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The Effect of Different Drying Methods on the Phytochemical Properties of the Selected Seaweeds

Radhika D [1] Veerabahu C[2], Vijayalakshmi K [3]

[1]Associate Professor, Department of Zoology, V. O. Chidambaram College, Thoothukudi, Tamil Nadu, India – 628008.

[2]The Principal, V. O. Chidambaram College, Thoothukudi, Tamil Nadu, India – 628008.

[3]Research Scholar, Department of Zoology, V. O. Chidambaram College, Thoothukudi, Tamil Nadu, India – 628008

Email:drradhi24@gmail.com

Abstract

Seaweeds are good sources for the nutrition and pharmaceutical sectors. The intention of this study was designed to screen the constituent's selected seaweed collected from Rameswaram and Tuticorin, the Southern coast of India. The present study investigated the presence of phytochemical constituents of the green, brown and red seaweed under different types of drying methods. The extraction of some biochemical constituency stimulates productive application that needs desiccation stepwise to prohibit by removal of the synthetic composition and increases their real-life values and assist process which is consuming time and exhausting processes The valuable substratum of different seaweeds was studied by shade drying, sun drying Hot air oven drying at 60˚and 80˚c and Microwave drying (800w). The phytochemical effects of ethanol extract on different types of Seaweeds such as *Stoechospermum marginatum, Padina gymnosperms, Ulva Lactuca, Hypnea pannosa*, and *Centroceras clavulatum* were scrutinized. The phytochemical sources of Test for Alkaloids, Terpenoids, Steroids, Coumarin, tannin saponin flavonoids, Quinone, anthraquinones, protein, Phenol, and Carbohydrate were determined the Result, credentialed by the low-Temperature drying methods and high-temperature drying methods prepared product with highest chemicals are induced by drying treatment and the species of seaweed used Fast drying methods to be beneficial to the level of specific chemicals. The single drying method could be identified as consistently superior for all species or all compounds of instigating appropriate techniques selected air oven drying 60˚ method has the potential in the area of drying selective material to better stability of bioactive components which is helpful to use further studies in pharmacology and Agricultural fields

Keywords: Different drying, Hot air oven drying, Microwave oven, and Ethanol extract.

1. Introduction:

Seaweeds can be classified into three broad groups based on their pigmentation, Brown, Red, and green seaweeds. Brown seaweeds are usually large, and range from the giant kelp that is often 20m long, too thick, leather-like seaweeds from 2-4 m long, to smaller species 30-60cm long. Red seaweeds are usually smaller, generally ranging from a few centimeters to about a meter in length; however, red seaweeds are not always red they are sometimes purple, even brownish red, but they are still classified by botanists as Rhodophyceae because of other characteristics Green seaweeds are also small with a similar size range to red seaweeds. Seaweeds are also called macroalgae, edible seaweeds were widely consumed especially in Japan, China, Korea, Taiwan, Singapore and Thailand, Brunei, Cambodia, Vietnam, South Africa, Indonesia, Malaysia, Belize, Peru, Chile, Scandinavia, Southwest England d, Ireland, Wales, California, Philippines and Scotland Chan et al.,1997) and they are associated with a significantly lower rate of Cancer, Thyroid diseases, Heart diseases, Dementia and Diabetes (Cornish et al., 2010). In India, seaweeds are utilized by Industry mainly for the production of agar, alginate, and carrageenan through various reports that have mentioned their utilization in food, agriculture, cosmetics, and pharmaceutical industries. (Kumar et al.,2010), Gresslerv et a.,2010; Flora and Hamid et al,2018) Phytochemicals also referred to as phytonutrients, are found in fruits, vegetables, whole grains, legumes, beans, herbs, spices, nuts, and seeds and are classified according to their chemical structures and functional properties. The terminology used to describe phytochemicals (flavonoids, proanthocyanins, procyanidins be confusing. Phytochemicals include compounds such as salicylates, phytosterols, saponins, glycosylates, polyphenols, protease inhibitors,

monoterpenes, phytoestrogen sulfides terpenes, lectins, and many more. In seaweeds company seaweed dried used to manufacture same industry hence needs dehydration process is offered (Gupta et al.,2011) In this study we study different types of drying methods and their Phytochemicals

2. Materials And Methods:

2.1 Collection of Seaweeds:

Seaweeds were manually collected from the intertidal zone at Tharuvaikulam on February 14, 2021, and identified according to Bourelly (1972) and Guiry (2018). In the laboratory, the harvested fresh seaweed samples were thoroughly cleaned with tap water to ensure they were free from epiphytes, foreign biota, sand, and other surface contaminants and stored at 4°C until they were extracted.

2.2 Drying Methods:

In the Food sector, the Microwave oven drying method may be fast drying in limited periods which also so destroyed the story of seaweeds processing (Zhang et al.,2 010, Hamrouni-Sellami et al.,2013, Zielinka & Michalska 2016)

Samples of each seaweed species (Fresh) were divided into five equal portions (300 g wet. each species) and then dried using five different procedures.

Following are the different drying methods used in this study.

a) Shade drying method
b) Sun drying (or) Solar drying method
c) Hot air oven 60 drying method
d) Hot air oven 80 drying method
e) Microwave oven drying method

a) Shade drying method:

The shade dry method is one of the drying methods. In this method, the drying process is performed in a dark place away from sun exposure and appropriate airflow. The wet seaweeds were dried for 1-10 days at room temperature. After drying, 300 grams of dried seaweed were taken and ground to a fine powder.

The Shade dried samples were code-named *Centroceras clavulatum* (A1), *Stecospermum marginatum* (B1), *Padina gymnosperm* (C1), *Ulva Lactuca* (D1), and *Hypnea paranoia* (E1).

b). Sun drying method:

The next drying method is Sun drying method. In this method, the seaweeds are exposed to direct sunlight and are left to dry for 7 hours. The sun-dried samples were code-named *Centroceras clavulatum* (A2), *Stoechospermum marginatum* (B2), *Padina gymnosperm* (C2), *Ulva Lactuca* (D2), and *Hypnea paranoia* (E2).

C) Hot air oven (60°c) drying method:

A hot air oven method is another drying method. In this method selected five Species were kept in an Aluminium tray and placed in the oven at 60°C for 3 hours. After 3 hours they were collected and weighed. Then they were packed in the zip-lock pouches. These samples were then These samples were then code-named *Centroceras clavulatum* (A4), *Stoechospermum marginatum* (B4), *Padina gymgymnosperm*4), *Ulva lacLactuca*4), and *Hypnea paranoia* (E4).

D) Microwave oven drying method:

Glass plates containing the plant materials were placed in a microwave oven with the power strength adjusted to 800 W for 30 minutes. These samples were then code-named *Centroceras clavulatum* (A5), *Stoechospermum marginatum* (B5), *Padina gymgymnosperm*5), *Ulva Lactuca* (D5), and *Hypnea paranoia* (E5).

2.3. Preparation of Crude extract:

The dried seaweeds were then ground to a fine powder using a stainless-steel blender. The powdered form of dried seaweeds was subjected to solid-liquid extraction by using 100% Ethanol solvent. Each 1 g of dried seaweed sample was extracted by using 10 ml of solvent (100% ethanol) with a solid-to-solvent ratio of 1: 10 (w/v). The mixture of powdered seaweeds and ethanol was continuously swirled at 150 rpm in a shaker incubator for 2 hours at 37°C before being filtered using Whatman filter paper number 1. The residue was then re-extracted twice following the same procedure. The collected filtrates were subjected to a rotary evaporator to remove the entire ethanol and finally the crude extract was formed and then stored at −20°C until further analysis.

2.4 Qualitative Phytochemical Analysis:

Seaweeds were assessed for the existence of the phytochemical analysis by using the following standard methods 15

2.4.1. Test for Terpenoids

1ml of sample extract, one bit of Tin, and continued thionyl chloride was eroded to a test tube and the pink color change indicated the presence of Terpenoid content.

2.4.2. Test for Steroids:

1 ml of chloroform and an equal volume of concentrated H2SO4 were added with the 5

ml aqueous plant crude extract. The color change from bluish-red to cherry indicates the presence of steroids

2.4.3. Test for Coumarin:

1ml of extract and 1mlof 10% NaOH were added to a test tube and the white precipitation showed the presence of the coumarin content.

2.4.4. Test for Tannins:

1 ml of lead acetate was added to the 1 ml of aqueous extract. White Precipitate formation showed the presence of tannins.

2.4.5. Test for Saponins:

5 ml of distilled water was mixed with 1 ml of aqueous crude plant extract in a test tube and it was mixed vigorously. Copius Lather Formation showed the presence of Saponins.

2.4.6. Test for Anthraquinones.

1 ml of seaweed extract was added to 1 ml of aqueous ammonia solution and pink, violet, or red color indicated the presence of anthraquinones in the ammonia phase.

2.4.7. Test for Proteins:

Xanthoprotein test was used for the protein analysis. 1ml extract and 1 ml con. Nitric acid (HNO3) was added to a test tube and boiled for a few minutes after that this setup was allowed to cool at room temperature then 20% NaOH was added to this. The appearance of orange color indicated the presence of Protein.

2.4.8. Test for Carbohydrates:

For carbohydrate analysis, Fehling's test was used. In this method, Benedict's solution was added to the seaweed extract and continued to heat for 5 minutes in a water bath. Change of color into green or yellow or red color indicated the carbohydrates.

2.4.9. Test for Glycosides

We added 2 ml concentrated H2SO4 to the whole aqueous plant crude extract and a few drops of Anthrone were added to this solution. A Green color paste formed which indicated the presence of the steroidal aglycone part of the glycoside.

2.4.10. Test for Catechins:

1ml of sample and a few drops of Ehrlich reagent and a few drops of Con.HCl was added to a test tube. The appearance of pink color indicated the presence of Catechins.

2.4.11. Test for Fixed Oil:

1ml of sample extract was placed on Whatman filter paper. The appearance of a grease spot indicates the presence of fixed oil.

2.4.12. Test for Flavonoid

1 ml of sample extract and 1-2 magnesium turnings were added and 1-2 drops of concentrated HCL were added to this solution. The appearance of red color indicated the presence of flavonoids

2.4.13. Test for Quinones:

1ml of sample extract and 1ml con. sulphuric acid was added to a test tube and is added. The appearance of red color indicated the presence of Quinones

3. RESULTS AND DISCUSSIO

Many studies identified the health benefits of Phytochemicals. Researchers have found that Phytochemicals have the potential to stimulate the immune system, prevent toxic substances in the diet from becoming carcinogenic, reduce inflammation, prevent DNA damage, and aid DNA repair. This study aimed to identify the effect of different drying methods on the phytochemical property of the seaweed extracts. Roohinejad et al.,2017 studied seaweeds as rich sources of sustainable food products and beverages. The seaweed comprises chemical additives and that is for pigment formation(astaxanthin) and also to initiate hydrocolloid properties (carrageenan, agar, and alginate) widely used as food in Asian countries (Holdt & Kraan 2018)

3.1. Phytochemical analysis of Seaweed extracts dried by different methods

3.1.1. Phytochemical analysis of *Centroceras clavulatum* extract dried by different methods

The Preliminary phytochemical analysis conducted on the differently dried extract of *Centroceras clavulatum* revealed the presence of chemicals like alkaloids, saponins, terpenoids, tannins, Flavonoids, Quinones, Anthraquinones, Glycoside Catechins and steroids which are known to exhibit medicinal as well as physiological activities. It is also reported the presence of such Phytochemicals varied based on the different drying methods. Particularly, Phytochemicals like Flavonoids and Coumarin are available only in two drying methods. In this flavonoid was available the e the in shade dry method. Quinone is obtained only by the Hot air oven (80°C) drying method. Phytochemical analysis of *Centroceras clavulatum* extract dried by different methods is given in table 3.1.1.

3.1.2. Phytochemical analysis of *Stoechospermum marginatum* extract dried by different methods

The presence of 15 Phytochemicals was tested in this study and only 14 Phytochemicals were found in *Stoechospermum marginatum*. Flavonoid was not available in the Stoechospermum *marginatum* extract. 7 Phytochemicals are completely present in all drying methods Anthraquinone was obtained by Shade dry and Hot air oven (60°C) methods and Saponins were available only in Hot air oven drying methods. Phytochemical analysis of *Centroceras clavulatum* extract dried by different methods is given in table 3.1.2.

3.1.3. Phytochemical analysis of *Padina gymnosperm* extract dried by different methods

Results clearly describe that Out of 15 Phytochemicals 6 Phytochemicals are completely present in all drying methods. Terpenoids were not available in *Padina gymnosperm* extract. Quinones and Catechins were obtained by two methods only but both were present in the extract of Shade dry method. Coumarin was absent only in the Sun-dried method and Saponins were lost only the in 80°C and Microwave oven drying methods. Phytochemical analysis of *gymnosperm* extract dried by different methods is given in table 3.1.3.

3.1.4. Phytochemical analysis of *Ulva Lactuca* extracts dried by different methods

In *Ulva Lactuca,* a maximum of 8 Phytochemicals were obtained by all drying methods which means these 8 Phytochemicals didn't show any impact of drying methods. Terpenoids were absent only in a Hot air oven at a high temperature(80°C) but surprisingly saponins were as available only in a Hot air oven at a temperature (of 80°of C). Only the in-microwave oven drying method Phenol was absent. Phytochemical analysis of *Ulva Lactuca* extract dried by different methods is given in table 3.1.4.

3.1.5. Phytochemical analysis of *Hypnea paranoia* extract dried by different methods

Results clearly describe that 7 Phytochemicals are completely present in all drying methods in *Hypnea pannosa*. Alkaloids and Terpenoids were only absent in a Hot air oven heat temperature (80°C). Tannins were absent t the n Hot air oven high temperature (80°C) drying method and Microwave oven method. Flavonoids were absent in the Hot air oven high temperature (80°C) drying method and the Sun-dried method. On the other hand, Saponins were available only in High temperature (80°C) oven drying method. Phytochemical analysis of *Padina gymnosperm* extract dried by different methods is given in table 3.1.5.

Table 3.1.1

Phytochemical analysis of *Centroceras clavulatum* extract dried by different methods is given in

Phytochemicals	**A1**	**A2**	**A3**	**A4**	**A5**
Alkaloids	_	+	+	+	+
Terpenoids	+	+	+	+	+
Steroids	+	+	+	+	+
Coumarin	+	_	_	+	_
Tannin	+	+	+	+	+
Saponins	+	+	+	+	+
Flavonoids	+	+	_	_	_
Quinones	_	_	_	+	_
Anthraquinones	+	+	+	_	_
phenols	+	+	+	_	+
Protein	+	+	+	+	_
Carbohydrate	+	+	+	+	+
Glycosides	+	+	+	+	_
Catechin	+	+	+	+	_
Fixed oil Test	_	+	+	+	+

(+) indicates the presence of compounds (-) indicates the presence of compounds

A – C.C

A1- Shade Drying

A2-Sun Drying

A3-Hot Air oven 60 ˚c

A4- Hot Air oven 80 ˚c
A5-Microwave oven

Table 3.1.2.

Phytochemical analysis of *Stoehospermum marginatum* extract dried by different methods

Phytochemicals	B1	B2	B3	B4	B5
Alkaloids	+	+	+	_	_-
Terpenoids	+	+	+	+	+
Steroids	+	+	+	+	+
Coumarin	+	+	+	+	+
Tannin	+	+	+	+	+
Saponins	__	_	+	+	_
Flavonoids	_	_	_	_	_
Quinones	+	+	+	+	+
Anthraquinones	+	_	+	_	_
Phenols	+	+	+	+	+
Protein	+	+	+	+	+
Carbohydrate	_	+	+	+	+
Glycosides	+	+	_	+	+
Catechin	_	+	+	_	+
Fixed oil Test	_	+	+	+	+

(+) indicates the presence of compounds (-) indicates the presence of compounds

B- S.M
B1- Shade Drying
B2-Sun Drying
B3-Hot Air oven 60 ˚c
B4- Hot Air oven 80 ˚c
B5-Microwave oven

Table 3.1.3.

Phytochemical analysis of *Padina gymnospora* extract dried by different methods

Phytochemicals	C1	C2	C3	C4	C5
Alkaloids	+	+	+	+	+
Terpenoids	_	_	_	_	_
Steroids	+	-	+	+	+
Coumarin	+	-	+	+	+
Tannin	+	+	+	+	+
Saponins	-	+	+	-	-
Flavonoids	+	+	+	-	-
Quinones	+	-	+	-	-
Anthraquinones	+	+	+	+	+
Phenols	+	-	-	+	+
Protein	+	+	+	+	+
Carbohydrate	+	-	-	+	+
Glycosides	+	+	+	+	+
Catechin	+	-	-	+	-
Fixed oil Test	+	+	+	+	+

(+) indicates the presence of compounds (-) indicates the presence of compounds

C1- Shade Drying
C2-Sun Drying
C3-Hot Air oven 60 ˚c
C4- Hot Air oven 80 ˚c
C5-Microwave oven

Table 3.1.4.

Phytochemical analysis of *Ulva Lactuca* extracts dried by different methods

Phytochemicals	D1	D2	D3	D4	D5
Alkaloids	+	+	+	+	+

Terpenoids	+	+	+	-	+
Steroids	-	+	+	+	-
Coumarin	+	+	+	+	+
Tannin	+	+	+	+	+
Saponins	-	-	-	+	-
Flavonoids	-	+	-	-	-
Quinones	-	+	+	+	+
Anthraquinones	-	+	+	+	-
Phenols	+	+	+	+	-
Protein	+	+	+	+	+
Carbohydrate	+	+	+	+	+
Glycosides	+	-	+	+	+
Catechin	+	+	+	+	-
Fixed oil Test	+	+	+	-	+

(+) indicates the presence of compounds (-) indicates the presence of the compound
D1- Shade Drying
D2-Sun Drying
D3-Hot Air oven 60 ˚c
D4- Hot Air oven 80 ˚c
D5-Microwave oven

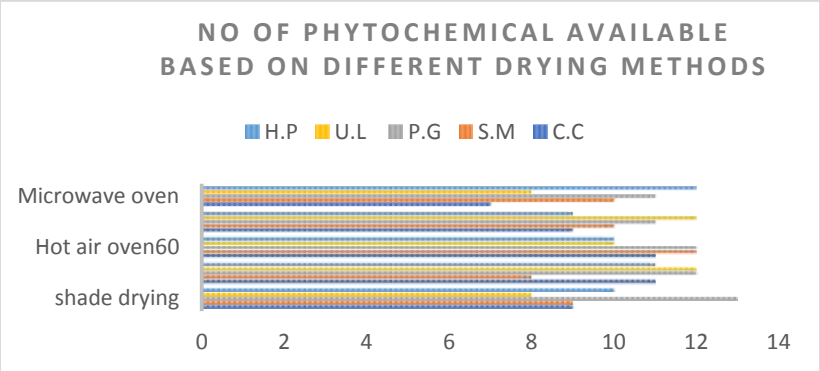
Table 3.1.5.

Phytochemical analysis of *Hypnea paranoia* extract dried by a different method

Phytochemicals	**E1**	**E2**	**E3**	**E4**	**E5**
Alkaloids	+	+	+	_	+
Terpenoids	+	+	+	_	+
Steroids	+	+	+	+	+
Coumarin	+	+	+	+	+
Tannin	+	+	+	-	_
Saponins	_	_	_	+	_
Flavonoids	+	_	+	_	+
Quinones	+	+	+	+	+
Anthraquinones	_	+	_	+	_
Phenols	+	+_	+	+	+
Protein	_	_	_	_	+
Carbohydrate	+	+	+	+	+
Glycosides	_	+	_	+	+
Catechin	+	+	+	+	+
Fixed oil Test	+	+	+	+	+

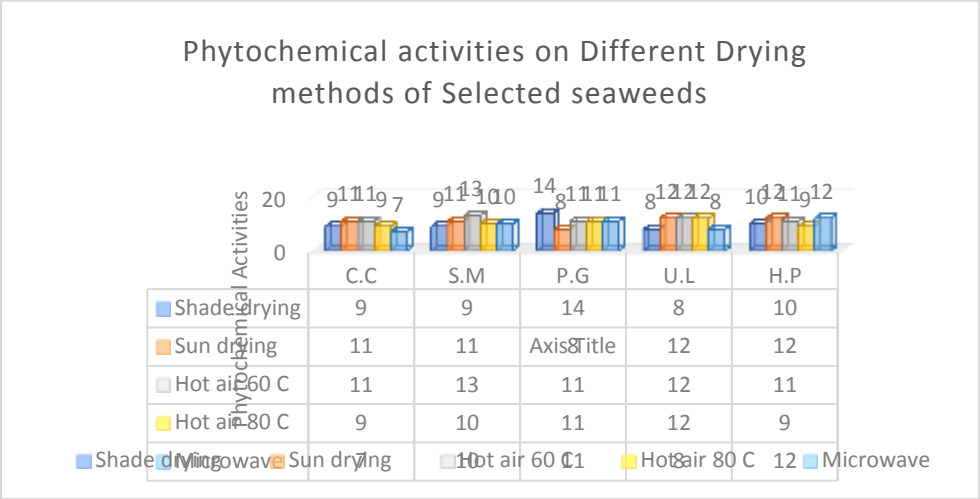
(+) indicates the presence of compounds (-) indicates the presence of compounds
E1- Shade Drying
E2-Sun Drying
E3-Hot Air oven 60 ˚c
E4- Hot Air oven 80 ˚c
E5-Microwave oven

Figure-1



C.C – Centeroceras clavulatum
S.M -- Stoechospermum marginatum
P.G –Padina gymnosporam
U.L.—Ulva lactuata
H.P.—Hypnea pannosa

Figure-2



Based on the procedure of the drying method required the efficient breakdown of cytological units which mainly the leads to release of phytochemicals during extraction by Cox et al., 2012.Figure -1. clearly describes that more in the shade drying method and Microwave oven method a high number of Phytochemicals in *Padina gymnospora.* Next to the Hot air oven60˚C and 80˚C dry methods, the Sun drying method holds a low number of Phytochemicals and the Microwave n drying method holds high several Phytochemicals next to the Hot air oven method (80°C) drying method Sun-dried method. In contrast to this Padina gymnosperm hold a high number of Phytochemical than thein y had shade dry method and holds a low number of Phytochemicals in the sun-dried method.

Variation of metabolites insists 3 brown seaweeds and recognized in chemical profile changes depend upon the different drying methods (Hamid et al.,2018). Though sun-dried methods hold a high number of Phytochemicals Tables 3.1.3 and 3.1.5 clearly show that in some cases Phytochemicals such as Flavonoids and Coumarin will not be available in the extracts prepared by the Sun-dried method but available in other drying methods. So, the Hot air oven (60°C) drying method is the best method for good phytochemical activity according to this study. Other notable aspects of this study are as follows. Steven et al.,2018 explained freeze-drying and convective air drying at 25,40,70˚C in Saccharina Bellissima that denote any effects when drying methods of some chemical components studied. A recent study, compared components of chemicals in oven-dried (25,40,60˚C) in Ulva Regina, Gracillaria SPS, and Fucus vesiculitis of fresh seaweed comprised that the extraction of polyphenols and its reaction influences drying treatment by Silva et al.,2019. *Centroceras clavulatum* holds a high number of Phytochemicals in the sun-dried method and oven-dried method (60°) C and it holds a minimum number of Phytochemicals in the microwave oven-dried method. In *Stecospermum marginatum*, the oven-dried (60)C drying method was very effective maximum number (12) of Phytochemicals were obtained in this method. Shade dried method is a less effective method for this species because the number of Phytochemicals obtained was only 09 out of 15. In *Padina* is shown by a shade-dried method which holds 13 Phytochemicals. On the other hand, a very low effect is shown by a sun-dried method which holds 8 Phytochemicals In *Ulva Lactuca*, three

methods (Sundry method, oven-dry (60°C), (and 80°) method) equally holds a high number of Phytochemicals (12). Shade dries and the Microwave oven method equally holds a low number of Phytochemicals (8).] In *Hypnea pannosa*, maximum (12) activity is exhibited in sun-dried and minimum activity (9 Phytochemicals) is exhibited in microwave oven dry method in oven dry (80) ˚C method. The best method is the Shade dry Method in Padina is good. Medium *in Ulva* and *Hypnea* and low activity of *Centromeres clavulatum* in this method. The above-said methods best concluded that the shade dry method& Minimum activity was observed in Sun dry Method. The medium activity was observed in the Microwave oven dry method.

4. CONCLUSION:

Seaweeds play a major role in society by contributing to global health. Bioactive compounds present in Seaweeds have been studied for more usage and better efficiency. Bioactive compounds such as phenols, proteins, flavonoids, alkaloids, etc. have positive effects on human health. Seaweeds are a good source of bioactive components and phytochemicals, both in terms of their profile and concentration. Various drying methods affect the bioactive components (phenolics, flavonoids, alkaloids, etc.) of Seaweeds differently. In this study, we investigated the impact of microwave, oven, shade, and sun-drying methods on the phenols, flavonoids, saponins, Steroids, Tannins, Coumarins, alkaloids, and protein content of five selected seaweeds. The results indicate that Shade drying and a Microwave oven are the best methods to maintain all the bioactive components in *seaweeds*, whereas the lowest levels were seen in sun-dried. However, microwave and shade methods have the potential in the area of drying sensitive material to better stability of bioactive components. From the above study, it can be concluded that the Shade drying and Microwave oven method should be used for effective study, and preparation of food supplements and drugs also.

5. References

1. **Chan JCC, Cheung PCK, Ang PO (1997)** Comparative studies on the effect of three drying methods on the nutritional composition of seaweed Sargassum epiphyllum (turn) C Ag. J Agric Food Chem 45:3056–3059
2. **Cornish ML, Garbary DJ (2010)** Antioxidants from macroalgae: potential applications in human health and nutrition. Algae 25:155–17
3. **Cox S, Gupta S, Abu-Ghannam N (2012)** Effect of different rehydration temperatures on the moisture, the content of phenolic compounds, antioxidant capacity and textural properties of edible Irish brown seaweed. LWT Food Sci Technol 47:300–307
4. **Gressler V, Yokoya NS, Fujii MT, Colepicolo P, Filho JM, Torres RP, Pinto E (2010)** Lipid, fatty acid, protein, amino acid and ash contents in four Brazilian red algae species. Food Chem 120:585–59
5. **Gupta S, Abu-Ghannam N (2011)** Recent developments in the application of seaweeds or seaweed extracts as a means for enhancing the safety and quality attributes of foods. Innov Food Sci Emerg Technol 12:600–609
6. **Hamid SS, Wakayama M, Soga T, Tomita M (2018)** Drying and extraction effects on the three edible brown seaweeds for metabolomics. J Appl Phycol 30:3335–3350
7. **Hamid SS, Wakayama M, Soga T, Tomita M (2018)** Drying and extraction effects on three edible brown seaweeds for metabolomics. J Appl Phycol 30:3335–3350
8. **Hamrouni-Sellami I, Rahali FZ, Rebey IB, Bourgou S, Limam F, Marzouk B (2013**) Total phenolics, flavonoids, and antioxidant activity of sage (Salvia officinalis L.) plants as affected by different drying methods. Food Bioprocess Technol 6:806–817
9. **Holdt SL, Kraan S (2011**) Bioactive compounds in seaweed: functional food applications and legislation. J Appl Phycol 23:543–597
10. **Kumari P, Kumar M, Gupta V, Reddy CRK, Jha B (2010**) Tropical marine macroalgae as potential sources of nutritionally important PUFAs. Food

Chem 120:749–757

11. **Roohinejad S, Koubaa M, Barba FJ, Saljoughian S, Amid M, Greiner R (2017)** Application of seaweeds to develop new food products with enhanced shelf-life, quality, and health-related beneficial properties. Food Res Int 99:1066–1083
12. **Silva AFR, Abreu H, Silva AMS, Cardoso SM (2019**) Effect of oven-drying on the recovery of valuable compounds from *Ulva rigida*, *Gracilaria* sp. and *Fucus vesiculitis*. Mar Drugs 17:90–107
13. **Stévant P, Indergård E, Ólafsdóttir A, Marfaing H, Larssen WE, Fleurence J, Roleda MY, Rustad T, Slizyte R, Nordtvedt TS (2018)** Effects of drying on the nutrient content and physicochemical and sensory characteristics of the edible kelp Saccharina latissima. J Appl Phycol 30:2587–2599
14. **Zhang M, Jiang H, Lim RX (2010)** Recent developments in microwave-assisted drying of vegetables, fruits, and aquatic products-drying kinetics and quality considerations. Dry Technol 28:1307–1316
15. **Zhang M, Tang J, Mujumdar AS, Wang S (2006**) Trends in microwave-related drying of fruits and vegetables. Trends Food Sci Technol 17: 524–534
16. **Zielinska M, Michalska A (2016)** Microwave-assisted drying of blueberry (Vaccinium corymbosum L.) fruits: drying kinetics, polyphenols, anthocyanins, antioxidant capacity, color, and texture. Food Chem 212:671–680

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