Nutritional value and mineral content of seaweed from Binuangeun Beach, Indonesia and potential use as fish feed ingredient

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Abstract. Seaweed represents an important economical resource in Indonesia. They are potentially as good source of nutrient. Furthermore, they have the most nutritious and rich in mineral than any other feedstock. The levels of minerals are ten to twenty times from total mineral content of terrestrial plants. This experiment was carried out to evaluate the nutritional value and mineral content of several seaweeds namely Caulerpa, Palmaria and Ulva, in order to utilize as fish feed ingredient. Seaweeds were collected from Binuangeun Beach, Banten and south coast of Java Island. Carbohydrate by different (NFE) and ash contents were the most two abundant components. Seaweeds Caulerpa, Palmaria and Ulva contained 44.73%, 53.74%, 55.31% NFE; and 27.36%, 22.81%, 20.51% ash based on dry weight, respectively. These contained high amounts of Na, K, Ca, and Mg ranged 0.72-5.65 g 100g-1, Fe, Mn, Cu, and Zn ranged 2.09x10^-4-0.09 g 100g^-1. The quantity of the bio-essential elements (Fe, Zn, Cu) followed as Fe>Zn>Cu. The iron content was rich in the sequence of Caulerpa>Palmaria>Ulva and its range was found to be 0.01-0.09 g 100 g^-1 in dry weight. The result showed that Caulerpa, Palmaria and Ulva are valuable resource and potentially to be utilized as fish feed ingredient.

1. Introduction
Feed has been considered the greatest problem in fish culture. To date, feed ingredients depend mostly on importation, which make them economically unstable; thus, the price of feed can drastically change over time. To reduce dependence on such importation, exploration of local plants has been extensively carried out, including rice bran [1], cassava leaves [2] and palm kernel meal [3]. Nevertheless, the use of these materials is hampered by their high content of crude fibers, which are difficult to digest, and presence of anti-nutritional substances such as phytic acid. To deal with this challenge, numerous researches have been conducted to search for alternative plant-based ingredients for feed production [4].

Macroalgae, also known as seaweed, is potentially employed as alternative source for manufacturing fish feeds considering that it is nutritious and easy to culture [5]. Previous study [6] reported that nutritional composition (dry basis/db) of the seaweed as follows: protein 10-17.44%; lipid 0.11–3.60%; ash 12.40-32.85%; crude fiber 5.74% and nitrogen-free extract 41.47–59.10%.

Seaweed has a much higher mineral content than terrestrial plants because seaweed absorbs minerals from the sea as their habitat for growth [7]. The minerals from macroalgae are useful in enhancing the metabolic reactions (enzymatic regulation of lipid, carbohydrate and protein metabolism). The diversity of seaweeds in Indonesia encourages scientists to convert them into various valuable products, with
regard to replacement of the imported feeds. This can be promising since seaweeds can grow rapidly, while the properties of many coasts in Indonesia seem to fit the requirements for their growth. Furthermore, it is noteworthy that nutritious ingredients in feed enable to enhance growth performance of fish, while also significantly reducing the polluted waste from fish farming activities. Therefore, investigation on nutritional profile of the proposed ingredients is inevitable. This current work aimed to evaluate the nutritional composition of seaweeds, namely Caulerpa, Palmaria and Ulva, collected from Binuangeun Beach, Province of Banten; besides, the potentiality of these seaweeds as feed ingredients for freshwater fish was discussed.

2. Materials and methods

2.1. Preparation of seaweed meal

Fresh seaweeds were collected from Binuangeun Beach, Banten Province, south coast of Indonesia. Immediately after collecting, seaweeds thoroughly washed with tap water then dried in a convection oven at 60 °C for 72 h before being ground to fine powder and kept in hermetic bags for further analysis.

2.2. Determination of nutritional composition of seaweed meal

Seaweed meal (50 g) was used to determine chemical composition, i.e. moisture, protein, lipid, ash, crude fiber and mineral content. Sample was oven-dried at 105 °C approx. 3-4 h until reaching a constant weight for determining moisture content. Afterwards, total protein was assessed by using Kjeldahl method and calculated from the elemental N determination using the nitrogen-protein conversion factor of 6.25 according to the standard [8]. Soxhlet extraction with petroleum benzene as solvent was used to determine total lipid content [8]. The ash content determined heating sample in furnace at 600 °C for 4 h. Determination of crude fiber content was carried out with aid of acid and alkali solvents. The carbohydrate content was estimated by difference / NFE (%): 100 – (moisture + ash + protein + lipid + crude fiber). The concentration of the minerals was determined by means of an atomic absorption spectrophotometer (AAS) equipped with a hollow cathode lamp according to the method [9]. Mineral concentration was calculated from calibration curves of the respective analytical grade standard minerals. Analysis data reported on a dry matter basis (db).

2.3. Data expression

The data was collected, sorted and entered into the computer program Microsoft Excel of Windows 10 Professional and expressed as mean ± standard deviation. The experiment was conducted at triplicates (n = 3).

3. Results

Table 1 shows the proximate composition of seaweeds. We found that the highest content of protein was found in Caulerpa (16.83%, db), then Palmaria (6.46%, db) and Ulva (7.42%, db). Meanwhile, lipid content in all studied seaweeds was less than 2.00%, db. Afterwads, the greatest chemical component in seaweeds was carbohydrate (based on nitrogen-free extract), comprising 40-60% db, while the second one was attributed to ash content. The content of ash showed a variability between samples, namely Caulerpa 27.36% (db), being much higher than Palmaria 22.81% (db) and Ulva 20.51% (db). Data demonstrated that ash content in seaweed was much greater than that in terrestrial plants. In all of the seaweeds studied, content of crude fiber was less than 10.00% (db), which is often lower than that in terrestrial plants.

| Nutrient (%, db) | Caulerpa | Palmaria | Ulva |
|------------------|----------|----------|------|
| Moisture         | 7.37 ± 0.19 | 6.46 ± 0.12 | 7.42 ± 0.15 |
| Protein          | 16.83 ± 0.32 | 13.99 ± 0.19 | 15.43 ± 0.27 |
| Lipid            | 1.72 ± 0.03 | 1.52 ± 0.07 | 1.65 ± 0.04 |
| Ash              | 27.36 ± 2.28 | 22.81 ± 1.32 | 20.51 ± 1.39 |
| Crude fiber      | 9.35 ± 0.27 | 7.93 ± 0.19 | 7.12 ± 0.11 |
| NFE              | 44.73 ± 1.08 | 53.74 ± 2.65 | 55.31 ± 3.65 |
Table 2. Mineral content of seaweed meals.

| Mineral    | Caulerpa | Palmaria | Ulva    |
|------------|----------|----------|---------|
| Natrium (Na) | 0.82     | 1.05     | 2.35    |
| Magnesium (Mg) | 0.72     | 0.91     | 3.14    |
| Kalium (K)   | 0.48     | 4.85     | 0.67    |
| Calsium (Ca) | 5.65     | 2        | 3.68    |
| Iron (Fe)    | 0.09     | 0.07     | 0.01    |
| Mangan (Mn)  | $1.10 \times 10^{-6}$ | $0.71 \times 10^{-6}$ | $0.59 \times 10^{-6}$ |
| Copper (Cu)  | $2.09 \times 10^{-4}$ | $2.2 \times 10^{-4}$ | $2.58 \times 10^{-4}$ |
| Zinc (Zn)    | $1.12 \times 10^{-5}$ | $1.37 \times 10^{-5}$ | $0.90 \times 10^{-5}$ |

4. Discussion

This work showed that the carbohydrate by difference (NFE) accounted for the greatest proportion in seaweeds. This is in agreement with previous report [6], finding that NFE comprised up to 59.10%, db of seaweed. The carbohydrate fraction refers to digestible part for fish, including starch which is an intracellular energy storage [7].

The greatest proportion after carbohydrate (NFE) is ash, in which it is found higher than terrestrial plants. The ash content in seaweeds closely relates to its habitat containing high content of salts and a variety of minerals [7]. Ash content in seaweeds may differ, depending on several factors, such as species, location, geographical condition, season, environmental, physiological properties, and mineralization [11]. This present research confirmed that ash content in seaweed tended to be higher than that in other sources, such as rice bran (14.75%, db) [12], pollard (5.80 %BK), and corn (1.07%, db) [13], which make it compatible as source of mineral for fish feed.

Furthermore, the crude fiber in all studied seaweeds was less than 10.00% db, in general, terrestrial plants contain more crude fiber in comparison with seaweeds. Crude fiber is also reported to exert anti-nutritional activity observed in monogastric animals [14], also enables to represent quantity of digestible fiber and affects energy digestion. Presence of crude fiber could produce pellets with weak internal structures, which make them easy to decompose in water [15], crude fiber in feed is responsible for the digestibility.

Protein content of seaweeds in this current investigation, ranged from 13-16% db. The variability of protein content depends highly on season and environmental condition [16]. Compared to protein content in other sources such as rice bran (11.01%, db) [12] and corn (8.83%, db) [13], seaweeds contain a higher quantity of protein.

Lipid content present in all seaweeds is less than 2.00% db. We noticed that seaweeds could not serve as source of lipid. However, the content of unsaturated fatty acid in seaweeds is comparable than that in terrestrial plants. The variability of lipid content in seaweeds can vary, regarding to species, geographical condition, season, temperature, salinity, light intensity, and interaction of aforementioned factors [17].

The minerals Na, K, Ca, Mg in Caulerpa, Palmaria and Ulva were found in large quantities, ranging from 0.72 to 5.65 g 100g⁻¹, while the minerals Fe, Mn, Cu, Zn ranging from $2.09 \times 10^{-4}$ - 0.09 g 100 g⁻¹. The quantity of bio-essential elements (Fe, Zn, Cu) was arranged as follows: Fe> Zn> Cu, while considered to Fe content, the sequence was Caulerpa>Palmaria> Ulva, ranging from 0.01-0.09 g 100 g⁻¹ in dry weight. Seaweed has a much higher mineral content than terrestrial plants because seaweed absorbs minerals from the sea as their habitat for growth [7]. Besides being present in large quantities, the minerals contained in seaweed have high biological availability so can be absorbed and utilized [18, 19]. Feed ingredients requires feed stock that have good nutrition, non-toxic, have no anti nutrient factors, have good digestibility and found in abundant quantities. Seaweed used in this study meets these requirements.
5. Conclusion
This present research concluded that fraction of carbohydrate (NFE) (44-55%, db) and ash (20-27%, db) became the most abundant components in seaweeds. The high amount of Na, K, Ca, Mg was found, ranging from 0.72 to 5.65 g 100 g⁻¹, while other components, namely Fe, Mn, Cu, Zn, ranged 2.09×10⁻⁴-0.09 g 100 g⁻¹ in all seaweeds investigated. The result showed that Caulerpa, Palmaria and Ulva were potential for use as fish feed ingredient.

6. References
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