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THE REDUCTION OF HCN CONTENTS AND WATER USE OF *TACCA LEONTOPETALOIDES* UTILIZATION THROUGH ETHANOL PRODUCTION WITH THE POTENTIAL OF DISTILLERY WASTES AS ORGANIC FERTILIZER

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ABSTRACT

Tacca tuber (*Tacca leontopetaloides*) is one of the wild plants found in coastal areas and has high carbohydrate potential. Coastal people traditionally processed Tacca into flour which needed washing many times to reduce the HCN contents. High volume of clean water is needed, while the wash-water disposed of is contained HCN residue and risky contaminating the stream. The ethanol production has been chosen as a simple method that can be done traditionally which the resulted products and also the byproducts can be used by the community. Aims of the research were to identify alternative Tacca utilization method in reducing the HCN contents and water use through ethanol production. Two processing methods (i.e.: Tacca flour and ethanol production) compared in water use and HCN contents of the wastes, the research has done experimentally and analyzed descriptively. The results showed that the ethanol-making process could decreased 91.63-95.03% of HCN contents and reduce the water use 40% from the Tacca flour process, with the potential of distillery wastes as an organic fertilizer that contained C of 5.40-51.31%, N of 0.75-0.95%, P_2O_5 of 0.09-0.80% and K_2O of 0.93-2.99%.

KEY WORDS: HCN, Fertilizer, *Tacca leontopetaloides*, Water use

INTRODUCTION

Tacca (*Tacca leontopetaloides*) is one type of flowering plant that could be the alternative source of carbohydrate. Tacca tuber contained 89.4% of carbohydrate, so it has the potential to be used as staple food (Ukpabi *et al.,* 2009). Tacca tuber also contained 77.86% of starch which consists of 22.82% of amylose and 55.04% of amylopectin (Utama *et al.,* 2018). This potential also showed that in several areas in Indonesia, Tacca consumed as a rice substitute or processed into flour to make cakes or pastries.

In addition to carbohydrates, other chemical compound precisely becomes a problem in Tacca utilization for food products. Tacca cannot be directly consumed because its toxic contents such oxalic compounds, cyanides, phytates, alkaloids, tannins and saponins (Ndouyang *et al.,* 2014). There also bitter compounds such as taccaline, b-cytosterol, cerylic alcohol and sapogenin steroid contained in Tacca (Manek *et al.,* 2005). The tuber of Tacca contained HCN of 256.76 ppm which is a concern to be controlled (Utama *et al.,* 2018).

Simple fermentation method were taken by the local people to decrease the toxic contents and then convert the fermented tuber into Tacca flour. The combination of fermentation and oven drying can reduce the 52-85.6% of phytochemicals found in tubers (Montagnac *et al.,* 2009). Fermentation method was done first because the processing of raw tuber are difficult to do because the commodities are easily deteriorate. Lactic acid bacteria used to ferment Tacca so that causing a change in the chemical compound and the amylograph characteristics of resulted in Tacca flour (Setiarto and Widhyastuti, 2016). The fermentation by lactic acid bacteria is also indicated to be able to reduce the presence of toxic compounds such as cyanide (HCN) and taccaline in Tacca flour (Abiodun and Akinoso, 2014).

On several occasions, Tacca were soaked several times to decrease the toxicity then the fermentation began. The phytochemicals contained in Tacca can play a role as antimicrobials that could inhibit lactic acid bacteria fermentation so that no dilution needed to decrease the toxicity (Utama *et al.,* 2018). Meanwhile according to Kunle *et al.,* (2003), toxic compounds in Tacca can be eliminated by boiling. The bitter compound can be removed by soaking Tacca tubers in fresh water (Setiarto and Widhyastuti, 2016). Unfortunately, the washing and soaking water of Tacca tubers are contained a lot of anti-nutrients such as saponins, sodium oxalate and HCN so that it become difficult to manage or dispose to the environment.

The difficulty of managing the remaining washing and soaking water from the Tacca tubers results in problems. The wastewaters could result in odors and the toxicity that make it hard to dispose directly into the environment. Besides that, the high volume of water in washing and soaking processes also become a big problem, because Tacca grow in the coastal area that basically need a high volume of clean water. The existing process of Tacca with using LAB fermentation and oven drying methods for Tacca flour production is not appropriate because it tends to disturb the environment.

In order to get better environmental impact, other simple fermentation methods were tried in utilizing Tacca tubers. High contents of carbohydrates are potential as raw material for alcoholic conversions such as ethanol (Utama *et al.* 2019). Yeasts have been known as one of the best microorganisms in ethanol production with the ability to surviving at the high phytochemical substrate. The familiar yeasts such as *Saccharomyces cerevisieae* has been shown to reduce the amount of HCN in tubers (Prasad and Dhanya, 2011). Meanwhile non-*Saccharomyces* yeasts such *C. natalensis* were found as Tacca indigenous yeast that could results 3.46% ethanol from Tacca with 2:1 dilution with fresh water (Utama *et al.,* 2018). Some research also found that ethanol distillery wastes were potential as fertilizer so that could reduce the disposal of wastewater to the environment (Utama *et al.,* 2017).

The research aims to compare the existing method of Tacca utilization i.e.: Tacca flour processing and the ethanol fermentation process with regard to water use, HCN contents and also other benefits to the environment. Better utilization method could be suggested as an alternative that be implemented for environmental friendly Tacca utilization.

MATERIALS AND METHODS

Tacca tuber is taken from the farmer of West Bangka District, Bangka-Belitung Island Province, Indonesia. The making of Tacca flour and ethanol from Tacca tuber are following the traditional method that is done by the local people of West Bangka (Fig. 1) (Mustafa 2015; Utama *et al.* 2018). The differences in water use on Tacca flour and ethanol making is shown in Water 2 utilization frequency. Tacca flour making use 1:1 Tacca and water ratio so that for 1 kg Tacca will need 1L of clean water to soaked Tacca gratin then it precipitated, filtrated and repeated 4 times. Meanwhile the ethanol making use 2:1 dilution of Tacca and water ratio so that for 1kg Tacca will need 2 L of clean water. The difference between total water volumes used in the process is measured. Wastewater resulted from Tacca gratin soaking and ethanol distillery wastes process were measured volume and HCN contents to determine the toxicity of wastewater. The contents of HCN were measured using titration method. The distillery wastes were analyzed for its potential for fertilizer which consist of the contents of Nitrogen/N (Kejldahl), Phospate/ (P2O5)/P (Bray I), and Potassium/K (Atomic Absorbtion Spectrophotometer/AAS) (Utama *et al.* 2017). The research done with experimental methods, data were analyzed descriptively.

RESULTS AND DISCUSSION

The Contents of HCN in Tacca Utilization

The results of HCN contents analysis (Table 1) in the existing Tacca flour processing indicate that more soaking is done then the HCN levels decreased. Fresh Tacca tuber contained 256.76 ppm HCN which exceeds the safe cyanide level in foods of 30 ppm (Iwuoha *et al.,* 2013). Tacca flour processing shows that 1 times washing and 4 times soaking can

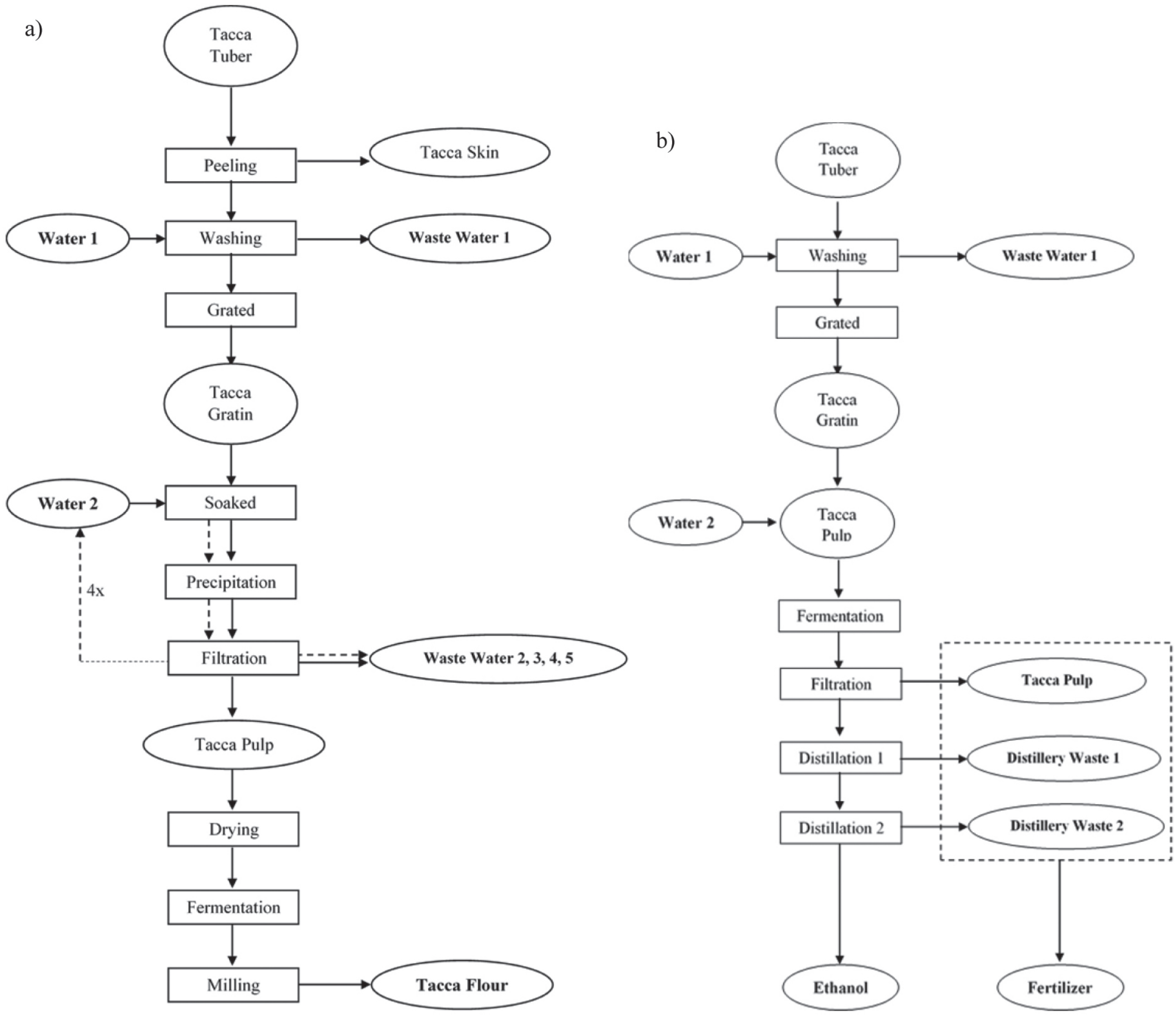

Fig. 1. (a) Tacca flour making process, (b) ethanol making process

Table 1. Analysis of HCN contents in the utilization of Tacca

Item	HCN (ppm)	%	Volume
Tacca Tuber	256.76	100	1000 mg
Tacca Flour	35.76	13.93	768.7 mg
Tacca Flour Processing			
Washing 1	63.32	24.66	920 ml
Soaking 1	52.22	20.34	972 ml
Soaking 2	36.21	14.02	975 ml
Soaking 3	33.28	12.96	966 ml
Soaking 4	29.45	11.47	968 ml
Average Wastewater HCN	42.90	16.69	
Total Wastewater			4801 ml
Ethanol-making			
Distillery waste 1	21.50	8.37	1062 ml
Distillery waste 2	12.75	4.97	774 ml
Average Wastewater HCN	17.13	6.67	
Total Wastewater			1836 ml

reduce HCN levels to 29.45 ppm, while Tacca flour products contained 35.76 ppm HCN. Utilization of Tacca for ethanol production through fermentation has been shown could reduce levels of HCN without spending the high volume of clean water for soaking. The distillery wastes from ethanol-making process shows that with 1: 2 dilution of Tacca and water ratio and also the distillation process, the HCN can be reduced to 12.75 ppm.

As consequences of a high volume of clean water for soaking, the wastewater resulted were also higher than the ethanol-making process. Table 1 showed that Tacca flour processing resulted in 4801 mL wastewater which is higher than the ethanol-making process wastewater of 1836 mL. The average of HCN contents if the Tacca flour processing wastewater mixed was 42.90 ppm, while the ethanol-making process wastewater shown the average of 17.13 ppm. The results also have shown that the ethanol-making process resulting in a lower potential of water pollution than Tacca flour processing.

Several steps in ethanol-making process shown influencing the amount of HCN. Fermentation as main process in ethanol-making has proven effective as cyanide detoxification method (Iwuoha *et al.* 2013). Microorganisms convert glucose to organic acids so that could decrease pH that inhibits the hydrolyze activity enzyme as HCN-forming catalyst (Kobawila *et al.* 2005). Besides that, HCN were water soluble and has the boiling point of 29 °C, so that could reduce by the distillation process that occurred at temperature of 78-80 °C (Gunawan *et al.*, 2015; Utama *et al.*, 2019).

Water Use in Tacca Utilization

The existing method of Tacca flour processing and the ethanol making process are measured based on the water use volume. Table 2 showed that total water volume for Tacca flour processing is 5L, while ethanol-making process is 40% lower (3L). High content of HCN in Tacca tuber drive the farmer to soak the Tacca four times so that resulted in higher water use in Tacca flour processing. Ethanol making shown more efficient water use than Tacca flour processing.

For the most part, the generation of energy such ethanol devours high amounts of water. Meanwhile, the expression "water-energy nexus" is very important to realize sustainable water management (Miglietta *et al.*, 2018). Ethanol production stimulating water utilization and contamination that is correspondingly expanding. Ethanol-making is an escalated water-consuming industry that demonstrated 15-30 tons of water utilization for creating 1 ton of ethanol (Zhang *et al.*, 2017). Water use and efûuent disposal during ethanol-making process can decrease water quality that leads to water scarcity (Dominguez-Faus, 2011).

However, starch based ethanol making can be done with effective water management. The huge amount of thermal energy utilized in ethanol plants likewise confines the minimum water utilization that can be accomplished. Heat exchange network improvement can decrease the water utilization by diminishing and integrating the utilization of energy, steam, and cooling water (Liu *et al.* 2019).

Distillery Wastes Quality for Fertilizer

The results in Table 3 showed that the distillery wastes has high Carbon and Potassium. Tacca tuber has high amylose and amylopectin that was represented in 77.09-82.65% carbohydrate that was carbon based compound, while other compound shown 6.73 - 7.84 % N based protein, 2225.9 – 2704.6 ppm of phosphor and 9048.6 – 9667.4 ppm of potassium (Susiarti, 2015). Final contents of the wastewater resulted from the raw material

Table 2. Water use volume in Tacca utilization

Utilization	Process	Volume	Total
Tacca Tuber		1.000 mg	1.000 mg
Tacca Flour			
Processing	Washing	1.000 mL	5.000 mL
Water 1	Soaking 1	1.000 mL	
Water 2	Soaking 2	1.000 mL	
	Soaking 3	1.000 mL	
	Soaking 4	1.000 mL	
Ethanol Making			
Water 1	Washing	1.000 mL	3.000 mL
Water 2	Dilution	2.000 mL	

composition and the ethanol-making process that tend to decrease the chemical composition.

The wastewater contents can play a role as fertilizer or soil nutrient that is necessary to maintain good quality soil and crop productivity. Organic C and Nitrogen are main nutrients for vegetation growth that are also useful to determine the quality, nutrient balance of soil and sustainable land management (Ge *et al.,* 2013). Potassium supports plant to resist water stress or low transpiration with the mechanisms as a cell osmotic regulator (Hartati *et al.* 2018). Another functional role of potassium is enzymes activator, stimulator, and transport of assimilates, and control the transport of water through stomatal movement, also increase plant branching that determine the crop yield (Grzebisz *et al.* 2013; Hasanuzzaman *et al.* 2018).

Table 3. Distillery wastes potential for fertilizer

Parameter	Unit	Tacca Pulp	Distillery Wastes
C/N Rasio		68.41	5.68
Carbon (C)	%	51.31	5.40
Nitrogen (N)	%	0.75	0.95
Phosphor (P_2O_5)	%	0.09	0.80
Potassium (K_2O)	%	0.93	2.99

The utilization of ethanol-making process wastewater also reduces the water pollution potential resulted from Tacca utilization. The distillery wastes have lower volume and HCN contents that below the safe level, so that could directly be utilized as fertilizer. Different from Tacca flour making that resulting soaked water that disposed of ethanol-making resulted in distillery wastes as a by-product that can be fully utilized for fertilizer or soil nutrient (Utama *et al.* 2019).

CONCLUSION

The ethanol-making process could be an alternative method for Tacca utilization besides Tacca flour processing. The process could lower HCN contents of 12.75-21.50 ppm, reduce the water use 40%, with the content of distillery wastes contained C (5.40-51.31%), N (0.75-0.95%), P_2O_5 (0.09-0.80%) and K_2O (0.93-2.99%) that potential as fertilizer or soil nutrients. Tacca utilization through ethanol-making, also reduces the potential of water pollution through fully utilizing the by-product.

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REFERENCES

Abiodun, O.A. and Akinoso, R. 2014. Effect of delayed harvesting and pre-treatment methods on the antinutritional contents of trifoliate yam flour. *Food Chemistry*. 146 : 515-520.

Dominguez-Faus, R. 2011. The Water Footprint of Fuel Ethanol. Dissertation. Rice University, Houston, Texas.

Ge, S., Xu, H., Ji, M. and Jiang, Y. 2013. Characteristics of Soil Organic Carbon, Total Nitrogen, and C/N Ratio in Chinese Apple Orchards. *Open Journal of Soil Science*. 03 (05) : 213-217.

Grzebisz, W., Gransee, A., Szczepaniak, W. and Diatta, J. 2013. The effects of potassium fertilization on water-use efficiency in crop plants. *Journal of Plant Nutrition and Soil Science*. 176 (3) : 355-374.

Gunawan, S., Widjadja, T., Zulaikah, S., Ernawati, L., Istianah, N., Aparamarta, H.W. and Prasetyoko, D., 2015. Effect of fermenting cassava with *Lactobacillus plantarum, Saccharomyces cereviseae,* and *Rhizopus oryzae* on the chemical composition of their flour. *International Food Research Journal*. 22 (3) : 1280-1287.

Hartati, S., Suryono, and Purnomo, D. 2018. Effectiveness and efficiency of potassium fertilizer application to increase the production and quality of rice in entisols. *IOP Conference Series: Earth and Environmental Science*. 142 : 012031.

Hasanuzzaman, M., Bhuyan, M., Nahar, K., Hossain, Md., Mahmud, J., Hossen, Md., Masud, A., Moumita, and Fujita, M. 2018. Potassium: A Vital Regulator of Plant Responses and Tolerance to Abiotic Stresses. *Agronomy*. 8 (3) : 31.

Iwuoha, G.N., Ubeng, G.G. and Onwuachu, U.I. 2013. Detoxification Effect of Fermentation on Cyanide Content of Cassava Tuber. *J. Appl. Sci. Environ. Manage.* 17 (4) : 567-570.

Kunle, O.O., Ibrahim, Y.E., Emeje, M.O., Shaba, S. and Kunle, Y. 2003. Extraction, Physicochemical and Compaction Properties of Tacca Starch – a Potential Pharmaceutical Excipient. *Starch - Stärke*. 55 (7) : 319-325.

Liu, H., Ren, L., Zhuo, H. and Fu, S. 2019. Water Footprint and Water Pinch Analysis in Ethanol Industrial Production for Water Management. *Water*. 11 (3): 518.

Manek, R.V., Kunle, O.O., Emeje, M.O., Builders, P., Rao, G.V.R., Lopez, G.P. and Kolling, W.M. 2005. Physical, Thermal and Sorption Profile of Starch

Obtained from *Tacca leontopetaloides*. *Starch - Stärke*. 57 (2) : 55-61.

Miglietta, P.P., Morrone, D. and De Leo, F. 2018. The Water Footprint Assessment of Electricity Production: An Overview of the Economic-Water-Energy Nexus in Italy. *Sustainability*. 10 (1) : 228.

Montagnac, J.A., Davis, C.R. and Tanumihardjo, S.A. 2009. Nutritional Value of Cassava for Use as a Staple Food and Recent Advances for Improvement. *Comprehensive Reviews in Food Science and Food Safety*. 8 (3) : 181-194.

Mustafa, A. 2015. Analisis proses pembuatan pati ubi kayu (tapioka) berbasis neraca massa. *AGROINTEK*, 9 (2) : 118-124.

Ndouyang, C., Njintang, N., Facho, B., Scher, J. and Mbofung, C. 2014. Effect of Processing Method on the Antinutrient Content of *Tacca leontopetaloides* (L.) Kuntze Flour. *British Journal of Applied Science & Technology*. 5 (3) : 258-269.

Prasad, S. and Dhanya, M.S. 2011. Determination and detoxification of cyanide content in sorghum for ethanol production using *Saccharomyces cerevisiae* strain. *Journal of Metabolomics and Systems Biology*. 2 (1) : 10-14.

Kobawila, S.C., Louembe, D., Keleke, S., Hounhouigan, J. and Gamba, C. 2005. Reduction of the cyanide content during fermentation of cassava roots and leaves to produce bikedi and ntoba mbodi, two food products from Congo. *African Journal of Biotechnology*. 4 (7) : 689-696.

Setiarto, R.H.B. and Widhyastuti, N. 2016. Pengaruh Fermentasi Bakteri Asam Laktat *Lactobacillus plantarum* B307 Terhadap Kadar Proksimat and Amilografi Tepung Taka Modifikasi (*Tacca leontopetaloides*). *Jurnal Ilmu Pertanian Indonesia*, 21 (1) : 7-12.

Susiarti, S. 2015. Potensi To'toan (*Tacca Leontopetaloides* (L.) O. kuntze) Sebagai Bahan Pangan Di Pulau Kangean, Jawa Timur [Potency of *Tacca Leontopetaloides* (L.) O. kuntze as a Source in Kangean Island, East Java. *Berita Biologi*. 14 (1):

Ukpabi, U.J., Ukenye, E. and Olojede, A.O. 2009. Raw-Material Potentials of Nigerian Wild Polynesian Arrowroot (*Tacca leontopetaloides*) Tubers and Starch. *Journal of Food Technology*. 7 (4) : 135-138.

Utama, G.L., Kurnani, T.B.A., Sunardi, and Balia, R.L. 2017. Reducing cheese-making by-product disposal through ethanol fermentation and the utilization of distillery waste for fertilizer. *International Journal of Geomate*. 13 (37) : 103-107.

Utama, G.L., Sidabutar, F.E.E., Felina, H., Wira, D.W. and Balia, R.L. 2019. The utilization of fruit and vegetable wastes for bioethanol production with the inoculation of indigenous yeasts consortium. *Bulgarian Journal of Agricultural Science*. 25 (2): 264-270.

Utama, G.L., Sugandi, W.K. and Lembong, E. 2018. Dilution Ratio of *Tacca leontopetaloides* in the Production of Bioethanol with the Inoculation of Indigenous Yeasts Consortium. *Journal of the Japan Institute of Energy*. 97 (9) : 270-273.

Zhang, T., Xie, X. and Huang, Z. 2017. The policy recommendations on cassava ethanol in China: Analyzed from the perspective of life cycle "2E&W". *Resources, Conservation and Recycling*. 126 : 12-24.