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Performance Evaluation of a Food Waste Mixer

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----------ABSTRACT----------
Pre-treatment of food waste is necessary to enhance the performance of food wastes-to-energy systems egbio-digesters and gasifiers. In this research, performance test of a food waste mixer was conducted usingfood waste samples comprising 3kg of shelled corn, 1kg of flour and 2kg of boiled rice replicated three times at mixing durations of 3minutes, 6minutes and 9minutes based on the standard test procedure for farm batch feed mixers developed by ASAE. The degree of mixing attained after 9 minutes of operation was 96.09% with a coefficient of variation of 3.91%.
Key Words: *Mixing, Degree of Mixing, Coefficient of Variation, Standard deviation*

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I. INTRODUCTION

Solid waste disposal and management is a critical problem in Nigeria (Ezechi et al, 2017). Annually, a huge quantity of municipal solid waste is generatedand theimproper disposal of these untreated wastes can be deleterious. Air pollution, underground water contamination, land degradation, soil contamination and habitat deterioration can be caused by poor waste disposal (Odoemene and Ofodu, 2016). Environments close to dumpsites are constantly exposed to risk of infection, reduced agricultural yield, severe challenge to environmental safety, public health, decline in benthic communities due to toxicity and exposure to hazardous compounds (Ukpong et al, 2015; Ayuba et al, 2013). The situation is made worse by the indiscriminate dumping of refuse at roadsides, streets, waterways and empty lands. The impact of this waste management practice in Nigeria is environmental deterioration and efforts to improve waste management in the country have not recorded significant success.

Studies have shown that about 47.39% of the total solid waste is organic wastes(majorly food waste) (Ajero and Chigbo, 2012; Igbinomwanhia et al, 2014) and have high energy content. Consequently, it offers good potential as feed stock for power generation as researched by Iqbal and Hudhaifa (2014).

In order to maintain a clean Municipal environment, urban waste must be effectively managed through appropriate reduction, reuse and/or recycled practices (Dauda and Osita, 2003). Waste management generally involves the collection, transfer, treatment, recycling, resources recovery and disposal of waste in any location. The goals of waste management are therefore, to promote a quality environment, generate employment, and thus, support the efficiency and productivity of the economy.

Effective pre-treatment of food waste is important for good performance on further processing for energy utilisation. This pre-treatment starts with the collection of the food waste and homogenisation using a food waste homogeniser.Lindley, (1991), stated that a satisfactory mixing process produces a uniform mixture in a minimum time with a minimum overhead cost, power, and labour. Some variations between homogenized samples should be expected, but an ideal mixture would be one with minimal variation in composition.

There is usually an optimal mix time, which is determined experimentally according to Makange et al, (2016). This can be obtained by measuring the standard deviation of some critical components and requires taking multiple samples, at least ten, from various parts of the mixer at a succession of times (Makangeet al, 2016). The goal of this study is to conduct the performance evaluation of a food waste homogenizer.

II. MATERIALS AND METHOD

Performance test of the food waste homogenizer shown in Figure1 was conducted by evaluating its ability to blend food waste samples and duration of mixing using 6kg of boiled rice, 9kg of shelled corn and 3kg of flour as shown in Figures 2 to 4 respectively.

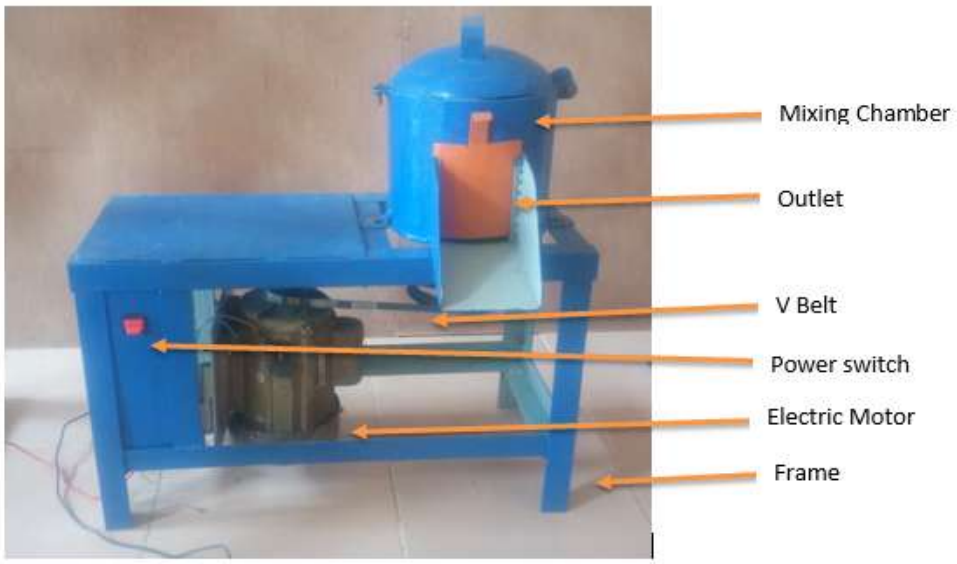

Figure 1: Food Waste Homogenizer

Figure 2: Rice

Figure 3: Shelled Corn

Figure 4: Flour

Test Procedure

The mixer's performance test was conducted and replicated three times according to the standard test procedure for farm batch feed mixers developed by ASAE, (2006); Prashim et al, (2016). Shelled corn was introduced as the tracer for the purpose of testing the mixing performance. Three mixing durations of 3minutes, 6minutes and 9minutes were considered in the cause of conducting the tests. At the end of each test run, ten samples of 300g were drawn from the mixed components and the coefficient of variation among blended samples and mixing levels, were computed using the expressions given by Ibrahim and Fasasi (2004).

The following procedures were used for the performance test:

1. Put the first replicate in the homogenising machine and operate it for 3min.
2. Measure out ten (10) different samples of 300g of the homogenised mixture after three minutes.
3. Separate the unmixed corn from each sample and measure the mass of the unmixed corn (X) for each sample.
4. Compute the mean weight using equation (1).

$$x = \frac{\sum X}{n} \quad (1)$$

Where; x = mean weight of ten samples and n = number of samples in this case, n=10

5. Determine the standard deviation using equation (2).

$$S = \sqrt{\frac{\sum (X - x)^2}{(n - 1)}} \quad (2)$$

Where S is standard deviation

6. Determine the coefficient of variation using equation (3) and its mean using equation (4).

$$CV = \frac{S}{X} * 100 \quad (3)$$

$$cv = \frac{\sum CV}{n} \quad (4)$$

7. Determine the percentage of mixing level using equation (5).

$$\%D_m = (1 - cv) \times 100 \quad (5)$$

8. Repeat steps 1 to 7 after running the homogenizing machine for 6minutes and 9minutes.
9. Repeat steps 1 to 8 with the other two (2) replicates and compute the average percent mixing level

Figures 5 and 6 show the homogenised food waste samples after three and nine minutes of mixing respectively.

Figure 5: Food waste sample after three minutes of mixing

Figure 6: Food waste sample after nine minutes of mixing

III. RESULTS AND DISCUSSION

Table 1 shows the various masses of the unmixed corn of the three replicates for mixing durations of 3minutes, 6minutes and 9minutes

Table 1 Mass of unmixed corn for the three replicates

	First triplicate			Second triplicate			Third triplicate		
S/N	3 min	6 min	9 min	3 min	6 min	9 min	3 min	6 min	9 min
1	20.1	21.1	18.8	20.1	21.3	18.1	18.1	20.3	20.0
2	29.0	21.9	19.6	21.0	21.0	17.9	22.0	20.2	17.9
3	21.4	22.4	18.3	21.4	21.9	17.3	27.4	20.1	18.3
4	31.7	24.7	18.7	23.7	20.7	19.7	29.7	19.7	18.7
5	22.8	23.0	18.9	22.8	23.0	18.0	35.8	22.0	19.0
6	24.9	23.9	20.9	24.9	21.9	17.9	24.9	23.9	18.9
7	27.5	23.9	19.1	32.9	23.9	18.9	20.5	21.9	17.9
8	23.0	20.0	18.9	22.0	21.1	19.1	21.9	21.1	19.1
9	28.9	22.9	19.6	28.9	19.6	18.9	28.9	21.6	18.9
10	34.9	22.9	18.0	30.9	22.6	18.6	21.9	22.6	19.6
Total	264.2	226.7	190.8	248.6	217	184.4	251.1	213.4	188.3
Mean	26.42	22.67	19.08	24.86	21.7	18.44	25.11	21.34	18.83

The mean weight of the samples, coefficient of variation and degree of mixing results are presented in Table 2.

Table 2: Food waste homogeniser machine's performance

	3 Minutes mixing operation			**6 Minutes mixing operation**			**9 Minutes mixing operation**		
Replicate	Mean weight of the samples (g)	Coefficient of variation, (%)	Degree of mixing, (%)	Mean weight of the samples (g)	Coefficient of variation, (%)	Degree of mixing, (%)	Mean weight of the samples (g)	Coefficient of variation, (%)	Degree of mixing, (%)
1	26.42	18.12	81.89	22.67	06.17	93.83	19.08	04.25	95.75
2	24.86	18.03	81.97	21.70	05.71	94.29	18.44	03.90	96.10
3	25.11	21.23	78.77	21.34	06.17	93.83	18.83	03.58	96.42
Total	76.38	57.36	242.56	65.71	18.06	281.94	56.35	11.74	288.26
Mean	25.46	19.12	80.85	21.90	06.02	93.98	18.78	03.91	96.09

The summary of the performance test analysis of the food waste homogeniser is shown in Table 3.

Table 3: Summary of performance test result for the food waste homogeniser

Mixing Time (Min)	Replicate Coefficient of variation (CV, %)			Average CV (%)	Degree of mixing (%)
	I	II	III		
3	18.11	18.03	21.23	19.12	80.88
6	06.17	05.71	06.17	06.02	93.98
9	04.25	03.90	03.58	03.91	96.09
Total	28.53	27.65	30.99	29.05	270.95
Mean	09.51	09.21	10.33	09.68	90.32

The average coefficient of variation from the performance test was 9.68% while a mixing performance of 96.09% was achieved after 9 minutes of operation which is an improvement on the 94.06% as reported by Makange et al, (2016).

IV. CONCLUSION

A food waste mixerwas evaluated to determine its ability to blend food waste samples and duration of mixing using boiled rice, shelled corn and flour. A mixing performance of 96.09% was achieved after 9minutes of operation while the average coefficient of variation from the performance test was 3.91%. From the result analysis, it can be seen that the performance of the machine was satisfactory.

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