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Formulation of Instant Granule of Japanese Taro Tuber Extract (*Colocasia esculenta* L. Schoot) Based on Milk With Various Binders for Stunting Prevention

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ABSTRACT: Japanese taro root extract (*Colocasia esculenta* L. Schoot) includes Fe and Zn, which the body need to prevent stunting. The goal of this investigation was to see how different binder types affected the physical and chemical properties of instant granule preparations. The formula for an instant granule dry extract of Japanese taro root was developed using the wet granulation method with various binders, including PVP (F1), Mucillago amili (FII), and Na-CMC (FIII), and then tested for physical, chemical, and Fe and Zn content using Atomic Absorption Spectrophotometry. The test findings showed that the flow rate of instant granules of Japanese taro root extract formulations I, II, and III was (4.6840-4.7956) g/s, with an angle of repose of 26.86-31.08°. The granules had particle sizes ranging from 670,2295-703,2438 µm, a compressibility index of 15.91-19.00%, and moisture content of 2.80-3.58%. The immediate granule test was performed after being dispersed in water; formulations I, II, and III had dispersion periods of 40.33-50.33 seconds, specific gravity of 1.0099-1.0101 g/mL, viscosity of 1.3589-1.6352 cps, sedimentation volume of 0.940-0.955, and pH of 6.60-6.65. Formulas II using 10% muchilago amyl binder had the greatest Fe and Zn levels, at 34.40 mg/kg and 16.19 mg/kg, respectively. The statistical test revealed a significant effect of different binders on angle of repose, moisture content, dispersion time, pH, and viscosity of Japanese taro root extract granules (p-value < 0.05).

KEYWORDS: Japanese taro root (*Colocasia esculenta*); wet granulation; instant granule.

1. INTRODUCTION

The prevalence of stunting has decreased from 24.4% in 2021 to 21.6% in 2022, based on data from the Indonesian Nutrition Status Survey [1]. Even though there has been a decline, the prevalence has not yet reached the national target of 14% until 2024 [2]. One plant food source that is rich in iron is taro (*Colocasia esculenta* (L) Schoot), because it has advantages compared to cassava tubers and sweet potatoes. Taro contains superior protein, vitamin B1, riboflavin, minerals P and Fe and has low fat content [3]. Traditional Drink Powder is a drink product in the form of powder or granules made from a mixture of sugar and spices with or without the addition of other food ingredients and permitted food additives [4]. Instant drinks have the advantage that they can be easily served quickly by simply brewing them. In instant granule preparations, there are several ingredients needed to make them, such as binders, glidants, dyes, sweeteners, fillers and essence. One of the important components in making instant granules is the binder component which functions to unite the powder particles in granules which increases compactness. The binders used in this research were PVP 3%, mucilago amylum 10% and Na CMC 3%. The binder used is chosen to have strong adhesion, is non-toxic and non-irritant, easy to obtain and relatively cheap [5]. The comparison between the three binders used greatly determines the physical and chemical properties of the final product.

2. MATERIALS AND METHODS

2.1. Materials

The main ingredients used are Japanese taro tubers (*Colocasia esculenta* L. Schoot) from the Research Institute for Medicinal and Aromatic Plants (BALITRO) Bogor, West Java; maltodextrin; PVP; Na-CMC ((Multi Chemical Indotrading); mucilago starch (Merck); Aerosil (HDK Wacker); full cream milk(NZMP) ; Strawberry essence (Redbell); aspartame; food coloring (Indocol); buffer pH 4 and 7; distilled water; ethanol 96%; HNO_3; and $HClO_4$. Equipment : analytical balance (GR-200, AND), spray dryer (LabPlant® SD Basic), pH meter (HI

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2211), oven (U30, Memmert, granule flow tester, Karl Fischer (870 KF titrino plus), shield shaker, moisture analyzer (A&DMX-50), Ostwald viscometer, glass tool (Pyrex), and volumetric tool (Pyrex).

2.2. Methods

2.2.1. Availability of study plant materials

The research materials were obtained from the Research Institute for Medicinal and Aromatic Plants (BALITRO) in Bogor, West Java, and identified at the University of Indonesia's Herbarium Depokensis (DEP), Biota Collection Room. The sweet potato simplicia was cleaned, sliced, sun-dried, powdered, sieved with a 4/18 sieve, extracted with 96% solvent, and thickened using a rotary evaporator at 40 °C, 175 mBar pressure, and 35 rpm rotation speed until a thick extract was achieved. The thick extract is spray dried with an additional 30% maltodextrin. The spray dryer has an inlet temperature of 100 ^{o}C and an exit temperature of 75 to 85 ^{o}C.

2.2.2. Physical and Chemical Properties of the Extract

Quality control of a dry extract of taro tubers (*Colocasia esculenta* L. Schoot), including organoleptic testing, checking water content with a Karl Fisher moisture meter, checking iron and zinc content with an atomic absorption spectrophotometer (SSA), and determining flow properties directly and indirectly with a granule flow tester [3,11].

2.2.3. Instant Granule Formulation (Table 1)

Every ingredient is weighed. The dry extract of Japanese taro tubers is then combined with full cream milk, strawberry essence, and stevia and blended until smooth. (mix 1). Incorporate the binder into mixture 1. Formula I: Add Pvp to the mixture, then gradually add pure water until a compact mass is produced. Formula II: Mucilago starch is generated in hot water at 70 °C for one day. Formula III involves developing NaCMC in hot water at 70 ^{o}C for one day. The compact substance was sieved through a number 12 sieve. The granules were dried at 40-50°C for 15 minutes. The moisture content of the granules is assessed. The dry grains were filtered with a number 16 sieve. Add the aerosil and stir until well combined. The produced granules were compared to immediate granules of dried extract of Japanese taro tuber.

2.2.4. Physical and chemical analysis of instant granules

Organoleptic (visual inspection of color, smell, and taste); particle size distribution using a multi-level sieve with 25 g granules; compressibility with 25 g granules using a Jolting volumeter at the 10th, 50th, 100th, and 500th tap volume is measured according to the scale on the measuring cup, and the percent compressibility is calculated; Instant granule flow parameters are determined directly and indirectly using a granule flow tester, dispersion time, and moisture content with a SHIMADZU MOC63U moisture balancing tool. Instant granule pH (1 g granule dispersed in 10 mL of water) was measured using a pH meter, and the iron and zinc content was determined using Atomic Absorption Spectrophotometry [6, 7, 11].

2.2.5. Data Analysis

Data was analyzed using one-way ANOVA to determine the influence of binders in formulas I, II, and III on angle of repose, moisture content, dispersion time, pH, and viscosity of Japanese taro root extract granules.

3. RESULTS

Japanese taro tuber simplicia powder has a fineness of 4/18. These findings fulfill the parameters outlined in the Indonesian Herbal Pharmacopoeia (FHI), which says that 100% of the powder can pass through sieve number 4 and no more than 40% can pass through sieve number 18. The thick extract of Japanese taro tubers is spray dried to get a yellowish white powder (Table 2). Organoleptic examinations of the three instant granule formulae revealed that Japanese taro tuber extract is pink, smells like strawberries, and tastes pleasant. The pink tint is the result of the inclusion of a coloring ingredient during the granule manufacturing process. Strawberry essence is used as a flavoring in the instant granule formulation in all three formulae,

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giving it a sweet aroma and taste. This demonstrates that the use of PVP, Mucilago amili, and Na-CMC does not impact the organoleptic test findings of instant granules before they are dispersed (Table 3).

Table 1. Formulas for Japanese taro tubers *(Colocasia esculenta* L. Schoot*)*.

Material	**Formula**		
	FI (%)	**FII (%)**	**FIII (%)**
Extract	10	10	10
polyvinyl pyrrolidone (PVP)	3	-	-
Muchlago amyly	-	10	-
CMC Na	-	-	3
Aerosil	0,1	0,1	0,1
Food coloring	0,25	0,25	0,25

Table 2. Dry extract from Japanese taro tubers (*Colocasia esculenta* L. Schoot).

Test parameters	**Result**
Mineral content	
Iron (Fe)	3.33 mg/Kg
Zink (Zn)	10.97 mg/Kg
Organoleptic	
Color	Yellowish white
Smell	odorless
Form	powder
Flow properties and angle of repose	
Flow properties	5.86 g/s (free flowing)
Angle of repose	26.76^{o} (special)
Moisture content	5.55%
Compressibility index on the 500th beat	7.02% (special)
Particle size distribution	average diameter 286.43 μm

Table3. Characteristic formulas derived from physics and chemistry.

Evaluation result	**Japanese Taro Tuber Extract Instant Granule Formula**		
	Formula I (PVP)	Formula II (mucilago amylum)	Formula III (Na CMC)
Flow properties and angle of repose			
Flow properties	4.79±0.39 g/s (free flowing)	4.68±0.23 g/s (free flowing)	4.68±0.24 g/s (free flowing)
Angle of repose	27.10^{o} (special)	26.85^{o} (special)	31.08^{o} (good)
Compressibility index on the 500th beat	19.00% pretty good	15.91% pretty good	17.39% pretty good
Moisture content	2.80±0.06%	2.87±0.16%	3.58±0.29%
Particle size distributions	average diameter 646.45 μm	average diameter 661.07 μm	average diameter 670.46 μm
Dispersion time	40,33±1,53 s	50,33±0,58 s	46,33±1,15 s
pH	6.63±0.02	6.65±0.00	6.60±0.02
Specific gravity	1.0099±0,00 g/mL	1.0099±0,00 g/mL	1.0101±0,00 g/mL
Viscosity	1.3589 Cps	1.5164 Cps	1.6352 Cps
Sedimentation volume	0.95±0.04	0.94±0.03	0.95±0.02
Mineral content	Zn = 8.16 mg/kg Fe = 25.66 mg/kg	Zn = 16.19 mg/kg Fe = 34.40 mg/kg	Zn = 9.53 mg/kg Fe = 12.78 mg/kg

4. DISCUSSION

The resulting powder has an equally dispersed particle size, making it easier to dissolve. To extract the chemicals present in simplicia during the extraction process. DER-native compares the weights of the simplicia used to produce one gram of extract. Based on the results, DER-native was 10.2916. This result indicates that 10.2916 grams of Japanese taro tubers are required to produce 1 gram of extract [8.9]. To avoid stunting, the nutrients in 100 g of product must meet Indonesian Ministry of Health guidelines, specifically Fe (iron) of 4.0-7.5 mg and Zn (zinc) of 2.0-3.75 mg [10]. The results obtained from Japanese taro extract do not meet the criteria, with Fe levels of 0.333 mg/100 g and Zn levels of 1.097 mg/100 g, which are still low. The water content of Japanese taro root extract meets the standards, which are less than 10% [8]. Water is a favorable medium for microbial development, so the lower the water content produced, the less chance of microbial growth during the storage process.

The flow qualities of Japanese taro tuber extract are easy to flow; this can be attributed to the extract being spray dried, resulting in small granules that dry into solid particles. Japanese taro tuber extract meets the requirements for a good compressibility index, which is less than 20%. A high percent compressibility rating indicates that there is no significant reduction in volume when pressure is applied. This is heavily influenced by the porosity, density, and particle size of the active ingredient powder in filling the empty space between the particles. After conducting a particle size distribution test with a sieve shaker, the average diameter was 286.4283 μm. The highest percentage weight recorded in mesh 120 could be attributed to the powder form of Japanese taro tuber extract. An excellent particle size distribution has a bell-shaped graph, which means that the particle size is not prominent in only one size [11]. Because aerosil comprises particles of very large sizes that are small and delicate, the flow properties for formula I-III demonstrate free flowing and a decrease in moisture content of granules compared to dry extract. Aside from being adsorbents, they can also be utilized as glidants at concentrations ranging from 0.1 to 1.0% to improve flow characteristics by reducing friction between particles [16,17]. The pH of the instant granule formulation of Japanese taro tuber extract was tested to ensure that it was stable and acceptable. The suggested pH range for functional drinks is 6-7. If the drink's pH is excessively acidic, it may upset the stomach; if it is too alkaline, it may taste bitter [12].

According to Stokes' law, the sedimentation speed is exactly related to specific gravity. The turbidity ratio velocity increases with higher specific gravity. These data demonstrate that instant granules sink because their specific gravity is greater than that of water, which is 1 g/mL. The discrepancy in specific gravity values between formulations is due to variances in the quantity of empty space within the particles. The higher the specific gravity, the greater the distance between particles [6].

Formula III yields higher specific gravity and viscosity readings than formulas II and III. This is due to the huge amount of hydroxyl and carboxylate groups, which provide Na-CMC a higher water absorption capacity than PVP and Mucillago amili. A high suspension viscosity will impede the deposition of the preparation. Sedimentation is considered good if the value F = 1 represents an ideal dispersion system. At high quantities, the Na-CMC binder slows the deposition of Japanese taro tuber extract. This is consistent with STOKES' law, which states that the sedimentation speed is directly related to the specific gravity. The sedimentation ratio velocity increases with higher specific gravity [13,14]. The Zn and Fe content in FII, which contains 10% mucilago amili binder, climbs to 3,440 mg/100 g and 1,619 mg/100 g from the results of extract testing, and practically fulfills the standards of the Indonesian Ministry of Health for fulfilling nutrition to prevent stunting [10]. This is because it contains mucilago amili, a natural substance derived from cassava starch that contains a high concentration of vitamins and minerals, as opposed to Na CMC and PVP, which are semi-synthetic and synthetic binders, respectively [15].

5. CONCLUSION

Based on the findings of testing instant granules of Japanese taro tuber extract, the following conclusions were drawnJapanese taro root extract (*Colocasia esculenta* L. Schoot) can be transformed into a direct granule preparation that passes physical and chemical standards utilizing a wet granulation technique. The one-way ANOVA statistical test found a significant difference (p-value <0.05) between the types of binder (PVP, Mucillago Amili, and Na-CMC) in angle of repose, dispersion time, moisture content, and viscosity. FII with 10% mucilago amyl binder had the highest Fe and Zn contents (34.40 mg/kg and 16.19 mg/kg, respectively).

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