Iranica Journal of Energy & Environment 5 (2): 167-172, 2014
ISSN 2079-2115
IJEE an Official Peer Reviewed Journal of Babol Noshirvani University of Technology
DOI: 10.5829/idosi.ijee.2014.05.02.08

BUT

Effects of Binding Ratios on Some Densification Characteristics of Groundnut Shell Briquettes

[1]O.A. Oyelaran, [2] B.O. Bolaji, [3]M.A. Waheed and [4]M.F. Adekunle

[1]Department of Research and Development, Hydraulic Equipment Development Institute, Kano, Nigeria
[2, 3]Department of Mechanical Engineering, Federal University of Agriculture, Abeokuta, Nigeria
[4]Department of Forestry, Federal University of Agriculture, Abeokuta, Nigeria

Received: March 30, 2014; **Accepted** in Revised Form: June 11, 2014

Abstract: This study has revealed that groundnut shell can be compacted to a stabled state with binding material. The densification of the groundnut shells aid in transporting and storing, making it more economically than is possible at unprocessed state. The effects of binder (cassava starch gel) show that the highest lateral and axial expansion was 1.91 and 6% respectively. Maximum density, relax density, relaxation ratio ranges between 411 to 441 kg/m^3, 201 to 202 kg/m^3, 2.03 to 2.19, respectively. Other results are durability in the range of 69.89 to 93.52%, while the calorific value ranges between 19.82 to 21.97 MJ/kg. The overall, briquettes performances showed that 20% binder have the most outstanding resultin terms of durability. It was found that the amount of binder used have significant influence on the properties of the briquettes.

Key words: Briquettes · Groundnut shell · Binder · Cassava starch gel · Durability · Density

INTRODUCTION

Biomass is defined as the biological degradable fraction of products, waste and residues from agriculture (including animal and vegetable materials), forestry and the biological degradable fraction of industrial and household waste [1]. The usage of biomass for the production of energy is one of the various means of reacting to the problems associated to energy crisis. The use of biomass as a source of energy is a matter of growing importance and discuss as agreed by Ana [2], Fernando [3] and Kaygusuz [4].

Several kinds of promising fuel-biomass such as swine manure[5], coconut oil [6], cashew shell waste [7], soft wood waste [8], algae [9], maize cob [10], coconut shell and waste paper admixture [11] were investigated. Tonnes of groundnut shellare produced annually in developing countries. The disposal of these shellsin the fields hasbeen by burning, sometimes disposed indiscriminately most especially in the rural areas of developing countries, thereby causing health hazard. Because of the highheating value of groundnut shell demonstrated when compressed to arelatively high density with binder. Experiments have shown that groundnut shell can becompressed and stabilized to a high density.

Biomass briquetting is the process of increasing the density of biomass into higher density, energy concentrated, storable and transportable solid fuel called briquette. Process of translating biomass into solid fuel involves drying, cutting, grinding and pressing with or without the aid of a binder. Therefore, attemptshave been made towards improved, efficient and sustainable utilization of biomass. Densification of agricultural residues in the form of briquettes is therefore a promising technique for this purpose. Densification improves heating value, handling and transportation characteristics of agricultural residues by increasingits density. The aim of this workis to study the effects of binding ratios on some densification characteristics of groundnut shell briquettes.

MATERIALS AND METHODS

Groundnut shells were collected from the processing sites at Dawanu, Kano, Nigeria. The shells were hammer milled and sieved. Particles that passed

Corresponding Author: O.A. Oyelaran, Department of Research and Development, Hydraulic Equipment Development Institute, Kano, Nigeria. Tel: +2348028253912, E-mail: ajanioyelaran@gmail.com

Please cite this article as: Oyelaran, O.A. , B.O., Bolaji, M.A. Waheed and M.F. Adekunle, 2014. Effects of Binding Ratios on Some Densification Characteristics of Groundnut Shell Briquettes. Iranica Journal of Energy and Environment, 5(2):167-172.

through the 850μm sieves and were retained on the 600μm sieves were used. The groundnut shell was sundried for three days before stocking. Cassava starch was used as the binder in this study. The reason for choosingcassava starch in this research is because of relative availability, ease of preparation and cost of binder.

The groundnut shell and binder were thoroughly mixed in order to obtain a uniformly blended mixture. Mixtures were prepared with four different percentages (5, 10, 15 and 20) of binder with fixed weight of groundnut shell. In each case, fixed quantities of the samples were hand-fed into the design and produced press and compacted. The dwell time of 5 minutes as in Olorunnisola [11] was used. The machine is a motorized briquetting machine, According to the design of the moulds, twelve (12) briquettes were produced per batch.

Briquette stability was measured in terms of its dimensional changes when exposed to the atmosphere [12]. The stability of briquettes produced from the groundnut shell with varying binding ratio examined in this study was determined in terms of dimensional expansion in the axial and lateral directions. Immediately after extrusion from the mould, the briquette length, breath and height were measured using vernier caliper. Briquette mass was also determined with a digital scale. Therefore, the (initial) density of each and every newly formed briquette was evaluated for the defined combination of material. Additionally, the dimensions of each briquette formed were measured after 5, 10, 30, 60, 1440 minutes, 7[12] and 19 day period to determine the diametral and longitudinal expansion, along with the relaxed density of briquette.

The compressed density also called maximum density (density immediately after compression) of the briquette was determined immediately after ejection from the moulds as the ratio of measured weight to the calculated volume. The relaxed density (density determined when dried) and relaxation ratio (ratio of compressed density to relaxed density) of the briquette were determined in dry condition of the briquette after about 19 days of sun drying to a constant weight. The relaxed density was calculated as the ratio of the briquette weight (g) to the new volume (cm^3). This gave an indication of the relative stability of the briquette after compression.

Durability signifies the measure of shear and impact forces a briquette could withstand during handling, storage and transportation processes [13]. The durability test was carried out according to Al-Widyan *et al*.[14] method, where the briquettes were drop from a height of 1.85 m on a flat steel plate four times. The durability (%) was calculated as the ratio of the final weight of the briquette retained after four drops to the initial weight of the briquette. The fraction of the briquette that remained unshattered was used as an index of briquette durability. The durability rating of the briquette was expressed as a percentage of the initial mass of the material remaining on the metal plate and this gave an indication of the ability of the briquette to withstand mechanical handling [15].

Leco AC-350 Oxygen Bomb Calorimeter interfaced with a microcomputer was used to assess the heat values of the produced briquettes. Two grams of the briquettes was measured and the screw mould bracket was used to re-mould the briquette to the appropriate calorimeter bucket size. Ten (10) ml distilled water was poured into the bomb and the industrial oxygen cylinder was connected to the bomb and the valves were opened and bomb was filled slowly at pressure range of 2.5-3.0 Mpa for a minute. The bomb was placed inside a canister bracket containing distilled water and the bomb lid was covered. The switch was turned on and the microcomputer was set for the determinations which automatically calibrate and measure the energy values and display the values on the screen for recording after feeding the necessary data on the briquettes. The data and result of the experiment are displayed on computer screen [16]. The result of the test is shown on Table 3.

RESULTS AND DISCUSSION

Figure 1 shows dimensional change of briquettes in the axial and lateral directions. The results of the stability test reflect the trend observed in compressed and relaxed density of the briquettes. The observed linear expansions were relativelysmaller compared to the axial expansion. When the stability tendency was viewed along the blending ratios, briquettes sample A produced with 5% binder in both axial and lateral directions were observed to mexhibit the best stability. Thus, sample 5% blend produced the most stabilising effect, followed by briquettes with 10% binder blend. This validates that stability of the briquette is a function of the binder levels and compressed density [17].

The stability of the briquettes, which is expressed in terms of percentage axial and lateral expansions, is presented in Figure 1. From the figure, it was observed that briquettes expanded largely in the axial direction than in the lateral direction. The change in briquette dimensions in the axial direction was up to 6% compared to maximum of 1.91 % in the lateral direction.

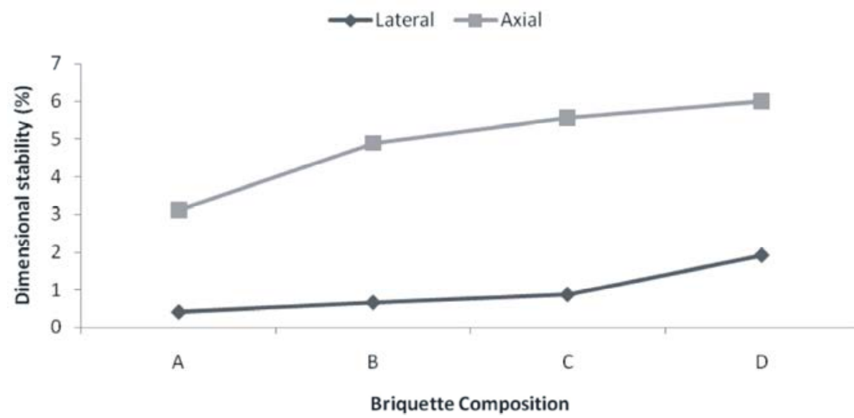

Fig. 1: Comparative result of dimensional stability of briquettes

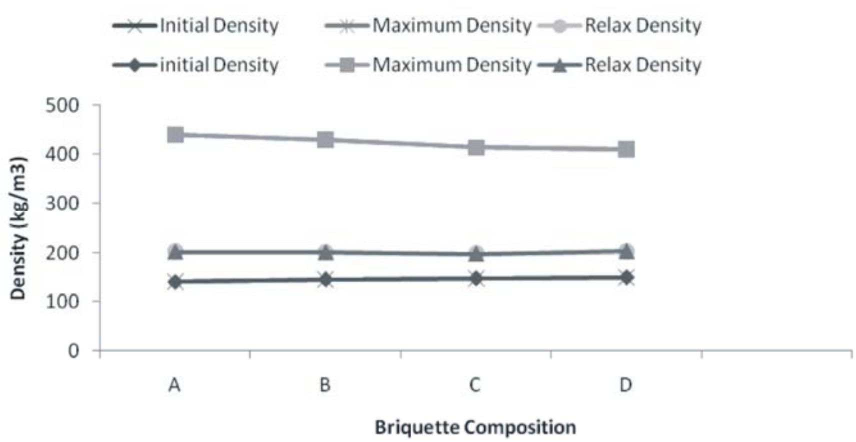

Fig. 2: Comparative result of densities of briquettes

Table 1: Result of compaction ratios of briquetteswith binder

Sample	Maximum density (kg/m^3)	Initial density (kg/m^3)	Compaction Ratio
A	441.08	142	3.11
B	430.75	147	2.93
C	414.56	149	2.78
D	411.01	151	2.72

Table 2: Result of durability testof briquettes

Sample	Weight before test (kg) m_b	Weight after test (kg) m_a	Durability (%)
A	0.146	0.102	69.89
B	0.142	0.126	88.90
C	0.141	0.129	91.55
D	0.144	0.135	93.52

Table 3: Result of bomb calorimeter test result of fuel samplesof briquettes

Samples	Calorific Value (kJ/kg)
A	19,820.43
B	20,545.35
C	21,456.13
D	21,968.32

A similar expansion result was also reported byresearcher [14] during briquetting of olive cake. Oladeji [18] in his work investigationed the effects of different binding ratios on some densification characteristics of corncob briquettes reported a similar trend change in briquette dimensions in the axial direction of up to 4.15%

compared to maximum of 1.76 % in the lateral direction. The axial expansion of briquettes increased as the percentage binder ratio increased. The lowest percentage binder ratio by weight A (5%) has the least axial and lateral expansions of 3.11 and 0.42, respectively. The implication of this is that, the lower the percentage binder ratio, the more stable are the briquettes produced.

Densities of Briquettes: Figure 2 shows the initial, maximum and relaxed densities of briquettes produced from groundnut shell under four different percentage binder ratios. The mean initial densities of the briquette with the percentage binder ratio A, B, C and D were 142, 147, 149 and 151 kg/m^3 respectively. The maximum densities for percentage binder ratio by weight A, B, C and Dwere 441.08, 430.75, 414.56 and 411.01 kg/m^3 respectively (see Figure 2). The values of the maximum densities are higher than the initial density of the uncompressed briquettes. It was observed that the higher the percentage of binder ratio by weight, the lower the maximum density *i.e.* that the maximum density decreased with increasing percentage binder ratio by weight. The same thing could be true for relaxed density for A, B, C and D were 201.41, 200.35, 197.41 and 202.45 kg/m^3 respectively. The values of maximum densities obtained with percentages of binders were less than the minimum value of 600 kg/m^3 recommended by Mani et al. [19] and Gilbert et al. [20] for efficient transportation and safe storage. The implication of this is that using percentage binder ratio up to 20 % may result in briquettes of good quality in term of density.

Table 1 shows the compaction, density and relaxation ratios obtained from the groundnut shell briquettes under four different percentage binder ratios. The values for compaction ratios of A, B, C and Dare 3.11, 2.93, 2.78 and 2.72, respectively. For the four weight percentages of binder examined in this study with percentage binder ratio A (5%) having the highestvalue. Higher compaction ratio implied more void in the compressed materials. Higher figure indicates more volume displacement, which is good for packaging, storage and transportation and above all, it is an indication of good quality briquettes [21]. From Table 1, it was observed that the compaction ratio decreased with increasing percentage binder ratio by weight and in this regards, the lowest percentage binder ratio exhibited the best result of 4.03. Furthermore, the values of compaction ratio obtained in this study compare and compete favourably well with notable biomass residues. For example, compaction ratio of between 3.20 and 9.70 was obtained by Boluwafi [22] during briquetting of guinea corn residue. In the similar manner, compaction ratios of 4.2 and 3.5 were obtained during briquetting of groundnut and melon shells, respectively [23]. While Oladeji, [24] obtained a compaction ratio of 3.80 during briquetting of rice husk.

The mean values of density ratio with percentage binder ratio by weight A, B, C and D are 0.46, 0.47, 0.48 and 0.49, respectively. The higher the value of the density ratio for a given mass, the less relaxed the briquettes are. There is practically little differences in the value of density ratio obtained for the four percentage binder ratios examined in this study.

The mean relaxation ratios of briquettes produced were found to be 2.19, 2.15, 2.10 and 2.03, for percentage binder ratio by weight A, B, C and D respectively (Table 1). Lower value of percentage binder ratio indicates a more stable briquette, while higher value indicates high tendency towards relaxation *i.e*. less stable briquette. The values of relaxation ratio obtained in this study indicate that briquettes produced with binder ratio are more stable than briquettes produced with the three other percentages binder ratios. A reciprocal relationship was observed between density ratio and relaxation ratio of the briquettes

Durability Resistance of Briquettes: The decisive factor regarding durability of briquettes reflect on the severity of handling, transportation and storage and weather conditions of the locations where the products are transportedor exported [25]. Therefore, the measurement of durability is critical indescribing briquette quality, in view of the fact that it predicts briquette performance in transportation, storage and handling. However, Karunanithy e*t al*. [26] and Dobie [27] suggested that fines up to 5% (by weight) would be an acceptable level and greater than 5% would reduce storage capacity and create problems in flow characteristics. It has been reported thatAdapa *et al*, [28]; Tabil and Sokhansanj, [29] classified the durability into high (> 0.8), medium (0.7-0.8) and low (< 0.7) depending upon the values. Table 2 shows that durability of the briquettes varied between 69.89 and 93.52 % while the losses vary between 6.48 and 30.11%. From the obtainedvalue it can be concluded that an addition of 10 to 20% of binder will give a good briquette in terms of durability.

The shattering resistance depends upon amount of concentration of binders. It increased with increase in amount of binder. The differences in durability between briquettes might be due to chemical composition including lignin, extractive, cellulose and hemicelluloses[26]. For briquettes formed with 5% binder, the shattering resistance was the minimum of 69.89%. The maximum was recorded by the briquettes with the highest percentage of binderat 20% binder as 93.52 %.These are relatively high values, even higher than the range of reported values of 46.5 and 88.4% by Wamukonya and Jenkins [30] for sawdust and wheat straw briquettes. The observed increased in briquette durability with increase in starch content could also be attributed to the adhesive role the starch played in the briquettes[11].

Calorific Values: From Table 3, Calorific values increases with increase in concentration of binders. Based on the figure below, it is found that most of the briquettes fulfil the minimum requirement of calorific value for making commercial briquette (>17500 J/g), as stated by DIN 51731 [31]. From the result, it is found that briquette D having the highest binder ratio by weight (20%) has the highest gross calorific value of21,518kJ/kg; while briquette A that with the lowest value of binder (5%) has the lowest value of 18,220 kJ/kg. This proved that the gross calorific value is most influenced by the composition of briquette.

CONCLUSIONS

Cassava starch gelas binder in groundnut shell briquettes has enhanced the heating value, durability rating and densities of the briquettes as evident in this research work. The effect of binder (cassava starch gel) shows that the highest lateral and axial expansionswere 1.91 and 6%, respectively. Maximum density, relax density, relaxation ratio were in the range of 411 to 441 kg/m^3, 201 to 202 kg/m^3, 2.03 to 2.19, respectively. Other results are durability of between 69.89 to 93.52%, while the calorific value ranged between 19,820 to 21,968 kJ/kg. The overall performances showed 20% binder have the most outstanding result. It was found that the amount of binder used have significant influence on the properties of the briquettes. So the groundnut shell briquettes provide better alternatives to fossil fuel for firing heating and melting devices in the areas where groundnut is grown. The increasingly use of these wastes in composite briquette form, will help in solving disposal problem; apart from providing good alternatives to fossil fuel.

REFERENCES

1. Patel, B. and B. Gami, 2012. Biomass Characterization and its Use as Solid Fuel for Combustion. Iranica Journal of Energy and Environment, 3: 123-128.
2. Gómez-Loscos, A., M.D. Gadea and A. Montañés, 2012. Economic growth, inflation and oil shocks: are the 1970s coming back? Applied Economics, 44(35): 4575-4589.
3. Galembeck, F., 2010. Synergy in food, fuels and materials production from biomass. Energy and Environmental Science, 3(4): 393-399.
4. Kaygusuz, K. and S. Keleş, 2008. Use of biomass as a transitional strategy to a sustainable and clean energy system. Energy Sources, Part A: Recovery, Utilization and Environmental Effects, 31(1): 86-97.
5. Xiu, S., A. Shahbazi, L. Wang and C.W. Wallace, 2010. Supercritical ethanol liquefaction of swine manure for bio-oils production. American Journal of Engineering and Applied Sciences, 3(2): 494.
6. Singh, P., J. Khurma and A. Singh, 2010. Coconut oil based hybrid fuels as alternative fuel for diesel engines. American Journal of Environmental Sciences, 6(1): 71.
7. Mohod, A., S. Jain and A. Powar, 2010. Energy option for small scale cashew nut processing in India. Energy Research Journal, 1(1): 47.
8. Khalil, A.M., A.F. Al-Shawabkeh, A.S. Mazahreh, M.S. Al-Damanhoory and J.M. Quasem, 2009. Utilization of soft wood wastes as a feed stock to produce fuel ethanol. American Journal of Engineering and Applied Sciences, 2(2): 451.
9. Sharif Hossain, A., A. Salleh, A.N. Boyce, P. Chowdhury and M. Naqiuddin, 2008. Biodiesel fuel production from algae as renewable energy. American Journal of Biochemistry and Biotechnology, 4(3): 250-254.
10. Wilaipon, P., 2007. Physical Characteristics of Maize Cob. Briquette under Moderate Die Pressure. American Journal of Applied Sciences, 4(12): 995-998.
11. Olorunnisola, A., 2007. Production of fuel briquettes from waste paper and coconut husk admixtures. Agricultural Engineering International: CIGR E. Journal., IX: 1-11.
12. Sotannde, O., A. Oluyege and G. Abah, 2010. Physical and combustion properties of briquettes from sawdust of Azadirachta indica. Journal of Forestry Research, 21(1): 63-67.

13. Adapa, P., L. Tabil and G. Schoenau, 2009. Compaction characteristics of barley, canola, oat and wheat straw. Biosystems engineering, 104(3): 335-344.
14. Al-Widyan, M., H. Al-Jalil, M. Abu-Zreig and N. Abu-Hamdeh, 2002. Physical durability and stability of olive cake briquettes. Canadian Biosystems Engineering, 44: 341-346.
15. Sah, P., B. Singh and U. Agrawal, 1980. Compaction Behavior of Straw. Journal of Agricultural Engineering-India, 18(1): 89-96.
16. Obi, O.F., C.O. Akubuo and W.I. Okonkwo, 2013. Development of an Appropriate Briquetting Machine for Use in Rural Communities. International Journal of Engineering and Advanced Technology, 2(4): 578-582.
17. Chaiklangmuang, S., S. Supa and P. Kaewpet, 2008. Development of fuel briquettes from biomass-lignite blends. Chiang Mai J. Sci., 35(1): 43-50.
18. Oladeji, J., 2011. The Effects of some processing parameters on physical and combustion characteristics of corncob briquettes. An Unpublished Ph. D Thesis of the Department of Mechanical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
19. Mani, S., S. Sokhansanj, X. Bi and L.G. Tabil, 2004. Compaction of corn stover. ASAE/CSAE Meeting, Paper No.041160, St. Joseph, MI.
20. Gilbert, P., C. Ryu, V. Sharifi and J. Swithenbank, 2009. Effect of process parameters on pelletisation of herbaceous crops. Fuel, 88(8): 1491-1497.
21. Davies, R.M. and U.S. Mohammed, 2013. Effect of Processing Variables on Compaction and Relaxation Ratio of Water Hyacinth Briquettes. International Journal of Scientific Research in Knowledge, 1(9): 308-316.
22. Bolufawi S.J., 2008. Briquetting Characteristics in Relation to Fuel Values of Guinea Corn (Sorghum bicolor) Residue, An Unpublished Ph.D Thesis of the Department of Agricultural and Environmental Engineering, University of Ibadan, Nigeria.
23. Oladeji, J., 2010. Fuel characterization of briquettes produced from corncob and rice husk resides. Pacific Journal of Science and Technology, 11(1): 101-106.
24. Oladeji, J., 2012. Comparative Study of Briquetting of Few Selected Agro-Residues Commonly Found in Nigeria. Pacific Journal of Science and Technology, 13(2): 80-86.
25. Khoush Taghaza, M., S. Sokhansanj and B. Gossen, 1999. Quality of alfalfa cubes during shipping and storage. Applied Engineering in Agriculture, 15(6): 671-676.
26. Karunanithy, C., Y. Wang, K. Muthukumarappan and S. Pugalenghi, 2011. Physiochemical characterization of briquettes made from different feedstock. Biotechnology Research International, ID 165202, pp: 1-9.
27. Dobie, J.B., 1961. Materials-handling systems for hay wafers. Agricultural Engineering, 42(12): 692-697.
28. Adapa, P., G. Schoenau, L. Tabil, S. Sokhansanj and B. Crerar. Pelleting of fractionated alfalfa products. in 2003 ASAE Annual International Meeting, Las Vegas, Nevada.
29. Tabil Jr, L. and S. Sokhansanj, 1996. Process conditions affecting the physical quality of alfalfa pellets. Applied Engineering in Agriculture, 12(3): 345-350.
30. Wamukonya, L. and B. Jenkins, 1995. Durability and relaxation of sawdust and wheat-straw briquettes as possible fuels for Kenya. Biomass and Bioenergy, 8(3): 175-179.
31. Yuhazri, M., H. Sihombing, N. Umar, L. Saijod and P. Phongsakorn, 2012. Solid Fuel from Empty Fruit Bunch Fiber and Waste Papers Part 1: Heat Released from Combustion Test. Global Engineers and Technologists Review, 2(1): 7-13.

Persian Abstract

DOI: 10.5829/idosi.ijee.2014.05.02.08

چکیده

مطالعات نشان داده است پوست بادام زمینی می تواند با استفاده از مواد چسبنده، به حالت پایدار و ثابتی فشرده شود. فشرده سازی پوست های بادام زمینی به حمل و نقل و ذخیره سازی کمک می کند که تولید آن از لحاظ اقتصادی نسبت به حالت فشرده نشده، مقرون به صرفه تر است. بررسی اثر چسب نشاسته کاساوا نشان داده است که بیشترین انبساط عرضی و محوری به ترتیب ۱/۹۱ و ۶ درصد می‌باشد. محدوده حداکثر دانسیته، چگالی آزاد و نسبت انعطاف پذیری به ترتیب بین ۴۱۱ تا ۴۴۱ کیلو گرم بر متر مکعب، ۲۰۱ تا ۲۰۲ کیلو گرم بر متر مکعب و ۲/۰۳ تا ۲/۱۹ می‌باشد. محدوده پایداری آن ۶۹/۸۹ تا ۹۳/۵۲ درصد، در حالی که ارزش گرمایی آن بین ۱۹/۸۲ تا ۲۱/۹۷ مگاژول بر کیلوگرم بوده است. در حالت کلی راندمان بریکت (قالب فشرده) نشان داده است که استفاده از ۲۰ درصد چسب، نتایج مطلوبی در دوام و پایداری محصول دارد. در نهایت مقدار چسب استفاده شده اثر قابل توجهی بر روی خواص بریکت دارد.