e-Module in Producing Briquettes from Melinjo (*Gnetum gnemon*) Shell with Various Particle Sizes and Binder Concentrations for Vocational School Students

Asep Bayu Dani Nandiyanto*, Enjang Rohman, Mustika Nuramalia Handayani, Silmi Ridwan Putri

Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229 Bandung, Indonesia
nandiyanto@upi edu, enjangrohman81@upi.edu, mustika@upi.edu, silmiridwanppp@upi.edu

Abstract: The purpose of the research is to study the effect of the use of videos and e-module to understand the production of briquettes from melinjo (*Gnetum gnemon*) shell with various particle sizes and binder concentrations for vocational school students. The production of melinjo skin briquettes is conducted using two factors of the completely randomized design (particle size and concentration of tapioca). The study of the briquettes characteristics conducted is compressed density, relaxed density, relaxation ratio, percentage of moisture content, burning rate, specific fuel consumption, percentage of resistance index, and percentage of durability index. The learning process used a quasi-experimental method (One-group pretest-posttest). The learning is performed in two sessions by using video and e-module. Evaluation of student learning outcomes conducted through pretest, after video posttest, and after e-module posttest. Based on the analysis of variation, the concentration of tapioca, and the size of the particle have a significant effect on the briquettes' characteristics. The t-test results of the pretest, after video posttest, and after e-module posttest indicated that the average students' knowledge value increases and varies significantly on each test. This e-module can also be used to improve vocational high school students' knowledge of melinjo skin briquettes.

Keywords: Briquette, e-Module, Melinjo Skin, Video.

Corresponding Author
*Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi No. 229 Bandung, Indonesia
*nandiyanto@upi.edu

1. Introduction

The electronic module or e-module is a display of information in a book format that is presented electronically which acts as a learning medium that can make the learning process more interesting, interactive, can be done anywhere and can improve the quality of learning (Kadek, 2017); (Sukaryadi, 2018). E-modules have been broadly used as a platform for learning at different levels of schooling, including vocational schools (Mahara and Yoman, 2016). Various vocational high school materials have been converted into e-modules to improve student learning outcomes.

Septranesti and Lazulva (2019) stated that the use of e-modules in chemistry learning in vocational students is practical and effective in increasing student knowledge. Prasetiyowati and Tandyonomanu (2018) reported that the use of e-modules will enhance learning outcomes for vocational school students in three-dimensional animation subjects. Solihudin (2018) stated that web-based e-module learning will enhance the development of vocational students to acquire knowledge of physics. In the meantime, the e-modules for agricultural waste processing materials such as biobriquettes have never been established.

Biobriquettes are briquettes produced from organic materials, agricultural waste, or biomass (Martynis, Sundari, and Sari, 2012). Biobriquette is a coal substitute biofuel that is being developed (Sharman, Priyank, and Sharma, 2015). The quality and performance of briquettes are influenced by several factors such as briquette adhesive (Zhang, Sun, and Xu, 2018) and the particle size of the briquette producing (Mitchual, Mensah, and Darkwa, 2013). One of the potential agro-industrial wastes that could be used as biobriquettes is melinjo (Gnetum gnemon).

In Indonesia, many melinjo are processed into various processed products. As an example, in West Java melinjo production reached 335 tons in 2016 (BPS, 2018). At the time of processing melinjo, the melinjo skin will be discarded and become waste. On the other hand, vocational high school students majoring in agriculture must have expertise in agro-industrial waste treatment. Therefore, it is necessary to have an e-module in producing melinjo skin briquettes with variations in particle size and binder concentrations for vocational school students. The purpose of the research is to study the effect of the use of videos and e-module to understand production of briquettes from melinjo (*Gnetum gnemon*) shell with various particle sizes and binder concentrations for vocational school students.

2. Method

2.1. Producing Briquettes from Melinjo Skin

The raw materials for briquette production are waste from melinjo (*Gnetum gnemon*) skin, tapioca flour, and water. The tools used are a knife, scale, oven, thermometer, and saw-mill. The production of melinjo skin briquettes is conducted using two factors of the complete randomized method with three replication analysis. The first factor is the tapioca concentration at the levels of 10, 20, 30, 40.50%. The second factor is the particle size at levels 1000 - 465, 250 - 125, and 105-74 µm.

The briquettes processing consists of several stages, namely the size reduction, drying (T= 60°C, t = 3 h), carbonization (T= 250°C, t = 2 h), crushing, sieving (according to particle size variable), mixing the raw materials (based on the tapioca concentration variable), molding with a pressure 14 N/cm^2, and drying the briquettes until the weight is constant (T= 130°C).

The analysis on the melinjo skin bio briquette characteristics includes the compressed density (CD), relaxed density (RD), relaxed ratio (RR), percentage moisture content (PMC), burning rate (BR), specific fuel consumption (SFC), percentage of resistance index (PWRI), and percentage of durability index (PDI). The data were processed using a 5% analysis of variance to determine the significance of the variables on the characteristics.

2.1. Teaching Method

Research participants are 28 students of grade 11 vocational high schools in Bandung, Indonesia. Students' demographic data are collected including the IQ level, report scores on Mathematics, Biology, agricultural machine tools, and basic cultivation to identify students' preliminary condition.

The learning process uses a quasi-experimental method one-group pretest-posttest. The learning is conducted in two sessions; each session is carried out in one learning meeting. The first session is learning using video. The video explains the manufacturing process and characteristics of the melinjo skin briquettes which are uploaded on Google Drive in the mp4 format. The evaluation of the first session of learning uses a pretest to determine students' initial knowledge of melinjo skin briquettes and a posttest to determine the effect of using video on student knowledge.

The second learning session uses the melinjo skin briquette e-module. The e-module is made based on the results of the posttest after video to improve students' understanding of melinjo leather briquettes. The e-module creation uses the flipbook maker platform. The e-module is shown in Figure 1. The second session of learning evaluation is carried out using posttest after e-module. Evaluation is conducted to determine the level of students' knowledge after learning using e-modules. The pretest and posttest questions consisted of 10 true and false questions about melinjo skin briquettes.

Furthermore, the first and second session data of the pretest, posttest after video, and posttest after e-module are processed using the paired t-test to determine the increase in student understanding after learning using video and e-module.

3. Results and Discussion

3.1. Melinjo skin briquette characteristics

3.1.1. Compressed density (CD)

The effect of tapioca concentration and particle size on compressed density is illustrated in Figure 2. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on the compressed density and the treatment interaction have a significant effect ($\rho < 0.05$) on the compressed density.

Figure 2 displays a briquette with a 50% tapioca concentration with a particle size of 105-74 µm having the highest compressed density value with an average value of 1.19 $g.cm^{-3}$. The lowest compressed density is on melinjo skin briquettes with a 10% tapioca concentration with a particle size of 1000-465 µm and with an average value of 0.97 $g.cm^{-3}$. The smaller the particle size and the higher the tapioca concentration, the higher the CD briquette value. This is consistent with Davies's research (2014), which notes that the CD value is directly proportional to the concentration of the binder due to the interaction of the adhesive with carbon particles increases with higher tapioca concentrations and finer particle size (Olorunnisola, 2007).

3.1.2. Relaxed Density (RD)

The effect of tapioca concentration and particle size on relaxed density (RD) is shown in Figure 3. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on RD and the treatment interaction has a significant effect ($\rho < 0.05$) on RD.

Figure 3 illustrates that briquettes with 50% tapioca concentration at a particle size of 105-74 µm have the highest RD average, namely 90 $g.cm^{-3}$. The lowest RD is melinjo skin briquettes with 10% of tapioca concentration at a particle size of 1000-465 µm with an average value of 0,49 $g.cm^{-3}$.

The larger the particle size and the smaller the tapioca concentration, the lower the RD value of briquettes. Mitchual, Mensah, and Darkwa (2013) found that briquettes with small particle sizes tend to have a higher RD value than those with a larger particle size as it is related to the interaction of a wider surface area of the material with the adhesive, thus giving a higher RD value.

Fig 1. The e-module appearance

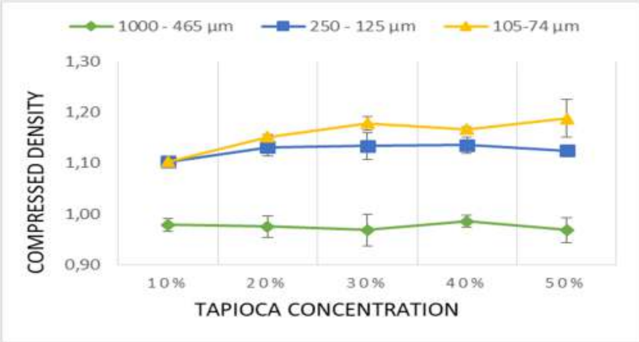

Fig. 2 Effect of tapioca concentration and particle size on CD

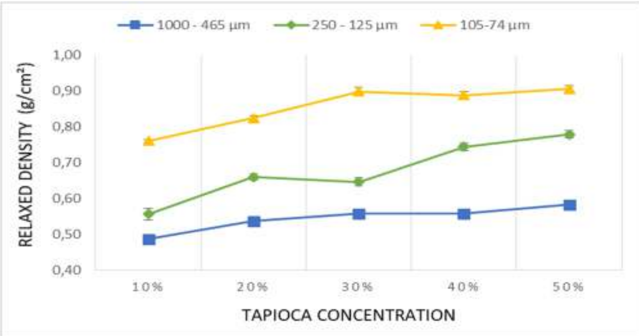

Fig. 3 Effect of tapioca concentration and particle size on RD

3.1.3. Relaxed Ratio (RR)

The effect of tapioca concentration and particle size on the relaxed ratio (RR) can be seen in figure 4. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on RR and the treatment interactions has a significant effect ($\rho < 0.05$) on RR.

Based on Figure 4, the briquette with the highest RR is 10% tapioca concentration briquettes with a particle size of 1000-465 µm and with an average value of 2.08. The lowest RR is briquette with 30% tapioca concentration with a particle size of 105-74 µm with an average value of 1,31 $g.cm^{-3}$. The larger the particle size and the lower the tapioca concentration, the higher the RR briquettes value. This is in line with research (Olorunnisola, 2007) which states that briquettes with high CD and RD provide relatively lower RR values.

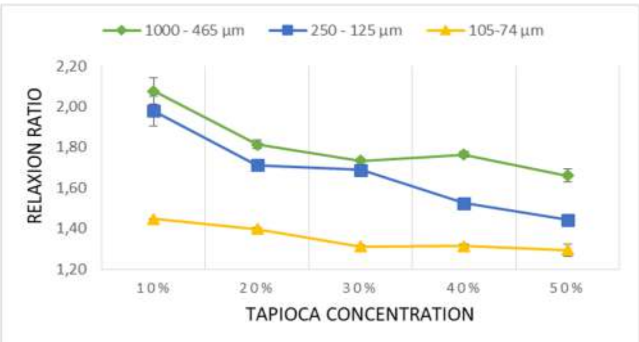

Fig. 4 Effect of tapioca concentration and particle size on the RR

3.1.4 Percentage moisture content (PMC)

The effect of tapioca concentration and particle size on PMC briquettes is displayed in Figure 5. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on PMC and the treatment interaction has a significant effect ($\rho < 0.05$) on PMC briquettes. Onukak, Dabo, and Ameh (2017) stated that briquettes with finer particles will have higher humidity.

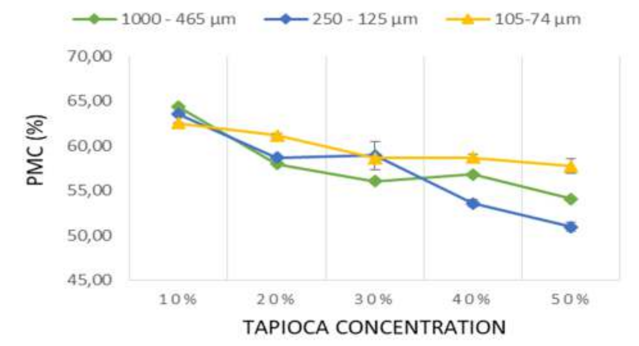

Fig. 5 Effect of tapioca concentration and particle size on PMC

3.1.5 Burning Rate (BR)

The BR value shows the average period of briquette burned per unit of time (Onukak, Dabo, and Ameh, 2017). Figure 6 shows the effect of tapioca concentration and particle size on the BR value. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on the BR value and the treatment interaction has a significant effect ($\rho < 0.05$) on the BR briquettes.

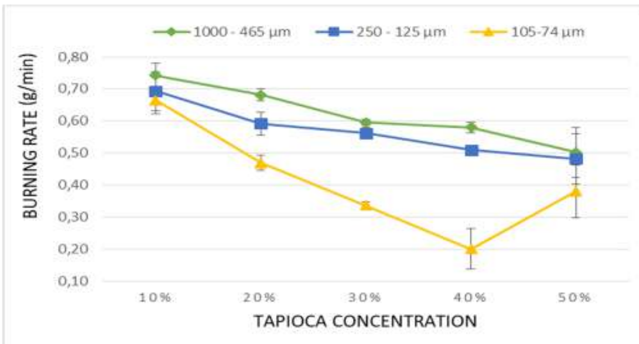

Fig. 6 Effect of tapioca concentration and particle size on BR

Figure 6 displays that the briquette with the highest BR is the 10% of tapioca concentration with a particle size of 1000-465 µm and with an average value of 0.74 g/minute. The lowest BR is the briquette with 40% tapioca concentration with a particle size of 105-74 µm with an average value of 0.2 g/minute. The larger the particle size and the lower the tapioca concentration, the higher the BR value of the briquettes. Meanwhile, Onukak, Dabo, and Ameh, (2017) stated that briquettes with less adhesive will burn faster than those with much adhesive and the particle size of briquettes is inversely proportional to the burning rate of the briquettes.

3.1.6 Specific Fuel consumption (SFC)

SFC is the amount of fuel (briquettes) needed to boil water per unit of a minute (Rajaseenivasan, Srinivasan, Qadir, and Srithar, 2016). Figure 7 shows the effect of tapioca concentration and particle size on SFC briquettes. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on and the treatment interaction has a significant effect ($\rho < 0.05$) on the SFC of briquettes.

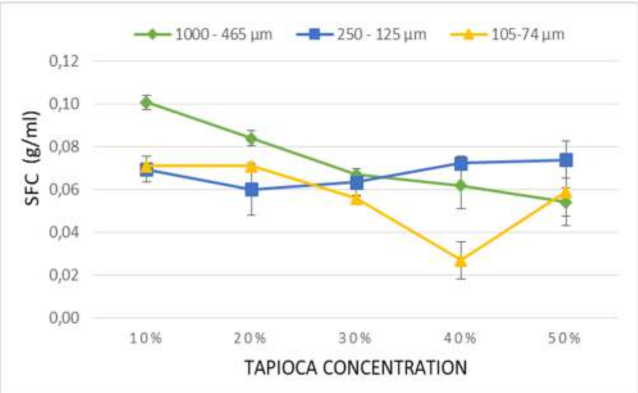

Fig. 7 Effect of tapioca concentration and particle size on SFC

Based on Figure 7, the briquette with the highest SFC is the 10% of tapioca concentration briquettes with a particle size of 1000-465 µm and with an average value of 0,1 g/ml. The lowest SFC is briquette with 40% of tapioca concentration with a particle size of 105-74 µm and with an average value of 0,03 g/ml. The larger the particle size and the lower the tapioca concentration, it tends to increase the SFC value of the briquettes. Although at the size of 250-125 µm, the higher the tapioca concentration, the higher the SFC value. According to Rajaseenivasan, Srinivasan, Qadir, and Srithar (2016), the SFC value is highly dependent on the calorific value of the ingredients and the addition of adhesive can reduce the calorific value of a briquette.

3.1.7 Percentage of Resistance Index (PWRI)

The percentage of resistance index (PWRI) is performed to determine the level of resistance of briquettes to water exposure (Kpalo, Zainuddin, and Manaf, 2020). Figure 8 shows the effect of tapioca concentration and particle size on PWRI briquettes. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on the PWRI value and the treatment interaction has a significant effect ($\rho < 0.05$) on the PWRI of briquettes. Kpalo, Zainuddin, and Manaf (2020) stated that the value of water resistance is related to briquette density, low density can reduce briquette water resistance (Kpalo, Zainuddin, and Manaf, 2020).

3.1. 8 Percentage of Durability Index (PDI)

The percentage of the durability index is the capacity of briquettes to remain intact and the resistance of briquettes not to break due to collisions or during storage and transport (Olugbade, Ojo, and Mohammed, 2019). Figure 9 shows the effect of tapioca concentration and particle size on the PDI value of briquettes. The results of the analysis of variance show that the treatment of tapioca concentration and particle size has a significant effect ($\rho < 0.05$) on the PDI value and the treatment interaction has a significant effect ($\rho < 0.05$) on the PDI value of briquettes.

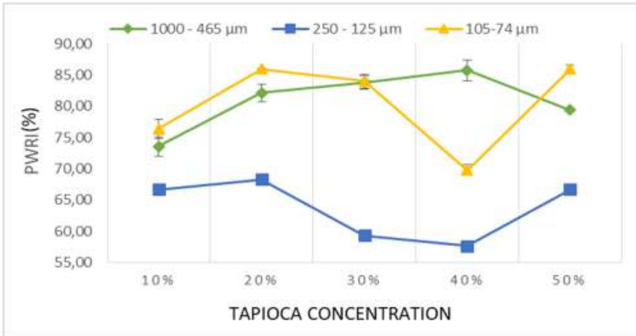

Fig. 8 Effect of tapioca concentration and particle size on PWRI briquettes

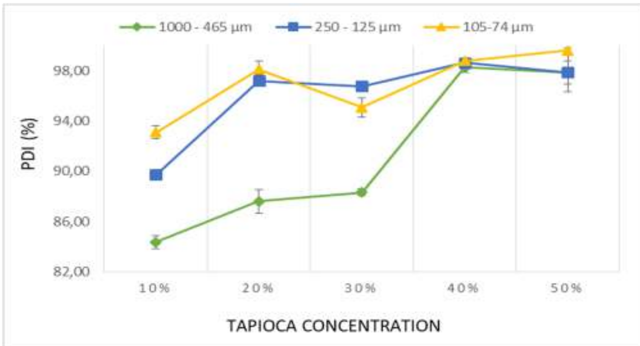

Fig. 9 Effect of tapioca concentration and particle size on PDI briquettes

Figure 9 shows the PDI value at particle size 1000-465 µm and is smaller than the particle size 250 -125, and 105-74 µm. Martynis, Sundari, and Sari (2012) explained that the finer the particle size, the stronger the bio briquette produced. Besides, the size of the two particles indicated that the higher the tapioca content, the higher the PDI value. The high concentration of tapioca increases the bond between the particles and the binder and improving the durability of the briquettes (Olugbade, Ojo, and Mohammed, 2019).

3.2. Teaching Results

3.2.1. Student demographics Data

Based on the IQ score, respondents were divided into low IQ (80-89 IQ), medium (90-109 IQ), and high (110-119) IQ (Suryani, Labellapansa, Shiddiqie, and Hidayat, 2019). Figure 10 shows the student's IQ score. There are 46% (13 students) who have low IQ, 39% (11 students) are at a moderate IQ level, and 14% of students (4 students) have a high IQ.

Students' scores on several subjects may indicate students' interest in the topic being studied shown in Table 1. The table also shows the students' abilities that can support students in understanding melinjo skin briquettes.

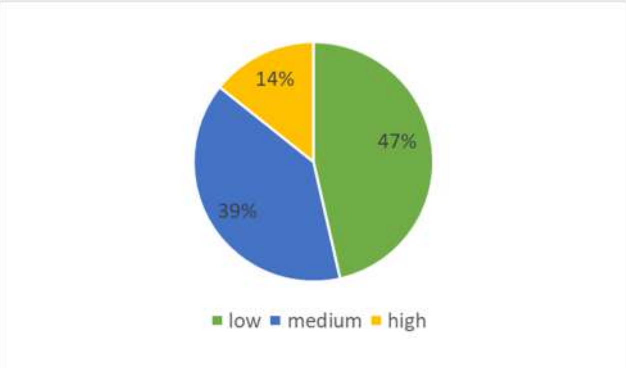

Fig. 10 Groups of Student IQ

Table 1. Students average scores based on students' school report

No	Subject	Average score
1.	Mathematics	81.58
2.	Biology	77.39
3.	Agricultural Machine Tools	81.00
4.	Basic Cultivation	77.65

3.2.2 Learning Outcomes Analysis

Students learning outcomes in two sessions evaluated using the pretest and posttest shown in Table 2. The students' pretest and posttest questions are the ten true-false statements that are used to assess students' understanding of the melinjo skin briquette material. The pretest results show students' initial knowledge about melinjo skin briquettes. Students' initial knowledge about skin briquettes melinjo including the less, it can be seen from the average pretest score of 43.79

Table 2 shows students' learning outcomes have improved in each session. There is an increase in the value of each question indicator after the use of the video and e-module. After the first learning session (using video), students' knowledge increases with an average score of 68.27. Likewise, in learning using e-module, the average student's knowledge increases up to 80. Thus, the use of videos and e-modules can improve students' knowledge. This is in line with literature that additional media can improve the learning process for students (Maryanti, Hufad, Sunardi, Nandiyanto, and Al-Obaidi, 2020; Nandiyanto, Asyahidda, Danuwijaya, Abdullah, Amelia, Hudha, and Aziz, 2018; Nandiyanto, Raziqi, Dallyono, and Sumardi, 2020).

Table 2. Students learning outcomes

No	Question	Pretest	Posttest	
			After video	After e- module
1.	Briquettes' raw materials are divided into coal briquettes, bio-coal briquettes, and bio bricks.	58.62	89.66	100.00
2.	Coal briquettes serve as biofuel as they can be used continually as fuel.	3.45	27.59	75.86
3.	Briquettes are made by combining carbonized raw materials with adhesive ingredients. Carbonization is the process of transforming organic material into charcoal.	51.72	82.76	86.21
4.	The purpose of the adhesive on the briquette is to attract water and form a solid texture by binding the two substrates.	44.83	75.86	82.76
5.	The smaller the size of the carbonized raw materials, the higher the density of the briquettes so the briquettes are stronger.	62.07	75.86	79.31
6.	Density is the ratio between the briquette mass and volume. The density of the briquette is affected by its shape and volume.	34.48	44.83	75.86
7.	BR is the average burnt time of the briquette. The better the briquette, the lower the burning rate.	37.93	65.52	72.41
8.	BR is the average burnt time of the briquette. The smaller the particle size, the lower the BR value.	55.17	79.31	96.55
9.	PWRI is an analysis that shows the percentage of water absorbed by the briquette. Good briquettes are briquettes that have a high PWRI value.	44.83	65.52	86.21
10	The higher the SFC, the better the briquette quality (more economical).	44.83	75.86	86.21

The level of significance of students' knowledge before and after the use of video is shown in Table 3. The results of the paired t-test using video in the first session have a significant effect ($\rho < 0.05$) on student learning outcomes with a value of $\rho = 0.005$. This is in line with literature that adding video significantly increased participant's cognitive load when learning procedural knowledge (Hong, Pi and Yang, 2018).

The value of student knowledge after learning using e-module is higher than using video. The level of significance of students' knowledge after the use of video and e-module is shown in Table 4. The application of e-module has a significant effect ($\rho < 0.05$) on student learning outcomes after the use of videos with a value of $\rho = 0.02$. This is because e-modules are made based on the results of evaluating student knowledge after the use of videos so that they can correct misunderstandings and increase student knowledge scores. Using e-modules as a learning tool makes the learning process more interesting, interactive, accessible, and can enhance the quality of learning (Sukaryadi, 2018). According to Mulyadi, Atmazaki, and Syahrul, (2019), one of the advantages of using e-modules is that it can inspire students as the assignments are limited by students' abilities, therefore, the use of e-modules can improve the quality of students' comprehension.

Table 3. Paired sample test pretest and after video

	pretest	*After video*
Mean	43.79310345	68.62069
Variance	277.579601	352.6225
Observations	10	10
Pooled Variance	315.1010702	
Hypothesized Mean Difference	0	
df	18	
t Stat	-3.127480148	
P(T<=t) one-tail	0.002909283	
t Critical one-tail	1.734063607	
P(T<=t) two-tail	0.005818566	
t Critical two-tail	2.10092204	

Table 4. Paired sample test after video and after e-module

	After video	*After e-module*
Mean	68.27586	84.13793
Variance	353.5474	79.79918
Observations	10	10
Pooled Variance	216.6733	
Hypothesized Mean Difference	0	
df	18	
t Stat	-2.40958	
P(T<=t) one-tail	0.013446	
t Critical one-tail	1.734064	
P(T<=t) two-tail	0.026892	
t Critical two-tail	2.100922	

4. Conclusion

Based on the analysis of variance, the tapioca concentration, and the size of the particle affect the briquettes characteristics significantly. Briquettes with relaxation ratio value, percentage moisture content, burning rate, and the highest specific fuel consumption are on briquettes with the 10% tapioca concentration and particle size of 1000-465 µm. Meanwhile, briquettes with compressed density, relaxed density value, percentage of durability index, and the highest percentage of water resistance index are on briquettes with 50% of tapioca concentration and the particle size of 105-74 µm. Based on the t-test results of the pretest, after video posttest, and after e-module posttest, show that the average students' scores have improved and are significantly different on each test. The use of e-modules as a learning medium makes the learning process more interesting, interactive, and increases student motivation to study independently. Thus, the e-module can also be used to improve vocational students' understanding of melinjo skin briquettes.

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