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Design, construction and performance evaluation of an *Àmàlà* making machine

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Abstract

An *àmàlà* making machine was designed and constructed to make *àmàlà* preparation an easy one and remove the fatigue usually experienced during manual preparation. The machine frame was from galivanised and stainless steel materials and it is capable of preparing *àmàlà* of averagely 1.074–2.68 kg by weight. It has two compartments, the heating and stirring compartments. The stirrer has six flat paddles arranged asymmetrically and powered by a 0.94 HP electric motor. The performance evaluation of the machine revealed that the output by weight is significantly different ($P < 0.5$) indicating that weight is not equal due to different input. There was reduction in weight with decrease in temperature of the paste from 90–66 °C residence time 5–2.5 min and quantity of heat stored by the paste from 210.16–8.64 KJ as the input reduced. The density of the paste increases as the volume of water reduces (1223.83 kg/m^3 at 1.8 Litre of water to 2303.33 kg/m^3 at 0.6 Litre of water). Although, pastes produced at various ratio of yam flour and water are adjudged suitable by panellists in terms of colour, taste, aroma during sensory evaluation test, but 0.5 kg of flour produced overall acceptable paste with 1.8 Litre (maximum pot capacity), while 0.35 kg of flour produces overall acceptable paste with 0.6 Litre (minimum pot capacity)in term of modability, and texture.

1. Introduction

Àmàlà is a thick brown paste or porridge made from yam, which had been peeled, cleaned, dried and then blended into flour. It is the most popular among other foods like *eba* and pounded yam proudly found among Yoruba speaking people. It is prepared by mixing flour of yam or cassava called *èlùbó* to boiling water, then stirred very well to mix and smoothen it. The market of yam flour has increased considerably in the recent 30 years in such a way that *àmàlà* is more frequently consumed in urban areas of Nigeria and Benin (Cotonou in particular) than very traditional pounded yam (Mestres et al, 2004).

It cannot be eaten alone but complemented with any kind of stew or soup especially among those that are found in south west Nigeria like, *gbegiri*, *ewedu*, *egusi*. Among these two types of "*àmàlàs*" (i.e. *àmàlà lafun* made from cassava flour and *àmàlà gidi* made from yam flour) the one made with yam flour called *àmàlà isu* is widely accepted and even used in occasions.

The *àmàlà isu* which the machine is designed to prepare involves mixing of yam flour with boiling water. The best yam for yam flour production is *Kokoro* group of white yam (*Discorea rotundata*) cultivars (Mestres et al, 2004; Adedeji, 2010). The tubers are washed, peeled, sliced, parboiled and sun dried. The dried slices are grounded into flour using burr mill, and sieves to obtain finer particle. The addition of the flour to boiling water, when stirred quickly together, gives a smooth paste. The reconstituted flour (known as *Kokonte* in Ghana and *Àmàlà* in Nigeria) is popular for feeding both adults and children, and it is an important source of carbohydrate for many people in yam zone of west Africa (Akissoe et al., 2003).

Meanwhile, to ease the design, some properties of yam flour needed to be known. Adedeji (2010), gave the pH of yam flour to be between 6.25 and 6.93. The bulk density ranges from 0.54 to 0.7 g/ml. The dispersibilty ranges from 66 to 72.5%, water absorption index is within 99.2–245.25% and pasting

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property are; peak viscosity 150.83–317.2RVU, trough of the yam flour from 120.62 to 214.38RVU, breakdown of yam flour which ranged from 12.75RVU to 93.46RVU.

Moreover, since *àmàlà* is prepared even manually by mixing of water and flour therefore it is necessary to select appropriate mixing device. Amber et al. (2005) also gave different types of blades as helical blade, that simulates auger, symmetrical and asymmetrical blades which simulate the solid paddle design of a butter churn, angled blade to model industrial mixer propeller design, and hollow blade was created to model blade design of kitchen mixers. Therefore, in this design, symmetrical and asymmetrical blades were selected because both *àmàlà* and butter are in paste form.

Despite the importance of *àmàlà* among south west people of Nigeria, its preparation remains manuall The person preparing the amala is usually subjected to stress during stirring and sweats a lot, which makes the process difficult. Therefore, the need to produce a machine that will prepare *àmàlà* easily and hygienically. This paper therefore report the design, construction and testing of an *àmàlà* making machine.

2. Materials and methods

2.1. The preliminary investigation on making of Àmàlà

In the design of an *Àmàlà* making machine, adequate information on the manual processing is required, such as ratio of flour to water, temperature of the paste immediately after preparation, number of turning before a smooth paste is achieved and stirring time.

In other to obtain this information, that is, ratio of flour to water, temperature of the paste immediately after preparation, number of turning before a smooth paste is achieved and stirring time, questionnaire was distributed among 16 women who have been preparing "*àmàlà*" manually on daily basis. The questionnaire was distributed among the housewives and canteen owners living or having their shops located around Idi-Ape and Abayomi areas of Iwo Road, Ibadan. The questionnaires were then examined and necessary information that will help in the design were extracted and recorded accordingly with 8 of the respondents giving information on yam flour paste (*àmàlà isu*) and the other 8 respondents on cassava flour paste (*àmàlà láfún*). The manual preparation of *àmàlà* include, boiling of clean water, addition of flour, removal of the heat source (if it is *àmàlà láfún*), continuous stirring, addition of hot/cold water (if it is *àmàlà isu),* and stir further till required texture/smoothness will be achieved.

2.2. The machine parts and materials used

The machine construction includes materials like, stainless steel flat bar, stainless rod, aluminium pot with cover, electric cooker/heater, an electric motor and a clamping bush.

After construction the machine has major parts like a heating compartment, a cooking pot, an electric motor, control switches and a stirrer. The function of each of the parts is given below.

(i) **Electric cooker/heater:** this is needed to raise the temperature of the water to boiling point, and also supply heat for cooking the food when water is added.
(ii) **Cooking pot:** an aluminium pot is used for preparation of the food, by placing it on the heater to boil the water and prepare the food.
(iii) **Electric motor:** the electric motor is to power the stirrer. The type of electric motor selected is a single phase electric motor. The power produced will be transmitted to the stirrer coupled directly to the motor with the aid of a bushing.
(iv) **The stirrer:** the stirrer comprises of stainless shaft, and the paddles made from stainless flat bars that was welded to the shaft to stir the mixture together. It is necessary to be cautious of the material corrosion due to persistent contact with water in the presence of air, and also because it will be involved in food preparation. Therefore, stainless steel was used for the stirrer due to its resistance to corrosion and readily availability in the market. The choice of flat bar for the paddle is to provide more contact area for the paste stirring, thereby enhance smooth stirring within a short period.

2.3. Design specifications

The major part to design for is the stirrer which includes the shaft and the paddle because every other part can be obtained directly from market. The stresses found in shaft design are torsional stress, and bending stress.

The following assumptions were made:

(i) The material to stir is a semi-solid material
(ii) The shaft diameter is 15 mm (0.015 m)
(iii) The thickness of the paddle is 3 mm
(iv) There are six paddles arranged asymmetrically in pairs with 10mm distance from each pair.

2.3.1. Determination of torsional stress

To mix a semi solid material, as given by Bobic et al. (2011),

The shear stress,

$$\tau = \gamma\,\eta \ldots \quad (1)$$

where, γ = shear rate (s^{-1}); η = viscosity (kg/ms); and, shear rate,

$$\gamma = \frac{4\pi n}{1-k^2} \ldots \quad (2)$$

where, n = speed in revolution per second; k = ratio of the diameter covered by the paddle to the pot diameter (d/D).

Due to the slow speed expected to avoid ball formation in the paste spillage during stirring and to ensure thorough stirring of the mixture, 75 rpm is assumed as the speed of rotation of motor.