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Foam-Mat Drying Techniques of *Spirulina platensis* Improve the Properties of Facial Masks

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A B S T R A C T

Spirulina platensis is a renewable nutritious microalga featuring beneficial properties, such high antioxidant, which made S. platensis as a prominent active component of natural cosmetics. S. platensis was used in this investigation on a facial mask as a skin care product. Numerous methods were developed to enhance the properties of facial masks. Many S. platensis extracts are dry powders since the cosmetic industry's recent rise. In this study, foam-mat and non-foam-mat drying methods were used as treatments in a completely randomized design (CRD). The results show that the facial mask with an addition of foam-mat drying techniques of S. platensis had better properties than the other one, which contains 0.383±0.0042 mg/100g of beta-carotene, 3,548≤μ≤3,798 of irritation score, 39.612,3cPs viscosity content, and 7.5±0.1 of pH. Heat-sensitive goods can be dried using the foam-mat method. Additionally, foam-mat drying has gained popularity due to its ease of use, affordability, quick dry duration, and enhanced product properties.

Keywords: *Spirulina platensis*, drying, beta-carotene, foam-mat drying, facial mask

1. Introduction

One type of microalgae with a lot of promise is *Spirulina* sp. Numerous traits and a high nutritious content make *Spirulina* sp. suitable for application in foods and cosmetics. According to Ragusa et. al. (2021), *Spirulina platensis* components contain antioxidants, antiviral, and the ability to enhance the immune system and repair damaged cells. Spirulina contains antioxidants that can shield the body from free radicals and stop degenerative illnesses. Costa et al. (2017) stated that Spirulina has a high antioxidant content that helps shield our skin from harm brought on by pollution, free radicals, and other environmental pressures. One of the strongest antioxidants found in Spirulina is carotenoids, with beta-carotene as the most abundant pigment in it. Beta-carotene plays an important role on measures of actual health, including facial appearance (Foo et al., 2017). These days, more people are aware of the need of keeping their skin healthy, and they follow skin care regimens to avoid damaging their facial or body. The application of Spirulina into facial masks is one example. The application of Spirulina to facial masks is feasible considering the bioactive compound contained in Spirulina, beta-carotene, is capable of reducing wrinkles, removing acne scars, brightening, and moisturizing facial skin. acne scars (Villaret et al., 2019; Bin-Jumah et al., 2021).

Several techniques for preserving Spirulina for application in the food and pharmaceutical industries have been explored in earlier study. Since spirulina is perishable, techniques of drying might be employed as a substitute to preserve its quality prior to utilization. Foam-mat drying is a common technique of drying used to preserve the advantageous organic content of Spirulina. Foam-mat drying is a different technique that enables the extraction of water from liquid and pureed materials. This drying procedure involves adding an edible foaming ingredient to a liquid material and whipping it into a stable foam (Hardy & Jideani, 2017). The objective of this study is finding out how well Spirulina powder dries at various temperatures using foam-mat and non-foam-mat drying techniques and its application to produce a facial mask.

2. Material and Methods

2.1 Material

In this study, we used fresh *S. platensis* from BBPBAB (Balai Besar Perikanan Budidaya Air Payau), Jepara, Central Java, Indonesia. The ingredients that are used in the drying process of S. platensis are egg whites, methylcellulose, and aquades, while the ingredients of the facial masks are polyvinyl alcohol (PVA), carboxymethylcellulose (CMC), glycerin, nipagin (Methylparaben), nipasol (Propilparaben), and distilled water.

The equipments used in this study Ovens (Binder), pH meters (LT Lutron), analytical balances (O'haus), hotplates, Toledo Metler's syncroelectric Brookfield viscosity tests, glassware (IWAKI Pyrex) and other equipment used for detailed analysis purposes.

2.2 Methods

S. platensis Drying Procedures

a. Foam-mat Drying Method

The foam-mat drying method is carried out by preparing 21% *S. platensis*, then added with 76% aquades, then adding the 2.5% white eggs and 0.5% methylcellulose, then mixing all ingredients until homogeneous using a medium-speed mixer. After homogeneous, the dough has been coated with plastic and continued with the drying process at the specific temperature. *S. platensis* is dried at different temperatures of 50°C, 60°C, and 70°C.

a. Non-foam-mat Drying Method

Non-foam-mat drying method is carried out by preparing 25% *S. platensis* then added with 75% aquades, then mix all ingredients until homogeneous using a medium-speed. After homogeneous, a dough poured into a tray that has been coated with plastic, and continued with the drying process at the specific temperature. *S. platensis* is dried at different temperatures of 50°C, 60°C and 70°C.

Facial Mask Productions

The method of making facial masks refers to research conducted by Setyaningsih et. al. (2019). In accordance with the study's treatment, Spirulina-free facial masks (A), facial masks with drying foam-mat Spirulina (B), and facial masks with non-foam-mat drying Spirulina (C) were made as follows: PVA (polyvinyl alcohol) is combined with 80°C distilled water to get the desired expansion, agitated, and then combined with carboxymethyl cellulose (CMC) in cold distilled water. Afterwards, PVA is mixed with glycerin, nipagin, and nipasol that have been dissolved in hot distilled water, CMC, TEA (triethanolamine), and *Spirulina* powder in that sequence. Table 1 displays the production of facial masks.

Table 1 – Facial Mask Formulation

Materials	**Facial Mask Types**		
	A	**B**	**C**
Spirulina platensis (%)	-	2	2
PVA (%)	12	12	12
CMC (%)	1	1	1
Glycerin (%)	10	10	10
Nipagin (%)	0.2	0.2	0.2
Nipasol (%)	0.05	0.05	0.05
TEA (%)	2	2	2
Distilled water (%)	74.75	72.75	72.75

Beta-carotene analysis on Spirulina powder

Beta-carotene analysis was referring to Biswas et.al. (2011). A glass test tube containing a 1 g sample was precisely weighed. Following the addition of 5 ml of cold acetone, the tube was maintained at 4 ± 1 °C for 15 minutes with periodic shaking, vortexed for 10 minutes at high speed, and then centrifuged for 10 minutes at 1370 × g. After collecting the supernatant into a different test tube, the chemical was extracted again using 5 mL of acetone and centrifuged once more. After being combined, the two supernatants were run through Whatman filter paper No. 42. The extract's absorbance was measured in a UV-Vis spectrophotometer at a wavelength of 449 nm. Additional diethyl ether, acetonitrile, and methanol extracts were also made in the same way as described.

Moisture analysis on Spirulina powder

Moisture content, was determined according to AOAC (2005).

Facial Mask Analysis

The quality of facial masks is analyzed for beta-carotene content, water content, and other analyses such as pH, skin irritation, sensory evluation, and viscosity (Septiani et al., 2020).

Data Analysis

Data were expressed as mean of three replicates ± standard error (SE). Data for the sensory evaluation of all facial masks formulas were subjected to the analysis of variance followed by Tukey-Multiple comparison.

3. Results and Discussions

3.1 Characterization of Spirulina platensis Powder

The results of the *S. platensis* powder are displayed in Table 2.

Table 2 – Dried *S.platensis* Powder

Drying Techniques	*Drying temperature (°C)*	*Beta-carotene (mg/100g)*	*Drying Time (h)*	*Moisture content (%)*
Foam-mat drying	50	17.251 ± 0.548	17.32 ± 0.14	6.48
	60	21.768 ± 1.508	15.30 ± 0.15	5.54
	70	23.640 ± 0.116	13.23 ± 0.14	4.76
Non-foam-mat drying	50	8.209 ± 0.026	18.58 ± 0.51	6.42
	60	11.672 ± 0.510	16.62 ± 0.35	5.16
	70	15.354 ± 0.388	14.58 ± 0.31	4.98

The data are the average results of three repetitions ± standard deviation

The beta-carotene levels *in S. platensis* that employ this method are higher than those that did not since the foam-mat drying method takes less time than the non-foam-mat drying technique. An ingredient's nutritional value can be preserved with a brief drying period. According to Djaeni et al. (2015), as the amount of foam increases, consequently increases the drying rate. The applied temperature may be impacted. The applied temperature may be impacted. The drying period can be accelerated by lowering the temperature. The drying times for the two approaches vary by around one to one and a half hours. The inclusion of methyl cellulose as a foaming stabilizer and egg whites as a foaming agent essentially causes this variation in drying time. When exposed to heat, egg whites or foaming agents may broaden the material's surfacial coverage. Egg whites are frequently employed as foaming agents because they help preserve the foam's stability and texture (Ihsani et al., 2024). Since foam can increase the material's surfacial area, dried S. platensis with foam mat drying has a lower moisture content than when no foam mat drying is utilized. According to Ihsani et al. (2024), variations in moisture content can impact a material's texture, appearance, and shelf life. **Figure** 1 shows dried *S. platensis* by foam-mat drying and non-foam mat drying.

(a) **(b)**

Fig. 1. Appearance of dried *Spirulina* powder: with foam-mat drying (a); with non-foam-mat dring

3.2 Sensory Properties of Spirulina platensis' s Facial Mask

Sensory properties of facial mask produced in this study was presented in **Table 3**.

Table 3 – Sensory Properties of Facial Mask with *S. platensis* Addition

Type of Facial Mask	*Texture*	*Color*	*Odor*
Spirulina-free (A)	Less thick	Clear	Chemical tipical
With foam-mat dried *Spirulina* (B)	Thick	Green	Spirulina's distinctive aroma
With non-foam-mat dried *Spirulina* (C)	Very thick	Dark green	Spirulina's distinctive aroma

Spirulina powder offers an enormous effect on the facial mask's physical appearance, particularly in terms of color and odor, as Table 3 demonstrates. Furthermore, compared to the other two facial masks (A and C), the facial mask containing Spirulina powder made using the foam-mat drying process (B) has a brighter green hue that is consistent with its raw material. The quality of the facial mask is impacted by the essential addition of dried spirulina powder with specific treatments. The drying method using foam-mat drying creates a texture that is neither too thick nor too runny considering the facial mask's texture has varying viscosities. This is in line with research by Gharehbeglou et al. (2023), which added powder particles to food, which had a sensory impact on product visuality.

3.3 Impact of Spirulina platensis' s Facial Mask on Skin

The functionality of the face mask from this study was determined by a simple method by applying the face mask to the back of the palm. In addition to minimizing possible risks, this test method is expected to be able to represent how far the face mask from the study is in accordance with expectations. The skin irritation test was conducted on 20 panelists, where after applying the face mask to the inner arm, it took 15 minutes to determine the level of irritation.

Table 4 – Irritation Score of Facial Mask with *S. platensis* Addition

Type of Facial Mask	*Reddish*	*Itchy*	*Skin hardening*
Spirulina-free (A)	0	0	0
With foam-mat dried *Spirulina* (B)	0	0	0
With non-foam-mat dried *Spirulina* (C)	0	0	0

With a primary irritation index score of 0, it can be said that the all-facial masks formulation is safe for skin use and does not irritate it. The neutral pH characteristics of Spirulina allow them to cover the deficiencies of each base property that impacts irritation tests without affecting other additions. Additionally, because it contains glycerin as a humectant to provide the skin a moisturizing sensation, it is safe to use again as well as previously studied (Ramadani and Sari, 2023). This result is consistent with research by Fadhilah et al. (2022), who tested clay mask preparations on test animals to determine their level of discomfort.

3.4 Dry Time of Spirulina platensis' s Facial Mask

Table 5 displays the duration of drying test results for the face masks that had dried *S. platensis*

Table 5 – Dry Duration of *Spirulina*'s Facial Mask

Type of Facial Mask	*Dry duration (min)*
Spirulina-free (A)	20.6 ± 0.5^{a}
With foam-mat dried *Spirulina* (B)	19.3 ± 0.2^{b}
With non-foam-mat dried *Spirulina* (C)	18.6 ± 0.5^{c}

Notes:

-The data are the average results of three repetitions ± standard deviation

-Data followed by different lowercase marks on the same line showed a noticeable difference ($p<0.05$)

Control face masks take the longest to dry out of all of them; this could be because of their thickness and viscosity, which are applied to the back of the hand. A face mask's drying time can also be influenced by a number of variables, including the amount of PVA, glycerin, and water content. According to Fauziah et al. (2020), the drying time is influenced by the PVA's effect on the sample; the higher the PVA concentration, the quicker the drying time. Glycerin in the gel recipe, on the other hand, can be utilized as a humectant, which in order to make the gel more stable, it should both hydrate the skin and retain its proportion of water.

3.5 Viscosity, pH, and Beta-carotene of Spirulina 's Facial Mask

Beta-carotene is one of the anti-aging ingredients in Spirulina. In addition to the physical and sensory aspects of the face mask, the primary factors in this study were the amount of beta-carotene, viscosity, and the level of acidity (**Table 6)**.

Table 6 – Viscosity, pH, and Beta-carotene of *Spirulina*'s Facial Mask

Type of Facial Mask	*Viscosity (cPs)*	*pH*	*Beta-carotene (mg/100 g)*
Spirulina-free (A)	31.453,33±934,54 [a]	7.6±0.115[a]	Undetected[a]
With foam-mat dried *Spirulina* (B)	39.612,33±1636,98[b]	7.5±0.1[b]	0.383±0.0042[b]
With non-foam-mat dried *Spirulina* (C)	40.424,66±1078,01[b]	7.66±0.06[c]	0.091±0.004[c]

Notes:

-The data are the average results of three repetitions ± standard deviation

-Data followed by different lowercase marks on the same line showed a noticeable difference ($p<0.05$)

Table 6 shows the Spirulina-free facial mask had the lowest viscosity compared to others, and there were no significant differences of viscosity between the B facial mask and the C facial mask. This value is much lower than the viscosity of the face mask in the previous study by Nihal et al. (2018) of 175–198 cPs, considering that Spirulina was applied in making the face mask as much as 10%. In contrast, the pH of the face mask from this study has a higher range compared to the pH range of the face mask from that study, between 6.1 and 6.8. The same acidity level as Nihal et al. (2018) also occurs in the face mask from the study by Setyaningsih et al. (2019). However, the viscosity of the face mask from the study by Setyaningsih et al. (2019) is 175 times thicker than the face mask from this study, even though the amount of Spirulina added is 1.25% lower. Many factors influence the characteristics of face masks, including formulation. Measuring the amount of beta-carotene in this face mask is crucial because it can brighten the face in addition to hydrating it. Table 6 demonstrates that adding Spirulina significantly alters the face mask's properties ($p <0.05$), particularly the face mask that uses Spirulina powder and foam-mat drying methods has the greatest beta-carotene content of all the face masks. This suggests that the bioactive antioxidants found in spirulina can be preserved by the processing method. However, there are several drawbacks, such as beta-carotene's poor chemical stability in application and its trapped water insolubility (Lima et al., 2021).

4. Conclusion

The scientific community has paid close attention to Sprulina since they are a sustainable, natural, and green biological resource. This study provides an overview of the possible uses of spirulina's active components in the cosmetics industry. Research has shown that the foam-mat drying methods used on spirulina are safe and effective alternatives to cosmetic chemicals for anti-aging. To improve the microalgae industry's development, experts should concentrate on enhancing biotechnology research in the future and incorporating digital control.

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