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Preference of Red Flour Beetle, *Tribolium castaneum* (Herbst) to Dehulled Millet Grains

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ABSTRACT

Preference of red flour beetle to the processed millet grains *i.e.*, dehulled foxtail millet, little millet, proso millet, kodo millet and barnyard millet was tested under free-choice and found higher numbers of red flour beetles moved into proso millet (16.75) followed by foxtail millet (9.75). Insect population buildup was observed under both free-choice and no-choice conditions, higher populations of *T. castaneum* (90.5 and 125.0 no.s respectively) were noticed after 80 days of insect release in dehulled proso millet indicating that it is the most preferred compared to other millets tested. The total sugars were found at higher levels in foxtail millet (59.21%) followed by proso millet (58.94%) and kodo millet (58.85%). Phenols were at the highest level (36.26 mg GAE /100g) in barnyard millet followed by little millet (32.75 mg GAE /100g). Presence of higher contents of sugars and lower contents of phenols in proso millet and foxtail millet probably make them susceptible to pest attack.

Key words: *Dehulled minor millets, Preference and Red flour beetle.*

Millet crops are often considered as climate resilient crops due to their ability to withstand various environmental hardships and resistance to insect pests and diseases coupled with higher productivity even under low input management. Millets are not only rich sources of fibre, minerals, vitamins and other nutrients; they also contain several health-promoting phytochemicals (Rao *et al.*, 2011). It was also reported that millet based foods have lower glycemic index compared to other cereal based products. Of late, minor millets have become integral part of regular diet for several people. Thus, with the increased consumer awareness on health benefits of millets, their cultivation by the farmers and marketing of dehulled or decorticated millets by the traders gained momentum in the recent years. Minor millets such as little millet and finger millet are known to be practically free from insect attack even after storage for longer periods, probably due the presence of some toxic and anti-metabolite chemical compounds (Rajendran and Thayumanvan, 2000). Hard, thick and intact hull of millet grains is an important protective structure that prevents the penetration of insect pests into the kernel. However, simple processing techniques like dehulling, soaking and cooking result in significant decreases in anti-nutrients and improve protein digestibility, bioavailability of minerals (Vithal and Machewad, 2006) and also consumer acceptability. On the other hand, these processed millet grains are vulnerable to storage insect pests which cause both quantitative and qualitative losses. In general, presence of damaged grain, broken and foreign materials favour insect multiplication and consequent development of moulds in the processed commodities. The red flour beetle, *Tribolium castaneum* (Herbst) is a major pest commonly found in stored cereal grains, processed grain products, oilseeds, nuts and dried fruits. Adult beetles and larvae feed on stored food stuffs and cause considerable loss. In case of serious infestation, the product turns yellowish and mouldy, has a pungent, nasty odour and becomes unfit for human use. Information on insect preference and population build up of red flour beetle in dehulled millets may be useful in taking suitable preventive measures for safe preservation of processed grains.

MATERIAL AND METHODS

Experiments were conducted to know the preferences of red flour beetle, *T. castaneum* and progeny development among five different dehulled millets under free-choice as well as no-choice conditions at Post Harvest Technology Centre, Bapatla during 2018-19. Further, an attempt was made to understand the biochemical factors of dehulled millets responsible for preference or non-preference of red flour beetle. Dehulled millet grains *viz.*, barnyard millet, foxtail millet, kodo millet, little millet and proso millet (Table 1) were procured from the local market and their moisture content was ranged from 10.37 to 10.68% (wet basis).

Table 1. Particulars of the minor millets

S. No	Common name	Vernacular name in Telugu	Scientific name
1	Barnyard millet	Ooda	*Echinochloa crusgalli* (L.) P.Beauv
2	Foxtail millet	Korra	*Setaria italica* (L.) Beauv
3	Kodo millet	Aarika	*Paspalum scrobiculatum* L.
4	Little millet	Sama	*Panicum sumatrense* Roth ex Roem. & Schult
5	Proso millet	Variga	*Panicum miliaceum* L.

Table 2. Preference and population build up of *T. castaneum* in dehulled millet grains under free-choice conditions

Tr. No.	Dehulled millet	Insects (No.) moved into grain	Adult population (No.)		
			40 DAR	80 DAR	Total
T_1	Barnyard millet	9.5 (3.07)[b]	2.25 (1.47)[d]	4.50 (2.10)[c]	6.75 (2.58)[d]
T_2	Foxtail millet	9.75 (3.10)[b]	26.75 (5.17)[b]	18.0 (4.21)[b]	44.75 (6.68)[b]
T_3	Kodo millet	6.75 (2.56)[b]	4.0 (1.99)[d]	1.25 (1.11)[d]	5.25 (2.23)[d]
T_4	Little millet	8.25 (2.86)[b]	10.50 (3.23)[c]	6.75 (2.59)[c]	17.25 (4.13)[c]
T_5	Proso millet	16.75 (4.06)[a]	52.25 (7.19)[a]	38.25 (6.18)[a]	90.50 (9.50)[a]
	SEm±	0.21	0.23	0.18	0.18
	CD (0.05)	0.63	0.67	0.57	0.67

* Figures in parentheses are square root transformed values;
DAR: Days after release of insects.
In each column values with similar alphabet do not vary significantly at p = 0.05

Table 3. Population build up of *T. castaneum* in dehulled millet grains under no-choice conditions

Tr. No.	Dehulled millet	Adult population (No.)		
		40 DAR	40 DAR	40 DAR
T_1	Barnyard millet	8.5 (2.98)[c]	6 (2.42)[c]	14.5 (3.78)[c]
T_2	Foxtail millet	40.25 (6.38)[b]	13 (3.60)[b]	53.25 (7.29)[b]
T_3	Kodo millet	6.5 (2.64)[c]	2.25 (1.50)[d]	8.75 (2.95)[d]
T_4	Little millet	1.5 (1.31)[d]	2.75 (1.61)[d]	4.25 (1.99)[e]
T_5	Proso millet	81 (9.0)[a]	44 (6.62)[a]	125.0 (11.18)[a]
	SEm±	0.19	0.14	0.2
	CD (0.05)	0.73	0.56	0.75

* Figures in parentheses are square root transformed values;
DAR: Days after release of insects.
In each column values with similar alphabet do not vary significantly at p = 0.05

Table 4. Biochemical constituents of the dehulled millet grains

Tr. No.	Millet name	Total Sugars (%)	Protein (%)	Total Phenols (mg GAE /100g)
T_1	Barnyard millet	52.97[c]	8.73[b]	36.26[a]
T_2	Foxtail millet	59.21[a]	6.45[d]	18.62[bc]
T_3	Kodo millet	58.85[a]	9.39[a]	16.11[c]
T_4	Little millet	54.95[b]	9.09[ab]	32.75[a]
T_5	Proso millet	58.94[a]	8.25[c]	22.45[b]
	SEm±	0.36	0.15	2.09
	CD (0.05)	1.09	0.45	6.28

* In each column values with similar alphabet do not vary significantly at p = 0.05

Insect bioassays

Preference of red flour beetle towards the dehulled millets and their population buildup was observed under free-choice as well as no-choice conditions.

Free-choice test

Each dehulled millet grain (100 g) was taken in a plastic plate (10 cm diameter and 2 cm height) and arranged in a circle in a round plastic tray (40 cm diameter and 9 cm height) and a total of 60 unsexed *T. castaneum* adults were released in the centre so that the insects get equal opportunity to secure the food grains of their choice. It was closed with another tray of same size by keeping in reverse position and secured tightly with binder clips and allowed for three days. Thus, four replications were maintained. After 3 days of insect release, the millet grains along with the insects were transferred individually into plastic jars (250 ml). The number of adults moved into each type of millet grains was counted and allowed for their development. The progeny development was observed in terms of adult emergence at 40 and 80 days after release of insects.

No-choice test

Similarly for no-choice test, 100 g of each millet grain was taken in jar (250 ml) and a total of 20 insects were released into each and there were four replications. Data on adult emergence at 40 and 80 days after release of insects were recorded.

Estimation of biochemical constituents

The dehulled millet samples were analysed for biochemical constituents *viz*; proteins, total sugars and phenols using standard methods of estimation as suggested by Sadasivam and Manickam (1996).

Statistical Analysis

The data on different parameters of both insect bioassays and biochemical analyses were subjected to statistical analysis of variance by Completely Randomized Design with four replications for the test of significance.

RESULTS AND DISCUSSION

Under free-choice conditions significantly higher number of red flour beetles was found to be moved into proso millet (16.75). The numbers of insects moved into other millets ranged from 6.75 in kodo millet to 9.75 in foxtail millet and they were at par with each other. The progeny development at 40 days after release of insects (DAR) was found to be at highest (52.25 no.s) in proso millet followed by foxtail millet (26.75 no.s). Similar trend in emergence of adults was found at 80 DAR also. Overall population build up after 80 days was recorded at the highest in proso millet (90.50 no.s) followed by foxtail millet (44.75 no.s). The total adult insect population emerged in 80 days was found to be the least in kodo millet (5.25 no.s) which was at par with barnyard millet (6.75 no.s).

More or less similar trend was noticed with insect population development in dehulled millets under no-choice conditions also. Highest populations of insects were recorded in proso millet at 40 DAR (81.0 no.s) and 80 DAR (44.0 no.s). Total adult population after 80 days was 125.0 no.s in proso millet followed by 53.25 no.s in foxtail millet. In little millet (4.25 no.s), kodo millet (8.75 no.s) and barnyard millet (14.5 no.s) lesser adult populations of red flour beetle were recorded.

Higher adult populations of *T. castaneum* in dehulled proso millet under both free-choice and no-choice conditions (90.5 and 125.0 no.s respectively) indicated that it is the most preferred compared to other millets tested. On the other hand, kodo millet and little millet with few numbers of adults were found to be less preferred by red flour beetle. According Prakash *et al*. (1982), the grain resistance to pest infestation depend on physical and biochemical grain properties, as well as on the pest feeding and/or oviposition preference. Similarly, Cogburn and Bollich (1986) emphasized that apart from the integrity of the rice husk, hardness and texture of the kernel surface are crucial for oviposition and further development, and also suggested that nutritive compounds play a role in grain resistance.

The dehulled millet samples were analysed for biochemical constituents; proteins, total sugars and phenols, The total sugars were found significantly at higher levels in foxtail millet (59.21%), proso millet (58.94%) and kodo millet (58.85%) which were at par with each other. Barnyard millet recorded the lowest content of sugars (52.97%). The protein content was found higher levels in kodo millet (9.39%) and little millet (9.09%) and the latter was at par with barnyard millet (8.73%). Foxtail millet recorded the lowest content of protein (6.45%). Total phenols were at the highest level (36.26 mg GAE /100g) in barnyard millet followed by little millet (32.75 mg GAE /100g).

Presence of higher contents of sugars and lower contents of phenols in proso millet and foxtail millet probably make them susceptible to pest attack. Though direct relation between insect development and biochemicals could not be established, the physical factors also need to be considered for drawing conclusions. The results were in conformity with earlier researchers. Murad and Batool (2017) demonstrated that varieties of wheat with higher protein and carbohydrate content, higher grain weight and lower grain hardness were more susceptible to grain moth. In the same way, the physical characters such as pod size, shell thickness and reticulations of groundnut pods of different genotypes influenced their susceptibility/ tolerance reaction to bruchid (Rekha *et al*., 2017). Several aspects such as preferences for oviposition and/or feeding, physical and chemical grain properties and changes during the grain processing are involved in grain resistance to infestation with store products pests (Prakash *et al*., 1982).

Although, it was also evident that no single physical factor or biochemical constituent is responsible for resistance/susceptible reaction against storage insects (Rekha and Gopala Swamy, 2017) as in this study, the information generated on insect preference towards dehulled millets under storage may be useful to take appropriate care and measures for the management of grain insect infestations. Higher populations of *T. castaneum* were noticed after 80 days of insect release in dehulled proso millet followed by foxtail millet under both free-choice and no-choice conditions indicating that they are preferred compared to other millets tested. While, the presence of higher contents of sugars and lower contents of phenols probably make them susceptible to pest attack.

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