KEMENTERIAN PENDIDIKAN, KEBUDAYAAN, RISET DAN TEKNOLOGI
UNIVERSITAS PEMBANGUNAN NASIONAL "VETERAN" JAWA TIMUR
UPT TEKNOLOGI INFORMASI DAN KOMUNIKASI
Jl. Raya Rungkut Madya Gunung Anyar Surabaya Telp.(031) 8793589
Laman: http://upttik.upnjatim.ac.id, Email: upttik@upnjatim.ac.id

SURAT KETERANGAN
HASIL PEMERIKSAAN TINGKAT PLAGIARISME
Nomor : 303/UN63/UPTTIK/VIII/2022

Yang bertanda-tangan di bawah ini,

Nama : Mohamad Irwan Afandi,ST,

NI P3K : 197607182021211003

Jabatan : Kepala UPT TIK – UPN "Veteran" Jawa Timur

dengan ini menerangkan bahwa Penulis telah melakukan pemeriksaan tingkat kesamaan (plagiarisme) menggunakan *software* **Turnitin** secara mandiri terhadap dokumen dalam daftar di bawah ini:

Judul Karya Tulis	: Analysis of bio-briquette preparation from teak tree (Tectona grandis Linn. f)
Jenis Publikasi	: Jurnal
Penulis	: Renova Panjaitan, S.T., M.T.
Tingkat Kesamaan (%)	: 12%

Demikian Surat Keterangan ini dibuat dengan sebenarnya, agar dapat digunakan sebagaimana mestinya.

Surabaya, 12 Agustus 2022
Kepala UPT TIK

Mohamad Irwan Afandi, ST, MSc.
NI P3K 197607182021211003

2. Analysis of bio-briquette preparation from teak tree (Tectona grandis Linn. f)

by Renova Panjaitan

Submission date: 21-Jul-2022 09:15AM (UTC+0700)
Submission ID: 1873220602
File name: riquette_preparation_from_teak_tree_Tectona_grandis_Linn._f.pdf (509.38K)
Word count: 3237
Character count: 17083

International Journal of Eco-Innovation in Science and Engineering Vol 3 (1), 2022 (31-33)
https://ijeise.upnjatim.ac.id/ E-ISSN: 2721-8775

Article

Analysis of bio-briquette preparation from teak tree (*Tectona grandis* Linn. f)

Renova Panjaitan[1,a], Ian Yusuf Syaputra[1], Cintaka Natanaelli[1], Lucky Indrati Utami[1], Retno Dewati[1], Kindriari Nurma Wahyusi[1,b*]

[1]Chemical Engineering Department, Engineering Faculty, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya, 60294, Indonesia
E-mail : [a]renova.p.tk@upnjatim.ac.id, [b]kindrinurma@gmail.com
*Corresponding author: kindrinurma@gmail.com | Phone number: -

Received: 4th April 2022; Revised: 27th April 2022; Accepted: 29th April 2022;
Available online: 19th May 2022; Published regularly: May and November

Abstract

The government has taken energy deflation seriously and is trying to find solutions by implementing energy efficiency and utilizing renewable energy sources. That action also supports the procedure to save the world from the ongoing climate crisis. One of Indonesia's potential renewable energy sources is biomass, which can be in the form of plantation waste such as teak branches. Based on the analysis results, charcoal made from teak branches had a carbon content about 62.5968%, so it was pretty potential to be used as raw material for bio-briquettes. In this research, bio-briquette from teak branches' charcoal using tapioca binder has been successfully carried out. The manufacture of bio-briquettes was studied by observing the effect of the size parameters of teak charcoal and binder ratio on the heating value and water content of briquettes. The analysis results showed that these two parameters significantly affected the quality of teak branches' bio-briquette. In the ranking, the particle size was much more significant in influencing the calorific value of bio-briquettes, while the binder ratio had more influence on the water content value. The obtained bio-briquettes' calorific value and water content have met the established standards.

Keywords: ANOVA, biomass energy, carbonization, calorific value, solid fuel

1. Introduction

Based on the estimated data, the researchers uttered that the reduction rate of global fossil energy reserves reaches four billion tons per year [1]. The world's fossil energy reserves would be exhausted within the next forty years at such a rate. Therefore, the world has made various efforts to reduce dependence on fossil energy by promoting energy efficiency and utilizing renewable energy. This step is also in line with global efforts to deal with the current climate crisis. As stated in the Paris Agreement, the nations agreed to restrict the increase in the global average temperature to a value of 1.5°C from pre-industrial temperatures [2]. As one of the countries that engaged ratify the agreement, Indonesia committed to reducing greenhouse gas (GHG) emissions by 29% under the Business as Usual (BaU) scenario by 2030 [3], [4]. In achieving this target, the government makes a serious effort to increase energy sources other than fossils, namely geothermal, solar, wind, hydropower, marine energy, and bioenergy like biogas, waste, biofuel, and biomass [5].

The potential of Indonesia's biomass can reach 49.81 gigawatts, but only about 445 megawatts have been installed [6]. Biomass energy raw materials can be in the form of agricultural waste. One agricultural waste that has not been utilized is teak tree branches. The teak tree (*Tectona grandis* Linn. f) is a plant that can grow well in tropical and sub-tropical areas with rainfall of around 1300-3800 mm/year [7]. This plant is spread in almost all regions in Indonesia, with thousands of hectares in one district [8]. Teak plants can absorb CO_2, so they have a high enough potential to store carbon. Based on research conducted by Lukito and Rohmatiah [9], a one-hectare teak plant can absorb 50.113 tons of CO_2, which is equivalent to 13.66 tons/ha of carbon. That study also added that teak plants could produce biomass reaching 27.30 tons/ha, of which the branches alone contributed 6.7% to this number. The wood from the teak plant is in great demand as a material for making furniture because of its durable and robust nature [7]. As for teak branches, the local community usually collects a small portion for direct use as firewood, while the rest becomes rotten and is not used. Meanwhile, it has the potential to be used as raw materials for making bio-briquettes.

Biobriquette is a dense fuel coming from biomass [10], [11]. Biomass that has been processed through the carbonization stage into bio-briquettes has proven to be more advantageous than biomass used directly as fuel. The advantages are more environmentally friendly, easy to transport and store, easy to handle [12], [13], and higher calorific value. Bio-briquette, as one of the renewable energy sources, is expected to support the household energy needs and collaboratively reduce the use of coal in the industrial sector, such as steam power plants. Some biomasses have been utilized as materials for making briquettes, such as coconut shell, durian skin [14], corncob, rice husk [12], tree leaves and bamboo [13] and palm kernel shells [15]. Thoha and Fajrin [16] have studied the manufacture of briquettes from teak leaves, but research on making briquettes from teak branches is still limited. Therefore, research about the manufacture of briquettes from teak branches is required.

In making briquettes, binder selection materials need to be considered. The binder material must have good adhesive properties, not reduce the thermal properties of the resulting briquettes, and be free of pollution [13]. Organic binders such as starch and molasses are preferred because of producing relatively little ash on briquette combustion [16].

Meanwhile, Aransiola et al. [17] observed the effect of binder type on briquettes from corncob. That study stated that cassava starch, corn starch, and gelatine could produce high-quality briquettes where the binder with cassava delivered products with better physical properties.

Therefore, in this research has carried out the manufacture of briquettes from teak branches using starch as a binder.

In this case, the quality of the briquettes would be observed based on the calorific value and water content due to the influence of particle size of carbonized biomass and the binder ratio in briquettes composition. In the previous study [18], it was said that these two parameters influenced the quality of the briquettes produced. The data obtained will be analyzed statistically using ANOVA.

2. Materials and Methods

2.1. Materials preparation

The teak branches were obtained from two-year-old teak plants collected from Dawarblandong District. The components were cut into a size range of 3-5 cm (Fig. 1). The binder was tapioca flour dissolved with boiling distilled water at a ratio of 1:2 (gr/ml).

Fig. 1. Teak branches before the carbonization process

2.2. Processing the biobriquettes

The first step in the manufacture of bio-briquette was the carbonization stage. At this stage, the teak tree branches were carbonized at a temperature of 300°C for 3 hours to produce charcoal. Before further processing, an approximate analysis was carried out on the carbonized teak branches. The analysis results (Table 1) showed that charcoal was feasible as raw material with a relatively high carbon content of 62.5968%.

Table 1. The approximate analysis of carbonized teak tree branches

Carbon (%)	Water content (%)	Ash content (%)	Volatile matter (%)
62.5968	2.3532	13.7506	21.2994

Furthermore, the charcoal (Fig. 2) was ground and sieved using five variations of sieve sizes, namely 30, 40, 50, 60, and 70 mesh. The next stage was mixing with the binder. Charcoal powder was mixed with tapioca paste under the variable values of 0.2; 0.4; 0.6; 0.8, and 1 (gr/gr) on the ratio of binder to biomass, where the mass of charcoal powder used was constant at 50 gr. The mixture was stirred until mixed well. After that, the following process was molding. The mixed dough was put into a cylinder molding with a diameter of 3.1 cm and a height of 3.4 cm, then compacted using a manual press. The last stage was drying. The solidified bio-briquettes were removed from the mold and aired at room temperature for 24 hours. After that, a further drying process was carried out using an oven at a temperature of 105°C for 5 hours. Thus the bio-briquettes of teak branches were obtained in Fig. 3.

Fig. 2. Carbonized teak branches

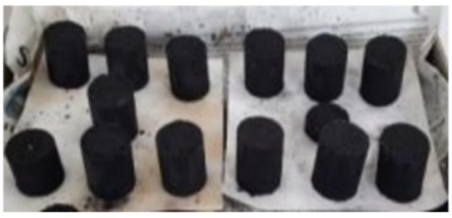

Fig. 3. Teak branches biobriquette

2.3. Analysis

Research data collection was carried out with a complete randomized design so that the number of samples was 25 samples. The quality of bio-briquettes was then analyzed by measuring the water content and calorific value of each samples product. The moisture content test was performed using the oven-dry method following the ASTM D-3173 standard [19], and the calorific value test using a bomb calorimeter by a standardized laboratory, Lab. Chem-Mix Primary. The data then were analyzed statistically using a two-way ANOVA using Minitab software.

3. Results and Discussion

The manufacture of bio-briquettes from teak branches with tapioca flour adhesive has been successfully performed. Data analysis of calorific value and moisture content samples were presented in interaction plots as shown in Fig. 4 and Fig. 5, respectively. In those figures, it can be seen that the graphs formed were linear lines. These represented no interaction between the particle size factor and the binder ratio to the two response variables, calorific value, and water content of the bio-briquettes in the specified parameters value range. The graph also showed that the increase in the ratio of binder to teak charcoal from 0.2 to 1 (gr/gr) was directly proportional to the increase in calorific value and moisture content of the bio-briquette samples. Meanwhile, the change in the charcoal particle size from 30 mesh to 70 mesh increased the calorific value of products but caused a decrease in the moisture content.

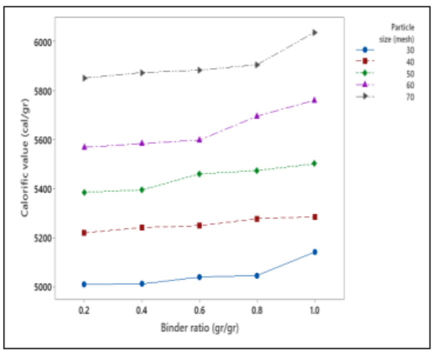

Fig. 4. Interaction plot for calorific value

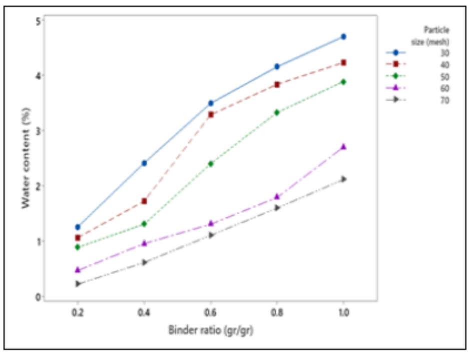

Fig. 5. Interaction plot for water content

The phenomenon was also described clearly on the main effect graphs, as shown in Fig. 6 and Fig. 7. The change in particle size and binder ratio resulted in an ascending line on the calorific value graph, while on the water content graph, the change in particle size formed a downward graph, and binder ratios formed an ascending graph. The larger the mesh size, the smaller the particle size. So it can be said that the smaller the particle size, the higher the calorific value of bio-briquettes but the lower the water content. Meanwhile, the greater the binder ratio, the greater the calorific value and moisture content of bio-briquettes. The phenomenon due to changes in particle size that occurred in this study was also reported by Ristianingsih et al. [18]. They stated that biomass in small size was preferred to manufacture bio-briquette because it could produce products with a higher heating value due to a more extensive heat transfer cross-sectional area. Meanwhile, the phenomenon caused by the change in binder ratio in this study has similarities and differences with the observations made by Bazenet et al. [20] in making briquettes from rubberwood. That study stated that the addition of binder tapioca would reduce the heating value of the briquettes because it increased the moisture content of the sample. However, in this study, the more adhesives used in the briquette composition, the water content value increased, but the calorific value also increased. The phenomenon was slightly different from the theory that the higher the water content, the lower the calorific value. However, the graph in Fig. 6 more clearly displayed that particle size was more significant in influencing the calorific value than the binder ratio. It was shown from the vertical line of the graph formed by the change in the particle size to the calorific value, while the binder ratio tended to establish a sloping graph. In contrast, Fig. 7 showed that both particle size and binder ratio almost had the same effect on the moisture content value.

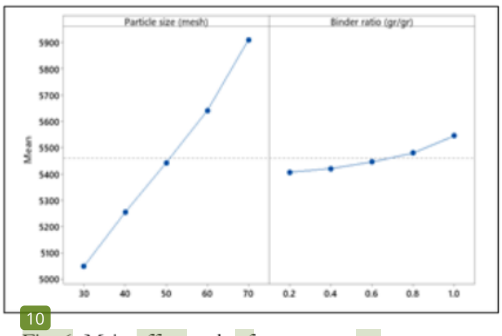

Fig. 6. Main effect polt of parameter on calorific value

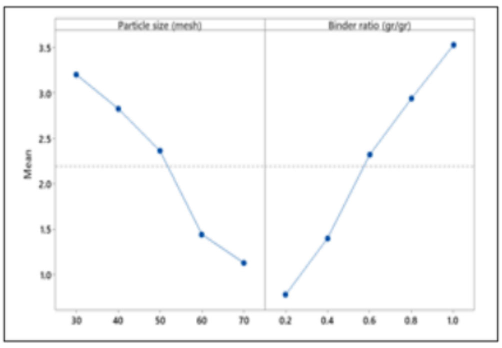

Fig. 7. Main effect polt of parameter on water content

Statistically, when analyzed further, the analysis of variance (ANOVA) results (Table 2 & Table 3) showed that the particle size factor and binder ratio had a p-value smaller than 0.05 for the response to heating value and moisture content. It meant these two parameters significantly affect the calorific value and water content. However, based on the higher value, the F-value of parameter particle size in the calorific value response was much higher (F-value = 669.3) than the F-value of the binder ratio (F-value = 18.4). In contrast, in the moisture content response, the F-value of binder ratio was slightly larger (F-value = 49.27) than the F-value of the particle size (F-value = 31.06). The data clarified that the particle size parameter had a much more significant effect on the calorific value than the binder ratio. Conversely, for the response value of the moisture content, the binder ratio parameter had a more substantial influence on the particle size.

Table 2. Analysis of variance for calorific value

Source	DF	Adj SS	Adj MS	F-value	p-value
Particle size	4	2229324	557331	669.3	0.000
Binder ratio	4	61185	15296	18.4	0.000
Error	16	13324	833		
Total	24	2303833			

Table 3. Analysis of variance for water content

Source	DF	Adj SS	Adj MS	F-value	p-value
Particle size	4	15.694	3.9235	31.06	0.000
Binder ratio	4	24.895	6.2238	49.27	0.000
Error	16	2.021	0.1263		
Total	24	42.610			

Therefore, from the results of this study, it is suggested that for the manufacture of bio-briquettes from teak branches with tapioca as the binder, even though an increase in the binder ratio increased the calorific value, the use of a smaller amount of binder and a smaller particle size (larger mesh) was more recommended. Further suggested that the next researcher can conduct research reviewing this statement from the economic analysis aspect.

Moreover, the bio-briquette produced in all variations of the parameters in this research had a calorific value of 5010.479 cal/gr – 6037.611 cal/gr and a moisture content of 0.2207% - 4.7001%. This value has met the applicable quality standards of briquettes (SNI 1/6235/2000), with a minimum calorific value of 5000 cal/gr and a maximum moisture content of 8% .

4. Conclusions

Bio-briquettes from teak branches could be prepared using tapioca as the binder. Observing the effect of particle size parameters and binder ratio for the range of values used, 30 – 70 mesh and 0.2 – 1 (gr/gr) obtained that the calorific value would increase along with the increase in particle mesh size (smaller particle size) and binder ratio, while the water content was getting smaller with smaller particle size, and getting bigger with higher binder ratio. The ANOVA results showed that these two factors significantly affected the resulting bio-briquette samples' heating value and moisture content. Furthermore, the statistical analysis results of this study suggested using biomass in small size and a small amount of adhesive in the manufacture of bio-briquettes. However, this study proposed to confim this statement based on economic point of view for future research. The bio-briquette calorific value and moisture content had met SNI 1/6235/2000.

References

[1] M. Saleem, "Possibility of utilizing agriculture biomass as a renewable and sustainable future energy source," *Heliyon*, vol. 8, pp. 1–11, 2022, doi: 10.1016/j.heliyon.2022.e08905.

[2] United Nations, *Paris agreement*. 2015.

[3] D. J. E. B. T. dan K. Energi, *Rencana Strategis 2020-2024*. Jakarta: Direktorat Jenderal Energi Baru, Terbarukan dan Konservasi Energi, 2020.

[4] A. E. Setyono and B. F. T. Kiono, "Dari Energi Fosil Menuju Energi Terbarukan: Potret Kondisi Minyak dan Gas Bumi Indonesia Tahun 2020 – 2050," *J. Energi Baru dan Terbarukan*, vol. 2, no. 3, pp. 154–162, Oct. 2021, doi: 10.14710/jebt.2021.11157.

[5] Suharyati, S. H. Pambudi, J. L. Wibowo, and N. I. Pratiwi, *Outlook Energi Indonesia 2019*. Jakarta: Dewan Energi Nasional, 2019.

[6] S. Yana, M. Nizar, Irhamni, and D. Mulyati, "Biomass waste as a renewable energy in developing bio-based economies in Indonesia: A review," *Renew. Sustain. Energy Rev.*, vol. 160, no. 5, p. 112268, 2022, doi: 10.1016/j.rser.2022.112268.

[7] Widiatmaka, A. Mediranto, and H. Widjaja, "Karakteristik Klasifikasi Tanah dan Pertumbuhan Tanaman Jati Var Unggul Nusantara di Ciampea Kabupaten Bogor," *J. Pengelolaan Sumberd. ALam dan Lingkung.*, vol. 5, no. 1, pp. 87–97, 2015.

[8] A. H. Supriatna and N. Wijayanto,

"Pertumbuhan Tanaman Pokok Jati (Tectona grandis Linn F .) pada Hutan Rakyat di Kecamatan Conggeang , Kabupaten Sumedang," *J. Silvikultur Trop.*, vol. 2, no. 3, pp. 130–135, 2011.

[9] M. Lukito and A. Rohmatiah, "Estimasi Biomassa dan Karbon Tanaman Jati Umur 5 Tahun (Kasus Kawasan Hutan Tanaman Jati Unggul Nusantara Desa Krowe, Kecamatan Lembeyan Kabupaten Magetan)," *Agritek*, vol. 14, pp. 1–23, 2013.

[10] Siswanto, K. Nurma Wahyusi, and R. Panjaitan, "Charcoal fuel from the mixture of coconut shell waste and coal: effect of carbonization temperature and the amount of coal mass in the mixture," *E3S Web Conf.*, vol. 328, p. 01019, 2021, doi: 10.1051/e3sconf/202132801019.

[11] H. Roliadi and G. Pari, "Energy Conversion from Woody Biomass Stuff: Possible Manufacture of Briquetted Charcoal from Sawmill-Generated Sawdust," *Indones. J. For. Res.*, vol. 3, no. 2, pp. 93–103, 2006.

[12] J. Nagarajan and L. Prakash, "Preparation and characterization of biomass briquettes using sugarcane bagasse, corncob and rice husk," *Mater. Today Proc.*, vol. 47, pp. 4194–4198, 2021, doi: 10.1016/j.matpr.2021.04.457.

[13] A. Narzary and A. K. Das, "Study of effects of addition of charcoal and binder derived from taro on physiochemical properties of briquettes made from tree leaves," *Sustain. Energy Technol. Assessments*, vol. 52, p. 102119, 2022, doi: 10.1016/j.seta.2022.102119.

[14] W. Nuriana, N. Anisa, and Martana, "Synthesis preliminary studies durian peel bio briquettes as an alternative fuels," *Energy Procedia*, vol. 47, pp. 295–302, 2014, doi: 10.1016/j.egypro.2014.01.228.

[15] B. Osei Bonsu, M. Takase, and J. Mantey, "Preparation of charcoal briquette from palm kernel shells: case study in Ghana," *Heliyon*, vol. 6, no. 10, p. e05266, 2020.

[16] M. Y. Thoha and D. E. Fajrin, "Pembuatan Briket Arang dari Daun Jati dengan Sagu Aren Sebagai Pengikat," *J. Tek. Kim.*, vol. 17, no. 1, pp. 34–43, 2010.

[17] E. F. Aransiola, T. F. Oyewusi, J. A. Osunbitan, and L. A. O. Ogunjimi, "Effect of binder type , binder concentration and compacting pressure on some physical properties of carbonized corncob briquette," *Energy Reports*, vol. 5, pp. 909–918, 2019, doi: 10.1016/j.egyr.2019.07.011.

[18] Y. Ristianingsih, P. Mardina, A. Poetra, and M. Y. Febrida, "PEMBUATAN BRIKET BIOARANG BERBAHAN BAKU SAMPAH ORGANIK DAUN KETAPANG SEBAGAI ENERGI ALTERNATIF," *J. Info Tek.*, vol. 14, no. 1, pp. 74–80, 2013.

[19] ASTM International, *Standard Test Method for Moisture in the Analysis Sample of Coal and Coke*. United States, 2003.

[20] R. A. Bazenet *et al.*, "Pengaruh Kadar Perekat Terhadap Karakteristik Briket Arang Limbah Kayu Karet (Hevea brasiliensis Muell. Arg)," *J. Tek. Pertan. Lampung*, vol. 10, no. 3, p. 283, 2021, doi: 10.23960/jtep-l.v10i3.283-295.

2. Analysis of bio-briquette preparation from teak tree (Tectona grandis Linn. f)

ORIGINALITY REPORT

12%	9%	8%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	ijeise.upnjatim.ac.id Internet Source	5%
2	www.coursehero.com Internet Source	1%
3	Q A M O Arifianti, A Rahmat, U Anggarini, E F Nugrahani, K K Ummatin. "Production of Briquettes to Utilize Woody Cutting Waste at Universitas Internasional Semen Indonesia (UISI)", Journal of Physics: Conference Series, 2021 Publication	1%
4	Maskun, Achmad, Naswar, H Assidiq, S N Bachril. "Conflict of norms in Indonesia’s sustainable development policy: Mineral and coal mining sector", IOP Conference Series: Earth and Environmental Science, 2021 Publication	1%
5	R P Dewi, M Kholik. "The effect of adhesive concentration variation on the characteristics	1%

of briquettes", Journal of Physics: Conference Series, 2020
Publication

6	www.e3s-conferences.org Internet Source	1 %
7	Musabbikhah, H Saptoadi, Subarmono, M A Wibisono. "Analysis and Selection of the Best Model of Biomass Briquette Based on Calorific Value", Journal of Physics: Conference Series, 2019 Publication	<1 %
8	www.warse.org Internet Source	<1 %
9	"Proceeding of the 2nd International Conference on Tropical Agriculture", Springer Science and Business Media LLC, 2018 Publication	<1 %
10	Proceeding of LPPM UPN “Veteran” Yogyakarta Conference Series 2020 – Engineering and Science Series, 2020 Publication	<1 %
11	Sarifah Nurjanah, M Mu’minah, M Saukat, M Muhaemin et al. "Characteristic of briquette from kemiri sunan (Reutealis trisperma) shell at several binder ratios", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %

12	Z Helwani, W Fatra, L Arifin, M R Othman, Syapsan. " Effect of process variables on the calorific value and compressive strength of the briquettes made from high moisture (EFB) ", IOP Conference Series: Materials Science and Engineering, 2018 Publication	<1%
13	B D Afrah, M I Riady, N Thereza, H Widhaningtyas, M Siregar. "Sustainability of Using Low-Rank Coal as Energy Source through The Upgrading Brown Coal (UBC) Process by Adding Waste Cooking Oil", IOP Conference Series: Earth and Environmental Science, 2019 Publication	<1%
14	Khyati Shukla, Khushboo, Pratibha Mahto, Vinod K. Singh. " Enantioselective synthesis of tetrahydrofuran spirooxindoles domino oxa-Michael/Michael addition reaction using a bifunctional squaramide catalyst ", Organic & Biomolecular Chemistry, 2022 Publication	<1%
15	Wahidin Nuriana, Nurfa Anisa, Martana. "Synthesis Preliminary Studies Durian Peel Bio Briquettes as an Alternative Fuels", Energy Procedia, 2014 Publication	<1%