

Effects of Operating Parameters on the Performance of a Mixer cum Pelletizer for Livestock Feeds

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Abstract

The performance of a mixing/pelletizing machine is dependent on the right combination of process variables for the formation of biomass feed pellets for livestock. The performance of a mixer/pelletizer was evaluated in terms of bulk density, pelletizing efficiency, throughput capacity, shattering index, compressive strength and drying time of pellets. The process variables were moisture content, binder conditions and mixer speeds. The data obtained from the tests were statistically analyzed. The analysis of variance test showed that the moisture content, binder condition, the interaction between moisture content, mixer speed and binder condition were significant at 5 % confidence limit. Duncan's New Multiple Range Test showed that levels of the moisture content, binder condition and mixer speed were significantly different at 5 % confidence level. The results revealed that as moisture content increased from moisture content of 20 to 30 % (db), the pelletizing efficiency and the throughput capacity increased and peaked at 26 % (db). The highest throughput capacity of 116.12 kg/h and pelletizing efficiency of 86.7 % were obtained at moisture content of 26 % (db), 0.5 kg of molasses as binder and 800 rpm mixer speed. The highest bulk density obtained was 1118 kg/m³ and the longest drying time of 2 hours 40 minutes at moisture content of 26% (db), binder condition of 0.5 kg and mixer speed of 800 rpm. Above moisture content of 26 % (db), the drying time remained constant at 2 hours 40 minutes without any change. The proximate analysis results revealed that the highest carbohydrate content was 53.16 ± 0.10 %, highest crude protein content was 20.45 ± 0.22 % while the highest crude fibre was 8.44 ± 0.05%. The quality of livestock feed pellets formed would be enhanced by the right choice of process variables.

Keywords: Mixer, Pelletizer, Process variables, Performance indices, Moisture content

1. Introduction

In Nigeria, good numbers of farmers face a lot of challenges in raising their livestock as result of unavailability of quality feed at the right time and the high cost of production. Most livestock farmers are unable to procure the required machines to increase their production rate. The present production rate of both animals and poultry birds does not meet the human population growth and demand in the country due to the high cost of acquiring imported feeds at the market (Balami *et al.*, 2013 and Dogo 2001). Pelleted feeds are more palatable, can be handled easily and often result to improved feeding when compared to the un-pelleted feeds (Okewole and Igbeka, 2016). Pelleted feeds result in better growth of livestock and increased production efficiency (Kilburn and Edwards, 2001; Greenwood *et al.*, 2004; McKinney and Teeter, 2004). The mixing of the ingredients of animal feed into high density pellets could help to enhance homogeneity of feed and result in improved animal nutrition. Pellets are easier to store and transport. Okewole and Igbeka (2016) reported that the quality of pellets could be obtained by measuring their respective density and durability. The changes in density of pellets after a storage period of one month was determined in order to investigate its dimensional stability. It was reported that applied pressure and pre-treatment were significant parameters affecting the pellet density. The choice of pelletizing methods to be employed will depend on the feeding habit of the ruminant to be fed and its physical requirements (Gabriel *et al.*, 2007). However, the production of feed pellets involves feeds sourcing, grinding, and mixing with other ingredients to obtain desired ration, addition of water or steam, drying and cooling. This determines the nutrients composition, acceptability and palatability of feed which in turn reflects in the livestock performance. In addition, storability of pellets is very important for feed durability (Gabriel *et al.*, 2007). Vijayagopal (2004) stated that parameters that influence the pelletized feeds are basically the operating conditions of the designed pelletizing machine and the rheological properties of the feeds. The operating condition of the machine include the temperature, applied pressure, die aperture diameter and throughput. The rheological properties of the feeds include moisture content, physical characteristics, type of materials used and their chemical composition, the amount and type of starches, protein and fats and Leakage flow. Tumuluru (2014) investigated the effect of moisture content variations and other process factors such as density, retention time and pressure on biomass materials pellet durability. It was reported that controlling densification process parameters like density,

moisture content, retention time and pressure will have vital effects on the quality of pelleted feeds produced (Tumuluru, 2014). High durable pellets (96 %) were obtained at moisture content range of 33 to 34 % (w.b), die speed greater than 50 Hz and preheating temperature greater than 70°C. In addition, Tumuluru *et al.* (2011) stated that for densification, thermal preconditioning treatments, mechanical preprocessing and equipment parameters could influence both the quality and cost of densified products produced. The effects of speed of the press, feed rate, and moisture content on the performance of a pelletizing press were investigated (Okewole and Igbeka, 2016). It was stated that these parameters were significant for pellet efficiency, throughput capacity, pellet durability and pellet bulk density. The optimum pelletizing efficiency, throughput capacity, pellet durability and pellet bulk density obtained were 95.79%, 166.28 kg/hr, 98.04% and 0.85 g/cm³ respectively. From the foregoing, it is clear that the pelletizer operating variables and biomass material conditions significantly influence the quality of pellets formed. Therefore, the objective of this research paper was to investigate the effects of some operating parameters on the performance of a mixing/pelletizing machine in making livestock feed pellets. Crop residues and other feed ingredients were used. This will help in knowing the correct combination of process variables for the formation of biomass feed pellets for livestock.

2. Materials and Methods

2.1 The Mixing/Pelletizing machine

The mixing and pelletizing machine (figure 1) comprise of Mixing hopper, Mixing Chamber, Molasses container, Pelletizing hopper, Pelletizing barrel and the supporting frame. It was powered by a 5 hp electric motor which provided power for both the mixer and the pelletizer. Dried feed constituents at specific moisture contents and binder (molasses) were mixed in the mixing chamber for a period of 10 minutes to achieve a uniform mix. The slurry material formed was then fed into the pelletizer hopper by opening the aperture on the lower end of the mixing chamber. The formed slurry flowed freely by gravity into the pelletizing unit of the machine where the actual pelletizing job took place. The extrusion process which produced the pellet was facilitated by the rotary action of the screw press that compressed the slurry against the die plate at one end thereby leading to the extrusion of pellets.

2.2 Sample Preparation

Elephant grass was cut and dried. The remaining materials like maize stover, cassava peels, wheat bran, groundnut cake, cassava starch and bone meal were obtained from the market, after which, the dirt was removed before drying to 10 % moisture contents (dry basis) (db). The feedstock comprised of 0.88 kg of Elephant Grass, 0.27 kg of Maize Stover, 0.17 kg each of Cassava Peels, Cassava Starch, Cassava Starch, Wheat Bran, Bone Meal, and Groundnut Cake. These materials were cleaned and pulverized using a hammer mill of 3 mm screen aperture as recommended by Karkania *et al.* (2012).

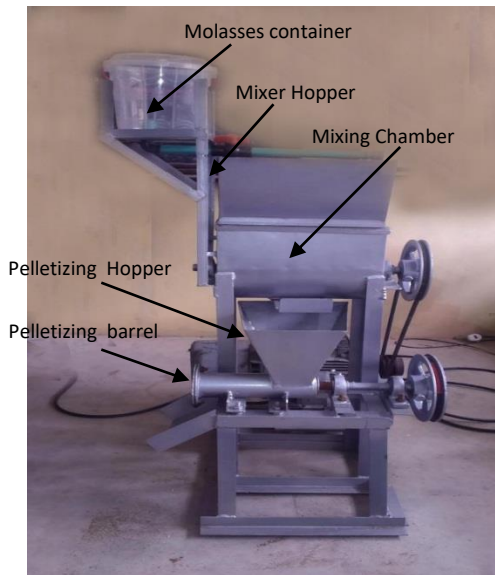


Figure 1. Pictorial of the Mixing/Pelletizing machine

The pulverization process (size reduction) helped to accelerate the pelletization process. Garcia-Maraver (2013) claimed that in pelletization techniques, the moisture percentage of the raw material before extrusion should be between 22 and 26 % (db) to ensure high-quality pellet production. For this work, three moisture levels were used (22, 24 and 26 %) dry basis (db). These moisture levels were achieved by applying equation (1) as given

by Adejumo and Abayomi (2012). With the desired final moisture content known, the initial moisture level and weight of the feedstock was used to calculate the quantity of water that needs to be added to each batch for the pelletization process.

$$Q = W_t \left(\frac{M_f - M_t}{100 - M_f} \right) \quad (1)$$

Where Q = Quantity of water added (kg), W_t = Initial mass of Sample (kg),
 M_f = Final moisture content of sample (%) (db),
 M_t = Initial moisture content of sample (%) (db)

For the expected final moisture contents with other parameters remaining constant, the quantity of water that was added was calculated from equation (1). A basis of 2 kg was used for each run in testing the machine. As such the input variables for the testing of the machine involved feedstock varied at three different levels of moisture contents, three binding conditions and three mixing speeds.

2.3 Experimental Design

The experimental design of the study was a 3x3x3 factorial experiment in a completely randomized design used to evaluate the performance of the mixer/pelletizer. The three factors that were considered in the factorial design were three levels of moisture content (22, 24 and 26 %) dry basis (db), three levels of binder conditions (0 kg molasses, 0.5kg of molasses and 0.9 kg molasses as binder) and three levels of machine speeds (600, 800 and 1,000 rpm). Three different sizes of pulley diameters respectively were used for achieving the various mixer speeds. Each treatment combination was performed in three replicates, making a total of 81 values. Stopwatch was used to determine the time taken for each experimental process. The bulk density, pelletizing efficiency, throughput capacity, shattering index, compressive strength and drying time of pellets were analyzed with a view of knowing the effects of treatment combinations on the properties of the formed pellets.

2.4 Data Analysis

The results obtained from the experiment were analyzed using (SPSS) Statistical Package for Science and Social Sciences, version 16. The range of the factors was based on the review of literature and tryer experiments. Data obtained from the measured parameters of the pelletizer was analyzed

statistically for the Analysis of Variance (ANOVA). Duncan's New Multiple Range Test analysis was also carried out for operating parameters which were binder condition, moisture content and operating speed. These analyses would help to indicate the significant effect of the factors as well as the interaction effect on the performance indices. The result obtained would be further analyzed using Duncan's New Multiple Range Test (DNMRT) in order to know the significant difference between each level of treatment factors at 5% confidence level.

2.5 Proximate Analysis

A laboratory test was conducted on the samples of the pellets at the Industrial Chemistry Department of the University of Ilorin to determine their nutritional properties. The proximate analysis was carried out on selected sets of data from the following treatment combination: $M_1B_1S_1$ (moisture content of 22 % (db), 0 kg molasses, 600 rpm), $M_2B_2S_2$ (moisture content of 24 % (db), 0.5 kg of molasses, 800 rpm) and $M_3B_3S_3$ (moisture content of 26 % (db), 0.9 kg of molasses, 1000 rpm). These nutritional parameters include; Ash, Moisture content, Crude Fibre, Crude Protein, Crude Fat and Carbohydrate.

2.6 Variation of moisture content on Performance indices

A further moisture analysis test was conducted to investigate the moisture variations as it affects the performance indices: throughput capacity, bulk density, pelletizing efficiency, shattering index, compressive strength and drying time. Six moisture levels were used (20, 22, 24, 26, 28 and 30%) dry basis (db). The machine was run at a speed of 800 rpm and binder condition of 0.5 kg of molasses was used. Each test was replicated three times and the average values were determined. These average values were used to generate graphs to depict the performance indices variations as the moisture contents changed.

2.7 Performance Indices

In carrying out the performance evaluation, the following parameters were used:

- i. Throughput capacity of Machine (T_m) which can be expressed in kg/h and given as:
- ii.

$$T_m = \frac{W_g}{t} \quad 2$$

where: T_m = Capacity of Machine with respect to time (kg/h), W_g = Weight of extruded pellets (kg) t = Total time taken to extrude the pellets (h)

- iii. **Bulk density:** The volumes of pellets were determined by using water displacement method. A known mass of pellet was placed in a graduated cylinder filled with water. The volume of water displaced is the volume of the pellets. Dividing the known mass by the volume of water displaced gives the bulk density of the formed pellets as shown in the equation below.

$$D = \frac{M}{V} \quad (3)$$

where, D = Density (kg/m³), M = Mass (kg), V = Volume (m³)

- iv. **Pelletizing Efficiency** was calculated using the formula in equation 4:

$$P_e = \frac{X_a}{X_b} \times 100 \quad (4)$$

where: P_e = Pelletizing efficiency (%). X_a = Weight of formed pellets obtained (kg), X_b = Weight of mash fed into the pelletizer (kg)

- v. **Shattering Index**

Shattering index was used for determining the hardness of the pellets. Pellets with known weight and length were used. The test was conducted on the produced pellets in the Agricultural and Biosystems Engineering Department of University of Ilorin. The test was conducted in accordance with the shatter index described by ASTM D440-86 2002 using drop shatter method developed for coal (Bailey and Blankenhovn, 1982). The shatter resistance of the pellets was calculated using Equation (5) as suggested by (Tumuluru, 2014).

$$\text{Shattering Index (\%)} = 100 - \left[\frac{W_1 - W_2}{W_1} \times 100 \right] \quad (5)$$

where: W_2 =weight of pellet after shattering/tumbling (kg), W_1 =weight of pellets before shattering/tumbling (kg)

- vi. **Compressive Strength:** This was carried out with the Universal Testing Machine (Model No: FS300CT) in the Departmental laboratory of Agricultural and Biosystems Engineering, University of Ilorin. The formed pellet was placed in-between two plates of the machine and with the machine set at Compressive strength, the compression head of the machine moved downwards towards the lower plate as it compresses the materials against the second plate till the pellets starts to fail. The pressure reading obtained was recorded as the Compressive strength of the formed pellets. The compressive strength helps to know how to handle materials during transportation.
- vii. **Drying Time:** This is the time taken in drying the pellets for each treatment combination to the desired safe storage moisture content. The oven was set at a drying temperature of 105 °C and the drying was monitored at intervals of 30 minutes to ascertain the changes in weights of the dried pellets. The difference between the initial and final weight divided by the initial weight gave us the current moisture content of the dried pellets. The total time taken to obtain the desired moisture content is regarded as the drying time. According to ZhenhuaWang *et al.* (2012), the safe moisture content for storing dried pellets is 10 %. Data obtained from the experiment was used to plot the moisture content against drying time curve.

3. Results and Discussion

3.1 Statistical Analysis of the Experimental Data

The analysis of variance for the effect of the factors: moisture content, binder condition and mixer speed on the performance indices of the formed pellets are presented. The analysis showed the significant effect of the factors as well as their interactions to ascertain on the parameters: throughput capacity, bulk density, pelletizing efficiency, shattering index, compressive strength, and drying time. Further analysis of the result was also carried out using Duncan New Multiple Range Test (DNMRT) and results are presented. This shows if the levels of the factors are significantly different.

3.2 Duncan New Multiple Range Test (DNMRT) for the Effect of factors on the Performance indices

Table 1 shows the summary of the DNMRT for throughput capacity, bulk density, pelletizing efficiency and shattering index of the pellets. From the

table, it could be seen that the levels of moisture content and machine speed are significantly different at 5% confidence level for throughput capacity. For bulk density, the effects of the three levels of binder condition are significantly different from each other at 5% confidence level. While the effect of the three levels of machine speeds on the bulk density are not significantly different. Table 1 also shows that there was significance difference at 5% confidence level for the levels of moisture content, binder condition and machine speed used for pelletizing efficiency and shattering index.

Table 1: Mean effects of Moisture contents, Binder condition and Mixer speed on the Performance indices

Mea- sured Para- meter	Factors								
	M			B			S		
	1	2	3	1	2	3	1	2	3
TC	96.95 ^a	107.93 ^b	113.93 ^c	105.91 ^a	107.53 ^b	105.37 ^a	86.67 ^a	105.30 ^b	126.84 ^c
BD	1138.19 ^a	1136.7 ^a	1166.22 ^b	1144.85 ^b	1162.93 ^c	1133.33 ^a	1143.22 ^a	1154.67 ^a	1143.22 ^a
PE	82.48 ^b	85.03 ^c	77.81 ^a	79.89 ^a	86.45 ^c	85.05 ^b	79.89 ^a	81.63 ^b	83.81 ^c
SI	92.72 ^a	92.44 ^a	92.44 ^b	89.61 ^a	93.94 ^b	96.56 ^c	93.11 ^a	93.22 ^a	93.78 ^a

M = Moisture content (db), B =Binder Condition and S =Machine speed (rpm), M₁ = 22% , M₂ = 24 % , M₃ = 26 % B₁ = 0kg B₂ = 0.5 kg, B₃ = 0.9 kg, S₁ = 600 rpm, S₂ = 800 rpm and S₃= 1000 rpm, TC = Throughput Capacity, BD = Bulk Density, PE = Pelletizing Efficiency SI = Shattering Index. Means with the same letters are not significantly different but means with different letters are significantly different at 5 % confidence level:

3.9 Proximate Analysis of the pellets

Results obtained from proximate analysis conducted on selected samples of the produced pellets at the three treatment combinations are as presented in the Table 2. From the table, samples with 22 %(db) moisture, 0 kg molasses, 600 rpm (M₁B₁S₁) had the highest amount of 53.16 ± 0.10 % carbohydrate which represents the energy value of the feed. This was followed by sample with 24 % (db) moisture, 0.5kg molasses, 800 rpm (M₂B₂S₂) while sample with 26 %(db) moisture, 0.9kg molasses, 1000 rpm (M₃B₃S₃) had the least amount of carbohydrate with a value 50.70 ± 0.32 %. Sample M₃B₃S₃ had the highest amount of crude protein with a of 20.45 ± 0.22 % while the lowest

amount of crude protein was obtained from sample M₁B₁S₁ as 19.38 ± 0.11%. However, the crude protein content of all the samples were observed to be higher than the common minimum of 7.7 % by NRC (2001) and 7.0 % by Minsson, (1990). The carbohydrate content of the produced pellets was observed to be higher than the 44 % minimum level suggested by NRC (2001). The minimum crude fiber content of all the samples analyzed were observed to be higher than the values of 31.6 % suggested by Kafeel *et al.* (2013).

3.3 Effect of Moisture Content on Throughput Capacity

The effect of moisture content on the throughput capacity of the machine is as shown in figure 2. The figure shows that the highest throughput capacity of the machine pellets was recorded as 116.12 kg/h at a moisture content of 26 % (db) while the lowest throughput capacity was recorded as 86.5 kg/h at a moisture content of 30 %(db).

Table 2. Average values of Proximate Analysis of selected Samples of the Pellets

Nutrient %	Parameter Combinations		
	M ₁ B ₁ S ₁	M ₂ B ₂ S ₂	M ₃ B ₃ S ₃
Ash	4.85 ± 0.02	5.04 ± 0.07	5.08 ± 0.06
Moisture Content	8.62 ± 0.15	9.05 ± 0.13	9.14 ± 0.11
Crude Fibre	8.27 ± 0.04	8.27 ± 0.08	8.44 ± 0.05
Crude Protein	19.38 ± 0.11	20.16 ± 0.06	20.45 ± 0.22
Crude Fat	5.76 ± 0.05	5.86 ± 0.12	6.21 ± 0.09
Carbohydrate	53.16 ± 0.10	51.54 ± 0.17	50.70 ± 0.32

Note: M₁B₁S₁ (22 %(db) moisture, 0 kg molasses, 600 rpm), M₂B₂S₂ (24 % (db)moisture, 0.5 kg of molasses, 800 rpm) and M₃B₃S₃ (26 % (db) moisture, 0.9 kg of molasses, 1000 rpm).

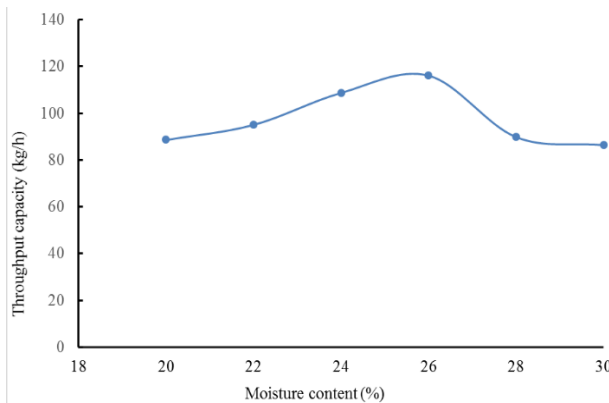


Figure 2. Effect of Moisture Content on Throughput Capacity

The figure revealed that as moisture content increased, the throughput capacity also increased. Above 26 % (db) moisture content, the throughput capacity decreased as the moisture content increased. Very high moisture content (30 %) (db) does not favour high throughput capacity also because it inhibits proper formation of the pellets. The results obtained is in the same trend as that of Ojomo *et al.* (2010) who reported that as moisture content increased from 3 to 15 %, throughput capacity also increased from 5 to 20 kg/h. This difference in capacity maybe as a result of the different feed materials used, die configuration, quality of water added and the speed of the pelletizer.

3.4 Effect of Moisture Content on Bulk Density of Pellets

The effect of moisture content on the bulk density of the pellets is as shown in Figure 3. The figure shows that the highest bulk density of the formed pellets was recorded as 1310 kg/m^3 at a moisture content of 30 % (db) while the lowest bulk density was recorded as 1103 kg/m^3 at a moisture content of 20 % (db). Figure 3 also revealed that as moisture content increased, the bulk density also increased. It was observed that the density of pellets produced varied between 1103 and 1310 kg/m^3 which is close in values to the range of 900 to 1000 kg/m^3 obtained by Guillermo *et al.* (2002). This difference maybe as a result of the different particle size, the type and quantity of the binder used and the applied pressured for extrusion.

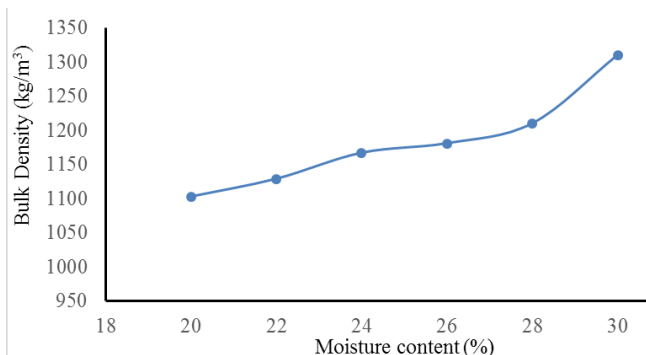


Figure 3. Effect of Moisture Content on Bulk Density of Pellets

3.5 Effect of Moisture Content on Shattering Index

Figure 4 shows the effect of moisture content on the shattering index. The figure shows that the highest shattering index of the formed pellets was recorded as 98% at a moisture content of 26 %(db) while the lowest shattering index was recorded as 81 % at a moisture content of 30 %(db). The figure revealed that as moisture content increased from 20 – 26 % (db), there was a corresponding increase in shattering index from 91 % to 98 %. However, above moisture content of 26 %(db) the shattering index decreased as moisture content increased. The results obtained also showed that pellets formed at higher moisture contents using binders generally has higher shattering index than those formed at lower moisture content. Hence, the formed pellets resist shatter. This is in agreement with the work of Fellows (1998) that moisture content of pellets is a great factor that affects how a pellet responds to hardness test.

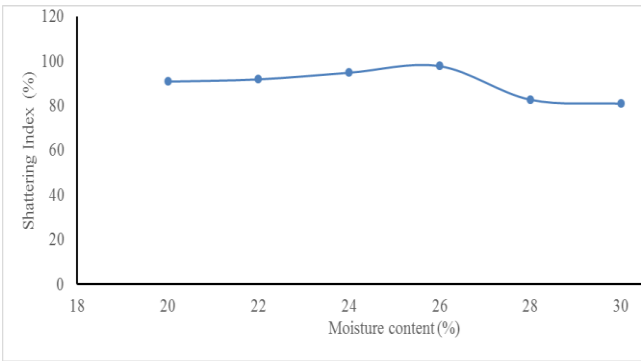


Figure 4. Effect of Moisture Content on Shattering Index

3.6 Effect of Moisture Content on Compressive Strength

Figure 5 shows that the highest compressive strength of the formed pellets was recorded as 189 MPa at a moisture content of 30 % (db) while the lowest compressive strength was recorded as 68 MPa at a moisture content of 20 % (db). The figure revealed that as moisture content increased, there was corresponding increase in compressive strength. The results obtained also showed that pellets formed at higher moisture contents using binders generally has higher compressive strength than those formed at lower moisture content. Similarly, Agidi Gbabo *et al.* (2015) reported that as binder/moisture concentration increases from 10 % to 40 %(db), the compressive strength of formed pellets also increased from 0.2 KN/m² to 1.2 KN/m² which implies better handling during transportation.

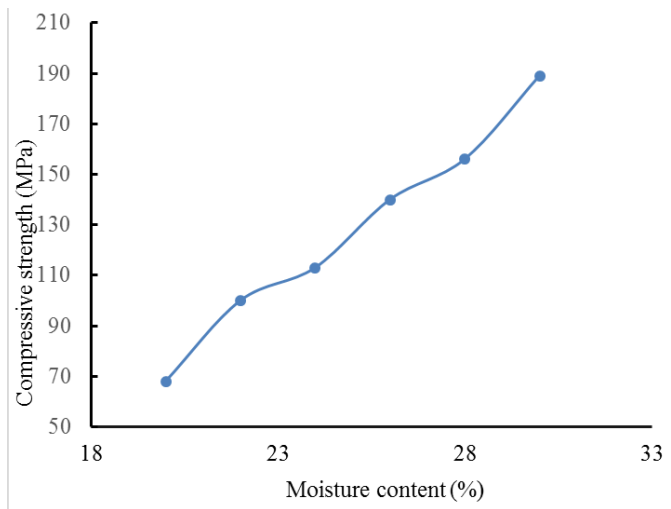


Figure 5. Effect of Moisture Content on Compressive Strength

3.7 Effect of Moisture Content on Pelletizing Efficiency

The effect of moisture content on the pelletizing efficiency of the formed pellets is as shown in Figure 6. Figure 6 showed that the highest pelletizing efficiency of the machine pellets was recorded as 86.76 % at a moisture content of 26 %(db) while the lowest pelletizing efficiency was recorded as 70.9 % at a moisture content of 20 %(db). The figure also revealed that as moisture content increased, the pelletizing efficiency also increased. The pelletizing efficiency peaked at 26 % moisture content and then began to decline afterwards. At low moisture content (20 %) (db), there seem not to be enough moisture to bind the feed constituents together for proper pellet formation and ejection. Very high moisture content (30 %) (db) does not favour pelletizing efficiency either because it inhibits proper ejection of formed pellets. Generally, the highest pelletizing efficiency of 86.76 % obtained at a moisture content of 26 %(db) indicates that the addition of adequate water helped in the proper formation and extrusion of formed pellet. The result is slightly lower than the values of 91.4 % and 92.6 % obtained by Collins and Olasunkanmi (2008) using manual and electrical power respectively. It can therefore be inferred that high moisture addition does not allow pellets to form properly thereby leading to a reduction in pelletizing efficiency. The result obtained is in agreement with the experiment carried

out by Ojomo *et al.* (2010). Ojomo *et al* (2010) reported that as moisture content increased from 3 to 15 %(db), pelletizing efficiency also increases from 10 % to a maximum of 87.56 %.

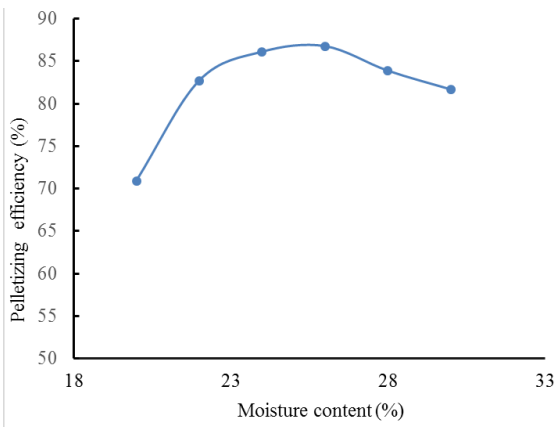


Figure 6. Effect of Moisture Content on Pelletizing Efficiency

3.8 Effect of Moisture Content on Drying Time

The effect of moisture content on drying time of the formed pellets is as shown in Figure 7. Drying time is the time taken to dry the pellets to the desired safe storage moisture content. As shown in Figure 7, moisture content has a tremendous effect on the drying time of the formed pellets. The figure revealed that the highest drying time of 2 hours 40 minutes for the formed pellets was recorded at moisture contents of 26, 28 and 30 %(db) while the lowest drying time of 2 hours was recorded at a moisture content of 20 %(db). The result revealed that as moisture content increased, the drying time also increased but stabilizes at 26 % (db) moisture content. From 20 to 26 %(db), the drying time increases from 2 hours to 2 hours 40 minutes. Above 26 % (db) moisture content, the drying time remained constant at 2 hours 40 minutes without any change. The dried pellets formed are shown in Figure 8.

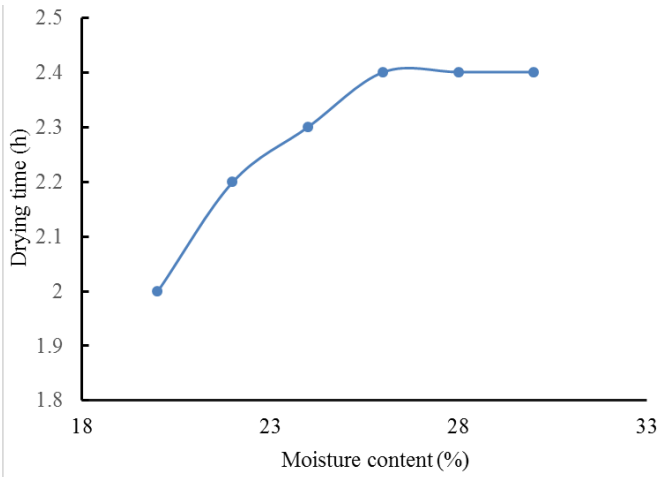


Figure 7. Effect of Moisture Content on Drying Time



Figure 8. Pictorial View of the formed Pellets after drying

4. Conclusions

The performance of a mixer/pelletizer was evaluated in terms of bulk density, pelletizing efficiency, throughput capacity, shattering index, compressive strength and drying time of pellets. The process variables were moisture

content, binder conditions and mixer speeds. Moisture content, binder condition, mixer speed and their interactions were found to affect the performance of the mixing/pelletizing machine significantly at 5 % confidence limit. The highest throughput capacity of 116.12 kg/h and pelletizing efficiency of 86.7 % were obtained at moisture content of 26 % (db), 0.5 kg of molasses as binder and 800 rpm mixer speed. The highest bulk density obtained was 1118 kg/m^3 and the longest drying time of 2 hours 40 minutes at moisture content of 26% (db), binder condition of 0.5 kg and mixer speed of 800 rpm. Above moisture content of 26 % (db), the drying time remained constant at 2 hours 40 minutes without any change. The proximate analysis results revealed that the highest carbohydrate content was $53.16 \pm 0.10 \%$, highest crude protein content was $20.45 \pm 0.22 \%$ while the highest crude fibre was $8.44 \pm 0.05\%$.

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