International Journal of Engineering and Applied Sciences (IJEAS)
ISSN: 2394-3661, Volume-3, Issue-4, April 2016

Performance Evaluation of a Small Scale Maize Grains Dryer

Ibrahim S. O, Fashina A. B., Akande F. B., Sanusi B. A.

Abstract— **Maize is a food material for both humans and animals and its production and preservation is therefore important so as to make it available and affordable throughout the year. The preservation of surplus crops including maize can be regarded as one of the first and most important processing technique. Maize is usually harvested with high moisture contents that make its storability difficult, to avert this maize dryer was developed and its performance evaluated.Freshly harvested maize [DMR –Yellow) collected from the agricultural engineering demonstration farm of the polytechnic, Ibadan, Saki Campus was used as test materials. In order to assess the performance of the dryer in form of uniformity in temperature distribution, temperature distribution test was conducted. Performance of the dryer was tested by introducingshelled maize of 35%(wb) initial moisture content into the dryer. Samples were collected from the dryer at an interval of 30 minutes until the drying time was 4.5 hours. Moisture contents of the samples collected were determined. The results of temperaturedistribution tests showed that the dryer reaches an equilibrium state in terms of temperature distribution after the 15th minute of operating the dryer irrespective of the set temperature and air velocity. The values of moisture contents decrease progressively from 34.70 to 13.57 % (wb) as the time increases from 0.0 to 4.5 h at 40 ^{o}C. It decreases from 34.70 to 13.35 % (wb) and from 34.70 to 12.23% (wb), at 45^{o}C and 50 ^{o}C, respectively, within the same time frame. There is a progressive decrease in moisture content of the maize grain as the drying time and air velocity increases for all the pre – set temperatures (40, 45 and 50 ^{o}C). It was further revealed that, the reduction in moisture content of the maize grain were faster at higher air velocities and air temperatures.**

Index Terms— **Maize, Dryer, Drying Temperature, Drying Time and Air Velocity.**

I. Introduction

Maize (*Zea mays* L.) is the most important cereal in the world after wheat and rice with regard to cultivation areas and total production [1] ;[2]. The name maize is derived from the South American Indian Arawak-Carib word *mahiz*. It is also known as Indian corn or corn in America [3] ;[1]. It was introduced into Nigeria probably in the 16th century by the Portuguese [15]. In Nigeria, maize is known and called by different names depending on the locality. It is called 'igbado'or 'yangan' in Yoruba); 'masara'in Hausa; 'ogbado' or 'oka' in Ibo; 'apaapa' in Ibira; 'oka' *in* Biniand isha; 'ibokpot' or 'ibokpot union' in Efik and 'igumapa' in Yala, [4].

The global production of maize was estimated to about 300 million tones per year. One hundred and forty five million (or about 50 per cent) are produced in USA alone[5]; [3]; [1]. In Nigeria, its production is quite common in all parts of the country, from the north to the south, with an annual production of about 5.6 million tones in 1992.In Nigeria, maize produced per year is far below the total demand of the country. This is reflected in the daily disequilibrium between supply and demand of the grains, thus, leading to frequent fluctuation in price showing stronger force for demand relative to supply[6]. According to the Food and Agriculture Organisation, Nigeria's maize production rose from 7.1 million tons in 2006 to 7.8 million tons in 2007. Worldwide production of maize was 785 million tones, with the largest producer, the United States, producing 42%. Africa produces 6.5% and the largest Africa producer is Nigeria with nearly 8 million tones, followed by South Africa. Africa imports 28 % of the required maize from countries outside the continents [7]. Since maize is a food material for human and animal, it should not only be available but affordable throughout the year. The concept of food security proposes that food should be available, accessible and affordable, when and where needed in sufficient quantity and that this state of affair should be sustained every time [8].

According to [9], the bulk of maize grains produced in Nigeria were from the South-West ecological zone. They also reported that Western Nigeria generally produced about 50% of Nigeria green maize, the remaining 50% being split between the North and the east. Although large proportion of the green maize is still being produced in the southwestern part, there has been a dramatic shift of dry grain production to the savanna, especially the Northern Guinea savanna[10]. South West can now be regarded as the maize belt of Nigeria, if production and post-harvest handling are well planned. In this zone, farmers tend to prefer maize cultivation to sorghum.

The preservation of surplus crops and farm produce can be regarded as one of the first and most important techniques of crop processing. The techniques selected for preservation of a particular crop in a particular area will depend on a number of factors such as, the nature of crops, climatic conditions, availability of materials and the degree of technology available [11].

Drying reduces the amount of water contained in the crop after harvest to an acceptable level for marketing, storage or processing [12].Both grain temperature and moisture content are critical in maintaining quality. Mould and insect activities are greatly reduced if grains are stored at temperatures below 15^{o}C at safe moisture levels for storage. The safe moisture content for maize storage is 14% (wb). However, these depend on grain variety, length of storage, storage structure, and geographical location.

Ibrahim S. O, Agricultural Engineering Department, The Polytechnic, Ibadan, Oyo State

Fashina A. B., Agricultural Engineering Department, LadokeAkintola University of Technology, Ogbomoso,OyoState.

Akande F. B., Agricultural Engineering Department, LadokeAkintola University of Technology, Ogbomoso,OyoState.

Sanusi B. A., Agricultural Engineering Department, The Polytechnic, Ibadan, Oyo State

The major input in a drying process is the heat which raises the temperature of the inlet air which is blown through a static grain bulk to be dried. The wet grains can only be dried if the inlet air conditions are drier than the wet grain. This means that the moisture contained in the inlet air can be removed by raising its temperature, thus, increasing its ability to remove moisture from a wet grain. The exit air which leaves the dryer after passing through the wet bulk of grain could accumulate and subsequently condense within the dryer if there are no adequate exit channels and if the airflow rate is low [13].

Also, during drying, the conditions of grains nearest to the inlet are always different from those nearest to the outlet and continue along single line within the bulk. These differences may occur as temperature of the air voids between grains and as moisture contentof the grain when the progression of the air fronts are not uniformly distributed [14].

II. MATERIALS AND METHODS

Freshly harvested maize (DMR-Yellow) of different moisture content was the major material for this study. The maize samples were collected from the Agricultural Engineering experimental farm of The Polytechnic Ibadan, Saki Campus, Nigeria.

2.1Description and mode of operation of the dryer

The dryer is an in-bin type with agitator. It has a cylindrical bin as the drying chamber, with slanting and perforated floor. A shaft placed at the center of the cylinder with spikes at alternate sides to each other serves as agitator. The agitating shaft is driven by a gear type electric motor. The upper lid of the cylinder is perforated and an opening cut-out to serve as inlet (grain hopper) for the grain to be dried. Heated air is forced into the cylinder by a centrifugal fan blowing directly on a heater element. The heated air picks moisture from the grains as it comes in contact with the grains in the chamber and releases same to the atmosphere through the perforated lid of the bin. The agitator ensures even distribution of the air by reducing the resistance to air flow. Figure 1 shows the Isometric view of the dryer.

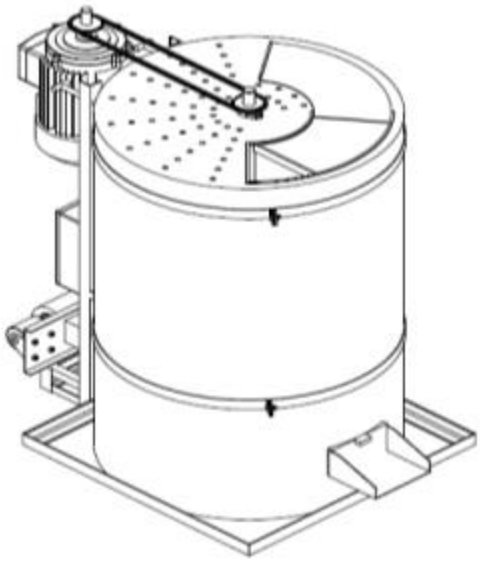

Figure 1: Isometric view of the dryer

2.2. Performance Evaluation of the Dryer.

Preliminary tests were conducted on the dryer to test the air flow and temperature distribution in the dryer. This was done by running the dryer empty and setting the temperature at 40°C, 45°C and 50°C in turns. The air velocity was also set at 2.2m/s, 2.5m/s and 2/8m/s in turns. A digital anemometer was used to determine the air temperature and air velocity for different combinations at an interval of 5minutes and the data recorded. This was done to calibrate the dryer and obtained uniformity in air velocity and temperature distribution within the drying chamber.

Detailed tests were carried out to determine the drying rate in the drying chamber at different air velocity and air temperature combinations and also test the time it takes the dryer to effect maize drying to safe storage moisture content of 13 % (wb). Test samples were taken from the drying chamber at an interval of 30 minutes and the moisture contents determined for different combinations of air velocity, air temperature and grain bed were recorded.

III. RESULTS AND DISCUSSIONS

The results of dryer's calibration and maize drying with the developed dryer are presented.

3.1.Results of the dryer's calibration

Figures 2(a) to 2(c) show the plots of mean air temperatures within the drying chamber against time for no load Condition at different preset temperature conditions. Figure 2(a) shows that at various air velocities considered (2.2, 2.5 and 2.8 m/s) and at the preset temperature of 40 °C, temperature of the dryer stabilizes to 40 °C at the 15th minute and continues steadily through the 45th minute. At the pre-set temperature of 45 °C, and air velocities 2.2, 2.5 and 2.8 m/s, the dryer temperature stabilizes to 45 °C and continues steadily through the remaining time of the test, this could be seen in Figure 2(b). Similar pattern was observed in Figure 2(c) when the pre-set temperature was set at 50 °C and the air velocities were 2.2, 2.5 and 2.8 m/s. These show that the dryer temperature stabilizes to a desired value relative to the pre-set temperature after running the dryer for fifteen minutes irrespective of the three air velocities employed. [15],observed a similar for the preliminary test of a cabinet dryer.

3.2 Effects of drying time and air velocity on moisture content of maize grain at various pre- set temperatures

Table 1 shows the descriptive statistic of moisture content with time and air velocity at various drying temperatures. At 40 °C air temperature and 2.2 m/s air velocity, the moisture content of maize grain decreased from 34.7 % wb to 14.6 % wb as the time of drying increased from 0.0 h to 4.5 h. At 40 °C air temperature and 2.5 m/s air velocity, moisture content of the grain reduced from 34.7 % wb to 13.5 % wb as time increased from 0.0 h to 4.5 h. similarly, at 40 °C air temperature and 2.8 m/s air velocity, the moisture content of maize grain decreased from 34.7 % wb to 12.6 % wb as the time of drying increased from 0.0 h to 4.5 h.

Table 1 further revealed that, at 45 °C air temperature and 2.2 m/s air velocity, moisture content decreased from34.7% wb to 13.9 % wb between 0.0 h and 4.5 h drying time. At 45 °C air temperature and 2.5 m/s air velocity, moisture content decreased from34.7% wb to 13.1 % wb between 0.0 h and 4.5 h drying time. While, at 45 °C air temperature and 2.8 m/s air velocity, moisture content decreased from34.7% wb to 11.5 % wb within the same time frame.

It could also be seen that, at 50 °C air temperature and 2.2 m/s air velocity, the moisture content of maize grain decreased from 34.7 % wb to 13.2 % wb as the time of drying increased from 0.0 h to 4.5 h. At 50 °C air temperature and 2.5 m/s air velocity, the moisture content of maize grain decreased from 34.7 % wb to 12.5. % wb as the time of drying increased from 0.0 h to 4.5 h. At 50 °C air temperature and 2.8 m/s air velocity, it decreased from 34.7 to 10.0 % wb as the time of drying increased from 0.0 h to 4.5h.

There is a progressive decrease in moisture content of the maize grain as the drying time and air velocity increases for all the pre – set temperatures (40, 45 and 50 °C). It was further revealed that, the reduction in moisture content of the maize grain were faster at higher air velocities and air temperatures.

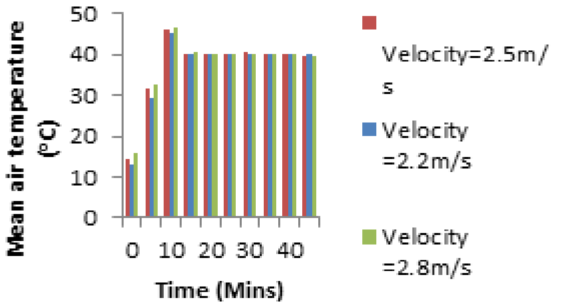

Figure 2(a): Mean air temperature with time at a temperature of 40 °C

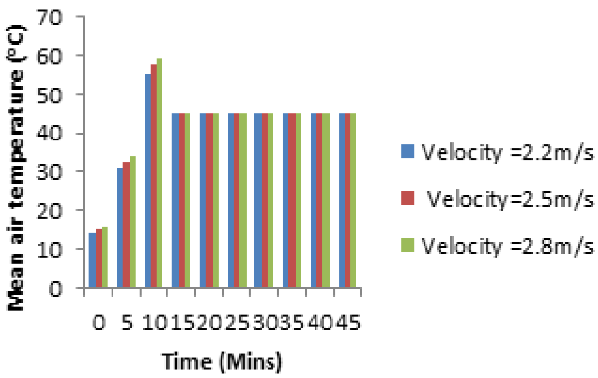

Figure 2(b): Mean air temperature with time at a preset temperature of 45°C

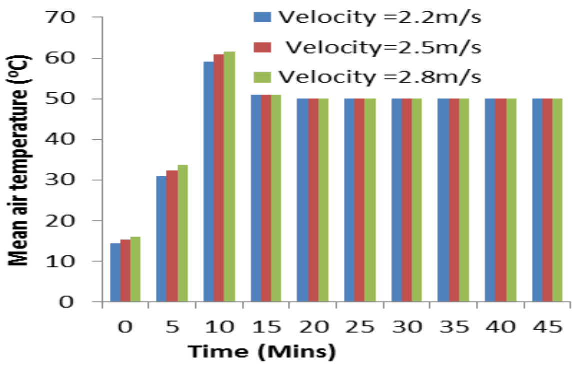

Figure 2(c):Mean air temperature with time at a preset temperature of 50°C

Table 1: Descriptive statistic of moisture content with time and air velocity at various drying temperatures

Process parameter	Time (h)	2.2 (m/s) mc	SD	2.5 (m/s) mc	SD	2.8 (m/s) mc	SD
Temperature (40°C)	0.0	34.7	0.10	34.7	0.10	34.7	0.10
	0.5	31.6	0.12	29.5	0.10	28.5	0.13
	1.0	29.8	0.10	28.1	0.12	27.5	0.10
	1.5	28.5	0.11	27.1	0.10	25.9	0.12
	2.0	26.4	0.10	25.1	0.10	24.5	0.10
	2.5	23.5	0.10	21.5	0.12	20.8	0.10
	3.0	21.6	0.13	20.0	0.10	19.1	0.13
	3.5	19.8	0.10	18.5	0.11	17.7	0.10
	4.0	17.2	0.12	16.7	0.10	15.3	0.10
	4.5	14.6	0.10	13.5	0.13	12.6	0.11
Temperature (45°C)	0.0	34.7	0.10	34.7	0.10	34.7	0.12
	0.5	31.2	0.10	29.5	0.10	28.1	0.10
	1.0	29.5	0.11	27.5	0.12	26.0	0.11
	1.5	28.1	0.10	26.8	0.10	25.9	0.10
	2.0	26.2	0.12	25.1	0.10	24.5	0.10
	2.5	23.6	0.10	21.5	0.11	20.8	0.12
	3.0	21.1	0.11	19.5	0.10	18.5	0.10
	3.5	19.6	0.13	18.2	0.12	17.5	0.13
	4.0	17.1	0.10	16.5	0.10	14.1	0.11
	4.5	13.9	0.13	13.1	0.13	11.5	0.10
Temperature (50°C)	0.0	34.7	0.10	34.7	0.10	34.7	0.10
	0.5	30.9	0.10	28.0	0.12	26.3	0.11
	1.0	29.1	0.12	27.5	0.10	26.0	0.10
	1.5	27.4	0.10	26.1	0.11	25.2	0.12
	2.0	25.0	0.10	23.1	0.10	22.5	0.10
	2.5	23.5	0.13	21.5	0.13	20.8	0.10
	3.0	21.3	0.10	19.1	0.10	18.5	0.11
	3.5	19.1	0.10	18.2	0.12	17.0	0.10
	4.0	16.7	0.10	15.5	0.10	13.5	0.12
	4.5	13.2	0.12	12.5	0.10	10.0	0.10

IV. CONCLUSIONS

The test for uniformity in heat distribution within the drying chamber at different test conditions showed that there was a sharp rise in temperature within the chamber for a short time at the beginning of the test. However, uniformity in temperature distribution within the drying chamber was observed at about 15 minutes to the start of the test.The dyer was able to reduce maize with initial moisture content 34.7 % (wet basis) to between 14.6 and 10 % (wet basis) within the time frame of 4.5 h depending on the air temperature and air velocity employed.

REFERENCES

[1] J.Silvertown and D.Charlesworth (2009).Introduction to plant population biology.John Wiley and Sons, *2*, 187-231.

[2] G. E. Wickens, (2001). *Economic botany* (pp. 1-16).Springer Netherlands**.**

[3] M.Rahmatullah, A. Khatun, N. Morshed, P.K. Neogi, S. U. A. Khan, S. Hossan and R. Jahan, (2010). A Randomized Survey of Medicinal Plants used by Folk Medicinal Healers of Sylhet Division, Bangladesh. *Advances in Natural & Applied Sciences*, *4*(1), 87-94.

[4] IITA,.(2007). International Institute for Tropical Agriculture annual report, 2007.

[5] J. Boye, F. Zare and A. Pletch (2010). Pulse proteins: processing, characterization, functional properties and applications in food and feed. *Food research international*, *43*(2), 414-431.

[6] A.B. Olaniyan and E.O. Lucas (2004). Maize hybrids cultivation in Nigeria: a review. *J. Food, Agric. Environ*, *2*, 177-181.

[7] FAO,(2010) . Food grain processing and storage techniques, 5,17-29.

[8] P. O. Agboola (2002). Economic analysis of household level food insecurity and coping strategies in south-western Nigeria. First Seminar Paper (Ph.D.), Department of Agricultural Extension and Rural Development, University of Ibadan, Nigeria, Pp 2-6

[9] B.A. Ogunbodede and S.A. Olakojo.(2001). Development of srigaasiasticatolerant hybrid maize (Zea mays L.) varieties: *Tropical Agriculture Research and Extension 4(1): 201-209.*

[10] J.E. Iken, and N.A. Amusa (2004).Maize research and production in Nigeria. *African Journal of Biotechnology, vol.2, Pp 74 -79.*

[11] J. O. Olajide and O. J.O. Oyelade (2002)Performance evaluation of the strategic grain reserve storage (SGRSP) in Nigeria**.** *Technovation*, 22(7),463-468.

[12] R. G. Moreira and F. W. Bakker- Arkema (2002). A feed forward/feedback adaptive controller for commercial cross-flow grain dryers. *J. Agric. Eng. Res.*, 45: 107-116.

[13] T.K. James, A.R.Henry-Luka and G. Mazza (2006). Flavour retention during rehydration of onion.*Food Process Engineering*, 1, 399- 406.

[14] J.A. Darby (2006).CSIRO Stored grain research laboratory,1,1 - 19.

[15] P.P. Opiriari (2008).Development, performance evaluation and mathematical modelling of a shelled corn dryer. M.Sc. Theses Submitted to the Department of Agricultural Engineering, University of Ibadan, Nigeria.

Dr. A.B. Fashina is an Associate Professor of Agricultural Engineering with specialization in Farm Power and Machinery and Crop Processing and Storage in the Department of Agricultural Engineering of the LadokeAkintola University of Technology, Ogbomoso, Nigeria. He is a Fellow of the Nigerian Institutions' of Agricultural Engineers and Nigerian Society of Engineers, has over 40 scholarly articles in referred journals.

Dr. F.B. Akande is an Associate Professor of Agricultural Engineering with specialization in Farm Power and Machinery in the Department of Agricultural Engineering of the LadokeAkintola University of Technology, Ogbomoso, Nigeria. He is a member of the Nigerian Institutions' of Agricultural Engineers and Nigerian Society of Engineers and a registered Engineer with the Council for the regulation of Engineering in Nigeria. He has over 35 scholarly articles in referred journals and conference proceedings.

Engr. S.O. Ibrahim is a Principal Lecturer with specialization in Farm Power and Machinery in the Department of Agricultural and Bio-Environmental Engineering of The Polytechnic, Ibadan, Nigeria. He is a member of the Nigerian Society of Engineers and a registered Engineer with the Council for the regulation of Engineering in Nigeria. He has over 15 scholarly articles in referred journals and conference proceedings.

Mr. A.B. Sanusi is a Lecturer with specialization in Farm Power and Machinery in the Department of Agricultural and Bio- Environmental Engineering of The Polytechnic, Ibadan, Nigeria. He holds a Master Degree in Agricultural Engineering and has over 10 scholarly articles in referred journals and conference proceedings