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The optimization of porang starch-lactose as a co-processed excipient for bajakah (*Spatholobus littoralis* Hassk) root dried extract effervescent tablet

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Abstract
Previous research has confirmed the efficacy of Bajakah root from Kalimantan, Indonesia. One of them is the high antioxidant activity. Still limitation of information Bajakah root in the pharmaceutical dosage form. This study will formulate bajakah root in an effervescent tablet delivery system. Co-processed excipients of lactose-porang starch are designed to produce excellent flow properties, improve tablet hardness, and have good compatibility. However, the proportions of porang starch and lactose as co-processed excipients will be determined using the Simplex Lattice Design (SLD) method with tablet hardness, friability, and dissolve time response parameters. Granules were tested for the flow properties and repose of angle. The tablets were tested for weight uniformity, hardness, brittleness, and dissolve time. The antioxidant activity was tested using the DPPH method, and all test data was analyzed using the One Sample T-test. Bajakah root has IC50 0f 0.155 mg/mL and quercetin content of 2.19% w/w. The effervescent tablets with co-processed excipient porang starch-lactose in the ratio of 64: 36% w/w provide good physical stability, tablet weigh uniform, granule flow time of 10.45 ± 0.29 g/sec, granule repose of angle of 27.52 ± 0.95°; tablet hardness 5.74 ± 0.07 Kg, friability of 0.549 ± 0.03%; dissolve time 86 ± 4 seconds.

Keywords: Bajakah root, Co-processed excipient, Effervescent tablets, Porang.

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Optimasi amilum porang-laktosa sebagai *co-processed excipient* tablet effervescent ekstrak air akar bajakah (*Spatholobus littoralis* Hassk)

Abstrak
Penelitian sebelumnya telah mengkonfirmasi manfaat kesehatan akar Bajakah yang berasal dari Kalimantan, Indonesia. Salah satunya adalah aktivitas antioksidan yang kuat. Informasi formulasi bentuk sediaan farmasi dari akar bajakah masih terbatas. Penelitian ini akan memformulasikan akar bajakah dalam sistem penghantaran tablet *effervescent*. Eksipien pati porang-laktosa yang dikombinasi bersama dirancang untuk menghasilkan sifat alir yang sangat baik, meningkatkan kekerasan tablet, dan memiliki kompatibilitas yang baik. Namun proporsi pati porang dan laktosa sebagai eksipien *co-processing* akan ditentukan menggunakan metode *Simplex Lattice Design* (SLD) dengan parameter kekerasan tablet, kerapuhan, dan respon waktu larut. Granul *effervescent* diuji sifat aliran dan sudut diamnya. Tablet *effervescent* diuji keseragaman bobot, kekerasan, kerapuhan, dan waktu larut. Aktivitas antioksidan diuji dengan metode DPPH, dan seluruh data pengujian dianalisis menggunakan uji *One Sample T-test*. Akar bajakah memiliki aktivitas antioksidan dengan nilai IC_{50} 0,155 mg/mL dan kandungan kuersetin 2,19% b/b. Tablet *effervescent* dengan *co-processed* eksipien pati porang-laktosa dengan perbandingan 64:36% b/b memberikan stabilitas fisik yang baik, berat tablet seragam, waktu alir granul 10,45 ± 0,29 g/detik, sudut istirahat granul 27,52 ± 0,95°; kekerasan tablet 5,74±0,07 Kg, kerapuhan 0,549±0,03%; waktu larut 86 ± 4 detik.

Kata Kunci: Akar bajakah, Co-processed excipient, Tablet effervescent, Umbi porang.

1. Introduction

Bajakah root (*Spatholobus littoralis* Hassk) is a plant empirically used by Kalimantan's people as traditional medicine. Based on the phytochemical screening by Nur Syafitir et al[19], Bajakah root contains flavonoid, saponin, tannin, and polyphenol. Iskandar and Warsidah[16] found that the bajakah root contains alkaloid and steroid, and the main secondary metabolites is flavonoid. Research by Fitriani et al[11] stated that the antioxidant activity (IC_{50}) of Bajakah roots is 0.026 mg/mL stronger than vitamin C, which has an IC_{50} value of 0.031 mg/mL. Processing of the Bajakah root as traditional medicine is still simple by boiling or brewing. The bitter taste and aroma are unpleasant and unstable enough to be stored for a long time, so it needs to be developed into a practical and efficacious dosage form. Effervescent tablets are the choice for producing pharmaceutical preparations from bajakah root infusions. This preparation is expected to accelerate drug absorption because it does not go through the stages of disaggregation and disintegration. Effervescent tablets make it easy for people who have difficulty swallowing conventional tablets. The balanced ratio of acids and bases in effervescent tablets makes it a gastric-compatible buffer.[21] In effervescent tablets, the active substance will be released more quickly when the tablet is put in water because of the reaction between the acid and carbonate sources.[5] Effervescent tablets are prepared using the direct compression method.

Co-processed excipient is a technique of developing excipients for direct compression by combining two or more excipients with physical modification without changing the chemical structure of each constituent. A combination of several excipients will produce new excipients that have properties that can complement and cover the undesirable properties of a single excipient. Co-processed excipients successfully developed and patented, such as StarLac® containing starch and lactose, have succeeded in accelerating tablet disintegration and drug release and producing good flow and compressibility properties.[20] Another advantage of co-processed excipients is that they produce tablets that increase tablet speed, minimize the use of lubricants, and improve tablet hardness and compatibility.

Porang (*Amorphophallus muelleri* Blume) is a local tuber belonging to the *Araceae* tribe and the Monocotyledoneae class. This tuber contains amylum and amylopectin, which can act as tablet fillers, binders, and capsule wrappers in the pharmaceutical industry.[27] Fresh porang tubers produced an amylum yield of 7.65%, while in the form of starch, it was 10.24%. Porang also contains glucomannan and has high economic value because it is exported to several countries such as Taiwan, Korea, China, Netherlands, England, and other European countries. Processing of porang tubers produces flour as a food ingredient for making konyaku (a type of tofu) and shirataki (a kind of noodle) for Japanese cuisine, also for polish fabrics such as cotton/wool, paper adhesives, paints which have better properties and practical.

In conventional tablets, starch and lactose are commonly used as an excipients and ingredient fillers.[15] Amylum included plastics materials,[25] a glucose homopolymer having α-glycosidic bonds; starch consists of two fractions that can be separated by hot water. The dissolved fraction is called amylose, and the undissolved fraction is called amylopectin. Using starch as a co-processed excipient is still limited; porang is one of the local tubers that can produce starch. Lactose is sugar obtained from milk and can be in the form of anhydrous or monohydrate. Lactose is soluble in water and more soluble in boiling water.[17] This research will isolate starch from porang tubers, which will then be processed with lactose to become a co-processed excipient. This co-processed excipient will be used as a filler for the dried extract of the bajakah root in effervescent tablet.

Co-processed excipients were processed using the wet granulation method and PVP K30 as a binder. Ermawati et al[9] reported that co-processed excipient development was carried out by combining suweg tuber starch (*Amorphophallus campanulatus* Bl. Decne) and lactose as a filler with a ratio of 64.32%: 35.68% can produce excipients which has flow properties and compressibility according to the requirements and profiles good drug release. This study determined the proportions of suweg starch and lactose as co-processed excipients using the Simplex Lattice Design method with the hardness parameters and dissolution time. Simplex Lattice Design is one of the mixed optimization methods used to determine the profile of mixed effects on a parameter.[6]

2. Materials and Methods

2.1. Tools

Analytical balance (KERN: ABS 220-4, Germany), hot plate (IKA C-MAG, Germany), magnetic stirrer (Cole Permer, Canada), moisture analyzer (Ohaus, USA), Freez-Drying (alpha LD plus), hardness tester (Tianjin Guoming Medicinal Equipment Co., Ltd, China), friability tester (Tianjin Guoming Medicinal Equipment Co., Ltd, China), climate chamber (Memmert, Germany), oven (Memmert, Germany), tablet machine (Single Punch TDP 1.0, China.

2.1. Materials

Porang tubers harvested on a Gawanan, Central Java, Indonesia; lactose (DMV-Fonterra Excipients GmbH & Co. KG); citric acid anhydrous (Weifang Ensign Industry, China); sodium bicarbonate (repacking by CV Agung Jaya, Surakarta, Indonesia); sucrose (J.T Baker, USA), PVP K-30 (repacking by Planet Kimia, Jakarta, Indonesia); sodium benzoate (Gloria Interchem PVT Ltd, India), taro flavor powder (Ever Style Foodstuff Industrial Co., Ltd, Taiwan); water (repacking by Saba Kimia, Surakarta, Indonesia); DPPH reagent (Sigma-Aldrich Corporation, USA

2.2. Methods

2.2.1. Samples preparation

Plant determination was conducted by comparing plants with literature based on plants' morphological and taxonomic characteristics. It was conducted at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, UNS Surakarta, Indonesia.

Porang tubers were aged 8-10 months and harvested at the end of March 2022.[30] Porang tubers were washed, peeled, and grated. Grated results were then extracted with water at a ratio of 1:3 and 5:3 for 15 minutes and then filtered, which was done twice. The filtrate obtained was kept for 12 hours, and the water was removed to obtain a precipitate of starch. The wet starch was then dried in an oven at 60°C for 5 hours until dry, then sieved using a 90-mesh sieve.[24] The water content of porang tuber starch was analyzed using a moisture analyzer.

Bajakah roots of 50 grams were boiled with 1000 mL of water; this process was repeated twice with a ratio of 1:20 and 1:10 using the inundation method, which was heating for about 15 minutes at a temperature of around 90°C. Bajakah root solution is then filtered and dried using a freeze dryer for 5 days to get the dried extract of bajakah root.

2.2.2. Antioxidant activity test of bajakah root dried ex tract

DPPH reagent powder was weighed carefully 15.8 mg and then dissolved with pro-analysis 96% ethanol in a 100 mL volumetric flask. Take a solution of 1.0 mL of 0.4 mM DPPH stock solution using a 100-1000 µL micropipette and dilute with 96% ethanol p.a in a 5 mL measuring flask. The maximum wavelength of a solution was scanning in the range of 200-700 nm using a UV-Vis spectrophotometer, where 96% ethanol p.a solution is blank. Bajakah root dried extract was weighed 500 mg and then dissolved with 96% ethanol p.a in a 50 mL volumetric flask. The stock solution I was taken was 0.5; 1.0; 2.0; 3.0; 4.0; and 5.0 mL using a 100-1000 µL micropipette into 5 mL volumetric flask, then 96% ethanol p.a was added respectively.

The stock solution I was taken in the amount of 2.0 mL, then adds 1.0 mL of 0.4 mM DPPH solution was into a 5 mL volumetric flask and diluted with 96% ethanol p.a. The mixed solution was read for its absorbance at the maximum wavelength of DPPH using a UV-Vis spectrophotometer. The standard curve was obtained by relating the concentration (y-axis) and the absorbance value obtained. The calculation of the curve linearity standard was done by calculating the value of the coefficient of relation (r), which gives the best linearity (r>0.99). After the linear regression equation is obtained, the IC_{50} of the bajakah root can be calculated.[29]

2.2.3. Active Ingredients Test of Bajakah root dried ex tract

The standard curve: Weigh the quercetin standard 10.0 mg and add 0.3 mL of 5% sodium nitrite. After 5 minutes add 0.6 mL 10% aluminum chloride, wait 5 minutes, add 2.0 mL sodium hydroxide 1.0 M. Add distilled water to 10 mL using a measuring flask. Transfer into a cuvette, fixed absorption at a wavelength of 510 nm.

Weigh 50 mg of the sample and add 0.3 mL of 5% sodium nitrite. After 5 minutes, add 0.6 mL 10% aluminum chloride, wait 5 minutes, and add 2 mL sodium hydroxide 1.0 M. Add up to 10 mL of distilled water with a measuring flask. Move to the cuvette; absorption remains at a wavelength of 510 nm.

2.2.4. Optimization of Co-processed excipient

Co-processed excipients were optimized by combining porang starch and lactose. Based on the hardness and tablet dissolving time response, the proportion of co-processed excipients to produce an optimum effervescent tablet formula with the simplex lattice design method. The upper limit of lactose and porang starch on software design experts was 100%, and a lower limit of 0% due to the absence of previous research which optimizes porang starch as co-processed excipients. Based on the upper and lower limit values using the simplex lattice design method, eight formulas were obtained with variations in the composition of porang starch-lactose.

Co-processed excipients were formulated using the wet granulation method and PVP K-30 as a binder. Porang starch and lactose were weighed according to the amount of composition obtained from the Simplex

Lattice Design. Co-processed excipients of 30 grams required a ratio of PVP K-30 and tablet fillers of 1:9, namely PVP K-30 of 3 grams and tablet fillers of 27 grams. PVP K-30 was added with 10 mL of hot water and stirred until it swelled, add starch and lactose, then stir until it formed a moist mass. The moist mass is sifted through a sieve of 18 mesh. Granules were dried in the oven at 50°C for 30 minutes. The dry granules were then sieved through a 30-mesh sieve to obtain co-processed excipients.[14] Co-processed excipients of effervescent tablet formula analyzed based on tablet hardness and dissolution time response. The optimum formula was determined by analyzing the test results based on the hardness response and tablet dissolving time. Design Expert software will analyze the model of the response. The optimum formula was determined based on good standard criteria of effervescent tablet with a desirability value close to one.[22]

2.2.5. Tablet formulation of bajakah root dried extract

Table 1 was the effervescent tablet formula. Composition of citric acid and sodium bicarbonate required for tablets effervescent was with a mole ratio of 1: 3.4. The orientation results using a comparison of citric acid and sodium bicarbonate ratio 2.3: 7.8; 2.4: 8.2; 2.5: 8.5; 2.6: 8.8 tablets were obtained. The best a mole ratio of citric acid: Na bicarbonate for 500 mg effervescent tablet was 2.5: 8.5, with the percentage of citric acid: sodium bicarbonate of 29.76% and 44.3%, respectively. Co-processed excipients were added to formulas, a maximum of 12% of the total weight of the tablet. Na benzoate as a preservative was used according to requirements determined by the European Commission[10] for oral preparations at a maximum of 0.5%. Taro Flavor Powder contains dextrose monohydrate, flavor, and dyes maximum limit for food additive consumption of 3000 mg/KgBB/day.[7]

2.2.6. The evaluation of granule and Tablet of bajakah root dried extract optimum formula

Granules of 100 grams were weighed and then put in a funnel, open the cover of the test equipment so that the granules flow. Granule flow time was recorded, and the granule flow rate was calculated by equation (1) and replicated three times. The granule heap was then measured for the height and diameter of the cone formed, and the angle of repose of the granule was calculated by equation (2) and replicated three times. Equation (1) V=m/t where m was granules weight (grams), t was time (second), and V was granules flow rate (g/second). Equation (2) Tg β=h/r where h was distance (cm), and r was radius (cm) and Tg β was angle of response (°).

A total of 20 tablets were weighed, and the average weight of each tablet was calculated. The weight of tablets should not deviate at two tablets weighing 5% from the average weight, and all the tablets should be at most 10% from the average for tablets. These requirements for tablet weight above 300 mg can also be calculated as Standard Deviation and Coefficient of Variation. A total of six tablets were taken randomly and tested with a hardness tester. The scale on the equipment test was read when the tablet was broken, the results obtained were recorded, and then the average value was determined. A total of 20 tablets were dust-free and then weighed and rouned using a friabilator tester for 100 rounds for 4 minutes, then dusted and weighed again. The tablet friability was calculated from the reduced tablet weight after treatment and calculated by dividing the last weight with the initial weight then multiplying it by 100 percent. The effervescent tablet was put into a beaker containing 200 mL of distilled water at room temperature 25°C ± 1°C. Dissolving time was calculated from when the effervescent reaction ended until it formed a clear solution; the test was repeated three times. The granuls and tablet effervescent of bajakah root dried extract can be seen in Figure 1.

2.2.7. Physical evaluation of effervescent tablet at var ying storage temperature

A physical evaluation of tablet at varying storange temperature was carried out for four weeks. The effervescent tablet optimum formula was stored in

Table 1. The effervescent tablet of bajakah root dried extract optimum formula

Tablet ingredients	Weight (mg)	Function
Bajakah root dried extract	25.0	Antioxidant
Natrium bicarbonate	221.5	Base phase
Citric acid	150.0	Acid phase
Co-processed excipient	60.0	Tablet filler
Sucrose	2.5	Sweetener
PVP	30.0	Tablet binder
Natrium benzoate	2.5	Preservative
Taro Flavour	8.5	Flavouring agent
	500.0	

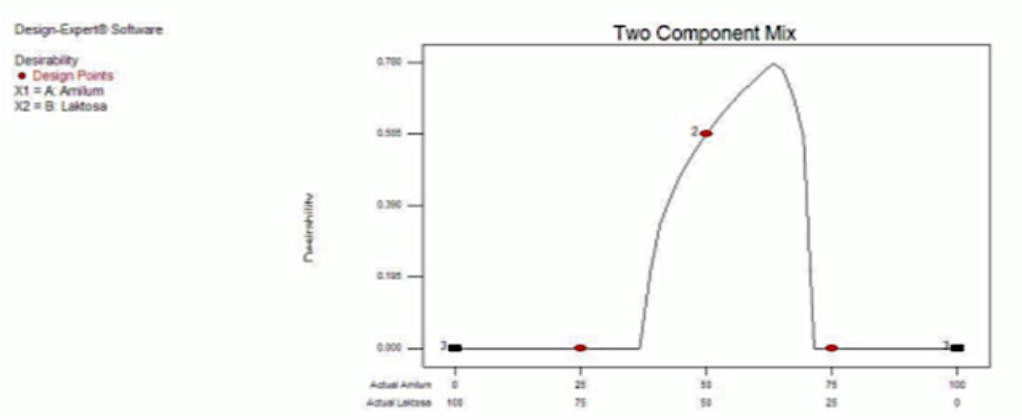

Figure 1. The contour plot diagram of co-processed excipient optimum formula

aluminum foil at room temperature. Tablets evaluated the parameters of physical properties, including hardness, friability, and time dissolved at week 0 and week 4.[18]

2.2.8. Data Analysis

Optimization of the co-processed excipients of the combination of porang and starch lactose using the Software Design Expert Method Simplex Lattice Design with hardness and dissolving time response. The physical properties test of granules, tablets, and stability by statistical analysis of the T-test using SPSS software, in addition to evaluating the results of research based on the study of research journals and the Indonesian Pharmacopoeia and USP compendia.

3. Results

Determination carried out at Biology Laboratory, Mathematics, and Natural Science, Universitas Sebelas Maret, Surakarta, Indonesia, with document number 013/UN27.9.6.4/Lab/2022. Based on referring to the Flora of Java by C.A. Baecker and R.C. Bakhuizen van den Brink, Jr. (1963, 1968) showed that tubers belong to the family Araceae, genus *Amorphophallus* and species *Amorphophallus mueller* (Blume) and has another name *Amorphophallus oncophyllus* Prain ex Hook. F. The resulting starch yield was 12.0%. Porang tuber starch form has brown sugar color with a tuber-specific odor and smooth texture. The acceptable starch water content to inhibit the microbes was 15%.[24] The water content results of porang tuber starch were 11.05%, which shows that the water content of starch complies with the requirements.

Optimization of co-processed excipients to determine the effect of a mixture of porang starch and lactose as a co-processed excipient. Their effect on the properties of effervescent tablets form. The results of the effervescent tablets evaluation were presented in Table-2. Tablet hardness of less than 2 Kg does not meet the effervescent tablet hardness requirements.[13] The mathematical equation for tablet hardness was Y= 0.015 (A) -0.029 (B) + 1.019 (A)(B), this equation shows a quadratic model, which means that the combination of porang starch and lactose was an interaction. Those models show a significant value and a lack of fit parameters that were not significantly different. This indicates the suitability of the observed response data with the model.[23] The combination of porang starch and lactose that causes the increase in tablet hardness was indicated by a positive coefficient value of +1.019(A)(B). Amylum contains amylopectin, which has an important role as a binder. Lactose can form intergranular bonds with PVP K30 stronger than intergranular starch bonds,[13] so effervescent tablets with co-processed excipients of lactose-starch combination meet the requirement for the tablet hardness. Based on the evaluation results the dissolving time of all effervescent tablet formulas meet the required-time standard by WHO,[28] which was less than 300 seconds. On average, the fastest dissolving time was owned by the dominant formula of lactose, while the dominant formula of starch owned the longest dissolving time. The mathematical equation for the dissolving time of effervescent tablets was Y = 2.17 (A) + 2.68 (B) – 4.42 (A)(B). This equation shows a quadratic model, which means there was an interaction in the combination of porang tuber starch and lactose.

The desirability value obtained based on Software Design Expert was 0.8; this value was close to 1, which meant the formula recommended by software to produce the best product.[22] The co-processed excipient combination based on tablet hardness and dissolving time response was a combination of porang starch-lactose in ratio of 64%: 36%. A predicted hardness value of optimum formula was 4.98 Kg and 90 seconds dissolution time, respectively. The contour plot diagram of co-processed excipient optimum formula can be seen in Figure 2 where the optimum ratio of porang starch-lactose in ratio of 64%: 36%.

Figure 2. The result of bajakah root dried extract effervescent tablet optimum formula. There is co-processed excipient optimum ratio of 64: 36% [A], Bajakah root dried extract effervescent tablet [B], and solution of Bajakah root dried extract efferves cent tablet [C]

3.1. Antioxidant Activity

The result of the DPPH maximum wavelength was 518 nm. The relationship between the concentration of the extract solution (mg/mL) with antioxidant activity (%) showed that with the increase in the concentration of the extract, the antioxidant activity also increases. The IC_{50} value of the Bajakah root is calculated using the linear regression equation obtained on the standard curve of y = 356.48x – 4.657. In this study, the IC_{50} value obtained was 0.155 mg/mL, which means it is classified as very potent because it has an IC_{50} value of less than 50 mg/mL. Compared with research by Salsabila H[26] the IC_{50} value obtained was 0.071 mg/mL. So, from Therefore, it can be concluded that the Bajakah root dried extract used in this study contains potent antioxidants.

Bajakah root dried extract and tablet were calculated using the linear regression equation obtained on the quercetin standard curve of y = 0.00457 x - 0.01116 with correlation coefficient r^2 = 0.99889. The quercetin content in the extract was 2.19% w/w, and after being formulated into an effervescent tablet, it was 1.26% w/w.

3.2. Evaluation of bajakah root dried extract

3.2.1. Effervescent tablet of optimum formula

Based on the evaluation results, the flow rate of the formula powder mixture optimum has an average of 10.45 ± 0.24 gram/second. This flow rate complies with good flow rate requirements between 4-10 grams/second4. According to Aulton,[4] fixed angle powder less than or equal to 30° indicates that the powder is flowing freely, while the repose of angle which is greater or equal to 40° power the flow is not required. Results show an average repose of angle is 27.52° ± 0.95, and this indicates a repose of angle granule of effervescent tablet optimum formula meets the required properties of good flow. Flow properties of the granule influence weight uniformity during filling from the hopper into the die at a constant volume so that uniform tablet weight is obtained. Weight uniformity is also related to the uniformity of drug content in tablets. The result of the weight uniformity optimum formula effervescent tablet is 498.6± 4.89 mg. According to Gootenilleke et al,[12] the hardness of effervescent tablets is between 2 -10 Kg. The result of the hardness test of effervescent tablets of the bajakah root dried extract optimum formula was 5.74 ± 0.07 Kg. The resulting tablet hardness meets the requirements of the claim patent by Gootenilleke et al.[12]

Table 2. The results of the evaluation of the hardness response and dissolving time of tablets based on Design Expert Software

Run Formula	Porang starch (%)	Lactose (%)	Hardness (Kg)	Dissolve Time (second)
1	100	0	3,81 ± 0.08	120 ± 4.51
2	50	50	5.75 ± 0.10	86 ± 3.06
3	100	0	1.89 ± 0.08	110 ± 4.58
4	0	100	2.81 ± 0.04	51 ± 4.58
5	50	50	5.78 ± 0.05	82 ± 3.18
6	0	100	2.69 ± 0.10	47 ± 4.55
7	25	75	2.81 ± 0.05	90 ± 4.12
8	75	25	2.64 ± 0.06	94 ± 5.05

Table 3. The results of the evaluation of the hardness response and dissolving time of tablets

Test Parameter	DX Prediction	Test Evaluation	p-value	Description
Hardness	4.98 Kg	5.74 ± 0.07 Kg	0.05	Not significant
Dissolve time	90 second	86 ± 4 second	0.02	Not significant

Friability affects the hardness and dissolving time of effervescent tablets. The small value of fragility causes tablet hardness to increase and extends the dissolution time. The friability of a good effervescent tablet is less than 1%.[17] Fragility is also a consideration for the acceptance of tablet hardness. If tablet hardness is small, but its fragility still meets the standard, so tablet hardness is accepted. The results of the friability test of the bajakah root dried extract effervescent tablet fulfill good tablet friability requirements, with an average of 0.549 ± 0.03%. The dissolving time of an excellent effervescent tablet is less than 5 minutes.[28] The results of the dissolving time of bajakah root dried extract effervescent tablets with an average dissolution time of 86 ± 4 seconds.

3.2.2. Verification of test result of optimum formula tablet with DX software prediction

The response of the optimum formula effervescent tablet's physical properties was analyzed using IBM Statistics 21 software one sample t-test. The respons of hardness and dissolution time compared with the predicted results of design expert software with a 95% confidence level. The p-value is confirm no different significant with the predicted results of the design expert, if the value is > 0.05 (Table 3).

4. Discussion

Flow properties affect the uniformity of filling the powder into the die on the machine tablet. The flow properties will affect the weight and active substance uniformity in tablets. Things that can affect the granule flow are the shape and size of granule particles, particle size distribution, surface roughness, and decrease in surface energy and surface area.[4] Evaluation of the angle of repose is one of the tests for the flow properties of granules. The test is carried out by measuring the diameter and height of the cone formed by the granule flowing from the funnel.

A tablet hardness test was carried out to test the resistance of tablets during packaging and distribution. The hardness of effervescent tablets is smaller than conventional tablets,[3] tablet hardness affects the dissolution time because tablet hardness is related to the dissolution time. The increasing hardness of tablets affects the longer the dissolution time. The disintegration process of effervescent tablet begins with the penetration of water into tablets, which causes the reaction of citric acid with sodium bicarbonate which produces carbon dioxide gas. This gas breaks the bonds between particles in the tablet so that the tablet breaks and dissolves. In addition, the presence of starch as a co-processed excipient with a swelling mechanism helps the disintegration of effervescent tablets.

Pysical evaluation at varying storage temperature test of effervescent tablets was carried out for four weeks, and the analysis parameters were hardness, brittleness, and dissolving time. Effervescent tablets were tested on week 0 and week four during storage of effervescent tablets in an aluminum foil pouch at room temperature (Table 4). The main factor that influences the stability of effervescent tablets is humidity, both in the sample and in the formulation chamber environment and storage. The absorption of water into the sample from the environment can initiate the effervescent reaction between citric acid and sodium bicarbonate. The reaction will cause an autocatalytic reaction by continuously producing water from reaction results, thereby affecting the physical and chemical properties of the tablet effervescent.[1]

The results showed a decrease in tablet hardness during four weeks of storage at room temperature; this affected the greater the friability and the long dissolving time of the tablets. This shows that the optimal storage temperature for effervescent tablets is in cool temperature. Physical properties of bajakah root dried extract effervescent tablets of the optimum formula change during four weeks of storage, but these changes are not significantly different. This is because the effervescent tablets have low water content, so the early effervescent reactions due to interactions between citric acid and sodium bicarbonate can be

Table 4. The results of stability test of bajakah root dried extract effervescent test

Test Parameter	Stability Test Results		p-value	Description
	Week-0	Week-4		
Hardness	5.74 ± 0.07 Kg	5.25 ± 0.03 Kg	0.12	Not significant
Friability	0.549 ± 0.03%	0.556 ± 0.02%	0.11	Not significant
Dissolve time	86 ± 4 second	92 ± 2 second	0.06	Not significant

prevented. The insignificant changes in physical parameters indicated that the effervescent tablets were stable during storage for four weeks.

5. Conclusion

The composition of porang starch-lactose as a co-processed excipient with a ratio of 64%: 36% w/w produces an optimum formula for bajakah root dried extract effervescent tablets based on the Simplex Lattice Design method. Bajakah root has IC_{50} 0f 0.155 mg/mL and quercetin content of 2.19% w/w. The effervescent tablets with co-processed excipient porang starch-lactose in the ratio of 64: 36% w/w provide good physical stability, tablet weigh uniform, granule flow time of 10.45 ± 0.29 g/sec, granule repose of angle of 27.52 ± 0.95°; tablet hardness 5.74 ± 0.07 Kg, friability of 0.549 ± 0.03%; dissolve time 86 ± 4 seconds.

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Conflict of Interest

The authors declare no conflict of interest.

References

1. Allen L, & Ansel H C. *Ansel's pharmaceutical dosage forms and drug delivery systems*. Lippincott Williams & Wilkins; 2013.
2. Rosch, M., Lucas, K., Al-Gousous, J., Pöschl, U., & Langguth, P. (2021). Formulation and characterization of an effervescent hydrogen-generating tablet. Pharmaceuticals, 14(12), 1327. https://doi.org/10.3390/ph14121327.
3. Ermawati, D. E., Rahmasari, M., & Susanto, N. C. A. (2023, August). The effect combination of porang tuber starch-manitol on the physical properties of bajakah root (Spatholobus littoralis Hassk) dried aquous extract lozenges. *In Journal of Physics: Conference Series* (Vol. 2556, No. 1, p. 012022). IOP Publishing doi:10.1088/1742-6596/2556/1/012022 .
4. Bhatia, V., Dhingra, A., Chopra, B., & Guarve, K. (2022). Co-processed excipients: Recent advances and future perspective. *Journal of Drug Delivery Science and Technology*, 71, 103316. https://doi.org/10.1016/j.jddst.2022.103316 .
5. Banker G S, Anderson N R, & Lachman L. *Tablet in the Theory and Practice of Industrial Pharmacy.* III, diterjemahkan oleh Siti Suyatmi. 1986; 643-704.
6. Bolton S, & Bon C. *Pharmaceutical statistics: practical and clinical applications*. CRC press; 2009.
7. BPOM, Obat B P. Peraturan kepala Badan Pengawas Obat dan Makanan Republik Indonesia nomor 12 tahun 2014 tentang persyaratan mutu obat tradisional; 2014.
8. Ermawati, D. E., Tambunan, R. R., & Darojati, U. A. (2024). The Effect of Combination of Porang Tuber Starch (*Amorphophallus muelleri* Blume) with Lactose on the Physical Properties of Bajakah Root (*Spatholobus littoralis* Hassk) Water Extract's Tablet. Jurnal Farmasi Sains dan Komunitas (Journal of Pharmaceutical Sciences and Community), 21(1), 17-22. https://doi.org/10.24071/jpsc.005765.
9. Ermawati D E, Andini B P, Prihapsara F, Farida Y, Rohmani S, Kundarto W, & Nugraheni E R. Optimization of Suweg starch (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) and lactose as co-processed excipient of Ibuprofen-PEG 6000 solid dispersion of effervescent tablet. In AIP Conference Proceedings. 2020; Vol. 2237, No. 1, p. 020061). AIP Publishing LLC. https://doi.org/10.1063/5.0005632
10. Iwansyah, A. C., Fauzi, H., Cahyadi, W., Hariadi, H., Indriati, A., Wardhani, R., & Abd Hamid, H. (2023). Development, physiochemical and sensory evaluation of a new effervescent tablet formulation based on Moringa oleifera leaves extract. International Journal of Food Engineering, 19(3-4), 133-141. https://doi.org/10.1515/ijfe-2022-0170 .
11. Fitriani E S, & Saputra S H. karakteristik tanaman akar bajakah (*Spatholobus littoralis* hassk) dari loakulu kabupaten kutai kartanegara. 2020. 10.26578/jrti.v14i2.6590
12. Taymouri, S., Mostafavi, A., & Javanmardi, M. (2019). Formulation and optimization of effervescent tablet containing bismuth sub-citrate. Journal of Reports in Pharmaceutical Sciences, 8(2), 236-244. DOI: 10.4103/jrptps.JRPTPS_11_19.
13. Gunatilake S K, Samaratunga S S, & Adekola F A. Effects of binder on the physico-chemical properties and the quality of paracetamol tablets. *Der Pharma Chemica.* 2016; 8(4), 237-242. https://doi.org/10.47191/ijpbms/v3-i2-01
14. Hadinugroho W, Martodihardjo S, Fudholi A, & Riyanto S. Evaluation of Polymers as binder on Coprocess of tablet. *International Journal of ChemTech Research.* 2017; 10(5), 46-51.
15. Sengar, A., Tile, S. A., Sen, A., Malunjkar, S. P., Bhagat, D. T., & Thete, A. K. (2024). Effervescent tablets explored: Dosage form benefits, formulation strategies, and methodological insights. World Journal of Pharmaceutical Research, 13(18), 1424-1435. DOI: 10.20959/wjpr202418-33988.
16. Iskandar D. Qualitative Phytochemical Screening and Antioxidant Activity of Ethanol Root Extract of *Spatholobus littoralis* Hassk. The Journal of Food and Medicinal Plants. 2020; 1(1), 13-15.
17. Kemenkes R I. Farmakope Indonesia Edisi V. Jakarta: Direktorat Jendral Bina Kefarmasian dan Alat Kesehatan Republik Indonesia. 2014; 195.
18. Taymouri, S., Mostafavi, A., & Zaretaghiabadi, S. (2022). Design, Formulation and Evaluation of Physicochemical Properties of Valacyclovir Effervescent Tablet. Trends in Pharmaceutical Sciences, 8(3), 135-146. 10.30476/TIPS.2022.95385.1145.
19. Nursyafitri D, Ferdinan A, & Rizki F S. Skrining fitokimia dan parameter non spesifik ekstrak etanol akar bajakah (*Spatholobus littoralis* Hassk.). Jurnal Farmasi IKIFA. 2021; 1(1), 64-73. https://doi.org/10.25077/jfmp.1.1.13-

15.2020
20. Binab, K. A., Gaurav, A., & Mandal, U. K. (2019). A review on co-processed excipients: current and future trend of excipient technology. Int J Pharm Pharm Sci, 11(1), 1-9. DOI: http://dx.doi.org/10.22159/ijpps.2019v11i1.29265 .
21. Patel S G, & Siddaiah M. Formulation and evaluation of effervescent tablets: a review. Journal of drug delivery and therapeutics. 2018; 8(6), 296-303. https://doi.org/10.22270/jddt.v8i6.2021
22. Raissi S & Farsani R E. Statistical process optimization through multi-response surface methodology. International Journal of Mathematical and Computational Sciences. 2009; 3(3), 197-201. scholar.waset.org/1307-6892/14692
23. Ramadhani R A, Riyadi D H S, Triwibowo B, & Kusumaningtyas R D. Review pemanfaatan design expert untuk optimasi komposisi campuran minyak nabati sebagai bahan baku sintesis biodiesel. Jurnal Teknik Kimia dan Lingkungan. 2017; 1(1), 11-16.
24. Richana N, & Sunarti T C. Karakterisasi sifat fisikokimia tepung umbi dan tepung pati dari umbi ganyong, suweg, ubikelapa dan gembili. 2020; 1(1), 29-37. https://repository.pertanian.go.id/handle/123456789/11154
25. Mohammed, K. A. B., Ibrahim, H. K., & Ghorab, M. M. (2016). Effervescent tablet formulation for enhanced patient compliance and the therapeutic effect of risperidone. Drug delivery, 23(1), 297-306. DOI: 10.3109/10717544.2014.912693.
26. Salsabila H. penentuan aktivitas antioksidan infudasi akar bajakah tampala (*Spatholobus littoralis* hassk) dan kalalawit (*Uncaria gambir* roxb) dengan metode dpph. Jurnal Crystal: Publikasi Penelitian Kimia dan Terapannya. 2023; 5(1), 22-29. https://doi.org/10.36526/jc.v5i1.2583.
27. Suksaeree, J., Monton, C., Charoenchai, L., Chankana, N., & Wunnakup, T. (2023). Optimization of process and formulation variables for Semha–Pinas extract effervescent tablets using the Box–Behnken design. AAPS PharmSciTech, 24(1), 52. https://doi.org/10.1208/s12249-023-02514-x.
28. World Health Organization. Revision of monograph on tablets. Final Text for Addition to The International Pharmacopoeia; 2011.
29. Margiati, D., Ramdani, D., & Wulandari, A. Comparative study of antioxidant phycocyanin extracts activity between S. platensis with S. fusiformis using DPPH method. Indonesian Journal of Pharmaceutical Science and Technology. 2019; 6(2), 52-58.
30. Chairiyah, N., Harijati, N., & Mastuti, R. The Relationship of Chemical Compounds and Crystal Development in Porang Tuber (*Amorphophallus muelleri* Blume). The Journal of Experimental Life Science. 2023: 13(1), 1-11.