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Safe Storage Guidelines for Soybeans at Different Temperatures and Moisture Contents

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Abstract

Poor storage capacity of soybean makes it prone to fungal spoilage and heating during storage, resulting in lower quality. Early prediction of the fungal spoilage in stored soybeans is very difficult because fungi are often too small to be seen with the naked eye. Here a new method for fungus to early detection is adopted: it is called counting fungal spores. Soybeans with moisture contents of 11.4, 12.1, 13.0, 13.9, 14.3 and 14.7%, were held at 6 temperatures 10, 15, 20, 25, 30 and 35℃ for180d. Samples were taken at regular intervals and the fungal spores counted. The safe storage conditions (temperature, moisture content, duration) were estimated by means of a curve fitted using the power function fitting. It can predict of soybean spoilage by fungus before there is visible damage.

Keywords: soybean, storage, fungal spoilage, early prediction, spores

1. Introduction

The tolerance of soybean to storage is poor, and the phenomenon of fungal spoilage and caking occurs easily. The storage of fungus is one of the main factors affecting the storage safety of soybean (Shelar and Shaikh, 2008). The study of soybean moisture, storage temperature and fungal growth is an important research direction to solve the early prediction of fungus damage in soybean storage. In recent decades, many reports on soybean storage fungi have been reported, in China and elsewhere in the world. Milner (1946) discovered that fungal infections could lead to a decline in soybean quality, and the increase of respiration and free fatty acids in soybean storage was mainly caused by the growth of harmful fungi. Kennedy (1964) conducted a survey of soybeans in five U.S. states, and found that the main growing fungus in soybeans was Aspergillus glaucus. Dorworth (1968) found that when the soybean moisture was 12.0 to 12.5% mc (moisture content), the storage fungus would slowly infect the soybean. As the moisture content increased, the infection rate increased gradually. Wilson (1993) showed that soybeans at10.5% mc can be stored at any temperature with no fungal growth. There are also some other related research reports about the safety storage and quality of soybeans (Hou et al., 2002; Wilson et al., 1995; Kong et al., 2009).

However, few studies have been reported on the early detection of fungal hazards in soybean storage.

Most of the grain storage fungi have aerobic growth characteristics. During grain storage, under suitable conditions, fungi begin to grow on the grain surface. This paper adopts a new method for early detection of grain storage fungi, which is counting fungal spores, and the prediction of the spoilage of stored soybeans by fungi. By studying the growth of fungi in soybeans with different moisture contents stored at different temperatures, the relationship between soybean moisture and temperature and initial growth time of fungi was preliminarily established, so as to provide safe storage guidelines for soybean storage.

2. Materials and Methods

Samples of soybean harvested from Heilongjiang Province

The soybean moisture was adjusted to 11.4, 11.4, 12.1, 13.0, 13.9, 14.3 and 14.7% respectively by the way of natural drying of water, or spraying water and holding at 4℃ about one month. Then the samples were packed in 1.0L bottle and kept in closed storage in a thermostat at different temperatures (10, 15, 20, 25, 30 and 35℃). Samples were taken every 10d. The moisture content was determined by oven method (105℃ for 3h). The growth of the fungus in the stored grain was determined by counting fungal spores.

Counting fungal spores

Ten g of soybeans were placed in 80 mL test tube, 30 mL of water added, stoppered, shaken for 1 min. The water was filtered through 60-80 um mesh filter cloth, and the filtrate siphoned into the count area of blood cell count board. Fungal spores were counted under a microscope at 600-800 times magnification. This method has been used for repeated experiments on wheat and rice samples with different levels of infection (n = 8), and the relative standard deviation (RSD%) range was 8.2 to 31.4% (Cheng et al. 2011). The fungal spore count correlates well with the plate colony plate counts, the correlation coefficient was $R^2 = 0.8479$ (Cheng et al., 2011). The method is based on the traditional cell counting method. By detecting the concentration limit of fungi spores ($1 \times 10^5.g^{-1}$), it eliminates the interference of fungal spores carried by the sample of no fungal growth, and achieves the purpose of only detecting fungal growth during storage. This method can detect fungal growth on the grain surface before it is seen with the naked eye. If fungi only grow a little, the growth of fungi can be detected presences of spores.

3. Results

The relationship between soybean moisture, storage temperature and the fungal growth was studied by regular sampling. The results showed that soybean storage was safe up to 11.5%mc. About 12.0%mc is the critical moisture for soybean fungus growth, and with the increase of moisture the growth of fungi will accelerate gradually. When the soybean is stored under 15℃, the low temperature inhibits the growth of fungi. Soybean stored over 20℃, might see fungi growth.

Most of the grain storage fungi have aerobic growth characteristics. During soybean storage, under suitable conditions, fungi begin to grow on the grain surface first. According to this feature, the method of counting fungal spores can detect the growth of fungi at the early stages before the infestation can be seen by the naked eye. This allows for early detection and warning of fungal growth.

The concentration of fungi spores 1 to $3 \times 10^5 g^{-1}$was determined as the initial growth limit, and the initial growth time of fungi was recorded by regular detection. The initial growth time was plotted with storage temperature and fitted using a power function curve. The predictive relationship between storage moisture and temperature and initial growth time of fungi was obtained (Fig. 1).

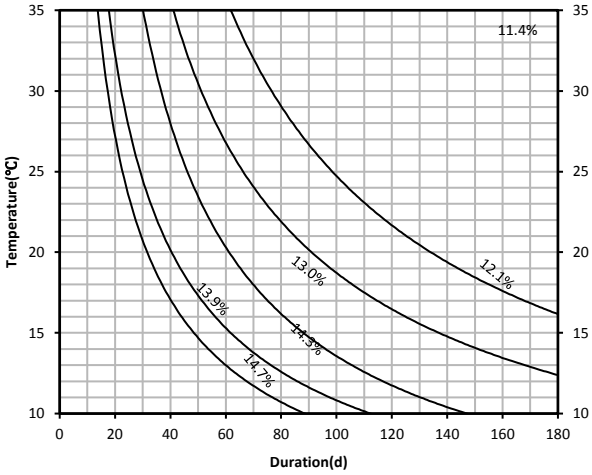

Fig.1 The conditions, temperature, time, and moisture content where there are1 to 3×10^5 g^{-1}fungal spores.

For a given moisture content with a given temperature the duration that soybean can bt safely stored is estimated. This curve is completed under isothermal conditions. Due to the large climate changes in the regional grain storages, the actual situation of local grain storage should be taken into consideration when using this curve.

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Evaluation of aflatoxin contamination of stored maize in the Brong-Ahafo region of Ghana

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Abstract

This study assessed the aflatoxin contamination and the presence of fungi in three maize varieties (*Obatanpa*, *Abontem* and *Aburohemaa*) stored using different storage methods namely storage in hermetic bags, woven polypropylene sacks and local crib in the Nkoranza-South district of the Brong-Ahafo region of Ghana. A factorial design arrangement was laid out in a randomized complete block design (RCBD). The isolation and identification of fungal pathogens associated with maize samples before and after storage were carried out on potato dextrose agar (PDA). Total flatoxin levels in the three maize varieties was determined by the use of enzyme-linked immunosorbent assay (ELISA) at 450 nm wavelength. Six fungi species were identified in the maize namely: *Aspergillus flavus, Penicillium* sp, *Fusarium* sp., *Lasiodiplodia theobromae*, *Colletotrichum gleosporioides* and *Rhizopus*. Before storage, *Abontem* variety recorded significantly higher ($p < 0.05$) total aflatoxin levels (113.56 ppb) compared to *Obatanpa* (2.91 ppb) and Aburohemaa (2.96 ppb). Maize samples stored in the polypropylene sack established significantly higher ($p < 0.05$) total aflatoxin levels of 82.9 ppb compared to hermetic bags (48.9 ppb) and local crib (48.9 ppb) after storage for six months. Aflatoxin levels under the interactive effect of variety and storage method was significant ($p < 0.05$). Overall storage of maize in hermetic bags significantly reduced aflatoxin levels hence the need to encourage maize farmers and traders to adopt hermetic bag storage technology.

Key words: aflatoxin, fungi, maize varieties, *Obatanpa*, *Abontem*, *Aburohemaa*, hermetic bag, polypropylene sack, local crib.

1. Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops grown globally, and it is the third after wheat and rice in total food grain production (Anupama *et al*., 2005). It has a very high adaptability and productivity hence it is produced in most countries of the world (Dlamini *et al*., 2012). Maize is a staple food for an estimated 50% of the population of sub-Saharan Africa (FAOSTAT, 2006). The crop is grown in all the six agro-ecological zones of Ghana and has a cultivated area of 1,023459 ha and an average yield of 1.72 tonne per hectare, making it the major cereal crop (MoFA-SRID, 2015). New varieties with improved quality have been developed in Ghana to increase output. Some improved maize varieties available in Ghana include *Abeleehe, Aburotia, Dobidi, Dorke, Kawanzie, Kwadaso local, Obatanpa, Okomasa, Mamab*a, *Abontem*, and *Aburohema* (Manga, 2010; Tweneboah-Koduah, 2013).

The quality of grain is usually assessed by its germination capacity, weight, microbial contamination, insect infestation and nutritional content. Grain quality is affected by temperature, moisture content, relative humidity, storage period, and several other biological factors (Jayas and White,