Design and development of CO_2 fumigation setup with automatic gas controlling system for safe storage of grains

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Abstract

The development of alternative treatments for pest control in food commodities has increasing demand from the food industry, which should meet consumer demands for the reduced use or elimination of pesticides. Carbon dioxide (CO_2) is a fumigant that leaves no objectionable residues in the treated commodity; relatively safer and helps to retain the quality of treated grains than the conventional treatment. It is required to develop air tight bin/storage structure for the retention of CO_2 for the effective management of stored pestsat farm or household level. For treating stored pests with CO_2 has demand in the international market since it leaves no residues to the treatedgrains.In the present study we have developed airtight container for CO_2 fumigation and automatic CO_2 controller system for regulating the CO_2 concentration.

1. Introduction

There are increasing restrictions on the use of pesticides and on the number of chemical compounds officially registered for pest control in durable food products. Moreover, the use of methyl bromide for the fumigation of food commodities and facilities must be phased out in accordance with the Montreal protocol due to its effect on the ozone layer (UNEP, 2006). The development of alternative treatments for pest control is an increasing demand from the food industry and has been promoted by governments through legislation and the funding of research projects. Alternatives should meet consumer demands for the reduced use of elimination of pesticides, while at the same time maintaining a high degree of control efficacy.

This modified atmosphere storage has many advantages compared to conventional methods of storage (Rahman and Talukder, 2006). Atmospheres which could be utilized for this purpose in grain storage are those with reduced $O_2$and those with increased CO_2 content or a combination of the two. Means of producing such atmospheres include the purging of airtight silos or containers with CO_2 from CO_2 cylinders. Carbon dioxide causes a progressive hypoxia or anoxia when used alone at a high purity level. The problem with CO_2fumigation requires high level of airtightness/ airtight containers to retain the required gas concentration throughout the fumigation period. In the present study, airtight acrylic container was designed and developed for the CO_2 fumigation. PVC bins available in the local market was made airtight for fumigating the grains with CO_2. Also, automatic gas control system was developed for regulating the CO_2 concentration by setting the time.

2. Methods and Materials

2.1 Design and development of acrylic bin for carbon dioxide fumigation

Lab modelCO_2 fumigation set up was designed and fabricated at Indian Institute of Crop Processing Technology, Thanjavur. It consists of a circular outer acrylic cylindrical tube with the dimension of 37 x 27 cm (ht x dia) which is pasted on a flat acrylic sheet at the bottom. At the top of the acrylic bin, PVC (Poly Vinyl Chloride) end cap was used to make the set up air tight so that itsmore suitable for carbon dioxide fumigation. Provision for gas inlet and outlets were also provided to maintain the required concentration.

Fig 1. Acrylic bin for CO_2 fumigation

2.2 PVC bins for Carbon dioxide fumigation

PVC bins available in the local market with 100 kg capacity was made airtight by placing a rubber gasket on the top lid of the PVC bin. Provisions were given on the top, middle and bottom of the bin and were connected with gas tubes to measure the concentration of carbon dioxide at all the places.

Fig 2. PVC bin for CO_2 fumigation

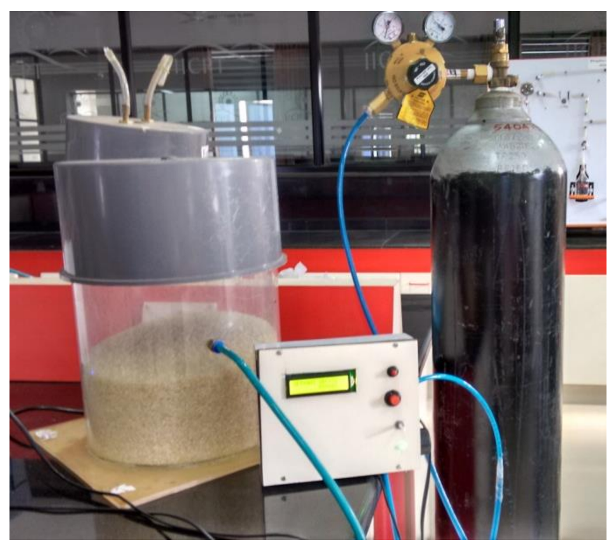
Retention of carbon dioxide for a period of 30 days was recorded. Carbon dioxide was flushed from the bottom of the bin and the CO_2 concentration was measured using CO_2 analyzer to monitor the carbon dioxide concentration.

2.3. Automatic carbon dioxide gas controlling system

Automatic gas controlling systemwas developed to set the fumigation timings. This system consists of Transformer, Power card, Power supply Board, Micro controller Board, LCD, Gas control valve and Relay Board.

Transformer will step down the power supply voltage (0-230V) to (0-6V) level. Power card and power supply board helps to supply power to the unit.

Time control unithas automatic on/off mechanism by which we can set the fumigationtime from 3



seconds to 2 hours. CO_2 is flushed into the system

Fig 3. Gas controlling system

with the required concentration of CO_2, the fumigation time required was standardized.Once it is standardized the time, the automatic on/off system helps to stop the flow of CO_2 from the cylinder to the bin through gas control valve.

Micro controller is a standalone unit, which can perform functions on its own without any requirement for additional hardware like I/O ports and external memory.

Liquid Crystal Displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal. LCD consists of two glass panels, with the liquid crystal material sand witched in between them. When the LCD is in the off state, light rays are rotated by the two polarizers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarizers, which would result in activating / highlighting the desired characters.

Relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are doublethrow switches.

3. Results and Discussion

3.1 Evaluation of different bins for CO2 fumigation

CO_2 and O_2 concentration in acrylic bin is given in (Fig. 4). CO_2 concentration decreases as the no. of days prolongs with increased O_2 in both the bins (fig 4 and 5). CO_2 concentration in acrylic bin was decreased from 29.00 % to 22.84 %, whereas incase of PVC bin CO_2concentration was decreased from 28.20 to 20.40 % in (fig 5). Acrylic bin with end cap has better CO_2 retention than PVC bins. From the farmers point of view, PVC bins are cheaper and readily available in the local market can be exploited for fumigation purpose, whereas acrylic bins are comparatively costlier and are not available in the market. Several researchers have investigated the use of CO_2 as an inert gas on different insect pests of grains. The exposure period can be reduced if the concentration increases. The use of carbon dioxide as a fumigant is accepted by biodynamic and organic market as it is not considered to be a chemical treatment. High concentrations of CO_2 have been shown to be effective in controlling various stored product insect pests (Bendall*et.al*, 2002 and George, 1998). From the present research study, CO_2 concentration at 40 % for the period of 15 days is effective in controlling major stored product pests of rice.

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