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RESEARCH ARTICLE

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MODIFICATION OF POULTRY FEED MIXER

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ABSTRACT

A poultry feed mixer that I developed before was modified and evaluated for its performance using sodium chloride (NaCl) as tracer. Position of feeding table was modified and assembled at the lower part of connecting frustum and the volume of mixer also increased to 200kg/batch feed mixing capacity. The machine was tested using a feed composed of 106.8 kg cracked corn, 48 kg wheat bran, 20 kg nug cake, 10 kg cracked soybean, 10 kg fish meal, 2 kg lime stone, 2 kg premix, 0.20 kg methionine, 0.40 kg lysine and 0.6 kg salt (NaCl) replicated thrice at four mixing durations of 10, 15, 20 and 25 minutes and screw shaft speed of 100, 150 and 250 rpm. The effectiveness of mixing was assessed on the basis of percent salt content, and percent coefficient of variation (CV %) and percent degree of mixing (DM %) of sample collected at the end of each test. The best values of coefficient of variation (8.42%) and degree of mixing (91.58%) were obtained at mixing screw shaft speed of 150 rpm and mixing time of 20 minutes. Easy of operation and capacity of mixing also doubled than previous developed one. The modified poultry feed mixer, should be operated at speed of 150 rpm with maximum mixing time of 20 minute in order to make the owning and operating of the machine productive (in terms of kg/hr) and economical (in terms of labour and energy cost birr/kg) of mixed quality feed.

KEYWORDS: Poultry, poultry feeds and feed mixer

1. INTRODUCTION

Feed production for livestock, poultry or aquatic life involves a range of activities, which include grinding, mixing, pelleting and drying operations. New (1987) gave a summary of the different types of machinery needed for the production of various types of feeds and they include grinders, mixers, elevators and conveyors, mixers, extruders, cookers, driers, fat sprayers and steam boilers.

Mixing is one of the most essential and critical operations in the process of poultry feed manufacturing, yet it is frequently given little consideration. The objective in mixing is to obtain a completely homogeneous blend. In other words, every sample taken should be identical in nutrient content (Fei, 1997). Uneven ingredient dispersion of feeds may lead to reduced bird performance. In order for birds to reach their genetic potential for growth and meat yield, levels of protein, energy vitamins and minerals must be provided in their proper ratio (Fei, 1997).Essentially, 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. The manual method of mixing feed ingredients is generally developed to characterized by low output, less

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efficient, labour intensive and may prove unsafe, hence, hazardous to the health of the intended animals, birds or fishes for which the feed is prepared.

Different research centers and organizations had tried to import and develop animal feed mixer. The imported feed mixers are very expensive and large in size so that only Unions and large micro enterprise used and which is not affordable to farmers. Asella Agricultural Engineering Research center is one of them that developed Poultry feed mixer. The problem of this mixer is small in size and feeding hopper is found on the upper part of mixing chamber and that cause difficulty during filling the chamber with feed ingredients. The amount of labour required operating the machine and time to fill the mixing chamber with feed ingredient is so high. It has no ladder to climb on and brings difficulty during fill. This study is therefore, an attempt towards modification, manufacturing and performance evaluation ofvertical screw type poultry feed mixer developed this center.

2. MATERIALS AND METHODS

2.1. Materials

A locally modified and manufactured vertical batch mixer was used for its performance evaluation study. To evaluate the performance of the mixer, a standard test procedure was used. The standard defined a uniform test procedure and measurement for evaluating the mixing ability of an on-farm portable batch mixer.

2.2. Methods

Poultry feed mixer part identification and modification process was done at Asella Agricultural Engineering Research center work shop. The parts that modified were volume of mixing chamber and ingredients feeding hopper.

2.2.1. Modification of mixing chamber

The mixing chamber consists of two unequal cylinders (upper and lower cylinders) that were connected through a frustum with bolt and nut. This mixing chamber was made from 1.50 mm sheet metal which were cut, rolled and welded together. The upper cylinder has a diameter of 600 mm and a height of 500 mm while the lower cylinder diameter increased from 150 mm to 170 mm and the height also increased from 100 mm to200 mm. The connecting frustum height increased from 500 mm to 850 mm.The total volume of this chamber was computed using the relationship given by Balami, *et. al.*, (2013) and is shown below.

$$V_T = V_U + V_F + V_L$$

The net volume of the mixing cylinder was determined as follow:

$$V_{net} = V_T - V_{sc} - V_S$$

Where: V_T = total volume of mixing chamber, m^3;V_U = volume of upper cylinder, m^3;V_F = volume of frustum, m^3;V_L = volume of lower cylinder, m^3;V_{net} = net volume of the mixing chamber, m^3;V_{sc} = volume of screw casing, m^3;V_s = volume of shaft, m^3.

2.2.2. Modification of feeding hopper

The most important part of poultry feed mixer that require modification was feeding hopper. That was because of its difficulty during fill the mixing chamber with ingredients. To feed the ingredients through this part it requires climbing on another material because it was not reachable from the ground. Falling was occurred during fill the chamber with feed ingredients. It also consumed large time during filling because of lifting the feed from the ground and climbing on the ladder in order to fill the mixing chamber. Therefore, bringing the feeding hopper to the lower part of connection frustum was done. This was reduce time of filling and amount of labour required to operate the mixer.

2.3. Description of Poultry Feed Mixer

A vertical poultry feed mixer was modified and constructed at Asella Agricultural Engineering Research Center. The mixer consists of the essential component parts as shown in Figure 1. The mixing section has two cylindrical bodies (upper and lower) with different diameters that are connected together through a frustum. The upper cylinder has a diameter of 600 mm and its height is 500 mm. The lower cylinder height is increased to200 mm from 100 mm and a diameter of 170. The height of the frustum, which connects the two cylinders, is increased to 850 mm from 500 mm. Both cylinders and the frustum were constructed using a mild steel sheet metal of 1.5 mm thickness. An opening of 100 mm x 90 mm was provided at the lower end of the lower cylinder. This opening was connected to the discharge chute. The mixing chamber is

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provided with a centrally based, vertical acting auger conveyor that operates inside a close fitting tube of 170 mm diameter and 1000 mm in height. The auger is formed with inside diameter of 25 mm that corresponded to the screw shaft made of mild steel rod with 25 mm diameter. The helix of the auger is made with a uniform diameter of 165 mm having pitch of 100 mm. All these machine components are connected to each other with bolt and nut.

Figure 1. Major components of the prototype poultry feed mixer

The feed ingredients to be mixed were introduced into the mixing chamber via a trapezoidal hopper. The hopper was constructed with the following dimensions: major width 490 mm, minor width 200 mm, length 300 mm had a height of 200 mm. The hopper was made to stand at an inclined angle of 60^0 with respect to the mixing chamber when fixed in place. All the parts that make up the machine were mounted on a trapezoidal frame robustly built with detachable stands. An angle iron of 50 mm x 50 mm x 5 mm was used in the construction of the frame, for its rated strength and stability in service. The frame has the following dimensions: 1500 mm height, 1000 mm lower length, 800 mm lower width and 800 mm upper length and 700 mm upper width. The source of power was electric motor and connected to the screw shaft through v-belt and pulleys with adjustable electric motor sit. The screw shaft is supported by two radial ball bearings hinged at the top and bottom part to simplify and facilitate efficient power transmission.

2.4. Working Principle of the Machine

During operation with the switch of the mixer's electric motor set at the "ON" position, the feed ingredients are introduced into the mixer via a trapezoidal shaped hopper located at the lower part of the mixing compartment. Material introduction into the mixer is in order of quantity, with the bulkier among the components introduced into the machine first. With the material inside the mixing chamber, the rotating action of the centrally based vertical acting auger, lifts it up from the lower cylinder through the close fitting tube and drops it high up at the end of the tube. After thorough mixing is achieved the shatter or flap of the discharge channel is open to allow the mixed components out of the mixer where the need for using the machine is only to mix feed constituents. Complete evacuation of the material is facilitated by the opening of shatter found at the lower end cover of cylinder chamber. At the end of evacuation operation, the motor switch is put off.

2.5. Mixer Performance Evaluation

The modified poultry feed mixer was loaded with all the feed ingredients` prepared on the basis of recommended rations. The tracer material, NaCl, was added last and the mixing was started. Ten 100 g sample was taken during the discharge of the mixed feed at equal time interval. The sodium chloride concentration was determined according to the method developed by FAO (1981).

$$NaCl_{cons} = \frac{Titre \times factor \times 0.1}{weight\ of\ sample} \times 100\%$$

Where: Titre value = volume of the Titre used; factor = 0. 0058; 0.1 = concentration of $AgNO_3$

The performance of feed mixer assessed on the basis of salt concentration as analyzed in the laboratory and its mean concentration, variation between samples (standard deviation) and coefficient of variation (CV) using the following equations as recommended by Herrman and Behnke (1994).Mixers with salt concentration CV values of 10% and below were considered to be the best.

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$$CV\,\% = \frac{SD}{\bar{y}} \times 100$$

$$\bar{y} = \frac{\sum y_i}{n}$$

$$SD = \sqrt{\frac{\sum \left[y_i - \bar{y} \right]^2}{n-1}}$$

Where: CV % = percent coefficient of variation; SD = standard deviation; = mean; $\sum$ = sum; y_i= individual sample analysis results; n = total number of samples.

2.5.1. Experimental design

The experimental design was randomized complete block design with three replications. Treatments consisted of factorial combinations of three mixing speeds (100, 150, and 250rpm) and four mixing time (10, 15, 20, and 25 minutes). Analysis of variance appropriate to the design of the experiment to evaluate the significance of the factors on mean salt concentration, coefficient of variation and percent mixing were tested using MSTAT-C software. Duncan multiple ranges test at 0.05 probability level were computed to delineate the significance differences between and/or among treatment means (Gomez, 1984) and a graph plotted.

3. RESULT AND DISCUSION

The necessary modification of a vertical poultry feed mixer were considered in depth. Proper modification was carried out on the machine to avoid failure on both auger blades and auger shaft. Themodified poultry feed mixer was manufactured using local materials, skill, experience and expertise. The modified poultry feed mixer has the ability to mix about 200kg/per batch. Tests were carried out at four mixing periods (mixing time) and three mixing speeds (auger shaft speeds, rpm) to evaluate the mixing performance of the modified feed mixer based on salt concentration of mixed feed as measured by mean value of concentration, standard deviation and coefficient of variability. Results obtained and discussions on the same are presented in the following sections

3.1. Effect of Mixing Duration and Screw Shaft Rotation on Feed Uniformity

Table 1 gives the mean concentration of salt (sodium chloride, NaCl), coefficient of variation and degree of mixing of feed ration mixed using the prototype poultry feed mixer developed at the auger shaft speed of 100, 150 and 250 rpm and various levels of mixing time.

Table 1:Mean prototype poultry feed mixer performance at mixing time of 10, 15, 20 and 25 minutes for each auger shaft of 100, 150 and250 rpm.

Mixing dur. (min)	Shaft Speed (rpm)	Mean NaCl Concentration (%)	Mean CV %	DM(%)
10	100	0.250	20.27	79.73
15	100	0.241	14.37	85.63
20	100	0.24	12.79	87.21
25	100	0.243	11.25	88.75
Mean	-	**0.244**	**14.67**	**85.33**
10	150	0.24	17.43	82.57
15	150	0.235	14.54	85.46
20	150	0.25	8.42	91.58
25	150	0.248	10.42	89.58
Mean	-	**0.243**	**12.70**	**87.30**
10	250	0.232	17.03	82.97
15	250	0.229	14.10	85.90
20	250	0.248	12.64	87.36
25	250	0.237	12.18	87.82
Mean	-	**0.236**	**13.99**	**86.01**

The mean percent concentration of NaCl, and percent coefficient of variation and degree of mixing of the prototype machine at mixing auger speed of 100 rpm and holding/mixing time of 10, 15, 20, and 25 minutes were found to be 0.250, 20.27 and 79.73, 0.241, 14.37 and 85.63, 0.240, 12.79 and 87.21, and 0.240, 11.25, and 88.75, respectively. Though the salt concentration over the test periods (10, 15, 20, and 25 minutes) remained almost identical and the degree of mixing increased with increasing mixing time in minutes, the coefficient of variations were well above 10%, which is considered to be the turning point; values above that indicate inadequate level of mixing, i.e. none uniformity in mixing feeds. Mixing poultry feed, using the modified mixer, at auger shaft speed of 100 rpm for duration of 25 minutes gave a mean percent coefficient of variation of 11.25, which is close tooptimum level.

The mean percent concentration of NaCl, and % CV and degree of mixing of the modified machine at mixing auger speed 150 rpm and mixing time of 10, 15, 20, and 25 minutes were found to be 0.24, 17.43 and 82.57; 0.235, 14.54, and 85.46; 0.250, 8.42 and 91.58 and 0.248, 10.42 and 89.58, respectively. From Table 1, it can be seen that, at the mixing auger shaft speed of 150 rpm, mixing time of 20 and 25 minutes resulted in % CV of 8.42% and 10.42%, respectively. The two values of coefficient variations obtained at mixing times 20 and 25 minutes are within upper boundary of rating as indicated by Herrman and Behnke (1994) (values of % CV< 10, 10 – 15, 15 -20 and > 20 are rated excellent, good, fair and poor, respectively, in terms of uniformity of mixing). Hence, the mixing uniformity was superior at the combination of 150 rpm and 20 minutes of mixing time and which is similar to the finding of (Gosa, 2016).

Table 1 gives values of the performance indicators of the prototype poultry mixer when operated at a constant mixer auger shaft speed, 250 rpm and different holding/mixing time (10, 15, 20, and 20 minutes).The mean percentCV and and mean percentDMof the prototype machine at mixing auger speed 250 rpm and holding/mixing time of 10, 15, 20, and 25 minutes were found to be 17.03 and 82.97; 14.10 and 85.90; 12.64 and 87.36; and 12.18 and 87.82 respectively.

Table1 clearly indicate that the % CV and % DM decreased and increased, respectively, as the speed of mixer shaft speed and holding/mixing time increased. Nonetheless, the optimum level of mixing with % CV of 8.42 and % DM of 91.58 were observed at the mixer auger shaft of 150 rpm and mixing time of 20 minutes. Hence, it can be concluded that the mixer should be operated at speed of 150 rpm with maximum mixing time of 20 minutes in order to make the owning and operating of the machine productive (in terms of kg/hr) and economical (in terms labour and energy cost birr/kg of mixed quality feed(Crenshaw, 2000).

From Table 1 it can be noted that the least % CV was below 10 % indicating excellent mixing. The % CV of speeds below and above 150 rpm was higher though the mixing time was increased up to 25 minutes. The findings of Gbadamosi and Magaji (2005) and Gosa (2016) indicated similar trend. This is due to the very fact that at low mixing auger shaft speeds (rpm) the magnitudes of both axial (lifting accelerations) and radial (centripetal accelerations) acceleration of the feed ingredients were so small that all materials might tended to move as a unit. On the other hand, at high mixing auger shaft speeds (rpm) the magnitudes of both axial (lifting accelerations) and radial (centripetal accelerations) acceleration of the feed ingredients were so high that segregation of individual feed ingredient became inevitable; hence increase percent of coefficient of variation is consequence.

Results of the analysis of variance (ANOVA) revealed that the mixing screw shaft speed and the interaction of the same with mixing time had high significant effect ($p < 0.05$) on percent coefficient of variation, percent degree of mixing and percent concentration of NaCl.

4. CONCLUSION

The poultry feed mixer was successfully modified, constructed and evaluated. The results clearly indicate that the percent coefficient of variations and percent degree of mixing decreased and increased, respectively, as the speed of mixer shaft speed and mixing time increased. Nonetheless, the optimum level of mixing with percent coefficient variation of 8.42 and percent degree of mixing of 91.58 were observed at the mixer speed of 150 rpm and mixing time of 20 minutes. Hence, it can be concluded that the feed mixer, should be operated at speed of 150 rpm with maximum mixing time of 20 minutes. Increase in mixing time beyond the time indicated above will require the farmers to spend extra money on electrical power and labor costs during feed mixing.

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