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A comparative study of pest attack on basmati rice under different stored conditions and packaging

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Abstract
The practice of short duration storage of rice in sacks is practiced all over India; storage of basmati rice is made in woven sacks of jute, cotton and other indigenous plant fibres, in recent few decades polypropylene bags have taken over woven sacks in urban India. In the traditional storage techniques the rice becomes more vulnerable to insect attacks and spoilage, chemical methods have proven to be efficient but the residual toxins have been of great concern. A comparative study was conducted to find the vulnerability and the effects of pest on basmati rice stored in woven jute bag containers, bamboo straw container, polypropylene and silo (plastic). The results of the investigation showed that the basmati rice stored in woven bags were more vulnerable to pest infestation, the rice stored at lower moisture contents below 8 percent was observed to have lower plague of pest and insects. The varieties of basmati rice used for the study were Pusa 1121, Basmati 385, Muradabadi 6465, 386 Haryana and Basmati 198. The effect of pest infestation and moisture variation within the grains in the samples taken for the trails was also attributed to the packaging materials and adulteration. The percent of pest attack in different layers of each package was found and the maximum pest infestation was found in woven jute bags. *Sitophilus oryzae* (L.), *Rhyzopertha dominica* (F.) *Oryzaephilus surinamensis* (L.) and *Oryzaephilus Mercator* where the major pests found in basmati rice varieties after 48 weeks of storage in various storage containers.

Keywords: Basmati, pests, insects, Pusa 1121, grains, silo (plastic), packaging, moisture content

1. Introduction

The food scarcity in India is predominantly due to the lack of proper technologies to conserve food grains in surpluses throughout the short harvest time periods instead to a lower production [22, 23].

A fairly large amount of food grains gets spoiled after harvest as a result of inadequate storage and processing units. Furthermore, substantial food grains production could be affected due to fluctuations in periodicity and climatic factors like temperature, humidity and rainfall. [2]

The basic need of a grain storage method or a structure is to protect the food grains from the attack of insect, rodents and avert the spoilage of the grains by microbial growth due to moisture [14].

The grain loss during post harvest in India was 12 to 16 million metric tons every year. The World Bank estimates that this loss in food grains is capable of feeding one third of Indian people under poverty. The estimated pulses losses account for 9.5% of the total production in India [21].

Amid all the unit operation involved in post harvest the maximum loss of 7.5% is attributed to grain storage. The storage losses in paddy account up to 2.5% of the total production in India compared to storage losses of 2.5% in wheat, 3.5% in maize and 5% in pulses [12].

All these losses can are attributed to the pest and insect infestation in stored food grains. The other contributing factors that add to these results are lack of requisite qualities of proper practices in food grain storage and management post harvest, poorly designed storage structures and materials used for storage.

Storage tank made of poly vinyl chloride can be used for rice and other food grain storage acting as an efficient hermetic storage. A major advantage is that storage tanks made up of PVC can be easily made into different shapes and size within a very short span. Plastic PVC storage tanks or containers branded as silo for grains storage are kept in shade in indoors, and away from direct sun light at an elevation to enable easy discharge of the stored rice grains [20].

A house made up of bamboo is constructed using bamboo splits attached to one another by carpentry for storing large quantity of rice and other food grains. The walls are constructed using bamboo splits which are closely fitted without any gap between them. The bamboo walls are coated with cow dung and cow urine is sprinkled all over the structure to forbid pests, rodents and birds. The house can be constructed in rectangular or square shape with 4 m × 4 m × 3 m dimension to give a storage capacity of 1000 kg. [16]

It is absolutely necessary to keep rice at a refreshingly low temperature and dry throughout the storage period. The several natural resources affiliated with the approval of artificial insecticides have called for the research for safe, dependable and viable storage designs, which does not have a negative effect on secondary consumables, other commodities and the environment. Hence, this investigation was initiated to determine the various factors that influence pest infestation in basmati rice stored in different packaging material.

2. Materials and Methods

2.1. Selection of feedstock and storage material:

The varieties of basmati rice used for the study were Pusa 1121, Basmati 385, Muradabadi 6465, 386 Haryana and Basmati 198. The basmati rice varieties selected for the current investigation were stored in three different storage containers made up of three different materials. The storage containers were made up of woven jute, bamboo straw, silo (plastic) and polypropylene.

2.2. Solarisation of basmati rice varieties

The method of heating rice in the sun to annihilate insect pests is termed as solarisation [6]. This method was employed to ensure that the insects present in the rice and other fungal infections were ward off to ensure and prevent any such kind of infestation during the study. The basmati rice varieties were sun-dried by spreading the rice grains on cement floors over which a bamboo mat was spread to reduce the moisture content kill most of the infestive agents.

2.3. Experimental Conditions

The basmati rice varieties selected for the study were Pusa 1121, Basmati 385, Muradabadi 6465, 386 Haryana and Basmati 198. The varieties of basmati rice selected for the investigation were procured from the local market, then were packed and stored in 25 kg capacity containers. The basmati rice varieties were stored in four different storage containers. Basmati rice varieties were stored in woven jute bag containers, bamboo straw container, polypropylene and silo (plastic).

The 50 kg basmati rice samples were stored in the four different storage containers for a period of 48 weeks and were periodically analysed for insect infestations and fungal developments in each samples, there were 20 different sampling containers or packages used for the investigation. Basmati rice samples were taken from each contained for analysis once in a week. The rice samples were checked for moisture content, infestation of insects and fungal infections. The moisture content of the basmati rice samples were analysed based on the procedures adhering to ASTM E871-82(2013), types of insects found in the different depths and layers of each sample in different packages.

3. Results and Discussion

Basmati rice samples from each storage containers were analysed for moisture content once in a 4 weeks. There was a very meagre surge in the moisture contents of rice varieties stored in the woven jute bag containers. The Table 3.1 furnishes the initial moisture content of the rice varieties. The moisture values of the samples furnished were recorded before they were subjected to the study. The temperature throughout the study period was maintained at room temperature, in a shady, dry, well ventilated place away from direct sunlight.

Table 1: Initial moisture content of the basmati rice varieties at the beginning of the trails

Variety	Moisture Content (%)
Pusa 1121	8.0
Basmati 385	9.5
Muradabadi 6465	9.0
386 Haryana	9.5
Basmati 198	9.5

The average moisture content of the basmati rice varieties are furnished in the Table 3.2, there was moisture addition observed in all the varieties of the basmati rice stored in jute bags at the end of the 48 weeks storage. The moisture addition in plastic silo containers was very minimal to negligible compared to all the basmati rice varieties stored in the other containers. The moisture penetration in plastic silos containers was the most minimal, very closely followed by polypropylene container which exhibited similar moisture content at the end of the study.

Table 2: Final moisture content of the basmati rice varieties after 48 weeks of storage in various containers made of different materials

Average Moisture (%) at the end of 48 weeks				
Varieties	Type of Storage Materials			
	Jute	Bamboo	Polypropylene	Silos
Pusa 1121	8.5	8.4	8.0	8.0
Basmati 385	10.2	9.9	9.6	9.6
Muradabadi 6465	9.5	9.5	9.1	9.2
386 Haryana	10.2	10.0	9.6	9.6
Basmati 198	10.1	9.9	9.6	9.5

Random samples were drawn from each of the storage containers and were analysed for pest infestation. There were four main pests found in the basmati rice stored in the four different storage containers. The four pests identified were weevils, fauvel, *surinamensis* and *dominica*.

The basmati rice varieties stored in woven jute bag containers were found to have been infested with all the above cited pests; however there weren't any traces of fungal development inside the containers throughout the period. The pests were observed to be present in different layers of all the containers as the sampling was done at different layers and pests were identified.

The beetle species *Sitophilus oryzae* (L.) was observed in the basmati rice varieties stored in woven jute bags were in the size of 5 mm in length on an average. These weevil insects were found in all the varieties, but were a bit shorter in growth in the Pusa 1121 variety in which they were found to be grown to only 3 mm in length. The *Oryzaephilus Mercator* was found in all the containers, while it was detected to be present in different layers of the containers irrespective of the basmati rice variety stored in them. These fauvel beetles were observed to have grown to a length of 2.5 mm in length, they were marked as to be of flattened in appearance when observed by naked eyes. *Oryzaephilus surinamensis* (L.) were found to be predominantly present in the Basmati 198 stored in all the containers. These were detected to be grown to a length of 2.7 mm and were depicted to be of dark brownish colour in appearance. A dozen of these beetles were observed in the Basmati 198 stored in bamboo containers. The pest found in higher populations in the rice varieties stored in woven jute bag containers was *Rhyzopertha dominica* (F.); the size of the beetle was measured to be of 2.6 mm in length.

Metal silos used for storing rice grains are made of galvanized iron and by recycling oil drums. The metal silos have turned out to be the most efficient and cost effective storage containers for enhancing the shelf life of rice grains as they tend to be hydrophobic and air tight in conditions. The accessibility to rice and other food grains for pest is inconceivable when stored in the metal silo. The silos made up of steel are much efficient against insects, contamination by water; henceforth, metal silos are of the highest quality containers when it comes to grain storage. Nevertheless, the metal silos should be placed in shade and proper ventilation, preventing exposure to direct solar radiation and any possible heat source that could lead to condensation inside the storage container [1].

Sitophilus oryzae (L.), popularly known as the rice weevils do not prey on rice grains which have intact rice hulls [3, 8], further *Rhyzopertha dominica* (F.), and Angoumois grain moths are attributed to lower boring of rice grains, *Sitotroga cerealella* (Olivier), is much capable of infestation of rice grains segregated as complete hulls. The larvae of these two species are attributed to penetrate the rice grain and pass through the rice hull or by a coerce entry via the gaps between the palea and lemma. These gaps are that are so belittled that they can't be observed and detected under intense magnification. Both of these pests are cognized to enter the rice grain through the scars at the grain's base which are due to the result of abscission [9, 10].

The rice grain borer of minimal importance, *Rhyzopertha dominica* (F.), boasts with a possibility of becoming actually the most destructive pest that infests stored rice. *Rhyzopertha dominica* (F.), belongs to the family *Bostrichidae*, which are in general termed as the powder post beetles, the beetle has the distinguished shape of this family, which is elongated and cylindrical, its head Bent abruptly downward below the hood like prothorax which is the anterior part of an insect's thorax; bears the first pair of legs. *Rhyzopertha dominica* (F.) are grain borers which measure about 3 mm in length and 1 mm in width. The beetle was observed to be dark brownish in appearance. The insect is capable of surviving deep inside a mass of rice grains, develops a large population and prey on heaps of rice when their existence is found in the storage containers. The older adult beetles feed and multiply for weeks, the females can lay eggs in the range of 300 to 500 on grain mass [11].

Once larvae hatch, the next movement is boring into rice kernels and then follow the development just like the weevils. When they are grown into mature adults, they tend to become strong fliers, enabling themselves to migrate to other areas [7], thus easy spread of infestations from isolated populations in storage bins and warehouses to fresh harvested rice grain. Residual infestations are bound to prevail in all type of grain storage area and transportation carrier if not the unit is cleansed within uses [10]. Rice grains from a modern mill acts as a comparatively wretched medium for the growth of insects under storage condition. This is due to the removal of essential nutrients from polishing [17].

The vulnerability of milled rice grains to infestation is related directly to the degree of milling. Gently milled rice grain is much more vulnerable to pest infestation than polished rice grains [18, 19].

At present, harvested rice has a moisture content of about 20% which is then dried with heated air and the moisture content is reduced to less than 12.5%. High moisture rice in the crop field appeared to be not suitable for pest growth until [5] displayed that the rice grain maturity and moisture content varied to a great extent between the panicles of rice plants in the same field and also between the rice grains on the same panicle. Furthermore the Angoumois grain moths and the meagre grain borers often are trapped in insect traps baited with pheromone in standing rice crop fields [7].

Pests and insects tend to prey on and stored rice grains, damage agricultural commodities during storage, processing and supply. Postharvest losses in food grains like rice, wheat are costly in particular. The capital costs invested in the grain crop have the value at its highest point; the post harvest loss of comparatively low percentages is significant from a financial point of view. There are various insect species are connected with stored food grain and rice grain products, however only 50 pests are classified as deleterious [11].

Riddance of pest contamination or infestation in exported food grains, be rice or other grains, is a prime concern of any nation that intends to export its agricultural produce [13].

Rice is one of the food grains which act as a main source of calorific requirements for people around the world and also in the form of animal feed. Spoilage of rice grains during storage results in the lack of food for millions of people around the world, which also comprises of masses suffering from undernourishment. The various basmati rice storage system and methodology in the current study are intended to render a longer shelf life against insect infestation and environmental factors.

4. Conclusion

Generally the pests found in rice grains are categorized as weevils but there are diverse types of pests that affect rice grains. Pests during basmati rice storage are noticed to be copious in storage regions with warm and humid climate, under such favourable conditions they can lead to severe grain losses under storage. Since basmati rice is cultivated, harvested and stored in tropical and subtropical climatic conditions they are vulnerable to pest infestations. Rough rice is prone to a lesser convincible to any pest infestation compared to other food grains, the reason being that grain hull partly shields the edible portion. In spite of this, still the rice hull cannot completely preclude infestation in rough rice. A portion of harvested basmati rice grains come with defects in the grain hull which accommodate pest insects. The diverse types of practices followed in basmati rice harvesting, drying, handling and storage along with environmental conditions during the cultivation season can affect the condition of the rice hull. The variety of the rice itself is an important factor in pest infestation. Apart from these few species of pests are capable of detecting different ways to penetrate into the rice grains though the grains are comprised of intact hulls. Many larvae and pest in clumps forms are present in the kernels by creating a webbing of grains one to another. These clumps are removed from the rice and discarded with straw and trash when the grain is cleaned before processing. Pest infestation in milled and processed rice grains calls for fumigation and again a remilling process to ward off the insect carcasses and residues.

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