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Experimental Investigation of Drying Parameters for Mass Production of Viable Corns.

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Abstract: Corn are routinely seen dumped in villages and major cities during the peak of harvest. Therefore it is necessary that corn are properly dried and stored to ensure availability and wholesomeness throughout the year. The main objectives of this study are to: (i) Determine the temperature range and moisture contents required for production of viable corn (ii) Validate the viability of the corn so produced by planting them. The moisture contents of corn seeds were measured with a grain moisture meter, (PM400, Japan). Five kg of corn seeds of the same samples A, B, C, D and E containing 32% initial moisture content were dried at 50 ^{0}C, 55 ^{0}C, 60 ^{0}C, 65 ^{0}C and 70 ^{0}C respectively for 80 minutes. As drying progressed, four corn each which were at different moisture contents, different drying time for a particular drying temperature were sow. Sample dried at 50 ^{0}C with moisture contents between 32 and 6 were viable. Viability of the seed was lost at drying time of 80 minutes, which corresponded to 0% moisture content. Samples (B, C and D) dried at 55 ^{0}C, 60 ^{0}C, 65 ^{0}C with moisture contents between 32 and 8; 32; 30.4 and 6; 32 and 4 respectively were viable but viability was lost at a drying time of 70 minutes. Sample E dried at 70 ^{0}C with percentage moisture contents between 32 and 8 were viable but the seeds lost viability at a drying time of 60 minutes. Emergence of sample (A) occurred after 5 days with moisture contents between 32, and 6, likewise samples (B, C, D and E) with moisture contents between 32 and 13.1; 32 and 11.4; 32 and 9.5; 32 and 14 respectively. Also emergence of samples (A, C and D) with 7% moisture contents occurred after 6 days while the emergence of samples (B and E) occurred after 7 days. Corn can be dried at room temperature up till 70 ^{0}C and still remain viable provided the moisture content is not lower than 10% and emergence of corn will occur in 5 days. It takes 6-8 days for emergence of corn when the moisture content is below 10 %.

Keywords: Corn drying, drying temperature, moiture loss, viability

Introduction

In West-Africa and other parts of the world, most of our locally made foods are made up of cereal grains such as maize, rice, millet. Most of these cereal grains are harvested at the peak of the rainy season,

making preservation difficult and causing most of these grains to perish. This results in scarcity in the supply of the grains which leads to subsequent hunger and malnutrition. Meanwhile corns are routinely seen dumped in villages and major cities during the peak of harvest. Therefore it is necessary that corns are properly dried and stored to ensure availability and wholesomeness throughout the year.

Drying is a dual process of heat and mass transfer of moisture from the interior of the product to the surrounding of air (Hall, 1980). Beneth [2], stated that the term drying from the industrial stand point is understood to represent the removal of liquid from a solid by thermal means. Drying also means the removal of water from a suspension or solution of a liquid [1]. Mclean [9], revealed that drying involves the abstraction of moisture from the product by heating and the passage of air mass around it to carry away the release vapour. Drying is a thermo physical and physio-chemical operation by which the excess moisture from a product is removed, Sahay [10].

It can also be define as a process of moisture removal due to simultaneous heat and mass transfer [3]. The objective of this work is to determine the temperature range and moisture contents required for production of viable corn.

Corn Drying

Corn is a cereal grain which is consumed worldwide such that it can be considered as an ultimate gift to mankind. The demand for corn is so paramount that the farmers grow two or more plantation per year, since corn can be processed into variety of food products. Hence, the drying calls for a controlled technique. Corn dries as the moisture from the inside of the kernels is evaporated from the kernel surface. Most of the moisture inside the kernel exits through the tip end of the kernels. The first few points of moisture can be easily removed using relatively little energy. Further moisture must be removed from deep within the corn kernels. As the outside layers of the kernel dry, the moisture must migrate out from the moist center. This moisture does not move to the surface as quickly as it is being evaporated from the surface of the kernel by the drying air. Corn kernel cracking are influenced by the speed of moisture removal and maximum kernel temperature, coupled with the rate of cooling after drying.

Importance of Drying

- Increase storage span: Dry grain is less susceptible to spoilage caused by the activities of fungal and microbial attack [7]. These wastage could be easily prevented by proper drying, which enhances storage of crops and grains over long period of time.
- Ease of handling: Packing and transportation of dry products are easier and cheaper because the weight and volume of dried products are less.
- Permit early harvest of crop: This allows the crops to be harvested on time for drying and instant cultivation and sowing to be possible.
- Grain viability: Since the rate of drying is controlled, the viability of the grain is directly linked to the temperature attained by grains during drying.

Description of Dryer

The cabinet corn dryer operate on the principle of batch drying, Figure 1. The dryer consist of a cabinet containing a drum in which the corns to be dried are poured through the hopper. The drum inside the drying chamber is fixed while the shaft that carries stirring paddles fins rotates. After the corns were loaded, the hopper closed and heated air of about 50 ^{0}C to 70 ^{0}C is blown across the corn from the heater housing through electrical heating element and fan. Both heater and fan terminals are connected to electricity.

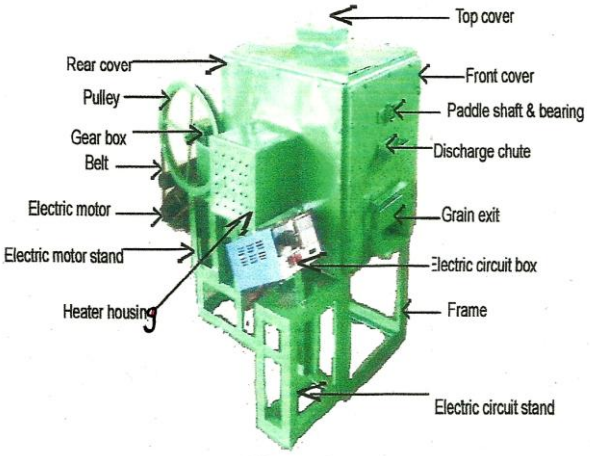

Fig. 1 Diagram view of the developed corn dryer

The heat being supplied by the heater is controlled by a thermostat which turns off the machine if inlet temperature exceeds the actual temperature required for drying. However, a digital thermocouple is used to measure the temperature inside the drying chamber and to regulate the required temperature needed for drying. There is a shaft joined with paddles that passes through the centre of the drum. A sprocket is fixed to this shaft and then connected to the reduction gear box through a chain drive and in turn connected to a pulley on the electric motor that was positioned outside the cabinet. During the drying process the gear box with the aid of an electric motor produce drive to the stirrer continuously. After drying, the discharge pot plate is opened where the dried grains are discharge to the receiving tray.

Materials and Methods

Material: Yellow corn purchased from the farm was used for the experimentation. It was hand shelled and sieved thoroughly with initial moisture content of 32 %.

Equipment for experimentation

The equipment used to take various measurement from the test rig are as follows:

- Grain moisture tester, digital type (PM400, Japan): for measuring the moisture contents of corn.
- Digital tachometer (RAYTEK, ST20, USA): for measuring the fan speed.
- Digital type stop watch (TECNO R7): for recording drying period.
- Weighing balance: for measuring the weight of the corn.

Plate 1 Moisture meter apparatus

Plate 2 Tachometer. Plate 3. Stop watch

Plate 4 Corn sample on a weighing balance

Experimental procedure

The dryer was subjected to Full- load test. Five samples of the same type of corn were used. A corn was weighed with a weighing balance. The procedures are as follows:

- The corn with known initial weight, initial moisture content was thoroughly sieved and poured into the drying chamber inside the dryer.
- A digital thermostat with a temperature sensor fixed to the wall of the drying chamber to facilitate temperature regulation was set at required drying temperature of 50 ^{0}C.
- The stop watch set to (0) minute.
- Power button of the dryer is switched ON at constant electricity supply.
- After 10 minutes in operation, the machine is OFF, the lid of the hopper is removed and a moisture meter is inserted.

Plate1.5 Moisture meter inserted in the drying chamber for readings.

- Moisture content is recorded with a digital moisture meter at four different points around the corn inside the drying chamber at 10minutes interval for a period of 80 minutes
- The same was repeated at a preset drying temperature of 55 ^{0}C, 60 ^{0}C, 65 ^{0}C and 70 ^{0}C.

Performance Parameters.

The following performance parameter for the dryer was estimated: Percentage (%) moisture contents of the sample using the procedure detailed by Handerson et al; (1997) and seed viability test.

Percentage (%) moisture contents

According to Handerson [4], the percentage (%) moisture contents is expressed as:

Where,

M_w=initial moisture content of sample, wet basis (%)

M_d=final moisture content of sample, dried basis (%)

Moisture Content (M.C)=$\frac{M_w - M_d}{M_w}$ x100 (1)

Viability test

Five kg of corn at 32 % moisture content were poured into the drying chamber. In order to ascertain the viability of the kernel, the moisture content as drying progressed of corn samples dried at these drying temperatures were immediately recorded. Viability was determined by picking four (04) pieces of corn from sample A with 32 %, 31 %, 29 %, 25 %, 20 %, 15 %, 10.3 %, 6 % and 0 % moisture level dried at 50 ^{0} C for a drying time of 80 minutes until there is no moisture in the corn. The selected corn kernels were sow in a polythene bag containing two corns each for a period of 5 days.

The same numbers of corn were also picked at 55 ^{0}C, 60 ^{0}C, 65 ^{0}C and 70 ^{0}C with moisture contents 32 %, 30.7 %, 28 %, 23.4 %, 18.4 %, 13.1 %,8 % and 0 %; 32 %, 30.4 %, 26.9 %, 22 %, 17 %, 11.4 %, 6 % and 0 %; 32 %, 30 %, 26 %, 21 %, 15.5 %, 9.5 %, 4 % and 0 %; 32 %, 29 %, 25 %, 20 %, 14 %, 8 % and 0 % for sample B, sample C, sample D and sample E respectively as indicated in table 1.

Dryer efficiency

The dryer efficiency is given by [11].

where, M =Mass of corn (kg)

L = Specific latent heat of vapourization of water, (kJ/kg)

T_d = Temperature of the dryer (^{0} C)

A = Area of the drying chamber (m^2)

t = Drying time (min)

Dryer efficiency, $(\eta_{d)}) = \frac{ML}{AtT_d}\ x\ 100$ (2)

$= \frac{5\ x\ 2256}{0.54\ x\ 0.44\ x\ 10\ x\ 50}\ x\ 100 = 95\ \%$

Results and Discussions

Results

Table 1 shows the percentage moisture contents and moisture losses of different samples of the corn at various temperatures with a digital moisture meter. Also, from the results of moisture content and average moisture loss presented in Table 1, the moisture contents of all corn samples (A to E) at 0 minutes (control samples) were 32 %. At 70minutes the moisture content of dried sample A at 50 °C was 6 %, but 8 %, 6 %, and 4 % moisture content dried sample B, sample C and sample D were recorded in 60 minutes at temperature 55 °C, 60 °C, and 65 °C respectively. However at 50 minutes the moisture content of dried sample E at70 °C was 8 %. The result also agreed with the suggestion by [12], that drying corns at 70 ^{0}C was the lowest temperature that destroyed viability of 21 % moisture content.

Table 1

Time (min)	Sample A 50^{0}C	Sample B 55^{0}C	Sample C 60^{0}C	Sample D 65^{0}C	Sample E 70^{0}C
0	32	32	32	32	32
10	31	30.7	30.4	30	29
20	29	28	26.9	26	25
30	25	23.4	22	21	20
40	20	18.4	17	15.5	14
50	15	13.1	11.4	9.5	8
60	10.3	8	6	4	0
70	6	0	0	0	0
80	0	0	0	0	0

Percentage (%) moisture content at various drying temperature and time at speed I (1400rpm)

where, Sample A = Corn dried at 50^{0}C
Sample B = Corn dried at 55^{0}C
Sample C = Corn dried at 60^{0}C
Sample D = Corn dried at 65^{0}C
Sample E = Corn dried at 70^{0}C
t = Drying time (minutes)

However, the percentage average moisture losses are 4.0 %, 4.57 %, 4.42 %, 4.57 % and 5.33 % obtained from dried corn respectively confirmed that corn dried at 70 ^{0}C got dried faster than corn dried at 50 ^{0}C, 55 ^{0}C, 60 ^{0}C, and 65 ^{0}C.

Fig 1, illustrates the effect of drying time on moisture content at various drying temperatures and time at speed I (1400 rpm). The drying curve in Figure (1) indicates that the drying time increases as moisture content decreases. Also the drying curves were observed slopping down as the drying time increases. This indicates fall in drying rate as drying process progresses.

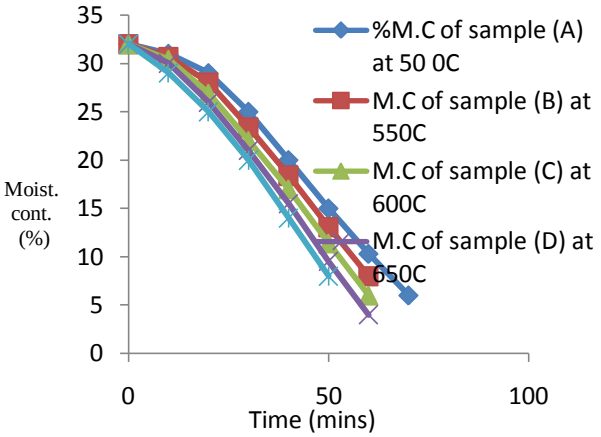

Fig 1 Moisture content versus drying time of corn at various drying temperature and time at (1400rpm)

Seed viability results

Plate 1 shows the results of four sample corn seeds which were picked from corn samples A, B, C, D and E, dried at 50 ^{0}C, 55 ^{0}C, 60 ^{0}C, 65 ^{0}C and 70 ^{0}C drying temperatures with the various percentage moisture contents were planted.

Plate 1 Planting of corn samples at various drying temperatures.

Germinated seed are called viable seeds while those that do not germinate are also known as non-viable seeds

Plate 2 Emergence of corn samples at various drying temperatures after 5 days.

Plate 2 shows the results of emergence corn dried at 50 ^{0}C, 55 ^{0}C, 60 ^{0}C, 65 ^{0}C and 70 ^{0}C drying temperature on each corn samples A, B, C, D and E with the various moisture contents after 5 days of planting. The corn that emerge are viable and the corn which does not emerge are non-viable.

Plate 3(a) Front view showing emergence of corn samples at various drying temperature after 7 days.

Plate 3(a) shows corn sample (A & C) dried at 50 ^{0}C and 60 ^{0}C with moisture contents of 32 %, 31 %, 29 %, 25 %, 20 %, 15 %, 10.3 % ; 32 %, 30.4 %, 26.9 %, 22 %, 17 %, 11.4 % took 5 days to emerge while it increases to 7 days for 6% moisture content respectively. This indicate that at 6 % moisture content the number of days for emergence increases to 7 days due to low moisture contents and for moisture contents between 32 % to 10.3 % took 5days to emerge.

Also from Plate 3(a) sample (B & E) showed similar behavior in which the initial emergence was recorded in 5 days with corn dried at 55 ^{0}C and 70 ^{0}C with moisture content of 32 %, 30.7 %, 28 %, 23.4 %, 18.4 %, 13.1 % ; 32 %, 29 %, 25 %, 20 %, 14 %, while it took 6 days for 8 % moisture content to emerge respectively. This revealed that corn dried between 32 % to 13.1 % germinate in 5 days while at 8% moisture contents germinates in 6 days showing that the corn has low moisture content.

Furthermore, plate 3(a) sample (D) indicates that it took 5 days to emerge for corn dried at temperature of 65 ^{0}C with moisture contents 32 %, 30 %, 26 %, 21 %, 15.5 %, 9.5 %, while it took 7 days for 4 % moisture content to emerge, this implies that the corn has low moisture content but corn dried at 65 ^{0}C with moisture content between 32 % to 9.5 % emerges in 5 days.

Table 2(a) to (e) shows the results of the corn dried from 32 % initial moisture content to final moisture content (0 %) of each corn samples A, B, C, D and E, and at a drying temperatures of 50 ^{0}C, 55 ^{0}C, 60 ^{0}C, 65 ^{0}C and 70 ^{0}C for 10 minutes interval. Four sample corn seeds were planted two by two at different drying time and percentage (%) moisture contents. All were viable from drying time of (10 to 70) minutes for a drying temperature of 50 ^{0}C, (10 to 60) minutes for drying temperatures of 55 ^{0}C to 65 ^{0}C, and (10 to 50) minutes for a drying temperature of 70 minutes. The total number of corns that germinates or which does not germinates are regarded as viable or non-viable and recorded against each moisture contents of each samples.

Table 2(a)

Drying time (min)	**Moisture contents (%)**	**No. of viable corn**
0	32	4
10	31	4
20	29	4
30	25	4
40	20	4
50	15	4
60	10.3	4
70	6	4
80	0	Non- viable

Viability of corn dried from 32% initial moisture of sample A at 50°C

From Table 2(a), it is revealed that corn dried at 50^0C with moisture content of 32 %, 31 %, 29 %, 25 %, 20 %, 15 %, 10.3 % and 6 % were remarkably viable, but viability was destroy at 80 minutes, an indication that percentage moisture content is 0 %.

Table 2(b)

Drying Time (min)	Moisture Contents (%)	No. of viablecorn
0	32	4
10	30.7	4
20	28	4
30	23.4	4
40	18.4	4
50	13.1	4
60	8	4
70	0	Non- viable
80	0	Non- viable

Viability of corn dried from 32% initial moisture of sample B at 55°C

Table 2(b, c, d) indicates that corn dried at 55 ^{0}C, 60 ^{0}C, 65 ^{0}C with moisture contents 32 %, 30.7 %, 28 %, 23.4 %, 18.4 %, 13.1 %, and 8 %; 32 %, 30.4 %, 26.9 %, 22 %, 17 %, 11.4 % and 6 %; 32 %, 30 %, 26 %, 21 %, 15.5 %, 9.5 % and 4 % respectively were viable but viability was destroyed at 70 minutes indicating no moisture content present.

Table 2(c)

Drying time (min)	Moisture contents (%)	No. of viable corn
0	32	4
10		4
20	26.9	4
30	22	4
40	17	4
50	11.4	4
60	6	4
70	0	Non- viable
80	0	Non- viable

Viability of corn dried from 32% initial moisture of sample C at 60°C

Table 2(d)

Drying time (min)	Moisture contents (%)	No. of viable corn
0	32	4
10	30	4
20	26	4
30	21	4
40	15.5	4
50	9.5	4
60	4	4
70	0	Non- viable
80	0	Non- viable

Viability of corn dried from 32% initial moisture of sample D at 65°C

Table 2(e)

Drying time (min)	Moisture contents (%)	No. of viable corn
0	32	4
10	29	4
20	25	4
30	20	4
40	14	4
50	8	4
60	0	Non- viable
70	0	Non- viable
80	0	Non- viable

Viability of corn dried from 32% initial moisture of sample E at 70°C

Furthermore, Table 2(e) shows that corn with moisture content 32 %, 29 %, 25 %, 20 %, 14 % and 8 % were viable but non- viable at 60minutes, an indication that no moisture content present which were all within the moisture content limit for viability of corns as reported by [6].

Also comparing these viability results with past research project on corn drying by sun-drying, solar etc. The convective corn dryer with a reduction gearbox which reduces the speed of the stirrer/paddle during drying proved to be more efficient and effective due to the fact that heated air is distributed evenly across the corn in the drying chamber.

Conclusion

Generally, drying is very important because it increases the storage life of corns. The moisture loss obtained from dried samples (A, B, C, D and E) at 1400 rpm fan speed at drying chamber temperatures of 50 ^{0}C, 55 ^{0}C, 60 ^{0}C, 65 ^{0} C, and 70 ^{0}C were 4.0 %, 4.57 %, 4.42 %, 4.57 %, and 5.37 % respectively during 80minutes of continuous drying process in comparison with low moisture loss for the drying duration of 4 – 8 days or more as reported by [8], on corn drying with solar and sun-drying.

The viability of the corn obtained from the dried samples shows that corn dried at temperature of 50 ^{0}C for 70 minutes were only viable. Also corn dried at 55 ^{0}C, 60 ^{0}Cand 65 ^{0}C for 60 minutes were only viable while corn dried at 70 ^{0}C for 50minutes were only viable which validate an existing literature review of 60 ^{0}C that destroy viability of corn by some authors on corn drying with high moisture content because of the fact that a stirrer is incorporated in the drying chamber for effective distribution of uniform heated air to the corn.

The results on germination of the corn revealed that it took 5 days for moisture content between 32 % and 8 % germinates, but it took 7 days for 6% to germinate and 8 days for 4 % moisture content to germinate.

Recommendation

The following recommendations are hereby suggested for further work.

- Experimental investigation of different grains apart from corn.
- Optimization of the machine for a higher efficiency.
- Experimental investigation of drying corn at higher temperatures above 70 ^{0}C.
- Investigation of other drying parameters such as air flow rate, relative humidity among others.

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