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Biodegradation of spawn waste for environmentally friendly compost performed by *Bacillus cereus* S1, *Aspergillus* sp. and *Candida* G3.2.

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ABSTRACT

Mushroom media that is unproductive or called *baglog* (spawn) waste causes problem for mushroom farmers, since unmanaged and untreated spawn waste potentially pollutes the environment. The main component of spawn is cellulose which can be utilized as useful and environmentally friendly compost through degradation process by microorganisms. The objective of this study was to degrade spawn waste using decomposition agents such as *Bacillus cereus* S1, *Aspergillus* sp., and *Candida* G3.2 to generate compost. First, spawn waste was disengaged until they do not clot. Spawn waste were then added with 2% of glucose and 10 ml composter agent with a density of 10^8. The composition was mixed and incubated for 21 days until the compost is matured. Mature compost is characterized by decreasing temperature until similar to room temperature, smooth material, slight earthy smell and dark brown to black color. Nitrate, phosphate and potassium contents in mature compost were measured by spectrophotometric methods before and after composting process. The results showed that spawn waste can be used as compost with crumby texture, dark brown color, and earthy smell. Available nitrate concentrations in mature compost according to SNI 19-7030-2004 which is greater than 0.4%, while phosphate and potassium do not meet compost standards

Key words : *Spawn_waste, Biodegradation, Compost, Environmentally friendly.*

Introduction

The waste of mushroom cultivation media or unutilized spawn become accumulated waste and pollutes our environment which can be major challenge in mushroom cultivation industries. The main composition of spawn are sawdust and bran (Jasinszka *et al*., 2017), bran is rice mill waste which contains high amounts of cellulose whilst sawdust has lignin as main component. Spawn waste that rich in cellulose and lignin can be used as environmentally friendly fertilizer. Composting is biodegradation process of organic materials which carried out by composter microorganisms (Fitri *et al.,* 2016; Jedrczak, 2018; Sari *et al.,* 2019).

Some bacteria, fungi and yeast isolates are able to produce enzyme which is competent for cellulose and lignin degradation process, including *Bacillus cereus* is Gram positive bacteria that can increase lignocellulose degradation and nitrogen availability in cultivation media (Ribeiro *et al*., 2017; Artha *et al.,* 2019; Surtiningsih and Yusna, 2019), *Aspergillus* molds can excrete lignocellulolytic enzymes such as cellulase and amyloglucosidase for cellulose degradation (Dadeech *et al*., 2018; Agustina *et al.,* 2019) and *Candida* G3.2 is a yeast that is capable of produc-

ing cellulase to break brown cellulose into glucose (Alami *et al*., 2019).

Based on the ability of lignocellulose degradation, these three genera of microorganisms can be used as composting agent of spawn waste to generate environmentally friendly biofertilizer and boost soil fertility.

Materials and Methods

Starter

Subculture of *B. cereus* S1 according to Zulaika *et al*., (2017a), *Aspergillus* sp. according to Swapna and Lalchand (2016), and *Candida* G3.2 according to Alami *et al*., (2019).

Composting Process – Compost material (spawn waste) was packed into polybag, then 1% glucose and 10% microbial composter agent were added. Spawn media without microbial inoculant was used as positive control and soil garden was used as negative control. The sufficient amounts of sterile distilled water was added in order to achieve the initial moisture and optimize the composting process. Spawn media and inoculant were mixed manually until evenly distributed, then covered with gunny sacks (Zulaika *et al*., 2017b).

Compost Maturation Analysis – Compost maturation was analyzed based on its physical properties such as odor, color, texture and temperature. Whereas chemical properties (NPK) analysis was performed on available nitrate (NO_3^-), dissolved phosphate (PO_4^{3-}) and potassium (K_2O) content. Chemical analysis was carried out before and right after composting process. Compost temperature was measured everyday to prevent composting process from overheating, if the temperature is too hot stirring process needs to be conducted. The quality of mature compost physically and macronutrients content follows the Indonesian National Standard (SNI) 19-7030-2004. Mature compost can be characterized by its earthy smell, blackish colour (dark brown), crumb texture and cold temperature Zulaika *et al*., (2017b).

Measurement of NPKContent

N measurement was carried out using brusinsulphate methods (SNI 06-2480-1991), P measurement was carried out using Pikovskaya methods by Kang *et al*., (2014) and K measurement was carried out using potassium suppressor methods by Pratama *et al*. (2016).

Results and Discussion

Compost Maturation

B.cereus S1, *Aspergillus* sp and C*andida* G3.2. as single culture as well as consortium are able to compost spawn waste. The quality of compost based on its physical properties are fulfilled Indonesian National Standards (SNI 19-7030-2004) as follows: cool temperature (27 ^oC), earthy smell, blackish color and crumb texture (Table 1).

In the early composting process, spawn waste has light brown color with solid texture and 27 °C of temperature, after 14 days incubation, the temperature has increased until 30 °C. The sign of compost maturation began to appear on 21st day incubation, the temperature began to decline and the colour turn to brown. On 28th day incubation compost already matured by showing cool temperature 27 °C the same temperature with temperature in early composting process, blackish brown colour, earthy smell and smoother texture compared with the early

Table 1. The Quality of Mature Compost Based on SNI 19-7030-2004

Composter	SNI 19-7030-2004			
	T.27^oC	BB	CT	ES
B. cereus S1	"	"	"	"
*Aspergillus*sp.	"	"	"	"
Candida G3.2.	"	"	"	"
*Candida*G3.2 + *Aspergillus*sp.	"	"	"	"
B.cereus S1 + *Candida* G3.2.	"	"	"	"
*Aspergillus*sp. + *B. cereus* S1	"	"	"	"
*Aspergillus*sp + *B. cereus* S1+ *Candida* G3.2.	"	"	"	"
Positive control (Without inoculant)	"	"	"	"

Note: T. (temperature), BB (Blackish Brown), CT (Crumby Texture), ES (Earthy Smell)

process.

The increasing temperature on 14th day of composting as a result of composter microbes carried out metabolisms to degrade organic matter, so that heat energy is produced. Regarding Heribert *et al* (2010), composting agent start to undertake respiration process and produce energy which is used for degradation of organic matter process. Oxygen in respiration process act as electron acceptor for releasing energy from carbon source and produce CO_2, H_2O and heat. This exothermic reaction increased compost temperature (Purkan *et al.*, 2020). Matured compost has earthy smell. This scent as result of aerobic respiration using oxygen as electron acceptor. Graves *et al.* (2000), states that if composting process occurs in anaerobic condition, the electron acceptors are nitrate, sulphate and carbonate resulting a foul odour due to release of H_2S, methane and organic acid.

Compost texture turned into small grain, crumb and blackish brown. The changes of its texture and color were caused by decomposition of spawn waste material performed by decomposter agent. It changed the complex carbon molecule to be small carbon molecule. The result of Kumalasari and Zulaika (2016), stated compost which derived from leaves that contains high amounts of cellulose resulted smooth texture and smaller grain size. The colour of composted litter has changed from yellow to blackish brown at the end of composting.

Macronutrient N, P, K

Macronutrient content such as N, P and K contained in spawn waste before composting process were very low at 1.51%, 0.02% and 0.03%. Surya (2019), state that P and K nutrients added to spawn as mushroom cultivating media were adjusted to its needs, so that the amount was very limited. In non-productive spawn and subsequently used as raw material as compost, then spawn waste only has a few P and K nutrients, so that composter agent cannot release P and K from spawn waste because it has been exploited by mushroom.

The N availability which was resulted from both single culture or consortium degradation fulfilled which was more than 0.4%, meanwhile P and K are still below the standards, except on *Aspergillus* sp. + *B. cereus* S1 and *Aspergillus* sp + *B. cereus* S1 + *Candida* G3.2 treatment (Figure 1).Concentrations of N in compost have increased compared to spawn waste before composting. All isolates as composter were able to degrade cellulose and lignin, the single culture treatment from *Candida* G3.2. and *Aspergillus* sp. were able provide higher N than other isolates. Regarding Gilmore *et al*., (2015), fungi have better ability to degrade cellulose than bacteria because fungi has cellulase, xylanase and mannase to degrade hemicellulose, fungi also has polysaccharide deacetylase to degrade lignin.

Available P in mature compost which fulfilled the standards of SNI 19-7030-2004 were only showed in *Aspergillus* sp. + *B. cereus* S1 and *Aspergillus* sp. + *B. cereus* S1 + *Candida* G3.2 treatment, while a single isolate composter culture still below the SNI 19-7030-2004. Based on Gupta *et al* (2015), in bran as a raw material for spawn contains phytic acid as organic phosphate that is difficult to dissolve, so that in the release of dissolved phosphate, phytase enzyme is needed. *Bacillus cereus* and *Aspergillus* sp. has the ability to produce extracellular phytase, an enzyme which is belong to phosphatase group and able to release phosphate from insoluble com-

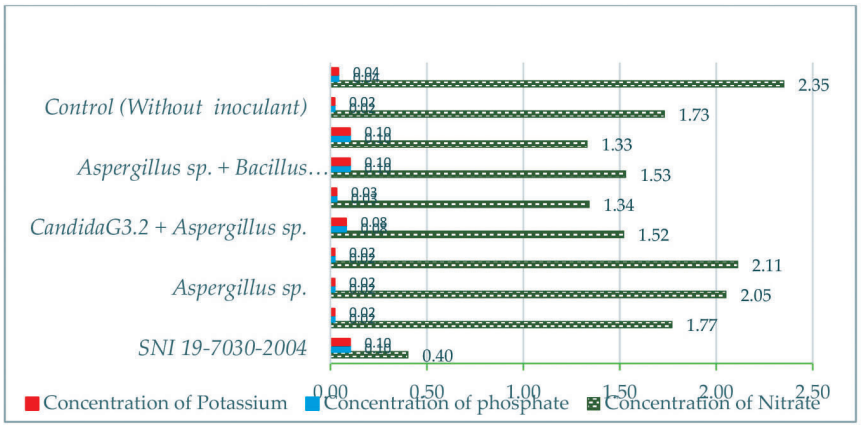

Fig. 1. The macronutrient (NPK) availability in mature compost

pounds. *B. cereus* S1 was able to secrete organic acids through glucose metabolism (Zulaika *et al.*, 2012), which is one of the mechanisms for solubilizing phosphate.

The available K content in mature compost which fulfilled SNI 19-7030-2004 strandard were showed only in the *Aspergillus* sp. + *B. cereus* S1 and *Aspergillus* sp + *B. cereus* S1 + *Candida* G3.2. whereas a single isolate as a composter cannot meet SNI 19-7030-2004. This showed that when compost is formed, the degradation activity of organic matter by the consortium composter is at its maximum condition. According to Prajapati and Modi (2012), the increase in potassium in the decomposition medium is due to the presence of potassium solubilizing bacteria, the composter using free K^+ ions present in the compost raw material as a catalyst for metabolic purposes, so that it affects the increase the amounts of potassium in mature compost.

Conclusion

Spawn waste can be composted by decomposer agent such as *B. cereus* S1., *Aspergillus* sp, and *Candida* G3.2 both in the form of single inoculum and consortium. All of the composter can release nitrate which fulfilled SNI 19-7030-2004 which was more than 0.4%. While the availability of phosphate and potassium which fulfilled the standards are only in *Aspergillus* sp. + *B. cereus* S1 and *Aspergillus* sp + *B. cereus* S1+ *Candida* G3.2 treatment.

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