Composition of Pigments and Antioxidant Activity in Edible Red Seaweed Halimenia durvilae Obtained from North Sulawesi

by Grace Sanger 2

Submission date: 07-Jan-2020 04:31PM (UTC+0700)
Submission ID: 1239738411
File name: INT._J._OF_CHEMTECH.pdf (525.34K)
Word count: 4401
Character count: 24660

International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.15, pp 255-262, 2017

Composition of Pigments and Antioxidant Activity in Edible Red Seaweed *Halimenia durvilae* Obtained from North Sulawesi

Sanger G.*, Rarung L.K., Kaseger B.E., and Timbowo S.

Faculty of Fishery and Marine Science, Sam Ratulangi University. Manado, Indonesia

Abstract : This study was carried out to identify the pigment and antioxidant activity extracted from *Halimeniadurvilae*. Hexane, acetone and ethanol were used as extraction solvent. The pigments were measured consisting of chlorofhyll a, chlorofhyll b, total chlorofhyll, chlorofhyll c_1+c_2, fucoxathin, carotenoids, phycocyanin and phycoerythrin, while 1,1-diphenyl-2-picrylhydracyl (DPPH)radical scavenging and ferric reducing antioxidant power (FRAP) were used to studied their antioxidant activity. Total Phenolic content (TPC) were also investigated. The result showed hexane extract respectively containing highest level of all pigments. The lowest value of pigment was phycocyanin, recorded for hexane, acetone and etanol extract were 0.7875 ± 0.08; 0.1475 ±0.08 and 0.1565 ±0.02µg g^{-1}dried weight. Ethanol extract exhibited the lowest TPC (7,605±0.383µg GAE(Gallic acid equivalent)g^{-1}.Good value of radical scavenging of DPPH was acetone extract (scavenging activity of IC_{50} 1.211±0.03 mg ml^{-1}), The highest Reducing power was acetone, 0.17±0.01 uM Fe2+/mg extract, respectively. Thus *H.durvilae* could be used as natural pigment and antioxidant source which is potential to be applied in food product as functional food.

1. Introduction

Seaweeds or marine macro algae are the prospective renewable resource in marine environment. About 6.000 species of seaweeds have been identified and are classified into green algae (Chlorophyceae), brown algae (Phaeophyceae) and red (Rhodophyceae) (Devi *et al*., 2011,Chandini*et al*., 2008).The color in case of green seaweeds is due to the attendance of chlorophyll a and b; beta-carotene (a yellow pigment) and variuostypical xanthophylls (Yellowish or brownish pigments). Fucoxanthin is the prominentof the xanthophylls pigment which is responsible for the color of brown seaweeds. This compounds masks the other pigments such as Cholorophyill a and c and other xanthophyills. Phycoerythrin and phycocyanin accountable for the color of red seaweeds and mask the pigments such as Chlorophyll a and beta-carote (Gupta and Abu-Ghannam, 2011.)Anthocyanins belonging to the flavonoid group are another group of pigments which are responsible for the red, purple, and blue colour Anthocyanins exhibited a high possible as colorants because of their low toxicity (Özkan and Bilek, 2014).

Macroalgae have been reported to have more then 2400 natural poducts of profitable significance in pharmaceutical, biomedical and nutraceutical industries. They have been utilized as ingredients in human and animal food preparations owning to their outstanding source of bioactive compounds which consist of sulfated polysaccharides, polyphenols, diterpenes, protein, essential fatty acids, dietary fiber vitamins and minerals((Chinnadurai et al., 2013, Özkan and Bilek, 2014, Chandihi *et al*., 2007).Among functional ingredients identified from marine algae, natural pigments have obtained specific attention as they have been found to

showmanyadvantageous biological activities such as antioxidant, anticancer, anti-inflammatory, anti-obesity, anti-angiogenic and neuroprotective activities. (Pangestuti and Kim, 2011).

Humans are impacted by many free radicals especiallyreactive oxygen species (ROS). ROS constitutes superoxide (O2 -), hydroxyl (HO•), hydrogen peroxide (H2O2) and nitric oxide (NO).These molecules are unsteady and highly reactive, and can harm cells by chain reactions, such as lipid peroxidation or configuration of DNA adducts . Extreme amounts of ROS may be injurious because they can damage essential bio-molecules: proteins, DNA and lipidsand other cells which consequences various diseases disorders such as cancer, diabetes, stroke, cataract, myocardial infarction, atherosclerotic and Parkinsons diseases (Wu *et al*.,1988; Chew*et al*., 2008).In order to diminish or avoid this damage of the human body by ROS antioxidants are believed to be protective, all cells perpectually contain antioxidants (Wu *et al*., 1998, Halliwell *et al*., 1995, Tapiero*et al*. 2002).

Natural antioxidants are chosen by consumer due to worry on the toxic and carcinogenic effect of synthetic antioxidant (Mantanjun *et al*., 2007, Ahn*et al*., 2003). Natural antioxidant considered safe for use as ingredients in medicine, dietary supplements, nutraceuticals and cosmetics with the intent of improving consumer health, reducing the belongings of damaging diseases and other broader aspects of immune system function (Shahidi, 2009, Pangestuti and Kim 2011, Yip *et al*., 2014). Additional, there are facts obtainable in the literature to show the potential defensive properties of seaweeds against oxidative stress in target tissues and lipid oxidation in foods.Consequently, consumption of antioxidant and addition of antioxida in food materials protect the body as well as against oxidative stress.Although seaweeds possess extensive applications in food and pharmaceutical industries, the ments and antioxidant activities of many types of seaweeds in Indonesian area are still unexplored.Hence, the present study was proposed to explore thepigments and antioxidant properties of *H.durvilae* which grows plentifully in NorthSulawesi.

2. Materials and methods

Sample preparation and extraction

Sufficient amount *of H. durvilae was* collected from Arakan Village, Manado North Sulawesi. The sample was completely washed with seawater and fresh water to eliminate epiphytes, dirt particles and shells. It was then brought tothe laboratory followed with shading-drying for two days and oven-dryed at 50 °C for 3 days and ground using mixer without producing heat and transformed to powder.

The dried samp was extracted using hexane, acetone and ethanol (1 : 10 w/v) The samples were incubated for overnight at room temperature in a dark place. Extraction was repeated three times till the sample became colorless. The procedure was carried out in triplicates. The extracts were filtered and concentrated in vacum rotary evaporator at 40 °C. The extracts were stored in dark glass bottle for future analysis.

Chemicals and reagents

1,1-diphenyl-2-picrylhydrazyl (DPPH) was purchased from Sigma Aldrich, Follin-Ciocalteu's phenol, butylatedhydroxytoluene (BHT), sodium carbonate (Na_2CO_3), potassium dihydrogen phosphate (KH_2PO_4, iron (III) chlorid -hydrate ($FeCl_3$), Trichloroacetic acid (TCA) and Potasium ferricyanide $K_3Fe(Cn)6$ purchased from Merk. All other solvent and chemicals were of analytical grade.

Pigment.

The pigments extracted using different solvents were quantified using UV-Visible spectrophotometer by reading the absorbance at their respective wavelengths and using the formulae given below:

-Chlorophyll l a (mg g-1) = [12.7 (A663) −2.69 (A645) V] / (1000×W) (Arnon, 1949).
-Chlorophyll Chl b (mg g^{-1}) = 2 x 0.645-4.68-A663)V]/(1000xW) (Arnon,1949).
-Total Chlorophyll (mg g-1) = [20.2 (A645) + 8.02 (A663) V] / (1000×W) (Jeffrey et al, 1961).
-Chlorophyll C1+C2 (mg g-1) = [24.36×A630−3.73×A664] (Jensen and Jensen, 1959 & Duxbury and Yentsh, 1956).
- rotenoids (μg g-1) = [7.6 (A480) − 1.49 (A510) V] / (1000×W) (Seely et al, 1972).
-Fucoxanthin (mg g-1) = A470 −1.239 (A631+A581−0.3 ×A664) − 0.0275×A664 /141(Sudhakar*et al*., 2013).

-Phycoerythrin (μg g-1) =[(A_{564} - A_{592}) - (A_{455}-A_{592}) 0.20] 0.12 (Beer and Eshel,1985)
-Phycocyanin(μg g-1) =[A_{618} - A_{645}) - (A_{592}-A_{645}) 0.15] 0.15 (Beer and Eshel,1985);
Where, A = Absorbance at particular wavelength;
V = Total volume of the pigment extract;
W = Weight of the sample used for extraction.

Total phenolic content (TPC)

The TPC of the extracts was measured using Follin Ciocalteu method as described by Ganesan *et al*., (2008) with modification. 50% Follin Ciocalteu´s phenol reagent (1 ml) was added to 0,1 ml extract and vortexed, Furthermore, added with 7% Na_2CO_3 (1 ml), and the reaction mixture was then incubated at room temperature for 30 min. The absorbance measured at 750 nm.TPC was expressed in terms of g gallic equivalents (μ GAE)/ g dried samples.

1,1-diphenyl-2-picrylhydrazyl (DPPH) assay

DPPH-scavenging potential of different concentrations of extracts was measured based on to test the scavenging ability of stable 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals by the seaweeds antioxidant. DPPH assay was measured using the method describe by Mensew. *et al*., (2008) with modification. Briefly, 2 ml of 93 µM DPPH (solution in methanol) was added to 0.5 ml extract at various dilutions. The mixture was then vortexed vigorously and left for 20 minutes at room temperature in dark condition. The absorbance was measured at 517 nm and it activity was expressed as percentage of DPPH scavenging activity relative to the control, using that following equation:

% Inhibition = [(A control – A sample) /A control] x 100%.

Ferric Reducing Antioxidant Power (FRAP).

Reducing power of seaweed extract was determined by the method prescribed by Chew*et al*., (2008). The antioxidant activity of the standards was estimated by using the increasing in absorbance caused by the generated ferrous ion. Briefly, 1.0 ml ofextractsat various dilutions were mixed with 1ml of 0,2 M phosphate buffer, pH 6,6 and 1ml potassium ferricyanide (1%). Reaction mixture was incubate at 50°Cfor 20 minutes. After incubation, 1 ml of trichloroacetic acid (10%) was added and centrifuged at 3000 rpm for10 minutes. From the upper layer, 1 ml solution was mixed with 1 ml steril water and 0,5 ml $FeCl_3$ (0,1%). Absorbance of all solution was measured at 700 nm. The FRAP value was expressed in terms of uM Fe2+/mg extract.

Statistical analysis

All experiments were conducted in triplicate. The means of parameterspigment composition, total phenol content and antioxidant activity presented as mean ± standart deviation.

3.Result and Discussion

Pigment

Regarding photosynthetic pigment a significant variation in content was recorded among the hexane, acetone and ethanol solvent studied (Tabel 1). The results show that *H. durvilae* contain highest amount of chlorophyll C1+C2 (2.26864 ± 0.04mg g^{-1} dried weight) whereas, the concentration of phycoerythrin and phycocyanin were found lowest, in hexane were2.33 ± 0.253and 0.7875 ± 0.08(µgg^{-1}). Nazir*et al*., (2013), the concentration of carotenoids, phycoerythrin and phycocyaninin red seaweeds were found higher than green seaweeds, Pereira *et al,* 2012 reported that red seaweeds *Gracilaria dumingencis* possesses more phycocyanin than green strain. Red seaweeds observed are insignificant variation in chlorophyll and phycocyanin (Plastino *et al*., 2004).Pereira *et al*, 2012, seaweeds contain three main photosynthetic pigments i.e. chlorophylls, carotenoids and phycobilins. These pigments provide protection against high light intensity and also support in light absorption and energy transfer to the reaction centre.

Table 1. Quantification of photosynthetic pigments of *H.durvilae* in different solvents

Parameter	Hexane	acetone	ethanol
Chlorofil a ($mg\ g^{-1}$)	0.181382 ± 0.01	0.01713 ±0.01	0.02181 ± 0.05
Chlorofil b ($mg\ g^{-1}$)	0.038453 ± 0.001	0.00315 ± 0.001	0.01918 ± 0.006
Total Cholorofil (mg/g^{-1})	0.219787 ± 0.05	0.02038 ±0.001	0.04097 ± 0.002
Total chlorofil c1+ c2 ($mg\ g^{-1}$)	2.26864 ± 0.04	0.08763 ±.0.001	0.90726 ± 0.22
Carotenoid ($\mu g\ g^{-1}$)	28.654 ±0.212	2.642 ±0.035	5.96 ± 0,3241
Fucoxantin ($mg\ g^{-1}$)	-0.37143 ± 0.03	0.023399 ±0.005	-0.0198 ± 0.04
Pycoerytrin ($\mu g\ g^{-1}$)	2.33 ± 0.253	0.48 ±0.018	1.13 ±0.081
Phycocyanin ($\mu g\ g^{-1}$)	0.7875 ± 0.08	0.1475±0.002	0. 1565 ±0.08

All the values are mean ± SD of triplicates

Carotenoids have highest content in hexane extract, 28.654 ±0.212$\mu g\ g^{-1}$. Carotenoids scavenge oxygen radicals and reduce oxidative stress. Thus, they denote antioxidant activity. The carotenoids are used in food, nutraceutical, and pharmaceutical preparations by their applications as colorants and their provitamin A activity. One of the most consumed carotenoid groups of pigments are responsible for the yellow, orange, and red colourof many foods, maintain to be intensely explored mainly because of their health-promoting properties. Carotenoids are unstable when they're exposed to light or oxygen because of their properties as highly conjugated and powerfully coloredisoprenoid plant compounds (Özkan and Bilek, 2014).

Variation in the pigment concentration is a reply to environmental variations that allows an organism to adjust under a specific habitat. Increased temperature, heavy metal accumulation and ill-inclined light due to extreme exploitation of natural resources and unrestrained anthropogenic activities, induces too much production of ROS which causes injury to biological membranes and unfavorably affect a number of pla physiological processes (Nasir *et al*., 2015). Pigment shows several capability to maintain i mune system, to help prevent cancer and is being utilized in cancer therapy, to aid to invigorate and energize the bodydetoxification of the liver, to normalize blood pressure and to struggle bad odors, bad breath as well as body odor by reason of the magnesium salts that it contains(Ferruzzi and Blakeslee, 2007).

Total Phenol Content

Various studies haveconcentrated on the biological activities or phenolic compounds, which are potential antioxidants and free radical-scavenger. Early researchreported that marine seaweeds extracts, particularly their polyphenols, have antioxidant activity. The most important active compounds in different seaweeds extracts have been revealed to the phlorotanins. The total polyphenol content (expressed as gallic acid equivalent) of *H.durvilae* extracts is shows in Fig.1. It was observed that hexane, aseton and etanol extracts had TPC 23.235±1,011; 22.151±1.967; 7.605±0.383µg $GAEg^{-1}$.Duan*et al*., (2006) observed TPC (73,7 mg GAE g^{-1}) in ethyl acetate soluble fraction of red algae *P.urceolata*. the TPC in brown algae, *Papenfussiella kurono* was 0.18 mg cathechin equivalent/g in ethanolic extract (Kuda*et al*., 2005).

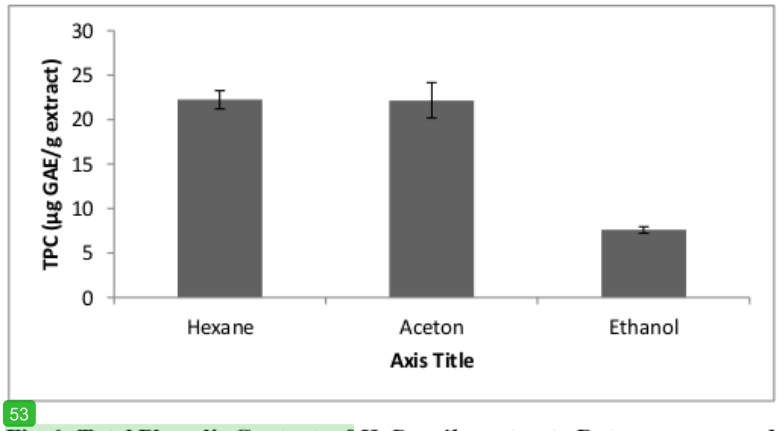

Fig. 1. Total Phenolic Content of *H. Durvilae* extract. Data are expressed as mean ±SD (n=3).

Marine alge contain phloroglucinol phenol (phlorotannins) which are probably excelent antioxidant, since plant phenolics can perform as ROS scavengers metal chelators and enzyme modulator and inhibit lipid peroxidation (Rodrigo and Bosco 2006).Phenol, 2-[(1-phenylethyl)thio] characterize a diverse group of pigment, extensively distributed in nature. They serve as accessory pigments to harvest light photosynthesis. Moreover, these type of pigments can give rise to rich in polyphenol compounds. Norisoprenoids resulting from the oxidative cleave of carotenoid are signal in development, provide as antifungal and antibacterial agents and donate to their flavor and aroma. th norisoprenoid derivatives detected were present in the Rhodophyta, namely α-ionone, geranyl acetone, β-ionone,2,3-epoxy-β-ionone, dihydroactinidiolide and 2,3-Epoxy-b-ionone(Valentão*et al*., 2010).

DPPH radical scavenging activity

DPPH is a compoun hat possesses a nitrogen free radical and is readily destroyed by a free radical scavenger. It has been used extensively as a free radical to assess reducing substances and is a valuable reagent for investigating the free radical scavenging activities of compounds. DPPH radical scavenging of *H.durvilae* are presented on Fig. 2.and expressed as presentation reduction of the initial DPPH• absorption by the tested compound.

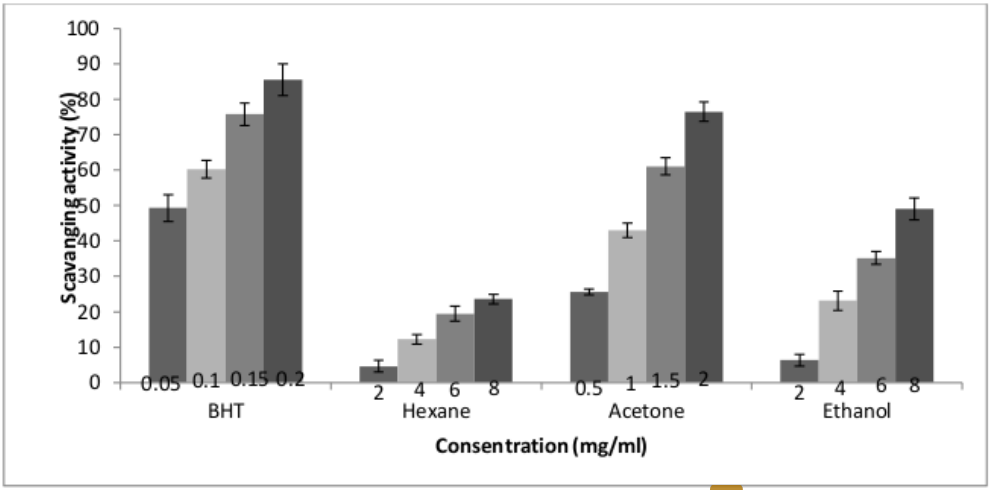

Fig 2. DPPH radical scavenging activity of *H. durvilae* extract. Data are expressed as mean ±SD (n=3).

The best radical scavenging obtained in the aseton extract. The radical scavenging of hexane, acetone and ethanol extracts were IC_{50} 15.940±1.63; 1.1676 ± 1.99 and 8.017± 2.31 mg ml^{-1}. The beneficial effect is could beside the high content f phenol, it may also be related to the high content of mineral, dietary fiber and pigment. The red seaweeds are a diverse eukaryotic lineage, characterized by accessory photosynthetic pigments phycoerythrin, phycocyanin and allophycocyanins arranged in phycobilisomes The extracts of *H.durvilae* showed better radical scavenging activity than ethanol extract of Kappaphycusalvarezii (Doty) (IC_{50}3.03 mg ml^{-1}) (Kumar *et al*., 2008) and the extract of *Palmaria palmita* (dulse) (IC_{50} 12.5 mg $ml^{-1)}$ (Yuan, Carrington &Walsh, 2005). Seaweeds are low in fat but have vitamins and bioactive compounds such asterpenoids, sulfated polysaccharides and polyphenol compounds, the later being a potential natu antioxidant not found in land plants (Chew e*t al.,* 2008).Algae polysaccharides participate essential function as free radical-scavengers in-vitro and antioxidant for the avoidance of oxidati damage in living organism. Their activity depends on numerous structural parameter, such as the amount of sulfation, the molecular weight, sulfation position, type of sugar and glycosidic branching. Furthermore, several reports expose that the sulfate and phosphate group in the polysaccharides cause the differences in their biological activities (Juan *et al*. 2005a). Dietary natural antioxidant are reported to help in preventing aging and other diseases. There are various evidences that seaweeds contain compounds with a moderately high antioxidant and antiproliferative activity(Yuan, Carrington &Walsh, 2005).

Ferric reducing antioxidant power (FRAP).

The antioxidant activity in FRAP was measured based on the capability of the antioxidant compounds in the sample to reduce ferric (III) to ferrous (II) in a redox-linked colourimetric reaction that involve single electron (Chew *et al*., 2008). FRAP assay was electron donor and it finished the oxidation chain reaction by reducing the oxidized intermediates into the stable form (Tachakittirungrod *et al*. 2007)

Fig. 3.shows that the highest reducing power of *H. durvilae* was acetone of 0.17±0.01 uM $Fe^{2+}mg^{-1}$ extract. The reducing ability of acetone extract considerably as same as TPC.There was strong correlation (R^2=0.96) between the reducing power and the TPC of the seaweeds methanolic extracts expressesed as phoglicinol equivalents. (Matanjun *et al*., 2008).

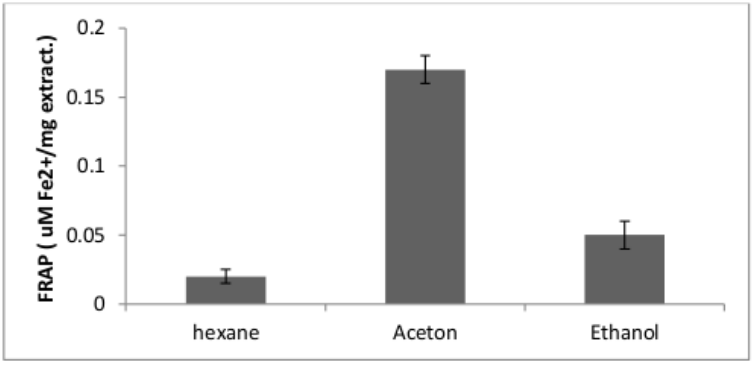

Fig.3. Ferric Reducing Antioxidant Power (FRAP) of *H.durvilae* extracts. Value are the mean ± SD (n=3)

The reducing power of red algae *Palmaria palmate* in 1-butanol extract was4.48 μg ascorbic acid equivalent (AAC) g^{-1} (Yuan & walsh, 2006). Polyphenols are reducing agent, and together with other dietary reducing agent such as vitamin C, E and carotenoid, referred to as antioxidant, protect the body's tissues against oxidative stress and connectedpathologies such as cancer, coronary heart disease and inflammation (Tapiero *et al*., 2002).The ethanolic extract of *K. alvarezii* showed higher inhibitory effect than did the positive control,BHT. This might be due to the presence of ascorbic acid and Vitamin A (β-carotene) content in the extract of *K.alvarezii* (Fayaz*et al*., 2005). The reducingpower property indicates that the antioxidant compounds are electron donor and can decrease the oxidized intermediates of the lipid peroxidation process, so that they can perform as primary and secondary antioxidants (Yen and Chen 1995).

Invitro antioxidant activity of κ-carrageenan oligosaccharides and their oversulfated, acetylated and phosphorilated derivatives was investigated by Juan *et al*. 2005. They are also reported that phosphorylated and sulfated glucans exhibited better antioxidant capacity than did glucans or other neutral polysaccharides, which indicated that polyelectrolytes, such as glucans sulfate or phosphate, might have enhanced scavenging activity. Moreover the sulfate content from *Porphyrayezoensis* was reported to contribute to the antioxidant activity. The cell walls of *K.avareziiis* known to be constitued of carrageenan, a sulfate polysaccharides,which may contribute to its antioxidant potential in addition to the presence of ascorbic acid, vitamin A and various phenolics (Kumar *et al*., 2008).

Conclusions.

In the present investigation the various solvent extracts of *H.durvilae* exhibited content of chlorophyll carotenes, phycoerythrine and phycocyanin. The highest content of pigments are in hexane solvent. The antioxidant activity by DPPH assay and reducing power showed the acetoneextract is highest. Thus *H.durvilae* could be used as natural pigment and source of antioxidant which is potential to be applied in food product as functional food. Future study is required for identification of the active compound in acetone extract which is responsible for highest antioxidant activity.

Acknowledgments.

The authors are grateful to Prof. Dr. Ir. Remmy Mangindaan M.Sc. from Sam Ratulangi University Manado, the head of Laboratory Chemistry of Natural product and Dr. Ir. Dikdik Kurnia, M.Sc, Ms. The head of MIPA laboratory from Padjadjaran University Bandung for their constant support and provide research facilities..

References

1. Ahn, C.B., JoonY J.and Kang D.S. 2004. Free Radical Scavenging Acrivityof Enzymatic Extract from a Brown Seaweed Scytophonlomentaria by Electron Spin Resonance Spectrometry. Journal of Food Research International 37: 253-258.
2. Arnon D., 1949. Copper Enzymes in Isolated Chloroplasts. Polyphenoloxidase in Beta Vulgaris.Plant Physiol. 24, 1-15.
3. Beer S., Eshel A. 1985. Determining Phycoerythrin and Phycocyanin Concentrations in Aqueous Crude Extracts Of Red Algae. Australian Journal of MarineAnd Freshwater Research. 36: 785 – 792.
4. Chandini S.K., GanesanP. and Bhaskar N. 2008. *In vitro* Antioxidant Activities of Three Selected Brown Seaweeds of India. *Food Chem*.,107: 707–713.
5. Chew Y.L., Lima Y.Y., Omara M., Khoob K.S. 2008.Antioxidant Activity of Three Edible Seaweeds from Two Areas in South East Asia.LWT.41: 1067-1072
6. Duxbury A.C., And Yentsch C.S. 1956. Plankton Pigment Nomographs. J. Mar. Res., 16: 92-101.
7. Devi G.K., Manivannan K.1., ThirumaranG., Rajathi F.A.A, Anantharaman P. 2011. In vitro Antioxidant Activities of Selected Seaweeds from Southeast Coast of India. Asian Pacific Journal of Tropical Medicine.205-211.
8. Duan, X., Zhang, W., Li, X. and Wang, B. 2006. Evaluation of Antioxidant Property of Extract and Fractions Obtained from A Red Algae, *PolysiphoniaUrceolata*. *Food Chem.*, 95: 37–43.
9. Fayaz M, Namitha K.K., Chidambara Murthy K.N., Swamy M., Sarada R., Khanam S, *et al*. 2005.Chemical Composition, Iron Bioavailability, and Antioxidant Activity of Kappaphycusalvarezzi (Doty).J.Agric Food Chem.53:792-797.
10. FerruzziM.G.and Blakeslee J. 2007. Digestion, Absorption, and Cancer Preventative Activity of Dietary Chlorophyll Derivatives. Nutrition Research 27:1-12.
11. Ganesan P., Chandini S., Kumar N.Bhaskar. 2008. Antioxidant Properties of Methanol Extract and Its Solvent Fractions Obtained from Selected Indian Red Seaweeds. BiresourceTechnology .99: 2717-2723.
12. Gupta S. and Abu-Ghannam N. 2011. Bioactive Potential and Possible Health Effects of Edible Brown Seaweeds.Trends Food Sci.Technol.2011; 22: 315-326.
13. Halliwell, B. and C.E. Cross, 1994. Oxygen-Derived Species: Their Relation to Human Disease And Environmental Stress. *Environ. HealthPerspect*., 102: 5–12.
14. Jeffry W. 1961. Paper-Chromatographic Separation of Chlorophyll And Carotenoids from Marine Algae. Biochem. J., 1961, 80, 336-342.
15. Jensen A. and Jensen S.L.1959. Quantitative Paper Chromatography of Carotenoids.Acta Chem. Scand. 13: 1863-68.
16. Kuda T.T., Sunekawa M., Goto H., Araki Y. 2005. Antioxidant Properties of Four Edible Algae Harvested in The Noto Peninsula, Japan. JFood Compos Anal.18:625-633.
17. Kumar, K.S., Ganesan,K. and Subba-Rao,P.V. 2008. Antioxidant Potential of Solvent Extracts of *KappaphycusAlvarezii* (Doty) Doty-An Edible Seaweed. Food Chem., 107: 289-295.
18. Matanjun P., Suhaila Mohamed S., Noordin Mohamed stapha, Kharidah Muhammad, Cheng Hwee Ming. 2008. Antioxidant Activities and Phenolics Content of Eight Species of Seaweeds from NorthBorneo. J Appl.Phycol.20:367-373.
19. Nasir K.M., Mobin M., Abbas Z.K., 2015.Variation in Photosynthetic Pigments, Antioxidant Enzymes and Osmolyte Accumulation in Seaweeds of Red Sea.Int J Plant Biol. Res. 3(1): 1028.
20. Özkan G. and BilekS.E. 2014. Microencapsulation of Natural Food Colourants. Int. J. of Nutrition and Food Sciences.3(3): 145-156.
21. Pangestuti, R. and Kim S.K. 2011. Biological Activities and Health Benefit Effects of Natural Pigments Derived from Marine Algae. *Journal of Functional Foods* 3: 255-266.

22. Pereira DC.,Trigueiro TG.,Colepicolo P., Marinho-soriano E.2012.Seasonal Changes in The Pigment Composition of Natural Population of *Gracilaria dumingensis* (*Graciliares*, Rhodophyta);Brazillians J. of Pharmacognosy. 22:874-880.
23. Plastino E.M., Ursi S.,Fuijii M.T.2004. Color Inheritance, Pigment Caractrization and Growth of A Rare Light Green Strain of *Gracilaria birdiae* ((*Graciliares*, Rhodophyta) phycological Research. 52:45-52.
24. Rodrigo R. Bosco C., 2006. Oxidative Stress and Protective Effect of Polyphenol: Comparative Studies in Humans and Rodent Kidney. A review. Comparatives Biochem. Physiol. Part C (142:317-327).
25. Seely G.R., Duncan M.J., & Vidaver W.E. 1972. Preparative And Analytical Extraction of BrownAlgae with Dimethyl Sulfoxide. Marine Biology, 12: 184-188.
26. Shahidi F., 2009. Nutraceuticals and Functional Foods: Whole Versus Processed Foods. *Trends Food Sci. Tech*., 20: 376–387.
27. Sudhakar M.P., Ananthalaksmi J.S. and Nasir B.B. 2013. Extraction and Purification and Study on Antioxidant Properties of Fucoxantin from Brown Seaweeds. J. of Chemical and PharmaceuticalResearch 5(7): 169-75.
28. Tapiero H., Tew K.D., Nguyen Ba G., Mathe'G., (2002). Polyphenols: Do They Play A Role in The Prevention of Humans Pathologies? Review.Biomed.Pharmaco. 56:200-207.
29. Tachakittirungrod S, Okonogi S, Chowwanapoonpohn S., 2007. Study on Antioxidant Activity of Certain Plant in Thailand: Mechanism of Antioxidant Action of Guava Leaf Extract. Food Chem.. 103:381-388.
30. Valentão P.,Trindade P.,Gomes D.,Guedesde Pinho P.,Mouga T. and Andrade P.B. 2010. *Codium tomentosum* and *Plocamium cartilagineum*: Chemistry and Antioxidant Potential J. FoodChemistry119.1359–1368.
31. Wu, Y., C. Hong, S. Lin, P. Wu and M. Shiao, 1998. Increase of Vitamin E Content in LDL and Reduction of Atherosclerosis in Cholesterol-FedRabbits by a Water-Soluble Antioxidant-Rich Fraction of *Salvia miltiorrhiza*. *Arterioscler.Thomb.Vasc. Biol*., 18: 481–486.
32. Yen G.C. Chen H.J., 1995. Antioxidant Activity of Various Tea Extract in Relation to Their Antimutagenicity.J. Agryc. Food Chem.43 27-32.
33. Yip W.H., Lim Seng Joe L.S. Mustapha W.A.W., Maskat M.Y. And Said M., 2014Characterisation and Stability of Pigments Extracted from *Sargassum binderi* Obtained from Semporna, Sabah. SainsMalaysiana 43(9): 1345–1354
34. Yokoya NS, Necchi O, Martins AP, Gonzalez SF, Plastino EM.2007. Growth Responses and Photosynthetic Characteristics of Wild and Pycoerythrin-Deficient Strains of *Hypnea musciformis*(Rhodophyta). Journal of Applied Phycology. 19: 197-205.
35. Yuan A., Zhang W., Li X., Lu X., Li N., GaoK., *et al*., 2005. Preparation and In-Vitro Antioxidant Activity of k-Carrageenan Olygosaccharides and Their Oversulfated, Acetylated and Phosphorylated Derivatives. Carbohydrate Research, 300: 685-692.
36. Yuan Y.V., Carrington M.F., Walsh N.A., 2005. Extracts from Dulse (Palmaria palmata) are Effective Antioxidants and Inhibitors of Cell Proliferation in vitro. Food ChemToxicol.43:1073-1081.
37. Yuan,Y .and Walsh, N.A. 2006. Antioxidant and Antiproliferative Activity of Extraxts from A Variety of Edible Seaweeds. Food And Chemical Toxicology, 44:1144-1150.

*****

Composition of Pigments and Antioxidant Activity in Edible Red Seaweed Halimenia durvilae Obtained from North Sulawesi

ORIGINALITY REPORT

19%	11%	13%	12%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to UCSI University Student Paper	1%
2	www.scribd.com Internet Source	1%
3	Submitted to Taylor's Education Group Student Paper	1%
4	businessdocbox.com Internet Source	1%
5	Tae-Hyung Kwon, Hwa-Jin Suh, In-Kyoung Lee, Bong-Sik Yun et al. "Determination of singlet oxygen quenching and antioxidant activity of Bieckols isolated from the brown alga Eisenia bicyclis", European Food Research and Technology, 2013 Publication	1%
6	dalspace.library.dal.ca Internet Source	1%
7	www.oilgae.com	

	Internet Source	1%
8	www.pharmahealthsciences.net Internet Source	1%
9	repositorio.unicamp.br Internet Source	1%
10	Submitted to Higher Education Commission Pakistan Student Paper	<1%
11	e-sciencecentral.org Internet Source	<1%
12	Vasantharaja Raguraman, Stanley Abraham L., MubarakAli D., Narendrakumar G. et al. "Unraveling rapid extraction of fucoxanthin from Padina tetrastromatica : Purification, characterization and biomedical application", Process Biochemistry, 2018 Publication	<1%
13	E. Conde. "Extraction of natural antioxidants from plant foods", Separation extraction and concentration processes in the food beverage and nutraceutical industries, 2010 Publication	<1%
14	www.sdiarticle2.org Internet Source	<1%

15	Submitted to International Islamic University Malaysia Student Paper	<1%
16	psasir.upm.edu.my Internet Source	<1%
17	Dongmei Liu, Jiwen Sheng, Zhijian Li, Huimin Qi, Yanlong Sun, Yu Duan, Weifen Zhang. "Antioxidant activity of polysaccharide fractions extracted from Athyrium multidentatum (Doll.) Ching", International Journal of Biological Macromolecules, 2013 Publication	<1%
18	www.omjournal.org Internet Source	<1%
19	studylib.net Internet Source	<1%
20	Bakthavachalam Babu. "PRODUCTION OF NATURAL BUTYLATED HYDROXYTOLUENE AS AN ANTIOXIDANT BY FRESHWATER PHYTOPLANKTON[1]", Journal of Phycology, 12/2008 Publication	<1%
21	Submitted to iGroup Student Paper	<1%
22	Arpita Sinha, Pankaj K. Srivastava, Nandita	<1%

Singh, P. N. Sharma, Hari Mohan Behl. "Optimizing organic and mineral amendments to jatropha seed cake to increase its agronomic utility as organic fertilizer", Archives of Agronomy and Soil Science, 2011
Publication

---

23 Abid Ali Ansari, Sulaiman Mohammad Ghanem. "Seasonal variation in the growth responses of some chlorophytic algal flora of the Red Sea", The Egyptian Journal of Aquatic Research, 2017 <1%
Publication

---

24 Cuellar-Bermudez, Sara P., Iris Aguilar-Hernandez, Diana L. Cardenas-Chavez, Nancy Ornelas-Soto, Miguel A. Romero-Ogawa, and Roberto Parra-Saldivar. "Extraction and purification of high-value metabolites from microalgae: essential lipids, astaxanthin and phycobiliproteins : High-value metabolites form algae", Microbial Biotechnology, 2014. <1%
Publication

---

25 www.npao.ni.ac.rs <1%
Internet Source

---

26 Submitted to Blackpool and The Fylde College, Lancashire <1%
Student Paper

---

27 file.scirp.org

	Internet Source	<1%
28	Submitted to Our Lady of Fatima University Student Paper	<1%
29	Samaraweera, A. Malshani, Janak K. Vidanarachchi, and Maheshika S. Kurukulasuriya. "Industrial Applications of Macroalgae", Handbook of Marine Macroalgae Biotechnology and Applied Phycology, 2011. Publication	<1%
30	skemman.is Internet Source	<1%
31	www.ncbi.nlm.nih.gov Internet Source	<1%
32	academicfoodjournal.com Internet Source	<1%
33	Submitted to Myongji University Graduate School Student Paper	<1%
34	Kwon, Tae-Hyung, Tae-Wan Kim, Choong-Gon Kim, and Nyun-Ho Park. "Antioxidant Activity of Various Solvent Fractions from Edible Brown Alga, Eisenia bicyclis and Its Active Compounds : Antioxidant effects of", Journal of Food Science, 2013. Publication	<1%

35	W. A. J. P. Wijesinghe, You-Jin Jeon. "Biological activities and potential cosmeceutical applications of bioactive components from brown seaweeds: a review", Phytochemistry Reviews, 2011 Publication	<1%
36	journals.plos.org Internet Source	<1%
37	RAJAURIA, GAURAV, AMIT KUMAR JAISWAL, NISSREEN ABU-GANNAM, and SHILPI GUPTA. "ANTIMICROBIAL, ANTIOXIDANT AND FREE RADICAL-SCAVENGING CAPACITY OF BROWN SEAWEED HIMANTHALIA ELONGATA FROM WESTERN COAST OF IRELAND : ANTIMICROBIAL AND ANTIOXIDANT PROPERTIES OF IRISH SEAWEED", Journal of Food Biochemistry, 2013. Publication	<1%
38	Bajpai, Monika, Alka Mishra, and Dhan Prakash. "Antioxidant and free radical scavenging activities of some leafy vegetables", International Journal of Food Sciences and Nutrition, 2005. Publication	<1%
39	ortopediaruggiero.it Internet Source	<1%

40	jornamental.iaurasht.ac.ir Internet Source	<1%
41	www.omicsgroup.org Internet Source	<1%
42	www.scielo.br Internet Source	<1%
43	Yuan, Y.V.. "Antioxidant and antiproliferative activities of extracts from a variety of edible seaweeds", Food and Chemical Toxicology, 200607 Publication	<1%
44	Submitted to Jawaharlal Nehru Technological University Student Paper	<1%
45	www.pjps.pk Internet Source	<1%
46	Jafarpour, Mehrdad, Ahmad Golparvar, Omid Askari-Khorasgani, and Shima Amini. "IMPROVING POSTHARVEST VASE-LIFE AND QUALITY OF CUT GERBERA FLOWERS USING NATURAL AND CHEMICAL PRESERVATIVES", Journal of Central European Agriculture, 2015. Publication	<1%
47	Fidelis, Gabriel, Rafael Camara, Moacir Queiroz, Mariana Costa, Pablo Santos, Hugo	<1%

Rocha, and Leandro Costa. "Proteolysis, NaOH and Ultrasound-Enhanced Extraction of Anticoagulant and Antioxidant Sulfated Polysaccharides from the Edible Seaweed, Gracilaria birdiae", Molecules, 2014.
Publication

---

48 Lone, I.A.. "Protective effect of Rumex patientia (English Spinach) roots on ferric nitrilotriacetate (Fe-NTA) induced hepatic oxidative stress and tumor promotion response", Food and Chemical Toxicology, 200710 <1%
Publication

---

49 Natasha C Moroney, Alex HL Wan, Anna Soler-Vila, Richard D FitzGerald, Mark P Johnson, Joe P Kerry. " Inclusion of (red seaweed) in Atlantic salmon diets: effects on the quality, shelf-life parameters and sensory properties of fresh and cooked salmon fillets ", Journal of the Science of Food and Agriculture, 2015 <1%
Publication

---

50 U. Özgen, A. Mavi, Z. Terzi, A. Yıldırım, M. Coşkun, P.J. Houghton. "Antioxidant Properties of Some Medicinal Lamiaceae (Labiatae) Species", Pharmaceutical Biology, 2008 <1%
Publication

---

51 Elsa Uribe, Antonio Vega-Gálvez, Vivian García, Alexis Pastén, Katia Rodríguez, Jéssica <1%

López, Karina Di Scala. " Evaluation of physicochemical composition and bioactivity of a red seaweed ( ) as affected by different drying technologies ", Drying Technology, 2019
Publication

---

52 Gholamreza Dehghan, Abbas Shafiee, Mohammad H. Ghahremani, Susan K. Ardestani, Mohammad Abdollahi. " Antioxidant Potential of Various Extracts from . in Relation to Their Phenolic Content ", Pharmaceutical Biology, 2008 <1%
Publication

---

53 SABRINA COX. "EFFECT OF PROCESSING CONDITIONS ON PHYTOCHEMICAL CONSTITUENTS OF EDIBLE IRISH SEAWEED HIMANTHALIA ELONGATA : EFFECT OF PROCESSING ON HIMANTHALIA ELONGATA", Journal of Food Processing and Preservation, 11/2011 <1%
Publication

---

54 Arif Nisha Syad, Karutha Pandian Shunmugiah, Pandima Devi Kasi. " Antioxidant and anti-cholinesterase activity of ", Pharmaceutical Biology, 2013 <1%
Publication

---

55 Naoto Sato, Tomoe Furuta, Tomoyuki Takeda, Yoshikatsu Miyabe et al. "Antioxidant activity of <1%

proteins extracted from red alga dulse harvested in Japan", Journal of Food Biochemistry, 2019
Publication

56 ANAND P. KULKARNI. "CHEMICAL COMPOSITION AND ANTIOXIDANT ACTIVITY OF SAPOTA (ACHRAS SAPOTA LINN.) FRUIT", Journal of Food Biochemistry, 6/2007 <1%
Publication

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		