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Development of a Corn Drying System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Corn as a staple farm produce are usually harvested at a point or time when the moisture content is more than 25% (wet.basis).,and therefore, it is easily attacked by fungi and other diseases causing organism and even physical damage, thereby reducing the market value of the crop. Drying must be carried out on those products to prevent deterioration. The objectives of this research are to develop a device that can reduce the moisture content of corn using electronic components and equally carryout evaluation on the device. Shelled corns with initial moisture content of between 25-30% (w.b.) is the major material used in this research work. A Heating element incorporated in the device supplied the needed heat which was delivered to the drying chamber by the help of a centrifugal blower. The drying experiment was carried out at three different temperature thus; 45 ^{o}C, 55 ^{o}C and 65^{o}C. The moisture content at this varying temperature was used to determine the drying rate and the drying efficiency. The results showed clearly that the dryer air temperature affect the drying rate, the efficiency of drying, and the quality of the material. It is equally clear that the best drying rate and temperature is 65^{o}C average 4,95% / hour, high efficient at drying temperature 55^{o}C and 65^{o}C equal to 86,27% and 83,51%, and best material quality with dryer temperature 55^{o}C.

Keywords: Drying; Corn; foods; preservation; micro – controller.

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1. INTRODUCTION

A major operation in the food/crop processing industry is Drying, And this operation consumes a large quantity of energy. Dried foods are easy to handle, have longer storage life and can be added to other formulation and preparation. The drying operation is either used for preservation or for certain product manufacturing operations.

Modern Technologies have given birth to improved plant varieties from modern farm practices and modern farm machineries which have resulted into increased in quantities of damp grains available at market centers. Most of this grain must be dried before it is acceptable for storage or processing. [1]. Hot air is what is required for drying wet grain at higher rate, inadequate drying for grain makes it vulnerable to disease infection during storage and if the grains are over dried it reduces the quantity which invariably leads to monetary loss. Usually, when carrying out drying operation, a personnel determine the moisture level of the grain to the desired level but an automatic control system is more dependable.

Drying operations in the food processing industry account for between 10% to 25% of the total energy consumption [1]. The processed food industry is autrailias largest manufacturing industry and it account for 21.3% of total manufacturing turnover in addition to 18.7% of industry value. [2] The main goals in designing and industrial process is to reduce moisture at minimal cost. Presently, climate energy conservation plays a major role to make the process sustainable. To design a more efficient process, energy use and quality changes, as well as heat and mass transfer. Agricultural Machinery and Technology advancement must be under-studied, we have various methods of drying in carrying out the process. (Akipinar et al., 2006). The hydrodynamic conditions in the drying chamber makes it moisture removal and energy consumption reduction to be easy [3]. Loss of moisture during drying of biological materials is accompanied by physical changes and internal structural changes [4] which affect the final quality attributes of the dried product. Therefore, it may also affect the water absorption rate while temporary exposure to high humidity conditions which will, in turn, have an implication on the handling susceptibility of the product (Odilio et al., 2006; Odilio et al., 2010). Most engineers do not realize that drying is a problem of preservation or structural transformations rather than the removal of water (Aquilera, 2003). During the past decade, many advances in technology and methods have emerged with the goal of minimizing degradation of various quality attributes of food products during drying. Therefore, careful selection of drying techniques and the optimization of drying conditions play a significant role. Physical changes (such as deformation of shape and size, as well as color changes and micro structural changes) have a direct effect on consumer decisions in buying a product. Agricultural crops are important for the human diet, depending upon their nature, including vitamins, mineral and fibers. Some crops are highly seasonal and are usually available in plenty. In the peak seasons, the selling price of crops becomes too low, leading to heavy losses for the grower. Furthermore, this leads to an unnecessary stock in the market, resulting in the spoilage of large quantities. Due to its seasonal nature, a need was felt to preserve crops over a period of time for use during off-seasons. Preservation of crops can prevent the huge wastage and make them available in the off-season at remunerative prices. Additionally, the seasonal nature of availability has led to efforts to extend the shelf life of crops by dehydration. Various drying methods have been practiced for dehydrating crops. These technologies need sophisticated equipment and skill training, the adoption of which appears difficult at the field or rural level. There are many drying techniques are available. The most common technique is via air, in which heat is applied by convection, which carries away the vapor as humidity from the product. Examples of this include sun drying and artificial drying. Other drying techniques are vacuum drying and fluidized bed drying, where agricultural products are kept in vacuum conditions and water is used to evaporate and fluidize the material. These methods are suitable for heat sensible crops. Drum drying is another method, where a heated surface is used to provide energy; and spray drying that atomizes the liquid particles to remove moisture, like in milk powders. Special drying and curing techniques are used for preservation of big onion crops. This shows that drying is one of the most important preservation techniques or methods for food crops.

Indonesia have high productivity of corn. The average corn productivity of all varieties was 6,4 tons/ha (Fahni and Sujitrio, 2015). Based on data from the Central Bureau of Statistics [5], each year the production of corn is increasing. In

2015, corn production in Indonesia had reached 19,612,435 tons.

Corn harvesting is done by picking whole skinned corn at a high moisture content of more than 30%. At this situation, corn become more vulnerable to fungi, bacteria, or physical damage. Therefore, it is necessary to do the correct postharvest handling. After harvesting, the corn is peeled and dried until the moisture content reach 20-25%. This is done with purpose that the corn would not be destroyed during the shelling process. The corn is separated from the cob. However, with that value of moisture content, the corn seeds are not safe to store and have to be dried to a moisture content of around 14%. Drying is an important stage in postharvest handling to maintain the quality of corn during the storage period. According to Indonesian National Standard SNI 013920-1995 (BSN, 1995), to maintain the quality of corn seed.

From the previous research, the process of postharvest handling at the farmer level is still done manually where drying is conducted by drying under the sun depending on the weather [6]. Such treatment conditions are very susceptible to *Aspergillus flavus* which produces aflatoxin.

Farmers in Indonesia mostly using traditional method to dried the corn seed, using sun as the heating source and cement floors or tarps as the mats for corn. This method is cheap but very difficult to predict the result because it is depend on the weather. Sun drying have weakness which are the temperature of cement floors cannot be controlled. High drying temperature might result (Fahni and Sujitrio, 2015).

Numerous machines have been developed to dried corn to eliminate these problems also boost the selling price of corn grains due to improved quality. But the existing corn grain drying machines still have many problems. For example, capacity of the machine was too small therefore the product cannot be dried at the same time. The remaining corn will be stacked, wait to be dried. When this happened the contamination of fungi is very high. For drying using bed dryer type, there is provisions for maximum material thickness, therefore to meet the desired capacity by increasing the size of the length and width of the bed without adding to its height, so the machine will need a huge space. In fact, a lot of dryer were not suitable for the farmer needs because it have large capacity and can only be operated by large industries.

Corn drying is an important aspect in the handling and processing of corn. The process of post harvest handling at the farmer level is done manually where drying is conducted under the sun depending on wheather an such treatment conditions are very succeptible to different fungi infection other diseases. Sun drying have weakness which are the temperature of the cement floor be controlled. High drying temperature might result into corn grains to easily break or cracks, when rain suddenly come, the farmer usually bring the corn seed back to the storage house wrapped with the tarps, this treatment can make the corn catches moist and trigger fungi and bacteria to proliferate [7].

The aim of this work is to develop a corn drying system. To achieve this aim, the following specific objectives are set.

i. To develop a prototype of a corn drying system using low energy consumption electronic components.
ii. To evaluate the developed system by carrying out drying at different moisture content

2. MATERIALS AND METHODS

Materials used for this study is shelled corn, the varieties is NK 6328 from Mando market, Igabi local Government Area of Kaduna State. As well as DK 88 varieties from same market. The main components of this device consist of drying chamber/unit, Sensing unit, Heating unit blower, and control panel. Supporting equipment used in the research were temperature data logger, grain moisture tester, thermo hygrometer, hot wire airflow meter.

2.1 Temperature and Humidity Control System (THC)

The Temperature and humidity control system has three main control buttons namely; set, -adjust and +adjust, thus set, -, +.

To set the temperature, press and hold set button, it will display Po, use the adjust keys to change from Po through P5. Select P1, while in P1 press set button to display C (temperature) or H (humidity). When temperature C is displayed

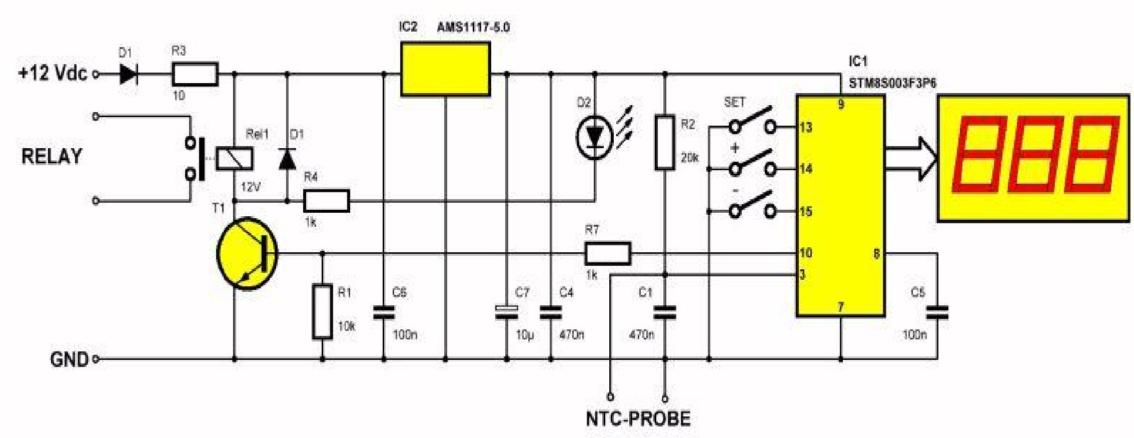

Fig. 1. Circuit diagram of the devise

use the adjust keys to set the required temperature e.g 40c. The same is applied to the moisture content, which is the humidity e.g 20%. After each setting allow the system parameters to automate. Each time the system is switched on, select P1 because Po is the factory initialization

2.2 Summary of the Procedure

Po – Select H
P1 – Select 0.5
P2 – Select 40
P3 – Select 35
P4 – Select 00

Step 1; Switch on the system
Step 2; Press the set switch until Po is displaced, then press + or – button to select between C and H. C means Cool, H means Heat. Select H
Step 3; Press Set to select P1, under P1, obtain 0.5
Step 4; Press Set to select P2 then obtain 40
Step 5; Under P3 obtain 35
Step 6; Under P4 obtain 0.0
Step 7; Under P5 obtain 0

Adjust the temperature to be
40c – OFF
37.5 – ON.

2.3 STM85003F3P6

This is a micro – controller that is programmed to measure temperature and moisture content of various seed at different time. It was programmed to function manually to make the design a universal type, the three buttons are used for inputting a pre – determined values. The first from top is the set button, the second and the third are for varying the values. These buttons are connected to pin 13, 14 and 15 respectively, pin 3 is the input that is connected to the sensor. The sensor can measure both temperature and humidity. Pin 10 is the output pin that is connected to the base of the transistor through a limiting resistor R7. Once the output is high it stimulate the transistor to turn on the relay. See Fig. 1 for the devise circuit diagram.

3. RESULTS AND DISCUSSION

3.1 Drying Rate

Fig. 2 and 3 shows the moisture reduction during drying and the appearance of the grain after drying, respectively. The drying starts at the initial moisture content of 25% wet bases. This prototype drying device could not work for the initial moisture content of the grain more than 30%, because at high moisture content (above 30%), Some grain sticked on the drying chamber thereby causes burnt on the grain. It takes about 4.5 hour to reduce the moisture content into 14% at the air temperature of 65^{o}C. The drying rates is about 4%/hour at air temperature of 65^{o}C. The corn have high tolerant for high temperature during drying, because this product is just for the food and feed. If the corn is used for seed, then the air temperature should not more than 43^{o}C. High drying rate indicates the high performance of the dryer. Indonesian National Standard revealed that the drying rate should 3-5%/hour for corn (SNI 4412-2011 2011).

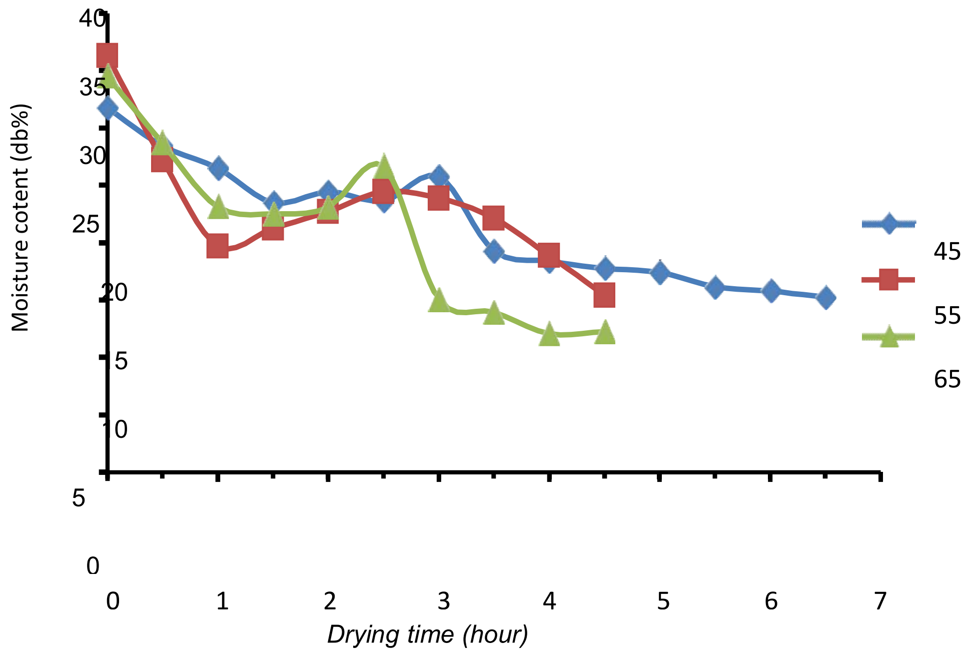

Fig. 2. Moisture content of the material during drying

Fig. 3. Appearance of the grain after drying

Drying is a major operation in the agricultural and food industry. It is often used as a primary operation for preservation of food materials, or as a secondary process in some manufacturing operations. Drying, a higher energy-consuming process, is also often practiced in the industry using direct thermal energy from the sun or driers and ovens. From the viewpoint of preservation of energy, it is desirable to store food at ambient conditions. This can be achieved by drying operations which reduces moisture content and water activity to prevent spoilage under long-term storage conditions. Key benefits of drying are an increased shelf life and a reduction of product volume and weight, which facilitates easy storage and transportation.

Food drying is a complex process involving mass and heat transfer accompanied by physical and structural changes. The combined effect of higher surface area per unit volume and absence of skin shows higher drying rates in many materials. Materials with skin may experience case-hardening during drying. The expected qualities, such as texture and color at the end of drying, depend on physical changes occuring during the drying process. Drying takes place in the falling period for most of the grains and food materials. Many empirical and fundamental models are also available to describe the drying behavior more accurately. Both the increase in drying rate with drying temperature and diffusion of moisture through the material can be described by an Arrhenius relation.

The selection of a drying method depends on product nature, the situation, and provision of energy input. In terms of cost considerations, energy often becomes a key factor. As most food materials possess higher moisture levels, the energy requirement needed for moisture reduction is considerably high. Therefore, reduction of energy in the process is essential in reducing the drying cost. Moreover, reduction of the external volume or shrinkage observed during drying of some materials can cause an adverse effect on the quality of the products expected by the end-customer.

Considering both minimization of energy and achieving quality is essential when selecting a drying method. Significant progress has been made in the recent years in the research and development of drying technology to improve product quality, reduce costs, and improve environmental performance.

4. CONCLUSION

It can generally be concluded that the prototype electronic dryer can be used for drying the shelled corn. The drying rate was obtained 4%/hour at the drying temperature of 65^{o}C. The dryer temperature affects the drying rate, the greater the temperature of the dryer used, the greater the drying rate. This device can only dry shelled corn with a moisture content of less than 30%.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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