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Development of Home-Based Smart Ugali Cooker for Domestic Application

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ABSTRACT

An ordinary house has several chores that need to be done daily or for some days every week. It starts with house cleaning, laundry, kitchen-related chores, and family upkeep. These are works carried out by women in most cases and in most families. However, with the advances, changes, and evolutions being observed in our societies, the case is changing worldwide. Equality in engagement in education and production has brought a balance in such duties which are now carried out by both men and women, from one perspective. On the other perspective, women carry fewer house chores being engaged in other socio-economic activities. Most families and schools in Tanzania and Africa at large take posho (ugali) as a staple food. The whole process of preparing ugali is complex and time-consuming yet other house chores need attention as well. This has increased the need to simplify several house chores since individuals need less contact time with house-oriented activities, and need increased efficiency while putting more focus on other production activities. The development of a home-based smart ugali cooker is rather a needed contribution to the bigger environment of house automation and smart homes. The Home-Based Smart Ugali Cooker is an embedded machine created with the sole aim of easing the process of ugali cooking in households. The machine is created focusing on the smartness of the system, automation, kitchen fitting, neatness, and user-friendliness. This paper illustrates the operations of a home-based smart ugali cooker, which is an embedded system, as well as different components used in creating it. It also explains the advantages it has over the ordinary processes used in preparing ugali and the way forward.

Key Words: Embedded systems, Internet of Things (IoT), Ugali, User-friendly, Ugali cooker, Automation.

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1. INTRODUCTION

Ugali is taken as a daily meal in most families in Eastern and Southern Africa. It is made of a mixture of flour and boiled water. Different types of ugali exist and are prepared in different ways in different countries [1]. These different types are given different names based on societies and the names describe the ingredients used in making the ugali [2]. The different types of ugali each has different nutrient levels [3] and are used for different health purposes. They start with cures, suppressions, and prevention of diseases and disorders and growth. Examples: Cassava ugali is used by many people since it is good at fighting hunger. It lasts longer in the stomach and is also very good for diabetes control [4]. Sorghum on the other hand grows in arid and semi-arid areas. The sorghum ugali is common in such areas because it is also a countermeasure to hunger in dry seasons. Also, there is maize ugali which is commonly known as sembe. It is popular for strength provision and that's why many people prefer it to other kinds of food [5]. The cooking of the ugali process involves the gradual addition of flour in hot water while mixing at an average temperature till the mixture is stiff or firm but smooth. This whole process requires physical energy and time. This called for the implementation of a home-based smart ugali cooker that prepares ugali with minimal human energy and intervention. The current advancement in technology has made it possible to develop an embedded system that does just that work.

The developed home-based smart ugali cooker makes ugali cooking easier and less time-consuming for the person looking forward to engaging in such an activity. An individual can prepare ugali while simultaneously carrying on with other activities. A user is only notified when the ugali is ready. On top of it all, such research is crucial for the involvement of local African cultural

processes in the automation world without significant implications on changing the process's existence. With the great involvement of IoT technology, the study has a great contribution to the scientific world.

2. LITERATURE REVIEW

The smart ugali cooker which is IoT based was developed in the year 2021, by students of Nelson Mandela African Institution of Science and Technology (NM-AIST) to simplify the process of cooking ugali [6]. However, the machine is not as smart as the name suggests. This cooker has several technical issues that put human health at risk. Some of the observed shortcomings include but are not limited to;

- *Automation.* The machine works depending on the cook's availability. The machine can't automatically turn off when ugali is ready. There, therefore is no determining factor of whether the ugali is ready or not thus a high possibility of getting an overcooked or undercooked ugali. This is accounted for if the chef is inexperienced. It may result in related health issues after consuming the food.

- *The system's structure and size.* It has a crude-looking structure made of very hard metals for the base. Roughly the machine weighs above 40 kilograms, has a height of one meter, and a width of approximately 70 cm. Its structure is lacking user-friendliness which is very essential regarding the neatness of the kitchen.

- *Uncovered cooking saucepan.* The mingling stick, motor, and circuit are centered on top of the machine right above the cooking saucepan. It exposes the cooked food to the environment and machinery waste from the components above. It becomes very risky to have dirt falling into the food thus causing health issues for humans.

- *Uninsulated electrical wires and heating panel.* The exposure of both electric and heating components pauses danger to the users of the system. This can result in health problems such as heat cramps, heat rashes, heat exhaustion, heatstroke, and electric shocks which makes it user-unfriendly.

- *Nsima cooker;* The Nsima Cooker which is similar to how the Rice Cooker works, was developed by Zack Salawe from Malawi [7]. He developed it to avoid the use of manpower while cooking the Nsima. The machine is developed employing electronic and metallic materials. The machine makes use of minimal energy and can be controlled remotely using a mobile device.

- *Gwatamatic;* The Gwatamatic is an Iconic machine that was developed by William Gwata from Zimbabwe [8]. It was created for mass service for caterers of a large amount of sadza. The limitations are based on its size, it is costly, uses a big amount of electricity, and requires high maintenance.

2.1 Research Objective

Define the research objective of the study in two or three sentence.

3. METHODOLOGY

This conducted research was focused on developing a home-based smart ugali cooker to address challenges portrayed by the smart ugali cooker as well as adding important features. The home-based smart ugali cooker is an IoT-based embedded machine that mixes up ingredients at the right temperature and comes up with well-cooked food(ugali). The ingredients are water and flour. Water is boiled to 90 degrees centigrade which is later mixed with flour (maize or any other flour of the cook's choice) in a quantified amount and kept in constant stirring until ugali is stiff enough.
The methodology used can be categorized into several aspects which will be stipulated as follows.

3.1 Design and development

The Home-based Smart Ugali Cooker design was made from two perspectives, firstly, the software; the automation part, and secondly; the mechanical part of the system. The mechanical part is based on the fabrication of the physical cooker made out of metal. The cooker is comprised of the heating coil for heating, the cooking pan, the lid, the flour container, and lastly the general metallic housing to enclose the entire system. The metallic housing is made of two layers that are separated with the insulation wool for heat sinking. The software and automation aspects are comprised of the microcontroller and its associated sensors and actuators to facilitate the cooking process. The microcontroller is programmed to accommodate the necessary steps to cook ugali. Figure 1 is a block diagram of the home-based smart ugali cooker which shows how different electronic components are connected to the microcontroller based on their input and output functionalities.

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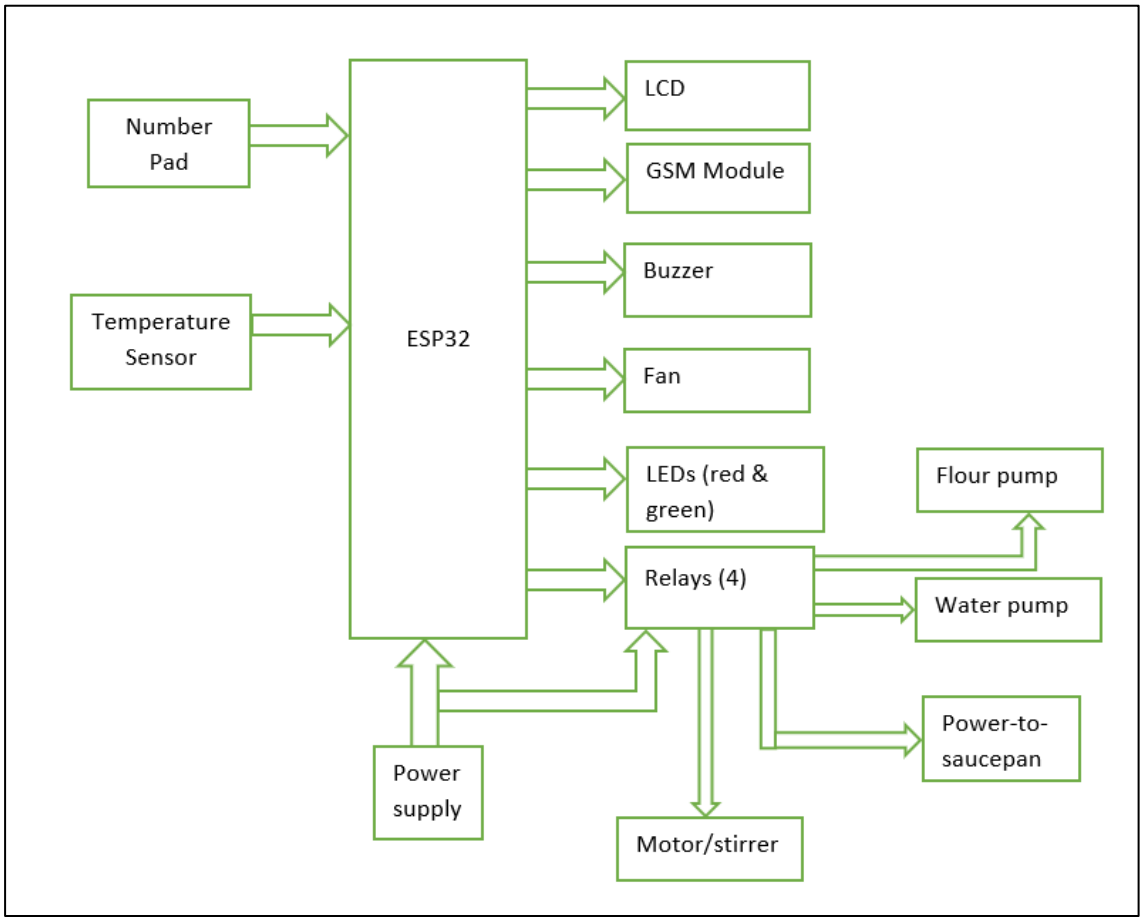

Figure 1: Home-based smart ugali cooker block diagram

Throughout the development process, 4 stages were followed which are listed hereunder and presented in figure 2.

- Stage 1: Circuit design using Proteus.
- Stage 2: System circuit demonstration using a breadboard.
- Stage 3: Implementation by soldering.
- Stage 4: Packaging

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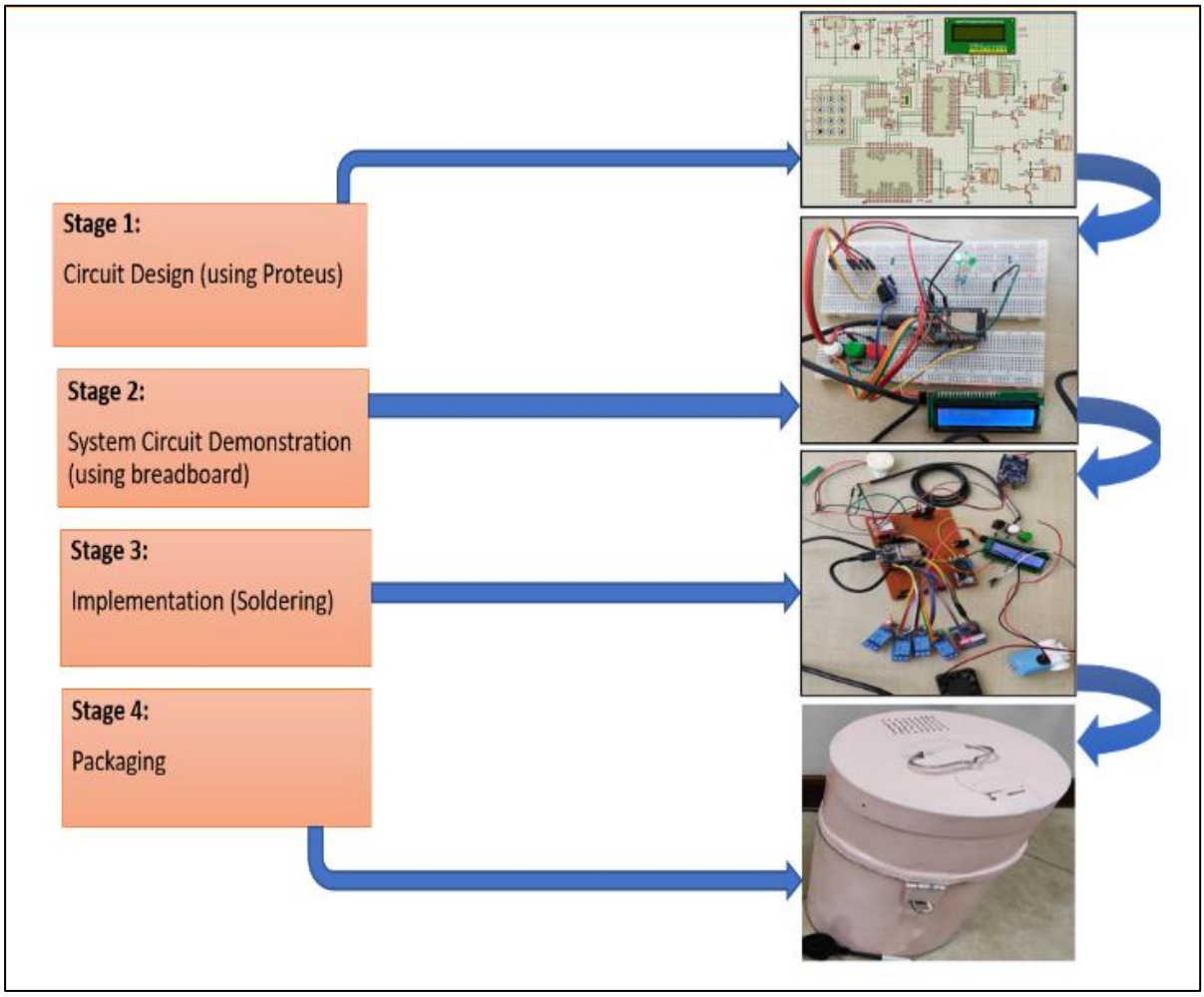

Figure 2: Home-based smart ugali cooker development process

3.2 Upgraded Functionalities of the home-based smart ugali cooker

• *Portability and kitchen accommodating.* The first and foremost focus was put on the reduction of the size and weight of the system. This was achieved by using a small motor and a lighter material in the fabrication of the mechanical part. A thin sheet of metal was used to cover up the outer part of the machine making it lighter. The machine has a diameter of 24 and a height of 60 cm which makes it weigh approximately 20 kilograms.

• *Automation of some operations.* The second major focus was put on the automation of the system. The chef inputs the number of people to cook for and the process initiates on such a basis. The amount of water poured into the pan, the amount of flour poured and the time of cooking are all calculated based on the number of people input. It has LED indicators to show the system's functionality and an LCD to display ongoing activities at a specified time. Lastly, the system automatically goes off when the time is due with a buzzer notification to alert a nearby user that the system is done cooking.

• *Insulation.* The system heating coil and cooking pan are both inside the cooker. The cooker is insulated using insulation Wool and aluminum pur. The heat dispensed outside the system has been reduced to 90% and hence increased safety for usage. The wires are all well covered and placed inside insulation tubes away from easy reach which makes it safer for use around children and other dependents with or without strict supervision.

3.3 Operation of the Home-Based Smart Ugali Cooker

Figure 3 an activity diagram illustrates the automatic operation of the ugali cooking process.

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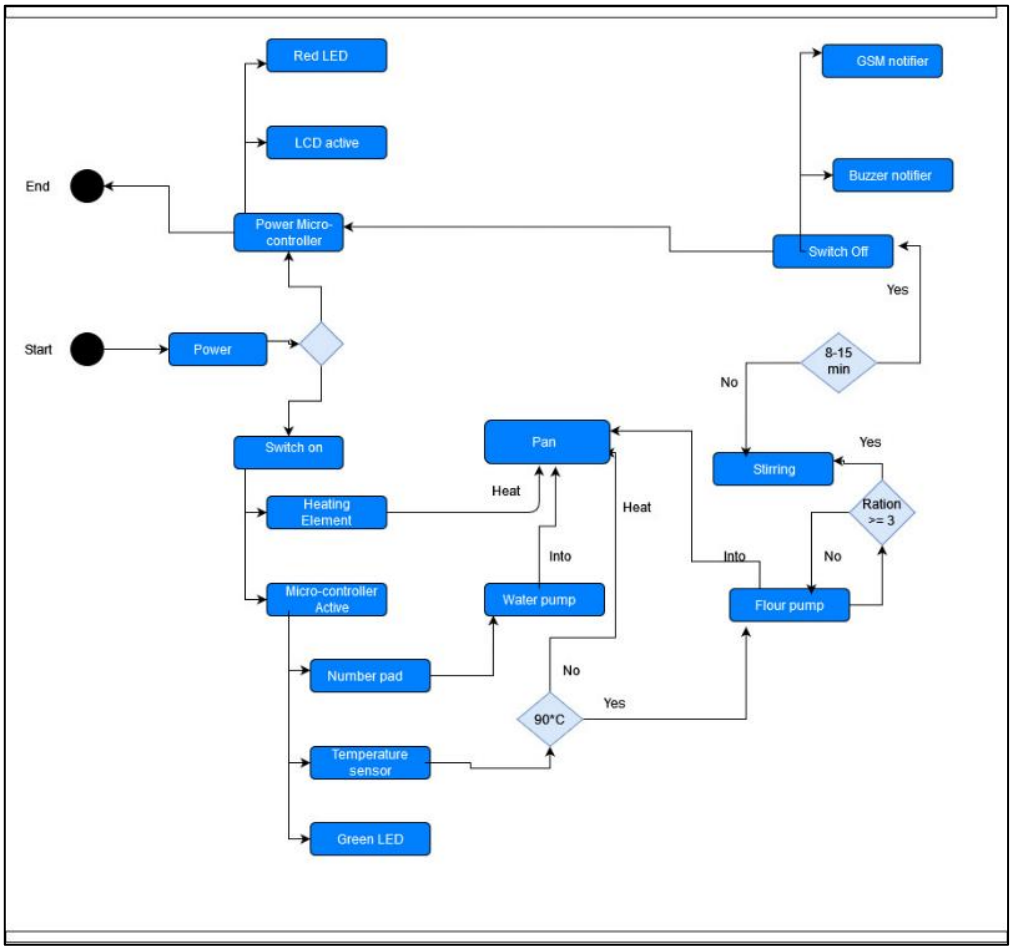

Figure 3: Home-based smart ugali cooker activity diagram

3.4 Materials Used

• **NodeMCU ESP 32.** The is a dual-core microcontroller with Wi-Fi and Bluetooth capabilities. The board was chosen because of its small size and strong capabilities.

• **Temperature Sensor.** This is an electronic device used to sense the surrounding temperature. A trigger is placed on it to activate any given activity at once if a certain temperature is reached.

• **Light Emitting Diodes (LEDs),** were used to indicate machine status and the buttons pressed.

• **Relay Switches.** Four relay switches were used; to control the servo motor, the water pump, and the steering motor and to turn on the equipment.

• **Servo motor.** The servo motor was used to open and close the inlet of the flour container. It opened three times under a delay determined by the button pressed to determine the number of people.

• **Buzzer**. Once the cooker goes off, that is, when the ugali is ready, it alarms to notify a user that the food is ready and the machine has gone off.

• **Flour Container**. It contains the flour that is poured into the saucepan with the use of the servo motor.

• **Stirring rod**. This is the stirring arm that is attached to the Stepper motor and rotates to thoroughly mix the ingredients used.

• **NEMA 17 Stepper Motor.** This is programmed to rotate the stirring rod.

• **5v Water Pump.** It pours water from the water container into the saucepan. The quantity of water depends on the number of people to be prepared for.

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• **Liquid Crystal Display (LCD).** This displays the water temperature, the number of persons to be cooked for, and the status of the system (OFF/ON/Boiling Water/Ugali is ready).

• **Push Buttons.** These are pressed to start the cooking process and also to enter the number of consumers. There are three buttons, for 1 Person, 2, and 3 people. The button pressed determines the cooking time, the amount of water poured and the amount of flour used.

• **Insulation Wool and aluminum foil**. These help to prevent the discharging of heat from inside the system.
• **Heating Coil.** It heats the saucepan to boil water to the required temperature.

Figure 4 is the flowchart that brings out the bigger picture of how the ugali cooking process starts and ends which makes it easier to operate and makes it user-friendly.

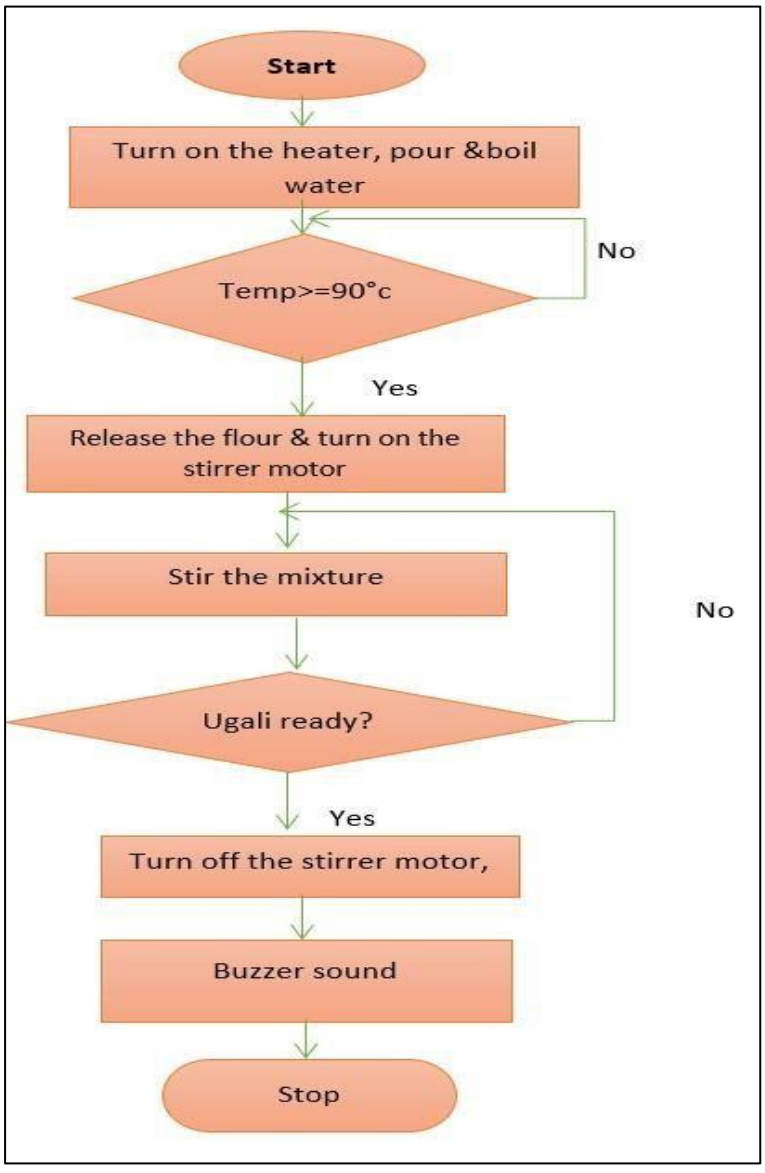

Figure 4: Home-based smart ugali cooker flowchart

4. RESULTS AND DISCUSSION

A smaller, neater, and lighter home-based smart ugali cooker is developed. The system is powered by a direct current (DC) on the control unit side (12V) and an Alternative current (AC) on the heating element (240V). Both systems need to be connected to the power source. The buttons are used to decide the amount of water to be poured into the system, the amount of flour to be used and the length of time to mix the ingredients. The maximum time that the system takes use to cook the ugali is 30 minutes in the worst-case scenario. Figure 5 presents the system's entire outlook after developing and assembling it while figure 6 presents the interior look.

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Figure 5: Exterior & interior smart ugali cook appearance

5. CONCLUSION

This Homebased smart Ugali cooker is more simplified, portable, and accommodative for daily home usage with more advancement in the automation aspect leading to less user interaction. The user's role is to input the number of people to be cooked for at a particular/time and turn on the machine to complete the entire process automatically. The system has an automatic cooking process, reduced size, insulated heating components, electric wires, and lastly its neatness. Automation of the system has been implemented to 80% enclosing of the system was a success to 90% and cleanability is possible since the cooking pan and steering rod are both detachable.

The button pressed will determine the number of ingredients needed to cook a specific amount of ugali. The home-based smart ugali cooker has three push buttons colored white, red, and green. The amount of ingredients dispensed is summarized in the table below.

Table 1: Summary of the button activity

Button	*Water amount (liters)*	*Flour pouring delay*	*No. of flour rations*	*Mixing time*
White (Button 01)	*1*	*2 seconds*	*03*	*9 minutes*
Red (Button 02)	*1.5*	*4 seconds*	*03*	*12 minutes*
Green (Button 03)	*2*	*6 seconds*	*03*	*15 minutes*

6. RECOMMENDATIONS AND FUTURE WORK

More research can be done to bring about better results on the home-based smart ugali cooker. The following are some of the recommendations to better the system.

- Use of a lighter and stainless material to fabricate the housing of the system.
- Make use of industrial sensors, components, and actuators with better calibration.
- Design a better steering rod and incorporate more motors for more movements in different directions.
- The system should be able to detect malfunctions and/or incomplete processes and indicate where they have occurred to ease the maintenance process.
- Keep the warm mode option after cooking to keep the ugali warm in case an individual is far.

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- Development of a mobile application that can control the ugali cooking process remotely.

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