Effect of molasses on the chemical characteristics of seaweed-based organic fertiliser

Nurhayati1*, W Cahyaningtyas2, R Kusumawati1, and J Basmal1

1Research Center for Marine and Fisheries Product Processing and Biotechnology, KS. Tubun Petamburan VI, 10260, Jakarta, Indonesia; Departement of Fisheries Product Technology, Fisheries Faculty of Sriwijaya University, Palembang-Prabumulih KM.32 Indralaya, Palembang, Indonesia
Email: n_hay04@yahoo.com

Abstract. Organic fertiliser is one of the essential factors needed in natural farming. Seaweed can be used as raw material for making organic fertilisers because it contains complete growth hormones, macro, and micronutrients for plant growth. The formulation of seaweed and silage for organic fertiliser has low levels of C-organic, so other materials are needed, for example, molasses. Addition of molasses in organic fertiliser formulations carried out to evaluate the optimum molasses concentration and study the chemical characterisation of organic fertilisers. The chemical characteristics measured were moisture content, ash content, potassium content, C-organic, N-total, and C/N ratio. The results showed that an increase in molasses concentration led to an increase in the moisture and C-organic content, and C/N ratio. The addition of 26% molasses (PTB2) was the best treatment, resulting in fertiliser with a moisture content of 6.37%, 30.01% ash content, 0.83% N-total, 0.04% potassium content, 37.58% C-organic, and 44.93 C/N ratio.

1. Introduction
The consumption of organic products continues to increase, including in Indonesia. The high demand for organic food is based on people's aspiration to live healthier and save the environment. One crucial factor required in organic farming is the availability of organic fertiliser that can improve soil fertility [1] [2]. The use of organic fertiliser is intended to address problems from the use of synthetic/chemicals fertilisers that have been proven to damage the soil and the environment [3]. Environmentally friendly fertiliser can improve the nature of physical, biological, and chemical soil and enhance the life of microbial soil that is a source of nutrients for plants [3]. The need for organic fertiliser increases with the increasing demand for organic food. The global organic fertiliser market is expected to continue to increase with a growth rate of 7.2% over the forecast period 2019-2027 with a value of approximately US $ 6.7 billion in 2018 [4].

Organic fertiliser is a fertiliser that is partially or entirely derived from organic materials such as plants or animal waste that have been through an engineering process. The fertiliser can be in solid or liquid form to meet the requirements of plant nutrients and can improve the physical, chemical, and biological properties of soil [5]. Excess of organic fertiliser can improve the soil structure and has a
complete nutrient content, although the amount is less than chemical fertilisers and can improve plants' resistance to disease [6]. Seaweed can be used as raw material for organic fertiliser due to the complete content of hormones and nutrients for plant growth [7].

Seaweed can be used as the raw material of fertiliser among the types of seaweed that do not meet the standard of the raw material of hydrogel production due to fault handling post-harvest and unsuitable harvesting age well as the waste of the seaweed processing industry. The amount of solid waste produced by the seaweed processing industry is 67-73% [8]. The solid waste contains 45-50% minerals consisting of macro elements (Ca, Mg, K, S, and P) and micro elements (Fe, Zn, Cu, Mn, and B), and has 50-55% organic compounds [9], [10]. While in the processing industry of seaweed Sargassum, the solid waste produced reached 80% from the initial weight of processed seaweed [9]. The waste contains macro and micronutrient, and growth hormone that is beneficial to spur crop growth [11], [12]. E. Cottonii also contains hormones in the form of a growing agent, i.e., auxin, gibberellin, cytokinin, zeatin, and kinetin [11]. The improvement of the macro-N-element can use fish silage [9], [13].

A critical parameter on organic fertiliser is the C/N ratio. Organic material with a C/N ratio higher than 30 will decompose for a long time; conversely, if the ratio is too low, it will be lost N because it evaporates during the decomposition process. One of the C-organic sources is the molasses, the waste of sugar mills. Molasses, or often called drops of sugarcane, are the residue of the repeated crystallisation of sugar, so it is no longer possible to be processed into sugar [14]. In this research, the addition of molasses in the formulation of seaweed solid fertiliser formulations are carried out to evaluate the optimum concentration of the molasses addition and to study the chemical characteristics of organic fertiliser produced.

2. Materials and Methods

2.1. Materials

The materials used were a solid waste of agar extraction, which taken from the agar processing industry in Brebes-Central Java. The Sargassum sp., was obtained from Binuangeun, Banten, and the E. cottonii was taken from Domas village, Serang Regency. The crude fish was obtained from TPI Kronjo, and the molasses was taken from Yogyakarta. Another material used was crude phosphoric acid for the manufacture of fish silage. The equipment used was flour machines, plastic drums, water bath, pellet presses, and drying machines.

2.2. Methods

2.2.1. Raw material preparation

a. Solid waste of agar processing

The solid waste is a by-product of the agar processing industry. It was dried, powdered and sieved to produce 40 mesh size of agar waste flour.

b. Sargassum flour

Fresh Sargassum sp. was harvested from the coast, sun dried, floured, and sieved to obtain Sargassum flour.

c. E. cottonii paste

Dry E. cottonii was boiled in water to form a cottonii paste. This paste function is as a binder in solid organic fertiliser formulations.

d. Fish silage

Crude fish is processed into fish silage by grinding and soaking them in a phosphoric acid solution, homogenising milled coarse fish and using phosphoric acid to reach a pH of 3-4; The drum was then tightly closed. The process of making silage takes seven days, and pH measurements were carried out periodically. The pH value is stabilised in the pH range 3-4 by adding phosphoric acid.
2.2.2. Solid organic fertiliser formulation

The process of making seaweed solid organic fertiliser was carried out in two stages. The first stage is the preparation of basic seaweed fertiliser consisting of agar waste flour, Sargassum flour, E. cottonii paste, and fish silage, as shown in Table 1. The second stage is the formulation of basic solid fertilisers with variations in the concentration of molasses, as shown in Table 2.

**Table 1. Basic solid organic fertiliser formulation.**

| Materials       | Percentage (%) |
|-----------------|----------------|
| 1 Agar waste flour (g) | 13%           |
| 2 Sargassum flour (g)   | 12%           |
| 3 cottonii paste (g)    | 74%           |
| 4 Silage (g)            | 2%            |

**Table 2. Seaweed solid organic fertiliser with molasses addition.**

| Materials       | Treatments (%) |
|-----------------|----------------|
|                 | PTB0 | PTB1 | PTB2 | PTB3 | PTB4 | PTB5 |
| Basic fertilizer (P) | 100  | 79   | 74   | 69   | 64   | 59   |
| Molasses (TB)     | 0    | 21   | 26   | 31   | 36   | 41   |

To determine the quality of seaweed solid organic fertilisers, measurements of moisture content [15], ash content[16], total N [17], C-organic [18], and potassium (K) by the gravimetric method measured. The data obtained were analysed using One Way Anova (P <0.05) with three repetitions. If there are significant differences between treatments, Duncan's follow-up test carried out using SPSS 17.0.

3. Results and Discussion

3.1. Moisture content

The moisture content of solid organic fertilisers ranged from 5.11 -7.23% with the lowest value in the PTB0 treatment and the highest in the PTB5 treatment. This increase in moisture content corresponds to an increase in the concentration of molasses (TB) and a decrease in the proportion of fertiliser (P) (Figure 1). The given treatment had a significant effect on increasing the moisture content (p< 0.05). PTB5 treatment was significantly different from PTB0 and PTB1, but not significantly different from other treatments. The hydrocolloids in seaweed are reversible to differences in moisture content. Still, the molasses is hygroscopic so that the solid fertilisers produced tend to draw moisture from air.
3.2. Ash content

The amount of ash content in solid organic fertilisers is influenced by the composition of the ingredients. Ash content indicates several minerals or materials that are insoluble in a product. The results showed that the ash content in the organic fertiliser formulation ranged from 24.03-47.67% with the highest value found in the control treatment (PTB0) and the lowest in the PTB4 treatment of 24.03% (Figure 2). An increase in molasses (TB) and a decrease in the use of basic fertilisers (P) causes the ash content in organic fertilisers to decrease. The increase in the concentration of molasses had a significant effect (p <0.05), where the ash profile of the solid organic fertiliser produced decreased. The amount of ash in molasses ranges from 7-15% [14], while the measured ash content in basic organic fertilisers is 47.67% (PTB0). The high level of ash in basic organic fertilisers is caused by the presence of diatomaceous soil (silicate), NaOH, or KOH in agar waste. This material is used for the purification of agarpectin in the agar extraction process. In addition, the high ash content in basic organic fertilisers also comes from the mineral in rough fish silage.

Figure 1. The moisture content of solid organic fertiliser seaweed.

Figure 2. Ash content of solid organic fertiliser seaweed.
3.3. **Potassium content**

The potassium (K) content on solid organic fertiliser from seaweed tends to increase. Potassium levels ranged from 0.03% to 0.04% with the lowest value in the PTB1 treatment (0.03%) and the highest in the PTB3 treatment (0.04%). However, increasing the concentration of molasses did not have a significant effect (p > 0.05). The amount of potassium is relatively low. This mineral is the third essential macronutrient after nitrogen and phosphorus for plant growth. Lack of potassium results in slow plant growth, susceptibility to disease, roots not growing well, and low yields. [19]. The content of potassium in the K\textsubscript{2}O form in the organic fertiliser requirements standard in Indonesia is at least 6% [20]. Therefore, the best formulation in this study needs more examination by adding the other ingredients as a source of potassium.

![Figure 3. The potassium content of solid organic fertiliser seaweed.](image)

3.4. **Nitrogen Total**

Nitrogen is one of the required macronutrients for the formation of cells and a key ingredient in the plants’ photosynthesis process. Total N content in solid organic fertilisers ranged from 0.80 to 0.95% with the highest value in the control treatment (PTB0) and the lowest in the PTB5 treatment. Increasing the concentration of molasses had a significant effect on decreasing levels of N-Total (p <0.05). All ingredients used in the formulation contribute to the total N content of seaweed organic solid fertiliser. The range of total N in molasses ranges from 2.5-4.5% [14], this value is lower than the total N content in seaweed. Therefore, although the concentration of molasses increased, the total N content tended to decrease (Figure 4).
3.5. C-organic
The C-organic content ranged from 20.22-47.53%. The lowest value was measured in the treatment without the addition of molasses (PTB0) and the highest in the PTB5 treatment (Figure 5). Increasing the concentration of molasses had an effect on increasing levels of C-organic (p < 0.05). Decree of the Minister of Agriculture Number 70/Permentan/SR.140/10/2011 concerning granule/pellet organic fertiliser states that the C-organic content is at least 15% [21]. Thus, the C-organic content in all treatments have to meet the standard for solid (granules/pellets) organic fertiliser.

![Figure 4. N-total content of solid organic fertiliser seaweed.](image)

3.6. C/N ratio
Regulation of the Minister of Agriculture Number 70 / Permentan / SR. 140/10/2011 specifies a C/N ratio of at least 15-25 [24]. In the study, it was found that the C/N ratio was 21.33-60.01, higher than the requirements (Figure 6). It showed that the increase in the molasses concentration has a significant effect on the increase of the C/N ratio (P < 0.05). The addition of 2% silage to the total basic fertiliser was unable to increase the N content. Thus, the use of silage needs to be increased in order to meet the N requirements of organic fertilisers.

![Figure 5. C-organic content of solid organic fertiliser seaweed.](image)
Based on the data obtained, the addition of 26% molasses (PTB2) has low moisture content and high C-organic content, which is not significantly different from the higher use of silage in PTB3 and PTB4. PTB5 has excessive C-organic content and causes a high C/N ratio. A high C/N ratio (> 25) can cause immobilisation, humus formation, accumulation of organic matter, and can inhibit the decomposition process of organic matter [22]. The high C/N ratio was due to the high levels of C-organic not being balanced by the N-total content in organic fertilisers. The amount of nitrogen and potassium in the whole treatment is lower than that of the quality standard of solid organic fertiliser/granule in PERMENTAN Number 70/Permentan/SR.140/10/2011. Further research on silage concentration or usage the other types of raw materials, is necessary to meet the regulation.

4. Conclusions
Agricultural land that uses chemical fertilisers has a low C-organic content (<2%) and caused the damaged soil condition. Increasing the concentration of molasses and reducing the proportion of basic organic fertilisers increased the moisture, potassium, and C-organic content, and C/N ratio. For land with high C-organic requirements, the formula with the addition of molasses can be a solution in improving soil quality. However, the effect of adding molasses to the fertiliser that may change soil fertility and agricultural production needs to be further studied.

References
[1] Niassy S, Diarra K 2012 Effects of organic inputs in urban agriculture and their optimisation for poverty alleviation in Senegal, West-Africa, in Organic fertilisers types, production and environmental impact (New York: Nova Science Publisher, Inc) pp 1–22
[2] Wu Y, Yang L 2012 A prospectus for bio-organic fertiliser based on microorganisms: recent and future research in agricultural ecosystem, in Organic fertilisers types, production and environmental impact (New York: Nova Science Publisher, Inc) pp 163–206
[3] Dinesh R, Srinivasan V, Ganeshamuthry A N, Hamza S 2012 Effect of organic fertilisers on biological parameters influencing soil quality and productivity, in Organic fertilisers types, production and environmental impact (New York: Nova Science Publisher, Inc) pp 23–46
[4] Shah 2020 Global organic fertilizer market to reach around us$ 12.5 billion by end of 2027. Coherent Market Insights, GlobeNewswire
[5] Toan P V, Minh N D, Thong D V 2019 Organic fertiliser production and application in Vietnam," in Organic fertilisers types, production and environmental impact (London: IntechOpen) pp 115–124
[6] Zhou H, Peng X, Perfect E, Xiao T, Peng G 2013 Effects of organic and inorganic fertilisation
on soil aggregation in an Ultisol as characterised by synchrotron based X-ray microcomputed tomography. *Geoderma* **195–196** 23–30

[7] Packiasamy R, Govindasamy C 2018 Seaweed fertilisers in modern agriculture *Int. J. Res. Publ.* **14** 1–5

[8] Munifah I, Sunarti T C, Irianto H E, Meryandini A 2015 Biodegradation of solid wastes of agar seaweed processing industry by indigenous cellulolytic Bacillus pumilus LA4P, *Biosci. Biotecnol. Res. Asia** **12** 3 1957–64

[9] Basmal J, Widanarto A, Kusumawati R, Utomo B S B 2014 Pemanfaatan limbah ekstraksi alginat dan silase ikan sebagai bahan pupuk organik (Utilisation of alginate extraction waste and fish silage as raw materials for organic fertiliser) *J. Pascapanen dan Bioteknol. Kelaut. dan Perikan.* **9** 2 109-120 [In Indonesian]

[10] Zahid P B 1999 Preparation of organic fertiliser from seaweed and its effect on the growth of some vegetable and ornamental plants, *Pakistan J. Biol. Sci.* **2** 4 1274–7

[11] Sedayu B B, I. M. S. Erawan, L. Assaadad 2014 Pupuk cair dari rumpun laur *Eucheuma cottonii*, *Sargassum* sp, dan *Gracilaria* sp menggunakan proses pengomposan (Liquid fertiliser from *Eucheuma cottonii*, *Sargassum* sp. and *Gracilaria* sp. using composting process) *J. Pascapanen dan Bioteknol. Kelaut. dan Perikan.* **9** 1 61-68 [In Indonesian]

[12] Hong D D, Hien H M, Son P N 2007 Seaweeds from Vietnam used for functional food, medicine and biofertiliser *Journal of Applied Phycology* **19** 6 817–26

[13] Fahlivi M R 2020 Physicochemical characteristics of liquid fertilizer from fish viscera. Undergraduate Thesis, United Nations University Fisheris Training Programme, Iceland

[14] Clarke M A 2003 Syrups, in *Encyclopedia of food sciences and nutrition* (Maryland: Elsevier Science Ltd) pp 5711

[15] Standar Nasional Indonesia 2015 SNI 2354.2: 2015, cara uji kimia-bagian 2: pengujian kadar air produk pangan (SNI 2354.2: 2015, chemical testing methods - Part 2: testing the moisture content of fishery products) (Jakarta: Badan Standardisasi Nasional Indonesia), pp. 1–4 [In Indonesian]

[16] Standar Nasional Indonesia 2006 SNI 01-2354.1-2006, cara uji kimia-bagian 1: penentuan kadar abu pada produk perikanan (SNI 01-2354.1-2006, chemical test method - part 1: determination of ash content in fishery products) (Jakarta: Badan Standardisasi Nasional Indonesia) pp 1–4 [In Indonesian]

[17] Standar Nasional Indonesia 2006 SNI 01-2354.4-2006, cara uji kimia-bagian 4: penentuan kadar protein dengan metode total nitrogen pada produk perikanan (SNI 01-2354.4-2006, chemical test method - part 4: determination of protein content by total nitrogen method in fishery products) (Jakarta: Badan Standardisasi Nasional Indonesia) pp 1–5 [In Indonesian]

[18] Purbaningtias T E, Qayyumah N B, Kurniawati P, Wiyantoko B, Widati A A 2018 Comparative analysis method of C-organic in fertilisers by gravimetry and spectrophotometry. *AIP Conference Proceedings* **2026**

[19] Rawat J, Sanwal P, Saxena J 2016 Potassium and its role in sustainable agriculture, in *Potassium solubilising microorganisms for sustainable agriculture* (New Delhi: Springer India) pp 235–253

[20] Standar Nasional Indonesia 2018 SNI 77763:2018 pupuk organik padat (SNI 77763:2018, solid organic fertilizer) (Jakarta: Badan Standardisasi Nasional Indonesia) pp 1–29 [In Indonesian]

[21] Kementerian Pertanian RI 2011 Pupuk organik, pupuk hayati dan pembenah tanah (Organic fertilizers, biological fertilizers and soil repairers). Statute of Agriculture Ministry pp 17 [In Indonesian]

[22] Hairiah K, Van Noordwijk M, Cadisch G 2000 Carbon and nitrogen balance of three cropping systems in Northern Lampung, Netherlands *J. Agric. Sci.* **48** 3–17