World Development **66**: 49-68.

Ahmed K, Itino T, Ichikawa T (2003) Duration of developmental stages of *Callosobruchus chinensis* (Coleoptera: Bruchidae) on Adzuki bean and the effects of Neem and Sesame oils at different stages of their development. Pak J Biol Sci **6**: 932-335.

AOAC (2000) Official methods of analysis of AOAC International. 17th ed. Association of Official Analytical Chemist. Oakville, MD, USA.

Bamaiyi LJ, Onu I, Amatobi CI, Dike MC (2006) Effect of *Callosobruchus maculatus* infestation on nutritional loss on stored cowpea grains. Archives Phytopath Plant Prot **39**(2): 119-127.

Boxall R A (1986) A critical review of the methodology for assessing farm-level grain losses after harvest (G191). http://gala.gre.ac.uk/10793/

Bravo L, Siddhuraju P and Saura-Calixto F (1999) Composition of underexploited Indian pulses. comparison with common legumes. Food Chem **64**: 185-192.

De Lima CPF (1979) Appropriate techniques for use in the assessment of country loss in stored produce in the tropics. Trop Stored Prod Info **38**: 15-19.

Etokakpan OU, Eka OU, Ifon ET (1983) Chemical evaluation of the effect of pest infestation on the nutritive value of Cowpeas *Vigna unguiculata*. Food Chem **12**: 149-157.

FAO (1984) Prevention of post-harvest food losses. Food and Agricultural Organization Training Series No. 10, Rome, Italy. 20 p.

Hodges RJ (2013) How to assess postharvest cereal losses and their impact on grain supply: Rapid weight loss estimation and the calculation of cumulative cereal losses with the support of APHLIS. UK: Natural Resources Institute. 121 p.

Iqbal A, Khalil IA, Ateeq N, Khan MS (2005) Nutritional quality of important food legumes. Food Chem **97**: 331-335.

Jood S, Kapoor AC (1993) Protein and uric acid contents of cereal grains as affected by insect infestation. Food Chem **46**: 143-146.

Jood S, Kapoor AC, Singh R (1996) Chemical composition of cereal grains as affected by storage and insect infestation. Trop Agri (Trinidad) **73**: 161-164.

Khalil IA, Manan F (1990) Chemistry-one (Bio-analytical chemistry) (2nd ed.) Peshawar: Taj Kutab Khana.

Mangraj S, Mohpatra D and Patil RT (2013) Processing of pulses: equipment technology. Indian Food Ind **32**: 27-44.

Mohanthy S, Satyasai KJ (2015) NABARD Rural Pulse. Issue-X, July-August-2015.

Sales MP, Gerhardt IR, Grossi-de-Sá MF, Xavier-Filho J (2000) Do legume storage proteins play a role in defending seeds against bruchids? Plant Phys **124**: 515-522.

Satya S, Kadian N, Arjoo, Kaushik G, Sharma U (2016) Impact of chemical pesticides for stored grain protection on environment and human health. Pp. 92-97. In: Navarro S, Jayas DS, Alagusundaram K (eds) Proc 10th Intern Conf Controlled Atm Fumi Stored Prod (CAF2016), CAF Permanent Committee Secretariat, Winnipeg, Canada.

Sheahan M, and Barrett CB (2017) Review: Food loss and waste in sub-Saharan Africa. Food Policy **70**: 1-12.

Soris T, Kala K, Mohan VR, Vadivel V (2010) The biochemical composition and nutritional potential of three varieties of *Vigna mungo* (L.) Hepper. Adv Bioresearch **1**(2): 6-16.

Stathers T, Lamboll R, Mvumi BM (2013) Postharvest agriculture in changing climates: its importance to African smallholder farmers. Food Security **5**(3): 361-392.