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Designing and Experimenting Semi-automatic Green Grass Jelly Squeezer

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***Abstract*— In Indonesia, green grass jelly is widely known as traditional drink obtained from soaking grass jelly leaves in the water. Nowadays, the production process of grass jelly was conducted manually, which consumes lots of time and energy. Therefore, this research aimed to design a semi-automatic green grass jelly squeezer to accelerate and simplify the production process. Moreover, the squeezer performance and several quality parameters of the jelly produced by the squeezer were examined. The designing process of green grass jelly squeezer was conducted through several stages. Those were concept design, manufacture and assembled stage, performance test, modification, and examination. The result shows that the most efficient production process was at 6000 RPM and the digital value of 540. The measurements of Soluble Solid (SS) and gel strength show that jelly produced by the squeezer has higher SS and F_{max} than the control. The sensory evaluation shows jelly with the digital value of 520 get the best consumer acceptance, which means the consumer prefer neither too dense nor too solid green grass jelly. The result shows that no effect of digital value and RPM on syneresis examination.**

***Keywords*— grass jelly; semi-automatic; squeezer.**

I. Introduction

Grass jelly is a gel obtained from soaking the leaves or other parts of a particular plant in the water. In Indonesia, grass jelly is known as a traditional functional drink which has specific health benefit [1], [2]. Both *Cyclea Barbata* Miers and *Mesona Palustris* Bl, varieties of grass jelly, were commonly used as raw material to make grass jelly [3], [4]. Fig. 1 shows those four kinds of leaves [5]. Grass jelly derived from *Cyclea Barbata* Miers leaves known as green grass jelly—the widest grass jelly consumed in Indonesia beside the black grass jelly that derived from *Mesona Palustris* Bl leaves [6].

Nowadays, agribusiness scale for green grass jelly is smaller than black grass jelly. The production process of green grass jelly has been conducted manually which slow down the business development. Initially, squeezing the *Cyclea Barbata* Miers leaves is by hand in the water until some bubble appears will produce green grass jelly. The emergence of bubbles indicates the extract of green grass jelly from the leaves come out. Moreover, green grass jelly solution was divined from the leaf flakes, and the solution will be thickened by the time.

Much time and energy are required in the manual production process because the fresh *Cyclea Barbata* Miers leaves are quiet hard. Therefore, the merchant of green grass jelly modifies the method before squeezing by boil the fresh *Cyclea Barbata* Miers leaves until it is slightly wilted and soft. It is easier to get green grass jelly extract from the boiled *Cyclea Barbata* Miers leaves than the fresh one. However, the viscosities of the green grass jelly from the boiled *Cyclea Barbata* Miers are lower than the fresh leaves. Because of the lower viscosity, the merchant cheating on the consumers by adding some additives to increase the viscosity of green grass jelly solution.

The objective of this research was to design a semi-automatic green grass jelly squeezer to accelerate and simplify the production process of green grass jelly. Moreover, the squeezer performance and several high-quality parameters of green grass jelly made by squeezer were examined. This squeezer was made for the merchant of green grass jelly. The materials that used for this squeezer are food grade, so it is safe for food producing. This squeezer was also easy to clean and does not require complicated maintenance. Besides, control technology was applied, an exceptionally light sensor for measuring the turbidity of grass jelly liquid, so all of the product produced from this squeezer has the same standard

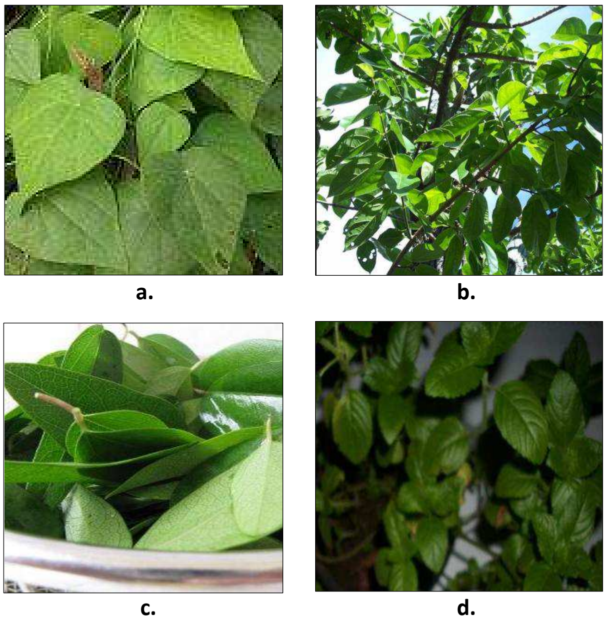

Fig. 1 Four kinds of leave that commonly used as raw material for grass jelly; (a) *Cyclea Barbata* Miers, (b) *Mesona Palustris* Bl, (c) *Stephaniahermandifolia*, and (d) *Premnaserratifolia*

II. Materials and Methods

Semi-automatic green grass jelly squeezer was designed at the workshop of Siswadhi Suparjo field laboratory, Department of Mechanical and Biosystem Engineering, Bogor Agricultural University, Indonesia.

A. Materials and Equipment

Materials for the manufacturing of functional parts of squeezer were stainless steel sheet, stainless steel solid stick, polyethylene, bolt and nut, AC motor, servo motor, and transparent container. In addition to building the electronic control, the materials were microcontroller AT mega 16 with the module, photodiode, red LED, buzzer, resistor, diode, adaptor, LM 324, Riley, PCB, rainbow cable, large cable, fuse and fuse port, and tin solder. All those parts were combined by using some equipment those were digital multi-tester, solder, screwdriver, scissors, welding machine, and drill.

Performance of the squeezer was examined by operating the machine to make green grass jelly from the leaves of *Cyclea Barbata* Miers mixed with water as a green grass jelly that commonly sold by the merchants. Jelly solutions made using the machine were put into sample cup for further examination.

B. Designing Process

The capacity for designing green grass jelly squeezer is 1.5 liter of solution. The designing process of green grass jelly squeezer was conducted through several stages, those were concept design, manufacture and assemble, performance test, modification, and examination stage.

1) Concept Design, there were two main parts of the machine: mechanical part and the electrical part. Solidworks 2011 was used to design a mechanical part that contains functional and structural layout (Fig. 2). To design the electrical part, the testing board was used to test all component for controlling the machine mechanism.

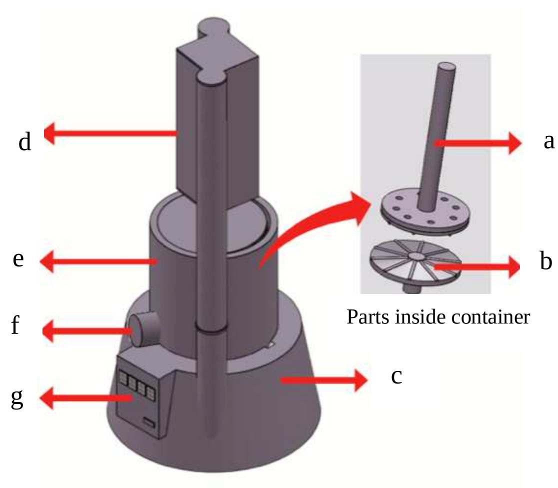

Fig. 2 3D Model of Green Grass Jelly Squeezer. (a) Upper squeezer (b) Bottom squeezer (c) AC motor (d) Servomotor (e) Container (f) Sensor module (g) Power button and speed controller

2) Manufacture and Assemble were conducted after concept design was settled based on main design, mechanism, capacity, power consumption, and materials. In this stage, the machine was manufactured at the workshop. The output of this stage is the semi-automatic green grass jelly squeezer.

3) The Performance Test is a stage to see whether the performance of the machine was as expected. The performance parameters, which were examined, are squeezing velocity and time. This stage is also an evaluation stage.

4) Modification stage conducted if the evaluations result from the previous stage was not as expected, so the machine should be modified to achieve a good performance. If the evaluation result from the previous stage is as expected, this stage can be skipped.

5) Examination stage was conducted after the machine run properly as expected, it was examined for producing green grass jelly. The quality of the jelly produced by the machine will be compared with the quality of the jelly produced by a merchant supervised by Research and Community Services Institution of Bogor Agricultural University with the same quantity of water and *Cyclea Barbata* Miers leaves. Flow diagram of a designing process of Semi-Automatic Green Grass Jelly Squeezer can be seen on Fig. 3.

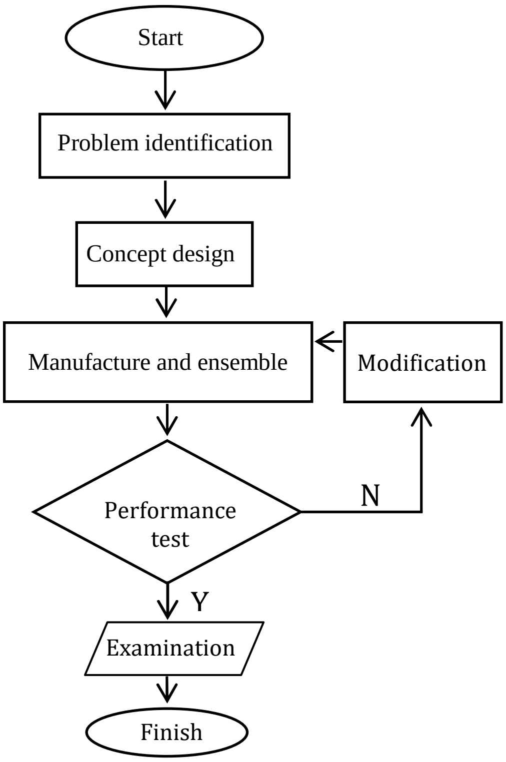

Fig. 3 Flow diagram of the designing process

C. *Examination*

1) Performance Examination: Performance examination of the machine was conducted by calculating requires time to squeeze *Cyclea Barbata* Miers leave from the machine was started until the light sensor module stopped it automatically at specific digital value. Table 1 shows the treatment combination for the samples. The entire sample for the examination was made from 500 ml of water and 30 gram of *Cyclea Barbata* Miers. Upper squeezer moves up and down at the velocity of 0.5 cm/s, while the minimum gap between the squeezers is 5 cm.

2) Quality Examination of Green Grass Jelly: The measurement of Soluble Solid (SS) [7] was conducted by using hand refractometer Atago PR-201. A 2-pipette drop of the jelly was placed on the refractometer to measure the soluble solid, which described as °Brix.

TABLE I
TREATMENTS COMBINATION FOR THE SAMPLES

Sample	Treatment condition	
	RPM	**Digital value**
1	2,000	520
2	2,000	530
3	2,000	540
4	5,000	520
5	5,000	530
6	5,000	540
7	6,000	520
8	6,000	530
9	6,000	540

Hardness measurement of green grass jelly is conducted by using Sun Rheometer same as measuring black grass jelly hardness [8]. Where the treatment condition as mention below:

1. Maximum load = 2kg
2. R/H Hold = 1,999 g
3. P/T Press = 30 mm/m
4. Velocity of paper = 300mm/minute
5. Velocity of apparatus = 30 mm/minute

A 7-point hedonic scale was applied in this research to evaluate sensory attributes: color, odor, flavor, texture, and overall acceptability. Hedonic scale range varies from 1 to 7, where one representing dislike remarkably and seven like extremely [9]. Twenty-nine students from Bogor Agricultural University are involved to assessed green grass jelly sample. The panelist are untrained people to evaluate sensory attributes. Every panelist assessed 15 samples in total where every sensory attribute (5 items) were made from a combination of speed rotation (5000 RPM) and three different digital value configuration: 520, 530, and 540. In this case, speed rotation does not affect sensory attributes significantly. Then only in the middle range speed (500 RPM) is used to make the sample. 100 ml of the jelly sample made by the squeezer presented to panelist directly. Moreover, the rank testing or sorting preference level to the provided sample was conducted.

Syneresis, which occurred during gel storage, was examined by storing the green grass jelly, which formed at room temperature (28°-30°C) for 24 hours, and 48 hours. Each grass jelly was placed in the sample cup to retain water, which was release from jelly during storage. Measurement was conducted by calculating the loss of grass jelly weight (W_t) during storage divide by the initial weight (W_o) [10].

$$Syneresis = \frac{Wo - Wt}{Wo} \times 100\% \quad (1)$$

Where W_o is initial weight before storage (gram) and W_t is weight after storage (gram)

III. RESULT AND DISCUSSION

A. *Semi-Automatic Green Grass Jelly Squeezer Design*

1) Design of Machine: The term of Semi-Automatic from the machine means loading and unloading process of water and *Cyclea Barbata* Miers leaves to the container was still conducted manually, however during squeezing process until it stops was conducted automatically based on the turbidity of the solution. Semi-automatic green grass jelly squeezer has several primary components specifically a transparent container, upper squeezer, bottom squeezer, and a light sensor module.

Transparent container, which chosen to support the light sensor module, was holding the *Cyclea Barbata* Miers leaves and water during the squeezing process. *Cyclea Barbata* Miers leaves, and water which were put in a transparent container would be crushed by bottom squeezer, which was rotating with 2000, 5000, or 6000 RPM, and upper squeezer, which was moving up and down with the velocity of 0.5

cm/s. The main functional parts of the squeezer were top and bottom squeezer.

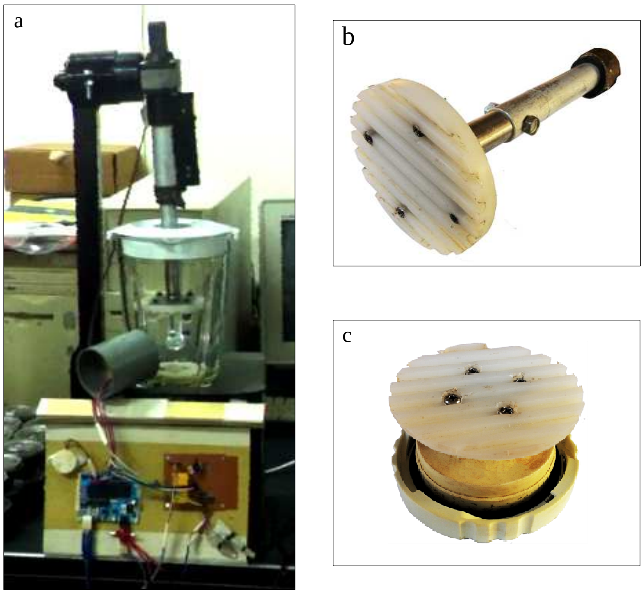

Fig. 4 (a) Complete structure of semi-automatic green grass jelly squeezer, (b) Upper squeezer (c) Bottom squeezer

Bottom squeezer was made from serrated-pattern polyethylene, whi1ch was united with a food-grade stainless steel sheet and it was connected to AC motor. AC motor was chosen because bottom squeezer requires high-speed rotation to squeezes *Cyclea Barbata* Miers leaves.

Moreover, upper squeezer, which was also made from the same materials as bottom squeezer was connected to stainless steel solid stick then it was connected to the servo motor. Upper squeezer requires not only slow speed but also the high strength to hold the tension from the leaves during compacting process. According to the calculation, AC motor that drives the bottom squeezer requires electrical power around 319,652 watt, while servomotor that drives the upper squeezer requires electrical power around 2.1 watt. The complete structure of Semi-Automatic Green Grass Jelly Squeezer and its main functional parts were shown on Fig. 4.

2) The Layout of the Electronic Control: The machine mechanism was controlled by microcontroller ATMega 16 and combined with a light sensor to sense turbidity of solution during the process. The microcontroller will read digital value (ADC) from the sensor based on the variation of turbidity. At first, the machine operates, by using human eye, after the solution color near to commercial green grass jelly, the machine stop and 3 ADC were determined: 520, 530, and 540. Those ADC were a standard of programming the machine to stop.

Components of electronic control were assembled on a PCB to make it compact. All components were connected to a microcontroller (AT mega 32). It was programmed based on the turbidity of green grass jelly solution to run their every function. The layout of electronic control can be seen in Fig. 5. When the machine was activated, bottom squeezer would rotate while upper squeezer moves up and down. During that process, the movement of upper squeezer was controlled by a microcontroller using a relay as negative-positive panel switcher. When the upper squeezer moved down until Bottom Dead Centre (BDC) the relay switched negative-positive panel of the servomotor, then the squeezer would go up until Top Dead Centre (TDC). At that position the relay re-switched negative-positive panel of servo motor then the squeezer would go back down, and so on.

Cyclea Barbata Miers leaves and water inside the transparent container would be crushed by bottom squeezer, which was rotating with 2000, 5000, and 6000 RPM while upper squeezer moves up and down at the velocity of 0.5 cm/s and the minimum gap between the squeezers is 5 cm. During that process, an LED emits the light, and jelly solution reflected it. The reflectance would be sensed by the photodiode to express turbidity as an analog value that will convert into a digital value by a microcontroller. The squeezer was programmed to stop automatically at a specific digital value in the amount of 520, 530, and 540.

In the beginning, the turbidity of the solution made by the squeezer was observed, when the turbidity of the solution was same as the turbidity of green grass jelly control, the digital value of it was noted. Then, after a couple of repetitions, the digital value of 520, 530, and 540 were provided as the standard of turbidity level. Using the response from the photodiode, the microcontroller would deactivate the upper and bottom squeezer by activating on-off relay and buzzer to make a loud sound as a sign when the machine stops.

3) Performance Examination: Testing the machine in actual condition is an essential part to understand the capability of the machine [11]. Fig. 6 shows the result of performance examination of semi-automatic green grass jelly squeezer. Fig. 6.a shows an outlier data on the digital value of 540. There is a condition where it takes longer squeezing process among other samples at the same digital value. The photodiode, which was disturbed by outside light that comes from the gap of sensor module could be the caused by this condition.

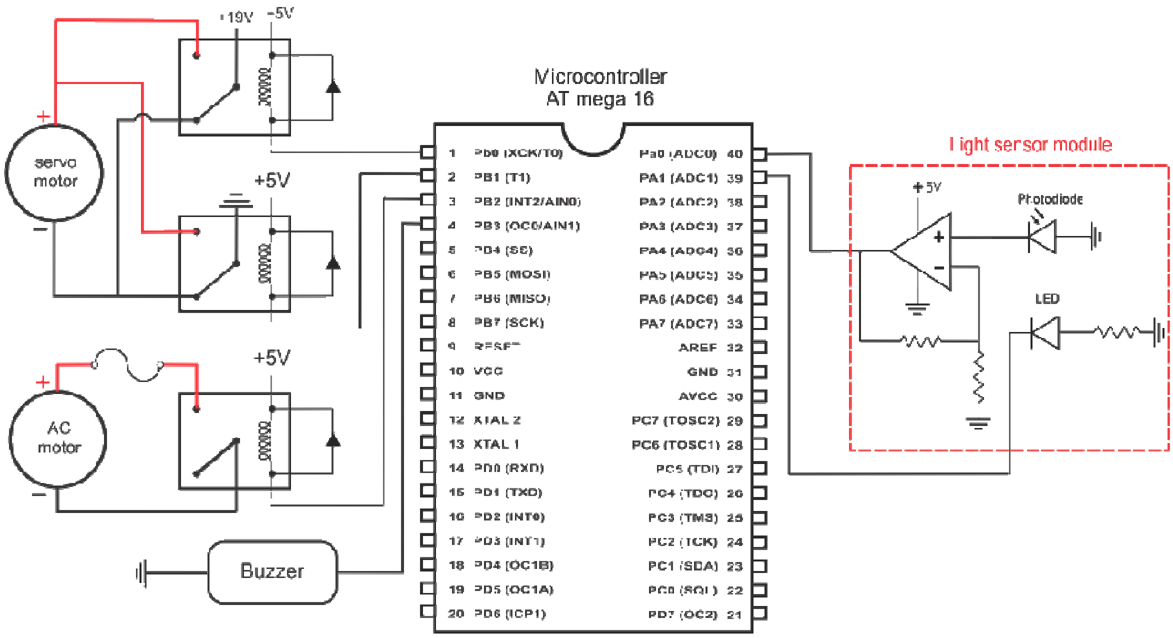

Fig. 5 The layout of the electronic control

Fig. 6.b shows there are two samples on 6,000 RPM that take longer squeezing process than on 5,000 RPM. The robust structure of *Cyclea Barbata* Miers causes stuck at one position. In such condition, the squeezer requires longer squeezing process to turn the position of the leaves. Moreover, 5,000 RPM and 6,000 RPM were not so different; hence, in some condition, both speeds take the same length of squeezing time. Moreover, jelly extract from the leaves come out in the short time. Fig. 6.c shows Sample 3, which was processed under 2000 RPM and the digital value of 540 takes the most extended squeezing process compare to other Samples. Moreover, the fastest squeezing process was Sample 9, which was processed under 6000 RPM and the digital value of 540.

Generally, the faster rotations of bottom squeezer, the shorter squeezing process of green grass jelly solution, because of the faster rotations of bottom squeezer, the faster *Cyclea Barbata* Miers leaves torn apart. Moreover, jelly extract from the leaves come out in the short time. The result shows the most efficient production process was at 6000 RPM and the digital value of 540.

B. Quality Examination of Green Grass Jelly

1) Soluble Solid: According to Rahmawansyah [12], Soluble Solid (SS) is a not-water matter consists of glucose, fat, protein, or ash and other components. Fig. 7 shows all SS of green grass jelly produced by the squeezer and the control, which was made by a merchant supervised by Research and Community Services Institution of Bogor Agricultural University. The results show that SS of the grass jelly produced by the squeezer varies from 1.75 to 3.5 (^{O}Brix) and they all were higher than the control in the same amount of water and *Mesonapalustris* leaves (500 ml of water and 30 gram of *Mesonapalustris* leaves).

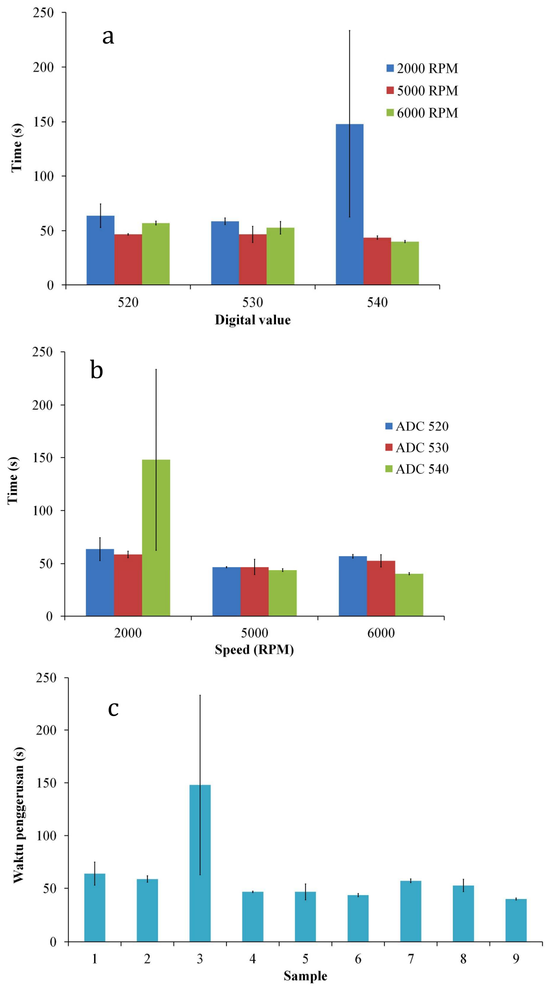

Fig. 6 (a) Digital value vs Time, (b) Bottom squeezer speed vs Time, (c) The required time to make each Sample with the combination of digital value and RPM

TABLE II
PROPERTIES OF GREEN GRASS JELLY PRODUCED BY SQUEEZER

Combination	Texture	Aroma	Flavor	Color	Overall Acceptability
C1	4.55 ± 1.53	3.86 ± 1.62	3.69 ± 1.56	4.10 ± 1.74	4.17 ± 1.20
C2	3.66 ± 1.65	3.76 ± 1.30	3.76 ± 1.46	4.52 ± 1.35	3.39 ± 1.33
C3	3.83 ± 1.75	3.90 ± 1.54	3.72 ± 1.49	4.14 ± 1.46	4.03 ± 1.24

*Mean ± SD; ** C1, digital value 520; C2, digital value 530; C3, digital value 540.

The phenomenon shows that the squeezer effectively produces more green grass jelly extract compare to manual method, so green grass jelly produced by the squeezer has higher SS than the control. In addition, high amount of SS from the sample can decrease water activity (aw) for microbial growth [13]. Consequently, it contributes to extending shelf life better than the control. Moreover, when a_w maintain in low level, some sensory attributes [14] in grass jelly will improve.

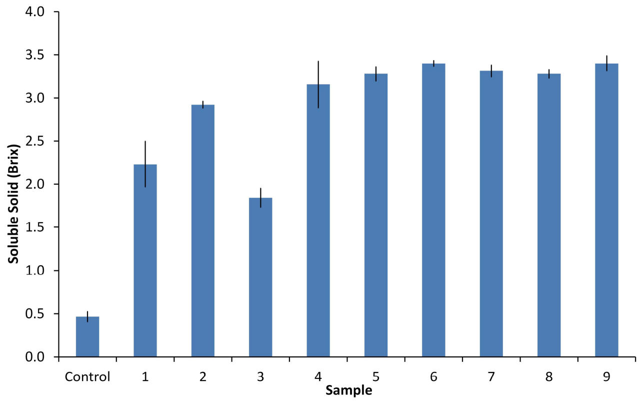

Fig. 7 Soluble Solid (SS) of sample and control

2) Texture Analysis: Hardness shows the required load to make the gel deform before it torn apart [15]. Deformation is the change of form, dimension, and position of some matters from both natural and artificial under space and time scale. Fig. 8 shows maximum load (F_{max}) of the samples and the control. The result shows green grass jelly produced by the squeezer has higher F_{max} than the control in the same amount of water and *Mesonapalustris* leaves.

The phenomenon shows that the squeezer effectively produces more green grass jelly extract compare to manual method, so green grass jelly produced by the squeezer is harder than the control.

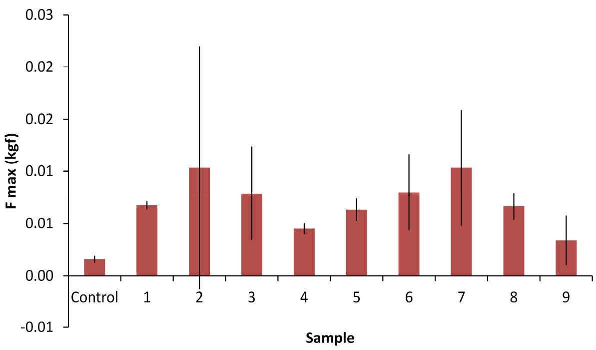

Fig. 8 Maximum load to deform the green grass jelly

3) Sensory Evaluation: As a new development product, the consumer acceptance of the green grass jelly produced by the squeezer must be examined. Sensory evaluation is one of an assessment method by using human sense to evaluate the quality of agricultural product or food. Sensory evaluation was conducted by using a hedonic scale which observes individual perception that involved like or dislikes impression. A 7-point scale was used rather than 9-point scale because of it more effective [16]

Table 2 shows that there was no significant difference in every digital value C1, C2, and C2 to sensory attributes. C1 generally resulted in higher acceptance for texture and overall acceptability but had the lowest score for flavor. C2 showed higher acceptance for flavor and color, while overall acceptability and texture gave the lowest level between the others. In C, it had the highest score for aroma, flavor, and, color.

According to the score, the sample of green grass jelly that was produced by the digital value of 520 got the best consumer acceptance seen by overall acceptability, which means the consumer prefer not too dense nor too solid green grass jelly.

4) Syneresis Measurement: Syneresis ability is one of the most important characteristics of starch. It is an ability to release water from gel during storage. Syneresis of starch was increasing during storage [15]. The observation of syneresis was conducted in 24 hours and 48 hours.

The increasing of syneresis during storage caused by the interaction between amylose and amylopectin chain, which develop to the junction zone, reflecting the beam of light. Accumulation and crystallization of amylose occurred at the beginning time of storing process. On the other hand, accumulation and crystallization of amylopectin occurred at the end of storage [15]. According to the observation, the increasing of syneresis each day can be seen in Fig. 9. The result shows that no effect of digital value and RPM on syneresis was observed.

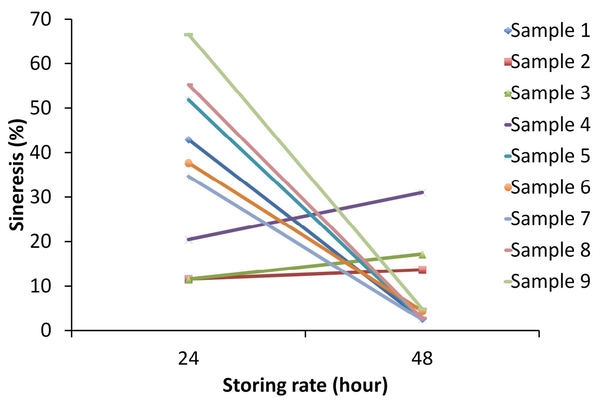

Fig. 9 Result of green grass jelly syneresis

IV. CONCLUSION

Semi-automatic green grass jelly squeezer works the fastest in the condition of 6000 RPM and the digital value of 540. The results for total soluble solid and gel strength show green grass jelly produced by the squeeze has higher soluble solid and F_{max} value than the control. The result of the sensory evaluation shows the sample of green grass jelly that was produced by the digital value of 520 got the best consumer acceptance, which mean the consumer prefer not too dense nor too solid green grass jelly and no effect of digital value and RPM on syneresis was observed.

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