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Research Article

Application of Flour Extracted from Porang (*Amorphophallus muelleri* Blume) in Formulating Peel-Off Mask

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Abstract

Background and Objective: Porang tuber (*Amorphophallus muelleri* Blume) is well-known in Indonesia, with high annual production, but still has few applications. Therefore, this work aimed to utilize the application of porang tuber in making peel-off masks. **Materials and Methods:** Five completely randomized formulas were made with increased porang flour concentration at 1, 2, 3 and 4%; a sample (without flour) was used as a control. The evaluation of gel formulations was based on organoleptic observation and physicochemical characteristics. The best product was selected using the Multi-Attribute Decision Making-Simple Additive Weighting Method (MADM-SAW). **Results:** The findings demonstrated that porang flour had a considerable impact on the peel-off gel's properties. The selected formula obtained in this study was a formula with 1% of porang flour. The product was homogenous with pH value of 5.51±0.01 and the viscosity value ranged from 37000±100 cPs. These data have followed the Indonesian National Standard for facial skin products. The gel also has good spreading, there was no irritation during the peeling process, which took less than 20 min the inhibition zone's diameter demonstrated active antibacterial activity against *Staphylococcus aureus*; the percentage of the free radical 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) was 13.85±1.62%, demonstrating the gel sample's antioxidant capabilities. **Conclusion:** According to the results, porang can create a good-quality peel-off gel mask product with flour at a 1% concentration. Further research needs to be conducted for upscale production.

Key words: Added-value product, antibacterial activity, DPPH inhibition, peel-off gel, porang application

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Food and energy security worldwide have significantly benefited from root and tuber crops. Over 860 million metric tons of primary and tuber roots were produced on roughly 60 million hectares of land worldwide in 2019[1]. Tubers are used in various industries due to their diverse qualifications, including food, medicines and cosmetics as emulsifiers, gelling agents, thickeners, film formers and additives[2]. However, the rapid tuber rotting during the post-harvest period, which results in quality and quantity losses, also lowers the crops' market value[3] as a new interest to limit significant economic loss caused by the perishable nature of tubers, product development or creating products with added-value, which has been regarded as a concerning and intriguing idea in this case.

Today's awareness and rising environmental consciousness imply that cosmetic companies must use more sustainable production methods and materials to satisfy consumer demand and stay competitive. As a result, demand for natural, eco-friendly and sustainable personal care products will increase[4]. It is strongly advised to utilize facial care and cosmetic products with active ingredients derived from natural sources[5]. The production of cosmetic goods is currently outpacing demand. Due to the ease of use, simplicity of removal after application with an elastic membrane and ability to have a direct effect, the peel-off gel mask is a form of skincare product that has gained popularity[6]. Its functions include pore cleaning, hydrating and nourishing facial skin. Additionally, this mask can address skin conditions like acne, wrinkles, aging and big pores in addition to helping the face retain more moisture as a cleanser, freshener, moisturizer and softener for the face skin, as well as creating an incredible feeling and relaxing facial muscles while using it[7].

As with other tubers, porang (*Amorphophallus muelleri* Blume) is rich in carbohydrates, but its applications have yet to be fully exploited. Porang has thus been considered the following research-focused material. This botanical entity is notably enriched with organic constituents, such as carotene, choline, niacin, riboflavin and thiamine, alongside the presence of soluble glucomannan as elucidated in prior studies of Chua *et al.*[8] and Keithley *et al.*[9]. Due to its gelling, texture-forming and thickening attributes, glucomannan assumes multifaceted roles as an emulsifying and stabilizing agent. This versatility positions it as a potentially valuable resource in diverse industries, encompassing food, cosmetics and pharmaceutical domains[10,11]. Motivated by the attributes above, the present investigation directs its focus toward formulating and evaluating the influence of porang flour incorporation on the characteristics of peel-off gel formulations.

MATERIALS AND METHODS

Study area: This research was carried out in the laboratory of the Faculty of Agricultural Technology, Andalas University from December, 2022 to March, 2024.

Materials: Porang (*Amorphophallus muelleri* Blume) flour (>80 glucomannan) was purchased from PT Paidi Indo Porang in Madiun, East Java, Indonesia and used as the research materials. The ingredients for making peel-off gel masks consist of Polyvinyl Alcohol (PVA), carboxymethyl cellulose (CMC), propylene glycol, methyl paraben and distilled water. For microbiological testing, sterile nutrient agar (NA) and *Staphylococcus aureus* bacteria are used. Furthermore, methanol and 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) were used to test antioxidant activity.

Research design: A completely randomized design was employed in this investigation. Porang's flour addition was used to make the peel-off gel mask at five concentrations (%) and three replications.

In five distinct formulations, porang flour concentration was added progressively at rates of 1, 2, 3 and 4% (percentage based on a total basis). As a reference, the control sample was devoid of all flour. Tuber flour and carboxymethyl cellulose (CMC) were used as the gel-forming ingredients in this procedure, whereas Polyvinyl Alcohol (PVA) acted as the film-forming agent. The composition had distilled water and alcohol as solvents, propylene glycol as the humectant and methyl paraben as the preservative.

Gel preparation: Following minor modifications, the gel preparation process was carried out using the approach described by Nguyen *et al.*[12]. Briefly, 2 g of carboxymethyl cellulose (CMC) was dissolved in water and stirred until homogeneous. In another part, 13 g of Polyvinyl Alcohol (PVA) was dissolved in distilled water heated at 80°C. Then, 10 mL of propylene glycol and 0.2 g of methylparaben were mixed into the PVA solution. The PVA solution was mixed with the CMC solution and homogenized. After that, add porang flour to the mixed solution according to the treatment. Finally, ethanol (4 mL) was added to produce a gel product.

Evaluation of gel formulations

Test for pH level: After obtaining the sample, it was diluted 1:1 in distilled water. A pH meter (OHAUS Starter 3100) was used to measure the solution's pH[13].

Test of spread capacity: The glass surface was covered with another glass, a 150 g weight and 1 g of each gel sample. After a minute, the gel's scatter diameter was determined[14].

Test of viscosity: A viscometer (B-One BMV 102M) with spindle no. 4 and a speed of 12 RPM was used to measure the viscosity of the gel (at least 50 mL)[14].

Test for drying times: Following the application of gel to the skin's surface, 1 g of the sample was allowed to dry and shed a film layer, at which point the peeling time was measured[14].

Test for antibacterial activity: The samples were subjected to an antimicrobial analysis using the Kirby-Bauer disk diffusion susceptibility method. In short, 15 mL of stable sterile nutritional agar (NA) with 0.1 mL of microbe culture (*Staphylococcus aureus*) spread on top of disc sheets absorbed gel sample. The inhibitory zone's diameter was measured and observed following a 24 hrs incubation period at 37°C[15].

Inhibition test for DPPH: Utilizing the technique described by Nguyen *et al.*[14], this characteristic was ascertained based on the inhibition % of DPPH radical scavenging activity. In summary, 10 mL of volumetric flask was used to dilute 1 g of each sample with methanol. The mixture was then vortexed and placed in an ultrasonic bath for 15 min. It was then continuously centrifuged for 5 min, removing 1 mL of the clear solution. The 0.5 mL of DPPH solution (0.18 mM) and 1 mL of distilled water were combined with the clear solution. For the blank, 0.5 mL of a 0.18 mM DPPH radical solution was combined with 2 mL of methanol. After giving the combinations a thorough shake, they were left in the dark at room temperature for 15 min. The inhibitory percentage of DPPH was observed through a spectrophotometer (Agilent Cary 8454 UV-Vis) at a wavelength of 517 nm and calculated by the Eq. 1:

$$\text{Inhibition (\%)} = \frac{A_b - A_s}{A_b} \times 100 \quad (1)$$

Where:

A_b = Absorbance of the blank

A_s = Absorbance of the sample

MADM-SAW test, organoleptic and irritation: A panel of thirty individuals under the age of thirty was given these exams. The irritated response or side effect was visually documented for 24-48 hrs following the application of the gel sample (0.5 g) to the skin's opening surface. Each of the five parameters for the organoleptic test-color, consistency, odor, applied feeling and acceptability is rated on a scale of 1 to 5 and a description based on the hedonic principle was provided in Table 1. The hue and uniformity were observed visually. To detect any smells, the product was smelled. Touch performance could be assessed by applying the product to the skin's surface[14,16].

As organoleptic and irritating testing was completed, the superior product was selected using the Multiple Attribute Decision Making with the Simple Additive Weighting Model (MADM-SAW) technique. To standardize the property, the standards were developed based on both physicochemical and organoleptic features. This was done by the research aim and the priority in characterizing the quality of cosmetic products. As a result, the criteria were ranked according to importance; the most crucial characteristics were pH and organoleptic features; the other crucial characteristics were peeling time, spreadability and functional features (antioxidant capability and antibacterial activity). Table 2-4 provided examples of the descriptions and how the options were weighed based on the criteria.

The normalize matrix (R_{ij}) was modified to the type of attribute and was calculated as in Eq. 2:

$$R_{ij} = \left\{ \begin{array}{l} r_{ij} = \dfrac{x_{ij}}{\text{Max } x_{ij}} \\ r_{ij} = \dfrac{\text{Min } x_{ij}}{x_{ij}} \end{array} \right\} \quad (2)$$

Where:

x_{ij} = Attribute value (i) that belongs to the criterion (j)

Max x_{ij} = Largest value of each criterion (if j is the advantage attribute (benefit))

Min x_{ij} = Smallest value of each criterion (if j is the cost attribute (cost))

Equation (3) yielded the biggest value during the ranking procedure, which was the outcome as the best choice (formulation). In brief, the weighting value in Table 4 was the result of multiplying the normalized matrix (R_{ij}) by the weight vector (W_j). Table 2-4 provided illustrations of the criteria:

$$V_i = \sum_{j=1}^{n} W_j \, R_{ij} \quad (3)$$

Table 1: Peel-off gel formulations' organoleptic representation

Parameter	Score	Description
Hue and uniformity	5	Bright translucence and homogeneity
	4	Semi-translucence and homogeneity
	3	Semi-translucence and semi-homogeneity
	2	Dark translucence and semi-homogeneity
	1	Dark translucence and heterogeneity
Odor	5	Really pleasant scent
	4	Pleasant scent
	3	Acceptable or light scent
	2	No smell or quite bad scent
	1	Very bad smell or strong chemical scent
Touch performance	5	Very cool sensation and a wonderful touch
	4	Pleasant touch with a cool feeling
	3	Very viscous or fluid sensation
	2	Unpleasant touch and sticky or fluidic feeling
	1	Extremely sticky or fluidic sensation, as well as an unpleasant touch
Favorite	5	Very like
	4	Like
	3	Normal
	2	Less like
	1	Dislike

Table 2: Alternative weighting of organoleptic criteria

Score	Weight category	Weight value
4.1-5.0	Very good	1
3.1-4.0	Good	0.75
2.1-3.0	Average	0.5
1.1-2.0	Bad	0.25
0-1.0	Very bad	0

Table 3: Alternative weighting of physicochemical criteria

Score	Weight value	pH	Peeling time (minutes)	Spreadability (cm)	Anti-bacterial	DPPH inhibition (mm)
5	1	>5-5.5	<15	>6-6.5	Very strong	>40
4	0.75	>5.5-6	>15-20	>5.5-6	Active	>20-40
3	0.5	>4.5-5	>20-25	>6.5-7	Moderate	>10-20
2	0.25	>4-4.5	>25-30	>5-5.5	Low	<10
1	0	<4/>6	>30	<5/>7	-	-

-: Not detected

Table 4: Weighting criteria of organoleptic test

Criteria	Weight category	Weight value
C1	Very important	1
C2	Important	0.75
C3	Medium	0.5
-	Normal	0.25
Cj	Not important	0

RESULTS AND DISCUSSION

Physicochemical properties of the raw material: Porang flour with 80% glucomannan was used in the research to observe this material's effects in making peel-off gel preparations and its physicochemical properties were analyzed. The specification needed to be determined since it affected the product quality. Porang is a unique commodity and has different characteristics due to the area where it grows[17,18]. In this study, the raw material for porang flour contains a water content of 6.19%. This data shows that flour can be applied and stored long. Flour products generally require a water content of less than 10%. Apart from that, porang flour has considerable antioxidant activity, worth 33.49%. This value shows the uniqueness of porang flour in that it also contains phenolic components that produce antioxidant activity. Furthermore, the pH of porang flour also shows a relatively neutral value. This value provides information that porang flour can be applied for cosmetic purposes.

The raw material presents a high inhibition percentage of DPPH due to the different amounts of active compounds acting as antioxidants. Both the flour's physical characteristics,

Table 5: Physical characteristics of gel preparations

	Physical parameters			
Porang flour concentrations (%)	pH value	Peeling time (minutes)	Spread diameter (cm)	Viscosity (cPs)
F0 (0%)	5.610.01[a]	36.670.58[a]	6.810.02[a]	14626.7110[e]
F1 (1%)	5.510.01[b]	18.330.58[b]	6.030.01[b]	37000.0100[d]
F2 (2%)	5.490.01[c]	18.001.00[b]	5.750.01[c]	53800.0100[c]
F3 (3%)	5.480.01[c]	17.330.58[b]	5.140.01[d]	98666.7116[b]
F4 (4%)	5.470.01[c]	18.670.58[b]	4.680.01[e]	118667.116[a]

Mean in the same column followed by different letters are significantly different ($p<0.05$) and Mean±SE

including the moisture content of 6.19% (below 10%) and pH value of 5.32 (generally slightly acidic), meet the flour standard for use and processing. The data in Table 5 shows that porang flour has suitable characteristics for use as raw material for peel-off masks. The low water content value was by flour quality standards. Meanwhile, the relatively neutral pH value and high enough antioxidant activity provide added value for porang to be applied in peel-off mask formulas.

Physicochemical characteristics of peel-off gel mask formulated from porang flour: To produce good cosmetic or facial products, physical characteristics play a crucial role in maintaining the stability and quality of the products. Table 5 shows the results of the physical analysis, including pH value, peeling time (minutes), spread diameter (cm) and viscosity (cPs) of the peel-off mask formulated with the addition of porang flour.

Acid degree: The pH value represents the acidity degree of the product[19,20] it is considered a crucial parameter in gel preparations that can be applied to the skin. The evaluation of the acidity degree was shown in Table 5; the results were significantly different ($p<0.05$). The greater the concentration, the lower the pH value; this reduction can be explained by the low pH value from the raw material (5.32) that gradually reduced the pH value of the added porang formulations. However, all formulas were around 5.4 to 5.6, whereas the normal skin pH ranges from 4.5 to 6.5[21]. It can state that the pH of the formulas meets the requirement for the pH standard in cosmetics that is safe and will not disturb the function of the skin.

Peeling time: According to the peeling time observation, the gel compositions from the tubers (apart from the control samples) had a drying time of less than 20 min (Table 5), which was still reasonable and not too long. According to the statistics, the peel-off gel mask dries within a reasonable 15- 30 min. The peeling time shows a significant difference ($p<0.05$) among formulas and shortens when increasing the concentration of the porang flour in the formulation; this can be explained by a high water absorbency of glucomannan (approximately 105.4 g water/g of glucomannan)[22] that have in porang flour, it also created the thicker and more viscous consistency of the gel to make the gel stable on the surface to evaporate and dry faster than the control sample.

Spreadability: The spreadability of gel preparations is defined as the gel's ability to spread on the skin's surface. The greater the scatter diameter, the greater the surface area that the gel can reach. Good spreadability can guarantee the distribution of a gel when applied to the skin; a suitable spread diameter ranges from 5-7 cm[19]. The significant difference ($p<0.05$) in the spread diameter was due to the added concentration of porang flour. When the concentration increases, the gel consistency becomes thicker and semi-homogenous, affecting and slowing the gel's spreading capacity. Therefore, the spread diameters of gel preparations reveal a value between 4.68-6.81 cm (Table 5), which indicates that the gels have good spreadability, except the sample with 4% porang flour shows the lowest spread diameter (4.68 cm).

Viscosity: In the cosmetics enterprise, determining a liquid's viscosity-or its resistance to flowing-accurately is essential to ensuring product quality and uniformity. Moreover, viscosity might affect the chemical stability of a cosmetic product over time in its packaging. The results of the data analysis in Table 5 have shown significant differences ($p<0.05$) in the viscosity evaluation from the samples. Viscosity increases significantly when more porang flour is added and has a thick consistency. It can be caused by the physical characteristics of glucomannan from the raw material. The glucomannan in pouring is characterized by high viscosity (27940 cPs), high solubility and water absorbency related to the morphologic features of glucomannan[10]. However, the samples with porang flour at 2, 3 and 4% present significantly high viscosity values and have a semi-homogenous consistency. Therefore, the chosen concentration is 1% of porang flour to ensure the standard viscosity range (37000 cPs) for the gel preparations according to the Indonesian National Standard (SNI) 20, which is 2000-50000 cPs and meets the requirement for homogenous consistency of the formula.

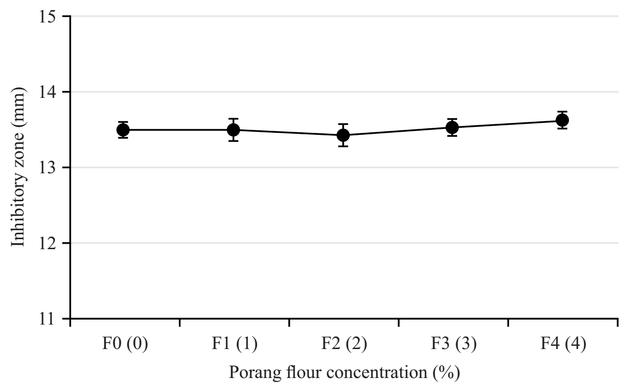

Fig. 1: Effect of porang flour addition on antibacterial activity of peel-off gel masks

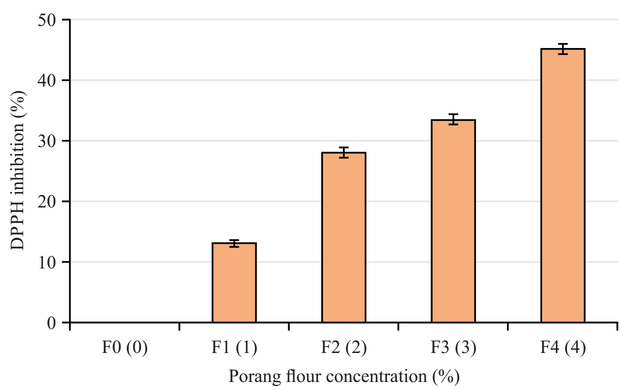

Fig. 2: Effect of porang flour addition on DPPH inhibition of peel-off gel masks

Antibacterial activity: The clear zone surrounding the paper disc serves as an indicator of the antibacterial inhibitory action. The diameter of the zone that prevents the development of bacteria is expressed in millimeters[15]. Figure 1 presented the findings regarding the antibacterial activity of *Staphylococcus aureus*. It indicates that the diameter values of the inhibition zones for each formulation are comparable to the control samples (i.e., without porang flour) and that there is no significant difference (p>0.05) in the size of the inhibition zone. Four categories were identified by Morales *et al.*[23] as the antimicrobial inhibitory zone's activity: Weak (<5 mm), moderate (5-10 mm), solid or active (>10-20 mm) and very strong or very active activity (>20-30 mm). By include methylparaben (0.2%), which is utilized in all formulations as a preservative and antibacterial agent[7], the inhibition zone among different formulations can be explained. As a result, every recipe demonstrates potent antibacterial action against the development of *Staphylococcus aureus*. The findings of the research also demonstrate the promise of porang flour in terms of ongoing research into its antibacterial qualities and its potential for augmentation with other powerful substances to improve antibacterial activity in product development.

DPPH inhibition: The purpose of the experiment is to determine whether porang flour has any antioxidant properties when used to prepare peel-off gel. The findings indicate that, with the exception of the flour-free control sample, the flour-containing samples had a strong antioxidant capacity as demonstrated by the reduction in the percentage of 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) free radical activity[24]. The antioxidant capacity of the samples varies significantly between concentrations and tends to increase with higher concentrations, as shown by the results in Fig. 2. Because porang flour is a raw material with a greater DPPH inhibition percentage, the added porang formulations provide improved resistance to free radicals. samples demonstrate a range of 13.85-45.08% of DPPH inhibition, suggesting that peel-off gel formulations derived from porang flour possess both antibacterial and antioxidant activity by decreasing the free radical of DPPH.

Organoleptic, irritation and MADM-SAW test: The results of the panelists' evaluations for the homogeneity and annoyance tests were displayed in Table 6. After analyzing the sample, the skin does not exhibit any erythema, irritation or adverse effects from any of the formulae. As a result, the recipes guarantee the security of the peel-off gel mask ingredients.

Furthermore, the results demonstrated that the porang formulae are less homogeneous-the homogeneity decreases with increasing concentration. Simultaneously, recipes with concentrations of 2, 3 and 4% receive negative scores from the panelists for the gel's color and consistency. Regarding the odor criterion, the majority of panelists reported that the control sample, which contained 0% porang flour, had an overpowering chemical odor. Because of the strong raw material odor, the score for this metric remains constant even with additional porang flour added at 3 and 4%[8]. For touching performance, 1% porang flour is the recipe with a high recommendation, a nice touch, an amazing feeling and an easy application. Due to their high viscosity and semi-homogenous consistency, the remaining formulae are sticky and have an unpleasant touch, whereas the control sample is fluidic and unstable when applied. The physicochemical properties and the greatest recommendation and acceptability based on the panelists' preferred reference, 1% porang flour, will determine the optimal concentration (Fig. 3).

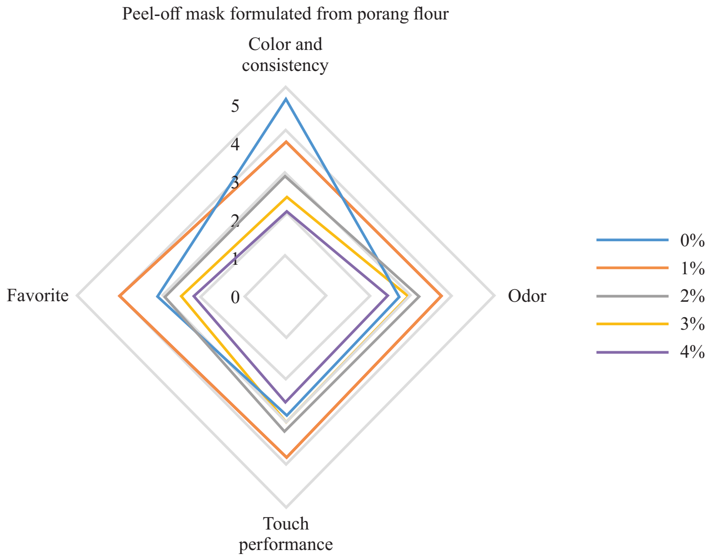

Fig. 3: Organoleptic evaluation of different porang concentrations in peel-off gel formulas

Table 6: Organoleptic evaluation of peel-off gel formulas

Porang flour concentrations (%)	Homogeneity	Irritation
F0 (0)	Homogenous	No irritation
F1 (1)	Homogenous	No irritation
F2 (2)	Semi-homogenous	No irritation
F3 (3)	Semi-homogenous	No irritation
F4 (4)	Semi-homogenous	No irritation

Table 7: Assessment criteria rate and rank for formulations based on MADM-SAW

	Criteria										
Porang flour (%)	C1	C2	C3	C4	C5	C6	C7	C8	C9	Total	Rank
0	0.00	0.75	0.67	1.00	0.50	0.50	0.75	1.00	0.00	5.17	5
1	1.00	0.75	1.33	0.75	0.75	0.75	0.75	1.00	0.50	7.58	1
2	1.00	1.00	1.00	0.50	0.75	0.75	0.50	1.00	0.75	7.25	2
3	1.00	1.00	0.33	0.50	0.50	0.50	0.50	1.00	0.75	6.08	3
4	1.00	1.00	0.00	0.25	0.50	0.50	0.50	1.00	1.00	5.75	4

Based on the total value and rank of the MADM-SAW with the highest score (7.58) and first rank (Table 7), the results showed that 1% porang addition was the best concentration for the final formula. The decision was in line with the panelists' recommendation from the previously described organoleptic survey.

The optimum value found in this research can provide information that porang flour has enormous potential when applied to the development of cosmetic products such as peel-off masks. Porang availability is abundant in Indonesia[25] however, the development of porang-based products has yet to be carried out much for non-food products since porang has only been developed for food products because of its glucomannan content[26]. Glucomannan is known as a prebiotic component that is good for intestinal health[27,28]. However, developing non-food products based on flour, mainly flour containing antioxidant components, makes the development of skin care products interesting[29]. It is hoped that the data from this research can become a reference for other researchers in developing porang flour-based cosmetic products.

CONCLUSION

Porang can be used to make a high-quality peel-off gel mask preparation, according to the results of an evaluation of the impact of porang addition on all formula's features. For the product formulation, the formula containing 1% porang flour is thought to be the ideal concentration. The selected method satisfies all requirements for features of cosmetics, including those related to pH, viscosity, homogeneity, peeling time and organoleptic testing. Additionally, the compositions have functional qualities like antioxidant and antibacterial capabilities.

SIGNIFICANCE STATEMENT

This research has developed a formula to produce a peel-off mask from porang flour. Porang is an agricultural commodity of concern because of its galactomannan content. Apart from being suitable as a raw material for food products, porang can also be developed as a raw material for cosmetic products. The development of mask products made from porang has yet to be widely reported because, so far, the development of porang-based products has mostly been for food purposes. Therefore, this research can be a basis for developing similar products in the future.

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