ABUAD Journal of Engineering Research and Development (AJERD)
ISSN (online): 2645-2685; ISSN (print): 2756-6811

Volume 8, Issue 2, 130-139

Performance Evaluation of Dough Mixing Machine

Kunle ONI[1], John Omowanle AKINMOLAYAN[1], Adeyemi Mathew IGE[2]

[1]*Food Science and Technology Department, Federal University Oye Ekiti, Ekiti State, Nigeria*
kunle.oni@fuoye.edu.ng/johnomowale2014@gmail.com

[2]*Mechanical Engineering Department, Federal University Oye Ekiti, Ekiti State, Nigeria*
adeyemimatthewige@gmail.com

Corresponding Author: *adeyemimatthewige@gmail.com*, +2348066063547
Date Submitted: 14/09/2024
Date Accepted: 25/06/2025
Date Published: 30/06/2025

***Abstract**: In bread-making, mixing is most crucial process to bring different ingredients together to achieve homogeneity, the quality of dough depends mainly on mixing processes. This study was carried out to evaluate the performance of dough mixing machine designed, by assessing the functional properties of wheat flour for the pasting properties and farinograph characteristics of the flour suitable for use in the mixing machine. A gear-driven electric motor of 1.23 kW maximum power supply with torque of 3.75 Nm was considered for the designed fabrication. The machine operated at 280 rpm with a mixing capacity of 31.9 kg/hr and an average efficiency of 94.7%. The dough mixer performance evaluation results analyzed for pasting property of the flour samples, indicated that flour from the Eagle Flour was the best for bread making with the value of peak viscosity of 792.1 RVU, trough viscosity of 193.6 RVU, breakdown viscosity of 598.5 RVU, setback viscosity of 73.9 RVU, final viscosity of 267.5 RVU, and pasting temperature of 50.2 ^oC. Result analysis shows that, Eagle Flour sample has a water absorption capacity, swelling capacity and bulk density of 152.69 %, 20.78 % and 0.78 g/ml respectively. Then, Farinograph characterized the mixing time, over mixing stability, and dough's rheological characteristics. The physical property of the bread obtained from fabricated dough mixer has a loaf volume of 1850 cm^3, specific loaf volume of 4.19 cm^3/g, density of 0.15 g/cm^3 and oven spring of 0.16 mm. The overall acceptability rating of 94.28% and 89.48% were recorded for the bread from the fabricated and commercial dough mixers, respectively. Hence, 5 kilograms (kg) of components was able to mix properly and effectively in 8.15 minutes on average, which is 36.91 kilograms per hour. The fabricated dough mixer has a good market prospect.*

Keywords: *Farinograph, Rheological, Machinability, Homogeneity, Stability*

1. INTRODUCTION

Bread and biscuit making majorly relies on mixing as one of its foundational steps. The gluten network that forms at this stage is largely important for the dough's viscoelastic qualities, its machinability, and the quality of the baked bread or biscuits. Mixing factors such as mixer type, rotation speed, mixing time and water quantity, and the qualities of the flour used greatly affect the final product's quality while making bread and biscuits [1].

Flour is finely powdered products of cereal grains and other starchy portions of plants. Flour is used in various food products and as a basic ingredient of baked foods. Wheat flour is most common flour for bread production because it contains high carbohydrate which make good source of energy. However, aside of carbohydrate wheat contains significant amounts of other nutrients like proteins, fiber, vitamins and minerals, which togetherness contribute to a healthy diet [2, 3]. Bread is made with four primary ingredients which include wheat flour, water, salt and yeast. Ingredients certainly have a role when it comes to bread making; the manufacturing process itself has a much greater impact on the final product. Baking bread requires a lot of mixing of dough. Mixers allow bakeries to produce more bread in less time while maintaining higher standards of cleanliness. Dough mixer is an electric driven machine, which uses a gear driven mechanism to rotate a set of beaters in a bowl containing the ingredients to prepare. In home and food industries, mixing of flour to form dough has been a necessity task; hence the need for an affordable flour mixing machine is on the increase.

There are several mixers designed for this operation ranging from; Stand mixers, planetary mixers, Stationary mixer, Spiral mixers and many more. The commercial production of bread and baked foods is on the increase, but the process cycle has remained largely manual especially the mixing unit operation. This manual mixing of dough as some challenges like waste of time, very slow, tiredness and laborious, with fairly, little or no guarantee of complete homogeneity of the final product, hence the need for an affordable flour mixing machine is on the increase [4]

This dough mixing machine is a gearbox-driven machine; hence when the power is switched 'ON,' the electric motor shaft transmits power utilizing a speed reducer gearbox spindle shaft. The spindle transfers the motion to the agitator's arm. The agitator shaft is inclined at an angle of 360^0 to the mixing bowl and rotates in a clockwise direction while the mixing bowl is fixed at a point, thus, producing a uniform mixture. Discharge of the contents of the bowl is achieved by raising the electric motor and gearbox spindle assembly off the mixing bowl. The bowl fixed to the machine's frame can be removed from the agitator shaft and cleaned after the mixing operation is completed.

Since knowing how a system would work before actually using it is vital, functionality and performance characteristics of the machine was determined via a performance assessment test [37]. With the dough machine built, 4 kilograms (kg) of components was able to mix properly and effectively in 7.45 minutes on average, which is 31.92 kilograms per hour recorded in Table 1. The primary objective of designing dough mixing machine is to assess the functional properties of wheat flour for the pasting properties and farinograph characteristics of the flour suitable for use in the mixing machine.

2. METHODOLOGY

2.1 Material, Design and Selection of Components

The machine's frame was manufactured out of mild steel, but the mixing bowl and blades (arm) was both made out of stainless steel. Stainless steel was used for the dough-contacting components of the machine in order to prevent cross-contamination [5]. The primary materials utilized to construct the machine components includes, one unit of 5 mm x 3 mm H-Channel mild steel with 921 mm × 920 mm × 310 mm diameter, two units of stainless-steel rods of 32.5 mm diameter for stirrer and shaft, and one unit of 12 inches pipe.

The 921 mm x 920 mm x 310 mm trapezoidal frame was created by cutting and welding together four 5 x 3 mm H-channel mild steel bars. Included is a 700 mm tall support stand, measuring from the top of the frame. In addition, a flat collar bearing of size 62042 was mounted on the frame to facilitate the rotation of the shaft [6]. Fonseca et al. [7] Explain that a machine's shaft is housed in a bearing to provide protection and keeps the shaft in place. The 32.5 mm shaft diameter led us to choose bearing size 62042. On top of that, a stand for attaching the electric motor of an input power of 1.23 KW, 220 V, 5.57 A recorded in Table 1 and speed reducer gearbox of 4.75 to 1 ratio was welded to the frame per the advice of [8]. Fabrication of the mixing drum began with a 10 mm thick stainless-steel plate imported from Nigeria. A rectangular chunk measuring 398.17 mm x 942.86 mm and two circular plates measuring 300 mm in diameter was separated from the plate during cutting. Using the bending machine, the rectangular piece was transformed into a cylinder with a diameter of 300 mm and a height of 398.17 mm, and the two ends were welded together. In addition, a circular piece was welded to one side of the drum to function as the drum's foundation. The drum cover was created using the second circular component.

However, a support was installed underneath the mixing drum to provide stability and dampen vibrations. Three pieces of gauge pipe with a 16 mm diameter was used to build the stand. The length of this phase is 337.5mm. In order to increase the stability, the extremities of the pipes that would otherwise touch the floor were bent flat (approximately 50 mm from the ends). The other ends were welded to a cylinder that serves as the mixing drum's base and measures 304 mm in diameter and 50 mm in height.

2.2 Sample Preparation and Ingredients Formulation

The ingredients such as flour, yeast, salt, sugar, powdered milk, yeast were sourced at Bisi market in Ado Ekiti, Ekiti State. A loaf of bread has a formulation around 57% flour, 36% water, 1% salt, 1% sugar, 1% fat, 1% milk powder, 0.8% yeast, and 0.1% calcium proportional in it [1]. All the ingredients sourced was prepared in the Food Chemistry/Analysis Laboratory at the Federal University, Oye Ekiti, Ikole Campus, the components were weighed using a Top loading balance (LP 4001A) according to the procedure outlined by [9]. Mixing and kneading was performed on a clean, non-reactive flat surface and the component was hydrated according to the original recipe. The dough was beaten and re-kneaded three times in a row, each time for 10 minutes, as suggested by [10, 11].

The dough was then shaped, divided, pan-proofed (kept at 33-45 °C for 55 minutes) and baked. When it was done, the dough went into a Kinelco electric oven to be cooked (Model at a temperature of 120 °C for the first 30 minutes and 200 °C for another 30 minutes). After around 20 minutes, the loaves were taken from the pans to cool completely at room temperature before being wrapped.

2.3 Determination of Physical Properties of Bread

A procedure similar to that reported by Chen et al [12] was used to analyze the bread samples for their physical characteristics. Top loading balances (LP 400IA) was used to measure the finished bread loaves weight. The bread's moisture content was also calculated by baking it at 120 °C for 4 hours, according the AOAC (2015) standard technique.

2.4 Statistical Analysis

At first, the sensory assessment data was put through a reliability test. We used Cronbach's alpha to do this. Cronbach alpha of 0.7 and above indicates an adequate level of internal reliability; hence, the reliability of the data may now be evaluated using this new criterion [13]. This analysis was performed with SPSS 26. Data from this research was analyzed using analysis of variance in Microsoft Excel (SPSS 26) for Windows. Means was also split using Duncan's multiple tests to see whether there was statistically significant differences in the values found for the various parameters under study. At a 5% level of significance, we also utilized the least significant difference (LSD) to assess the importance of the difference between each treatment pair.

Table 1: Design analysis

Parameter	Input	Analysis	Result
Power Input, P_1	From the electric motor specification, current (I) of 5.57 A and Voltage (V) of 220 V	P_1 = IV, therefore, $P_1 = 5.57 \times 220$ P_1 = 1225.4 W. P_1 = 1.23 KW	P_1 = 1.23 KW
Torque, T	Current I rating of 5.57 A, Voltage V rating of 220 V, Electromotive force E of the motor 0.4488 V, Rotational speed of the motor N1 of 1400 rpm. $T = E\times I\times V\times 60/(2\times 3.142\times N_1)$	$T = (5.57\times 220\times 0.4488\times 60)/2\times 3.142\times 1400$ T = 3.75 Nm	T = 3.75 Nm
Agitator Speed Ѡs of the stirrer	Rotational speed N_2 of electric motor at ratio 5 to 1 give 280 rpm (i.e 1400/5). Ѡs = $2\times 3.142\times N_2/60$	Ѡs = 2×3.142×280/60 Ѡs = 29.3 rad/s.	Ѡs = 29.3 rad/s.
Power Output P_2	Torque T of 3.75 N, N1 of 1400 rpm. $P_2 = 2\times 3.142\times T\times N_2/60$	$P_2 = 2\times 3.142\times 3.75\times 1400/60$ P_2 = 550 W P_2 = 0.55 KW	P2 = 0.55 KW
Efficiency, η	Power output P2 of 0.55 KW, Power input P1 of 1.23 KW. Efficiency, $\eta = P_2\times 100/P_1$	Efficiency η = 0.55×100/1.23 η = 44.88 % η = 45 %	η = 45 %
Force Exacted on the Agitator Shaft Fs	Mass of the dough, Md_0 of 3.964 kg, Acceleration due to gravity g of 9.81 m/s^2 $Fs = Md_0 \times g$	Fs = 3.964×9.81 Fs = 38.9 N	Fs = 38.9 N
Mixing Capacity Mc	Mass of the dough**,** Md_0 of 3.964 kg and Time taken of 7.45 minutes. $Mc = Md_0 \times 60/\text{Time(mins)}$	Mc = 3.964 × 60/7.45 Mc = 31.92 Kg/hr.	Mc = 31.92 Kg/hr.
Mixing Efficiency ηm	Total mass of ingredients fed into the mixing bowl T_1, splashed mass of ingredients during the mixing process T_2 (mean from 3 batches of mixing). $\eta m = (T_1 - T_2)\times 100/T_1$	ηm = (3850 - 205) ×100/3850 ηm = 94.68% ηm = 94.7 %	ηm = 94.7 %

3. RESULTS AND DISCUSSIONN

3.1 Physical Characteristics of Bread Made using the Fabricated Dough Mixer

Table 2 details the physical characteristics of the bread baked using the constructed dough mixer. A commercial dough mixer was used as a control, and its results showed a loaf volume of 1828 cm^3. The results showed that compared to the control, bread made with the homemade dough mixer yielded considerably ($p>0.05$) larger loaves. Due to the increased area, this has economic significance. Higher water activities and diluted gluten influenced physical contacts and impacted chemical reactions, all of which contributed to a larger loaf size during mixing, fermentation and baking indicated [21].

The volume of a baked bread was 4.19 g/cm^3 for the homemade mixers and 4.15 g/cm^3 for the professional ones. The volume was not significantly different. In baking bread, one crucial factor is the desired final loaf volume. It demonstrates the bread's ultimate gas retention and affects buyer decisions. As such, it is a very important metric. In addition, the degree of crumb aeration, the quality of the texture, the correct formulation, the freshness of the ingredients, and the care taken with the dough are all reflected in the particular loaf volume [22, 23]. Therefore, the industrial standard has been met by the manufactured dough mixer.

The bread density for both the homemade and commercial dough mixers was 0.15 g/cm^3 and 0.17 g/cm^3, respectively. When comparing densities, there was no statistically significant difference. The mixing function of the homemade machine performed well and compared well to the commercial version. The oven spring for home-made dough mixers was 0.16 mm while for professional ones it was 0.19 mm. In terms of statistical significance, there was also no difference. Many factors, including but not limited to dough quality (primarily the mixer and flour), yeast amount, fermentation depth, and oven temperature, contribute to the oven spring. When the loaf rises to its full volume and shape in the oven, creating an open crumb, the oven spring is superb [24].

The bread strength of the home-made dough mixers was 45.08 mm, whereas that of the commercial dough mixers was 47.69 mm. Stronger bread is the product of a dough with a developed gluten network, which captures and retains the carbon dioxide created by the yeast [25]. Despite a noticeable variation in bread strength, the bread produced by the manufactured dough mixer was competitive with that produced by a commercial mixer. In the case of the homemade dough mixers, the bread samples had a moisture level of 30.75 g/100g, whereas the commercial dough mixers averaged 29.88 g/100g. Comparing moisture levels, there was no statistically significant difference. The final moisture content after baking was statistically the same for all bread samples despite the fact that they were all exposed to the identical treatment except for the kind of mixer used while mixing duration was maintained constant. Therefore, the manufactured dough mixer is a highly suggested alternative for the commercial dough mixer.

Table 2: Quality characteristics of wheat flour used for the performance evaluation of the fabricated dough mixer

Parameters	**Values**
Moisture, (g/100g)	13.69±0.13
Swelling capacity, (%)	20.78±0.10
Gelatinization Temperature (°C)	54.7±0.11
Water absorption capacity (%)	152.69±1.02
Bulk density (%)	0.78±0.012
True density (%)	1.52±0.02

3.2 Quality Characteristics of Wheat Flour used for the Performance Evaluation of the Dough Mixer

Table 2 details the flour characteristics that were employed in the performance analysis of the manufactured machine. The flour had a moisture level of 13.69 g/100g g. The level of hydration in flour is referred to as its moisture content. The moisture level was much below the acceptable range of 14-16 % for long-term storage. Overly wet flours (those with a moisture content of more than 14 %) may support mold growth [26]. Suresh [27] Found that wheat flour had 13.28 % moisture, rice flour 11.22 % moisture, and potato flour 9.60 % moisture. The flour has a 20.78 % swelling capacity. The percentage of protein in wheat flour, rice flour, and potato flour was 17.60 %, 15.20 %, and 42.90 %, respectively [27]. The variability in amylose concentration may explain the wide range of moisture levels. How much a substance can expand depends on its particle size, kind, and how it was processed. Flour used to make bread is evaluated on its ability to expand while baking. The ratio of amylose to amylopectin is determined in part by this indicator of non-covalent contact between molecules in starch granules [28]. Amylose and amylopectin may be found in varied concentrations and proportions depending on the plant's origin.

Result in Table 2 shows that 54.74 °C is the gelatinization temperature for flour. Suresh [27] found that the gelatinization temperature for wheat flour was 59.22 °C, for potato flour it was 59.72 °C and for rice flour it was 57.58 °C. The temperature at which starch gelatinizes decreases as its concentration rises [27]. Gelatinization happens when the starch molecules' hydrogen-bonded sites (hydroxyl hydrogen and oxygen) are able to take more water due to the presence of heat and water. Through this "plasticizer action of water," the starch granules are completely dispersed throughout the liquid. As the starch aggregates are heated in a liquid like water, they rapidly absorb the liquid, expand, and burst, therefore increasing the starch's viscosity (stickiness) [29]. This also aids in ensuring complete uniformity. Gelatinization temperature is the temperature at which starch starts to change into a gel [30]. The gelatinization temperature of starch is influenced by many factors, including the kind of plant used, the quantity of water present, the type and concentration of salt, the amount of sugar, protein, and fat in the recipe, and the process of starch derivatization [31]. For many food preparations, particularly dough and baked foods, the protein's capacity to take in water is essential. Bread features, machineability, shelf life, proofing, bread crumb fracture stress, loaf size, bread yield, and other properties of the final product [32, 33].

Flour had a density of 0.78 g/ml. The bulk densities of rice, wheat, potato, and green gram flours were all between 0.72 and 0.91 g/ml, as reported by [27]. The initial moisture content and particle size of flour both affect the bulk density. Baking benefits from the high bulk density, whereas low bulk density would be useful for making dishes that go with it [34; 35). Bulk density shifts might be due to differences in the starch content of the flour. If there's a lot of starch in anything, the density is more likely to go up. Tiny particles, the right tapping or vibrating, a good compacting, and the right packing material may all contribute to a higher bulk density. Geometry, measuring methods, particle sizes, surface properties, and solid density are all important in determining bulk density [28]. The amount of packing material required is proportional to its bulk density [28]. Flour had a real density of 1.52 g/ml., noted that the actual densities of wheat flour and flaxseed flour were 1.40 g/ml and 1.77 g/ml, respectively [36].

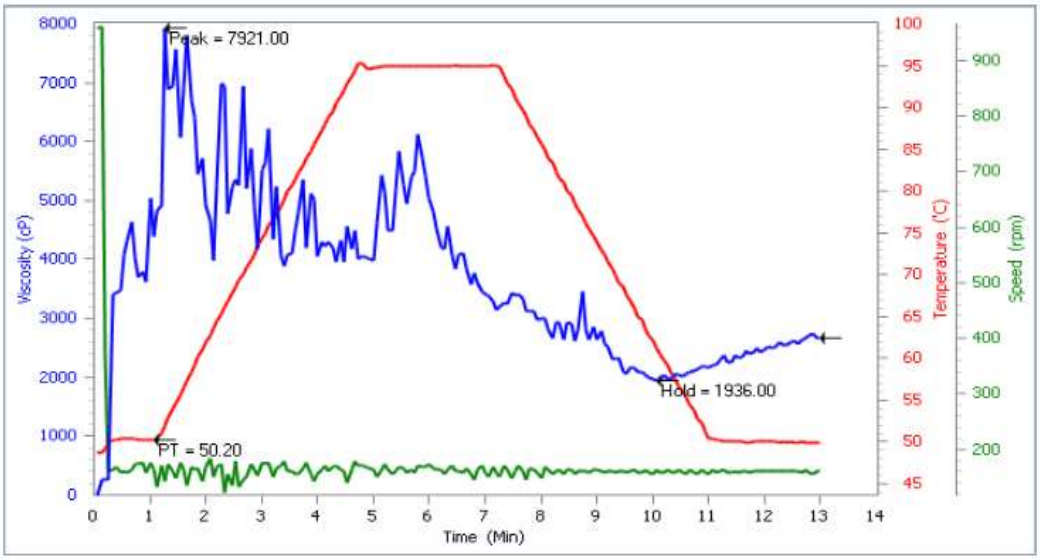

Figure 1: Pasting profile for wheat flour from eagle flour

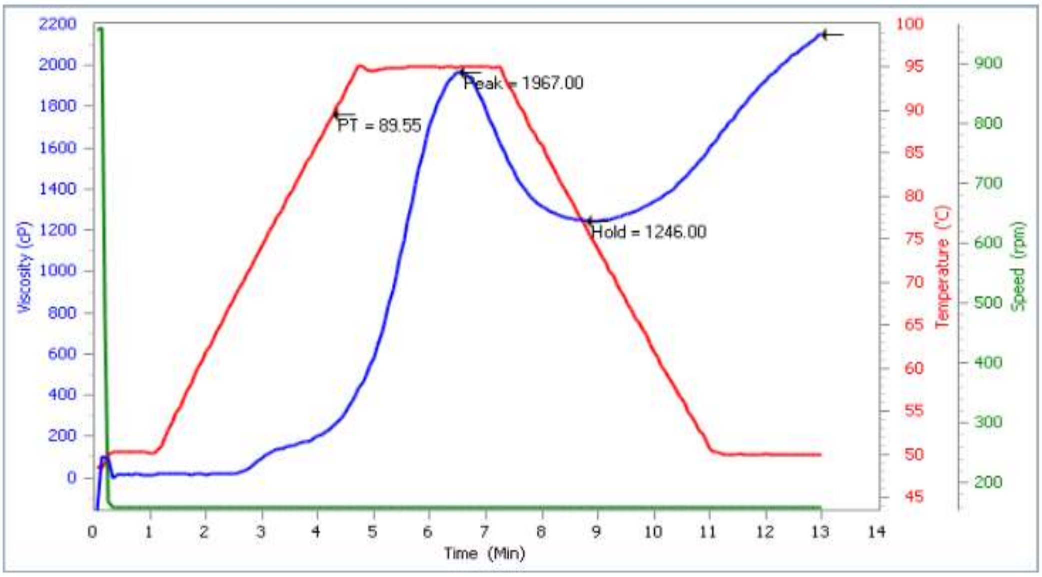

Figure 2: Pasting profile for wheat flour from Dangote flour

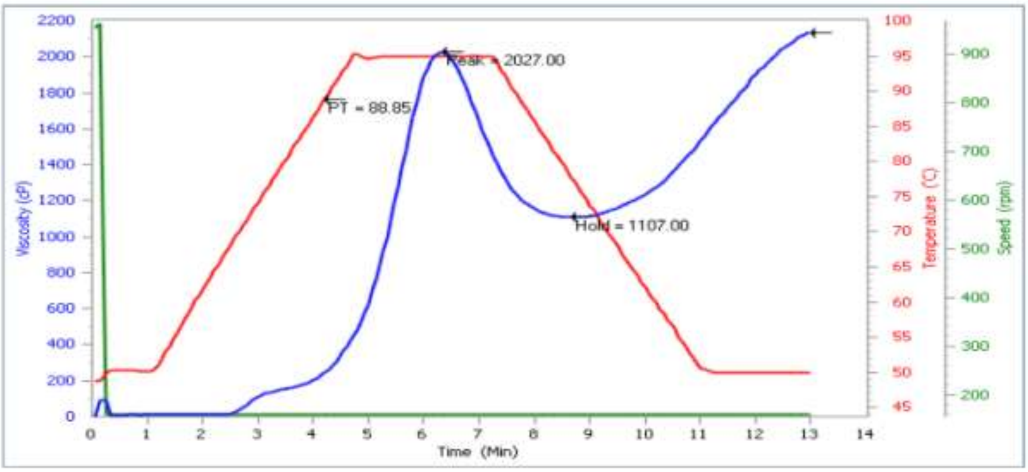

Figure 3: Pasting profile for wheat flour from Golden Penny.

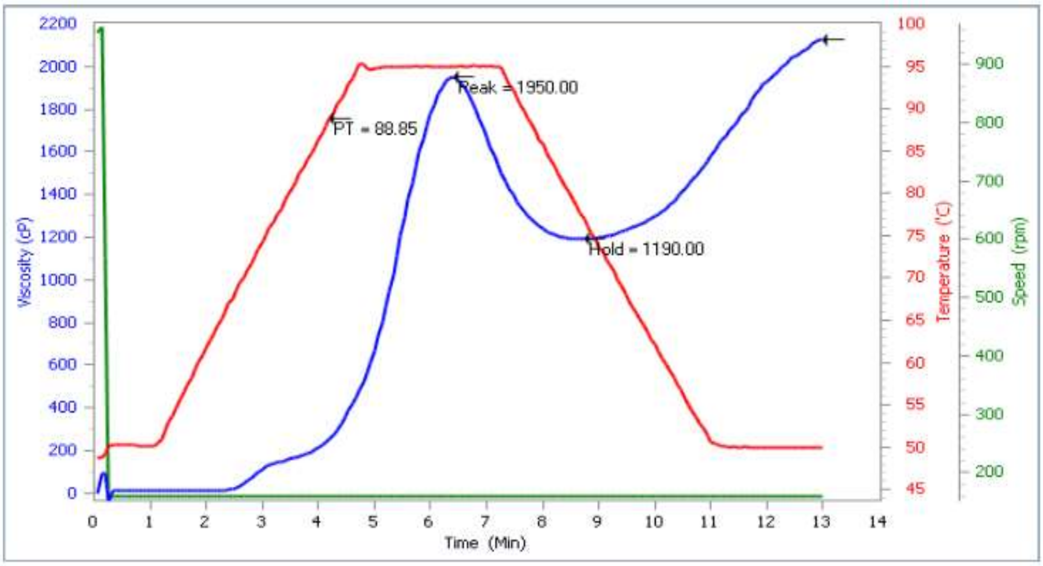

Figure 4: Pasting profile for wheat flour from Eagle flour-Dangote flour mixture.

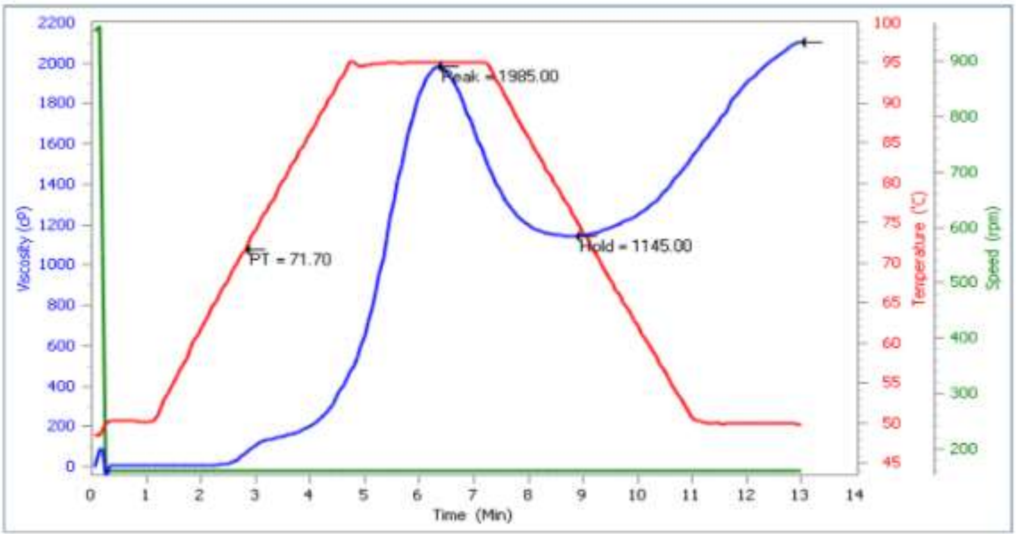

Figure 5: Pasting profile for wheat flour from Eagle Flour-Golden penny flour mixture

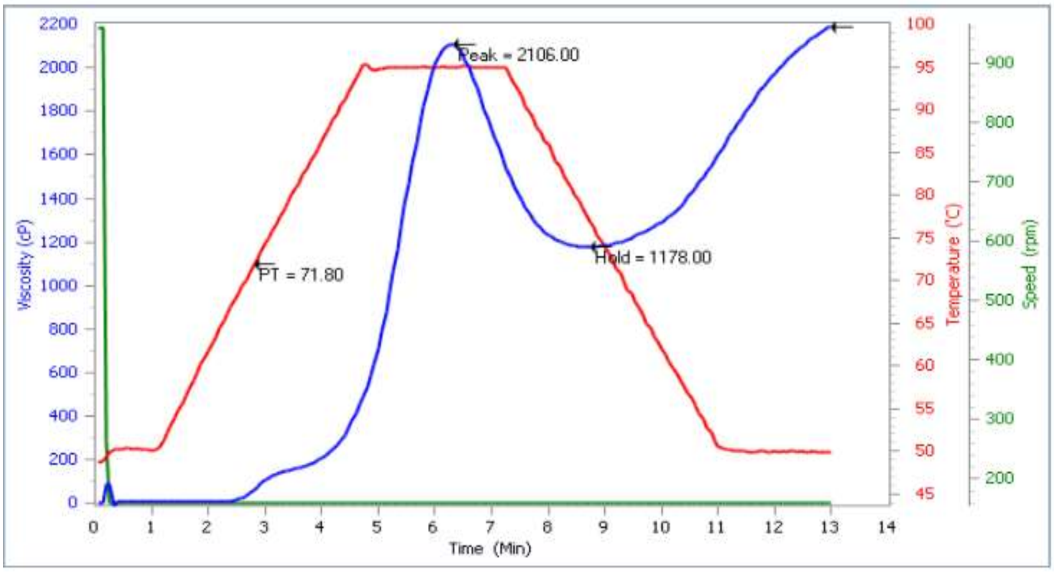

Figure 6: Pasting profile for wheat flour from Dangote Flour-Golden penny mixture

3.3 Pasting Properties of Flour for Performance Evaluation

The viscograms in Figure 1 to Figure 6 detail the pasting properties of flour samples sourced from various producers. Elements used in the pasting process reveal how wheat flour reacts to and recovers from heat. Indicative of the flour's tendency to gel when heated, the peak viscosity (PV) may help anticipate and plan for practical limitations. Wheat flour samples had an average PV of 792.1 RVU and a range of 195 RVU. Eagle Flour Company flour had the greatest value of 792.1 RVU, whereas a combination of Eagle Flour and Dangote Flour had the lowest. From the three firms, Dangote had the lowest value (196.7 RVU), while the Dangote-Golden Penny combo had the greatest value of 210.6 RVU for flour blends. Wheat flour was found to have 48 RVU, whereas quinoa flour was reported to have 18.6 RVU [14].

At the same time, Dereje *et al* [15] estimated that the PV of sweet potato flour to be between 82.7 RVU and 231.7 RVU. Mung bean flour was reported to have a PV of 90.9 RVU, whereas red kidney bean flour had a PV of 82.8 RVU respectively [16]. Since the PV reading for the Eagle Flour sample was the greatest, it followed that the dough made with this flour would be denser, more absorbent, and produce more bread. Cultivar, starch content and grade all have a role in the PV [17]. The lowest safe baking temperature for bread is called the pasting temperature (PT). In this investigation, the PT of wheat flour varied from 50.0 °C to 89.6 °C. As a result, baking using Dangote flour would need more energy than with the Eagle flour sample. The flour blend yielded a PT that varied from 71.8 °C to 88.9 ^{o}C. The PT values of flour blends made with Eagle flour and Golden Penny and Dangote flour and Golden Penny were identical. [14] Found that the PT for wheat flour was 60.70 °C, for quinia flour it was 69.2 °C and for potato starch it was 58.9 °C. [16] Recorded the mung beans PT of 77.85 ^{o}C, whereas [14] recorded the PTs of red cowpea of 76.93 ^{o}C and black cowpea of 82.48 ^{o}C.

Viscosity ranged from 110.7 RVU to 193.6 RVU at the trough. The value of Eagle Flour flour was the highest of all of the tested flours or flour blends. When treated to high temperatures or lengthy treatment, trough viscosity indicates resistance to breakdown. Thus, Eagle flour has been shown to be the most stable under extreme conditions. Eagle flour had the greatest breakdown viscosity at 72.1 RVU, whereas Dangote flour had the lowest at 598.5 RVU.

Wheat flour, quinoa flour, and potato starch was all found to have different viscosity breaking points of 17.9 RVU, 0.5 RVU, and 489.9 RVU, respectively [14]. The resulting paste's final viscosity (FT) varied from 212.6 to 267.5 relative viscosity units (RVU) among the flour samples. Eagle Flour Mill had the greatest value, while a combination of Eagle and Dangote flour had the lowest. The flour samples' reverse viscosity was between 73.9 RVU and 102.8 R.V.U. Golden Penny flour had the greatest setback viscosity, while Eagle Flour had the lowest. As a result, the data suggested that Eagle flour is less likely to undergo retrogradation after heating. Possible causes for observed differences between the flour samples include the use of various processing methods. There is also the possibility of significant producer profit through adulteration. Therefore, flour-producing enterprises need sufficient attention from food regulatory organizations like NAFDAC. From what we could see in terms of its pasting qualities, Eagle Flour Mill flour was the clear winner when it came to making bread and other baked goods. Therefore, Eagle flour was utilized in the testing of the custom dough mixer to ensure optimal results.

3.4 Farinograph Characteristics of the Flour

The Farinograph is a recording device built into a dough mixer that measures the torque exerted by the mixer blades. The mixing time, overmixing stability, and dough's rheological characteristics may all be calculated using this method. It's also a factor in determining how much water flour can absorb [18, 19]. Figures 7–9 of the Farinograph depict the flour samples and their respective dough development time (DDT), dough water absorption (DWA), dough stability (DS), dough breakdown time (DBT), Farinograph quality number (FQN), and dough mixing tolerance.

In Figure 7 and 8, 1.56 to 2.4-minutes DDT was seen. The Eagle Flour sample had the most DDT of all of the samples tested. [20] notes that all of the flour samples fall into the category of weak flour (DDT2.5). The range of values for consistency was 490 FE to 637 FE, with the Golden Penny sample having the highest value and the Eagle Flour sample having the second highest. Eagle Flour, Dangote Flour, and Golden Penny Flour all absorbed around the same amount of water (64 %), although at somewhat different rates (61.7 %). Water absorption rates for different types of flour range from below 55 % to over 60 %; strong flour absorbs more than 60 % of its weight in water [20]. Thus, the results of the three samples of flour were all Samples made with Eagle flour had a dough stability of 4.44 minutes, whereas those made with Dangote flour and Golden Penny flour had dough stabilities of 2.06 and 2.39 minutes, respectively.

Weak flour has a consistency of less than 3 minutes, medium flour takes 3 to 10 minutes, and strong flour takes more than 10 minutes [20]. The Eagle flour is the only strong sample, while the other two are weak. For example, Eagle flour had a 46 FE tolerance for mixing dough, whereas Dangote flour had an 81 FE tolerance, and Golden Penny flour had an 83 FE tolerance respectively. Flour with a BU reading over 100 is considered weak, between 60 and 100 is considered medium, 15 to 50 is considered strong, and readings below 10 are considered extremely strong [20]. Based on the data, only Eagle flour was classified as a strong, while the others were placed in the medium group. Eagle flour had a Farinograph quality number of 54, whereas Dangote flour had a rating of 32, and Golden Penny flour had a value of 34. Eagle flour required 5.24 minutes, Dangote flour 3.12 minutes, and Golden Penny flour 3.24 minutes to get the same level of dough development. The amount of water required to align the Farinogram with the 500-BU is the definition of water absorption. Popularity-wise, this Farinograph index reigns supreme. The DDT is the time it takes for the dough to achieve its peak consistency after the initial addition of water. This time is sometimes referred to as the Mixing Time or the Peak Time. The stability time is measured from when the curve's peak first touches the 500-BU line until it breaks free of that line. What we mean by "dough mixing tolerance" is the difference in BU between the first peak and the second peak taken five minutes later [20,19].

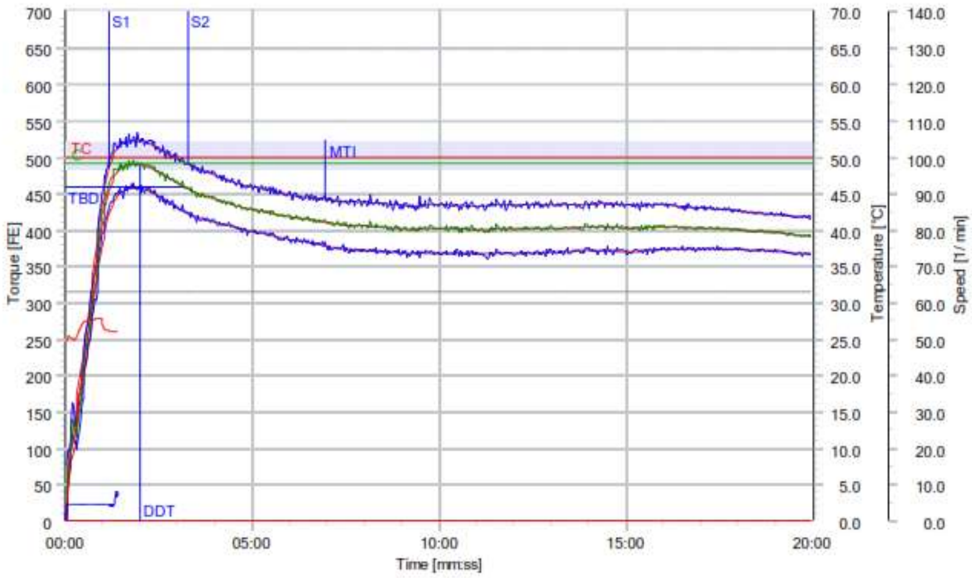

Figure 7: Farinogram for wheat flour from Eagle Flour

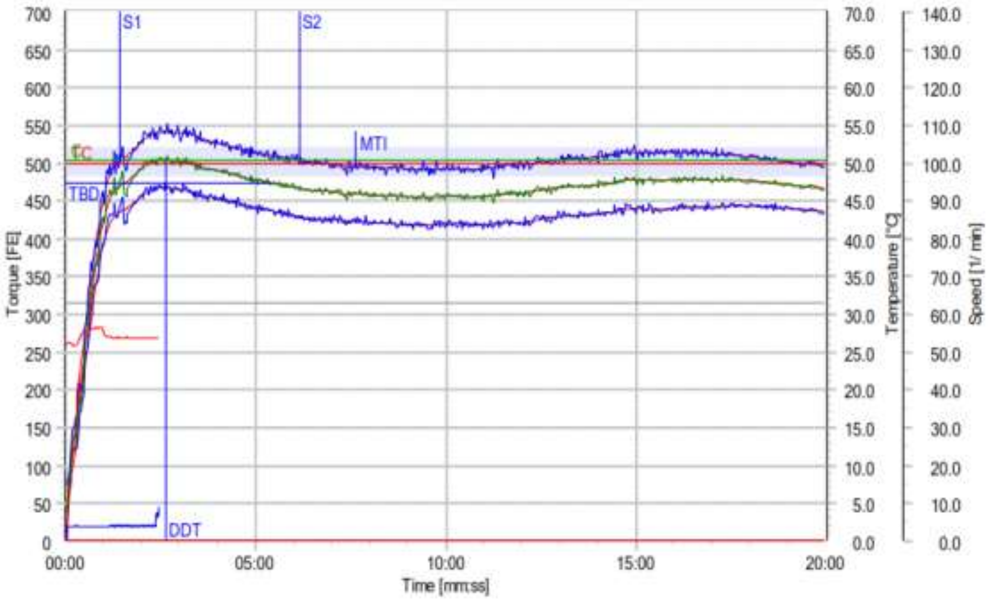

Figure 8: Farinogram for wheat flour from Dangote Flour

4. CONCLUSION

Eagle Flour was deemed to be the best flour to use for testing the dough mixer for baking bread, thus that's what was utilized. Eagle flour outperforms both Dangote and Golden Penny in terms of its ability to paste and perform other tasks. Using the homemade dough mixer, I was able to produce bread that, in terms of texture and flavor, was on par with store-bought alternatives. The bread's overall acceptability, however, was much higher with the homemade dough mixer than with the store-bought one. The idea behind the design dough mixer lies in the fact that the pilot mixing machine will decrease the tedious manual process, enhance the efficient mixing of dough to a convenient, continuous operation until a certain degree of required homogeneity is achieved and stimulate new designs in bread processing. The fabricated mixer built was seem enough competitive with commercially available dough mixers in terms of mixing time, efficiency and capacity.

REFERENCES

[1] Olaerts, H., & Vandekerckhove, L., (2018). A closer look at the bread making process and the quality of bread as a function of the degree of preharvest sprouting of wheat (Triticum aestivum). Journal of Cereal Science. 80(4), 188-197. DOI:10.1016/j.jcs.2018.03.004.

[2] Agrawal, Y.C., Singgvi, A. & Shodhi, R.S. (2017). Development of an Abrasive Brush Type Dough Mixing Machine. Journal of Agricultural Engineering Indian Society of Agriculture, 20(3&4), 179–182 Bakerpedia. Fermentation. Retrieved May 2, 2019.

[3] Ajibola W. A. & Ibrahim, G. W. (2020). Design and Fabrication of a Flour Mixing Machine. Journal of Advances in Engineering Design Technology 2(2020), 89-94, 2682-5848.

[4] Adeleke, A. E., Oni, O. K., Ogundana, T. O., Satimehin, A. A., & Oyelami, S. (2020) Development and Performance Evaluation of a Dough Mixing Machine. UNIOSUN *Journal of Engineering and Environmental Science*. 2(2), 31-40. DOI:10.36108/ujees/0202.20.0250.

[5] Fink, R. (2019). *Good hygiene practices and their prevention of biofilms in the food industry*. Cambridge Scholars Publishing. Release Date: 18th July 2019, 167.

[6] Van der Meer, E., & Dullemont, H. (2021). Trapping and tracking protocol for Taiwanese leopard cats (Prionailurus bengalensis). Institute of Wildlife Conservation, National Pingtung University of Science and Technology. 4(2022), 11. DOI:10.13140/RG.2.2.22907.39202

[7] Fonseca, C. A., Santos, I., & Weber, H. I. (2020). An experimental and theoretical approach of a pinned and a conventional ball bearing for active magnetic bearings. *Mechanical Systems and Signal Processing*, *138*, 106541.

[8] Magdy, M., Abdelhamed, O., Essam, M. A., Abdeltawab, N. M., & Shash, A. Y. (2022). Design and Manufacturing of an IC and Electrical Engine Race Car. In *Engineering Design Applications IV* (135-162). DOI:10.1007/978-3-030-97925-6_10

[9] Guerrini, L., Parenti, O., Angeloni, G., & Zanoni, B. (2019). The bread making process of ancient wheat: A semi structured interview to bakers. *Journal of cereal science*, *87*, 9-17.

[10] Igbabul, B., Num G. & Amove J., (2014). Quality Evaluation of composite bread produced from wheat, maize and orange, fleshed sweet potato Flours. *American journal of Food science and Technology 2, 4 (2014): 109 – 115.*

[11] Parenti, O., Guerrini, L., & Zanoni, B. (2020). Techniques and technologies for the breadmaking process with unrefined wheat flours. *Trends in Food Science and Technology*, *99*, 152-166.

[12] Chen, J., Zhang, F., Zhao, C., Lv, G., Sun, C., Pan, Y., & Chen, F. (2019). Genome‐wide association study of six quality traits reveals the association of the TaRPP13L1 gene with flour color in Chinese bread wheat. *Plant biotechnology journal*, *17*(11), 2106-2122.

[13] Adeniran, A. O. (2019). Application of Likert scale's type and Cronbach's alpha analysis in an airport perception study. *Scholar Journal of Applied Sciences and Research*, *2*(4), 1-5.

[14] Tiga, B. H., Kumcuoglu, S., Vatansever, M., & Tavman, S. (2021). Thermal and pasting properties of Quinoa—Wheat flour blends and their effects on production of extruded instant noodles. *Journal of cereal science*, *97*, 103-120.

[15] Dereje, B., Girma, A., Mamo, D., & Chalchisa, T. (2020). Functional properties of sweet potato flour and its role in product development: a review. *International Journal of Food Properties*, *23*(1), 1639-1662.

[16] Ratnawati, L., Desnilasari, D., Surahman, D. N., & Kumalasari, R. (2019, March). Evaluation of physicochemical, functional and pasting properties of soybean, mung bean and red kidney bean flour as ingredient in biscuit. In *IOP Conference Series: Earth and Environmental Science,* 251(1), 120-126).

[17] Fasuan, T. O., Uchegbu, N. N., Olagunju, T. M., & Falola, O. O. (2022). Bioactive profile of Borno brown Vigna unguiculata grains as influenced by pre-harvest synthetic chemicals. *Food Bioscience*, *45*, 101-506.

[18] Liu, J., Li, Q., Zhai, H., Zhang, Y., Zeng, X., Tang, Y., & Pan, Z. (2020). Effects of the addition of waxy and normal hull‐less barley flours on the farinograph and pasting properties of composite flours and on the nutritional value, textural qualities, and in vitro digestibility of resultant breads. *Journal of Food Science*, *85*(10), 3141-3149.

[19] Zhang, Y., Wang, X., & Guan, X. (2022). Effects of adding quinoa flour on the composite wheat dough: a comprehensive analysis of the pasting, farinograph and rheological properties. *International Journal of Food Science & Technology*. 57(11), 7099-7106.

[20] Kassomech, M. (2019). Farinograph language. http://www.iaom-mea.com/wp content/uploads/2019/09/D2-4-BRABENDER-Farinograph-Language.pdf .

[21] Sanz-Panella, J. M., Wronkowskab, M., Soral-Smietanab, M., & Haros, M., (2013). Effect of whole amaranth flour on bread properties and nutritive value. *Food Science and Technology*, 50, 679–685.

[22] Bondt De, Y., Hermans, W., Moldenaers, P., & Courtin, C. M. (2021). Selective modification of wheat bran affects its impact on gluten-starch dough rheology, microstructure and bread volume. *Food Hydrocolloids*, *113*, 106348.

[23] Monteiro, J. S., Farage, P., Zandonadi, R. P., Botelho, R. B., de Oliveira, L. D. L., Raposo, A., & Araújo, W. M. (2021). A systematic review on gluten-free bread formulations using specific volume as a quality indicator. *Foods*,*10*(3), 614-620.

[24] Kajura, H. (2022). *Effect of substitution of wheat flour with modified cassava flour on the quality of bread* (Doctoral dissertation, Makerere University). 1(4), 200-233.

[25] Whitney, K., & Simsek, S. (2020). Potato flour as a functional ingredient in bread: evaluation of bread quality and starch characteristics. *International Journal of Food Science & Technology*, *55*(12), 3639-3649.

[26] Raihan, M., & Saini, C. S. (2017). Evaluation of various properties of composite flour from oats, sorghum, amaranth and wheat flour and production of cookies thereof. *International Food Research Journal*, *24*(6), 2278-2284.

[27] Suresh, C. (2013). Assessment of functional properties of different flours. *African journal of agricultural research*, *8*(38), 4849-4852.

[28] Iwe, M. O., Onyeukwu, U., & Agiriga, A. N. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food & Agriculture*, *2*(1), 1-10.

[29] Pang, Y., Ali, J., Wang, X., Franje, N. J., Revilleza, J. E., Xu, J., & Li, Z. (2016). Relationship of rice grain amylose, gelatinization temperature and pasting properties for breeding better eating and cooking quality of rice varieties. *PloS one*, *11*(12), 0168483.

[30] Ali, Y., & Jane, J. L. (2015). Gelatinization and rheological properties of starch. *Starch-Starke*, *67*(3-4), 213-224.

[31] Auchi, C. G., Igwe, V. S., & Echeta, C. K. (2019). The functional properties of foods and flours. *International Journal of Advanced Academic Research, Sciences, Technology and Engineering*, 5(11), 131-160.

[32] Sapirstein, H., Wu, Y., Koksel, F., & Graf, R. (2018). A study of factors influencing the water absorption capacity of Canadian hard red winter wheat flour. *Journal of Cereal Science*, *81*, 52-59.

[33] Schopf, M., & Scherf, K. A. (2021). Water absorption capacity determines the functionality of vital gluten related to specific bread volume. *Foods*, *10*(2), 228-235.

[34] Zhu, Q., Xing, Y., Lu, R., Huang, M., & Ng, P. K. (2017). Visible/shortwave near infrared spectroscopy and hyperspectral scattering for determining bulk density and particle size of wheat flour. *Journal of Near Infrared Spectroscopy*, *25*(2), 116-126.

[35] Ocheme, O. B., Adedeji, O. E., Chinma, C. E., Yakubu, C. M., & Ajibo, U. H. (2018). Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends. *Food Science & Nutrition*, *6*(5), 1173-1178.

[36] Khan, A., & Saini, C. S. (2016). Effect of roasting on physicochemical and functional properties of flaxseed flour. *Cogent Engineering*, *3*(1), 1145566.

[37] Matthew, N. O., Sadiku and Mohammed. L, (1997). Performance analysis of token passing Local Area. *Network J journal of Engineering Research*, *2* (1), 2.