Daglish, G. J., and Pavic, H. (2008). Effect of phosphine dose on sorption in wheat. *Pest Management Science, 64*(5), 513-518.

Darby, J. (2011). *Technology to overcome inadequate fumigations and resistance selection.* (No. CRC50059). Black Mountain, ACT, Australia: Cooperative Research Centre for National Plant Biosecurity.

Dumas, T. (1980). Phosphine sorption and desorption by stored wheat and corn. *Journal of Agricultural and Food Chemistry, 28*(2), 337–339.

Cook, S. (2016). Evaluation of sealed storage silos for grain fumigation. (Unpublished Master of Science thesis). Kansas State University.

Isa, M. Z., Fulford, G. R., and Kelson, N. A. (2011). Simulation of phosphine in vertical grain storage: A preliminary numerical study. *Australian Mathematical Society*, (52), 759-772.

Isa, Z. M., Farrel, T. W., Fullford, G. R., and Kelson, N. A. (2016). Mathematical modelling and numerical simulation of phosphine flow during grain fumigation in leaky cylindrical silos. *Journal of Stored Products Research, 67*, 28-40.

Lawrence, J. (2010). *Three dimensional transient heat, mass, momentum and species transfer stored grain ecosystem model using the finite element method* (Unpublished Ph.D. dissertation) Purdue University, West Lafayette, Indiana.

Lawrence, J. and Maier, D. E. (2011). Development and validation of a model to predict air temperatures and humidities in the headspace of partially filled stored grain silos. *Transactions of the American Society of Agricultural and Biological Engineers, 54*(5), 1809-1817.

Price, L. A., and Mills, K. A. (1988). The toxicity of phosphine to the immature stages of resistant and susceptible strains of some common stored product beetles, and implications for their control. *Journal of Stored Products Research, 24*(1), 51-59.

Plumier, B. M., Schramm, M., and Maier, D. E. (2018). Developing and verifying a fumigant loss model for bulk stored grain to predict phosphine concentrations by taking into account fumigant leakage and sorption. *Journal of Stored Products Research*, 77, 197-204.

Reed, C. C., and Pan, H. (2000). Loss of phosphine from unsealed bins of wheat at six combinations of grain temperature and moisture content. *Journal of Stored Products Research, 36*(3), 263-279.

Sato, K., and Suwanai, M. (1974). Adsorption of hydrogen phosphide to cereal products. *Japanese Society of Applied Entomology and Zoology, 9*(4), 127-132.

Sun, Y.P. (1946). An analysis of some important factors affecting the results of fumigation on insects. St. Paul, Minnesota Agricultural Experiment Station. Technical Bulletin No. 177.

A Novel Engineering Design of Small Scale Metallic Silo for Food Safety in Rural India

Arjoo Nandal*, Santosh Satya, K. K. Pant, S. N. Naik

Centre for Rural Development and Technology, Indian Institute of Technology, New Delhi 110016, India.
*Corresponding author: arzoo.nandal.89@gmail.com
DOI 10.5073/jka.2018.463.082

Abstract

Wheat is an essential component of the human diet for most of the world. In India wheat is an important staple food crop and it is used for the preparation of a diversity of products like *roti*, *parantha* (semi fried), *puri* (fried), bread, pasta, noodles, buiscuits etc. It has been reported that ~60-70% of wheat produced is stored at home or farm levels for domestic consumption. In order to understand the rural grain storage system, an extensive field study was carried out in villages of Haryana state (India). The field study revealed that ~95% of families store their grains in metallic silos of different sizes (300 to 2000 kg) and only Aluminium phosphide tablets (locally called sulfas) are used to protect grains from storage pests. Aluminium phosphide (AlP) tablets are used in an unscientific manner to control insect pest infestation, resulting in residues in stored grain. An experimental study of 12 months was carried out to identify the problems associated with pest management in conventional metallic silos. The storage period was divided into two parts, i.e., summer and winter, of 180 days each. Ambient temperature and relative humidity (RH) were recorded continuously for the entire period and temperature inside the silos was also recorded at different locations. The emergence of 'hot spots' was found during May-June when the temperature ranged from 37.6 to 42.7°C inside the silo during the summer season. During this period ambient temperature and RH ranged from 22.6-44.2°C and 37-82%. At this stage, convection current caused moisture migration at the top and bottom of the silo, whereas in the winter season moisture migration inside the silo was observed only at the top layer. Wheat samples from the topmost layer, in the vicinity of the "hot-spot" and from the bottom layers were collected and analyzed for various quality parameters.

The wheat samples near the "hot-spot" emergence were found most deteriorated in every aspect, for instance, in terms of protein content (decreased by 21.77%), fat content (decreased by 64.05%), germination capacity (decreased by 84.06%), thousand kernel weight (decreased by 22.09%), ash content (decreased by 41.96%), acidity (increased from 3.07-6.23 mm/gm) and insect-damaged kernels (increased by 80%). The results confirmed that even in a very small silo of 100 kg capacity if grains are stored without any fumigation treatment,

there exists the potential for moisture migration because of temperature fluctuation causing hot-spot formation, leading to grain quality deterioration.

Keeping in view the above aspects, an integrated engineering design of a double wall metallic silo with the special provision of a vertical perforated metallic tube in the centre was designed and fabricated. Tri-layer materials were tested for their thermal properties for fulfilling the needs of thermal insulation in the double wall silo. Wheat straw was found to be the best material in terms of thermal conductivity with a value of 0.040 W/mK. The special provision consisted of a removable string fitted with plates for keeping AlP tablets. To understand the function of the perforated tube in the centre of the silo for preserving stored wheat quality, 100 Kg of wheat (HD2733) was filled in this silo and after 12 months storage, wheat samples (at different depths inside the silo) were collected with the help of grain probes and mixed properly for quality parameter determination. Seed germination was determined before and after storage. It was found that germination decreased from 96% to 84%. Moisture content increased during storage from 9.8 to 12.7%. The initial kernel damage observed was 2-3% whereas after storage it was in the range of 13-15%. The initial lipid content recorded was 2.08% whereas after storage it was 1.4%. Also, the protein content decreased by 9.01%. Other parameters also showed quality degradation with time. The results were compared with the control (conventional) silo and it was found that the newly designed silo was better in terms of preventing insect infestation and quality deterioration. Also, the newly designed silo had a special provision for keeping AlP tablets suspended in the perforated tube to better control insects.

Future vision

The gap in technology transfer in India is increasing the chemical load on stored grain which can be minimized by incorporating small changes in the existing design of silos. To avoid the unnecessary repetitive use of AlP tablets, scientific knowledge should be developed and adopted, for example, on suitable wrapping/packaging material for AlP release at a slow rate over longer periods for effective control of insect pests in stored grains.

Keywords: Wheat, thermal conductivity, AlP, insect trap, design.

Food industry practices affecting Integrated Pest Management

Pasquale Trematerra[1*], Francis Fleurat-Lessard[2]

[1]Department Agricultural, Environmental and Food Sciences, University of Molise, Campobasso, Italy
[2]INRA Bordeaux-Aquitaine, Villenave d'Ornon Cedex, France
*Corresponding author: trema@unimol.it
DOI 10.5073/jka.2018.463.083

Abstract

Manufacturers of dry food products have a real challenge to exclude pests everywhere along the food chain because of the rather complex and different environments of food industry buildings. Current practices that influence pest presence and development in food industry facilities have been identified in the stages of food plant design, food ingredient reception and storage, processing or conditioning of finished food, and marketing. The preventive pest control measures in the food industry may be ineffective because of a non-observance of simple rules of good manufacturing practice (GMP), such as permanent control and monitoring of critical points or the ban of unsafe practices favourable to pest entry and infestation in food plants. The underutilization of methods for rapid assessment of pest presence and movement within food industry facilities, as well as the inability to rely on pest monitoring data for the economic damage threshold (EDT), are also underlined. Practical tools for processing data from pest monitoring systems should improve pest presence detection and alert. More realistic EDTs need to be proposed with direct links to decision-making support. More practical predictive models are also required for predicting the long-term efficacy and resilience of corrective control methods in food processing buildings, which should render the implementation of complex IPM programs easier.

Keywords: pests, food industry, manufacturing practices, food processing, IPM program

1. Introduction

Pest management practices in food industries are facing an important need to protect durable food products against pest infestation as many markets have very low pest-induced damage tolerance and are also subject to increasingly intense scrutiny through external inspections and audits. There are somewhat antagonistic trends such as less reliance on the use of residual pesticide treatments