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# The Effect of Variation of Binding Materials on The Physical Quality of Batik Clam Shell Extract Tablets (*Paphia undulata* B.)

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## ABSTRACT

Indonesia is the largest archipelagic country which has shell commodities reaching around 2.752 tons with calcium content which can be utilized for the growth and development of the human body. One type of shellfish that is often found is batik clam (*Paphia undulata* B.). In order to utilize the shells of batik shells, research was carried out by determining the formulation and knowing the effect of variations in the type of binder on the physical quality of the preparation of batik shell extract tablets. Tablets were prepared by wet granulation method using three different binders namely FI (PVP), FII (gelatin), and FIII (CMC-Na) with a concentration of 4%. The data obtained were analyzed using the one way ANOVA test. The results showed that the various types of binder materials had a different effect on the physical quality of the tablets produced, based on the results of the ANOVA test analysis which showed a significant value of 0.000 ($p < 0.05$). Formulations that have good physical tablet quality namely FI with PVP binder and FII with gelatin binder, with a hardness test value of 14.44 kg ± 1.24; 12.57 ± 0.74 and a friability test of 0.20% ± 0.07; 0.38% ± 0.08 which is almost close to K+ (calcium lactate) of 17.47 kg ± 0.54 and 0.21% ± 0.05.

**Keywords :** Batik Mussels, CMC-Na, Gelatin, PVP

## INTRODUCTION

Indonesia is the largest archipelagic country in the world which has several areas that are centers for producing marine wealth (Ariyanti *et al.*, 2018). Based on fishery product export data in 2003 and 2004, Indonesia produced around 3.208 tons and 2.752 tons of coral and shellfish (Musapana & Amalia, 2020). Solid waste in the form of shells is the remainder of the shellfish processing industry, which so far has only been used for meat, while the shells have only been used as crafts or decorative arts, a mixture of animal feed, and many of them are also thrown away and become waste (Akbar *et al.*, 2019). Shellfish shell waste that is continuously thrown away without proper processing will increase and become a nuisance and pollute the environment (Ginting *et al.*, 2016). Thus, efforts are needed to overcome this so that it can be beneficial and reduce the impact on the environment.

Utilization of shellfish waste can be done by utilizing the nutrients contained therein as mineral elements and natural chemical compounds for various products, thereby increasing their added value (Islamiyah *et al.*, 2021). The nutrients that can be found in clam shells are the mineral content, especially calcium, which is quite high (Abidin *et al.*, 2016). The calcium content can be formulated into pharmaceutical preparations such as tablets, with the advantages of being practical, easy to consume and easy to carry (Mindawarnis & Hasanah, 2017).

Calcium is needed for the growth and development of the human body, especially in the formation of bones and teeth (Amran, 2018). Lack or deficiency of calcium can cause health problems, such as tooth loss, abnormal bone density and osteoporosis (Abidin *et al.*, 2016). Therefore, maintaining calcium intake is very necessary. One way to do this is to take calcium supplement tablets.

The type of shellfish that is often found and can be utilized for its calcium content in the Banyuwangi area is the batik shellfish (*Paphia undulata* B.) (Usman *et al.*, 2020). Based on research from Abidin *et al.* (2016), batik shells (*Paphia undulata* B.) have a fairly high calcium (Ca) content, namely 24.20% and in the form of calcium oxide (CaO) 53.38%.

Utilizing the contents of batik shells by formulating them into tablet preparations is one step to increase the economic value of the product, maintain environmental sustainability, and reduce the risk of environmental pollution (Abubakar *et al.*, 2021). Thus, this research will utilize the contents of batik clam shells which are first synthesized using the calcination method and then formulated into pharmaceutical preparations in the form of tablets.

## METHODS (Times New Roman ; uk 12)

The type of research carried out is experimental laboratory research. This research was carried out at the Pharmaceutical Preparation Technology Laboratory, Faculty of FAKAR, Strada Indonesia Health Sciences Institute, Kediri.

1. Tools and Materials

   The tools used are container, brush, crusher, mesh sifter, muffle furnace, analytical balance, horn spoon, porcelain cup, mortar and stamper, parchment paper, oven, single punch tablet press, granule and tablet testing equipment.

   The materials used are batik shells (*Paphia undulata* B.), PVP, gelatin, CMC-Na, Mg. Stearate, primogel, lactose, and distilled water.

2. Tablet Formulation

**Table 1.** Batik Clam Shell Extract Tablet Formulation (%)

| Material | Material Function | Material Concentration (%) | | | | |
|---|---|---|---|---|---|---|
| | | F I | F II | F III | K- | K+ |
| Batik Clam Shell Extract | Active Substance | 76.92 | 76.92 | 76.92 | 76.92 | Tablet *Calcium Lactate* (PT. AFI Farma) |
| PVP | Binder | 4 | - | - | - | |
| Gelatin | Binder | - | 4 | - | - | |
| CMC-Na | Binder | - | - | 4 | - | |
| Mg. Stearate | Lubricant | 1 | 1 | 1 | 1 | |
| Primogel | Disintegrant | 5 | 5 | 5 | 5 | |
| Lactose | Filler | 13.08 | 13.08 | 13.08 | 17.08 | |
| Weight of Tablet | | 650 mg | | | | |

3. Preparation of Batik Clam Shell

   The batik shells are washed, cleaned first under running water and brushed thoroughly to remove any dirt stuck to them, then dried in the sun until dry. After that, the batik clam shells are ground until smooth, then sifted to separate and homogenize the size of the powder.

4. Calcination of Batik clam Shell

   Batik shells that have been refined or turned into powder are calcined by: placing them in a crucible, then placing them in a muffle furnace. Turn on the furnace and set it at 900ºC, then wait for 4 hours (Maisyarah *et al.*, 2019). After that, turn off the furnace and remove the crucible, then let the calcined batik shell powder sit until it cools.

5. Wet Granulation

Mixing of ingredients is carried out using the wet granulation method. Prepare all the tools and materials needed first, then weigh each ingredient according to the needs of each formulation. First, a binder solution is made according to the type of binder and concentration required, by

dissolving the binder in distilled water until it is evenly dissolved. Add batik clam shell extract (active substance), lactose (filler), and primogel (disintegrant ) into the mortar, then grind and mix until homogeneous. Add the binder solution that has been made previously little by little while grinding until homogeneous and until a good granular mass is formed. After that, the wet granule mass was sieved using mesh sieve no. 14, then weighed and recorded the weighing results. Next, the granule mass was dried in an oven at a temperature of 50˚C. The dry granule mass was weighed again and the weighing results were recorded, then sieved using mesh sieve no. 16. Next, the granules are added with Mg. Stearate (lubricant) and mixed until homogeneous, then the physical quality of the granules is tested.

6. Granule Physical Quality Test

- Flow Time Test

A total of 100 grams of granules are put into a funnel with the bottom closed, then smooth the surface of the granules. Prepare a stopwatch, then open the funnel cover at the same time as turning on the stopwatch. Stop the stopwatch when all the granules have flowed and record the time required. Replication was carried out 3 times then the average granule time was taken to compare (Sari et al., 2021). The requirements for the granule flow time test are when the time required is no more than or equal to 10 seconds for 100 grams of granules. Thus, a good flow rate is no more than 10 grams/second (Winarti et al., 2016).

- Angle of Repose Test

The granules are put into a funnel with the bottom closed, then smooth the surface of the granules. Open the funnel cover and let the granules flow down until they form a cone, then calculate and record the angle of repose formed. Replication was carried out 3 times and the average angle of repose obtained was calculated. The angle of repose test requirement is 25° – 40° (Rusdiah *et al.*, 2021). The angle of repose is calculated using the following formula:

$$\text{Tan } \alpha = \frac{h}{r} \quad (1)$$

Information :
α : Still corner
h : Cone height
r : Cone radius (Sinaga & Manalu, 2021).

- Water Content Test

A total of 0.5 – 1 gram of granules is put into the moisture analyzer. Then activate the tool and wait until the granule moisture value is obtained. The water content obtained is recorded. Water content test requirements are less than 2 – 5% (Rijal *et al.*, 2022). Water content is preferably no more than 2%, however if the water content is more than 2% it is still acceptable provided it does not exceed 5%.

7. Tablet Printing

The granules that have been tested are printed using a single punch tablet printer with a weight of 650 mg per tablet, 200 tablets per formulation. Next, the printed tablets are tested for the physical quality of the tablets.

8. Physical Quality Test of Tablets

- Organoleptic Test

Tablets are observed through the sense of sight with several organoleptic assessment parameters such as shape, color, tablet odor, surface shape, and the presence of physical defects (Sari *et al.*, 2021).

- Weight Uniformity Test

A total of 20 tablets were taken randomly from each formulation and then weighed one by one using an analytical balance. Record each weighing result obtained, then calculate the average weight and percentage deviation for each tablet. The requirements for weight uniformity for tablets weighing more than 300 mg are that there must be no more than two tablets whose weight deviates from the average weight by more than 5%, and there must not be a single tablet whose weight deviates from the average weight by more from 10% (Garnadi *et al.*, 2019).

**Table 2.** Tablet Average Weight Deviation (Sinaga & Manalu, 2021)

| Weight (mg) | Average Weight Deviation (%) | |
|---|---|---|
| | Column A | Column B |
| 25 mg or less | 15% | 30% |
| 26 mg – 150 mg | 10% | 20% |
| 151 mg – 300 mg | 7,5% | 15% |
| More than 300 mg | 5% | 10% |

- Size Uniformity Test

A total of 10 tablets taken at random for each formulation were tested for size uniformity using a caliper. Measure the diameter and thickness of the tablets one by one, then record each measurement result obtained. The requirements for the size uniformity test are that the tablet has a diameter of no more than 3 times and no less than $1\frac{1}{3}$ the thickness of the tablet. Meanwhile, a good variation in tablet thickness is approximately 5% of the average value, or the difference in tablet thickness should be indistinguishable just by looking without measuring (Ani, 2016).

- Hardness Test

A total of 6 tablets were taken randomly from each formulation, then one by one they were placed on the tablet hardness tester, namely the hardness tester, in a perpendicular position between the anvil and punch. After that, the tool is turned on and the tablet will be pressed until it breaks, and when the tablet is broken or damaged, the indicator needle on the tool will stop at a number indicating the hardness of the tablet expressed in kilograms. Read and note the number scale that indicates the hardness of the tablet (Sari *et al.*, 2021). Replication was carried out 3 times and then the average tablet hardness was calculated. Tablet hardness test requirements are between 4 – 8 kg (Rustiani *et al.*, 2019).

- Friability Test

The tablet friability test was carried out using a friability tester. A total of 20 tablets were taken randomly for each formulation, then cleaned from dust. The tablet is weighed first and the result is recorded as the initial weight ($W_o$). After that, the tablet is inserted into the friability test equipment with a rotation speed of 25 rpm per minute for 4 minutes, then the total speed becomes 100 rpm. After 4 minutes, the tablet is removed and cleaned of powder/fines, then weighed again and record the results as final weight ($W_f$) (Gozali *et al.*, 2015). Replication was carried out 3 times, then the average and percentage of tablet friability were calculated. Tablet friability test requirements are no more than 1% friability (Rustiani *et al.*, 2019). The percentage of tablet friability can be calculated using the following formula:

$$\% \text{ Tablet fragility} = \frac{Wo - Wf}{Wf} \times 100\% \quad (2)$$

Information :
$W_o$ : Weight before rotation
$W_f$ : Weight after rotation (Ani, 2016).

- Disintegration Time Test

A total of 6 tablets were taken at random for each formulation, then tested for disintegration time using a disintegration tester. Prepare ± 650 ml of distilled water in a 1 liter beaker glass, then put it into the disintegration tester. Set the temperature and time of the disintegration tester to (37 ± 2)ºC for 15 minutes. Insert 6 tablets one by one into each basket tube, then insert the disc into each tube. After the distilled water temperature reaches 37ºC, the tube containing the tablet is inserted into a disintegration tester containing distilled water media. Then run the tool until all the tablets are crushed at a frequency of 30 times per minute. Note the time it takes for the tablet to completely disintegrate (Garnadi *et al.*, 2019). Lift the basket after completing the crush time trial. Replication was carried out 3 times and the average tablet disintegration time was calculated.

The requirements for the tablet disintegration time test are that all tablets must disintegrate in no more than 15 minutes for uncoated tablets, and no more than 60 minutes for

sugar-coated or film-coated tablets (Rustiani *et al.*, 2019). If there are 1 or 2 tablets that do not disintegrate completely within the required time period, then repeat with 6 or 12 other tablets, provided that no less than 16 of the 18 tablets tested must be completely disintegrated (Sinaga & Manalu, 2021).

9. Analysis of Results

Data collection was carried out by observing and measuring the physical properties of the granules and the physical properties of the tablets. Then the data obtained was presented in tabular form and analyzed using the One Way Analysis of Variance (ANOVA) test using the Statistical Package for the Social Sciences (SPSS) program with a confidence level of 95%.

## RESULTS AND DISCUSSION

This research aims to determine the effect of variations in the type of binder on the physical quality of batik shell extract tablet preparations (*Paphia undulata* B.), as well as to determine formulations that have good physical quality of tablet preparations.

A. Calcination of Batik Clam Shells

The previously ground batik shell powder is calcined at 900°C for 4 hours, because at this temperature it is able to fuse other compounds such as sodium (Na) and magnesium (Mg), organic components, as well as the minimum temperature required for the decomposition reaction. namely the reaction of separating a chemical compound into 2 or several parts or into simpler compounds (Maisyarah *et al.*, 2019).

After being calcined at a temperature of 900°C for 4 hours, the batik shell powder experienced a decrease in weight and the color of the powder changed from cream to white. The occurrence of this color change indicates the release and change in the composition of filler elements during the calcination process (Maisyarah *et al.*, 2019). The color change in batik shell powder can be seen in the image below:

(Before) (After)

**Picture 1.** Results Before and After the Calcination Process

B. Making Tablet Preparations

Tablet formulations are made with different types of binder used in each formulation, namely PVP (FI), gelatin (FII), and CMC-Na (FIII) with a concentration used of 4%. Tablet formulation as a negative control (K-) without using a binder and a positive control (K+) using generic calcium lactate® 500 mg tablets produced by PT. AFI FARMA Kediri-Indonesia. Tablets are made using the wet granulation method and printed with a weight of 650 mg per tablet for 200 tablets per formulation.

C. Granule Physical Quality Test

- Granule Flow Time

  The granule flow time test results are presented in the table below:

**Table 3.** Granule Flow Time Test Results

| Formulation | Flow Time (seconds) ± SD |
|---|---|
| Formulation I (PVP) | 3.57 ± 0.19 |
| Formulation II (Gelatin) | 3.34 ± 0.03 |
| Formulation III (CMC-Na) | 3.66 ± 0.10 |
| Formulation K- (Without Binder) | 4.24 ± 0.15 |

Based on the results obtained, it shows that the three treatment formulations for batik shell extract tablets in the granule flow time test with various types of binder had good flow properties, namely with flow speeds in the range of 1.6 – 4 seconds. These results are in accordance with the granule flow time test requirements, namely with a flow speed of no more than 10 grams/second (Winarti *et al.*, 2016).

ANOVA test analysis obtained a significant value of 0.000 ($p<0.05$) indicating that there was a significant difference in the average granule flow time based on variations in the type of binder used in each formulation. Then continued with the post hoc test and the results obtained were that there was a significant difference ($p<0.05$) in the flow time of K- granules (without binder) with the three treatment formulations as well as FII (gelatin) with FIII (CMC-Na), and there was no significant difference ($p>0.05$) in FI (PVP) with FII (gelatin) and FI (PVP) with FIII (CMC-Na).

Based on the granule flow time test results obtained, it shows that FII with gelatin binder has a faster flow time with a value of 3.34 seconds ± 0.03 and K- (without binder) has a longer flow time, namely 4.24 seconds ± 0 .15 compared to the three treatment formulations, namely FI (PVP), FII (gelatin), and FIII (CMC-Na). There are several factors that can influence the flow rate of granules such as shape, size, surface condition and humidity of the granules. The addition of a binder in the formulation aims to improve the physical properties of the tablet, provide adhesion and increase the cohesion of the granule mass, as well as increase the particle size so that it can provide good flow properties (Mindawarnis & Hasanah, 2017). The K- formulation does not use a binder, so the granule mass produced is no better than FI (PVP), FII (gelatin), and FIII (CMC-Na), and the resulting flow rate is longer compared to formulations that use a binder. The smaller the granule size, the more cohesive power it will have, which causes the granules to clump and can hinder flow time.

Testing the flow properties of granules is related to the uniformity of the weight to be made. Granules with poor flow speed will hinder the granule flow process from the hopper into the die, as a result the weight of the tablets produced will not be constant or vary (Rijal *et al.*, 2022).

- Repose Angle Test

  The granule repose angle test results are presented in the table below:

**Table 4.** Repost Angle Test Results

| Formulation | Angle of Repose (°) ± SD |
|---|---|
| Formulation I (PVP) | 28.04 ± 0.53 |
| Formulation II (Gelatin) | 31.26 ± 0.51 |
| Formulation III (CMC-Na) | 37.22 ± 0.52 |
| Formulation K- (Without Binder) | 38.61 ± 0.78 |

The angle of repose test is the maximum angle formed by the powder surface with a horizontal surface during the test. The angle of repose test was carried out to determine the particle cohesiveness of the powder mixture (Rijal *et al.*, 2022). The angle of repose test results obtained meet the angle of repose test requirements, namely 25° – 40°.

The results of statistical tests using the Kruskal-Wallis test obtained a significant value of 0.015 ($p<0.05$) indicating that there was a significant difference in the average angle of repose of granules based on variations in the type of binder used in each formulation. Then, to find out the different groups, the post hoc test was continued with the Mann-Whitney test. The results obtained show that there is a significant difference in the angle of repose of K- granules (without binder) with the three treatment formulations, FI (PVP) with FII (gelatin), FI (PVP) with FIII (CMC-Na) and FII (gelatin) with FIII (CMC-Na).

Based on the angle of repose test results obtained, FI with PVP binder had the smallest angle of repose with a value of $28.04^{\circ} \pm 0.53$ and K- without binder had the largest angle of repose with a value of $38.61^{\circ} \pm 0.78$. The difference in the size of the angle of repose can be influenced by the humidity of the granules and differences in the binder used (Rusdiah *et al.*, 2021). In the research of Mindawarnis and Hasanah (2017), it was explained that PVP can increase the particle size which causes the size and shape of the granules to become larger, and less fines are formed, so that the particles will flow through the funnel hole with a small cohesive force and produce granule flow properties the good one.

The angle of repose is directly proportional to the flow time, the smaller or faster the flow time, the smaller the angle of repose formed. The smaller the angle of repose that is formed, it means that the granules have less cohesiveness so that their flow ability becomes better and the larger the angle of repose that is formed, the more difficult it is for the granules to flow from the hopper to the tablet molding chamber so that the flow properties of the granules become worse (Puspadina *et al.*, 2021).

Evaluation of the angle of repose is related to the cohesive properties between granules. The flatter the pile of granules, the smaller the slope, so that the granules can flow at a constant speed and quantity. A good angle of repose will produce good flow properties and good flow properties will produce good weight uniformity (Winarti *et al.*, 2016).

- Water Content Test

  The granule water content test results are presented in the table below:

**Table 5.** Water Content Test Results

| Formulation | Water Content (%) ± SD |
|---|---|
| Formulation I (PVP) | 1.82 ± 0.14 |
| Formulation II (Gelatin) | 1.55 ± 0.19 |
| Formulation III (CMC-Na) | 2.03 ± 0.39 |
| Formulation K- (Tanpa Pengikat) | 1.71 ± 0.29 |

The water content test is carried out to determine the water content in the granules obtained after the drying process. Because water is a factor that can influence the storage time of granules, and the higher the water content, the easier it is for microbes and fungi to grow during storage (Putra *et al.*, 2019). Based on the results obtained, it shows that granules from FI (PVP), FII (gelatin), FIII (CMC-Na), and K- (without binder) meet the water content test requirements, namely less than 2 – 5%. It is preferred that the water content is no more than 2%, however if the results of the water content exceed 2% it can still be accepted provided it is no more than 5%.

ANOVA test analysis obtained a significant value of 0.245 ($p>0.05$) indicating that there was no significant difference in the average granule water content based on variations in the type of binder used in each formulation, so there was no need to carry out further post hoc tests. The results of these statistical tests show that the different types of binder in the batik shell extract tablet formulation did not provide different results on the water content of the granules in the three treatment formulations or K-.

D. Physical Quality Test of Tablets

- Organoleptic Test

  The organoleptic test assessment results obtained are presented in the table below:

**Table 6.** Organoleptic Test Results

| Formulation | Assessment Parameters | | | | |
|---|---|---|---|---|---|
| | **Shape** | **Color** | **Smell** | **Surface Shape** | **Physical Defect** |
| Formulation I (PVP) | Round | Pale yellow with white spots | Distinctive with a mixture of mint smell | Fine | No |
| Formulation II (Gelatin) | Round | Pale yellow with white spots | Distinctive with a mixture of mint smell | Fine | No |
| Formulation III (CMC-Na) | Round | Yellow with white spots | Distinctive with a mixture of mint smell | Fine | No |
| Formulation K- (Without Binder) | Round | Yellow with white spots | Distinctive with a mixture of mint smell | Fine | No |
| Formulation K+ (Calcium Lactate) | Round | White | Distinctive with a mixture of mint smell | Fine | No |

A comparison of the organoleptic test results for batik shell extract tablets can be seen in the image below:

Formulation I (PVP)

Formulation II (Gelatin)

Formulation III (CMC-Na)


K- (Without Binder) K+ (Calcium Lactate)

**Picture 2.** Physical Appearance of Tablets

Batik clam shell extract tablets have a round tablet shape, pale yellow and yellow color, with a characteristic odor of clam shell extract with a variation of mint smell, have a smooth surface shape without any physical defects. The pale yellow or amber color produced is the color contribution from a mixture of the active ingredient batik shell extract with the additional ingredients lactose, primogel, and a binder solution which produces a yellow color after adding the distilled water solvent. So the resulting batik shell extract tablets are yellow in color.

- Weight Uniformity Test

  The results of the tablet weight uniformity test are presented in the table below:

**Table 7.** Weight Uniformity Test Results

| Formulation | Weight Uniformity (mg) ± SD |
|---|---|
| Formulation I (PVP) | 730.83 ± 2.08 |
| Formulation II (Gelatin) | 742.5 ± 1 |
| Formulation III (CMC-Na) | 742.5 ± 1 |
| Formulation K- (Without Binder) | 738.67 ± 10.60 |
| Formulation K+ (Calcium Lactate) | 565.33 ± 4.31 |

The resulting weight uniformity test showed that the average weight of each formulation did not match the desired tablet weight, namely 650 mg. However, overall each formulation did not have a weight deviation of more than two tablets whose weight deviated from the average weight by more than column A, namely 5% and there was not a single tablet whose weight deviated from the average weight by more than column B, namely 10%. The weight deviation calculation is carried out using the resulting average weight. Meanwhile, the difference between the resulting weight and the desired weight is FI (PVP) 11.06%; FII (gelatin) 12.45%; FIII (CMC-Na) 8.57%; and K- (without binder) 12.00%. This is thought to occur because the tablet printer used cannot be adjusted according to the desired tablet weight, so the resulting weight depends on the tablet printer.

The results of statistical tests using the Kruskal-Wallis test obtained a significant value of 0.016 ($p<0.05$) indicating that there was a significant difference in the average uniformity of tablet weight based on variations in the type of binder used in each formulation. Then, to find out the different groups, the post hoc test was continued with the Mann-Whitney test. The results obtained showed that there was a significant difference in the weight of K+ (calcium lactate) tablets with K- (without binder), K+ (calcium lactate) with the three treatment formulations, K- (without binder) with FIII (CMC-Na), FI ( PVP) with FII (gelatin), FI (PVP) with FIII (CMC-Na) or FII (gelatin) with FIII (CMC-Na), and there was no significant difference in the weight of K- (without binder) tablets with FI (PVP ) or K- (without binder) with FII (gelatin).

- Size Uniformity Test

  Tablet size uniformity test results are presented in the table below:

**Table 8.** Size Uniformity Test Results

| Formulation | Average Measurement (mm) | |
|---|---|---|
| | Diameter ± SD | Thickness ± SD |
| Formulation I (PVP) | 12.76 ± 0.034 | 5.14 ± 0.020 |
| Formulation II (Gelatin) | 12.25 ± 0.023 | 4.90 ± 0.035 |
| Formulation III (CMC-Na) | 12.23 ± 0.003 | 5.23 ± 0.025 |
| Formulation K- (Without Binder) | 12.14 ± 0.006 | 4.86 ± 0.024 |
| Formulation K+ (Calcium Lactate) | 13.14 ± 0.064 | 3.38 ± 0.076 |

The tablet size uniformity test obtained showed that FI (PVP), FII (gelatin), FIII (CMC-Na), and K- (without binder) met the size uniformity test requirements, namely that the tablet had a diameter of no more than 3 times and no less than $1\frac{1}{3}$ tablet thickness. Meanwhile, K+ does not meet the size uniformity test requirements because the resulting diameter is more than 3 times the thickness of the tablet.

The results of statistical tests using the Kruskal-Wallis test obtained a significant value of 0.010 ($p<0.05$) indicating that there was a significant difference in average size uniformity based on variations in the type of binder used in each formulation. Then, to find out the different groups, the post hoc test was continued with the Mann-Whitney test. The results obtained show that there is a significant difference in the uniformity of the diameter of tablets K+ (calcium lactate) with K- (without binder), K+ (calcium lactate) with the three treatment formulations, K- (without binder) with the three treatment formulations, FI (PVP ) with FII (gelatin) or FI (PVP) with FIII (CMC-Na), and there was no significant difference between FII (gelatin) and FIII (CMC-Na). The results obtained also show that there is a significant difference in the uniformity of tablet thickness of K+ (calcium lactate) with K- (without binder), K+ (calcium lactate) with the three treatment formulations, K- (without binder) with FI (PVP), K - (without binder) with FIII (CMC-Na), FI (PVP) with FII (gelatin), FI (PVP) with FIII (CMC-Na) or FII (gelatin) with FIII (CMC-Na), and none significant difference in K- (without binder) and FII (gelatin).

Each formulation produces different tablet thicknesses, namely FI (PVP) 5.14 ± 0.020, FII (gelatin) 4.90 ± 0.035, FIII (CMC-Na) 5.23 ± 0.025, and K- (without binder) 4.86 ± 0.024. This is influenced by the amount of material filled into the mold or die, pressure that is not constant, and the amount of pressure during printing. Meanwhile, for measuring tablet diameter, the same results were obtained because the tablets were printed using the same tablet printer (Mindawarnis & Hasanah, 2017). The uniformity of tablet size will affect the appearance of the resulting tablet (Winarti *et al.*, 2016).

- Tablet Hardness Test

  Tablet hardness test results are presented in the table below:

**Table 9.** Tablet Hardness Test Results

| Formulation | Tablet Hardness (kg) ± SD |
|---|---|
| Formulation I (PVP) | 14.44 ± 1.24 |
| Formulation II (Gelatin) | 12.57 ± 0.74 |
| Formulation III (CMC-Na) | 2.17 ± 0.92 |
| Formulation K- (Without Binder) | 7.37 ± 0.56 |

| | |
|---|---|
| Formulation K+ (Calcium Lactate) | 17.47 ± 0.54 |

Tablet hardness is a parameter to describe the tablet's resistance to mechanical stress such as shaking, abrasion and cracking of the tablet during packaging, transportation and use. A tablet must have a certain hardness so that it has good strength or durability but is able to dissolve in the body when it meets digestive juices (Rustiani *et al.*, 2019). Based on the results of the five formulations, it shows that only K- (without binder) with a hardness value of 7.37 kg ± 0.56 meets the tablet hardness test requirements, namely between 4 - 8 kg (Rustiani *et al.*, 2019). In general, a good tablet is stated to have a hardness value of between 4 – 8 kg. However, this is not absolute, meaning that tablets that have a hardness of less than 4 kg can still be accepted provided that the friability value does not exceed the specified value. And tablets that have a hardness greater than 8 kg can still be accepted provided that the tablet still meets the specified disintegration and dissolution time requirements (Adnan, 2017).

Formulations that have higher hardness than the test requirements are FI (PVP) 14.44 kg ± 1.24, FII (gelatin) 12.57 kg ± 0.74, and K+ (calcium lactate) 17.47 kg ± 0.54. And the formulation that has a hardness that is smaller than the test requirements is FIII (CMC-Na) 2.17 kg ± 0.92. In research by Putri and Husni (2018) it is stated that PVP and gelatin as tablet binders can produce tablets with relatively large hardness, low brittleness, and longer disintegration time. Meanwhile, CMC-Na which is hygroscopic with the ability to absorb water up to >50% can be a factor in the small hardness value of the tablets produced (Ambari *et al.*, 2019).

ANOVA test analysis obtained a significant value of 0.000 ($p<0.05$) indicating that there was a significant difference in average tablet hardness based on variations in the type of binder used in each formulation. Then continued with the post hoc test and the results obtained were that there was a significant difference in the hardness of K+ (calcium lactate) tablets with K- (without binder), K+ (calcium lactate) with the three treatment formulations, K- (without binder) with the three treatment formulations, FI (PVP) with FII (gelatin), FI (PVP) with FIII (CMC-Na) or FII (gelatin) with FIII (CMC-Na).

Several factors can influence tablet hardness, namely compression pressure, the materials used, the nature of the material being compressed and the type of binder used. Tablet hardness is used as a measure of tablet compression pressure. The greater the pressure applied during tabletting will increase the hardness of the tablet (Najihudin *et al.*, 2021). Tablet hardness is directly related to brittleness and disintegration time, that is, tablets with high hardness will have a stronger bond and higher density, so that the tablet will have a small brittleness value with a longer disintegration time (Mindawarnis & Hasanah, 2017).

- Tablet Friability Test

  The results of the tablet friability test are presented in the table below:

**Table 10.** Tablet Friability Test Results

| Formulation | Tablet Fragility (%) ± SD |
|---|---|
| Formulation I (PVP) | 0.20 ± 0.07 |
| Formulation II (Gelatin) | 0.38 ± 0.08 |
| Formulation III (CMC-Na) | 12.75 ± 0.40 |
| Formulation K- (Without Binder) | 0.54 ± 0.13 |
| Formulation K+ (Calcium Lactate) | 0.21 ± 0.05 |

The tablet friability test shows the resistance of the tablet surface to friction during the packaging and shipping process until distribution to consumers. Based on the results of the friability test, it shows that the formulation meets the test requirements, namely FI (PVP) 0.20% ± 0.07, FII (gelatin) 0.38% ± 0.08, K- (without binder) 0.54% ± 0 .13 and K+ (calcium lactate) 0.21% ± 0.05. Meanwhile, FIII (CMC-Na) with a fragility value of 12.75% ± 0.40 does not meet the test

requirements, namely with a fragility of more than 1%. And the formulation that has the smallest fragility value is FI with PVP binder. This is because FIII has the lowest hardness and FI has high hardness. This result is in accordance with the theory that brittleness is also influenced by tablet hardness and the bonds between tablet particles, namely tablets with high hardness values have strong bonds between their particles, so they will produce small brittleness values and vice versa (Mindawarnis & Hasanah, 2017).

The results of the statistical test using the Kruskal-Wallis test obtained a significant value of 0.013 ($p<0.05$) indicating that there was a significant difference in the average tablet friability based on variations in the type of binder used in each formulation. Then, to find out the different groups, the post hoc test was continued with the Mann-Whitney test. The results obtained show that there is a significant difference in the fragility of K+ (calcium lactate) tablets with K- (without binder), K+ (calcium lactate) with FII (gelatin), K+ (calcium lactate) with FIII (CMC-Na), K- (without binder) with FI (PVP), K- (without binder) with FIII (CMC-Na), FI (PVP) with FII (gelatin), FI (PVP) with FIII (CMC-Na) or FII (gelatin) with FIII (CMC-Na), and there was no significant difference in K+ (calcium lactate) with FI (PVP) or K- (without binder) with FII (gelatin).

- Disintegration Time Test

  The tablet disintegration time test results are presented in the table below:

**Table 11.** Disintegration Time Test Results

| Formulation | Crushing Time (Minutes) |
|---|---|
| Formulation I (PVP) | > 45 Minutes |
| Formulation II (Gelatin) | > 45 Minutes |
| Formulation III (CMC-Na) | > 45 Minutes |
| Formulation K- (Without Binder) | > 45 Minutes |
| Formulation K+ (Calcium Lactate) | 12 minutes 34 seconds |

The results of the disintegration time test for FI (PVP), FII (Gelatin), and FIII (CMC-Na) batik shell extract tablets with a binder concentration of 4% did not meet the requirements for the disintegration time test for uncoated tablets, namely with a result of no more than 15 minutes (Rustiani *et al.*, 2019). However, the time required for FI (PVP), FII (Gelatin), and FIII (CMC-Na) batik shell extract tablets to disintegrate was more than 45 minutes, and only the K+ formulation with generic calcium lactate testing tablets was produced by PT. AFI Farma Kediri-Indonesia which meets the disintegration time test requirements by requiring a disintegration time of 12 minutes 34 seconds to completely disintegrate. So FI (PVP), FII (Gelatin), and FIII (CMC-Na) do not meet the tablet disintegration time test requirements.

ANOVA test analysis obtained a significant value of 0.008 ($p<0.05$) indicating that there was a significant difference in the average tablet disintegration time based on variations in the type of binder used in each formulation. Then continued with the post hoc test and the results obtained were that there was a significant difference in the disintegration time of K+ (calcium lactate) tablets with K- (without binder), K+ (calcium lactate) with the three treatment formulations, and there was no significant difference in K- ( without binder) with the three treatment formulations, FI (PVP) with FII (gelatin), FI (PVP) with FIII (CMC-Na) and FII (gelatin) with FIII (CMC-Na).

After the disintegration time test was carried out on the batik shell extract tablet formulation with variations in the type of binder used, it gave rise to new speculation regarding batik shell extract. Based on the results of the K- disintegration time test (without binder) which requires a disintegration time of more than 45 minutes or the same as FI (PVP), FII (Gelatin), and FIII (CMC-Na) which use a binder, batik shell extract is suspected to have potential as a binder in tablet formulations. In research by Sulaiman and Sulaiman (2020), one of the additional ingredients in tablet formulations that functions as a filler and binding agent is calcium (sulfate, carbonate or phosphate). Thus, K- without using a binder requires the same disintegration time as a formulation that uses a binder.

## CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the variations in the types of binders FI (PVP), FII (gelatin), and FIII (CMC-Na) in the formulation of batik shell extract tablets (*Paphia undulata* B.) use the wet granulation method. have different influences on the physical quality of the tablets produced, namely weight uniformity, size uniformity, tablet hardness and tablet friability. And the three treatment formulations that have good physical tablet quality are FI (PVP) and FII (gelatin) because they meet the size uniformity test requirements and have hardness and brittleness test values that are almost close to K+. However, these two formulations still do not meet the requirements of the weight uniformity test and disintegration time test.

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