Characterization and formulation of sunscreen from seaweed *Padina australis* and *Euchema cottonii* slurry

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**Abstract.** Exposure of UV light can cause skin rashes and sunburn, stimulating the formation of melanin. Long term UV exposure also can cause skin cancer. One way that can reduce negative impact of UV exposure is by using sunscreen. The aims of this study were to obtained the best ratio of seaweed *P. australis* and *E. cottonii* slurry to produce sunscreen cream and as well as obtaining sunscreen formulation with good stability. Creams were formulated consist of cream with different ratio of seaweed *P. australis* and *E. cottonii* slurry, i.e. A (control), B (1:1), C (2:1) and D (1:2). The commercial creams product also used as a comparator (KI and KII). The best ratio of *P. australis* and *E. cottonii* slurry was showed on cream B (1:1). Sunscreen creams have a good level stability, with no phase separation of dispersant and dispersed phase, and also no discoloration. Sunscreen creams have at least 1 year shelf life as there was no phase separation after centrifugal force at 3,800 rpm for 5 hours.

**Keywords:** antioxidant activity, *Euchema cottonii*, *Padina australis*, SPF, stability

1. Introduction

Skin is the largest organ in the human body. One major function of the skin is as a defense (barrier) against various external and internal harmful risks. One of the harmful external risk to the skin is ultraviolet (UV) light exposure. Exposure of UV light can cause skin rashes and sunburn, thus stimulating the formation of melanin. Long term UV exposure can also cause skin cancer. One way that can reduce negative impact of UV exposure is by using sunscreen.

According to Haryani *et al* (2014), *P. australis* contains phytochemical compound such as flavonoids and tannins. Prasiddha *et al* (2016) stated that flavonoid has potential as a sunscreen for their chromophore group which generally gives the yellow color of the plant. The chromophore group is a conjugated aromatic system which causes a strong ability to absorb light in the wavelength of UV light, both in UVA and UVB. Svobodová *et al* (2003) stated that tannins also known can protect damage against free radical caused by UV light. The
phytochemical compounds in *P. australis* make this type of seaweed potential to be developed as a natural raw material in the manufacture of sunscreen.

High antioxidant content in seaweed known to prevent aging and improve appearance. Setha *et al* (2013) reported that IC$_{50}$ value of *Padina* sp. is 200.88 ppm. Husni *et al* (2014) reported that IC$_{50}$ of *Padina* sp. were 37.68-48.03 ppm. Bambang *et al* (2013) also reported that IC$_{50}$ of *Padina* sp. were 54.98-113.72 ppm. Furthermore, Nursid *et al* (2013) also found that the antioxidant activity of *P. australis* and its availability to generate barriers value against free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) by 53% at 50 ppm dose. This value was higher than *Hormophysa triquetera* (45%) and *Turbinaria decurrens* (33%) at the same dosage.

One of the important factor in sunscreen production is the stability of the cream. Carrageenan is a hydrocolloid compound derived from *E. cottonii* that has been widely used in various fields of industry as a natural stabilizer. Anggadiredja *et al* (2006) stated that the hydrocolloid compound is indispensable compound in the sunscreen product because it serves as the gelling agent, stabilizer, emulsifier, and suspending agent.

Potency of seaweed extracts and slurry from brown seaweed as a source of antioxidants have been reported by previous researchers (Nurjanah *et al* 2016, Luthfiyana *et al* 2016, Nurjanah *et al* 2017, Maharani *et al* 2017, Diachanty *et al* 2017, Arifianti *et al* 2017, Gazali *et al* 2018, Gazali *et al* 2019). Additionally, brown seaweed *Sargassum* sp. contains vitamin C, vitamin E and bioactive compounds (Nurjanah *et al* 2017, Maharani *et al* 2017 and Dolorosa *et al* 2017), total phenolic content (Diachanty *et al* 2017), potential as a tyrosinase inhibitor (Dolorosa *et al* 2019, Sari *et al* 2019) and anti-collagenase activity (Mansauda *et al* 2018).

The study was conducted using seaweed that has been processed into a slurry, making it easier to implement and more economically viable (Nurjanah *et al* 2019, Nurjanah *et al* 2017, Nurjanah *et al* 2016, Dolorosa *et al* 2019, Luthfiyana *et al* 2016, Maharani *et al* 2017, Yanuarti 2017, Sari *et al* 2019). Research about seaweed slurry as raw material for cosmetics. Similar products have been widely circulated in the market, such as the manufactured product of Micro, Small and Medium Enterprises (SMEs). However, furthered research is needed on the characteristics and product formulations to obtain a better sunscreen product and qualified the health standards. The aims of this study were to obtain the best ratio of seaweed *P. australis* and *E. cottonii* slurry to produce sunscreen cream and as well as obtaining sunscreen formulation with good stability.

2. Materials and methods

2.1. Sampling
The main materials used in this research were brown seaweed *P. australis* and *E. cottonii*. *P. australis* was obtained from Tidung Island, Seribu Islands Jakarta Indonesia in a fresh conditions and transported to the laboratory using a cool box. Meanwhile *E. cottonii* was obtained from Serang, Banten, Indonesia. Sampling was done by collecting from the cultivation of local communities. *E. cottonii* samples were obtained in the dry state to avoid the risk of damage. The samples of *E. cottonii* were washed firstly to remove dirt and salt content.

2.2. Seaweed slurry preparation
Seaweed soaked with 5% calcium oxide solution for 12 hours (1:20). *P. australis* and *E. cottonii* were washed using deionized water to remove dirt and sands. Each *P. australis* and *E. cottonii* were blended and homogenized using deionized water (1:1).
2.3. Sunscreen cream preparation
The cream preparation process referred to Mishra et al (2014) with some modification. The oil phase materials including emulgade, stearic acid, cetyl alcohol liquid paraffin, butylated hydroxytoluene (BHT) and methyl paraben were mixed in a beaker glass until homogeneous (stock 1). The water phase including glycerin, triethanolamine (TEA) and seaweed slurry also mixed in a beaker glass until homogeneous (stock 2). Both stocks were further heated at 70-80°C until homogeneous. Creams were formulated to have different ratio of seaweed *P. australis* and *E. cottonii* slurry, i.e. A (control), B (1:1), C (2:1) and D (1:2). The commercial creams product also used as a comparator (KI and KII).

2.4. Total plate count analysis (SNI 16-4399-1996)
Cream was aseptically weighed for 1 g, put into a diluting solution (saline), and then homogenized thoroughly. Dilution process was conducted until factor of 10⁻³. Samples were then inoculated in sterile Plate Count Agar (PCA). Number of colonies that grew were reported as total microbes.

2.5. Antioxidant activity analysis (Salazar-Alanda et al 2009)
Measurement of antioxidant activity was using DPPH method. The antioxidant activity analysis was conducted by manufacturing DPPH and vitamin C stock, preparing the samples, and conducting antioxidant activity test based calculated based on 50% inhibitory value of free radical activity (IC₅₀) using linear regression equation.

2.6. Physical evaluation of creams
Physical evaluation of creams was conducted through of sensory evaluation, measurements of pH (Ditjen POM 1995) and viscosity (Martin et al 1993).

2.7. SPF value analysis (Pissavini and Ferrero 2004)
SPF value analysis was conducted using UV-Vis spectrophotometer. The average absorbance (Ar) were set at intervals of 10 nm. SPF values calculated from recorded absorbance.

2.8. Cycling test
Samples were stored at 4°C±2°C for 24 hours, then transferred into a preheated oven at 40°C±2°C for 24 hours. Stability test performed as many as six cycles while one cycle was equal to storing process of the sample in the refrigerator and oven at aforementioned conditions. After six cycle, the sample was then observed for the presence or absence of phase separation and inversion.

2.9. Centrifugal test (Botham et al 1994)
Samples were inserted into a test tube, then put in centrifuge with a speed of 5,000 rpm for 30 minutes. This treatment was the same as the treatment of their gravity for 1 year. Samples that have been centrifuged and then observed to see the separation of the oil phase to the aqueous phase.

3. Result and discussion

3.1. Characteristics of seaweed slurry
Analysis of total microbes was carried by counting every living cell that will develop into a colony that appeared on plates as index number of microbes that can live and contained within the sample based on Mitsui (1997). The results with total plate count (TPC) method indicated that there was no bacteria colonies on each sample. Based on these results, seaweed *P. australis* and *E. cottonii* slurry were safe to be used as raw materials for sunscreen cream. The maximum limit of total microbes allowed under SNI 16-4399-1996 is 1.0×10² colony/gram. The application of aseptic techniques in slurry production causing no contamination of bacteria. The
antioxidant activity test were also conducted on seaweed slurry using DPPH methods. Based on the test, IC$_{50}$ of _P. australis_ and _E. cottonii_ slurry were 121.63 ppm and 133.69 ppm.

The IC$_{50}$ value of _P. australis_ and _E. cottonii_ slurry obtained can be classified in a moderate level of antioxidant. Molyneux _et al_ (2004), reported that a compound can be categorized as a very powerful antioxidant if the IC$_{50}$ value less than 50 ppm, strong for IC$_{50}$ between 50-100 ppm, moderate value between 100-150 ppm and weak 150-200 ppm.

3.2. Physical evaluation

3.2.1. Sensory characteristics. Sensory test was performed using acceptance test or hedonic test to evaluate preference level of panelists to creams. Sensory test conducted on 30 panelists with ages ranging between 20-40 years. The parameters measured were appearance, color, aroma and homogeneity. The average values of appearance, color, odor and homogeneity of creams were presented on table 1.

**Table 1.** The average values of appearance, color, odor and homogeneity of cream.

| Parameter     | Cream       | 
|---------------|-------------|
|               | A (0)       | B (1:1)     | C (2:1)     | D (1:2)     |
| Appearance    | 5.06±0.65$^a$ | 4.67±0.73$^b$ | 4.63±1.03$^b$ | 4.63±0.35$^b$ |
| Color         | 4.83±0.84$^a$ | 4.56±1.05$^a$ | 4.53±0.77$^a$ | 4.50±0.80$^a$ |
| Odor          | 4.56±0.60$^a$ | 4.50±0.46$^a$ | 4.53±0.72$^a$ | 4.50±0.65$^a$ |
| Homogeneity   | 4.96±1.04$^a$ | 4.80±0.71$^a$ | 4.73±0.52$^a$ | 4.76±0.82$^a$ |

$^a$A= control, B= _P. australis_ and _E. cottonii_ (1:1), C= _P. australis_ and _E. cottonii_ (2:1), D= _P. australis_ and _E. cottonii_ (1:2), Different letters indicate significantly different ($p<0.05$).

The average values of appearance ranged from 4.63 to 5.13. The highest average value was a commercial product II (KII). Ramadhan (2011) stated appearance plays an important role in consumer acceptance for being the initial assessment of a product.

Color is one factor that determine visual acceptance of a product (Winarno 2008). The average values of colors ranged from 4.5 to 5.16. The highest value of colors found in commercial product II (KII). Commercial products used for comparison were white, while products with _P. australis_ and _E. cottonii_ slurry have brownish color. The color difference caused by brown _P. australis_ slurry on the formula. This is in accordance with (Mitsui 1997), the color of product is affected by the color of its constituent materials.

The average values of aroma ranged between 4.43-5.33. The odor of the cream made with _P. australis_ and _E. cottonii_ slurry were slight fishy odor, typical of seaweed. Because the product was made without additional fragrance, whereas the cream A has a chemical smell. The highest odor value was cream KII.

The average values of homogeneity ranged from 4.66 to 5.3. Commercial cream, both KI and KII have a higher values than the cream containing _P. australis_ and _E. cottonii_ slurry. The differences of value can be influenced by the cream making techniques, which commercial cream have been made with industrial equipment. It is in line with statement from Ahmad _et al_ (2013) who stated that homogeneity of cream is more emphasized on the techniques of making cream.

3.2.2. pH value. The pH value of cream products that are used for the skin should be in accordance with the reception of the skin 4.5-7.5. If the product has higher or lower pH value, it will cause skin irritation (Wasitaatmadja 1997). The pH values of the control and creams with _P. australis_ and _E. cottonii_ slurry were presented on figure 1.
Figure 1. The pH values of the control and creams with *P. australis* and *E. cottonii* slurry, A = control, B = *P. australis* and *E. cottonii* (1:1), C = *P. australis* and *E. cottonii* (2:1), D = *P. australis* and *E. cottonii* (1:2).

Based on SNI 16-4399-1996, cream recommended pH ranges between 4.5-8.0. According to these values, cream with the addition of *P. australis* and *E. cottonii* slurry were still safe to be used. Furthermore, Rahmanto (2011) also stated that the pH value of the final product is influenced by the pH value of raw materials that are used.

3.2.3. Viscosity. Viscosity is a factor that is closely related to the stability of the emulsion. The higher the viscosity, the smaller the rate of phase separation of dispersed and dispersing phase (Suryani et al 2000). The viscosity of all creams with *P. australis* and *E. cottonii* slurry including control ranged between 20,400-16,000 cPs. This result were still accordance with the SNI 16-4399-1996, where the terms of viscosity cream is between 20,000-50,000 cPs.

3.2.4. Antioxidant activity (IC₅₀). Measurements of antioxidant activity using DPPH free radical-scavenging method. The best IC₅₀ values was obtained on cream C, containing *P. australis* and *E. cottonii* slurry with the ratio of 2:1 (102.79 ppm). The IC₅₀ values of all creams were presented figure 2.

Figure 2. The IC₅₀ values of the control and creams with *P. australis* and *E. cottonii* slurry, A = control, B = *P. australis* and *E. cottonii* (1:1), C = *P. australis* and *E. cottonii* (2:1), D = *P. australis* and *E. cottonii* (1:2).
The IC50 values of creams with *P. australis* and *E. cottonii* slurry obtained can be classified into a moderate level of antioxidant, whereas cream A in the weak level. According to the results, the higher *P. australis* slurry added, the higher antioxidant activity of the cream. Molyneux *et al* (2004) also stated that a compound said to be a very powerful antioxidant if the IC50 value less than 50 ppm, strong between 50-100 ppm, moderate between 100-150 ppm and weak for 150-200 ppm.

**Sun protective factor (SPF).** The SPF value indicated ability of a sunscreen to protect skin from UV exposure. SPF values of creams presented on table 2. The highest SPF value was in the cream B with 1:1 *P. australis* and *E. cottonii* slurry. The lowest SPF value was in the control cream (2.026). Based on these results, creams with *P. australis* and *E. cottonii* slurry obtained can be classified in medium level. Damogalad *et al* (2013) stated that the division level of sunscreen can be categorized as minimum when the SPF value was around 2-4, medium when the SPF value was between 4-6, and extra if the SPF value between 6-8, maximized if the SPF value between 8-15 and ultra when SPF value over 15.

### Table 2. SPF values of creams.

| Creams | SPF     | Label information |
|--------|---------|-------------------|
| A      | 2.026±0.01 | -                 |
| B      | 5.229±0.02 | -                 |
| C      | 4.920±0.01 | -                 |
| D      | 4.697±0.01 | -                 |
| K      | 3.726±0.01 | 15                |

3.2.5. **Total microbes.** Based on the total plate count analysis, there were no microbial colonies growing on control and cream with *P. australis* and *E. cottonii* slurry. This can be caused by the application of aseptic techniques during the raw materials preparation to manufacture of creams. Additionally, the use of methyl paraben may also affect the growth of microbes. Rieger (2000) stated methyl paraben are commonly used in creams because it can prevent the growth of bacteria and fungi.

### Stability of creams

3.3.1. **Centrifugal test.** Centrifugal or mechanical test is a stability test which conducted to determine the shelf life of the cream. The centrifugal test both control and cream with *P. australis* and *E. cottonii* slurry showed no phase separation in the dispersed and dispersing phase. This result suggests that creams have at least 1-year shelf life. Lachman (1994) stated that the mechanical test conducted to determine the shelf life of cream for one year, where the force of gravity during one year can be illustrated with a rotation speed 3,750 rpm for 5 hours. The centrifugal test of control and cream with *P. australis* and *E. cottonii* slurry presented on figure 3.

![Figure 3.](image)

3.3.2. **Cycling test.** Cycling test is an initial stability test to estimate the stability of the cream. Cycling test carried out a low temperature (4°C±2°C) and hot temperature (40°C±2°C) for 6
cycles. The cycling test results showed that no phase separation between dispersed and dispersing phase. Rieger (2000) stated that the emulsion stability will increase with additional of suitable polymeric dispersant phase and a decrease in the particle size of the dispersed phase, so as to prevent or prolong the time of the recombining particles of similar results in phase separation.

4. Conclusion

The best ratio of *P. australis* and *E. cottonii* slurry was shown on cream B (1:1). Sunscreen containing *P. australis* and *E. cottonii* slurry had a good level stability, with no phase separation of dispersant and dispersed phase, and also no discoloration. Sunscreen creams had at least 1 year shelf life as there was no phase separation after centrifugal force at 3,800 rpm for 5 hours.

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References

Ahmad I and Agus A S R 2013 Uji stabilitas formula krim tabir surya ekstrak umbi bawang dayak (*Eleutherine americana* L. Merr.) *J. Trop. Pharm. Chem.* 2 159-165

Anggadirejja J T, Zatnika A, Purwoto H and Istini S 2006 *Rumput Laut* (Jakarta: Penebar Swadaya)

Arifianti A E, Anwar E and Nurjanah 2017 Aktivitas penghambatan tirosinase dan antioksidan serbuk rumpat laut dari *Sargassum plagiophyllum* segar dan kering *JPHPI 20* 488-493

Bambang B S, Kumalaningsih S, Susinggih W and Hardoko 2013 Polyphenol content and antioxidant activities of crude extract brown algae by various solvents *JLSB 3* 439-443

Botham P A, Earls L K, Fentem J H, Rogeut R and Sandt J J M 1998 Alternative methods for skin irritation testing: the current status *Altern. Lab. Anim.* 36 195-211

Damogalad V, Eddy H J and Supriati H S 2013 Formulasi krim tabir surya ekstrak kulit nanas (*Ananas comosus* L. Merr) dan uji in vitro nilai sun protecting factor (SPF) *Pharmacon Jurnal Ilmiah Farmasi UNSRAT* 2 12–16

Diachanty S, Nurjanah and Abdullah A 2017 Aktivitas antioksidan berbagai jenis rumput laut cokelat dari Perairan Kepulauan Seribu *JPHPI 20* 305-318

Ditjen POM 1985 *Formularium Kosmetika Indonesia* (Jakarta: Departemen Kesehatan RI)

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2017 Kandungan senyawa bioaktif bubur rumpat laut *Sargassum plagiophyllum* dan *Eucheuma cottonii* sebagai bahan baku krim pencerah kulit *JPHPI 20* 633-644

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2019 Tyrosinase inhibitor activity of *Sargassum plagiophyllum* and *Eucheuma cottonii* extracts *IOP Conf. Ser. Earth Environ. Sci. 278* 012020

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2019 Tyrosinase inhibitor activity of *Sargassum plagiophyllum* and *Eucheuma cottonii* extracts *IOP Conf. Ser. Earth Environ. Sci. 278* 012029

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2019 Tyrosinase inhibitor activity of *Sargassum plagiophyllum* and *Eucheuma cottonii* extracts *IOP Conf. Ser. Earth Environ. Sci. 278* 012029

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2019 Tyrosinase inhibitor activity of *Sargassum plagiophyllum* and *Eucheuma cottonii* extracts *IOP Conf. Ser. Earth Environ. Sci. 278* 012029

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2019 Tyrosinase inhibitor activity of *Sargassum plagiophyllum* and *Eucheuma cottonii* extracts *IOP Conf. Ser. Earth Environ. Sci. 278* 012029

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2019 Tyrosinase inhibitor activity of *Sargassum plagiophyllum* and *Eucheuma cottonii* extracts *IOP Conf. Ser. Earth Environ. Sci. 278* 012029

Dolorosa M T, Nurjanah, Purwaningsih S, Anwar E and Hidayat T 2019 Tyrosinase inhibitor activity of *Sargassum plagiophyllum* and *Eucheuma cottonii* extracts *IOP Conf. Ser. Earth Environ. Sci. 278* 012029

Gazali M, Nurjanah and Zamani N P 2018 Eksplorasi senyawa bioaktif alga cokelat *Sargassum* sp. Agardh sebagai antioksidan dari Pesisir Barat Aceh *JPHPI 21* 167-178

Gazali M, Zamani N P and Nurjanah 2019 The potency of green algae *Chaetomorpha crassa* Agardh as antioxidant agent from the coastal of Lhok Bubon, West Aceh *IOP Conf. Ser. Earth Environ. Sci. 278* 012029

Haryani T S, Sari B L and Triastinurmiatiningsih 2014 Efektivitas ekstrak Padina australis sebagai anti bakteri *Escherichia coli* penyebab diare *Jurnal Ilmiah Farmasi 4* 165-173

Husni A, Putra D R and Elana I Y B 2014 Aktivitas antioksidan Padina sp. pada berbagai suhu dan lama pengerengan *Jurnal Pascapanen dan Bioteknologi Perikanan 9* 165-173

Lachman L 1994 *Teori dan Praktek Farmasi Industri II Edisi ketiga* ed Siti Suyatmi (Jakarta: Universitas Indonesia)

Luthfiyyana N, Nurjanah, Nurilmala M, Anwar E and Hidayat T 2016 Rasio bubur rumpat laut *Eucheuma cottonii* dan *Sargassum* sp. sebagai formula krim tabir surya *JPHPI 19* 183-195
Maharani F, Nurjanah, Suwandi R, Anwar E and Hidayat T 2017 Kandungan senyawa bioaktif rumput laut *Padina australis* dan *Eucheuma cottonii* sebagai bahan baku krim tabir surya *JPHPI* 20 10-17

Mansauda K L R, Anwar E and Nurhayati T 2018 Antioxidant and anti-collagenase activity of *Sargassum plagypophyllum* extract as an anti-wrinkle cosmetis ingredient *Phcog. J.* 10 932-936

Martin A, Swarbrick J and Cammarata A 1993 *Farmasi Fisik: Dasar-dasar Farmasi Fisik dalam Ilmu Farmasetik Edisi Ketiga* ed Yoshita (Jakarta: UI-Press)

Mishra A P, Saklani S, Milella L and Tiwari P 2014 Formulation and evaluation of herbal antioxidant face cream of *Nardostachys jatamansi* collected from Indian Himalayan region *Asian Pac. J. Trop. Biomed.* 4 S679-S682

Mitsui 1997 *New Cosmetic Science* (New York: Elsevier)

Molyneux P 2004 The use of stable free radical diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity *J. Sci. Technol.* 26 211-219

Murugan A C, Vallal D, Karim M R, Govindan N, Yusoff M B M and Rahman M M 2015 In vitro antiradical and neuroprotective activity of polyphenolic extract from marine algae *Padina australis* *J. Chem. Pharm. Res.* 7 355-362

Nurjanah, Abdullah A and Nufus C 2018 Karakteristik sediaan garam *Ulva lactuca* dari Perairan Sekotong Nusa Tenggara Barat bagi pasien hipertensi *JPHPI* 21 109-117

Nurjanah, Abdullah A, Fachrozan R and Hidayat T 2018 Characteristics of seaweed porridge *Sargassum* sp. and *Eucheuma cottonii* as raw materials for lip balm *IOP Conf. Ser. Earth Environ. Sci.* 196 012018

Nurjanah, Aprilia B E, Fransiskayana A, Rahmawati M and Nurhayati T 2018 Senyawa bioaktif rumput laut dan ampas teh sebagai antibakteri dalam formula masker wajah *JPHPI* 21 304-316

Nurjanah, Luthfiyana N, Hidayat T, Nurilmala M and Anwar E 2019 Utilization of seaweed porridge *Sargassum* sp. and *Eucheuma cottonii* as cosmetic in protecting skin *IOP Conf. Ser. Earth Environ. Sci.* 278 012055

Nurjanah, Nurilmala M, Anwar E, Luthfiyana N and Hidayat T 2017 Identification of bioactive compounds seaweed *Sargassum* sp. and *Eucheuma cottonii* as a raw sunscreen cream *Proceedings of the Pakistan Academy of Sciences: Pakistan Academy of Sciences B. Life and Environmental Sciences* 54 311-318

Nurjanah, Nurilmala M, Hidayat T and Sudirdjo F 2016 Characteristics of seaweed as raw materials for cosmetics *Aquat. Procedia* 7 177-180

Nursid M, Wikanta T and Susilowati R 2013 Aktivitas antioksidan, sitotoksisitas dan kandungan fukosantin ekstrak rumput laut coklat dari pantai Binuangkeun, Banten *Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan* 8 73-84

Pamela R D 2012 Pengaruh stress psikologis terhadap fungsi pertahanan kulit *CDK-194* 39 420-422

Pissavini M and Ferrero L 2004 In vitro determination of sun protection factor chemist and head sun product research *International Research and Development Center* 1-5

Prasiddha I J, Laeliocattleya R A, Estiasih T and Maligan J M 2016 Potensi senyawa bioaktif rambut jagung (*Zea mays* L.) untuk tabir surya alami *Jurnal Pangan dan Agroindustri* 4 40-45

Rahmanto A 2011 *Pemanfaatan Minyak Jarak Pagor (Jatropha Curcas, Linn) sebagai Komponen Sediaan dalam Formulasi Produk Hand and Body Cream* [Thesis] (Bogor: IPB University)

Ramadhan W 2011 *Pemanfaatan Agar-Agar Tepung sebagai Texturizer pada Formulasi Selai Jambu Bijji Merah Lembaran dan Pendugaan Umur Simpannya* [Undergraduate Thesis] (Bogor: IPB University)

Rieger M 2000 *Harry’s Cosmeticology* 8th ed (New York: Chemical Publishing Co)
Salazar-Alanda R, Perez-Lopes L, Joel L and Noemi W 2009 Antimicrobial and antioxidant activities of plants from Northeast of Mexico *Evid. Based Complement Alternat. Med.* 2011 1–6

Sari D M, Anwar E, Nurjanah and Arifianti A E 2019 Antioxidant and tyrosinase inhibitor activities of ethanol extracts of brown seaweed (*Turbinaria conoides*) as lightening ingredient *Phcog. J.* 11 379-382

Setha B, Gaspersz F F, Idris A P S, Rahman S and Mailoa M N 2013 Potential of seaweed *Padina* sp. as a source of antioxidant *International Journal of Scientific and Technology Research* 2 221 – 224.

SNI 1996 SNI 16-4399-1996 *Sediaan Tabir Surya* (Jakarta: Badan Standardisasi Nasional)

Suryani A, Sailah I and Hambali E 2000 *Teknologi Emulsi* (Bogor: Institut Pertanian Bogor)

Svobodová A, Psotová J and Walterová D 2003 Natural phenolic in prevention of UV-induced skin damage, a review *Biomed. Papers* 147 137–145

Wasitaatmadja S M 1997 *Penuntun Ilmu Kosmetik Medik* (Jakarta: Penerbit Universitas Indonesia)

Winarno F G 2008 *Kimia Pangan dan Gizi* (Bogor: EMBRIO Press)

Yanuarti R, Nurjanah, Anwar E and Hidayat T 2017 Profil fenolik dan aktivitas antioksidan dari ekstrak rumput laut *Turbinaria conoides* dan *Eucheuma cottonii* *JPHPI* 20 230-237