Development of Fish Scraps Shredding and Mixing Machine for Fish Emulsion Fertilizer Production

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Abstract *– The use of organic fertilizers supports the sustainable agriculture of the Philippines through maintaining soil fertility and regaining the high yield and sustainability of the land. The development of fish scraps shredding and mixing machine can be of great help to the production of fish emulsion fertilizer in both quality and quantity. The study specifically covered the design, development and performance evaluation of the fish scraps shredding and mixing machine that was employed for fish emulsion fertilizer production. Preliminary tests were performed to establish operating conditions of the machine such as working capacity, shredding speed, mixing speed, mixing time and mixing capacity. The working capacity was found to be 750g of fish scraps. The shredding speed established was based on the variable frequency drive (VFD) at 50Hz which corresponds to 1800rpm. The actual performance of the machine was evaluated by determining the shredding rate and efficiency. Based from the results gathered from the performance evaluation of the machine, the shredding efficiency rate and efficiency was 164.19 g/s and 91.64%, respectively. The mixing capacity was 12kg of fish scraps and molasses with an acceptable mixing speed of 108 rpm, and a mixing time of 40 sec. For a 12 kg of fermented fish scraps and molasses mixture, the fish emulsion fertilizers extracted had a total mass of 8.2 kg which represented 68.33% yield for the mixture. The total NPK value of the produced fish emulsion fertilizer was within the standard range set by the Philippine National Standards for Organic Fertilizers.*

Keywords *– fish emulsion fertilizer, fish scraps, molasses, percent yield, shredding efficiency*

INTRODUCTION

Soil management has a major impact on soil quality. It concerns all operations, practices, and treatments used to protect soil and enhance its performance. Management of nutrients and soil fertility, soil salinity and integrated pests are integral components of sustainable agriculture practices. The use of organic fertilizers supports sustainable agriculture through maintaining soil fertility and regaining the high yield and sustainability of the land. It promotes recycling of farm wastes and other useful animal by-products which serve as inputs for organic fertilizer production. The production has been proven economically viable since raw materials do not add to operation costs because these are readily available and are abundantly found in the area.

Nutrient values vary greatly among organic fertilizers. Differences include variations in the age of organic material, decomposition, application method, timing, and incorporation time exposed to the elements such as sun and water [1]. Full adoption of organic crop production technology provides increased productivity and profitability while upholding an environmentally safe process.

Organic agriculture has continued to grow substantially despite the world economic crisis. It is now being viewed as an additional option to conventional or chemical agriculture and not just for the niche market. The government support for organic agriculture became more emphatic and accelerated in 2010 with the passing of the “Organic Agriculture Act of 2010” or RA 10068, which provides for its development and promotion in the country. Organic agriculture is one of the livelihood options being offered to farmers in the Philippine Agriculture 2020. Hence it is imperative to give more attention on this agricultural production system [2].

Fish fertilizer in particular, is a valuable product for promoting plant growth. It is high in nitrogen content necessary for growing plants, which can be naturally produced. Fish emulsion fertilizer is commercially available but more expensive compared to other types of organic fertilizers. However, fish emulsion can be made in several ways depending on the desired process. Usual production of fish emulsion goes through two stages of processing. The first stage breaks down the fish parts using enzymes, proteases, or chemical. Then, in the second stage, heat is used to break it down further and allow oils and other things like amino acids to be more easily removed [3]. The existing process requires a lot of human labor and handling. Since fish scraps are the main raw material, the process is cluttered and produces stinking odor. This study therefore seriously considered the initiative of developing a shredding and mixing machine of fish wastes to address the aforesaid concern.

The main thrust of this study was to design and develop a fish scraps shredding and mixing machine for fish emulsion organic fertilizer production. This covered the design and fabrication of the machine taking into consideration the system components and material specifications. Preliminary testing of the fabricated machine was conducted to establish various parameters such as working capacity, shredding speed, shredding size, mixing capacity and speed, and production time. Final performance of the machine was evaluated in terms of shredding rate and shredding efficiency. Percent yield of the fermentation process of the fish emulsion was determined as well as the properties such as pH level, and nutrient content of nitrogen (N), phosphorous (P) and potassium (K).

The study is deemed significant technologically and economically provided with its benefits to different sectors. The agricultural industries would become aware of the technological innovations that may replace conventional agricultural ways to modern techniques, which may profoundly contribute in the improvement of their economic activity. The organic fertilizer manufacturers particularly fish emulsion fertilizers would aid their process through an increased production rate in both quality and quantity measures.

MATERIALS AND METHODS

This study employed an engineering design, thorough planning and comprehensive analysis to achieve the objectives of the study. It also considered the performance and experimental testing to evaluate the performance of the fabricated machine. This involved good analysis and evaluation of the different parameters to realize the expected outcome. This covered the following stages:

Design Stage

This stage was focused on engineering calculations to determine the sizes and dimensions of materials that were used for fabrication, as well as the target capacity of the machine. Schematic layout of the proposed machine was presented specifying the different system components and dimensions.

Development Stage

This stage covered the fabrication of the machine taking into consideration the design specifications. Proper selection of materials was considered in terms of availability and cost.

Preliminary Testing Stage

Preliminary testing of the machine was conducted to establish the operating parameters of the fabricated machine. During this stage, some modifications were incorporated to rectify the problems encountered during initial operation. It also included several trial runs to come up with the desired operating conditions of the machine.

Final Performance Testing Stage

In the final testing stage, the performance of the machine was tested in terms of shredding rate, shredding efficiency, and percent yield. Shredding rate was determined based on the mass of fish scraps fed to the hopper of the machine over the total time of shredding. Likewise, shredding efficiency was determined by measuring the mass of the shredded fish scraps over the initial mass of the fish scraps multiplied by 100 percent. Percent yield was computed using the mass of the emulsion fertilizer produced over the initial mass of fish scraps and molasses mixture multiplied by 100 percent.

Experimental Testing Stage

The samples of the final product collected during the performance evaluation were tested to determine the properties and nutrient content.

Preparation of Raw Materials

Fish scraps were collected from the two public markets in Batangas City. These were composed of fish parts such as gills; intestine; fins; oftentimes fish bones and other internal organs, which dominated the collected fish scraps. Before processing, the fish scraps were visually inspected for the prevention of infiltrations that may damage the blades of the shredder. The large or oversized parts such as fish bones and gills from the large size fishes were excluded in the shredding process. Fish scraps were then strained initially to remove excess water upon obtaining the weight to be fed on the machine. The availability of the molasses was secured as they were the chemical mixed to fish scraps after the shredding process.

RESULTS AND DISCUSSION

System Components of the Machine

The final set up of the fabricated fish scraps shredding and mixing machine is presented in Figure 1.

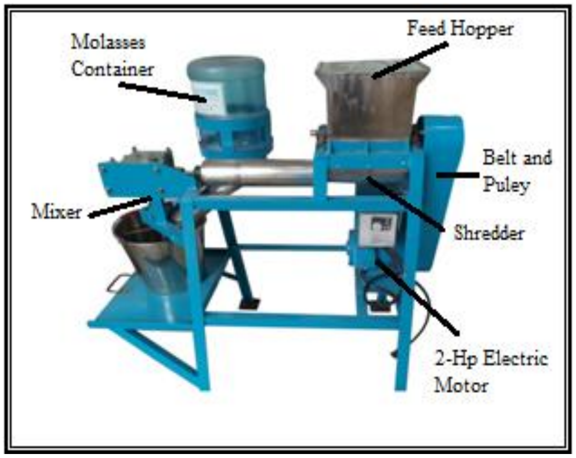

Fig. 1. The final set-up of the machine

The machine is composed mainly of the shredder and mixer that facilitate the fish emulsion production. The shredder consists of 38 mm x 2 mm thick 304 stainless flat bars welded on the 76-mm diameter stainless hollow tube. Through this tube is a shaft that rotates the blades and serves as the major component in reducing the size of the fish scraps. Further, the mixer is responsible for mixing the shredded fish scraps with the molasses. It is perpendicularly coupled to the shaft of the rotating shredder blades and screw conveyor but with a lower speed through the aid of gear box. The mixing blade was made of 304 stainless steel with 7-mm diameter rod bent and welded to a 20-mm diameter shaft.

The machine was provided with the feed hopper where the fish scraps were fed for shredding process. It is made up of a 2-mm thick 304 stainless steel. It has a clear, acrylic cover to prevent spillage of the shredded fish scraps. Moreso, a molasses container has a capacity of 40-L, which was installed in the machine for easy handling and transferring of the molasses during the mixing process.

The machine uses a 2-hp electric motor that serves as the prime mover of the machine. A belt and pulley assembly was used as flexible transmitting elements. A 50-mm diameter, single-pulley was used for the shaft of the shredder, 75-mm diameter, single-pulley for the shaft of the screw conveyor and another 75-mm diameter, double-pulley on the motor shaft. B150 belt was used to connect the shredder and motor pulleys while a B130 connects the screw conveyor and the motor pulleys.

Working Capacity and Shredding Speed

Table 1 shows the results of the preliminary testing in establishing the working capacity.

Table 1. Preliminary Testing Results for Establishing Working Capacity using 1080 rpm

Test No.	Mass of Feed (g)	Shredding Time (s)	Remarks
1	500	5.24	Passed
2	750	6.32	Passed
3	1000	N.A.*	Clogged

**N.A. – Not applicable*

Table 1 shows the results of various tests conducted to establish the working capacity. An initial speed of 1080 rpm was used to shred the varying amounts of fish scraps such as 500 g, 750 g, and 1000 g. It can be noted that the 500-g and 750-g feeds were completely passed the shredder blades without clogging with an average time of 5.24 s and 6.32 s, respectively. However, the 1000-g fish scraps were clogged and were not able to process completely.

Table 2. Preliminary Testing Results for Establishing Working Capacity using 1440 rpm

Test No.	Mass of Feed (g)	Shredding Time (s)	Remarks
1	500	2.94	Passed
2	750	5.73	Passed
3	1000	N.A.	Clogged

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Table 2 depicts the test results conducted using 1440 rpm shredding speed. The 500-g and 750-g feeds were successfully processed with an average time of 2.94 s and 5.73 s, respectively. Similar with the previous test, the 1000-g was not completely processed by the shredding blades.

Another test was conducted and the results are presented in Table 3.

Table 3. Preliminary Testing Results for Establishing Working Capacity using 1800 rpm

Test No.	Mass of Feed (g)	Shredding Time (s)	Remarks
1	500	2.29	Passed
2	750	4.93	Passed
3	1000	N.A.	Clogged

It can be noted in Table 3 that the shredding time of the fish scraps was gradually reduced due to increase in the shredding speed from 1080 rpm to a final speed of 1800 rpm. Still the 1000-g feed was not successfully processed. Confirmation of the working capacity and shredding speed was considered in the following tests. Hence, a working capacity of 750 g and a shredding speed of 1800 rpm were established.

Table 4. Mass of Shredded Fish Scraps and Mass of Losses using 750-g Feed and 1800 rpm

Test No.	Mass of Shred (g)	Mass of Losses (g)	Shredding time (s)
1	715.87	34.13	4.13
2	698.73	51.27	3.97
3	647.51	102.49	4.52
Mean	687.37	62.63	4.21

Table 4 presents the test results for the mass of shredded fish scraps and mass of losses using the 750-g feed at 1800 rpm. It can be noted that the computed mean values for mass of shred, mass of losses and shredding time were 687.37 g, 62.6 g, and 4.21 s, respectively. These values were used to determine the shredding rate and shredding efficiency for the final performance testing.

Shredding Rate and Shredding Efficiency

Table 5 shows the test results for determining the shredding rate and shredding efficiency. Results revealed that the computed mean values of the performance parameters with respect to shredding rate and shredding efficiency were 164.19 g/s and 91.64%, respectively.

Table 5. Final Performance Testing Results for Determining the Shredding Rate and Shredding Efficiency

Test No.	Shredding Rate (g/s)	Shredding Efficiency (%)
1	173.33	95.44
2	176.00	93.16
3	143.25	86.33
Mean	164.19	91.64

Shredding Size

The size produced by different speeds revealed similarity from each other. The fish scraps were reduced into multiple smaller sizes. The shredded fish scraps appeared to be slurry and part of the juices were observed.

Mixing Capacity

The mixing container was filled with fish and molasses using 1:1 ratio to determine the maximum mass of mixture that can be accommodated. A total of 12 kg mixture composed of both shredded fish scraps and molasses were determined as the maximum mixing capacity of the machine.

Mixing Time and Speed

The mixing time was the duration of the mixing process until the desired homogeneity, which was based on the visual appearance, was attained. Three different processing times such as 20 s, 30 s, and 40 s were tested to determine the most appropriate mixing time. It was noted that the mixture was not evenly mixed, where large volume of molasses was still visible in the surface of the container using the 20-s mixing time. For 30-s, it was observed that the mixture was slightly mixed but few traces of molasses were still noticeable. Color was unevenly distributed and unsatisfactory. Finally, at 40-s, the mixture was evenly mixed and the whole mixture was deep dark red in color. Thus, the 40-s time was chosen to be the best mixing time for the process.

On the other hand, the desired mixing speed was also tested by running the mixer in different speeds. The maximum speed that prevented spillage of the mixture and produced the most allowable vibration of the container while on operation was determined to be 108 rpm.

Percent Yield

After the mixing process, the mixture was placed in the container and left for fermentation. As provided by the Agricultural Training Institute, the fermentation was done in four (4) weeks [4]. Six samples having 2000 g of mixture (1000 g each component) were prepared and were harvested after four weeks. After fermentation, the mixture passed to the strainer and the liquid part of the solution was collected as fish emulsion fertilizer. The solid component was separated and disregarded. The results for the percent yield of the six samples are presented in Table 6.

Table 6. Percent Yield of Fish Emulsion Extracted After Four (4) Weeks of Fermentation

Sample No.	Mass of Mixture (g)	Mass of Extracted Fish Emulsion (g)	Percent Yield (%)
1	2000	1350	67.50
2	2000	1550	77.50
3	2000	1250	62.50
4	2000	1450	72.50
5	2000	1350	67.50
6	2000	1250	62.50
Mean	2000	1370	68.33
Total extracted mass (g)	=	*8200*	

The mean value of the percent yield of the extracted fish emulsion was 68.33% with a total mass of 8200 g (8.2kg) collected from the six samples.

Properties of Fish Emulsion Fertilizer

The properties of fish emulsion fertilizer in terms of nutrient content and pH level were tested at the Lipa Quality Control Center to know if the fish emulsion fertilizer contained important nutrients. The laboratory testing underwent three trials where each parameter was analyzed by registered Chemist and Agriculturist of the said testing center.

Table 7 presents the mean values of the nutrient contents and the pH value of the tested samples

Table 7. Mean Values of Laboratory Analysis of Fish Emulsion Samples

Parameters	Nutrient Content (Mean Values)
Nitrogen (%)	1.89
Phosphorous (%)	0.21
Potassium (%)	0.32
pH	4.19

Results revealed that the mean values of the nutrient contents of the fish fertilizer with respect to nitrogen, phosphorous and potassium were 1.89%, 0.21%, and 0.32%, respectively. A total NPK value of 2.42% was obtained and within the standard range (*standard range of 0.5-2.5%)* set by the Philippine National Standards for Organic Fertilizers [5]. The pH level of 4.19 was also acceptable for application.

CONCLUSION AND RECOMMENDATION

The fabricated machine can be considered technically and economically viable for fish emulsion fertilizer production. The economic gains of using the machine could be realized upon the utilization of the produced fish emulsion fertilizer onto cropland. Hence, it is recommended to test the produced fish emulsion fertilizer to various vegetable crops to determine its effectiveness in the plant growth. Further improvement of the machine could be done through incorporating two rotating blades to accommodate greater capacity of feed. Continuous consultation to the experts must be done to further enhance the design of the machine to ensure its reliability and performance, and finally to attain its commercial stage.

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