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Proximate Composition and Heavy Metal Contents of Edible Seaweeds *Kappaphycus alvarezii* and *Caulerpa* cf. *macrodisca* ecad *corynephora*

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ABSTRACTS

Edible seaweeds, such as *Kappaphycus* and *Caulerpa* genera, have been popularly consumed for centuries by the local people in the Tawi-Tawi, Philippines. This study examined the proximate composition and heavy metal contents of two edible seaweeds, namely *Kappaphycus alvarezii* (KA) (Rhodophyta) and *Caulerpa* cf. *macrodisca* ecad *corynephora* (CMC) (Chlorophyta), which are readily available in the public market of Bongao, Tawi-Tawi, Philippines. The results revealed significant differences in their proximate compositions. The moisture content was remarkably higher in KA (16.96±0.02 g.100^{-1}g) than that of CMC (10.49±0.08 g.100^{-1}g). CMC contained significantly more crude protein (7.14±0.80 g.100^{-1}g) than KA (2.73±0.40 g.100^{-1}g). The carbohydrate content of KA (44.82±0.34 g.100^{-1}g) was significantly higher than that of CMC (38.09±0.71 g.100^{-1}g). The ash content was notably greater in CMC (44.00±0.66 g.100^{-1}g) than in KA (34.91±0.39 g.100^{-1}g). The total fat content was substantially higher ($p \leq 0.05$) in KA (0.60±0.30 g.100^{-1}g) than in CMC (0.28±0.01 g.100^{-1}g). The heavy metal contents (mg.kg^{-1}) followed the order of K > Zn > Fe > Pb > Cu > Mn > Cd for KA and Zn > Mn > Pb > K > Fe > Cu > Cd for CMC. Fe, K, Cu, and Cd were significantly higher in KA than in CMC, while Zn, Mn, and Pb were remarkably higher in CMC than in KA. However, all these heavy metals were found to be within safe limits of WHO, the US (EPA and FDA), and EMA. These findings underscore the importance of considering these factors in seaweed consumption, affirming their enduring significance in human diets.

Keywords: Edible seaweeds, *Kappaphycus alvarezii, Caulerpa* cf. *macrodisca* ecad *corynephora,* Proximate composition, Heavy metals

Kappaphycus alvarezii ve *Caulerpa* cf. *macrodisca* ecad *corynephora* Türlerine Ait Yenilebilir Deniz Yosunlarının Yaklaşık Bileşimi ve Ağır Metal İçeriği

ÖZ

Kappaphycus ve *Caulerpa* cinsleri gibi yenilebilir deniz yosunları, Filipinler'in Tawi-Tawi bölgesindeki yerel halk tarafından yüzyıllardır popüler bir şekilde tüketilmektedir. Bu çalışmada, yenilebilir iki deniz yosunu olan ve Filipinler'de Bongao, Tawi-Tawi'deki halk pazarlarında kolaylıkla bulunabilen *Kappaphycus alvarezii* (KA) (Rhodophyta) ve *Caulerpa* cf. *macrodisca* ecad *corynephora* (CMC) (Chlorophyta)'nin yaklaşık bileşimi ve ağır metal içeriği incelenmiştir. Sonuçlar, deniz yosunlarının bileşimlerinde önemli farklılıklar olduğunu ortaya çıkarmıştır. KA'daki nem içeriği (16.96±0.02 g.100^{-1}g), CMC'ye (10.49±0.08 g.100^{-1}g) göre oldukça yüksek bulunmuştur. CMC, KA'ya (2.73±0.40 g.100^{-1}g) göre anlamlı derecede daha fazla ham protein (7.14±0.80 g.100^{-1}g) içermektedir. KA'nın karbonhidrat içeriği (44,82±0,34 g.100^{-1}g), CMC'den (38,09±0,71 g.100^{-1}g) anlamlı derecede yüksek bulunmuştur. Kül içeriği CMC'de (44.00±0.66 g.100^{-1}g), KA'ya (34.91±0.39 g.100^{-1}g) göre belirgin şekilde daha yüksek olmuştur. Toplam yağ içeriği KA'da (0,60±0,30 g.100^{-1}g), CMC'ye (0,28±0,01 g.100^{-1}g) göre önemli ölçüde daha yüksek bulunmuştur ($p \leq 0,05$). Ağır metal içerikleri KA için K >

Zn > Fe > Pb > Cu > Mn > Cd ve CMC için Zn > Mn > Pb > K > Fe > Cu > Cd sırasını takip etti. Fe, K, Cu ve Cd, KA'da CMC'ye göre anlamlı derecede yüksekken, Zn, Mn ve Pb, CMC'de KA'ya göre oldukça yüksek olmuştur. Ancak tüm bu ağır metallerin güvenli sınırlar içerisinde olduğu görülmüştür. Bu bulgular, deniz yosunu tüketiminde bu faktörlerin dikkate alınmasının öneminin altını çizmekte ve bunların insan beslenmesindeki kalıcı önemini doğrulamaktadır.

Anahtar Kelimeler: Yenilebilir deniz yosunu, *Kappaphycus alvarezii*, *Caulerpa* cf. *macrodisca* ecad *corynephora*, Yaklaşık bileşim, Ağır metal

INTRODUCTION

Throughout Asian and Pacific cultures, seaweeds have been consumed as traditional food sources. Notably, edible seaweeds offer unique nutritional benefits compared to terrestrial crops, particularly in their high mineral and fiber content [1, 2]. Some popular dishes traditionally made with seaweeds include salads, sushi, pickled seaweed accompanied by condiments like relish or vinegar, and soups [3]. Scientific evidence has shown that the consumption of seaweeds provides a positive impact on global health, especially in addressing the rising prevalence of lifestyle-related diseases resulting from poor dietary habits [4]. Beyond food, seaweeds are significant contributors to aquaculture and biomass production, with applications in cosmetics, pharmaceuticals, animal feed, and biofuels [5-9].

Kappaphycus alvarezii (Rhodophyta) and *Caulerpa* (Chlorophyta) species are globally recognized edible seaweeds. K. *alvarezii*, cultivated worldwide for its carrageenan content and economic value, finds uses in both food and non-food industries [10, 11]. Local communities even consider it edible, and its high nutritional composition has food scientists exploring its potential as an alternative flour source [12, 13]. Additionally, *Kappaphycus* species can be processed into flour and used in crackers and animal feeds [14-16]. *Caulerpa*, harvested from the wild or through aquaculture, is a common sight in local markets across the Indo-Pacific region [12, 17, 18]. Popularly consumed fresh in salads or snacks, *Caulerpa* offers a delightful texture and boasts numerous nutritional benefits, including being a source of phenolics and antioxidants [5, 19, 20]. Tawi-Tawi, a haven for seaweed production in the Philippines, is a prime example. This region, known as the country's seaweed capital, is a major producer of red seaweed varieties like *Kappaphycus*, *Eucheuma*, and *Solieria* spp., alongside green seaweed Caulerpa spp. [12, 21]. The bustling Bongao Public Market showcases the importance of edible seaweeds to the local community. Here, *Caulerpa* is enjoyed fresh, while *Kappaphycus* is typically boiled before being incorporated into salads, often featuring a combination of tomatoes, onions, and vinegar [12].

While extensive research in Tawi-Tawi has explored seaweed farming practices [21-28], ethnobotany [12], taxonomy [29-32], and the microorganisms within the seaweed ecosystem [33-35, 18], a critical knowledge gap remains. Previous research has neglected to investigate the levels of heavy metals and the detailed nutritional makeup (proximate composition) of commonly consumed edible seaweeds in Tawi-Tawi. This is particularly concerning for *Kappaphycus alvarezii* and *Caulerpa* cf. *macrodisca* ecad *corynephora*, two edible seaweed species readily available year-round in the bustling Bongao Public Market, a central hub for the local community. Understanding the levels of heavy metals and the proximate composition of these popular edible seaweeds is crucial. This information can provide valuable insights into their nutritional value for consumers and raise awareness of potential health risks associated with heavy metal content. Therefore, this study breaks new ground by determining the levels of heavy metals and proximate composition in *Kappaphycus alvarezii* and *Caulerpa* cf. *macrodisca* ecad *corynephora* sold at the Bongao Public Market in Tawi-Tawi, Philippines.

MATERIALS and METHODS

Sampling Site

The sampling site is the Bongao Public Market (Figure 1), the central wet market situated in the capital of Tawi-Tawi, the Bongao municipality. It is among the busiest public markets in the province.

Sample Collection

Edible seaweeds available in the market during the sample collection were considered in the study. Initially identified based on morphological characteristics as described in the paper of Dumilag [12], *Kappaphycus alvarezii* and *Caulerpa* cf. *macrodisca* ecad *corynephora* are the common edible seaweeds available all throughout the year. Originally from Banaran, Sapa-Sapa municipality, these seaweeds were obtained from a vendor in the public market of Bongao.

Drying of Samples

Edible seaweed samples were transported to the Fish Processing Laboratory of the College of Fisheries, Mindanao State University-Tawi-Tawi College of Technology and Oceanography. These were washed carefully and dried under the sun in a solar dryer for 3-4 days at a temperature ranging between 33 and 50°C. Dried seaweed samples were then sent to DOST-Region IX at Zamboanga City, Philippines, for analysis.

Heavy Metal Determination

Different heavy metals, including copper (Cu), cadmium (Cd), iron (Fe), manganese (Mn), lead (Pb), Zinc (Zn), and potassium (K), were determined by using the Flame Atomic Absorption Spectrophotometric (FAAS) method with dry ashing digestion technique at 500°C for 2 hr. A flame atomic absorption spectrophotometer (CAAM-2001, Hottine, China) was employed for the analysis [36].

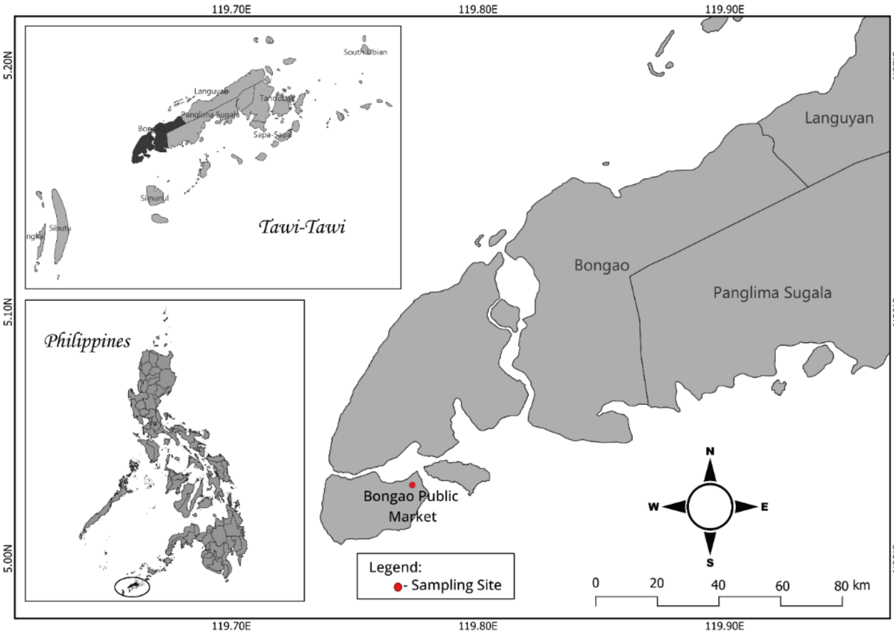

Figure 1. Sampling site for the present study

Proximate Composition

The proximate composition analysis of the edible seaweed samples included the assessment of moisture content, crude protein, total fat, ash, and carbohydrates. These components were quantified using the methods outlined in the AOAC guidelines. Specifically, the moisture content of the chosen edible seaweeds was determined through a gravimetric approach involving air-oven drying at a temperature of 65°C. The investigation of crude protein content employed the Kjeldahl method, which included steps such as block digestion and steam distillation. The analysis of total fat content utilized the Randall/Soxtec/Ether extraction-submersion method combined with acid hydrolysis. The ash content was evaluated via a gravimetric method involving furnace exposure at 600°C. Then, the determination of carbohydrate content was achieved by calculating the difference between 100 and the combined proportions of the previously mentioned components (moisture + ash + crude fiber + crude protein + total fat).

Statistical Analysis

Using the IBM SPSS version 20, an independent sample t-test was used to analyze the data. The significant difference was set at $p<0.05$.

RESULTS

The proximate composition of the edible seaweeds in the present study is shown in Table 1. The moisture content of *K. alvarezii* (16.96±0.02 g.100^{-1}g) was significantly greater ($p≤0.05$) than *Caulerpa* cf. *macrodisca* ecad *corynephora* (10.49±0.08 g.100^{-1}g). Crude protein was significantly higher (p≤0.0.5) in *Caulerpa* cf. *macrodisca* ecad *corynephora* (7.14±0.80 g.100^{-1}g) than in *K. alvarezii* (2.73±0.40 g.100^{-1}g). *K. alvarezii* contained a notable amount of carbohydrates (44.82±0.34 g.100^{-1}g) compared to *Caulerpa* cf. *macrodisca* ecad *corynephora* (38.09±0.71 g.100^{-1}g). Total fat content was remarkable in *K. alvarezii* (0.60±0.30 g.100^{-1}g) compared to *Caulerpa* cf. *macrodisca* ecad *corynephora* (0.28±0.01 g.100^{-1}g). Lastly, the ash content of *Caulerpa* cf. *macrodisca* ecad *corynephora* (44.00±0.66 g.100^{-1}g) was substantially higher ($p≤0.05$) than *K. alvarezii* (34.91±0.39 g.100^{-1}g).

Table 1. Proximate analysis of some edible seaweeds available in the Bongao public market, Tawi-Tawi, Philippines

Edible seaweeds	Moisture content (g.100^{-1}g)	Crude protein (g.100^{-1}g)	Carbohydrates (g.100^{-1}g)	Total fat (g.100^{-1}g)	Ash (g.100^{-1}g)
Kappaphycus alvarezii	16.96±0.02^{a*}	2.73±0.40^{b}	44.82±0.34^{a}	0.60±0.30^{a}	34.91±0.39^{b}
Caulerpa cf. *macrodisca* ecad *corynephora*	10.49±0.08^{b}	7.14±0.80^{a}	38.09±0.71^{b}	0.28±0.01^{b}	44.00±0.66^{a}

*: Note: Superscript letters that are different imply significant differences at $p≤0.05$.

The determined heavy metal concentrations in the edible seaweeds are shown in Table 2. The average concentration of heavy metals followed the order of K > Zn > Fe > Pb > Cu > Mn > Cd for *K. alvarezii* and Zn >

Mn > Pb > K > Fe > Cu > Cd for *Caulerpa* cf. *macrodisca* ecad *corynephora*. When these two edible seaweeds were compared statistically, the t-test revealed that the Fe content (4.03±0.05 mg.kg^{-1}) of *K. alvarezii* was significantly higher than that of *C.* cf. *macrodisca* ecad *corynephora* (0.59±0.02 mg.kg^{-1}). The Mn content (1.30±0.04 mg.kg^{-1}) of *K. alvarezii* was significantly lower ($p \leq 0.05$) than that of *C.* cf. *macrodisca* ecad *corynephora* (7.98±0.03 mg.kg^{-1}). Pb content was notably higher ($p \leq 0.05$) in *C.* cf. *macrodisca* ecad *corynephora* (3.26±0.21 mg.kg^{-1}) than in *K. alvarezii* (2.05±0.04 mg.kg^{-1}). Zn content was substantially higher ($p \leq 0.05$) in *C.* cf. *macrodisca* ecad *corynephora* (987.59±25.86 mg.kg^{-1}) than in *K. alvarezii* (8.52±0.19 mg.kg^{-1}). K content was recorded to be notably higher ($p \leq 0.05$) in *K. alvarezii* (12.75±0.42 mg.kg^{-1}) than in *C.* cf. *macrodisca* ecad *corynephora* (1.42±0.01 mg.kg^{-1}). The Cu content was remarkably greater ($p \leq 0.05$) in *K. alvarezii* (1.92±0.04 mg.kg^{-1}) than in *C.* cf. *macrodisca* ecad *corynephora* (0.39±0.01 mg.kg^{-1}). Cd content was noted to be 0.40±0.02 mg/kg in *K. alvarezii*, while the Cd content in *C.* cf. *macrodisca* ecad *corynephora* was below the method detection level (MDL). The analytical characterization of heavy metal detection limits and calibration ranges using FAAS is shown in Table 3.

Table 2. Heavy metals of some edible seaweeds available in the Bongao public market, Tawi-Tawi, Philippines

Edible seaweeds	Heavy metals (mg.kg^{-1})						
	Fe	Mn	Pb	Zn	K	Cu	Cd
Kappaphycus alvarezii	4.03±0.05^{a*}	1.30±0.04^{b}	2.05±0.04^{b}	8.52±0.19^{b}	12.75±0.42^{a}	1.92±0.04^{a}	0.40±0.02
Caulerpa cf. *macrodisca* ecad *corynephora*	0.59±0.02^{b}	7.98±0.03^{a}	3.26±0.21^{a}	987.59±25.86^{a}	1.42±0.01^{b}	0.39±0.01^{b}	< MDL*

*: Note: Different superscript letters imply significant differences at $p \leq 0.05$. *<MDL = below the method detection level.

Table 3. Analytical characterization of heavy metal detection limits and calibration ranges using Flame Atomic Absorption Spectroscopy (FAAS)

Heavy metals	Limit of detection (mg.kg^{-1})	Limit of quantitation (mg.kg^{-1})	Linear concentration range (mg.kg^{-1})	Standard reference material (SRM)/Certified reference material (CRM)
Fe	0.0001	0.0003	0.001-1	NIST SRM 2780, NIST SRM 2781
Mn	0.00005	0.00015	0.0005-0.5	NIST SRM 3114, NIST SRM 3115
Pb	0.0001	0.0003	0.001-1	NIST SRM 1643d, NIST SRM 981a
Zn	0.00003	0.0001	0.0003-0.3	NIST SRM 3114, NIST SRM 3115
K	0.0002	0.0006	0.002-2	NIST SRM 1486, NIST SRM 1487
Cu	0.00005	0.00015	0.0005-0.5	NIST SRM 3114, NIST SRM 3115
Cd	0.00005	0.00015	0.0005-0.5	NIST SRM 3104a, NIST SRM 3113

*: Note: Different superscript letters imply significant differences at $p \leq 0.05$. *<MDL = below the method detection level.

DISCUSSION

The proximate composition of seaweeds varies according to species and type. In general, the Rhodophyta members contain high protein content (32%), whereas Chlorophyta members contain highest carbohydrate content (35%) [37]. However, in the present study, this was not the case; the crude protein of *Caulerpa* cf. *macrodisca* ecad *corynephora* (Chlorophyta) was higher than *K. alvarezii* (Rhodophyta). Additionally, carbohydrate content was greater in *K. alvarezii* (Rhodophyta) than in *Caulerpa* cf. *macrodisca* ecad *corynephora* (Chlorophyta). Apart from species, various factors, including spatial and seasonal variations, geographical distribution, reproductive status, and environmental parameters, have an impact on the seaweed's chemical composition [38, 39]. In the present study, the crude protein of *K. alvarezii* (2.73±0.40 g.100^{-1}g) was comparably lower than other studies utilizing the same species sampled in different areas, such as 4.13-5.09% in Antique, Philippines [40], 5.38 – 6.8% in Malaysia [41, 42], 12.69 – 23.61% in India [43], but it was higher than those determined in Indonesia with protein content of 1.03 – 1.94% [44, 39]. The crude protein of *Caulerpa* cf. *macrodisca* ecad *corynephora* (7.14±0.80 g.100^{-1}g) in the present study, although higher than *K. alvarezii*, it was relatively lower compared with other species, such as 10.41% [45], 13.24% [46], 14.76% [47], 17.28% [48], 20.54 – 21.52% in *C. macrodisa* [49, 50]. Carbohydrates, which constitute the majority portion of *K. alvarezii* (nearly 45%), were found greater than *Caulerpa* cf. *macrodisca* ecad *corynephora* (38%) in the present study. Compared with other studies, the carbohydrate content of the present study was higher than that found by Adharini et al. [39] in Indonesia (4.55 – 5.24%) and by Suresh Kumar et al. [43] in India (23%), suggesting that location is one of the factors influencing the carbohydrate content of this species. When the carbohydrate content (38%) of *Caulerpa* cf. *macrodisca* ecad *corynephora* of the present study was compared with other *Caulerpa* species, it revealed similar content with *C. lentillifera* with carbohydrate content of 38.66% [45] but higher than *C. macrodisca* with carbohydrate content of 37.66% [50]. However, it was relatively lower than in other studies, where *C. lentillifera* with 43-53% carbohydrate content [47, 48] and 50% in *C. racemosa* var. *laetevirans* [48]. The total fat of seaweeds is generally more than 0.4 g.100-1 g [51]. In the present study, the total fat was found higher in *K. alvarezii* (0.60±0.30 g.100^{-1}g) than in *C.* cf. *macrodisca* ecad *corynephora* (0.28±0.01 g.100^{-1}g). In comparison with other studies, the total oil of K. alvarezii was higher at 0.9-1.0% [42]. In terms of ash content, *C.* cf. *macrodisca* ecad *corynephora* contain a higher amount of ash (44.00±0.66 g.100^{-1}g) than *K. alvarezii* (34.91±0.39 g.100^{-1}g). This species of *Caulerpa* has greater ash content than other species obtained from previous studies, such as 27% in *C. racemosa* var. *laetevirans* [48], 14-31% in C. lentillifera [47, 48], and 29% in similar species of *C. macrodisca* [50]. The ash content (34.91±0.39 g.100^{-1}g) of *K. alvarezii* in the present study was greater than those of *K. alvarezii* (16.3 – 17.1%) as reported by Xiren and Aminah [42] in India, but was within the range of ash content (30.27- 36.46%) found in Antique, Philippines [40].

Heavy metals, recognized as highly potent environmental pollutants, are released into aquatic ecosystems via the effluents of various industries, thereby leading to a critical issue of aquatic pollution [50]. Although edible seaweeds offer a rich supply of micronutrients, macronutrients, and bioactive substances, serving as potential ingredients in various food items, nonetheless, these seaweeds have the capacity to accumulate substances that could pose risks to human health and animals, specifically heavy metals [51]. In the present study, the average concentration of heavy metals followed the order of K > Zn > Fe > Pb > Cu > Mn > Cd for *K. alvarezii* and Zn > Mn > Pb > K > Fe > Cu > Cd for *C.* cf. *macrodisca* ecad *corynephora*. However, all these determined heavy metals were within the safety limits of WHO, the US (EPA and FDA), and EMA [54, 55, 56].

Iron (Fe) is naturally abundant in seaweeds. In *K. alvarezii*, the concentration of Fe ranged from 250 to 301 mg.kg^{-1} [39]. However, the Fe content in the present study was lower (4.03 mg.kg^{-1}) than previously reported. Caulerpa species are known to have high mineral content; for example, *C. lentillifera* has been reported to contain 511-1973 g.100^{-1}g of Fe [48], which is significantly higher than what was observed in *C.* cf. *macrodisca* ecad *corynephora* in the present study. A higher manganese (Mn) content was observed in *C.* cf. *macrodisca* ecad *corynephora* (7.98 mg.kg^{-1}) in the present study, which was greater than those found in *C. lentillifera* (0.860 mg.kg^{-1}) and *C. racemosa* (0.453 mg.kg^{-1}) as reported by Kasmiati et al. [57]. *Caulerpa* species have the ability to accumulate lead (Pb) metal [58]. In the present study, *C.* cf. *macrodisca* ecad *corynephora* had a relatively higher Pb content (3.26 mg.kg^{-1}). The Pb content (2.05 mg.kg^{-1}) in *K. alvarezii* in the present study was higher than in a previous study, where it was found to be 0.761 mg.kg^{-1} [59]. Zinc (Zn) is the most abundant heavy metal in *C.* cf. *macrodisca* ecad *corynephora* (988 mg.kg^{-1}) compared to *K. alvarezii* in the present study, as well as higher than in *C. lentillifera* in previous study [48]. *Caulerpa* species, such as *C. taxifolia*, also have the ability to adsorb Zn [60]. On the other hand, the Zn content (8.52 mg.kg^{-1}) of K. alvarezii was higher than in another study [61]. The potassium (K) content of edible seaweed in the current study was higher in *K. alvarezii* (nearly 13 mg.kg^{-1}) than in *C.* cf. *macrodisca* ecad *corynephora* (1.42 mg.kg^{-1}). Caulerpa species have lower K content, typically around 2 – 4% [55]. The copper (Cu) content of the determined edible seaweeds in the present study was higher in *K. alvarezii* (nearly 2 mg.kg^{-1}) than in *C.* cf. *macrodisca* ecad *corynephora* (0.4 mg.kg^{-1}), and the cadmium (Cd) content was 0.4 mg.kg^{-1} in *K. alvarezii* while it was undetectable in *C.* cf. *macrodisca* ecad *corynephora*. These findings were higher than those reported by Tresnati et al. [59] for *K. alvarezii*.

The cell wall of seaweeds is composed of a diverse range of polysaccharides and proteins. Among these, certain molecules contain negatively charged groups like carboxyl, phosphate, or sulfate, which serve as highly effective sites for capturing metals [62]. Research conducted by Bryan [63] demonstrated that seaweeds have a robust capacity to bind metals, and there is minimal exchange between the metals bound by the seaweeds and the surrounding water. This binding phenomenon enables seaweeds to accumulate trace metals, reaching concentrations thousands of times higher than those found in the surrounding seawater [64]. It's important to note that seaweeds specifically bind to freely available metal ions, whose levels are influenced by the composition of suspended particulate matter. This particulate matter, as shown by studies by Seeliger and Edwards [65] and Volterra and Conti [66], consists of a combination of organic and inorganic complexes.

The accumulation of metals in seaweeds is contingent on various factors, with the most pertinent ones being the availability of metals in the surrounding water and the seaweeds' uptake capacity [67, 68]. Seaweed's metal uptake occurs through two distinct mechanisms. The first involves a surface reaction where metals are adsorbed by the seaweed surfaces through electrostatic attraction to negative sites. Interestingly, this process is independent of factors affecting metabolism, such as temperature, pH, light, or the age of the plant. However, it is influenced by the relative abundance of elements in the surrounding water. This surface reaction appears to be the primary uptake mechanism for Zn. The second mechanism is a slower and more active process in which metal ions are transported across the cell membrane and into the cytoplasm. This type of uptake relies more on metabolic processes and seems particularly relevant for the uptake of Mn and Cu. Importantly, this active uptake mechanism is subject to variations due to changes in light, temperature, or the age of the plant [67, 68].

CONCLUSION

In conclusion, this study provides valuable insights into the proximate composition and heavy metal content of two commonly consumed edible seaweeds, *Kappaphycus alvarezii* and *Caulerpa* cf. *macrodisca* ecad *corynephora*, available in the public market of Bongao, Tawi-Tawi, Philippines. The findings highlight significant differences in their nutritional profiles, with *K. alvarezii* exhibiting higher moisture content and total fat while *C.* cf. *macrodisca* ecad *corynephora* showed greater crude protein and ash content. Importantly, both seaweeds fell within safe limits for heavy metal concentrations, assuaging potential concerns about their consumption.

This research contributes to the broader understanding of seaweed's nutritional value and safety considerations, underscoring its historical and contemporary importance as a vital marine resource in human diets. Further studies may delve into specific health benefits and culinary applications of these seaweeds, expanding our knowledge base in this area.

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