Chapter 18 Drying Foods-Determining Drying Rate of Corn and Sunflower Seeds

Introduction

When grains are harvested, they can be stored for a substantial amount of time before being processed. Depending on the harvesting conditions, storage facility, and moisture content of the grains, the quality of the grains can change considerably. Moisture content of the grain can be correlated with the growth of insects, molds, and fungi. It is essential to reduce the moisture content of the grains to ensure quality storage without spoilage. Different industrial methods have been used for grain drying. These methods include natural air/low temperature drying, thin-layer drying, high-temperature bin drying, and column drying. Equations such as the Page equation has long been used to determine the changes in moisture content of grains during drying. The Page equation is shown below:

$$\frac{M(t) - M_e}{M_i - M_e} = \exp(-k \cdot t^n)$$

The variable $M_i$ represents the initial moisture content in dry basis, $M_e$ is the equilibrium moisture content in dry basis, and $M(t)$ is the moisture content change in dry basis as a function of time. Variables $k$ and $n$ are the specific constants for each grain.

Objective

The purpose of this lab is to determine the change in moisture content of yellow-dent corn and sunflower seeds. Thin-layer drying method under variable drying air temperature and relative humidity will be used. The effects of drying air temperature and relative humidity on drying time will also be determined.

Materials and Methods

For this experiment yellow-dent corn and sunflower seed are selected. After the initial moisture contents are determined, the effect of drying air temperature and relative humidity on the drying time will be determined. Initial moisture content of the grains is measured before each experiment. Samples are taken at periodic intervals to measure the moisture content after the drying process has begun. The drying air temperatures for this experiment are 60°C and
70°C, and the air relative humidity values are 30, 40 and 50%. Table 1 shown below displays the variable conditions for each grain.

Table 1. Various conditions for each grain.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Drying Air Temperature °C</th>
<th>Drying Air Relative Humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>40</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>70</td>
<td>50</td>
</tr>
</tbody>
</table>

Graphs and Results

The graphs below show the change of moisture content as a function of time for yellow-dent corn and sunflower seed. Both grains are displayed for Trials 1-6 on the graphs below.

Trial 1
Trial 2

Moisture Content Change vs. Time

\[ y = 0.7915x - 3.6938 \quad R^2 = 1 \]

\[ y = 0.666x - 2.073 \quad R^2 = 1 \]

Trial 3

Moisture Content Change vs. Time

\[ y = 0.7241x - 3.8528 \quad R^2 = 1 \]

\[ y = 0.715x - 2.356 \quad R^2 = 1 \]
Trial 4

**Moisture Content Change vs. Time**

- Sunflower: $y = 0.7915x - 3.6938$  $R^2 = 1$
- Corn: $y = 0.7241x - 3.8528$  $R^2 = 1$

Trial 5

**Moisture Content Change vs. Time**

- Sunflower: $y = 0.715x - 2.356$  $R^2 = 1$
- Corn: $y = 0.7241x - 3.8528$  $R^2 = 1$
Analysis of Results

After the graphs were plotted for each condition further analysis was carried out by the use the Page's equation shown below:

\[ \ln[-y(t)] = \ln(k) + n\ln(t) \]

The slope of the line \(\ln[-y(t)]\) as a function of time \(\ln(t)\) will yield the value for \(n\), while the exponential of the intersection of the \(y\)-axis yields the \(k\) value. The \(k\) and \(n\) values are displayed on Table 2 below for each experimental condition.
Table 2. Values for n and k for each experimental condition.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Drying Air Temperature °C</th>
<th>Drying Air Relative Humidity (%)</th>
<th>n value (Corn)</th>
<th>k value (corn)</th>
<th>n value (Sunflower)</th>
<th>k value (Sunflower)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>30</td>
<td>0.7241</td>
<td>0.0212</td>
<td>0.715</td>
<td>0.0948</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>30</td>
<td>0.7915</td>
<td>0.0249</td>
<td>0.666</td>
<td>0.126</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>40</td>
<td>0.7241</td>
<td>0.0212</td>
<td>0.715</td>
<td>0.0948</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>40</td>
<td>0.7915</td>
<td>0.0249</td>
<td>0.666</td>
<td>0.126</td>
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<td>0.126</td>
</tr>
</tbody>
</table>

Discussion

The drying air relative humidity in relation to the change of moisture content of grains during drying for the same drying air temperature has little effect on it. Table 2 above shows that the n value remained the same when the drying air relative humidity increased. The k value also displays the same characteristics.

The change in moisture content as function time for yellow-dent corn and sunflower seed are displayed for each trial in the graphs above. For each trial the corn had a slightly steeper slope than the sunflower, which indicates that a larger amount of moisture is being removed from the grain in a shorter amount of time.

The purpose for plotting and comparing yellow-dent corn and sunflower seed drying rates is to see how each grain responds to various conditions. The analysis showed that the corn had a faster drying rate than the sunflower flower. The drying rate increased for both grains as the temperature increased. The drying rates for grains remained constant as temperature.

The Page equation was used in this experiment to determine the changes in moisture content of the two grains during the drying process. After plotting the change in moisture content as a function of time, n and k from the Page equation can then be determined. The slope of the line can yield the n value and the y-intercept is used to find k. The equation can be modified with the given coefficients to find the change in moisture content. The altered Page equation is shown below:

\[ \ln[-y(t)] = \ln(k) + n\ln(t) \]