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Performance Evaluation of Poultry Mixer

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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

The challenges facing the local poultry farmers in Ghana is alarming. Only a few farmers have access to poultry feed mixer. The government is interested in poultry industry as viable venture for self-employment. The mixer was evaluated by using five feed ingredients; maize, wheat bran, soya meal, oyster shell, and concentrate. The measurement comparison of feed rate, time, speed, moisture content, morphology, feed losses percentage, and mixer efficiency were performed on the mixer-machine. The mixer was characterized and analyzed using a feed component of three different measures of 4.5kg, 9.0kg, and 14.5kg with their respective time of 3 minutes, 6 minutes and 9 minutes respectively. Linear regression analysis was carried out on the test results collated during the evaluation of the mixer and the analysis contributed to the determination of the effectiveness and efficiency of the machine with different feed rates and times. The percentage loss, moisture content, production rate and machine efficiency were 7.95%, 15%, 90%, and 92.07% respectfully. The results indicated that variation in percentage loss among samples tested ranges from 5.56% to 9.33% with an average percentage of 7.95%. The results further revealed that the mixing capability of the proposed machine is effective, efficient and cheaper as compared to the existing machines used by small scale farmers. It is therefore recommended that poultry farmers should be encouraged to use the proposed mixing machine.

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1. INTRODUCTION

1.1 Background Literature

Food is one of the most important basic needs in the life of animal for survival. Machines are needed in terms of food production, preparation and other processing. The poultry subsector continues to play an essential role in providing employment and livelihood for a good percentage of the population in both urban and rural communities. The success of this sector lies heavily on feed availability. Feed availability also depends on the availability of both feed ingredients and the technology to mix the ingredients to satisfy farmers' demands. Victor [1], defined feed production as the process by which feed ingredients are mixed proportionally to produce compound feed, in the face of high costs of compounded feeds combined with their thoughtful quality/quantity, most poultry and pig farmers would want to produce their own feed.

The beginning of industrial scale production of animal feeds can be traced back to the late 1800s, this is around the time that the advancement in human and animal nutrition was able to identify the benefits of a balanced diet, and the importance or role the processing of certain raw materials played in this. William H Danforth in 1894 established Purina which is the world's leading producer of feed (Chime et al*.,* 2018). He added that, in the early 1900s, the animal feed industry expanded rapidly. Purina, the leader in the industry, expanded operations from the US into neighbouring Canada. They opened their first feed mill in 1927. This marked the beginning of the mechanization and industrial production of animal feed.

The electric standing mixer was invented in 1908 by Herbert Johnson, an engineer for the Hobart manufacturing company. The idea for creating this machine came from an incident in which he saw a baker mixing bread dough with a metal spoon [2]. He further used his engineering skills and intelligence to simulate the mixing action of the baker and came out with a mechanical tool simulating the process. The 80-quart mixer which he invented became the standard equipment by 1915. Rufus et al*.,* (2018), also observed that, in 1908, the feed industry was revolutionized by the introduction of the first feed mixer used for mixing pelleted feeds. Since then, there has been development in the area of designing and fabricating feed machines for commercial farmers.

There are a wide variety of mixers currently available for use in mixing components of animal feed. Selecting a particular feed mixer will depend mainly on the phase or phases which the components exist such as solid, liquid or gaseous phases. Some commonly used solid mixers include: Tumbler mixers, horizontal trough mixers, Vertical screw mixers etc. These are quite quick and efficient particularly in mixing small quantities of additives into large masses of materials. The results on mixer efficiency of different mixer types showed that the horizontal-type had a higher percentage of coefficient of variations (CVs) below 10% than the vertical-type. This could be due to mixing against the force of gravity such that dense materials like limestone and phosphates are difficult to elevate because of sliding and have the tendency to go to the bottom because of the height factor [3]. Study indicated that, some physical properties of raw materials including particle size, density, hygroscopicity and liquid addition, affect the mixing efficiency.

The mixing process is one of the most important steps in feed manufacturing. The goal of mixing is to meet label guarantees and produce a uniform feed that provides similar nutrient content to all animals consuming the feed [4]. Improper mixing of feed will result in poor quality products. Poor quality feed affects the growth and development of the animal hence affecting viability of the enterprise. Large quantities of feed will be very difficult to mix by hand if not impossible; this will inevitably lead to the production of poor-quality products and reducing production rate. This lowers the profits margin of the products. However, the cost of importation of foreign machine for mixing feed is very high compared to the producer's meagre resources. Generally, this affects the country's foreign exchange.

The traditional way of preparing animal feed mainly by the small- scale poultry farmer uses manual or the hand to mix, crush and measure the feed. In the medium scale production, feed mixing can be done either manually or mechanically. The manual method of mixing feed entails the use of shovel to intersperse the feed's constituents into one another on open concrete floors. However, the manual method of mixing feed ingredients is generally characterized by low output, less efficient, labor intensive and may prove unsafe, hence, hazardous to the health of the intended animals, birds or fishes for which the feed is prepared.

The machinery and equipment that are used for this purpose are usually imported and hence out of reach for the average small-scale or low-income poultry farmer. The challenge, therefore, is to construct, fabricate and evaluate a poultry feed mixer using local materials in order to reduce cost and hence make it available and accessible to the small poultry farmer. This machine should be simple to assemble, use and make handling easier and more comfortable for the peasant farmer.

The high cost of poultry feed machines in the country is pushing most of the small poultry farmers out of business. Currently, most small-scale farmers are on the verge of collapse due to the inability of farmers to purchase or have access to imported feed mixers to reduce costs and make them accessible to small poultry farmers (Nunoo, J. O. H. N. 2015). Therefore, this study constructed and evaluated the performance of a poultry feed mixer using local materials. This will also help reduce the cost of producing poultry feed and eventually reduce the cost of poultry products if small-scale poultry farmers can afford feed mixers. This means that poultry birds and eggs will be affordable, and so people will have the daily requirement of proteins that the body needs. Poultry production also earns the country more foreign exchange through exportation.

The objectives therefore seek to evaluate the effectiveness and efficiency of the machine based on the produced and equipment performance concerning the effectiveness of the mixing quality; and to conduct a comparative analysis of the existing and modified poultry feed machines.

2. MATERIALS AND METHODS

2.1 Mode of Operation

The machine is made up of a cylinder welded to a short thick plate of 3 mm to support the cylinder to the main frame. Inside the cylinder, where the shaft and the mixing blade are known as augers, houses the short mixing blades. The switch of the electric motor of the mixer is set at the ON position. The feed ingredients are introduced into the mixer through the feed gate in the upper part of the mixing chamber. The ingredients introduced into the chamber are in order of quantity. With the ingredients inside the mixing chamber, the rotating action of the centrally based horizontal acting ribbon lifts it from the lower part of the cylinder through the helical plate and drops it up at the upper end of the chamber. After thorough mixing is achieved, the flap of the charge channel is opened to allow the mixed component to exit the chamber.

2.2 Component Description

The machine which has been produced from the assemble of various components were designed based on the properties of materials including the frame, shaft, bearing, mixing chamber, chain and sprocket and mixing blades.

Frame: This component is the primary part of the machine made of angle mild steel and is used to support the weight of the machine. It is a ferrous metal material that possesses the required properties, such as ductility, plasticity, and considerable strength, which are capable of being fabricated to the required degree of functional tolerance. Other selected factors are being cheap and most abundant in the market in case of replacement, machinability, and workability.

Fig. 1. The frame

Fig. 2. The shaft

Fig. 3. Mixing cylinder

Fig. 4. The mixing ribbon

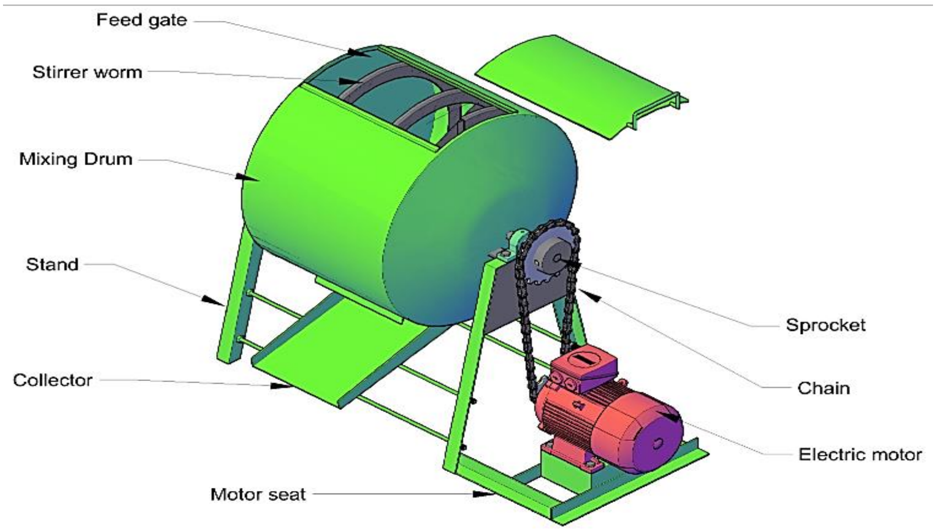

Fig. 5. Pictorial view of the poultry feed mixing machine

A shaft is a rotating machine element used to transmit power from one place to another. The power is delivered to the shaft by some tangential force, and the resultant torque (or twisting moment) set up with the shaft permits the power to be transferred to various machines linked to the shaft. It is made of mild steel based on the maximum permissible working stress for transmission shafts.

Mixing cylinder: The mixing cylinder of this machine used mild steel metal sheets, which are of considerable strength and are capable of being fabricated to the required degree of functional tolerance, which is preferably used for reliability of operation and lessened frequency maintenance. It is also used because of its abundance in the market and weldability.

Mixing ribbon: Ribbon is a thick sheet metal made of stainless steel which is made up of a shaft and helical blade. The helical blade is coiled around a cylindrical drum attached to the shaft and hence the helical blade forms a spiral shape on the shaft Fig. 4 shows the shaft and mixing ribbon.

2.3 Methods

Shaft speed was selected at the time the engine was started and allowed to warm up for five minutes and the ingredients were fed into the machine. The ingredients that were discharged at the outlet points were collected separately and analyzed to determine the performance characteristics of the machine at a set shaft speed.

However, the following ingredients were used for the conduct of the test, they include maize, wheat bran, soya meal, oyster shell, and concentrate. The test run of the machine was carried out to determine the mixing efficiency by using different capacities at different time intervals. Tables 1,2 and 3 indicate the weight of the ingredient and percentage of the mixer in chapter four.

The machine was first tested with 2.5 kg of maize, 1 kg of wheat bran, 0.5 kg of soya meal, and 0.25 kg each of oyster shell and concentrate, summing up to 4.5 kg weight as input feed for the first test run. Also, 5 kg of maize, 2 kg of wheat bran, 1 kg of soya meal and concentrate, and oyster shell were added with 0.5 kg each. The third test measurement was as follows; maize 7.5 kg, wheat brand 2.5 kg, soya meal 1.5 kg, and 0.75 kg each for concentrate and oyster shell.

The first test of the experiment was allowed to run for three (3) minutes, six (6) minutes, and nine (9) minutes for the second and third tests respectively. The output of the machine, during the experimental test, weighed 4.08 kg, 8.5 kg, and 13.8 kg for the input of 4.5 kg, 9.0 kg, and 14.5 kg for the first, second, and third tests respectively, and the efficiency of the machine was determined.

2.3.1 Parameters determination

In this process, the main parameters were determined and analysed; moisture content, losses and efficiency. These parameters were essential in assessing the performance and effectiveness of the mixer

2.3.2 Determine moisture content

Moisture content (wet basis) %, moisture content = Mo – Mi × 100/Mi

Mi = mass in grams of the dry test portion

2.3.3 Formula for peripheral speeds

Peripheral speed is given by Vp = W × R… (2.1)

$$Vp = \frac{2n\pi}{60} \frac{(d + 2h)\ m/s}{2} \ \ldots\ldots\ldots.. \quad (2.2)$$

Where n = drum speed (rpm)
h = height of stirrer worm (m)

2.3.4 Determination of losses

$$\%\text{ of unmixed produce} = \frac{(\text{quantity of unmixed produced from all leakage outlets})\text{x}100 \ldots\ldots}{\text{Total produced yield.}} \quad (2.3)$$

$$\%\text{ of blown loss} = \frac{(\text{produced obtained at input} - \text{outlet} + \text{produced blown overboard}) \times 100}{\text{produced yield}} \quad (2.4)$$

Yield = produced stacked in the machine + produced blown overboard + produced obtained at all outlets.

2.3.5 Determination of efficiencies

Mixing efficiency = 100% - percentage of unmixed produced (grains and ingredients) ….. . (2.5)

$$\text{Machine efficiency} = \frac{\text{(mixed grains and ingredients received at produced spout)}}{\text{Total mixed grains and ingredients received at spout}} \times 100\% \quad (2.6)$$

$$\text{machine efficiency} = \frac{\text{(mixed grains and ingredients received at produced spout)}}{\text{Total mixed grains and ingredients received at spou}} \times 100\%$$

Where ingredients received produced or output = 25.78kg

Total mixed ingredient or input = 28kg

$$\text{Therefore, machine efficiency} = \frac{(25.78)}{28} \times 100\% = 92.07\%$$

2.4 Performance Evaluation

Experiments were conducted to evaluate the performance of the manufactured poultry feed mixture to optimize the main operating parameters during feed processing. This section deals with the evaluation results of machine efficiency at different stages of tests with different evaluations of treated and measured ingredients, mixed rates, percentages, time, and moisture content. In experiment 1, machine efficiency was 90.7%, experiment 2 recorded 94.4%, and experiment 3 efficiency was 91.0% with different levels of produce weight. In experiment 1, the ingredient was 4.5 (kg) with a mixing rate of 4.08 (kg), a moisture content of 6%, and the time allowed was 3 minutes. Experiment 2, used 9 minutes for the ingredient of 9 (kg), mixing weight of 8.5 (kg), and moisture content obtained was 9(%), and the final test run for 9 minutes with the ingredient 14.5 (kg), mixing rate and moisture content was recorded as 13.2(kg) and 15% respectively. It was also indicated that the machine efficiency for the three stages of tests were 90.7%, 94.4%, and 91.0% for Test 1, Test 2, and Test 3 respectively with different produced weights. From the results obtained, a mixing time of 6 minutes and 9 minutes gave the best mixing time for experiments 2 and 3. However, the efficiency and production rates were also recorded as 92.0% and 90 kg/h, respectively.

2.5 Construction Materials

Tools and equipment used during the construction of the machine are; electric arc welding, drilling machine, portable hand grinding machine, lathe machine, hammer, try square, hacksaw, table vice, spanner, chisel, and so on. The selection of proper materials for engineering is a difficult problem for the designer. The best material serves the desired objectives at a minimal cost. The materials for each component of the poultry feed mixer were selected based on the desired objective at the minimum cost without compromising the availability and suitability of the materials for the working conditions in the services were also considered. The major properties of the material which were considered in the design are; strength, stiffness, ductility, toughness, fatigue, resilience, hardness, creep and machinability, cast ability, weldability, material visual appearance, frictional properties and internal vibration damping properties

3. RESULTS AND DISCUSSION

This section deals with the results obtained and discussions of the study. The analysis was centred on the weight and percentages of material, mixed at different weight of the ingredients, summary of the result and percentage loss due to the non-mixed ingredients and others. It also presents the mixed produced with constant moisture content and efficiency, mixed produce losses with constant moisture content and machine efficiency mixed produce with different test and machine efficiency as well as mixed produce surface particles structure. The analysis was centred on the duration of mixing, effectiveness and efficiency of the machine on the bases of the produce and the equipment performance of the poultry feed.

3.1 Percentage Loss

Fig. 6 shows the evaluation results for the total losses of the machine with a constant speed of 21.59 r/s and a moisture content of 14.5%. The result total loss percentages of under-mixed, normal mixed, and over-mixed were 2% in experiment 1, 6%, and 20% in experiments 2 and 3, respectively. It was indicated that over-mixed had the highest losses and under-mixed also recorded the lowest losses. In comparing the two machines, both machines showed the same pattern as indicated in the results of the experiment, and revealed that the loss rate of the two machines increased as the duration of time increased. However, the existing machine had a maximum loss of 22% compared to that of the modified machine. The evaluation result on total losses with a constant shaft speed of 21.59 rpm, at the under mixed, not much feed was lost as compared to normal mixed. However, at the over-mixed stage, where the machine was run at its maximum, the lost graph intersected with the constant shaft speed graph, which led to more feed lost at the point of intersection.

3.2 Moisture Content and Mixed Rate at Constant Speed

Fig. 7 shows the evaluation result for the mixed rate of ingredients with a constant shaft speed of 25.27 r/s. The evaluation moisture content of experiments 1, 2, and 3 were 6%, 10%, and 14%, and that of the mixed rate was also obtained as follows; 9%, 15%, and 20%, respectively. It is observed that, at a lower moisture content, the mixed rate was lower but increased as the moisture content also increased with constant machine speed. Comparing both machines, it was observed that the existing machine's mixed rate and moisture content were lower than those of the modified machine with the same quantity of ingredients at a constant machine speed.

3.2.1 Technical operation principles of the modified machine

Test one was a mixture of 4.5 kg and the result is represented in Table 1. At first, the machine was set on to run for about 3 minutes and mass of the product obtained at the outlet was recorded. The value was obtained for the weight of the ingredients, mixing time, efficiency of the machine and production rate were 4.5 kg, 3 minutes, 90.67% and 90 kg/h respectively. This means that, 4.5 kg of ingredients were processed for 3 minutes, the production rate was 90 kg/h and the efficiency of the machine is 90.67% during the first run test. Morad and Hend, [5], indicated that, on-farm feed system normally uses three types of mixers; vertically, horizontal and rotating drum. The mixing time on vertical mixers normally run 10 to 15 minutes and horizontal or rotating drum mixers can mix in 5 to 10 minutes. Therefore, the degree of mixing in 3 minutes achieved was 90.67%.

From Table 2, 9.0 kg, weight of ingredients were loaded into the machine and was allowed to run for about 6 minutes, after that, the mass of the product obtained at the discharged unit was 8.5 kg as recorded. The efficiency and production rate were determined as 94.44% and 90 kg/hr respectively. Therefore, the result in Table 2 shows an improvement in efficiency when the mixer was allowed to run for 6 minutes with the appreciable increase in capacity of 9.0 kg.

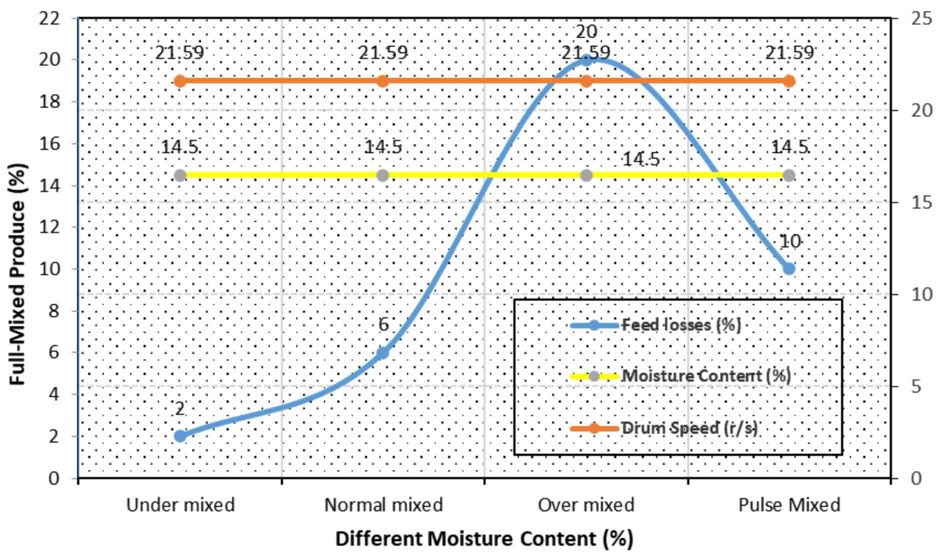

Fig. 6. Mixed production losses with constant speed moisture content and machine efficiency

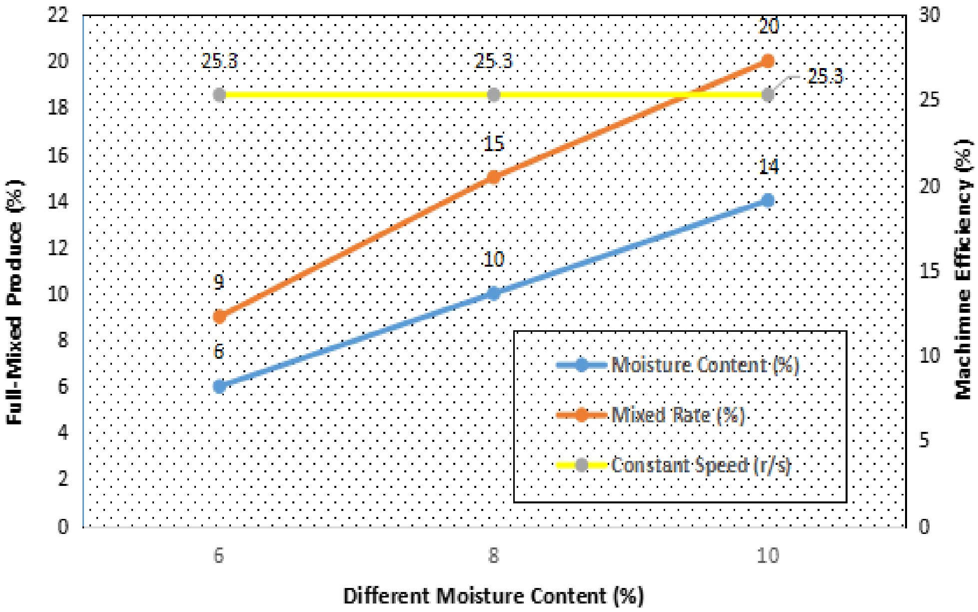

Fig. 7. Moisture content and mixed rate at a constant speed

Table 1. Weight and percentage of materials mixed to achieve 4.5kg of feed

S/N	Ingredients (kg)	Weight of Ingredients (Kg)	Percentage of mixer (%)
1	Maize	2.5	55.6
2	Soya meal	0.5	11.1
3	Wheat brand	1.0	22.2
4	Oyster shell	0.25	5.6
5	Concentrate	0.25	5.6
Total		**4.5**	**100**

Source: Field test, (2020)

Table 2. Weight and percentage of materials mixed to achieved 9.0kg of feed

S/N	Ingredient (kg)	Weight of Ingredient (Kg)	Percentage of mixer (%)
1	Maize	5	55.6
2	Soya meal	1	11.1
3	Wheat bran	2	22.2
4	Oyster shell	0.5	5.6
5	Concentrate	0.5	5.6
Total		**9.0**	**100**

Source: Field test, (2020)

Table 3. The weight and percentage of materials mixed to achieve 14.5kg of feed

S/N	Ingredient (kg)	Weight of Ingredient (Kg)	Percentage of mixer (%)
1	Maize	7.5	51.7
2	Soya meal	2.5	17.2
3	Wheat bran	3.0	20.7
4	*Oyster shell*	0.75	5.2
5	Concentrate	0.75	5.2
Total		**14.5**	**100**

Source: Field test, (2020)

Table 4. Summary of the results

Test	Ingredients Weight (kg)	Mixing Time (minutes)	Mixture Weight/Output(k)	Efficiency (%)
First test	4.5	3	4.08	90.7
Second test	9.0	6	8.5	94.4
Third test	14.5	9	13.2	91.0
Total	**28**		**25.78**	**92.1**

Source: Field test, (2020)

Table 3 shows 14.5 kg, weight of ingredients fed into the machine, which was then allowed for about 9 minutes to run, after that, the mass of the product obtained at the discharged unit was 13.2 kg as recorded. The efficiency and production rates were determined as 91.44% and 90 kg/hour respectively. However, the amount of mixing increased with increase in time from 6 to 9 minutes while there was a negligible reduction in degree of mixing, as time increases to 9 minutes. According to Balami et al., [6], a mixing performance of up to 95.31% was attained in 20 minutes of operation and evacuation of mixed materials from the mixer was at full capacity (60 kg) while the average value of coefficient of variation for the three replicates was 4.69%. Therefore, the result in Table 3 shows a significant reduction in efficient percentage by 3.41% resulting from the increase in feed capacity with respect to the duration time of 9 minutes. Hence, the machine could not perform effectively when 14.5 kg weight was loaded. It also indicated that increasing mixing time for more than 9 minutes decreases the discharge rate and the efficiency of the machine.

There is an increase in the uniformity of mixing as shown in Table 4, as the time of duration increases from 3, 6, and 9 minutes at a constant speed with respect to increase in weight, the mixer was able to achieve effective mixing between 6 to 9 minutes. Despite the quality uniformity of the mixture, there was a reduction in efficiency of the machine during the third test due to the increase in feed rate, as more ingredients were compacted in the mixing chamber and this caused a drop in pressure, henceforth causes a reduction in efficient of the machine.

3.3 Production Rate and Machine Efficiency

The constructed modified machine was tested, and the results showed a high machine efficiency of 92.07% and a production rate of 90 kg/h. When the efficiency of the modified machine was compared to that of the existing machine, it was discovered that the efficiency of the existing machine was 2.6% lower compared to 3.0% [7]. He also reported that an increase in the discharge time increased the discharge efficiency of the machine, thereby reducing the weight of residue ingredients. Henceforth, this might be due to the number of minutes allowed to run each test. If more time is allowed for the machine to run, its efficiency will increase.

3.4 The Effectiveness and Efficiency of the Machine

Table 5 shows mixing weight and mixing time of different weight of feed for which different tests were carried out. These included 4.5 kg, 9.0 kg and 14.5 kg of feed at different mixing time intervals of 3, 6 and 9 minutes with respect to the recorded mixing weights of 4.0 8kg, 8.5 kg and 13.2 kg respectively. This was used to determine the efficiency and mixing rate of the machine. The results obtained show that, the machine slightly mixed the ingredients of 4.5 kg at 3 minutes. However, when the weight was increased to 9.0 kg with respect to 6 minutes, the ingredients were fully mixed and also equally mixed when the weight was increased to 14.5 kg with respect to its corresponding time intervals. Peter [8] "observed that, the aspect of manual mixing is much healthier for birds and better in efficiency and output, than the use of shovel or hand and basin. Their outputs and efficiencies are not to be reckoned with in production of poultry feed in a proper commercial poultry farm". Daniyan et al., [9], "also indicated that, the performance evaluation of the machine was carried out to determine the mixing efficiency using different feed capacity at different time intervals and percentage recovery rate on the feed rate". The mixing time and degree of mixing was observed to increase with increase in feed weight. The horizontal feed mixer developed was highly efficient, cost effective and solves problems associated with manual mixing during livestock feed production. Therefore, the results showed that, the mixing capability of the machine is effective and efficient [10].

Table 5. Mixing weight and mixing time of different weights of feed

Test	Mixing Weight (Kg)	Time (s)	Mixing Rate
Test 1	4.08	3	Slightly mixed
Test 2	8.5	6	Fully mixed
Test 3	13.2	9	Fully mixed
Total	**25.78**	**18**	

Source: Field test, (2020)

Table 6. Percentage (%) loss due to non-mixed ingredients5.56

Test	Ingredient Weight (Kg)	Mixing Weight (Kg)	Percentage Lost (%)
Test 1	4.5	4.08	9.33
Test 2	9.0	8.5	8.97
Test 3	14.5	13.2	5.56
Average Total	**9.33**	**6.59**	**7.95**

Source: Field test, (2020)

3.5 Comparative Analysis

The result in Table 6 indicates the percentage loss of ingredients during the experiment tests for each operation, thus, experiment 1, 2 and 3, were 9.33%, 5.56% and 8.97% respectively. The results also indicated variation in percentage loss among the samples tested ranging from 5.56% to 9.33% with an average percentage of 7.95%. This percentage loss was due to the non-mixed ingredients and leakages from the mixing chamber of the machine.

The constructed modified machine was tested and the results showed high machine efficiency of 92.07%. When the efficiency of the modified new machine was compared to that of the existing machine, it was discovered that, the efficiency of the existing machine was 2.6% lower and also compared to the 3.0% [7]. He reported that, the increase of the discharge time led to an increase in the discharge efficiency of the machine thereby reducing weight of residue ingredients. Henceforth, this might be due to the number of minutes allowed to run for each test. If more time is allowed for the machine to run, the efficiency will increase more.

4. CONCLUSION

The poultry feed mixer was designed, constructed and evaluated and it was concluded that the machine can be used by small scale farmers to tend to their need of producing feed for their poultry. During test runs of the poultry feed mixer, the ingredients used for the conduct of the test included maize, wheat bran, soya meal, oyster shell and concentrate. These ingredients were used because, there are the common ingredients the poultry fowls feed since they possess the necessary nutrition for their growth and health. The experiment was carried out to determine the mixing efficiency by using different capacities at different time intervals. This was to assess and evaluate the mixing rate and quality of feed recorded at the end when different weights of feed are fed into the mixer.

The poultry mixer designed for this project was noted to have different mixing capacities in relation to weight of feed and production rate. This is because, the working capacity of the mixer was designed to be capable of mixing different weights of feed to an extent since poultry farms across the north have different sizes with regard to the number of birds in the farms. Therefore, farmers stand the chance to feed the mixer with the number of weights desired per farm. The value obtained for the weight of the ingredients, mixing time, efficiency of the machine and production rate were different because an efficient and quality poultry mixer should possess different mixing capacities when different weights of feeds are fed into the mixer.

The reduction in efficiency of the quality of mixing which also caused a drop in pressure due to the increased in feed rate as more ingredients were compacted in the mixing chamber happened as the result of the fact that the weight of feed influences the rate at which a mixer exerts pressure to accomplish a particular mixing of feed. Therefore, the machine need be improved and modified to increase its efficiency by using solar energy to power the machine to run its full capacity.

5. RECOMMENDATION

The common and most used poultry feeds among Ghanaian poultry farmers included maize, wheat bran, soya meal, oyster shell and concentrate. It is therefore imperative that the Ministry of Agriculture together with ministry of trade and industry, regional and district chief farmers should liaise among themselves to enhance, sustain and support the manufacture of feed mixture and cultivation of these feeds across the country. This ensures availability of feed mixer and efficient of the feeds on the Ghanaian markets for poultry farmers.

The test run of poultry mixer machines are very important for quality records and it remains an important issue to address. Therefore, engineers of poultry mixers should test machines and provide manuals or labels alongside with poultry mixers so that poultry farmers can use them effectively.

The poultry mixer designed in this study has capacity in terms of mixing rate, weight of feed and durability, hence poultry farmers should be given the necessary education on the use and maintenance of the mixer in order to effectively and efficiently use the mixer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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