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Effect of Cassava Starch and Tree Gum Binders on the Physical Properties of Onion Leaves Briquettes

Yahaya Abubakar Aliero[1] ✉
Garuba Mustapha Omotosha[2]
Surajo Abdullahi[3]
Anas Nomau Sabiyel[4]
Zayyanu Usman Magawata[5]
Mukhtar Muhammad Isa[6]

(✉ *Corresponding Author*)

[1,2,3,4,5]*Department of Physics, Kebbi State University of Science and Technology, Aliero, Kebbi State, Nigeria.*
[1]*Email: yahyaabubakaraliero@gmail.com*
[2]*Email: garbamustapha8888@gmail.com*
[3]*Email: abdullahis118@gmail.com*
[4]*Email: anasnomausabiel@gmail.com*
[5]*Email: uzayyanu@yahoo.com*
[6]*Raw Materials Research and Development Council, Abuja, Nigeria.*
[6]*Email: midoko2000@gmail.com*

Abstract

Onion leaves can be seen lying as a waste which also littered houses, markets, walk ways, and gardens of the study area. Briquetting of onion leaves is relatively new. The effect of a binder on the physical properties of onion leaves briquettes using two different binders of Cassava Starch and Tree Gum was studied. Three of each sample was produced with a different binder to briquettes ratio of 90:10, 85:15, and 80:20 using a manual press briquetting machine. The result of a water resistance measurement shows that all the sample of briquettes produced can resist water for more than 3 minutes, the result of compressed density, dimensional stability, relaxation ratio shows that samples binded with tree gum has the highest value compare to the samples binded with cassava starch. Based on the results obtained, it can be concluded that the briquette from onion leaves with cassava starch as binders can be used as a substitute for biogas.

Keywords: Briquettes, Onion leaves, Cassava starch, Tree gum, Physical properties, Biogas, Binders.

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Contents

Contribution of this paper to the literature
This study is trying to harness ways of utilizing 0nion leaves, cassava starch and tree gum as a waste product in the study area to the useful product by using these materials to produce briquettes as substitute for biogas used in cooking. It also serves as a guide use in making briquettes.

1. Introduction

Utilization of waste products to use as useful product can reduce the quantity of waste that liters our environment and its surrounding, most of the developed countries uses this idea to produce useful products to their people, community and their neighboring countries.

Biomass energy is categorized as one of the sustainable and renewable energy, for the duration of the plant life cycle; Plants used as biomass materials absorb carbon dioxide (CO_2) through photosynthesis and release gas in the combustion process at same rate, which leads to no net increase in atmospheric CO_2 quantity. Biomass has lower contents of sulfur and nitrogen, but its function has limited health risk and minimum environmental pollution when compared to fossil fuel combustion. Because of this reason utilization of biomass is eco-friendly than utilization of fossil fuels, however, agricultural wastes mostly have lower density and higher moisture content, which technically make them unsuitable for use in burning directly for the reason that they have handling and combustion problems. The Only solution for such problems is to convert biomass wastes to briquettes, which will increases the volumetric calorific values, reduces collection, storage, and transportation costs, and it will also improves biomass handling characteristics [1]. Groundnut shells, rice husk, dried leaves, coffee husk are some of the agro residues potentially which do not fake drying and collection problems, and they are normally associated with biomass materials. These agricultural waste products if they can be recycled very well into useful products, more goods will be made available to our society and communities, also there will be reduction in environmental pollution and other disease attack. If solid waste can be properly processed and used, then they are of great importance to our society. Agricultural waste such as leaves, rice husks, grasses, e.t.c, can also be used as solid fuel [1]. These wastes are from trees and plants that are usually gathered and left to decompose and burnt. In this our community, planting and producing of onions is one of their main source of income, this result to the high production of onions, only little amount of onion leaves are being used for consumption while the rest can be seen lying waste in farms, markets and houses.

Better briquettes with good and greater calorific value can be obtained when plastic waste mixed with biological materials (paper, wood sawdust, etc.). Drying process of biomass materials reduces its moisture content which is first employed in the briquetting process, lower moisture contents improves briquettes quality.

Briquetting technology uses mechanical and chemical properties in compacting and compounding of biomass materials into desirable shape of briquettes without use of binders or additives in the process. Biomass materials (paper, wood sawdust, wood shavings, rice husk, bark, straw, cotton, etc.) are compacted is the process employed in producing Briquette. When the biomass materials is on the process of briquetting, high pressure and temperature simultaneously act upon the mass, in which cellular structures within the material release lignin, which result in binding individual particles into a compact unit called briquette.

Municipal waste, plastic waste e.t.c. can also be used for Briquettes if they are compound and compacted with high temperature and pressure. That is the material to use as briquettes is pressed into the pressing chamber with high compacting pressure and high pressing temperature which at the end produce a very higher quality briquettes. To control quality of briquette, some physical parameters such as density, moisture content, durability, compaction ratio, density, and compressive strength, are to be considered [2]. Household cooking and boiling of water, bricks and bakery industries are commonly utilizing biomass briquettes as their source of energy.

The main aim of this study is to make biomass briquette from onion leaves using cassava starch and tree gum as a binders and to serve as a substitute to lose biomass, wood and other fossils fuel, in house hold cooking and other heat applied processes. With the objectives as to reduce onion leaves as a waste product, to investigate physical properties of the briquettes samples produce such as Water resistance, Compressed density, Relax density, Dimensional stability, Relaxation ratio and Durability test and lastly to compare the briquettes produced using two different binders.

2. Materials and Method

This section provides details explanation of the materials used as well as the method followed while conducting this research work.

2.1. Materials

The materials used to carry out this research work include: Onion Leaves, Hand press briquette molder, Binding materials (tree gum and cassava starch), Pot, Weighing balance, Meter rule, biomass stove.

2.1.1. Onion Leaves Collection and Preparation

Onion leaves were gathered from Aliero market. They were carefully selected; these leaves were further dried for 3 days and then shredded into pieces. They were then ground into powdery form with a grinding machine.

2.1.2. Hand Press Briquette Molder

Hand press briquette molder is a simple fabricated molder for producing briquette manually, it is of different size and shape in which hand is used in producing the pressure for compaction, Figure 1 illustrates the type of hand press briquette molder used in this work.

Figure 1. Briquette molder.

2.1.3. Binding Material

Binding materials are organic or in-organic substances used to bind the biomass material for good compaction especially for hand press briquetting process which binder must be apply.

2.1.4. Pot

Pot is used to boil water and is also used in the preparation of binding materials. Figure 2 illustrates the pot used in boiling water for the preparation of binders.

Figure 2. Pot.

2.1.5. Weighing Balance

Weighing balance also known as weighing scale is a device that measure mass of an object. Figure 3 illustrates how weighing balance was used in measuring the mass of the iomass materials and also the masses of the briquette produced.

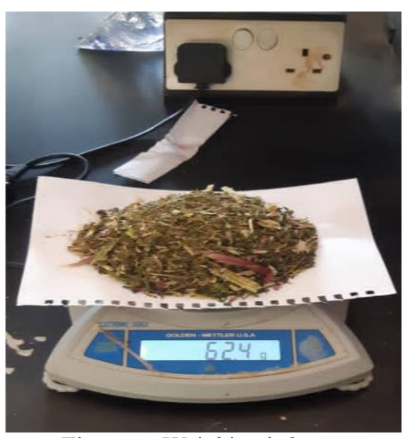

Figure 3. Weighing balance.

2.1.6. Meter Rule

Meter Rule is a device which is used to measure length of different objects. A meter rule of length 1m is equal to 100cm, on meter rule each centimeter is divided further in to 10 divisions which are called millimeters (mm). Figure 4 shows the typical metre used in measuring length and sizes of the briquette produced.

Figure 4. Meter rule.

2.1.7. Biomass Stove

Biomass Stove is a stove that uses wood, charcoal, sawdust, animal dung, and agricultural residues for cooking and boiling of water. Figure 5 illustrates the biomass stove used in preparation and testing of briquettes.

Figure 5. Biomass stove.

2.2. Method

2.2.1. Briquette Production Processes

2.2.1.1. Sorting

This is also known as sieving, usually all the unwanted materials or large biomass wastes are remove to ensure that all the required biomass samples are free from solid material and other impurities in order to have a good compaction in briquetting process.

2.2.1.2. Crushing

The biomass materials were crushed using grinding mill machine. During this process the biomass materials were chopped in to small pieces so as to enhance their compactness, this process is not however general but depends on the type of biomass materials.

2.2.2. Binder Preparation and Mixing

A standard quantity 900 g of onion leave was used, and 1391.8 g of tree gum was prepared by mixing of 1620 ml of cold water and keep it for 24 hours until it melts. And also Cassava starch of 1.0 kg was prepared by combining 1.0 liter of cold water and mixed in a plastic bucket, also water of 2.0 liters was boiled and poured in to the mixed starch and stirred gradually until it was cool. The Onion Leave were mixed with each of the two binder (Tree gum and Cassava Starch) separately in a biomass to binder percentage ratio of 90:10 %; 85 :15 %; and 80:20 %. Figure 6 illustrate sun drying process of the produced briquettes.

Figure 6. Sun drying of the produced briquette.

2.2.3. Physical Properties of the Briquette

2.2.3.1. Compaction Ratio

This was determined as the ratio of the depth of the moulder to the height of briquette produced [3]. The depth of the moulder of the briquetting machine used is 4 cm. Equation 1 presents formula of calculating compaction ration of the briquettes.

$$\text{Compaction Ratio} = \frac{\text{Depth of the Molder}}{\text{Hight of the Briquette}} \qquad (1)$$

2.2.3.2. Compressed Density

The mean compressed density was determined immediately after removal from the moulder, as a ratio of measured mass (g) over calculated volume (cm^3), [4]. The mass was obtained using a weighing scale, the volume calculated and a vernire caliper was used to obtain the linear dimensions. The ratio of measured mass over calculated volume was then determined using the Equation 2.

$$\text{Compress Density} = \frac{\text{Mass of wet briq}}{\text{volume of the briq}} \qquad (2)$$

2.2.3.3. Relaxed Density

The relaxed densities of the briquettes were determined in the dry condition of the briquettes after sun drying. Relaxed density can be known as spring back density. The relaxation density was calculated as the ratio of the briquette's weight (g) to the new volume (cm^3) as illustrated in Equation 3 [4].

$$\text{Relaxed Density} = \frac{\text{mass of dry briq}}{\text{volume of briq}} \quad (3)$$

2.2.3.4. Dimensional Stability

The height of 5 representative briquettes was measured at 0, 30, 60 (1 hour), 1440 (1 day) and 10,080 (7 days) intervals according to Sotande, et al. [5]. This is expressed in terms of the percent expansion as given by Mohsenin and Zaske [6] in Equation 4:

$$\text{Percentage Expansion} = \frac{I_{F-I_i}}{I_i} \quad (4)$$

Where I_f = Final height of briquette and I_i = Initial height of the briquette.

2.2.3.5. Relaxation Ratio

The relaxation ratios of the briquettes were determined in the dry condition of the briquettes after sun drying. The relaxation ratio was calculated as a ratio of the compressed density to the relaxed density as shown in Equation 5, Olorunnisola [4]. This helps observe the relative stability of the briquettes after compression.

$$\text{Relaxation Ratio} = \frac{\text{Maximum density}}{\text{Relaxation density}} \quad (5)$$

2.2.3.6. Durability

The briquette samples were dried to a constant weight and then dropped from a height of 2.0 meters onto a metal base. The fraction of the briquette that remained un shattered, was used as an index of briquette durability in percentage, [7]. The durability was calculated using Equation 6.

$$\text{Percentage Durability} = \frac{M_a}{M_b} \times 100 \quad (6)$$

Where M_a = mass of briquette after dropping (in Kg) and M_b = mass of briquette before dropping (in Kg)

2.2.3.7. Water Resistance

The water resistance tests were carried out according to the method described by Chaiklangmuang, et al. [8]. Water resistance of the briquettes was tested by immersing the briquette in a container filled with cold tap water and measuring the time required for the onset of dispersion in water. The higher the water resistance values, the more stable the briquettes are in terms of weathering resistance [9].

3. Result and Discussion

This chapter consists of the result obtained and the detail discussion of the result obtained from the research work. These briquettes were produced using Onion leaves and two different binders, which are, Cassava Starch and Tree Gum Figure 7 shows the examples of the briquettes produced from Onion Leaves.

Figure 7. Briquettes produced from onion leaves.

The result of the water resistance, compressed density, relax density, dimensional stability, relaxation ration and durability obtained from briquettes produced using cassava starch as a binder was shown in Table 1.

Table 1. Physical properties of briquette using cassava Starch as binder.

S/N	Briquette type	Water resistance(s)	Compressed density (Kg/m³)	Relax density (Kg/m³)	Dimensional stability	Relaxation ratio	Durability test
1	90:10%	5.170	0.3717	0.3890	-2.222	0.9557	80.162
2	85:15%	3.170	0.5953	0.3937	350	1.5125	83.739
3	80:20%	3.150	0.6587	0.3780	350	1.7427	81.752

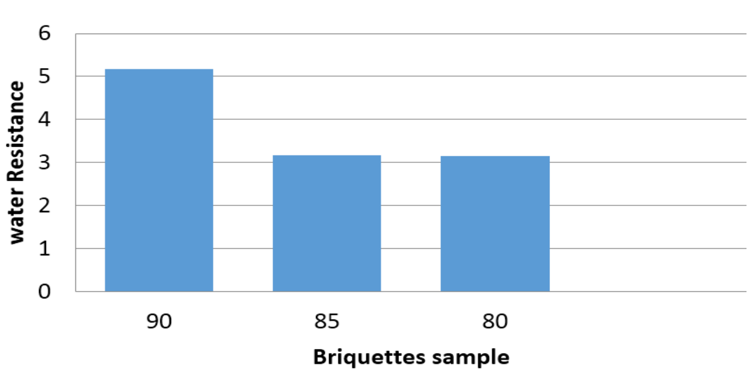

Figure 8. The graph of water resistance against briquettes samples produce using a cassava starch as a binder.

Figure 8 shows that the briquettes produced using cassava starch as a binder of 90:10% have the highest value of water resistance of 5.17. While the second highest is of 85:15% with the value of 3.17. While last one is 80:20% has the lowest value of 3.15.

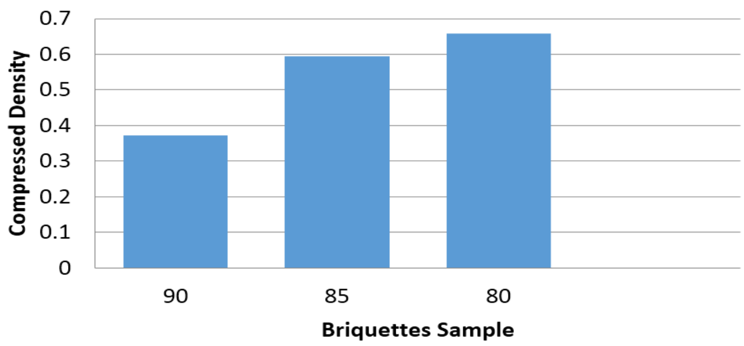

Figure 9. The graph of compressed density against briquettes samples produce using a cassava starch as a binder.

Figure 9 illustrates that the briquettes produced using cassava starch as a binder of 80:20% have the highest value of compressed density of 0.6587. While the second highest is of 85:15% with the value of 0.5953. While briquettes sample of 90:10% has the lowest value of 0.3717.

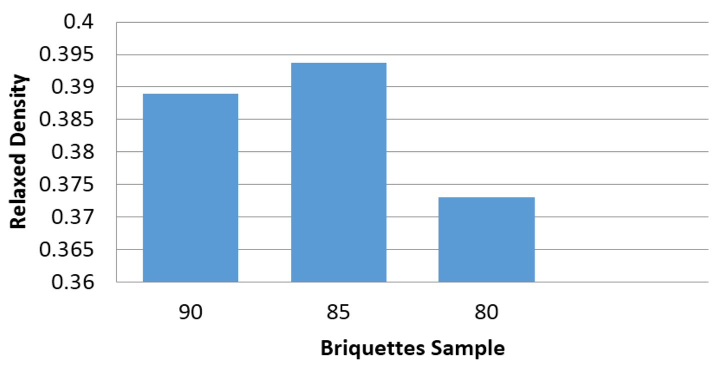

Figure 10. The graph of relaxed density against briquettes samples produce using a cassava starch as a binder.

Figure 10 shows that the briquettes produced using cassava starch as a binder of 80:20% have the highest value of relaxed density of 0.3730. While the second highest is of 85:15% with the value of 0.3890. While briquettes sample of 90:10% has the lowest value of 0.3037.

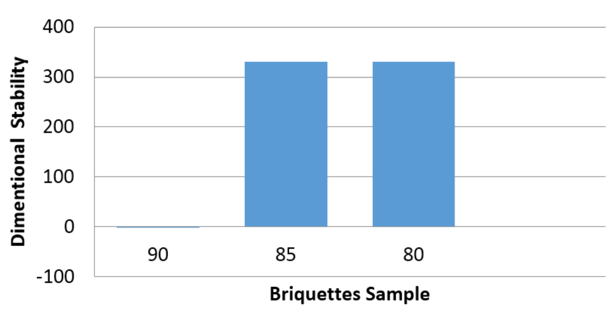

Figure 11. The graph of dimensional stability against briquettes samples produce using a cassava starch as a binder.

Figure 11 illustrates that the briquettes produced using cassava starch as a binder of 80:20% and 85:15% have the highest value of dimensional stability of 330. While briquettes samples with 90:10% has the lowest value of -2.343.

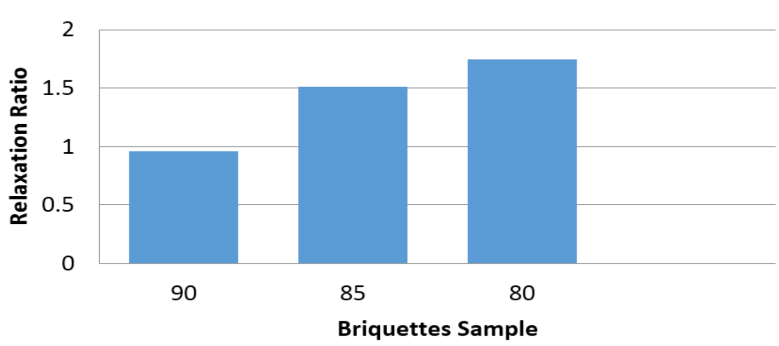

Figure 12. The graph of relaxation ratio against briquettes samples produce using a cassava starch as a binder.

Figure 12 shows that the briquettes produced using cassava starch as a binder of 90:10% have the highest value of relaxation ratio of 0.9557. While the second highest is 85:15% with the value of 1.5125. While last one is 80:20% has the lowest value of 1.7427.

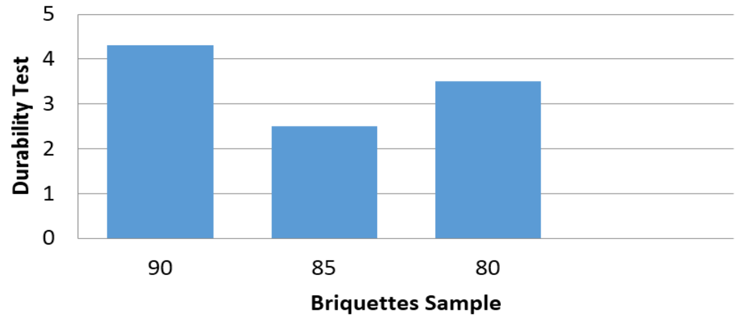

Figure 13. The graph of durability test against briquettes samples produce using a cassava starch as a binder.

From the Figure 13 above, the briquettes produced using cassava starch as a binder of 90:10% have the lowest value of durability test of 80.162. While the second highest is 85:15% with the value of 83.739. While last one is 80:20% has the second value of 81.752.

The result of the water resistance, compressed density, relax density, dimensional stability, relaxation ration and durability obtained from briquettes produced using tree gum as a binder was shown in Table 2.

Table 2. Physical properties of briquette using tree gum binder.

S/N	Briquette Type	Water resistance	Compressed density (Kg/m³)	Relax density (Kg/m³)	Dimensiona l stability	Relaxation ratio	Durability test
1	90/10%	5.17	0.3717	0.3890	-3.100	0.9557	80.1
2	85/15%	0.30	0.2110	0.3500	-3.100	0.6031	31.0
3	80/20%	48.00	0.1353	0.3843	-5.999	0.3521	42.1

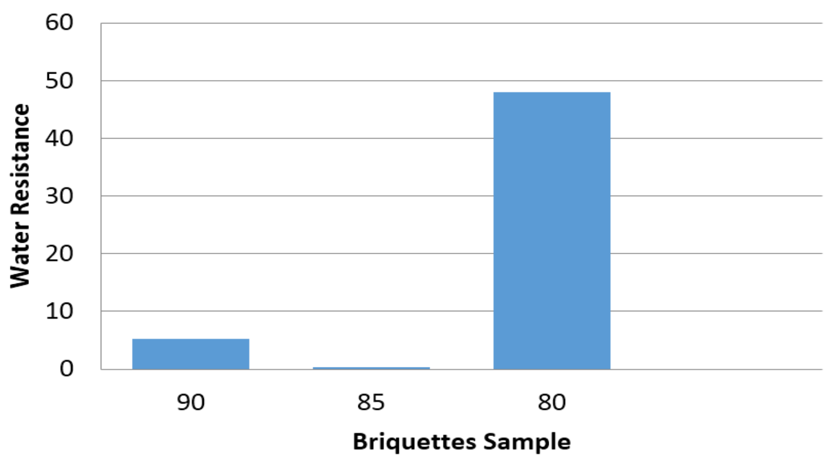

Figure 14. The graph of water resistance against briquettes samples produce using a tree gum as a binder.

From the Figure 14 above, it shows that the briquettes produced using tree gum as a binder of 90:10% have the second highest value of water resistance of 5.17. While the lowest is of 85:15% with the value of 0.30. While last one is 80:20% has the highest value of 48.00.

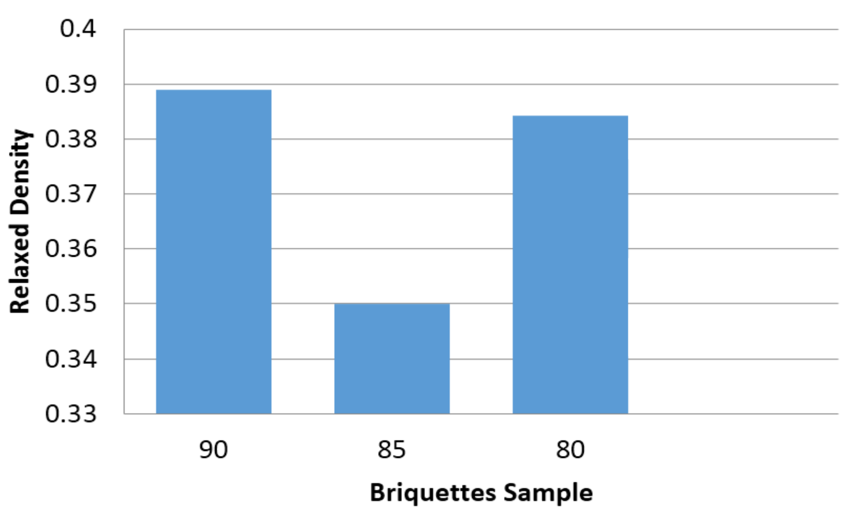

Figure 15. The graph of relaxed density against briquettes samples produce using a tree gum as a binder.

Figure 15 above shows that the briquettes produced using tree gum as a binder of 90:10% have the highest value of relaxed density of 0.3890. While the briquettes sample of 85:15% with the lowest value of 0.3500. While briquettes sample of 90:10% has the second highest value of 0.3843.

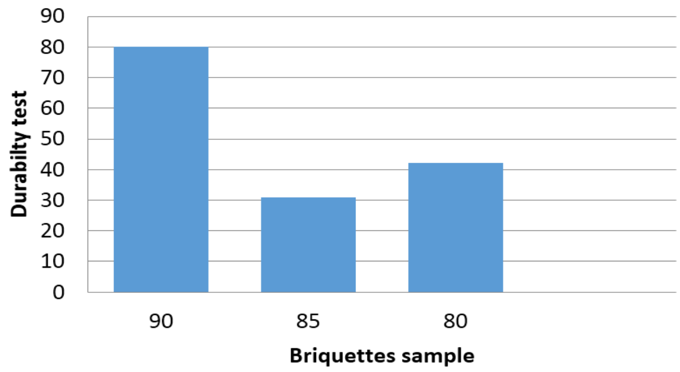

Figure 16. The graph of durability test against briquettes samples produce using tree gum as a binder.

From the Figure 16, it illustrates that the briquettes produced using tree gum as a binder of 90:10% have the highest value of durability test of 80.1. While the second highest is 80:20% with the value of 42.1. While last one is 85:15% has the lowest value of 31.0.

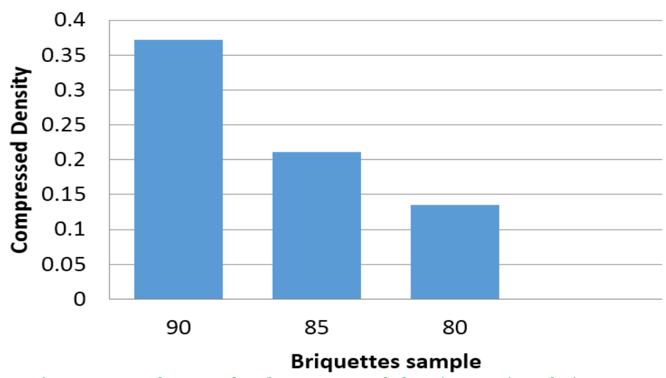

Figure 17. The graph of compressed density against briquettes samples produce using tree gum as a binder.

Figure 17 shows that the briquettes produced using tree gum as a binder of 90:10% have the highest value of compressed density of 0.3717. While the second highest is of 85:15% with the value of 0.2110. While briquettes sample of 80:20% has the lowest value of 0.1353.

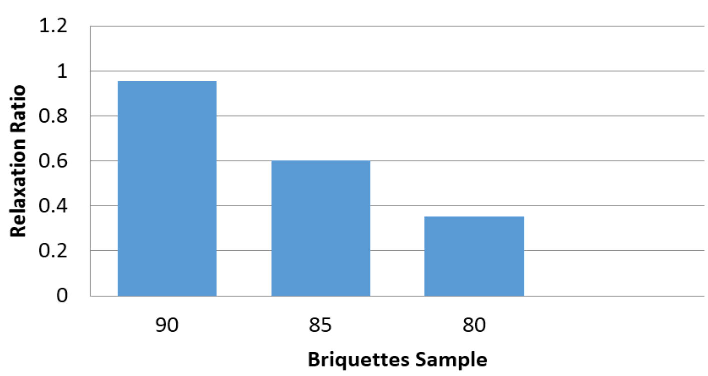

Figure 18. The graph of relaxation ratio against briquettes samples produce using tree gum as a binder.

From the Figure 18 above, it shows that the briquettes produced using tree gum as a binder of 90:10% have the highest value of relaxation ratio of 0.9557. While the second highest is 85:15% with the value of 0.6031. While last one is 80:20% has the lowest value of 0.3521.

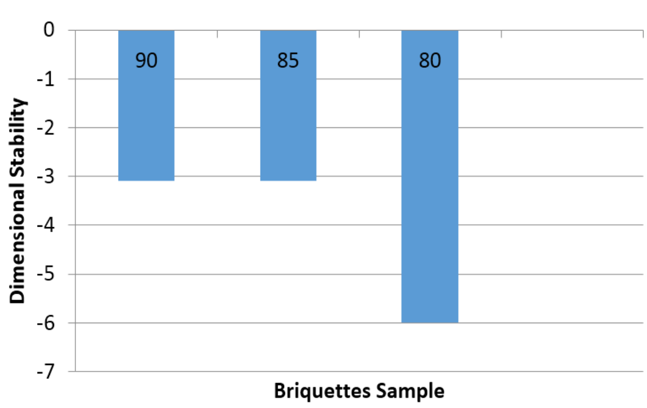

Figure 19. The graph of dimensional stability against briquettes samples produce using tree gum as a binder.

Figure 19 illustrates that the briquettes produced using tree gum as a binder of 80:20% has the lowest value of -5.999, and 85:15% and 90:10% has the value of -3.1.

4. Discussion

The briquettes were produced using Onion leaves and two different binders, these are, Cassava Starch and Tree Gum, three of each sample was produced with a different binder to briquettes ratio of 90:10, 85:15, and 80:20.

The result of Physical properties of briquette using tree gum and cassava starch as binder with different briquettes to binder ratio was obtained.

The result of Physical Properties of a water resistance measurement of Briquettes with a tree gum and Cassava starch as a binder of all the three samples of each binder shows that the sample of briquettes with 90:10% of Starch have the highest value of 5.17 water resistance and the lowest was the sample of the briquette of 80:20% of tree gum with the value of 3.15 water resistances.

The result of physical properties of a compressed density measurement of briquettes with a tree gum and cassava starch as a binder of all the three samples of each binder shows that the sample of briquettes with 90:10% of Starch have the lowest value of 0.3717 compressed density and the highest was the sample of the briquette of 80:20% of tree gum with the value of 0.6589 compressed density.

The result of physical properties of a relaxed density measurement of briquettes with a tree gum and cassava starch as a binder of all the three samples of each binder shows that the sample of briquettes 85:15% of a cassava starch have the highest value of 0.3937 Kg/m^3 relaxed density while the lowest is the sample of briquettes 80:20% of tree gum as a binder with the value of 0.3780 Kg/m^3 relaxed density. The result of physical properties of a dimensional stability of briquettes with a tree gum and cassava starch as a binder of all the three samples of each binder shows that the sample of briquettes of 85:15% have and the last sample of 80:20% of tree gum as a binder has the highest value of 350 m and the lowest is the sample of briquettes 80:20% of cassava starch has the same lowest value of -2.222. m. The result of physical properties of a relaxation ratio of briquettes with a tree gum and cassava starch as a binder of all the three samples of each binder shows that the sample of briquettes 80:20% of a tree gum have the highest value of 1.7427 relaxation ratio, while the lowest is the sample of briquettes 90:10% of cassava starch as a binder with the value of 0.9557 relaxation ratio. The result of physical properties of a durability test of briquettes with a tree gum and cassava starch as a binder of all the three samples of each binder shows that sample of the briquette sample 85:15% of cassava starch as a binder have the highest value of 83.739 g durability test, while the sample of briquettes 80:20% of durability test have the lowest 81.752 g durability test.

5. Conclusion

The present work examined the physical properties of briquettes produced from onion leaves using two different binders Cassava starch and tree gum at three different binders' levels 10%, 15%, and 20% using a manual press briquetting machine. The relaxed density of the briquettes with the two binders was not in the same range. This means that they will be easily broken during transportation and storage. The result of a water resistance measurement shows that majority of the sample of briquettes produce can resist water for more than 3 minutes. The compressed density results show that sample of briquettes with 90:10% of Starch have the lowest value of 0.3717 compressed densities and the highest was the sample of the briquette of 80:20% of tree gum with the value of 0.6589 compressed densities. The result of a dimensional stability shows that the sample of briquettes produced are dimensionally stable. In the relaxation ratio, binder affect the relative stability of the briquettes, as the higher the binder in cassava starch binder briquettes the higher the higher the relaxation ratio, while in tree gum binder briquettes the higher the binder the lower the value of relaxation ratio. Briquettes produced using cassava starch as a binder has higher durability than the briquettes produced using tree gum as a binder.

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