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SOIL CHEMISTRY, PHYTOCHEMISTRY, AND GC-MS PROFILES OF MORINGA LEAVES (*Moringa oleifera*) AS AN ANTIFATIGUE CANDIDATE FROM GEOTHERMAL, COASTAL, AND URBAN AREAS IN ACEH BESAR DISTRICT AND BANDA ACEH MUNICIPALITY, INDONESIA

Aditya Candra[1,2], Yudha Fahrimal[3,✉], Yusni[4], Azwar[5] and Tahara Dilla Santi[6]

[1]Graduate School of Mathematics and Applied Sciences, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; aditya_c@mhs.unsyiah.ac.id

[2]Department of Physiology, Faculty of Medicine, Universitas Abulyatama, Lampoh keude, Aceh Besar 23372, Indonesia

[3]Faculty of Veterinary Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; yudhafahrimal@unsyiah.ac.id

[4]Department of Physiology, Faculty of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; yusni@unsyiah.ac.id

[5]Department of Chemical Engineering, Faculty of Engineering, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; azwar.yahya@unsyiah.ac.id

[6]Faculty of Public Health, University Muhammadiyah Aceh, Banda Aceh 23245, Indonesia; tahara20tahara@gmail.com

✉Corresponding Author: yudhafahrimal@unsyiah.ac.id

ABSTRACT

Soil chemical components from different locations produce different macro-micro nutrients, phytochemicals compounds, and biological activities of the plant. This study aims to see whether soil chemistry from three different areas namely coastal, geothermal, and urban areas affect the phytochemical components and chemical compounds contained in Moringa (*Moringa oleifera*) leaves Soil chemical analysis showed that the coastal area had the highest macro-micro nutrients and the best phytochemical and chemical compounds of moringa leaves than those of the other two locations. The moringa leaves phytochemical compounds of the coastal area consisting of alkaloids, saponins, flavonoids, steroids, and phenolics. The GC-MS profile of moringa leaves from the coastal area contained 28 compounds, a geothermal area of 27 compounds, and an urban area of 24 compounds. Of all these chemical compounds, there are six similarities with the highest order namely Linolenic acid, 9,12,15- octadecatrienoic acid, Ethyl ester, Vitamin E hexadecanoic acid, Phytol, and neophytadiene. In conclusion, Moringa leaf from the coastal area has the highest concentration of soil chemical components, phytochemicals, and a number of compounds.

Keywords: Moringa, Coastal, Geothermal, Urban, Anti-Fatigue, GC-MS.

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INTRODUCTION

Ergogenic aids are used to improve exercise performance in achieving excellence in sports. Examples of ergogenic aids are exercise programs, sports mechanics, nutrition, various synthetic drugs made from chemicals or natural plant compounds, and psychology. They can directly improve the physiological aspects of body organs.[1] The need for Nutritional supplements is necessary to increase strength and endurance during the training period. The use of chemical-based supplements to enhance athletes' performance has been forbidden by international sports authorities. Ergogenic herbal ingredients from plants in recent years have been widely developed. Apart from not being included in the doping category, natural ingredients from the plants are also healthy and contain lots of essential and secondary metabolite compounds that are beneficial to the body.[2,3,4] Research on herbal ergogenic supplements continues to be developed and one of the potential plants is *Moringa oleifera. Moringa oleifera* is native to Southeast Asia, Africa, Arabia, and

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especially Indonesia.[5,6] This plant is well known for its great benefits in terms of nutrients and medicines. As a nutrient, it is used as a vegetable and moringa seed tempe.[6] Its benefit in medicines include antimicrobes, antioxidants, anti-constipation, antispasmodic, anti-inflammation, antioxidants, antimicrobes, antimutagent, anticancer, and anti-hypertension.[5] So that it has an excellent potency as antifatigue ergogenic material.[7,8,9] Several studies have proven that *M. oleifera* has nutraceutical potential. Among them, the use of *M. oleifera* extract repairs atrophic skeletal muscle in a malnourished experimental model.[10] Experiments on obese mice given quercetin extract (flavonoid naturally present in the plant) showed a reduction in skeletal muscle atrophy.[11] Administration of *M. oleifera* in rats carrageenan-induced inflammation inhibits the expression of cyclooxygenase-2 (COX-2) and induces nitric oxide (iNOS) which are the key factors in the inflammatory process.[12,13,14] This plant may also have an intracellular effect where the mitochondria increase in number or diameter to have a positive effect on producing energy for muscles.[14] Previous studies in herbal medicine have shown varying clinical results depending on the extraction method, plant species and its parts, soil type, and geographic location.[2] Research on the relationship between soil chemistry and phytochemical components and profiles of chemical compounds contained in Moringa leaves from three different locations has not been carried out. So that the plants that have the most compounds from this study will be considered to be used as ergogenic herbs from natural ingredients as antifatigue. This article describes the phytochemical components of *M. oleifera* from three locations namely geothermal, coastal, and urban areas in Aceh Besar district and Banda Aceh municipality, Aceh province, Indonesia.

EXPERIMENTAL

Samples

Soil samples and leaves of Moringa (*Moringa oleifera*) were taken from three different locations by purposive sampling. The sample of Kajhu village represents the coastal area with coordinates N 50 36'6.9354 "(lat) and E 95022'354522'(length), Ie serum village represents the geothermal area with coordinates N 5.5471820 (lat) and E 95.5469740 (length), and Lambhuk village represents the urban area with coordinates N 5.55142270 (lat) and E 95.3388432 (length).

Soil Preparation

Soil samples from the three locations of the Coastal area (Kajhu village of Aceh Besar District), geothermal area (Ie Seuum village of Aceh Besar District), and Urban area (Lambhuk village of Banda Aceh municipality) were analyzed in the soil and plant research laboratory of the Faculty of Agriculture of University of Kuala Banda Aceh. Moringa leaf samples (*Moringa Oleifera*) were analyzed in the biology laboratory and phytochemical screening was carried out in the laboratory of the chemistry department of the faculty of mathematics and natural sciences. The GC-MS examination was carried out at the Jakarta health laboratory.

Soil Chemical Analysis

All methods used in this study for soil chemical analysis were according to the United State Department of Agriculture Natural Resources Conservation Service.[15] About 0.5 gr soil sample was mixed with 5 ml of HNO3 p.a and 0.5 ml of HClO4 in a digestion tube and left for one night. The next day, it was heated in a digestion block at 100ºC for one hour. The temperature was increased to 150ºC. Once the yellow steam disappeared, the digestion block temperature was increased to 200ºC. Destruction was complete when white smoke comes out and the remaining extract was approximately 0.5 ml. The extract was diluted with ion-free water to an exact volume of 50 ml, and homogenized by shaking on the tube shaker. Measurement of soil Phosphate (P) was done by putting 1 ml of sample extract and standard series of P into a chemical tube each and diluting 10 times with deionized water. Two ml of the mixtures above were put into an individual test tube and ten ml of dye reagent P were added and homogenized using a tube shaker. The concentration of P in the solution was assessed using a spectrophotometer at a wavelength of 693 nm. Assessment of K, Ca, Mg, and Na concentration in the soil was done by pipetting 1 ml of soil extract and standard series into individual tubes and diluting 10 times with 0.25% La solution. The mixture was homogenized using a tube shaker. The concentration of Ca and Mg was measured using AAS while K and Na were measured using a flame photometer with a standard series as a comparison. Organic nitrogen compounds content in the soil was determined by spectrophotometry. Two ml of each soil extract and a series of standards were pipetted

into an individual test tube. Four ml of tartrate and Na-phenate were successively added, mixed, and left for 10 minutes. Four ml of 5% NaOCl was added into the solution, shaken, and measured with a spectrophotometer at a wavelength of 636 nm. Carbon concentration was calculated by mixing a half gram of each soil sample size <0.5 mm in an individual 100 ml flask with 5 ml K2Cr2O2 1 N followed by adding 7.5 ml of concentrated H2S04, mixed, and letting stand for 30 minutes. The mixture was analyzed with a spectrophotometer at 561 nm wavelength to measure the concentration of Carbon. The intensity of the green color formed is equivalent to the carbon content. The pH value indicates the concentration of H+ ions in the soil solution, which is expressed as – log{ H+}. An increase in the concentration of H+ increases the potential of the solution which is measured by the instrument and converted to a pH scale. The glass electrode is a special H+ selective electrode, making it possible to measure only the potential due to an increase in the H+ concentration. The potential that arises is measured based on the potential of the reference electrode (calomel or AgCl).[16] Measurement of pH was also done digitally using a 4 in 1 analyzer.

Moringa Leaf Extract

Moringa Leaf Simplicia began with the collection and sortation of raw materials, washing, chopping, air drying, dry sorting, milling, packing, and storage. Three kg of air-dried moringa leaves were powdered using a blender. The powder was sieved through a 60-mesh sieve, and mixed with 96% ethanol for 72 hours. The mashed moringa leaves were evaporated at a temperature of 35^0C for 48 hours. The obtained residue was stored at a temperature of 4^0C before use. [16]

Phytochemical Screening

Phytochemical screening was used to identify secondary metabolites contained in *M. oleifera* leaves. The tests were carried out in the form of examination of secondary metabolites from the flavonoid group with cyanidin reagent (magnesium powder and concentrated hydrochloric acid); a phenolic group with iron (III) chloride reagent; saponin group with foam and water testing; steroid group, triterpenoid with Lieberman Burchard reagent (acetic anhydrous acid and concentrated sulfuric acid); a group of alkaloids with reagents.[16]

GC-MS Analysis

The ethanol extracts of moringa leaves from the three locations were injected into the GC-MS tool. GC-MS analysis was using the intelligent technology 7890 gas chromatograph with the automatic sampler and 5975 mass. Electron ionization model with an energy of 70 eV, column hp ultra 2, the initial temperature of 80^0C then increased gradually by 3^0C until reaching a temperature of 150^0C, maintained for 1 minute, and finally increased by 20^0C to reach 280^0C and maintained 26 minutes. The carrier gas is helium, constant flow column mode with a column flow of 1.2 mL/min, injection volume of 5 mL.[17]

RESULTS AND DISCUSSION

The biology laboratory of the faculty of mathematics and natural sciences confirmed that the moringa leaves submitted for species identification was *Moringa oleifera* Lam. The chemical profile of the soil where the moringa trees grew was analyzed in the soil and plant research laboratory, Faculty of Agriculture, University of Syiah Kuala, Banda Aceh, which shows the minerals contained in each soil sample (Table-1). Table-1 shows that most soil chemical components that contribute to plant fertility, metabolic content, and the compounds produced by the plant from the coastal area have the highest concentration compared to those of two other locations. Although there is no available specific soil chemical component standard available for *M. oleifera* to grow optimally, judging from the number and concentration of phytochemical components of *M. oleifera* that grows in the coastal area shows that soil chemical component in the coastal area is the most preferable soil for *M. oleifera* to grow. Phytochemical analysis of Moringa leaves showed that the metabolic content from three sampling locations contains six metabolites, namely alkaloids, steroids, saponins, flavonoids, phenolics, and tannins (Table-2). Some alkaloids function as phytoalexins or antimicrobials, and others have long been used by humans as stimulants, drugs, narcotics, and poisons.[18] Alkaloids also function as antidiabetic, anti-diarrhea, maintain ion balance by replacing mineral alkaline, and as poisons that can protect them from insects and herbivores, growth regulators, and storage compounds capable of supplying nitrogen and other elements needed by plants.[19] Steroids are derived from squalene and terpenes which are organic compounds of sterol fat that are not hydrolyzed and have 17 carbon atoms

and 4 rings. Compounds that include steroid derivatives are estrogen, progesterone, cholesterol, and ergosterol. Steroid function includes hormones, maintain salt balance for the body, control metabolism, improve function of sexual organ, facilitate the digestive process, and stimulate growth receptors in muscles so that the body reacts to increase the production of muscle tissue.[20,21] Flavonoids, in inflammation, play a role in inhibiting COX, lipoxygenase, prostaglandins, and thromboxanes. The ability of bioactive compounds from *M. oleifera* as anti-inflammatory plays an important role in inhibiting fatigue because muscle damage triggered by activity, excessive exercise, and glycogen deficit will cause muscle damage which is characterized by inflammation.[22] Saponins are compounds that have amphiphilic properties and can reduce surface tension. The role of this compound is as an antibacterial, antifungal, lowering cholesterol in the blood and inhibiting tumor cell growth, and enhancing immune function by stimulating the production of T-cells, acting as an antioxidant, platelet aggregation, anti-inflammatory, analgesic, and reducing oxidative stress.[23,24,25] Tannins were also found in Moringa leaf. These secondary metabolites are recognized for their use as astringent, anti-diarrhea, anti-bacterial and antioxidant. Furthermore, Tannins not only function as defaunation agents but also protect feed protein. Tannins have a weakness in their function as defaunation agents because the phenol group in tannins also has antibacterial properties. Gram-positive bacteria are sensitive to certain polyphenols.[24,26] Phenolics or phenols are chemicals produced by plants as a result of environmental stress they experienced. Phenolic compounds function as protectors against UV-B rays and cell death, protect DNA from dimerization and damage, antioxidants, and prevent arteriosclerosis, brain dysfunction, diabetes, and cancer.[20,27,28]

Table-1: Soil Chemistry from Coastal, Geothermal and Urban locations where *Moringa oleifera* grows

S. No.	Parameter	Geothermal area	Coast area	Urban area
1.	pH H_2O	7.63	8.05	7.1
2.	pH KCL	6.43	7.15	6.10
3.	C-organic (%)	0.89	0.88	0.79
4.	N total (%)	0.13	0.11	0.11
5.	P availability (mg kg^{-1})	3.70	51.35	27.65
6.	Exchangeable alkaline Cation			
	Ca^{++} (cmol kg^{-1})	7.23	13.2	11.57
	Mg^{++} (cmol kg^{-1})	0.56	0.55	0.54
	K^{+} (cmol kg^{-1})	0.54	0.99	0.26
	Na^{+} (cmol kg^{-1})	0.30	0.32	0.24
7.	Exchangeable cation capacity (cmol kg^{-1})	19.6	21.20	18.4
8.	Saturated alkaline (%)	44.03	71.04	68.53

Table-2: Phytochemical Analysis of *Moringa oleifera* Leaves

Metabolite content	Reagent	*M. Oleifera* (Geothermal area)	*M. Oleifera* (Coastal area)	*M. Oleifera* (Urban area)
Alkaloid	Mayer	+	+	+
	Wagner	+	+	+
	Dragendorff	+	+	+
Steroid	Liebermann Burchard test	+	+	+
Terpenoid	Liebermann Burchard test	-	-	-
Saponin	Shaking	+	+	+
Flavonoid	HCl and Mg	+	+	+
Phenolic	$FeCl_3$	+	+	+
Tanin	Gelatin+H_2SO_4	+	+	+

The GC-MS Analysis of Ethanol Extract of *Moringa oleifera* Leaf

The GC-MS analysis were carried out at the Jakarta regional health laboratory. From this examination, chemical compounds, retention time, and concentration contained in the samples from the three locations were determined. There were differences in the number and content of compounds possessed by each *M. oleifera* leaf. The number of compounds in the sample of Moringa leaf from geothermal area was 27, coastal area 28, and urban area 24 compounds (Table-3). The results of the analysis of active compounds showed

that the *M. oleifera* leaf in the sample from geothermal area showed that the number active constituent was 27 compounds, the 1st peak was Neophytadiene with a retention time of 27,245 minutes and a concentration of 5.52%, The last peak (27th) was also occupied by neophytadiene compounds with a retention time of 44,366 minutes and a concentration of 1.34%. The coastal sample showed that the active ingredient content was 28 compounds, where the 1st peak was Neophytadiene with a retention time of 27,245 minutes and the concentration was 6.17%, while the last 28th peak was occupied by the compound 4-Ethyl-4-Methyl-2-Phenyl-6-Aza-Tricyclo(6,4,0,0 (2,6) Dodeca-8,10,12-Trien-7-One with a retention time of 51,502 minutes and a concentration of 1.16%. For the active compound of *M. oleifera* leaf, the urban sample shows that the active constituent is 24 compounds, the 1st peak is Neophytadiene with a retention time of 27,245 minutes and the concentration was 10,15%, while the last peak (24th) was also occupied by neophytadiene compounds with a retention time was 44,359 minutes and the concentration was 3,42 %.

Table-3: Comparison of Chemical Compound Components of Ethanol Extract of *Moringa oleifera* Leaves Geothermal, Coastal and Urban Areas

Peak No	*Moringa oleifera* Geothermal area				*Moringa oleifera* Coastal area				*Moringa oleifera* Urban area			
	Component	RT	Quality	Content (%)	Component	RT	Quality	Content (%)	Component	RT	Quality	Content (%)
1	Neophytadiene	27,245	99	5,52	Neophytadiene	27,245	99	6,17	Neophytadiene	27,245	99	10,15
2	Neophytadiene	27,458	99	1,41	Neophytadiene	27,472	99	1,48	Neophytadiene	27,472	99	2,50
3	(2E)-3,7,11,15-Tetramethyl-2-Hexadecen-1-Ol	27,651	90	2,16	Neophytadiene	27,658	98	2,39	(2)-3,7,11,15-Tetramethyl-2-Hexadecen-1-Ol	27,658	90	3,97
4	Hexadecanoic Acid, Ethyl Ester	28,637	99	3,12	Hexadecanoic Acid, Ethyl Ester	28,672	99	6,93	Hexadecanoic Acid, Ethyl Ester	28,624	99	2,38
5	Hexadecanoic Acid	29,182	99	10,94	n-Hexadecanoic Acid,	29,093	99	4,10	Hexadecanoic Acid	29,010	99	5,26
6	Phytol	29,492	55	3,82	n-Hexadecanoic Acid,	29,251	95	1,36	Hexadecanoic Acid	29,251	96	1,16
7	(2E)-3,7,11,15-Tetramethyl-2-Hexadecen-1-Ol	29,596	64	2,49	Phytol	29,520	90	5,94	Hexadecanoic Acid	29,368	96	1,15
8	9,12,15-octadecatrienoic acid, Ethyl ester	29,782	99	8,63	Ethyl 9,12,15-octadecatrienoate	29,817	99	14,36	Phytol	29,499	91	7,80
9	Octadecanoic Acid, Ethyl ester	29,865	97	1,66	Octadecanoic Acid, Ethyl Ester	29,897	98	2,28	9,12,15-Octadecatrienoic Acid, Ethyl Ester	29,748	99	5,65
10	Linolenic acid	30,258	99	21,59	Linolenic acid	30,113	99	9,79	Linolenic Acid	30,072	99	12,97
11	Linolenic acid	30,699	93	2,80	2-Methyl-Z,Z-3,13-octadecadienol	30,465	60	1,45	Linolenic Acid	30,444	74	1,38
12	Beta.-Pinone	30,796	64	3,17	(1R)-(+) Norinone	30,465	47	3,96	Methyl 8,11,14-Heptadecatrienoate	30,630	92	1,78
13	Icosane	31,237	95	2,14	Tetradecanoic Acid, Ethyl Ester	30,810	38	1,70	5,7-Dimethyl-1-6-Octadiene	30,820	55	3,66
14	Methyl 8,11,14-	31,382	90	1,71	Heptacosane ,1-Chloro-	31,261	95	2,19	9,12,15-Octadecatri	30,954	86	1,10

	Heptadecatrienoate								enoic Acid, Ethyl Ester			
15	Methyl 8,11,14-Heptadecatrienoate	31,609	90	1,99	Dyhyrocholesterol	31,513	91	2,52	Heptacosane,1-Chloro-	31,216	97	1,49
16	Heneicosanoic acid,2,4-dimethyl-,methyl ester	31,713	70	2,53	Octadecanoic Acid, Ethyl Ester	31,699	93	2,77	Stigmast-5-En-3-Ol	31,340	72	1,01
17	Nonadecane	32,195	96	1,88	Icosane	32,202	95	2,39	19-D-Torulosol	31,568	55	1,38
18	Methyl 5,11,14,17-eicosatetraenoate	32,333	87	1,19	Ethyl tetracosanoate	32,802	83	2,30	Celidoniol, Deoxy	33,471	98	1,62
19	Ethyl 3-Cyclohexylpropanoate	32,823	60	1,51	Squalene	33,009	96	1,56	Pyrrolo (3,4,-A) Carbazole-4-Carboxylic Acid, 1,2,3,3a,4,5,10,10b-Octahydro-10-Metyhl-1,3-Dioxo-2-Phenyl-1,3-Dioxo-2-Phenyl-Ethyl Ester, (3a Alpha, 4 Beta,10b Alpha)-	34,292	90	1,35
20	Squalene	33,037	99	2,02	Tricosame	33,478	98	2,06	.Gamma.-Tocopherol	35,312	91	4,03
21	Nonacosane	33,471	98	1,13	Gamma.-Tocopherol	35,285	94	1,62	Vitamin E	36,402	99	14,08
22	Gamma.-Tocopherol	35,257	93	1,18	Vitamin E	36,222	98	3,37	Pyridine-3-Carboxamide,Oxime, N-(2-Trifluoromethylphenyl)-	39,442	91	1,21
23	Vitamin E	36,215	98	2,84	A-Norcholestan-3-one,5-ethenyl-, (5 beta)-	40,380	81	1,59	Vitamin E	42,414	94	4,39
24	4,4,6a,6b,8a,11,15,14b-Octamethyl-1,4,4a,5,6,6a,6b,7,8,8a,9,10,11,12,12a,14,14a,14b-octadecahydro-2H-picen-3-one	39,387	90	2,48	Thieno (3,2-B) Pyridine,3,7-Dinitro-	41,690	64	1,16	Neophytadiene	44,359	89	3,42
25	Lanosterol	40,504	87	1,55	Vitamin E	42,538	93	4,90				
26	Vitamin E	42,600	96	3,33	Vitamin E	42,663	97	1,17				
27	Neophytadiene	44,366	89	1,34	(24z)-Stigmasta-4,24 (28)-Dien-3-One	42,966	98	2,16				
28					4-Ethyl-4-Methyl-2-Phenyl-6-Aza-Tricyclo (6,4,0,0 (2,6) Dodeca-8,10,12-Trien-7-One	51,502	74	1,16				

***Moringa oleifera* Leaf Compounds with the Highest Concentration**

The compounds possessed by Moringa leaves from these three different locations contained several compounds in common with the highest concentrations. These similarities indicate that although the peak number, concentration, and retention time are different, the main contents are almost the same. *Moringa oleifera* leaf compounds contained in the three sample locations apparently have biological activity that plays a very important role in overcoming fatigue with inflammatory inhibitors and free radicals, this is because compounds in Moringa leaves have high in anti-inflammatory and antioxidant effects (Table-4). Compounds 9,12,15- octadecatrienoic acid ethyl ester has anti-inflammatory, antioxidant, anti-cancer, anti-radiation, and antihistamin effects.[29] Hexadecanoic Acid compounds have anti-inflammatory, antioxidant, antibacterial, antifungal, pesticide, and antiviral effects.[30,31] Neophytadiene has a role as an anti-inflammatory, antibacterial, analgesic, and antirheumatic.[2] Vitamin E is an antioxidant, antidegenerative, anti-aging, anti-tumor, and maintains the immune system.[1,32] Phytol plays a role in anti-inflammatory, antioxidant, antimicrobial, anticancer,[33] and Linolenic acid as anti-malarial, anticancer, antioxidant, and anti-bacterial.[34] Several research showed that plants contain compounds that act as anti-inflammatory and antioxidants such as neophytadiene, vitamin E, 9, 12, 15 octadecatrienoic acid, squalene, and Phyto1.[29,32,33,35] Investigation on the ability of neophytadiene compounds to regulate inflammation induced by LPS both in vitro and in vivo conditions showed that administration of neophytadiene (12, 25, 50 mg/kg) for 7 days in rat followed by intraperitoneal injection of LPS (10 mg/kg) concluded that this compound significantly inhibited the production of NO and the inflammatory cytokines TNF-α, IL-6 and IL-10 both in vitro and in vivo conditions.[36]

Table-4: *Moringa oleifera* Leaf Components with the Highest Concentration from GC-MS Analysis

Highest concentration		Origin of Moringa oleifera Samples		
		Geothermal area	Coastal area	Urban area
1	Peak	10th	8th	21th
	Compound	Linolenic acid	9,12,15-octadecatrienoic acid, Ethyl ester	Vitamin E
	Concentration	21,59 %	14,36%	14,08%
2	Peak	5th	10th	10th
	Compound	Hexadecanoic acid	Linolenic acid	Linolenic acid
	Concentration	10,94%	9,79%	12,97 %
3	Peak	8th	4th	1th
	Compound	9,12,15-octadecatrienoic acid, Ethyl ester	Hexadecanoic acid, ethyl ester	Neophytadiene
	Concentration	8,63%	6,93%	10,15%
4	Peak	1th	1th	8th
	Compound	Neophytadiene	Neophytadiene	Phytol
	Concentration	5,52%	6,17%	7,80%
5	Peak	6th	7th	9th
	Compound	Phytol	Phytol	9,12,15-octadecatrienoic acid, Ethyl ester
	Concentration	3,82%	5,94%	5,65%
6	Peak	26th	25th	5th
	Compound	Vitamin E	Vitamin E	Hexadecanoic acid
	Concentration	3,33%	4,90%	5,26%

CONCLUSION

Soil from the three sampling locations, namely Coastal, geothermal and urban areas showed variations in number and concentration of macro- and micro-nutrients in moringa leaf. Soil samples from the Coastal area has the highest and best macro and micronutrients so that they could affect plant fertility, metabolic content, and the compounds produced. Secondary metabolites, namely alkaloids, steroids, saponins, flavonoids, phenolics, and tannins, and 28 compounds contained with various biological activities, especially anti-inflammatory and antioxidant compounds 9,12,15- octadecatrienoic acid, Ethyl Este,

Hexadecanoic Acid, Neophytadiene, Vitamin E, Phytol dan Linolenic acid. The six compounds with the highest concentration can act as antifatigue. There is a relationship or link between soil chemical elements with secondary metabolic content and the chemical compounds of a plant. This condition is evidenced by the soil chemistry of the Coastal area which has high macro and micronutrients so that the secondary metabolic content and chemical compounds possessed by the plant are also high.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing, and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

Aditya Chandra https://orcid.org/0000-0001-8729-2533
Yudha Fahrimal https://orcid.org/0000-0002-4958-477
Yusni https://orcid.org/0000-0002-2351-802
Azwar https://orcid.org/0000-0001-6622-5614
Tahara Dilla Santi https://orcid.org/0000-0003-3017-475X

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[RJC- 8128/2022]