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Tribal methods for millets preservation and storage in Bastar District of Chhattisgarh

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Abstract
Efficient post-harvest handling storage can tremendously contribute to socio-economic empowerment in developing nations. Farmers use traditional storage containers for storing food grains for their own need. These storage structures are comparatively cheap, eco-friendly and impart high shelf life to the stored commodities. These traditional storage systems could be applied in modern storage areas with minor modification, could save food commodities that would be damaged by insects. Although chemical methods of management of stored produce pests are highly successful, they leave behind toxic residues. The traditional wisdom and methods of storage can protect commodities from insect infestation for substantially longer periods.

Keywords: Tribal, millets, preservation, Bastar

1. Introduction
Millets generally known as highly mineral rich grains constitute the most vital diet component for the majority of people in the world (Rajashekar *et al.*, 2016) [23] providing the minerals consumed by the resource-poor and provide the rural folks with employment and sustainable source of income. Millets are the most commonly stored durable food commodities in the tropic and subtropics usually stored to provide food and feed reserves as well as seed for planting. The major millet crops cultivated in Bastar region of Chhattisgarh are foxtail (kakum/kangni), kodo, proso and maize (Asif *et al.*, 2013) [4]. According to Department of Agriculture and Farmers development (2018), Bastar produces 1.09% of India production of millets. In India, millet grain production is by far the major agricultural activity with 80% of arable land put into its cultivation. Postharvest losses are a major cause of concern worldwide where below 5% research funding has been allocated (Rajashekar *et al.*, 2012) [23]. The food problem in Chhattisgarh and India is largely due to the inability to preserve food surpluses during the short harvest periods rather than to low production. Grain production plays minimal role in the economies of developed and developing nations because agricultural production is seasonal while the demands for agricultural commodities are more evenly spread throughout the year (Rajashekar *et al.*, 2014) [22]. In order to satisfy the demand for a plentiful supply of millet grains must be stored throughout the year. A substantial amount of food grains is being damaged after harvest due to lack of adequate storage and processing facilities. Moreover, significant agricultural production could be impacted due to variations in periodicity and intensity of climatic events like floods and droughts, temperature and rainfall patterns (Arun *et al.*, 2017) [3]. In India, the estimated post-harvest losses account for 9.5% of total pulses production. Among the post-harvest operations, storage is responsible for the maximum loss (7.5%). This generally results from inadequate post-harvest management practices and imperfectly designed storage structure. Post-harvest facilities or appropriate storage technology has been the major problem of India and Nigeria and other developing nations for a long time. This has resulted in a considerable waste of agricultural output and hence considerable loss to the economy. After harvest, the grains may be stored temporarily in bulk or in bags for a month or two before being transferred to a structure. It is observed that different localities in Chhattisgarh and India have peculiar storage methods depending on the types of crop grown and farmers attain a varying degree of success in applying the basic principles involved in the safe storage of food grains. Storage practices differ and there are small or big storehouses, indoor or outdoor, temporary or permanent and individual or community storage design. These structures have open storage system, semi-open storage system and closed storage system (Gwinner *et al.*, 1990) [10]. Traditional methods of storage

are a type of knowledge, which has evolved into the community and has been passed on from one generation to another generation (Natarajan and Santha, 2006) [18]. Certain traditional methods of grains storage practices are unique to the culture of society and vary among countries, villages, locals and even communities. These indigenous practices originate from the cultural connection with specific environmental conditions and are based on traditional societies having intimate consciousness of their environment.

2. Purpose of food grains storage

Food grain storage plays a crucial role in the economies of developed and developing countries. Quality food grains must be supplied to the consumers for making different products and marketing, as well as to the farmers for sowing and growing healthy cereals and pulse grains. These required regular availabilities of agricultural outputs which will stabilize the economy of any country. In order to satisfy the demand for a plentiful supply, the grains must be stored throughout the year and gradually released to the market during off-season periods, which also stabilizes seasonal prices (Adejumo and Raji, 2007) [1]. The traditional methods of grains storage and preservation date back to since time immemorial which were developed in the communities and passed on from generation to generation (Natarajan and Santha, 2006) [18]. The storage containers are built from a variety of locally available materials differing in design, shape, size, and functions (Channal *et al*., 2004) [5].

3. Traditional grains storage practices and methods

3.1. Solarization

The process of heating grain in the sun to kill insects is called solarization. It is an old age practice by farmers before storing the grains and pulses in regions where the outdoor temperature reaches 20 °C or higher (Chua and Chou, 2003) [7]. The stored grains have been sun-dried by the farmers involves spreading the food grains on the bare grounds, on spread polythene or on tarpaulin, bamboo mat, roadsides or on rooftops to reduce the moisture content and killed most infestive agents.

3.2. Open fire place

In most rural farming communities, the majority of the farmers stored food grains near the kitchen where the heat and smoke of burning firewood penetrate to keep the food grains free from insect pest infestation (Sarangi *et al*., 2009) [24].

3.3. Open air/aerial storage

Unshelled millet cobs and other unthreshed cereals are suspended in bunches or sheaves, using rope or plant material, under eaves, from the branches of trees or the top poles driven into the ground (Ofor, 2011) [20]. The unthreshed cereals grains are commonly stored under the roof of dwellings, hanging from the roof timbers or spread out on a grid in the ceiling where high temperature due to direct solar radiation heats up the grains to reduce the moisture content and may also kill the developing larvae in the seeds thus preventing insect infestation.

3.4. Storage with diatomitzed earth

Diatomitzed earth (DE) is a dust formed from fossilized diatoms; consisting of entirely amorphous silicon in which the particle size ranges from 3 µm to more than 1 mm. DE is used as a natural insecticide for the protection of stored agricultural products. The most susceptible stored grain insects to least against DE are *Sitophilus oryzae, Sitophilus granarius, Ryzoperthedominica* and, *Triboliumcastaneum*.

3.5. Gourds

Gourds are made from the hard dried outer skins of fruits from the members of squash or Cucurbitaceae family generally found in tropics and subtropics (Wehner and Maynard, 2003) [26]. Gourds are used for storing small quantities of food grains (5–30 kg) required for home consumption or planting for a duration of six months to one year.

3.6. Crib

The Crib is an improvement on platform structure, which is a rectangular shaped enclosed structure elevated between 0.5 and 1 m above ground, supported on columns and has well-ventilated sides made of straw, palm leaves, bamboo or wire netting. The entire storage structure could be constructed with wood, bamboo, metal or wire mesh and roofed with thatch straw or iron sheet and faced in such a way that the prevailing winds blow perpendicular to the length. The legs are fitted with rat-proof device to prevent rodent infestation.

3.7 Straw bin

Paddy straw is used for building this type of storage structure. It is dried properly, specially prepared, kept straight and the dried straw is woven to form rope concentrically arranged over a large area with the bark of Erythrina indica and E. variegate placed along with the straw. For grains to be stored in this structure, they are mixed with sifted ash before being placed in the straw bin, thereafter the straw ropes are folded over the grains. This storage structure is usually suspended from the roof rafters (Jain *et al*., 2004) [12]. This type of design is used because of being inexpensive and easy management through locally available materials and low-temperature variation keeping the grain cool. Seed viability of grains stored in the straw bin can last for two years.

3.8. Nahu

Nahu is a traditional storage structure commonly used by the resource-poor farmers in the West Bastar district of Chhattisgarh, India for the storage of food grains such as rice, maize, millet, etc. The storage capacity of Nahu ranges from 5.0–8.0 t and can hold 0.20–0.24 t/nahu for seed purpose and the structure lasts for 20 years. These storage structures are constructed close to residential areas in the village, and in the cluster apart to avoid a fire outbreak. (Sarangi *et al*., 2009) [24].

3.9. Metal or plastic drums

Plastic or metal used for the organic solvents, petroleum products, vegetable or palm oil storage and transportation or water storage tanks are other materials used to provide hermetic storage of food grains in both countries after thorough washing in case the new one is not being used. One major disadvantage of grain storage in a drum is that the drum must remain sealed for it to be effective because the insect is prone to resume physiological activity at the slightest inlet of oxygen when opened indiscriminately (Makalle, 2012) [16].

3.10. Earthen bins/pots
Farmers across; have used the various agroecological zones of India and Nigeria used earthen bins/pots made of burnt clay mixed with or without straw as the binding material to provide strength for storing threshed food grains such as cowpea, maize sorghum, paddy, black gram and millet ranging from 5 to 1500 kg for short to long duration of time (Chattha *et al*., 2013) [14].

3.11. Bamboo bin
The Bamboo bins are made from bamboo splits, straw, raffia palm/ palm fronds closely intertwined or wooden planks to form a narrow opening at the top in the conical shape similar to the pyramid in a structure erected in any open space. The underlying principle of grains storage in this structure is that the ginger grass used in the top cover has insect deterrent action which prevents insects from settling down on the structure and the sterilizing effect of UV in solar radiation (Saravanan, 2010). The Bamboo bin storage structure is commonly used by farmers in the northern parts of Nigeria and Southern parts of India.

3.12. Storage bags
Short duration storage of food grains in sacks is widely used in farms, villages and commercial storage centers. Sacks made of woven jute, sisal, local grass, cotton and depend on the materials that are available in the area. Polyethylene storage bags create a highly efficient, hermetic storage environment for all crops. Polyethylene bag is placed inside ordinary storage bags for an additional layer of protection to form multi-layer polyethylene storage bags to ensure water resistant and completely air tight storage condition (Mutungi *et al*., 2015) [17].

3.13. Earthen pot-pile
Earthen pot-pile is a variant of earthen bin/pot made from clay and is used for storage of small quantities of threshed food grains ranging from 10 to 50 kg depending on the capacity of the pots (Ofor, 2011) [20]. The earthen pot-pile structure is cylindrical in shape and made up of different sizes or capacities usually arranged over one another at the corner region of the house. The pots fit exactly one over another in such a way there is no gap left to allow for insect gaining entry into the stored grains, with the smallest being at the top, covered by an earthen lid sealed with thick cloth, mud or clay and cow dung to ensure proper alignment into the opening (Oakley and Momsen, 2007) [19].

3.14. Storage with table salt
Rural farmers in developing nations utilized table salt for the short term duration storage of Cajanus cajan and Phaseolus vulgaris for 6–8 months. About 200 g of table salt is thoroughly mixed with 1 kg of C. cajan and P. vulgaris and sealed in jute bags. The underlying principle of this practice is that due to the abrasive action of the salt which prevents insect movement inside the storage container, insect infestation and population build-up is suppressed (Jeeva *et al*., 2006) [13].

3.15. Platform storage
The Traditional raised platform is used for stored grains to reduce moisture, larvae killing, and to discourage insects or other pests. It is built in the open space with strong or hard-forked sticks about 1 m high, crossed with split bamboo and other hard sticks. In some instances, straw mats, bamboo mats or raffia mats are spread on the platform. Under this storage method, shading, ventilation, and regular inspection are essential. Open platform storage is discontinued when the rainy season begins (FAO, 1998)

3.16. Use of camphor
Camphor is used for short-term storage of grains required for next season planting. The shelled grains or paddy are stored in bags or pots after being sun-dried and camphor is placed inside the storage bags or container. The mode of action of camphor used in such grains storage could be either fumigant, repellent or antifeedant attributed to pungent odor emanating from the camphor (Karthikeyan *et al*., 2009a) [14].

3.17. Mud house storage
Mud houses are used to store large quantities of food grains from 1000 kg to 2500 kg or above. The size depends on the farmer needs, but an average size dimension is 4 m × 4 m × 3 m to give a storage capacity of 2500 kg. Mud houses are made up of either mud alone or the walls are made of mud mixed with paddy straw and plastered over the bamboo splitted framework and the top is covered with tin roof. The entire structure along with the covered wooden planks is coated with clay and cow dung, allowed to dry and thereafter limewashed (Karthikeyan *et al*., 2009b) [15].

3.18. Bamboo house
Bamboo house is a variant of mud house and made up of bamboo splits joined by carpentry work. It is used for storing large quantities of food grains. The walls made up of bamboo splits are closely fitted with no gap existing between the bamboo frameworks. The walls can be coated with cow dung or sprinkled with cow urine to prevent insects and rodents from gaining entry to the product stored therein. After loading with grains, locally available medicinal plants with insecticidal properties such as Artemisia vulgaris, dried chilli, etc., are placed on the corner to prevent insect infestations (Karthikeyan *et al*., 2009b) [15].

3.19. Storage of grains with natural products/botanicals:
The practice of admixing of natural products or botanicals for the storage of food grains dates back to the very earliest periods of known history, well before the advent of synthetic insecticides/fumigants. The practice is common in Chhattisgarh and Bastar, with the increasing development of resistance and the negative impact of these synthetic insecticides on human health and environments (Isman, 2008) [11]. There is renewed interest in the utilization of these products for the management and preservation of stored grains from insect infestation. Being cheap and readily available, resources-poor farmers perceive that natural products possessed repellence, anti-feeding and ovipositional deterrence, fumigant or contact activity, growth inhibition etc., and uses them against storage insect pest than relying on the expensive, adulterated and not readily available synthetic insecticides to prevent storage pest from attacking their produce (Rajashekar *et al*., 2012) [23].

3.20. Storage with cow dung
Seeds meant for next season sowing are stored with cow dung after the seeds must have been ascertained to be properly

dried. Rural farmers believe that cow dung possess pesticidal properties to protect such seeds from insect infestation, they equally believe that cow dung immunostimulant properties increased seed viability (Karthikeyan *et al*., 2009) [14]. For seeds to be stored in cow dung, farmer collect fresh cow dung and made it to a plate-like round shape and the seeds are embedded into the cow dung and then sun dried for 2–3 days depending on the intensity of the sunlight. In the process of sun drying, the seeds get stuck onto the cow dung and then stored in open or inside a wooden box. Seeds treated this way can be stored for up to a year.

4. Conclusion

Food grains are the main source of human calorific requirements and animal feed worldwide and more so in developing countries. The spoilage of grains at the time of storage has resulted in the starvation of million people worldwide, including people who suffer from undernourishment. All the storage practices and methods review in this study are comparatively cheap and constructed with readily available local materials, eco-friendly, impart considerable high shelf life to stored food grains by effectively reduced or suppressed insect infestation. These traditional food grains storage and preservation practices can be improved upon or modified where necessary for effective grains storage to ensure the full realization of agricultural potential to meet the world's increasing food and energy needs.

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