Abstract

Food and nutritional security is an important dimension related to human dignity and societal development. In India wheat is a staple food crop grown and consumed at large scale. The production is seasonal that too affected by a number of factors that makes the storage of wheat an important post-harvest operation. In India ~ 60-70% of the produced wheat is stored at home/farm level. Storage losses is a critical issue and ~10% of the grain produced is lost during storage. In fact type of storage structure plays an important role in protecting the quality of stored grain. The storage structure serves as a barrier between the stored grain and ambient environmental conditions. Present study focuses on developing new suitable efficient storage structures to solve problems faced by the farmers for the storage of wheat.

To begin with, in order to understand the existing grain storage system used by the farmers, a field study was conducted in selected villages of Haryana (India). It was found that about 80% of farmers are using conventional metallic bins of different sizes to store their grains. In different structures lot of grain damage was found. Overall, it was noted that the conventional metallic bins were not good enough to provide the complete storage protection. The survey results emphasises on the need of designing new storage structures to minimise the storage losses. For designing the storage structure, various engineering properties of three different wheat varieties (MP-1106, UP-2254 and WH-542) and their behaviour at four different moisture content (8, 10, 12 and 14%) were studied. Thousand grain weight (TGW), true density, porosity, Angle of repose (AOR) increased with the increase in moisture content whereas bulk density, hardness, Initial cracking force (ICF) decreased with the increasing moisture. The knowledge about the various physical, gravimetrical, frictional and flow properties is important for designing process.

Temperature and moisture content are the most important factors affecting the quality of stored grain. Sometimes, the gradients caused due to the difference in temperature of stored grain and the ambient conditions are enough to form a ‘hot-spot’ inside the grain mass. A study was conducted to see the emergence of ‘hot-spot’ inside the small metallic bin (100 kg capacity) and its effect on the quality of stored grain was investigated. The results confirmed that even in small scale bins, temperature and moisture migration takes place which can form ‘hot-spot’. During the summer season, moisture migration is more at the top and bottom of the bin and a ‘hot-spot’ was found near the bottom of bin. Whereas during the winter season, moisture accumulation is only at the top of the bin and the ‘hot-spot’ is also
near the top surface of grain mass. The formed ‘hot-spot’ had a strong bearing on the quality of stored wheat. Maximum changes in quality of stored wheat were observed during the summer season and near the ‘hot-spot’. Protein content was decreased by 21.77 %, fat content by 64.05%, germination by 84.34% etc., other quality parameters also showed significant changes. The study clearly indicates the need of new storage material and design to protect the stored grain from the changing environmental conditions.

A comparative study of different types of materials for grain storage bags was also done. During the field survey different types of bags used for the purpose of wheat storage available in local market were collected. The bags used were jute bag with or without plastic lining, polypropylene bag, Hermetic bag and Eval bag. These bags were then compared for their thermal, mechanical and barrier properties. The results indicate the superiority of Eval and hermetic bags in terms of low thermal conductivity (0.054 and 0.062 W/mK) and good barrier properties (WVTR- 3.56 and 2.16 g/m²/24 hrs, OTR- 3.45 and 4.28 cc/m²/day) but have low mechanical properties that can be improved by using jute bag as a cover lining. Hence Eval and Hermetic bags can be used as an alternative to other commonly used bags to store grains.

Finally, based on the experimental findings, design of four new bins were developed and tested. The designs include- (i) bin with horizontal partition, (ii) bin with special provision of having perforated pipe for keeping the fumigant tablets, (iii) bin with perforated empty space at the bottom and (iv) double wall bin with insulation. After evaluating the change in quality parameters and change in moisture contents during the long storage period of nine months, it was found that out of these four new designs, the bin with special provision of centrally located perforated pipe for keeping fumigant tablets was found to be best for wheat storage. The best bin was not only best in terms of maintaining the quality of stored wheat but the curved plates in the central pipe were acting as an insect-pest trap thus reducing the infestation and also for their monitoring without disturbing the biological system. Wheat straw was found best in terms of low thermal conductivity (0.04 W/mK) and can be used as an insulating material in double wall metallic bin. Overall, the final novel design integrating double wall concept with metallic bin having special provision for keeping fumigant tablets will solve the storage problems of farmers in rural habitat. Infact popularisation of such a simple design of grain storage bin which can be fabricated by local artisans will go a long way in achieving food safety in rural India.