BIOLOGY, MEDICINE, & NATURAL PRODUCT CHEMISTRY ISSN 2089-6514 (paper)
Volume 14, Number 1, April 2025 | Pages: 107-111 | DOI: 10.14421/biomedich.2025.141.107-111 ISSN 2540-9328 (online)

Potential of Red Seaweed Juice in Reducing Blood Pressure and Lead Levels in Urine in Workers at Public Fuel Filling Stations

Evi Kusumawati[1,*], Imanuddin[1], Rofiqoh[1], Nadimin[2]
[1]Nutrition and Dietetics Study Program, Department of Nutrition, Health Polytechnic Ministry of Health Kendari, Indonesia.
[2]Nutrition and Dietetics Study Program, Department of Nutrition, Poltekkes Kemenkes Makassar, Indonesia.

Corresponding author*
rafaalazka@gmail.com

Manuscript received: 31 December, 2024. Revision accepted: 08 May, 2025. Published: 09 May, 2025.

Abstract

Lead (Pb) pollution, primarily from fuel combustion, poses severe health risks, including hypertension and systemic poisoning. Gas station attendants are particularly vulnerable to Pb exposure due to occupational hazards. This study investigates the efficacy of red seaweed (Eucheuma spinosum) juice, rich in antioxidants and bioactive components, in reducing Pb levels in urine and lowering blood pressure among gas station workers in Kendari City, Indonesia. A quasi-experimental pre-post-test control group design was employed. Thirty gas station attendants were divided into three groups: control (P0), treatment with seaweed juice once daily (P1), and treatment with seaweed juice twice daily (P2), each receiving 200 mL for two weeks. Urinary Pb levels and blood pressure were measured pre-and post-intervention. Phytochemical analysis of the seaweed juice confirmed the presence of antioxidants, phenolics, saponins, flavonoids, and triterpenoids. Data were analyzed using One-Way ANOVA and Kruskal-Wallis tests. The P1 and P2 groups exhibited a reduction in urinary Pb levels, whereas the P0 group showed an increase. However, statistical analysis indicated no significant differences in mean urinary Pb levels among groups. Blood pressure decreased in all groups, with the P2 group showing the most significant reduction in systolic pressure. Despite these trends, no statistically significant differences in blood pressure across the groups were observed. Red seaweed juice demonstrated potential in reducing Pb levels and improving blood pressure among gas station attendants. While statistical significance was not achieved, the findings suggest further research with larger sample sizes and longer intervention durations to confirm the therapeutic benefits of seaweed-based functional foods in mitigating Pb-related health risks.

Keywords: Lead poisoning; Red seaweed juice; Functional food; Antioxidants; Blood pressure; Occupational health.

INTRODUCTION

Lead heavy metal pollution is a serious problem in developed and developing countries like Indonesia. Lead pollution is closely related to mining, motor vehicle exhaust, and industries that use lead (Pb) metal as raw material. Most motor vehicle fuel in Indonesia still contains lead levels above the international minimum. The official specifications set by the Directorate General of Oil and Gas state that the maximum allowable lead content in fuel is 0.45 grams per liter. In contrast, international standards set a stricter limit, permitting a maximum lead content of only 0.15 grams per liter (Girsang, 2008).

Lead, or Tetra Ethyl Lead (TEL), which is abundant in fuel, especially gasoline, is known to cause systemic poisoning, which is characterized by several symptoms such as blindness and paralysis and even affects the formation of blood cells in the spine and inhibits the synthesis of hemoglobin (Hb) (Lanphear et al., 2024). Blood pressure is one of the most sensitive variables to chronic Pb exposure. Several studies have identified the mechanism by which lead can induce hypertension and cardiovascular disease through oxidative stress, functional deficiency of nitric oxide (NO), inflammation, increased central sympathetic nerve activity, and disruption of the regulation of the vasoregulatory system (Lanphear et al., 2024). Lead (Pb) poisoning often occurs in groups of people who are at high risk, such as workshop workers, toll road workers, public transport drivers, and refueling officers at public petrol filling stations (SPBU). Gas station attendants are one group of people vulnerable to exposure to lead (Pb). Klopfleisch et al. (2017) stated that the average level of lead in the blood of officers at the Jln. Adisucipto gas station, Jln. Monjali gas station, and Jln. Magelang gas station was 62.174 µg/dL. Research by Ayu et al. (2016) shows that the average level of lead in the blood of petrol station officers in Tamalanrea District, Makassar City, is >25 µg/dL.

High levels of lead in the body will accumulate in the liver, which will then induce the formation of free radicals. Efforts to reduce free radical levels in the body require antioxidant compounds, obtained from outside

the body through food consumption. Antioxidants from food sources have been known for a long time, but currently, the use of natural foods and drinks, which are widely known by the public, have not been utilized as a type of functional food source of antioxidants.

Marine macroalgae seaweed is currently being touted as a future plant food containing soluble dietary fiber, peptides, phlorotannins, carotenoids, and minerals as functional foods/nutraceuticals. The primary soluble fibers include alginate from brown macroalgae, carrageenan, and agar from red macroalgae, representing up to half the dry weight (DW) of seaweed. This fact makes macroalgae have a leading position in fiber content, surpassing most fruits and vegetables in improving health, including preventing colon cancer, type II diabetes, obesity, and cardiovascular disease.

Seaweed is a functional food that contains soluble dietary fiber, peptides, phlorotannins, carotenoids, lipids, and minerals, and can potentially become a high-value food product for cardiovascular health (CVD). Meanwhile, for the bioactive components, alginate and fucoidan (both polysaccharides), fucosterol (lipid), and fucoxanthin (carotenoid) are explicitly contained in seaweed (Wells ML, et all., 2017). Alginate, the main polysaccharide of seaweed, contributes to lowering cholesterol levels, increasing postprandial blood glucose and lowering blood pressure. Fucoidan polysaccharide, contained only in brown algae (which is the most commonly consumed seaweed), has antioxidant, anticoagulant, antithrombotic, and anti-inflammatory effects, as well as cholesterol-lowering and blood pressure-lowering (Li X., Li J. et al., 2016). Another nutrient, fucosterol, is contained as a lipid, especially in brown and red algae, and lowers blood glucose levels and blood pressure (Abdul Q.A. et al, 2016). Fucoxanthin, an algal carotenoid, has a stronger antioxidant effect than other carotenoids such as α-tocopherol. In addition, although not explicitly contained in seaweed, potassium and calcium reduce blood pressure levels (including vitamins B 1, B 2, B 6, and B 12), C, and E which have antioxidant effects.

This study aims to assess the effect of seaweed juice on lead levels in the urine and blood pressure of gas station officers.

MATERIALS AND METHODS

This type of research is a quasi-experimental type of research with a pre-post test control group design. The research was conducted by testing lead levels in urine and blood pressure, before and after administering seaweed juice. The research was carried out in July-November 2024 involving officers from Public Fuel Filling Stations in Kendari City.

Population and Sample

The population in this study included all Puuwatu, Punggolaka, and Lepo-Lepo gas station officers in Kendari City. The total sample was divided into four groups, namely control group, treatment group 1, and treatment group 2, with the following inclusion criteria:

1. Adults aged 20 – 45 years
2. Length of work as a gas station attendant is at least 1 year
3. Healthy condition and can communicate well
4. Not currently undergoing hormonal therapy or medication therapy that has the potential to cause low bone mass density or loss of bone mass, for example glucocorticoids, anti-convulsants, and hormonal drugs
5. Willing to be involved in research and sign *informed consent*.

From the total population at all gas stations, 30 people were taken as research samples.

Research Design

This type of research is a quasi-experimental type of research with a pre-post test control group design. The research was carried out by testing lead levels in urine and blood pressure, before and after administering seaweed juice.

Procedures Study

Material Preparation and Inspection

Blood pressure checks will be carried out at the Kendari city gas station, seaweed juice making will be carried out at the food laboratory of the Nutrition Department, Health Polytechnic, Ministry of Health, Kendari. Tests for seaweed juice heavy metal and phytochemical content were carried out at the Haluoleo University Integrated Laboratory.

Seaweed juice is juice whose main ingredient is grass plus palm sugar and fruit or coco pandan flavoring, given with a frequency of 1 time per day, 2 times per day, and 3 times per day with a dose of 200 milliliters for 2 weeks.

Blood pressure is the pressure experienced by blood in the arteries when blood is pumped by the heart to all parts of the human body. For normal systolic pressure is <130 mmHg, high if systolic pressure is ≥130 mmHg. Diastolic pressure is normal if <85 mmHg and high if the diastolic pressure is ≥85 mmHg.

Respondent Sampling

P0 - X0 - PP0
P1 - X1 - PP1
P2 - X2 - PP2

Information:
P0 = First measurement (pre-test) control group
P1 = First measurement (pre-test) treatment group 1
P2 = First measurement (pre-test) treatment group 2

X0 = No treatment
X1 = Seaweed juice treatment 1 time 200 cc for 2 weeks
X2 = Seaweed juice treatment 2 times 200 cc for 2 weeks

PP0 = Second measurement (post-test) control group
PP1 = Second measurement (post-test) treatment group 1
PP2 = Second measurement (post-test) treatment group 2

Data analysis

This research uses statistical tests *One Way Anova* (normal data) and *Kruskal Wallis* (abnormal data) to see the differences between before and after treatment in the research group, then to see the differences between the research groups using a test *Post*.

RESULTS AND DISCUSSION

Phytochemical Content of Red Seaweed

The results of the analysis of antioxidant, phenolic, saponin, flavonoid, and triterpenoid content in red seaweed (*Eucheuma spinosum*) were carried out qualitatively. This analysis was only carried out on dry products, so red seaweed that had been soaked for ± 1 mg until the color turned white had to be through a drying process in a cool place (not directly exposed to sunlight) ± 2 days, then the grinding process is carried out again using a blender for the dry ingredients until they become seaweed flour. The results of the analysis of the average antioxidant, phenolic, saponin, flavonoid, and triterpenoid content in red seaweed (Eucheuma spinosum) can be seen in Table 1.

Table 1. Phytochemical Content of Red Seaweed

No	Parameter	Methanol Extract
1	Antioxidant	+
2	Phenolic	+
3	Saponin	+
4	Flavonoid	+
5	Triterpenoids	+

Effect of Red Seaweed Juice on Lead (Pb) Levels in Urine

Figure 1. Effect of Red Seaweed Juice on Lead (Pb) Levels in Urine

Based on Figure 1 above, it can be seen that group P1 tended to decrease levels of lead (Pb) in urine, which was almost the same as the decrease in levels of lead (Pb) in group P2 urine, while group P0 samples tended to increase lead levels during the study (Figure 1).

Table 2. Comparative Analysis of Lead on Urine

Data analisis uji komparatif kadar Timbal (Pb) mg/L					
Kelompok	n	Rerata ± SD Awal	*p*	Rerata ± SD Awal	*p*
P0	10	0.20±0.08		0.21±0.08	
P1	10	0.22±0.07	0,24	0.10±0.07	0,09
P2	10	0.26±0.09		0.13±0.05	

Table 2 shows that the P1 group experienced a tendency to decrease lead (Pb) levels in urine, which was almost the same as the decrease in lead (Pb) levels in the urine of group P2. In contrast, the P0 group samples experienced a tendency to increase lead levels during the study. The results of the Kruskal Wallis test showed no difference in the mean urine lead levels before and after treatment in the three research groups (Table 2).

Effect of Red Seaweed Juice on Blood Pressure

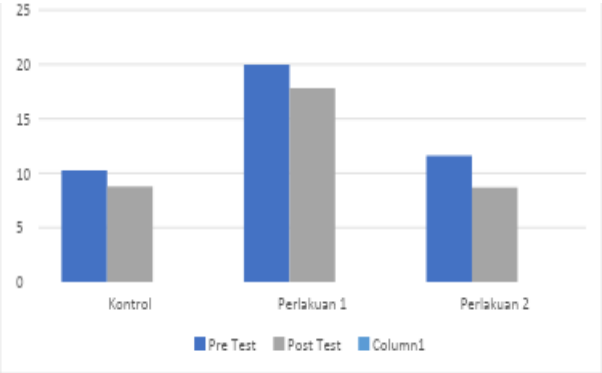

Figure 2. Effect of Red Seaweed Juice on Blood Pressure.

Figure 2 shows a decrease in systolic blood pressure in the three treatment groups. The P2 treatment group experienced a greater tendency to decrease systolic blood pressure levels compared to the P1 treatment group and the P0 control group. The tendency to decrease P1 systolic blood pressure levels was almost the same as the decrease in P0 systolic blood pressure.

Table 3. Comparative Result Analysis on Blood Pressure

Data analisis uji komparatif kadar Tekanan Darah (mmHg)					
Kelompok	n	Rerata ± SD Awal	*p*	Rerata ± SD Awal	*p*
P0	10	127,4±10.72		125.8±08.77	
P1	10	123.6±19.93	0.36	122.2±17.83	0.07
P2	10	127.8±11.61		124.3±8.69	

Table 3 shows a decrease in systolic blood pressure in the three treatment groups, where the blood pressure levels of the P2 treatment group experienced the more significant decrease at the end of treatment compared to the blood pressure levels of the P1 treatment group and

the P0 control group, the decrease in blood pressure levels between the P1 treatment group was almost the same magnitude. with the control group P0 at the end of treatment. The results of the Kruskal-Wallis test showed that there was no difference in the mean blood pressure levels at the beginning and end of treatment in the three study groups.

Discussion

Lead pollution in air, soil, and water comes from burning coal in factories, spraying pesticides, burning rubbish, using aerosols with added lead, recycling used lead acid batteries, and using lead pigments in paint, batik, and paralon pipes. Coal-fired power plants, traditional and small-scale gold mining, industry, ship waste, and cigarette smoke are sources of cadmium and lead metal contamination. Of the many existing sources of air pollution, motorized vehicles (transportation) are the largest source of air pollution (60%), the industrial sector 20% and others 20%. Around 85% of air pollution in Indonesia comes from motor vehicle emissions, affecting lead levels in the blood of active people on the streets. Worker groups at high risk of exposure to lead pollutants in the air include traffic police, street vendors, beggars, and fuel station (SPBU) officers (Ministry of the Ministry of Environment and Forestry and Unicef. 2022).

Lead can enter the human body in three ways: absorption in the skin, respiratory tract, and digestive tract. If this is limited to the contact area, it is called a local effect, but if these substances are absorbed into the blood circulation, they will be carried to various organs in the body and cause systemic effects. Apart from that, lead that enters the human body can then cause various kinds of disorders, such as hematological disorders, nervous disorders, cardiovascular disorders, and reproductive disorders. (Priyanto, 2009)

Lead excretion occurs through the digestive tract in feces, the excretory tract in urine, and sweat and hair. The percentage of lead excreted through urine is 75-80%, while only 15% occurs through feces. Lead levels in urine reflect recent exposure, so urine lead examination is used for occupational exposure (Palar, 2004).

Lead in the body acts as a free radical or as an oxidant. Conditions where free radicals exceed normal levels can decrease antioxidants, which can neutralize Reactive Oxygen Species (ROS), which in turn can reduce the total antioxidant capacity in the body. Lead in its ionic form (Lead acetate) can cause lipid peroxidation. Lipid peroxidation is a chain reaction that supplies free radicals. Lipid peroxidation causes fatty acid chains to break down and form final products with one of the most active carbon elements, malondialdehyde (MDA). MDA is a biomarker of oxidative damage because MDA is the result of polyunsaturated fatty acids (PUFA) in cell membranes and plasma lipoproteins through enzymatic and non-enzymatic processes. Increased MDA levels in the blood can indicate a high response between free radicals and unsaturated fats (Kodariah, et al., 2022)

Oxidative stress and chronic inflammation cause endothelial dysfunction that accelerates atherosclerosis and plaque. In addition, lead directly interferes with the release of tissue plasminogen activator (t-PA) and increases the release of plasminogen activator inhibitor-1, leading to coagulation abnormalities and increased risk of thrombosis and endothelial dysfunction, where endothelial cells are critical in the regulation, maintenance, and control of cardiovascular function. (Mustofa, et al,. 2024)

The active phytochemical compounds in seaweed are thought to directly affect endothelial cells, namely improving endothelial function by stimulating NO synthesis (Nitric Oxide). Endothelial cells release NO, which plays is important in increasing vasodilation, thereby reducing arterial stiffness and maintaining blood vessel tone, especially for relaxing blood vessels. NO results from changing L-arginine to citrulline, which is catalyzed by the Nitric Oxide Synthase (NOS) enzyme (Monsalve et al., 2017).

Lead levels in the urine of group P2 experienced the more significant decrease compared to lead levels in the urine of group P1, while lead levels in the urine of group P0 (control) increased after treatment. However, there was no difference in the mean urine lead levels at the beginning and end of treatment in the three research groups.

Based on research conducted by Hastuti (2009), regarding lead (Pb) levels in the urine of street children in Yogyakarta City, the research results showed that the average lead (Pb) level in the urine of street children in Yogyakarta City was 0.2234 mg/l. This has lead levels that exceed the normal threshold, namely $\geq$ 0.15 mg/l. Likewise, the lead level of gas station officers has an average lead level of 0.226 mg/L, and it is indicated that gas stations along the Puuwatu road are a busy trans-Sulawesi highway and are near the North Konawe border mining area.

Elevated systolic blood pressure predicts cardiovascular disease risk better than increased diastolic blood pressure. Elevated systolic blood pressure predicts cardiovascular disease risk better than increased diastolic blood pressure. Systolic blood pressure is much more important than diastolic blood pressure levels in predicting the risk of coronary heart disease, left ventricular hypertrophy, congestive heart failure, kidney failure, and mortality in people with hypertension. Systolic blood pressure remains more difficult to control than diastolic blood pressure (Jan N. Basile. 2022).

The active phytochemical compounds in seaweed are thought to have the same effect on cardiovascular and blood vessels. Specifically, the phytochemical compounds are thought to increase vasodilation, thereby reducing arterial stiffness and maintaining blood vessel tone, especially for relaxing blood vessels, by increasing

endothelial function and stimulating NO synthesis (Monsalve et al., 2017).

The potassium content in seaweed per 100 g is 380 mg, higher than that of tomatoes and kepok bananas. In contrast, dried seaweed will have a higher potassium content, namely 1,125 mg. Potassium can increase sodium and water excretion by inhibiting renin. Rennin circulates in the blood and works by catalyzing the breakdown of angiotensin I. Angiotensin I changes to its active form, namely angiotensin II, with the help of angiotensin-converting enzyme (ACE). Angiotensin II has great potential to increase blood pressure because it acts as a vasoconstrictor and can stimulate the release of aldosterone. Aldosterone increases blood pressure by sodium retention. The presence of potassium reduces Sodium and water retention, resulting in a decrease in plasma volume, cardiac output, peripheral pressure, and blood pressure (Lestari, 2012).

The decrease in systolic blood pressure in the three treatment groups, where the blood pressure levels of the P2 treatment group experienced the greatest decrease at the end of treatment compared to the blood pressure levels of the P1 treatment group and the P0 control group, the decrease in blood pressure levels between the P1 treatment group was almost the same as the P0 control group~~.~~, at the end of treatment.

The decrease in systolic blood pressure in the three treatment groups, where the blood pressure levels of the P2 treatment group experienced the greatest decrease at the end of treatment compared to the blood pressure levels of the P1 treatment group and the P0 control group, the decrease in blood pressure levels between the P1 treatment group was almost the same as the P0 control group. at the end of treatment.

Putri Research et al. 2023, show that 250 cc of cucumber juice given 2 times a day for 7 days effectively reduces blood pressure in hypertension sufferers in Surau Gadang Village, Padang City.

CONCLUSIONS

There was a tendency to reduce lead levels in the urine of gas station attendants after administering seaweed (Eucheuma spinosum) juice, although it was not statistically significant. There was a tendency to reduce systolic blood pressure in gas station attendants after administering seaweed (Eucheuma spinosum) juice, although it was not statistically significant. The effectiveness of administering seaweed juice at a dose of 200 ml/day for 14 days was greater than at 100 ml/day for 14 days~~,~~ in reducing urine lead levels and systolic blood pressure levels for gas station officers, although it was not statistically significant.

Competing Interests**:** The authors declare that there are no competing interests.

Funding**:** This research received funding from DIPA Poltekkes Kemendari Ministry of Health in 2024.

REFERENCES

Girsang, E. (2008). *Hubungan Kadar Timbal di Udara Ambien dengan Timbal dalam Darah pada Pegawai Dinas Perhubungan Terminal Antar Kota Medan* [Thesis, Universitas Sumatera Utara]. https://repositori.usu.ac.id/handle/123456789/41229

Lanphear, B., Navas, -Acien Ana, & Bellinger, D. C. (2024). Lead Poisoning. *New England Journal of Medicine*, *391*(17), 1621–1631. https://doi.org/10.1056/NEJMra2402527

Klopfleisch, B., Sutomo, A.H., dan Iravati, S., 2017, Kadar Timbal Dalam Darah Petugas Stasiun pengisian Bahan Bakar,Berita Kedokteran Masyarakat4(33), 205-212.

Ayu, F., Afirdah, W., dan Nourma, M., 2016 Hubungan Karakteristik Pekerjaan dengan Kadar Timbal dalam Darah Operator SPBU di Kecamatan Tamalanrea Kota Makassar, Fakultas Kesehatan Program Studi Ilmu Kesehatan Masyarakat, Universitas Nahdlatul Ulama Surabaya.

Wells ML, Potin P, Craigie JS, Raven JA, Merchant SS, Helliwell KE, Smith AG, Camire ME dan Brawley SH: Alga sebagai sumber makanan bergizi dan fungsional: meninjau kembali pemahaman kita. J Appl Phycol, 2017; 29: 949-982

Li X, Li J, Li Z, Sang Y, Niu Y, Zhang Q, Ding H dan Yin S: Fucoidan dari Undaria pinnatifida mencegah disfungsi vaskular melalui mekanisme yang bergantung pada PI3K/Akt/eNOS pada hipertensi yang diinduksi l-NAME model tikus. Fungsi Pangan, 2016; 7: 2398-2408

Abdul QA, Choi RJ, Jung HA dan Choi JS: Manfaat kesehatan fucosterol dari ganggang laut: ulasan. J Sci Pertanian Pangan, 2016; 96: 1856-1866

Dinas Ketahanan Pangan, K. dan P. P. D. J. (2017). Pusat produksiinspeksi dan sertifikasi hasil perikanan.

Jan N. Basile. 2022. Tekanan darah sistolik. 2022;325(7370):917–918. doi: 10.1136/bmj.325.7370.917

Kementerian Lingkungan Hidup dan Kehutanan dan Unicef. 2022. Ringkasan Kebijakan: Mengurangi Keracunan Timbal pada Anak-Anak di Indonesia

Kodariah L., Wahid A., A., Putri V., A., Fadilah T., I. 2022. Pengaruh induksi timbal terhadap kadar malondialdehid pada darah mencit (Mus musculus). Prosiding Aiptlmi

Mustofa M., A., et al. 2024. Hubungan antara Kadar Timbal dalam Darah dan Infark Miokard Senyap pada Populasi Umum. Journal of Clinical Medicine, 13(6):1582. doi: 10.3390/jcm13061582

Monsalve B., Meyer A., C., Palomo I., and Fuentes E. 2017. Mechanisms of Endothelial Protection by Natural Bioactive Compounds from Fruit and Vegetables. Anais da Academia Brasileira de Ciências; 89(1 Suppl.): 615-633

Lestari, A., P., dkk (2012). Pengaruh Pemberian Jus Tomat (Lycopersicum Commune) Terhadap Tekanan darah Pada Wanita PostMenopause Hipertensi. Semarang: http://eprints.undip.ac.id//38425/

THIS PAGE INTENTIONALLY LEFT BLANK