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ORIGINAL RESEARCH ARTICLE



Effects of compost quality from non-dairy creamer sewage sludge-solid compost biogas-rice husk char on bok choy mustard (*Brassica rapa* L.)

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ABSTRACT

Non-dairy creamer sewage sludge (NDCSS) has high organic matter and nutrients for compost production but NDCSS has a problem for the composting process because it has high moisture and slurry form. Therefore, the composting process of NDCSS requires mixing of other organic materials such as solid compost biogas (SCB) and rice husk char (RHC). Therefore, this study aims to determine the chemical properties of compost from a mixture combination of NDCSS, SCB, and RHC, and to assess compost quality as organic fertilizer from a mixture combination of NDCSS, SCB, and RHC through growth and yield of bok choy mustard (*Brassica rapa* L.). Experiments were carried out in greenhouses from March to September 2019. The research treatment consisted of 7 treatments mixture combination of NDCSS, SCB, and RHC for the composting process, and each treatment was repeated 4 times. The composting process is carried out by anaerobic or fermentation methods. The research layout was used as a randomized complete block design (RCBD). The NDCSS can produce compost with the highest N content, while the RHC will produce compost with the highest P. The mixture combination of NDCSS, SCB, RHC, and the mixture combination of SCB and RC will produce compost with the highest K content. Compost from NDCSS produces the best organic fertilizer because it is able to make the best biomass wet weight and dry weight of bok choy mustard biomass.

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INTRODUCTION

The food and beverage industry are developing, it has to comply with regulations standards related to environmental sustainability. This is closely related resulting waste from the production process. In the waste treatment process, final waste which tends to be difficult to process will be produced, such as sewage sludge. Sewage sludge is the final result of waste treatment in the form of solid sludge that settles at the bottom of a settling tank in a waste treatment facility. At a later stage the sludge must be removed or managed to reduce environmental pollution. Sewage sludge is generated from wastewater treatment and can pollute the environment. Sewage sludge is a potential source of compost for soil conditioners or organic fertilizers

because waste sludge is rich in organic matter, macro and micronutrients. Organic fertilizer from sewage sludge is very rich in macro and micronutrients, which can improve the physicochemical properties of soil and affect crop growth and yields (Jaffar *et al.*, 2017; Kumar *et al.*, 2019, 2020).

Non-dairy creamer industry is one of the foods and beverage industries, that has produces creamers are substitute products for milk or cream or dairy creamer. Non-dairy creamer is emulsion products of fat in water; hence the purpose of non-dairy creamer is to replace the milk powder or reduce the amount of milk in coffee, milk tea, oatmeal, hot chocolate, bakery, or other beverages (Dedin *et al.*, 2016). Non-dairy creamer can be powder-granule or liquid and generally used to add flavor to food and beverages. Non-dairy creamer does not contain

lactose, therefore it is described as being non-dairy products, although many contain casein, a milk-derived protein. Non-dairy creamer is a mixture of several food additives, it is made from glucose (starch derivative) and hydrogenated vegetable oil which is hydrogenated with the addition of permitted food additives. However, there is non-dairy creamer which is made without hydrogenated vegetable fats or oil. Normally non-dairy coffee creamers contain corn syrup solids (60% to 65%), vegetable oil (30%, hydrogenated coconut or palm oil), sodium caseinate (2% to 5%), and other ingredients (emulsifiers, stabilizers, anti-caking agents, and color and flavoring agents), and the non-dairy creamers have contained 58% carbohydrate, 32.5% fat, 8.5% protein, and 1.2% minerals (Huang *et al.*, 2019).

The by-products of the non-dairy creamer industry are liquid waste and sewage sludge. Sewage sludge management should be a serious concern because if not handled properly it can cause serious harm to the environment. Sewage sludge from non-dairy creamer industrial has high potential value as a source of organic matter and plant nutrition for soil properties improvement. The wastewater from non-dairy creamer production contains organic matter, especially carbon in the form of carbohydrates, proteins, fats, and lipid (Dewi *et al.*, 2016a; 2016b; Triyaswati and Ilmi, 2020) therefore sewage sludge from non-dairy creamer also contains high organic matter.

Non-dairy creamer sewage sludge (NDCSS) is an important type of solid organic waste and NDCSS compost is basic material organic fertilizer. Crop cultivation using organic fertilizers from NDCSS compost makes an effective sewage sludge management technique and reduces the cost of purchasing organic fertilizers. Sewage sludge used in agricultural soils is a cheap and effective alternative to the currently applied method of replacing mineral fertilization because waste sludge contains not only organic matter but also macro and micronutrients (Delibacak *et al.*, 2020). The utilization of waste sludge is a process of recycling valuable organic matter as a source of plant nutrition. Macro and micronutrients in the sewage sludge function as a source of plant nutrients and the organic matter in the sewage sludge can improve soil properties (Carter *et al.*, 2013). Sewage sludge is an effective source of organic fertilizer for soil physico-chemical properties improvement, affects crop growth and yield. Good waste management is using waste to be valuable raw material, non-dairy creamer wastewater contains organic substances, all with great potential to become a growth medium for microorganisms. Therefore, Dewi *et al.* (2017) have used non-dairy creamer wastewater with 75% concentration as the basic material for the growth medium of *Saccharomyces cerevisiae* for single-cell protein production.

The composting process from NDCSS can be carried out through an aerobic or anaerobic process. Composting is the process of biological decomposition of organic matter under thermophilic temperatures conditions as a result of biologically generated heat, to produce compost as the stable final product, free from pathogens and plant seeds. The final product of composting is compost which can be used as organic fertilizer. The NDCSS problem in composting process is high moisture

content and the soft slurry-like form. Meanwhile, the advantage of NDCSS is that it contains a high enough content of carbon and macronutrients such as N, P, and K. The research conducted by Sebastian and Simanjuntak (2018) with a preliminary analysis of the NDCSS from PT. Kievit Indonesia contains a total organic matter of 6.68%, total nitrogen of 0.11% N, total phosphate of 12.95% P₂O₅, total potassium of 0.007% K₂O, pH of 6.67, and C: N ratio of 36,56. Therefore, the compost for organic fertilizer from NDCSS requires the mixing of other organic materials, so that the compost produced has a good physical shape and a complete plant nutrient content. Some sources of organic matter that are abundant in agricultural areas are the solid digestates (solid compost biogas-SCB) and the rice husk char (RHC). Mixing SCB, RHC, and NDCSS are considered to be able to improve the compost quality as organic fertilizer is produced. On the other hand, the use of NDCSS, SCB, and RHC by composting process as organic fertilizer can be assessed as the use of industrial and agricultural waste for sustainable agricultural activities.

Utilization of biogas waste (digestate) such as solid digestate (solid compost biogas (SCB)) or liquid digestate (bioslurry (BS)) can substitute or reduce the use of mineral fertilizers in crop cultivation (Sogn *et al.*, 2018). Biogas waste (SCB and BS) is an organic waste rich in plant nutrients such as nitrogen, phosphate, and potassium. With an anaerobic decomposition process, the biogas waste has a lower C: N ratio (carbon to nitrogen ratio) than the raw material. The C: N ratio of biogas waste depends on decomposition time, but generally biogas waste has a C: N ratio lower than 25. The SCB can use to directly fertilize crops or mixed with other fertilizers. The SCB application would be improved soil carbon, nitrogen, phosphate, and potassium and that provides easily nutrient availability to plants and soil biota (Kumar *et al.*, 2015). The SCB could improve soil properties such as soil structure, soil fertility, and crop productivity, and it can be an excellent fertilizer (Warnars and Hivos, 2014; Przemyslaw *et al.*, 2020; Fabio *et al.*, 2020).

Rice husks are agricultural waste, it could be processed into rice husk char (RHC) for carbon soil sources. The soil organic matter can be increased by adding RHC (Mishra *et al.*, 2017). The RHC was the byproduct of a rice-husk gasification unit. Indonesia has a lot of rice husks, and this agricultural waste could be processed into RHC for increasing soil fertility. RHC would improve soil condition by improving soil chemical and physical properties (Xiao *et al.*, 2018). RHC application on soil would increase soil pH, availability of phosphorus (P), soil porosity, plant available water, and its increase in the exchangeable of potassium (K), magnesium (Mg), and silicon (Si) (Mishra *et al.*, 2017). Research is also similar to that conducted by Chen and Yu Fang (2020), that RHC could result in a significant change in soil characteristics such as pH, EC, Total Carbon, and available K. These indicate RHC has the potential used as an organic fertilizer.

Bok choy mustard (*Brassica rapa* L.) widely consumed and bok choy mustard planting required organic fertilizers in good quantity and quality. The compost as organic fertilizer from a mixture of NDCSS, SCB, and RHC was expected to increase the growth

and yield of bok choy mustard. Research with RHC and SCB as compost has been carried out by many researchers, but until now there has been no research on NDSS as compost. NDSS composting for organic fertilizers is one of waste management and reduces the cost of organic fertilization. Based on the description above, it is necessary to research a mixture combination of NDCSS, SCB, and RHC as compost for organic fertilizer and its effect on the growth and yield of bok choy mustard (*Brassica rapa* L.). The research purpose is (1) to determine the chemical properties of compost from a mixture combination of NDCSS, SCB, and RHC, and (2) to assess compost quality from a mixture combination of NDCSS, SCB, and RHC as organic fertilizer through growth and yield of bok choy mustard (*Brassica rapa* L.).

MATERIALS AND METHODS

Experiment design

The experiment was conducted at greenhouse in PT Kievit Indonesia and the soil laboratory in Universitas Kristen Satya Wacana. The research was conducted from March to September 2019. The treatment of mixture combination of non-dairy creamer sewage sludge (NDCSS), solid compost biogas (SCB), and rice husk char (RHC) on compost quality, growth and yield of bok choy mustard has consisted of 7 treatments, and each treatment was repeated 4 times (Table 1).

The research layout of mixtures combination from NDCSS, SCB, and RHC for compost production as organic fertilizer used a Randomized Completely Block Design (RCBD). The research stage with the following procedure:

1. Mix evenly a mixture combination of NDCSS, SCB, and RHC that have been determined for each treatment. Treatment of mixtures combination from NDCSS, SCB, and RHC based on weight ratios.
2. Organic matter composting process by anaerobic. Anaerobic composting process is an efficient technology for the conversion of organic wastes such as sewage sludge (Nwabunwanne et al., 2020). Organic matter pile from a mixture combination of NDCSS, SCB, and RHC were be composted for 3 weeks. During composting process was given the EM 4 (effective microorganism 4t) commercial inoculum for every week. EM4 was given 3 times in 3 weeks of the composting process. The dosage for each EM4 application is 335 ml EM4 per 1 ton of organic matter pile. Every week, at the time of the EM4 application, the organic matter pile from a mixture combination of NDCSS, SCB, and RHC were stirred and then composting process again. The composting process from a mixture combination of NDCSS,

SCB, and RHC was stopped at the third week, then the compost final were analyzed for chemical characteristics. The final compost that is produced is used to test the ability of compost as an organic fertilizer to the growth and yield of bok choy mustard. The composting 3 stages (3 weeks) of NDCSS, ECB, and RHC with the anaerobic process can see in Figure 1.

3. In subsequent research, the compost production from a mixture combination from NDCSS, SCB, and RHC was used as organic fertilizers for mustard bok choy planted in polybag containers. Oxisols was used as planting media (see Table 2 for soil characteristics) and organic fertilizers dosage usage from compost produced from mixture combination of NDCSS, SCB, and RHC is 40 tons.ha⁻¹. Bok choy mustard planting did not use inorganic fertilizers, therefore the need for plant nutrients relies on the treatment of organic fertilizers produced from mixtures combination of NDCSS, SCB, and RHC.

Data collection

The effect of a mixture combination of NDCSS, SCB, and RHC evaluations on compost quality, growth, and yield of bok choy mustard was carried out by measuring the following variables: 1) The initial characteristics of the organic matter pile from a mixture combination of NDCSS, SCB, and RHC with measurement of C: N ratio, pH, and moisture content. 2) final compost characteristic evaluation with measurement of nitrogen total, phosphate total, potassium total, pH, organic matter total, and C: N ratio. 3) The growth and yield of bok choy mustard were measured on plant dry weight biomass (shoot dry weight) and fresh weight (shoot fresh weight). Moisture content of organic matter pile and soil was measured by the gravimetric method. Total organic matter (total C organic) was measured with K₂Cr₂O₇ oxidation in an acidic condition and it used a spectrophotometer in the Walkley and Black method. N total was measured with the Kjeldahl method. Total phosphate and total potassium were measured with HCl as a solvent, where total P measurement used a spectrophotometer and total K measurement used a flame photometer. pH was measured with water as a solvent with the ratio soil: water of 1:10 and it used pH meter.

Data analysis

Chemical data of compost, growth, and yields of bok choy mustard were done statistical analyses by an analysis of variance (ANOVA) with F test on a significance level of at least $p < 0.05$, and when observation data has a significant effect on the treatments, it was analysis continue by Tukey's HSD (honestly significant difference) with a significance level of at least $p < 0.05$.

Figure 1. The composting stages of NDCSS, SCB, and RHC for 3 weeks.

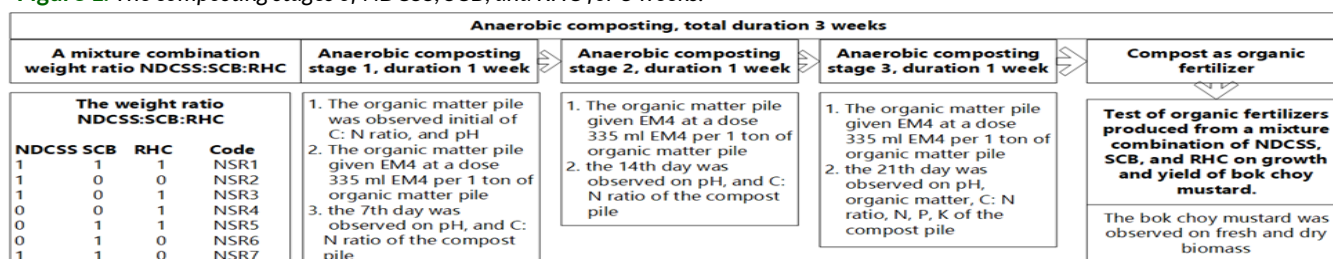


Table 1. The research treatment of weight ratio from combination NDCSS: SCB: RHC.

NDCSS	SCB	RHC	Code
1	1	1	NSR1
1	0	0	NSR2
1	0	1	NSR3
0	0	1	NSR4
0	1	1	NSR5
0	1	0	NSR6
1	1	0	NSR7

Remark: NDCSS = non-dairy creamer sewage sludge, SCB = solid compost biogas, and RHC = rice husk.

Table 2. Initial characteristics of the experimental oxisols.

Soil parameter	Value
Carbon organic total	1,26 % C
Nitrogen total	0,08 % N
Available phosphate	1,01ppm P
Available potassium	0,83 ppm K
pH-H ₂ O	7,6

RESULTS AND DISCUSSION

The initial characteristics of the organic matter pile from a mixture combination of NDCSS, SCB, and RHC

The NDCSS is industrial waste from food and beverage, while SCB and RHC are agricultural waste, where all the waste is organic matter was able to provide macro and micronutrients that increase soil fertility (Park *et al.*, 2019). Therefore, NDCSS, SCB, and RHC materials can be used as compost. The production of compost from a mixture of NDCSS, SCB, and RHC was done through an anaerobic composting process. However, before the anaerobic process was carried out, the organic matter pile from a mixture combination of NDCSS, SCB, and RHC was early measured for moisture content, pH, and C: N ratio.

Moisture content

Moisture content is an essential component of the organic matter composting process since it acts as a solvent, mass transfer of microorganisms, interaction between the substrate surface with microorganisms involved in the composting process (Nathia *et al.*, 2018). Table 3 shows at beginning of composting for the mixture combination treatment of weight ratios NDCSS, SCB, and RHC had moisture content various values from 5.81% (the lowest moisture content in the NSR4 treatment was only RHC) to 68.77% (the highest moisture content in the NSR2 treatment was only NDCSS). The ideal moisture content for anaerobic composting ranges from 60-70% (Guo *et al.*, 2012). Makan *et al.* (2013) suggested that initial moisture content of around 75% was considered suitable for efficient composting of organic solid waste and the final compost obtained showed good maturity levels and can be used for agricultural applications. Based on Table 3, the NSR2 treatment, which is only NDCSS, is a composting raw material with ideal moisture content for anaerobic composting processes. During composting, the moisture content of raw material will affect the

metabolic activity of microorganisms, and the amount of initial moisture content in composting is determined by the physico-chemical and biological properties of the organic matter that will be composted. Initial moisture content affects microbial activity and the physical structure of the final compost.

pH-H₂O

From Table 3, it can be seen that all treatment mixture combinations of NDCSS, SCB, and RHC have an initial composting stage of pH of organic matter ranging from 7.99 - 8.81. Based on this pH value, all organic matter waste used has an alkaline pH. Only the NSR6 (SCB) treatment had the lowest pH among other treatments. The SCB or solid compost biogas has a lower pH because when the manure undergoes anaerobic digestion, organic solids are converted into volatile fatty acids (VFA), and the accumulated organic acids cause the pH of the manure to be low (Bonten *et al.*, 2014).

C: N ratio

The initial C: N ratio of the organic matter pile would affect composting process rate and compost pile volume reduction. Carbon to nitrogen ratio (C: N ratio) means the ratio of carbon element amount in organic matter to its content of nitrogen element amount. The C: N ratio in organic matter is a sensitive indicator of compost (Ge *et al.*, 2013; Kishneth *et al.*, 2020). The best C: N ratio value of an organic matter resulting from composting is 20-30 carbon atoms compared to 1 nitrogen atom (20-30 carbon atoms: 1 nitrogen atom) (Priya *et al.*, 2017), and compost stability would occur if the organic matter has an initial C: N ratio about 30 (Ameen *et al.*, 2017). In Table 3, it can be seen that at the beginning of mixing NDCSS, SCB, and RHC materials, the NSC4 code treatment is rice husk char only and the NSR1 code treatment is a mixture of NDCSS, SCB, and RHC with a ratio of 1: 1: 1 having a high C: N ratio value of 33.29 and 30.48. Meanwhile, other treatments from a mixture of NDCSS,

SCB, and RHC had a low C: N ratio value (<20). In the treatment NSR1 (SCB only) and NSR4 (NDCSS: SCB: RHC of 1: 1: 1) had a low total nitrogen content but a high organic C content.

The beginning C: N ratio value from organic matter to be composted will determine the decomposition rate of organic matter and methane production. The ideal composting process of organic matter if the C: N ratio is around 20-30. The ratio of carbon to nitrogen (C: N) is the ratio of the amount of carbon in organic matter to the amount of nitrogen. The beginning high or low C: N ratio of organic matter will affect the composting process (Priya *et al.*, 2017). The high value of C: N ratio would result in stable pH and high methanogenic activity due to the enhanced buffering effect of the digestion medium, the maximum efficiency of organic matter composting was obtained at C: N ratio is 30:1 (Tanimu *et al.*, 2014) because when the C: N ratio higher than 30 occurred greatest methane production for the organic matter decomposition unit. As stated by Kishneth *et al.* (2020) that the organic matter ratio of carbon to nitrogen (C: N) is an important factor affecting the compost quality for organic fertilizer production. Ideal beginning C: N ratio of organic matter is around 25- 30, when organic matter composting has a high C: N ratio that would produce high methane (Kumar *et al.*, 2015), then during the composting process the value of the C: N ratio of organic matter will decrease. The C: N ratios of 25-30 had the best digestion performance composting process because of maximum methane produced, stable pH, and low concentrations of total ammonium nitrogen and free NH₃. So that, organic matter composting with a C: N ratio of 25-30 where it would be an efficient composting process (Wang *et al.*, 2014). However, several researchers have succeeded in composting with organic materials that have a lower beginning C: N ratio value (Zhu, 2007; Ogunwande *et al.*, 2008). Composting with a low begin-

ning C: N ratio (<20) has the advantage that it can fast process of composting organic matter, less bulking agents, and the efficiency of composting time but increasing loss of nitrogen as NH₃ emission. During composting, the important elements that are lost are nitrogen (N) and carbon (C). N is lost as NH₃ gas and C is lost either due to bio-oxidation of CO₂ or C mineralization. The high C: N ratio of organic matter in beginning composting leads to a slower composting process and the composting time required is longer.

Compost characteristics are produced from a mixture combination of NDCSS, SCB, and RHC and their effects on bok choy mustard (*Brassica rapa* L.)

pH H₂O

Composting materials with a mixture combination of NDCSS, SCB, and RHC have end pH in the final compost product was decreased largely as compared to their beginning pH (see Table 3 and Table 4). The low pH at the final composting caused by the volatilization of ammonia nitrogen and the release of hydrogen ions (H⁺) through the nitrifying activity of nitrifying bacteria, as well as carbon dioxide emissions and organic acid during organic matter decomposition (Azim *et al.*, 2018). Table 4, final compost has pH of compost (organic fertilizers) ranged from 7.58 in NSR2 (research treatment only on NDCSS or non-milk creamer waste sludge) to 8.41 in NSR 4 (research treatment only on RHC or rice husk charcoal). The optimum pH of compost is in the range of 5.5-8.5 (Roman *et al.*, 2015; Azim *et al.*, 2018), based on this pH standard of optimum so that the pH of the compost final resulted from composting process from a mixture combination of NDCSS, SCB, and RHC shows the ideal compost pH.

Table 3. The value beginning of moisture content, pH, and C: N ratio from mixture combination of NDCSS, SCB, and RHC before composting process.

The research treatment of weight ratio from combination NDCSS:SCB: RHC				Code	Moisture content (%)	pH-H ₂ O	C: N ratio
NDCSS	SCB	RHC					
1	1	1		NSR1	11.88	8.81	30.48
1	0	0		NSR2	68.77	8.12	5.64
1	0	1		NSR3	14.53	8.74	6.15
0	0	1		NSR4	5.81	8.40	33.29
0	1	1		NSR5	8.29	8.34	11.14
0	1	0		NSR6	18.77	7.99	4.06
1	1	0		NSR7	22.82	8.07	8.55

Remark: NDCSS = non-dairy creamer sewage sludge; SCB = solid compost biogas; RHC = rice husk char.

Table 4. The pH, Organic matter, and C: N ratio on compost produced by a mixture combination of NDCSS, SCB, and RHC.

The research treatment of weight ratio from combination NDCSS: SCB: RHC				Code	pH-H ₂ O	Organic matter total (%)	C: N ratio
NDCSS	SCB	RHC					
1	1	1		NSR1	7.75 a	12.68 ab	13.88 c
1	0	0		NSR2	7.58 a	20.67 c	3.56 a
1	0	1		NSR3	7.73 a	11.54 a	4.38 a
0	0	1		NSR4	8.41 b	22.14 c	13.58 c
0	1	1		NSR5	7.97 ab	9.43 a	8.41 b
0	1	0		NSR6	7.64 a	7.30 a	2.82 a
1	1	0		NSR7	7.76 a	18.47 bc	5.12 ab

Remark: NDCSS = non-dairy creamer sewage sludge; SCB = solid compost biogas; RHC = rice husk char.

Organic fertilizers from the NSR 4 treatment were recorded to have a significantly higher pH than other treatments NSR1, NSR2, NSR3, NSR6, and NSR7 during the composting period. Treatment NSR4 is organic material from RHC (rice husk charcoal) which has an alkaline pH. Rice husk contains a high content of silicon and potassium, it can significantly improve soil properties by adding organic carbon, decreasing soil bulk density, enhancing soil pH, so that it can increase available soil nutrients. As stated by Ogbe *et al.* (2015) that RHC has a high pH, so the compost from mixed materials of RHC will have a high pH. On the other hand, the low pH on composting of wastes has been correlated with a high concentration of organic acids (Ameen *et al.*, 2016)

Organic matter

Final compost has decreased organic matter content when compared to the beginning of composting (Table 3 and Table 4). The low level of organic matter is related to the loss of dry matter in the form of carbon dioxide due to microbial activity and water evaporation during the composting process (Tibu *et al.*, 2019). The decrease in organic matter during composting is related to the microbial decomposition activity on the organic substrate (Abdou *et al.*, 2016), which can be seen from the increase in temperature during composting where microorganisms consume carbon for energy.

Organic matter easily biodegraded to inorganic matter, so that during the composting process has been a breakdown of organic matter into inorganic materials or transformed into a more stable fraction. The decrease in the organic matter in final compost is a compost maturity and stability indicators (Tibu *et al.*, 2019). Based on Table 4, the research treatment of NSR4 (only RHC) and NSR2 (only NDCSS) have organic matter content was significantly higher when compared to other treatments. This is because the NSR4 (only RHC) treatment has a high lignin content and NSR2 (only NDCSS) has a high carbohydrate content in the form of vegetable oil because non-dairy creamer is made from corn syrup solids (60% to 65%), vegetable oil (30%, hydrogenated coconut or palm oil), sodium caseinate (2% to 5%) and other ingredients (emulsifiers, stabilizers, anti-caking agents, and color and flavoring agents) and the non-dairy creamers have contained 58% carbohydrate, 32.5% fat, 8.5% protein, and 1.2% minerals (Huang *et al.*, 2019), so that non-dairy creamer sewage sludge (NDCSS) still has a high oil and fat content which causes the biological decomposition process to run slowly. This condition would produce compost with high organic material content. The oil and fat decomposition by microorganisms will turn oil and fat into harmless organic and inorganic solids, CO₂, and H₂O (Matikeviciene *et al.*, 2012). Hydrolysis of fatty acids with long chains in oil and fat can inhibit the growth of various microorganisms, this condition makes the decomposition process slow. Such conditions make the decomposition process in the NSR2 treatment slower and when all treatment were stopped decomposition process, the compost final from NSR2 treatment still has a high content of organic matter.

C: N ratio

Compost for organic fertilizer must be sufficiently mature and not cause damage to crops. The value of the C: N ratio is used to determine the compost maturity. Park *et al.* (2019) stated that the C: N ratio compost can be an indicator of compost maturity since C and N concentrations relate to the metabolism rates of microorganisms during the composting process. The C: N ratio of final compost is determined by the parent organic matter and the length of the composting process (Roman *et al.*, 2015). The longer the composting process will produce compost with a low C: N ratio. Mature compost has a C: N ratio of around 15-10: 1 (Kopec *et al.*, 2018). By Park *et al.* (2019) stated that the C: N ratio decreased with long composting times, and the C: N ratio of compost between 5 and 6 was a suitable value indicating compost maturity. Based on this, the compost C: N ratio of the treatments NSR2, NSR3, NSR5, NSR6, and NSR7 had a C: N ratio value at maturity status when the composting process had been going on for 3 weeks using the anaerobic composting method.

The mature compost is compost both as a planting medium and as an organic fertilizer to support plant growth and yield. There is no absolute parameter to assess compost maturity, but the parameter C: N ratio of compost is commonly used to assess the compost maturity for organic fertilizer. The compost maturity produced will be determined by the parent organic material, the length of composting, microorganisms, and the composting method such as aerobic or anaerobic process. Table 4 shows that the treatments of NSR2, NSR3, NSR5, NSR6, and NSR7 had a C: N ratio <6 so that when the composting process was carried out for 3 weeks it has reached compost maturity, while NSR1 and NSR4 treatments have not reached compost maturity. This is because the treatment of NSR1 and NSR4, one of the types of parent organic matter is RHC which has a high initial organic C and low N total value (see Table 3) so that the 3 weeks of the composting process has not reached the C: N ratio between 5-6 (mature compost), as it was stated by Park *et al.* (2019) that mature compost has a C: N ratio of 5-6.

Nitrogen

The compost useful value as organic fertilizer depends largely on the content of macronutrients – N, P, K. Therefore, when compost production from a mixture combination of NDCSS, SCB, and RHC analyzed the nutrient content of N, P, and K at the end of the composting process. Nitrogen (N) is one of the most important elements needed for plant growth, and sewage sludge is a potential N source. The NDCSS composting is one method NDCSS prepare for organic fertilizer as an N source. SCB waste also contributes to high concentrations of N and has been used as organic fertilizer. Besides, RHC is a good source of potassium (K), and pH increasing compost and soil.

Table 5 shows the organic matter from NDCSS and SCB capable of producing compost with a high nitrogen content and a much higher nitrogen content than compost from RHC. This is because the initial characteristics of organic matter from NDCSS and SCB already have a higher nitrogen content than

RHC (see Table 3). NDCSS has a high nitrogen content (Table 3) because NDCSS is a waste from NDC (non-dairy creamer) which has about 8.5% protein (N source) and 1.2% other minerals (Huang *et al.*, 2019). This also applies to SCB, where initially SCB already has a high nitrogen content (Table 3) so that the resulting compost also has a high nitrogen content. Total nitrogen increases in final compost as a similar trend was observed by Al-Bataina *et al.* (2016) who showed an increase in nitrogen content in the compost along with an increase in the compost life period. The increase in nitrogen is caused by an increase in protein degradation, and the contribution of increasing microorganisms' biomass and nitrogen-fixing bacteria (Barthod *et al.*, 2018).

Phosphate

The phosphate nutrient content in compost is determined by organic matter kind and variations in microbial activity. During the composting process, there has been a release of P nutrients from organic compounds present in composted organic matter (Abdou *et al.*, 2016; Souley *et al.*, 2020). The total phosphorus content on the compost pile would be increased during the composting period because this is due to the precipitation of phosphorus in solid form which cannot be easily dissolved and leached out (Tibu *et al.*, 2019).

A low value of total phosphorus was found from NSR1, NSR2, NSR3, NSR5, NSR6, and NSR6 compost, and the significantly

highest value of total phosphorus was found from NSR4 compost (Table 5). Composting could increase the concentration of P total in the compost pile and decrease soluble P fractions leaching which might cause environmental problems following land application. An increase of P on compost was correlated with an increase in microbial P, pH value, decrease in organic matter, and decrease in the C: N ratio compost (Kopeck *et al.*, 2018).

Potassium

The potassium content in the compost pile will increase as the compost pile was shrinks size in end composting process (Singh and Kalamdhad, 2015). However, potassium in the compost pile has a very high chance of being lost due to leaching. High K concentrations were found in the early stages of composting. Potassium is very mobile and wasn't chelated by the humic acid from compost, so the amount of potassium will decrease with the composting process length. Table 5, shows that significantly lower potassium content was found for NSR2 compost and the highest potassium values were found for NSR1 and NSR5 compost. Potassium is a monovalent ion so that it wasn't chelated and easy to leach in humic acid. The leaching of potassium on compost has been due to excess moisture from the composting pile. If seen Table 3 shows NSR 2 treatment has the highest organic matter moisture so that during the composting process would be high potassium leaching.

Table 5. The nitrogen total, phosphate total, and potassium total on compost produced by a mixture combination of NDCSS, SCB, and RHC.

The research treatment of weight ratio from combination NDCSS: SCB: RHC				Code	Nitrogen total (N%)	Phosphate total (P ₂ O ₅ %)	Potassium total (K ₂ O%)
NDCSS	SCB	RHC					
1	1	1		NSR1	0.53 a	0.10 a	2.07 c
1	0	0		NSR2	3.43 d	0.33 ab	0.14 a
1	0	1		NSR3	1.57 b	0.14 a	0.94 b
0	0	1		NSR4	0.95 a	0.73 c	1.20 b
0	1	1		NSR5	0.82 a	0.45 b	2.42 c
0	1	0		NSR6	1.51 b	0.60 bc	1.29 b
1	1	0		NSR7	2.09 c	0.42 b	0.87 ab

Remark: NDCSS = non-dairy creamer sewage sludge; SCB = solid compost biogas; RHC = rice husk char.

Table 6. The effect of organic fertilizers produced compost from a mixture combination of NDCSS, SCB, and RHC on the fresh and dry weight bok choy mustard biomass.

The research treatment of weight ratio from combination NDCSS: SCB: RHC				Code	Fresh weight of biomass (g per plant)		Dry weight of biomass (g per plant)	
NDCSS	SCB	RHC						
1	1	1		NSR1	179.36	b	10.58	bc
1	0	0		NSR2	275.10	c	15.62	d
1	0	1		NSR3	176.87	b	11.44	c
0	0	1		NSR4	88.69	a	7.04	a
0	1	1		NSR5	107.62	a	7.47	a
0	1	0		NSR6	116.73	a	8.22	ab
1	1	0		NSR7	192.65	b	12.96	cd

Remark: NDCSS = non-dairy creamer sewage sludge; SCB = solid compost biogas; RHC = rice husk char.

Test of compost as organic fertilizers was produced from a mixture combination of NDCSS, SCB, and RHC on the growth and yield of bok choy mustard

The compost has been produced from a mixture combination of NDCSS, SCB, and RHC is tested for bok choy mustard planting to prove the phytotoxicity level of the compost. If the compost application test can give the highest growth and yield of bok choy mustard, the compost is suitable to be used as organic fertilizer. Table 6 shows all the composts produced from a mixture combination of NDCSS, SCB, and RHC was capable of growing bok choy mustard, but compost from NSR2 (organic matter from only NDCSS) treatment was able to provide the best growth and yield of bok choy mustard. This is because the compost produced from the NSR2 treatment has the highest nitrogen content. The results of the correlation analysis showed that the fresh weight of biomass had a positive correlation (0.800) with the nitrogen content in the compost. Likewise, the dry weight of biomass has a positive correlation (0.813) with nitrogen content in compost and the fresh weight of biomass (0.984). Based on Table 6, shows that organic fertilizers produced compost from non-dairy creamer sewage sludge (NDCSS) can provide the best growth and yield for bok choy mustard plants.

Conclusion

Food and beverage industrial waste such as NDCSS and agricultural waste such as SCB and RHC used as compost is a waste management strategy. The compost produced from this waste can be used as organic fertilizer for agriculture. NDCSS, SCB, and RHC separately or the mixture can be composted as organic fertilizer to increase growth and yield of bok choy mustard. NDCSS compost has high total N content but low total K content, while RHC compost has high total P content but low total N content. SCB compost and RHC compost have a total K content that is not different from each other but a higher total K content than NDCSS compost. NDCSS is a source of organic matter with high total N content, and SCB and RHC are sources of organic matter with high total P and total K content. Therefore, compost from a mixture of NDCSS and RHC or compost from a mixture of NDCSS and SCB has a higher total N content than compost from a mixture of SCB and RHC. However, if the three sources of organic matter, namely NDCSS, SCB, and RHC are mixed, then compost is produced with the highest total K content. Bok choy mustard is a horticultural plant where the leaves are harvested, so it really needs high N nutrients. Therefore, based on the growth and yield of bok choy mustard, compost from NDCSS is the best compost as an organic fertilizer for bok choy mustard, because compost from NDCSS can make the best biomass wet weight and dry weight biomass of bok choy mustard.

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