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Characteristics of Peel-off Gel Mask Formulated from Jicama (*Pachyhizus erosus*)

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A B S T R A C T

Food loss is a worldwide concern, especially the losses from the fresh tubers because of their quick rottenness during post-harvest without proper preservation. Meanwhile, the tuber is an excellent source of carbohydrates that can be used in a broad range of food and other industries. Therefore, creating added-value products from crops has been considered an intriguing idea for decades in order to reduce this matter and also can utilize raw materials from agriculture. This research aimed to determine and evaluate the effects of starch addition from Jicama on the characteristic of peel-off gel masks. Five different formulations were made with increased starch concentration at 1%, 2%, 3%, and 4%, and a control sample was formulated without adding starch. Organoleptic, spreadability, homogeneity, irritation, viscosity, pH, peeling time, and antibacterial and antioxidant activity were parameters in evaluating gel formulations. The best formula showed a homogenous consistency, there was no irritating reaction, and it had the highest sensory point from the panellist. The acidic degree and viscosity were 5.53 and 32867 cPs, respectively, which adhered to the Indonesian National Standard (SNI 2007) for facial skin products; the gel had good spreadability, and the peeling time was less than 30 minutes. Moreover, the gel presented an active antibacterial activity against *Staphylococcus aureus*; and antioxidant activity. According to the results, Jicama is recommended for application in making good quality peel-off gel mask products at 4% concentration.

INTRODUCTION

Root and tuber crops have played more crucial roles in global food and energy security. Yam or Jicama is one of the major root and tuber crops, which occupies approximately 60 million hectares worldwide and produced over 860 million tonnes in 2019 (FAO, 2021). With a wide range of properties, tuber starches are applied in food and other industries, such as additives, gelling agents, thickeners, film former and emulsifiers in food, pharmaceuticals, and cosmetics (Moorthy et al., 2018). However, the quick spoilage of fresh tubers during the post-harvest that causes losses in quality and quantities also recede the selling value of these crops (Sankarakutty, 2020). Thus, product development or adding-value products has been considered a concerning and interesting suggestion to minimize great economic loss due to tubers' perishable nature.

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The awareness, combined with the increased environmental consciousness, implies that cosmetic brands and manufacturers will have to adopt more sustainable production processes and components to meet the customers' needs and thrive in the industry. Therefore, interest in organic, sustainable, environmentally friendly personal care products will continue developing (Amberg and Fogarassy, 2019). Facial care and cosmetic products that use active substances from natural sources are highly recommended (Alves et al., 2020).

Currently, the manufacture of cosmetic products is overgrowing. The peel-off gel mask is one type of skin care treatment that is popular due to its simple usage, and it is able to impact directly on the skin with functions that include cleaning the pores and moisturizing and nourishing facial skin. Peel-off gel masks are practical because they easily peel off and lift like an elastic membrane (Rum, Suherman, and Idar, 2021). Moreover, this mask can help the skin improve hydration and treat skin issues like wrinkles, aging, acne, and large pores. It cleanses and moisturizes the skin and helps relax facial muscles as a cleanser, freshener, moisturizer, and softener for facial skin (Luthfiyana, Nurhikma, and Hidayat, 2019; Vieira et al., 2009).

Jicama (*Pachyhizus erosus)*, a research-targeted material, is an excellent carbohydrate source and contains various active substances, especially vitamin C (Noman et al., 2007). Other isoflavonoids, considered natural sunscreens, can protect and inhibit skin aging (Lukitaningsih, E., and Holzgrabe, 2014). According to the above reasons, this research aimed to formulate and evaluate the characteristic of peel-off gel masks from Jicama.

METHOD

Tools and materials

The tools used in this study were analytical grade, baker glass, graduated cylinders, a volume pipette, laboratory 20x20 cm glass, a sieve, a thermometer, a pestle, and mortar. This research used such instruments as a heating magnetic stirrer (AREC by Velp Scientifica), pH meter (OHAUS Starter 3100), viscometer (B-One BMV 102M), analytical balance (Ohaus PX224 Pioneer), air drying oven (BIOBASE), laminar air flow cabinets (Telstar BV-100), autoclave sterilizer (Hiclave HVE-50, Hirayama), incubator (Memmert BE 600 Incubator) and UV-Vis spectrophotometer (Agilent Cary 8454 UV-Vis).

The raw material used in this research was starch extracted from Jicama (*Pachyrhizus erosus*). Chemicals for making the peel-off gel mask consisted of Polyvinyl Alcohol (PVA), Carboxymethyl Cellulose (CMC), propylene glycol and methyl paraben and distilled water. The chemical properties including antimicrobial activity test were sterile NA, bacteria *Staphylococcus aureus*; and the antioxidant activity needed methanol and 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution.

Research design

The peel-off gel mask was formulated using a completely randomized design with Jicama starch at five concentrations (%) and three replications, as illustrated below:

Five variant formulations were made with increased starch concentration at 1%, 2%, 3%, and 4%; a control sample was without starch. In this process, PVA was used as a film-forming agent, CMC and flour from tubers acted as a gel base, methylparaben was a preservative, propylene glycol was a humectant, and distilled water and alcohol were solvents. Treatments of the addition of flour concentration (% based on total basis) used in this study were described in table 1.

Table 1. Treatments of addition of starch concentration (% based on total basis) in the peel-off gel base formulations

Compositions	Formulations				
	F0	F1	F2	F3	F4
Starch (%)	0	1	2	3	4
CMC (%)			2		
PVA (%)			13		
Propylene glycol (mL)			10		
Methyl Paraben (%)			0.2		
Distilled water (mL)			100		
Ethanol 96% (mL)			4		

Preparations of starch and gel formulations

The starch from Jicama was processed based on the method described by Warnida (2017) with some modifications. Briefly, the fresh tubers from West Sumatra, Indonesia, with 5 – 6 months of growing, were collected, washed, blended, and filtrated. The precipitate was kept to dry in the oven (below 50 ºC) until the moisture content was less than 10%. Obtained starch was sieved with a 100-mesh sieve.

The gel procedure was carried out according to Asben and Kasim (2020) report with some modifications. Polyvinyl Alcohol (PVA) was dissolved in hot distilled water at 80 - 90ºC with constant mechanical agitation until homogeneous (container A). Carboxymethyl Cellulose (CMC) was introduced into distilled water at room temperature until it was completely soluble (container B). Propylene glycol and methylparaben were incorporated with PVA in hot distilled water and stirred until homogeneous (container C). Gelatinized solutions (the starch suspension was heated until it expanded and formed a gel) with the proper concentrations were added according to the research treatments, and ethanol was added as the last step of gel preparation.

Characterization of Gel Preparations

Acidity Degree (pH) test

The sample was taken and dissolved in distilled water with a ratio of 1:1 based on the method of Pinto et al. (2021) with some modifications. Then, the pH of the solution was measured using a pH meter.

Spreadability Test

A total of 1 g of the sample was placed carefully on the glass measuring 20×20cm, then covered with another glass with a weight of 150 g on it and allowed to stand and measured the diameter of the gel was after 1 minute (Nurman et al., 2019).

Viscosity Test

A maximum of 100 mL of gel was put into a container and then placed on a viscometer with spindle no. 4 installed at the appropriate speeds. Recording the viscosity value was shown on the tool (Nurman et al., 2019).

Peeling time test

1 g of sample of the sample was weighed and spread using a mask brush over an area of 6.0 x 3 cm on skin parts (hand or forearm) and let dry until the film could be removed and the time was recorded (Vieira et al., 2009).

Antibacterial activity test

The antimicrobial activity of the sample was determined by using the protocol from the Kirby-Bauer disk diffusion susceptibility method. Briefly, spread evenly 0.1 ml microorganism culture (*Staphylococcus aureus*) 10^{-6} CFU on the 15 mL sterile nutrition agar (NA) surface. Then, disc papers extracted from the sample were put in a petri dish. The petri dish was incubated for 24 hours at a temperature of 37ºC. After that, the diameter of the inhibition zone was observed and measured (Hudzicki, 2012).

Antioxidant activity test

This assay was checked by calculating the inhibition percentage of DPPH radical scavenging activity. The procedure was conducted with modifications from Cao and Song (2019). Briefly, 2 mL of each sample was diluted with methanol, and then 2 mL of the clear solution was mixed with 0.5 mL of DPPH solution (0.36 mM) and 0.5 mL of methanol. Meanwhile, 2.5 mL methanol was mixed with 0.5 mL of 0.36 mM DPPH radical solution for the blank. The mixture was shaken vigorously and incubated at room temperature in the dark for 15 minutes. The inhibition percentage of DPPH radical scavenging activity was determined by a UV-Vis spectrophotometer at a wavelength of 517 nm and calculated by the equation (1):

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

Where A_b was the absorbance of the blank, and A_s was the absorbance of the sample.

Homogeneity, irritation, and organoleptic test

These tests will be performed on a panellist with 30 volunteers aged 18 - 35 years. The homogeneity was checked visually. The gels were placed between glasses, then pressed and observed. The sample is homogenous if no coarse grains or secondary particle aggregation is seen.

Table 2. The organoleptic description of the peel-off gels

Parameters	Score	Description
Color and consistency	5	Opalescent or semitransparent color and homogeneous gel
	4	Light-modified color and homogeneous gel
	3	Light-modified color and semi-homogeneous gel
	2	Intensely modified color and semi-homogeneous gel
	1	Intensely modified color and heterogeneous gel
Odor	5	Normal smell
	4	Light-modified smell
	3	Intensely modified smell
	2	Without smell or smell of chemical
	1	Bad smell or very strong smell of chemical
Touch performance	5	Very pleasant touch with a cool feeling and very easy application
	4	Pleasant touch with a cool feeling and easy application
	3	Quite sticky or fluidic touch
	2	Unpleasant touch
	1	Very unpleasant touch
Favorite	5	Very like
	4	Like
	3	Normal
	2	Less like
	1	Dislike

An irritation test based on the modifications from the method of (Farage et al., 2004) was carried out by applying a certain amount of sample on the skin surface (on the hand or forearm skin) and observing the results. After 24 - 48 hours of the application, and did not cause unwanted skin reactions, and this gel was considered not to irritate. The organoleptic test aimed to evaluate the panel's acceptability of the product by giving a score followed by the hedonic scale ranging from 1 to 5 (Mosquera Tayupanta et al., 2018) with some modifications. The consistency and the color are checked visually. The odor criteria are evaluated manually by smelling the product. Touch performance was observed by applying the product to the skin surface.

Data analysis

The collected data was analyzed using Microsoft Excel 2010 software for calculating and graphing and

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Stagraphics Centurion XVI software for analysis variance (ANOVA).

RESULTS AND DISCUSSION

Physicochemical properties of the raw material

Starch isolated from Jicama was added to the research formulas for peel-off gel preparations. Table 3 shows the moisture content (%), pH value, and the inhibition percentage of the free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) of antioxidant activity of the raw material.

Table 3. The physicochemical properties of Jicama starch

Moisture content	pH	DPPH inhibition
8.06 ± 0.01 %	4.92 ± 0.01	11.38 ± 0.04 %

The starch from Jicama in this research had a moisture content below 10%, and the pH value was generally slightly acidic, which meets the flour standard for storing and processing (Tortoe et al., 2017). Besides, Jicama starch also shows the potential for antioxidant activity due to the content of active compounds in the raw material (Noman et al., 2007).

Physicochemical characteristics of peel-off gel mask formulated from Jicama starch

Antibacterial activity

The antimicrobial activity is expressed based on the clear zone produced around the paper disc. The antibacterial effect is evaluated based on the diameter of the inhibitory zone against bacteria's growth, measured in mm (Hudzicki, 2012).

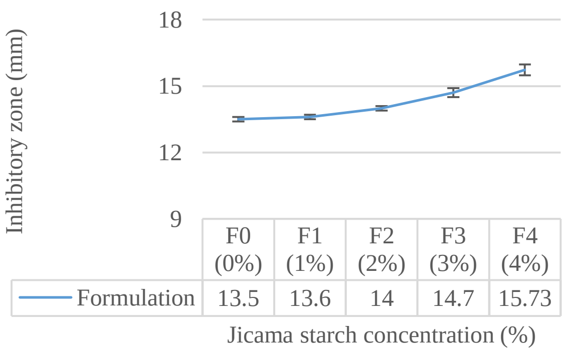

Figure 1. Effects of the starch concentration on the antibacterial activity of peel-off formulations

Figure 1 illustrates the antibacterial activity of *Staphylococcus aureus* in the gel formulas. There was a significant difference ($P < 0.05$) in the size of the inhibition zone among the formulation. The more the concentration of starch, the greater the diameter of the clear zone. The lowest diameter of the inhibition zone was the control sample (13.5 mm), and the highest was the formula at a 4% concentration of starch (15.73 mm). According to Morales et al. (2003), the activity of the antimicrobial inhibition zone was grouped into four categories, namely weak activity (<5 mm), moderate (5-10 mm), strong or active (>10-20 mm), very strong or very active (>20-30 mm). Therefore, all the formulas exhibited active antibacterial activity against the growth of *Staphylococcus aureus*. According to the results, Jicama starch shows potential in continuously studying the antibacterial properties and the application in product development from these crops and in incorporating with other antibacterial agents to enhance this functional property.

Antioxidant activity

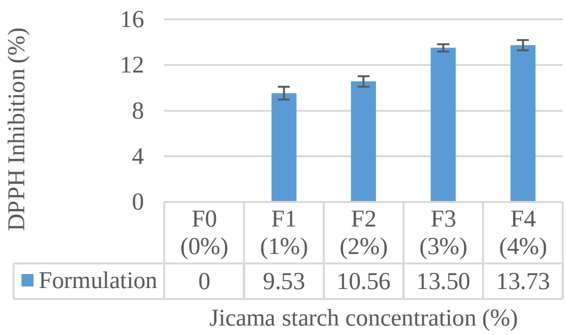

Figure 2. Effects of the starch concentration on the antioxidant activity of peel-off formulations

The experiment was conducted to investigate the antioxidant capacity of Jicama starch in peel-off gel preparations. The results report that all the formulas except the control sample (without starch) showed an antioxidant capacity exhibited through the inhibition percentage of the free radical activity of 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Cao, Yang, and Song, 2018). This inhibition can be explained by the content of active compounds especially vitamin C, a powerful antioxidant, are in the Jicama tuber (Noman et al., 2007). Similar to the antibacterial test, the antioxidant capacity of the samples was significantly different ($P < 0.05$) between the investigated starch concentrations and tended to increase with high concentrations. Thus, the Jicama starch at 4% concentration gave the highest free radical resistance (13.73%), which indicated that peel-off gel formulations with the starch extraction from Jicama presented not only antibacterial activity but also the capacity for inhibiting the free radical of DPPH as antioxidant activity.

Table 4. Effect of Jicama starch concentrations on the pH value and peeling time of peel-off gel formulas

Concentrations	pH value	Peeling time (min)
0% (control)	$5.61^{a} \pm 0.01$	$36.67^{a} \pm 0.58$
1%	$5.58^{b} \pm 0.02$	$31.67^{b} \pm 0.58$
2%	$5.56^{bc} \pm 0.01$	$28.67^{c} \pm 0.58$
3%	$5.54^{cd} \pm 0.01$	$26.67^{d} \pm 0.58$
4%	$5.53^{d} \pm 0.01$	$24.67^{e} \pm 0.58$

The mean in the same column followed by different letters are significantly different (P < 0.05)

Acidity degree

The pH value of acidity degree is one of the crucial parameters of the cosmetic. The results were showed in Table 4; the acidity degree of the formulas was significantly different (P < 0.05). The pH value decreased while increasing the addition of starch concentrations, and this trend is because of the low pH value of the raw material (pH 4.92). This test showed that all formulas are around 5.5 to 5.6, whereas the normal skin pH ranges from 4.5 to 6.5 (Nurman et al., 2019). It can be stated that the pH of all formulas met the pH requirement of the Indonesian National Standard (SNI, 2007) in facial skin products to ensure safety and not disturb the function of the skin.

Peeling time

The peeling time observation showed that the gel formulas with the addition of Jicama starch were less than 30 minutes of drying time (Table 4), and it was still acceptable and considered not too long. From the data, the peel-off gel mask meets a good drying time of between 15-30 minutes (Vieira et al., 2009). The higher the concentration, the significantly shorter the peeling time (P < 0.05). The decrease in peeling time can be explained due to the higher water absorption and solubility of Jicama starch (Martınez-Bustos et al., 2005). The gels were thicker and denser when adding more starch concentration in the proper gelatinization conditions, which made the gel stay stable on the surface and increased the speed of evaporation.

Spreadability

The spreadability of gel preparations is defined as the gel's ability to spread on the skin's surface, which is observed through the spread diameter. A good spread diameter ranges from 5 - 7 cm (Nurman et al., 2019). The spread diameters of gel preparations ranged from 6.23 - 6.81 cm (Table 5). The concentration affected the spreadability; the higher the concentration, the significantly smaller the diameter (P < 0.05). The gel consistency tended to increase the viscosity and became thicker, reducing the gel's spreading capacity. Therefore, the results indicated that all the gel formulas had good spreadability.

Table 5. Effect of Jicama starch concentrations on the spreadability and viscosity of peel-off gel formulas

Concentrations	Spreadability (cm)	Viscosity (cPs)
0% (control)	$6.81^{a} \pm 0.02$	$14626.7^{e} \pm 110$
1%	$6.76^{b} \pm 0.02$	$19783.3^{d} \pm 76$
2%	$6.55^{c} \pm 0.02$	$21800.0^{c} \pm 100$
3%	$6.43^{d} \pm 0.02$	$25183.3^{b} \pm 176$
4%	$6.23^{e} \pm 0.02$	$32866.7^{a} \pm 104$

The mean in the same column followed by different letters are significantly different (P < 0.05)

Viscosity

Viscosity, or the resistance of a liquid to flow, is a critical part of maintaining a consistent and controlling quality of the product in the cosmetics industry. Further, viscosity can impact a cosmetic product's chemical stability in its packaging over time (Epstein, 2009). The results of the data analysis in Table 5 reported significant differences (P < 0.05) in the viscosity evaluation from the samples. Viscosity increased when adding more concentration of Jicama starch. The trend is caused due to the morphology and gelatinization characteristics of Jicama starch with high viscosity and sticky consistency (Stevenson, Jane, and Inglett, 2007). All the formulas had the viscous range from 14626.7 to 3232866.7 cPs (Table 5), which ensured the standard viscosity according to the Indonesian National Standard (SNI, 2007), which is 2000 - 50000 cPs.

Homogeneity, irritation and organoleptic test

Based on the evaluation of the homogeneity and irritation test can be seen in Table 6. The results showed that the gels formulated from Jicama starch were homogenous. In addition, all formulations did not show any irritating reaction or side effects on the skin after doing the organoleptic test.

Table 6. Effects of Jicama starch concentrations on homogeneity and irritation

Starch concentrations	Homogeneity	Irritation
0% (control)	H	No irritate
1%	H	No irritate
2%	H	No irritate
3%	H	No irritate
4%	H	No irritate

H: homogenous

The organoleptic evaluation is illustrated in Figure 3. All formulations were stated in the homogenous consistency and the color with the light-modified from opalescent or semitransparent color for the color and consistency parameter. For the odor, most participants in the panellist agreed that the control sample (without starch) had a strong smell of chemicals. The formulas with low concentrations still had the scent of chemicals and a very light smell of the raw material. The formula with a high suggestion for a pleasant touch with a cool feeling and easy application was 4% of Jicama starch. Meanwhile, the formulas with a

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starch concentration below 4% were fluidic and unstable on the skin surface when applied, extending the peeling time. At the same time, the formula with 4% of Jicama starch concentration got the highest score from the panellist's evaluations for the parameter of favorite acceptance.

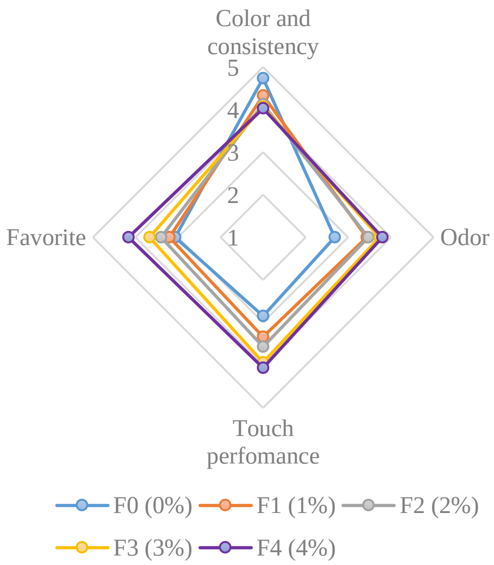

Figure 3. Organoleptic evaluation on the peel-off formulations

CONCLUSIONS

Based on the evaluation of the physicochemical characteristics of all formulas, the results stated that Jicama could be utilized to create a good quality peel-off gel mask preparation. The formula with 4% Jicama starch was considered the best concentration for the product formulation. The chosen formula met the criteria for the characteristics of cosmetics, such as pH, spreadability, viscosity, homogeneity, peeling time, and organoleptic tests. Moreover, the formula also presented functional properties, including antibacterial and antioxidant activities.

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