International Journal of Emerging Engineering Research and Technology
Volume 7, Issue 7, 2019, PP 1-7
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

Effect of Storage Time and Storage Space on Some Mechanical and Combustion Characteristics of Briquettes

Davies, Rotimi Moses[1] and Davies, Onome Augustina[2]

[1]*Department of Agricultural and Environmental Engineering, Niger Delta University, Yenagoa, Bayelsa State, Nigeria.*
[2]*Department of Fisheries and Aquatic Environment, Rivers State University, Port Harcourt, Rivers State. Nigeria*

**Corresponding Author: Davies, R. M., Department of Agricultural and Environmental Engineering, Niger Delta University, Yenagoa, Bayelsa State, Nigeria, Email: oluwadabobomigrace@gmail.com*

ABSTRACT

The effect storage time and storage space on the mechanical and combustion characteristics of briquettes produced from water hyacinth and plantain peels as binder agent at binder ratio 50% by weight of each feedstock and at compaction pressure of 10 MPa were investigated. It was revealed that the values of density, water resistance capacity, shattering index, compressive strength and rupture force , ignition time and burning rate of briquettes stored for 6 months had no significant difference (P>0.05) for briquettes stored in seal carton. After six period the variation in the values were very significant (P<0.05) for briquettes stored in seal carton. All briquettes stored in open carton showed significant different from three months (P<0.05).The briquettes are all stable even after one year of their production.

Keywords: *Rupture Force, Moisture Content, Thermal Properties, Density, Durability Index*

INTRODUCTION

Briquetting is a positive way of managing the menace associated with agricultural wastes and aquatic weeds and contributing meaningfully to environmental management thereby creating employment opportunities and generating income for those who are worst most affected by it (Mailu *et al*., 2000; Lindrey and Hirt, 2000; Olal, 2005; Kitunda, 2006 and Sophie, 2006). It provides substantial savings, improves the handling and hence reduces transportation cost in addition to production of a uniform, clean, stable fuel (Granada *et al*. 2002, Suhartini et al., 2011 and Wilaipon, 2007)). Densification through production of briquettes enhances combustion efficiency over the original material. Manufacturing of briquettes, wafers and pellets and their packaging will boost business of small and medium scale enterprise opportunities for production of hydraulic presses needs for densification of flammable materials such as wood waste (chips, sawdust), straw, coal, paper, cellulose and tobacco is commonly used energetically (by combustion) (Brožek 2011 and Brožek et al. 2012).

More than 75% of population in the developing nations of the world relied on utilization of biomass as their major source of energy for cooking and heating (Akinbami, 2001 and Ahmed and Haboubi, 2010). Success story on the acceptability, adoption and utilization of briquettes is still a mirage in developing countries owing to its high cost of production, high technology involved, lack of awareness on its sustainability, lack of readily available market and poor packaging and distribution systems for the product (Emerhi, 2011). The disadvantages of utilizing biomass residue in its natural and loose state as biofuel are low density, high moisture content, low heating value, high amount of smoke, low thermal efficiency that less than 5% and difficulties in handling, storage and transportation (Sharma *et al.*, 2006).

Direct burning of agricultural residues is very inefficient given that its thermal efficiency less than 5%. In addition to it, the management of agricultural residues such as its transportation, storage, and handling is very difficult, owing to its low density of about 60- 180 kg/mJ.

According to the study conducted by Brožek (2014) on storage place, storage manner and storage time in relation to mechanical properties of briquettes produced from spruce shavings. It was revealed that mechanical properties of briquette stored in a well closed plastic bag were not influenced by place and storage time. Meanwhile, briquettes stored in a net plastic bag undergo different intensive damage to briquettes and this largely affected by their storage place and storage time. Agricultural and industrial wastes are potentially enormous source of energy-giving materials. These comprises of aquatic plants, wood, herbaceous and crop and forest resources and animal wastes. In Nigeria, huge quantities of agricultural and industrial wastes are produced annually and are vastly under-utilized. Many a time these residues or leave are either burnt or left to decompose. Researchers have shown that these residues could be processed into charcoal, liquid fuel or combusted/gasified to produce electricity and heat (Enweremadu *et al*., 2004). There are various positive out looked for the use of agricultural wastes as energy source with a lot of environmental benefits. It helps to ameliorate climate change, reduces acid rain, soil erosion, water pollution and pressure on landfills. It ensures wildlife habitat and aids forest health through better management. There are been upsurge in the interest in developing environment friendly alternative fuel to the use of fossil fuels due to the topical changes in global environmental conditions and the increase in atmospheric concentration of carbon and sulphur compounds. According to Jaan *et al*. (2010) reported that fossil fuels have a limited potential and detrimental consequences on the environment.

Davies and Davies (2016) reported utilization of some invasive and prolific aquatic weeds such as water hyacinth, water lettuce, phytoplankton scum and water lily that smoothers water bodies, chokes other aquatic lives, prevent navigation. Aquatic weed favour mosquitoes breeding and fosters water borne diseases, environmental nuisance and threat to ecodiversity. Other researchers have worked production of briquettes from agricultural wastes and their energy potentials such as plantain peels and water hyacinth plant (Davies. 2017), orange pomace (Enweremadu *et al*., 2004); soybean and cowpea (Enweremadu *et al*., 2004); Guinea corn (Bamgboye and Bolufawi, 2008)); husk from soybcan and cowpea (Enweremadu et al., 2004); Waste Paper and Coconut (Olorunnisola, 2007), charcoal (Fapetu, 2000), neem wood residues (Sotannde *et al*., 2010) and energy crops (Plíštil *et al*. 2004). Thus, the main aim of this work was to evaluate the effects of storage condition and storage time on the physical and mechanical briquettes from water hyacinth and plantain peel.

MATERIALS AND METHODS

Pretreatment of Harvested Water Hyacinth

Water hyacinth plant was harvested and cleaned to devoid of foreign matters (stone, dust and plant materials) before drying. Cleaned water hyacinth was chopped into smaller pieces with knives in order to facilitate drying. Dried water hyacinth was ground using hammer mill. The particle size distribution 0.075 mm was achieved by using Tylers sieve in compliance with procedure described in ASAE424.1. (2003).

Preparation of Binder

Unripe plantain peels was separated out ripe ones. Unripe plantain peels samples were cleaned to devoid of foreign matters (stone, dust and plant materials) before drying. Sample were chopped by knives to reduce its size to facilitated drying. The dried raw materials were ground using hammer mill. The particle size was achieved by using Tylers sieves of various diameter or particles size openings. For this experiment, sieves size corresponding to 0.075 mm was chosen. One hundred grams (100g) of ground plantain peel was hydrated with 50 mls of boiling water (100 ^{o}C) to form colloidal solution of the binder and later put on fire. The colloidal solution was constantly stirred until smooth paste was formed. This facilitated the proper agglomeration of the particle. The consistency of the binder was maintained at a fixed level with its concentration in the sample mixture at 50% level of the residue by weight (Bamigboye and Bolufawi, 2008).

Figure1. *Harvested water hyacinth plant*

Preparation of Samples Briquette

Binder (ground plantain peels) in the ratio of 50% by weight of the residue stock was added residue rations. The agitating process was done in a mixer to enhance proper blending prior compaction. The blends were briquetted in a manually operated hydraulic powered press having capacity of 20 tonnes. Compaction tests on the blend samples were carried out using hydraulic press machine. A steel cylindrical die of dimension 14.3mm height and 4.7mm in diameter was used for this study. The die was freely filled with known amount of weight (charge) of each sample mixture and be positioned in the hydraulic powered press machine for compression into briquettes. The piston was actuated through hydraulic pump at the speed of 20 mm/min of piston movement to compress the sample. Compaction pressure was 10 MPa.

Storage Space

Three distinct storage spaces for storing briquettes were evaluated namely sealed carton box **(S1),** open carton box **(S2)** and open space **(S3)** all in the same room were used to store briquettes for a period of one year at room temperature between 27-31^{o}C. One hundred and fifty dry briquettes were divided into three groups. Fifty briquettes were arranged horizontally in a seal-up carton, **S1**; 50 briquettes were also arranged horizontally but in an open carton **S2** and remaining 50 briquettes were arranged in open space of the room **S3**. Open space store is to simulate natural way charcoal and other fuelwood are kept. All the briquettes were all stored in the same room.

Density

The density of the loose materials used was measured using ASABE (2003). The moisture content of the ground material before and after compaction was determined by the oven-drying method (ASABE, 2003). The initial weight of the sample was determined (W1), and placed in an oven set at 1030C for 24 hours. The samples was removed and cooled in a dissector, reweighed (W2). Moisture content of the sample was calculated from this equation:

$$M_c.\ (w.b) = \frac{\text{Loss of weight } \times 100}{\text{Weight of sample}}$$

Compressive Strength

The axial compressive strength (Nmm^{-2}) of the briquette was measured using Universal Testing Machine. The briquette was position directly under the plunger to be pressed. The machine operated until failure occurred on the briquette. Then, record the maximum force that corresponds to failure. The accuracy of the machine was ±0.5% with a maximum force of 2 kN. This machine consists of a sensor to measure the breaking force (F) of the briquette. The maximum load to cause failure was read on the computer attached to the equipment. The compressive strength of the briquettes was determined by using a universal testing machine and in line with ASTM 1037-93 (1995).

The compressive strength was then calculated from equation 6

$$\text{Compressive strength} = \frac{F}{A}$$

Resistance to moisture deterioration was determined by measuring the associated dimensional changes of the briquette when immersed in water at 27°C for 24 hours. The briquette sample was placed in a beaker and the initial height as shown by the indicator on the graduated scale was recorded. The beaker was filled with water, enough to submerge the briquettes completely. The briquettes absorbed moisture and the corresponding height with time was taken. The percentage relative change in height with time was computed from equation 8

$$He = \frac{Hf - Ho}{Ho}$$

Where

H_e = relative change in height (%)

H_o =initial height of briquette before immersion (cm)

H_f = height of the briquettes after specific period of immersion

The percentage relative change in diameter with time was computed from equation:

$$He = \frac{Dt - Di}{Di}$$

D_i= Initial diameter of the briquette under compression

D_t = final diameter of the briquette after expansion

Briquettes shattering index was measured according to D440-86 of drop shatter developed for coal (Lindley and Vossoughi, 1989). The durability of the dry briquettes was investigated using a durability tester and procedure according to ASAE standard method, S269.3.

(2003). Tumbling resistance of the briquettes was evaluated based on percentage of the initial mass of the briquette remaining in the box when subjected to tumbling process for a period of 10 min at 50rev/min. Fuel burning rate of the briquettes was determined according to Ndirika (2002). The change in briquette density is related to the change in briquettes dimension such as diameter and length and more especially shelf life of binders used to produce briquettes and moisture content.

Results and Discussion

The effect of storage time and storage place on the density of the briquettes was investigated. It was found that the values of density of briquettes stored in seal cartoon for 6 months had no significant difference ($P<0.05$). This observation could be adduced to possible strong binding force exhibited by the binder. It was observed after six months density decreased with increase in storage time of the briquettes for all the storage types. The reduction observed in the values of relaxed density of the briquettes from six months was significantly different. This observation could be attributed to considerable elastic recovery and stress relaxation processes that occurred due biodegradation of the binder over time thereby leaving the briquettes to be unstable. This might also be attributed to the fact that the biomass briquette is hygroscopic in nature, which absorbs moisture from atmosphere and resulted in increase in briquettes volume and thus, reduced relaxed density. Similar observation was reported by Sharma et al. (2006) on the bulk densities of tree leaves, saw dust and wheat straw briquettes prepared using molasses decreased from 751.06, 660.32, 366.6 kg/m3 to 711.29, 585.89 and 304.42 kg/m3, respectively after 2 months of storage briquettes. This might be due to the fact that the biomass briquettes are hygroscopic in nature which absorbs atmospheric moisture resulting in increase in volume of briquettes and thereby decrease in density.

Table1. *Effect of storage time on the physical and mechanical characteristics of water hyacinth briquettes*

Parameters		3 months	6 months	9 months	12 months
Density (kg/m^3)	S1	521.63±10.01a	517.36±5.68a	454.31±5.81b	412.32±5.31c
	S2	473.18±7.23a	431.42±7.38b	410.71±5.33c	365.51±8.72d
	S3	354.3±8.85a	311.59±4.18b	301.55±9.05c	298.34±3.53d
Relative change in height (%)	S1	8.58±0.55c	10.42±1.25b	12.78±0.69c	14.28±0.76a
	S2	10.97±2.50d	12.41±2.57c	14.58±0.55b	15.14±2.75a
	S3	15.82±2.15d	21.69±1.77c	26.18±1.13b	29.31±1.74a
Relative change in diameter (%)	S1	2.10±0.21a	3.97±0.28b	5.93±0.07c	6.34±0.05d
	S2	3.45±0.02a	3.34±0.05b	6.84±0.03c	8.42±0.21d
	S3	5.67±0.13a	8.85±0.34b	10.18±0.21c	13.51±0.37d
Shattering index	S1	94.3±0.04a	92.5±0.04a	73.8±0.03b	67.4±0.02c
	S2	89.1±1.13a	86.8±0.03b	70.2±0.01c	63.7±0.04d
	S3	72.45±1.13a	63.36±1.57b	52.69±0.95c	47.72±0.21d
Compressive strength N/mm^2	S1	4.42±0.45a	4.39±0.63a	2.47±0.23b	1.86±0.05c
	S2	3.41±0.02a	2.57±0.03b	1.72±0.10c	0.83±0.03d
	S3	2.97±0.05a	2.12±0.02b	1.23±0.07c	0.54±0.02d
Rupture force (N)	S1	857.48±1.25a	851.37±5.31 a	437.21±6.23 c	325.86±6.43 d
	S2	665.35±9.21a	563.57±8.87 b	379.34±5.68 c	283.69±3.81 d
	S3	610.46±5.98a	521.55±6.53 b	301.47±7.44 c	253.78±8.78 d
Durability (%)	S1	90.3±2.01a	89.1±0.57a	80.7±0.43b	63.7±0.32c
	S2	85.9±1.07a	82.2±0.56b	66.8±0.91c	60.1±0.53d
	S3	71.65±4.81a	65.41±01.32b	60.66±2.31c	56.54±1.05d
Ignition time (Sec.)	S1	96.75±2.31a	94.86±1.26b	73.98±3.27c	64.34±4.12d
	S2	86.64±3.54a	76.98±3.27b	64.96±3.26c	62.47±3.19d
	S3	79.96±2.05a	68.31±2.07b	60.57±3.53c	56.25±2.62d
Burning rate (g\min)	S1	0.74±0.03c	0.75±0.02c	0.98±0.01b	1.21±0.06a
	S2	0.87±0.01c	0.96±0.02c	1.37±0.01b	1.64±0.09a
	S3	1.13±0.02d	1.92±0.04c	2.45±0.06b	2.58±0.09a

According to Brožek (2014) reported that the briquettes density decrease was 14.7% at the expiration of six months. Briquettes stored after 12 months observed density decreased to 21.6%. At the storage in the closed unheated room. The density decrease after 6 months was of 37.8%, after 12 months of 38.4%. At the briquettes storage in the unheated, from one side open shelter, the density decrease after 6 months made 41.9%, after 12 months 38.9%.

The variation in the values of resistance to water penetration of the briquettes stored for 3 months at 6 months periods showed no significant difference (P>0.05) for briquettes stored in seal cartoon). It was noticed after six months there was significant in the variation in values obtained for resistance to water penetration of briquettes. The implication of this observation is that in a high relative humidity area such as Niger Delta of Nigeria six months might be more suitable and appropriate for shelf life of briquettes. Wakchaure1 and Indra, (2011) reported percentage water penetration of briquettes made from mustard stalk, mixed waste and wood waste. increased (2.7 to 184.1%) with increase in storage time.

Shattering index (durability) is a measure of the ability of a briquette to withstand mechanical handling. The durability of briquettes is a very important parameter to be considered for transportation processes and feeding combustion equipment. The mean shattering index ranged between 0.67±0.02 (for 12 months) to 0.95 ±0.04 (three months). The variations in the values were not significant (P<0.05) for six months. This is an indication that briquettes maintained high mechanical interlocking and adhesion between the particles, forming intermolecular bonds in the contact area. The implication of this observation is that at six months under the same condition and storage periods the briquettes stored will be durable, reliable and stable that stands mechanical handling and transportation and economical feasible. After six month, it was observed that there was a significant change in the shattering index (P>0.05).

There was no significant change in the variation of values of compressive strength at six months (P>0.05). It was observed that compressive strength of briquettes decreased with increase in storage time of the briquettes after six months significantly (P<0.05). Similar observation was reported by Sharma et al. (2006) on compressive strength of briquettes produced from using tree leaves, saw dust and wheat straw with molasses as binder after storage for 2 months, it was found that compressive strength decreased from initial values 14.64, 13.28 and 2.95 kg/cm^2 to 11.93, 9.3, 1.9 kg/cm^2, respectively. Compressive strength is one of the most important characteristics of a briquette that determined the stability, quality index and durability ((Hussain *et al*., 2002; Wilaipon, 2007 and Bisana and Laxamana, 2007 and Olorunnisola, 2007 and Kaliyan and Morey, 2009). The obtained values of compressive strength at the different storage periods and conditions were in agreement with those of Brožek (2014) on some biomass briquettes.

Ignition time of briquettes decreased with increase in storage period. The increase in ignition time might be owing to biological degradation of biomass briquettes. Density has positive correlation with ignition time of the briquettes. The higher ignition time observed with briquettes under storage six months could be attributed to low porosity exhibited between inter and intra–particles which did not enable easy percolation of oxygen and out flow of combustion briquettes due to high bonding force. Elongating storage time reduce the ignition time of the briquettes. It was apparent that density of the briquettes had positive impact on the ignition time of the briquettes. Thus, increase the porosity index of the briquettes which might cause reduction in time taken for the briquettes to be ignited. This implied inverse correlation between ignition time and the studied density (Onuegbu *et al.*, 2010). Burning rate of briquettes increased with increase in storage period.

The increase in burning rate might relate to biological degradation from the biomass briquette. The higher burning rate observed with briquettes after storage for six months could be attributed to high porosity exhibited between inter and intra–particles which enable easy percolation of oxygen and out flow of combustion briquettes due to low bonding force..Chin and Siddique (2000) studied the effect of density on the burning rate of some biomass briquettes. Saptoadi (2008) reported the average burning rate of palm biomass briquette was 0.43 g/min (Nasrin *et al*., 2008).

CONCLUSION

The variation in values of density, water resistance capacity, shattering index, compressive strength and rupture force, ignition time and burning rate of briquettes stored for 6 months had no significant difference (P>0.05) for briquettes stored in seal cartoon. After six period the variation in the values were very significant (P<0.05).All briquettes stored in open cartoon showed significant different from three months (P<0.05).The briquettes are all stable even after one year of their production.

REFERENCES

[1] Akinbami JFK. 2001. Renewable energy resources and technologies in Nigeria: present situation, future prospects and policy framework. Mitigation and Adaptation Strategies for Global Change,6, 155-181.

[2] Ahmed, T., and Haboubi, N. (2010). Assessment and management of Nutrition in older people and its importance to health. Clinical Interventions in Aging, 5, 207–216.

[3] Bamgboye, A. and Bolufawi, S. (2008). "Physical Characteristics of Briquettes from Guinea.corn (sorghum bi-color) Residue. *Agricultural Engineering International: the CIGR Ejournal. Manuscript 1364*.

[4] Brožek M. (2014)**.** Study of briquette properties at their long-time storage. Journal of Forest Science, *59*, 2013 (3): 101–106.

[5] Brožek M. (2011): Quality evaluation of briquettes made from biomass. In: Proceedings of the \5th International Scientific Conference Rural Development 2011. Akademija, 24.–25. November 2011. Akademija, Aleksandras Stulginskis University: 308–313.

[6] Brožek M., Nováková A., Kolářová M. (2012): Quality evaluation of briquettes made from wood waste. Research in Agricultural Engineering, ***58***: 30–35.

[7] Chin O. C.and Siddiqui, K. M. (2000). "Characteristics of some biomass briquettes prepared under modest die pressures," *Biomass and Bioenergy, vol. 18, pp. 223–228*.

[8] Davies RM., Davies OA. 2013. Physical and combustion characteristics of briquettes made from water hyacinth and phytoplankton as binder. *Journal of Renewable Energy*, Volume 2013, Article ID 429230, 5 pages**.**

[9] Davies RM, Abolude DS. 2012. Densification of Water hyacinth for Biofuel *FS Journal of Basic and Applied Sciences*, 1(1) 21-24.

[10] Davies RM, Abolude DS. 2012. Densification of Water hyacinth for Biofuel *FS Journal of Basic and Applied Sciences*, 1(1) 21-24.

[11] Emerhi EA. (2011). Physical and combustion properties of briquettes produced from sawdust of three hardwood species and different organic binders. Advances in Applied Science Research, 2 (6), 236-246.

[12] Enweremadu, C.C., Ojediran, J.O., Oladeji, J.T. and Afolabi, L.O. (2004). Evaluation of energy potentials in husk from soybcan and cowpea science focus 8:18-23.

[13] Hamelinck, C.N. and Faaji, A.P.C. 2006. Production of advancd biofuels.*International Sugar Journal* 108(1287):168-175.

[14] Husain, Z., Zainac, Z., Abdullah, Z. (2002). "Briquetting of Palm Fibre and Shell from the Processing of Palm Nuts to Palm Oil,"Biomass and *Bioenergy, Vol. 22, pp. 505-509*.

[15] Jaan Kersa, Priit Kulua, Aare Aruniita, Viktor Laurmaaa, Peter Križanb, Lubomir Šoošb and Ülo Kaskc.Determination of physical, mechanical and burning characteristics of polymeric waste material briquettes. Estonian Journal of Engineering, 2010, 16, 4, 307–316 doi: 10.3176/eng.2010.4.06

[16] Jekayinfa SO,. OmisakinOS. 2005. The energy production of some agricultural wastes as local fuel materials in Nigeria. *Agricultural Engineering International the CIGR E*-Journal of Scientific Research and Development Vol. VII, Manuscript EE 05 003: 10-19.

[17] Mailu, A.M. Oched, G.R.S., Gilonga, W., Njoka, S.W. (2000). Water Hyacinth: An Environmental disaster in the Winam Gulf of Lake Victoria and its control, ODINAFRICA. In: Proceeding of the 1st 10BG Water hyacinth Working Group Pror–105. http:hdl.hardle.net /1834/1281 (Accessed December 14 2008).

[18] Olal, M.A. (2005) Handicrafts Prepared from water Hyacinth. In: Organic Resources Management in Kenya, perspectives and Guidelines, forum for Organic Resources Management and Agricultural Technologies (FORMAT).

[19] Olal, M.A. Muchilwa, M.N. and Woomer, P.L. (2001).Water Hyacinth, Utilizations and the use of waste material for Handicraft production in Kenya. In: Nightingale D.L.M. (Ed) micro and small Enterprises and Natural Resource Use. Micro-Enterprises Support programme UNRP, Nairobi pp119-127.

[20] Olorunnisola A.O. (2007). Production of fuel Briquettes from Waste Paper and Coconut Husk Admixtures. Agricultural Engineering International: the CIGR Ejournal. Manuscript EE 06 066. Vol. 1X.

[21] Olorunnisola A.O. (2004). Briquetting of Rattan Furniture Waste.*Journal of Bamboo and Rattan.*Vol. 3 (2): 139-149.

[22] Onuegbu TU, Ekpunobi UE, Ogbu IM, Ekeoma MO., Obumselu FO.(2011). Comparative studies of ignition time and water boiling test of coal and biomass briquettes blend. IJRRAS; 7(2):153-159.

[23] Plíštil D., Brožek M., Malaťák J., and Heneman P. (2004): Heating briquettes from energy crops. Research in Agricultural Engineering, ***50***: 136–139.

[24] Sotannde, O.A, Oluyege, A.O, and Aba G.B. (2010). Physical and combustion of charcoal briquettes from neem wood residues. *Int. Agrophysics*, 24, 189-194.

[25] Kaliyan, N. and R. Morey. (2006). Densification characteristics of corn stover and switchgrass. Presented at the ASABE Annual International Meeting, July 9-12, 2006, `Portland, or. ASABE Paper No. 066174. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA.

[26] Kaliyan N. Morey R. 2009. Factors affecting strength and durability of densified biomass products Biomass and Bioenergy,33, 337-359.

[27] Sharmal , R K. Wakchaure G. C. and Samue D. V. K. (2006). Effect of Material and Binders on Storage and Burning Quality of Biomass Briquettes. Journal of Agricultural Engineering 43(4): October-December, 2006, 71-74.

[28] Suhartini S, Hidayat N and Wijaya S (2011). Physical properties characterization of fuel briquette made from spent bleaching earth. Biomass. Bioenergy 35, 4209–4214.

[29] Surrey, M.O. (2000). Biomass Energy Centre. www.biomassenergycentre.org.uk.

[30] Wakchaure G.C. and Indra Mani (2011). Thermal and Storage Characteristics of Biomass Briquettes with Organi.c Binders *Journal of Agricultural Engineering* 48(4);43-53.

[31] Wilaipon, P. (2007). Physical Characteristics of Maize Cob Briquettes under Moderate Die Pressure. American Journal of Applied Science. 4: 995-998.

Citation: *Davies, Rotimi Mose and Davies, Onome Augustina., "Effect of Storage Time and Storage Space on Some Mechanical and Combustion Characteristics of Briquettes", International Journal of Emerging Engineering Research and Technology, 7(7), 2019, pp.1-7*