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Chemical Analysis of Rice from Converted-to-Organic Paddy Field in Lombok Island

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Abstract

Chemical analysis has been undertaken to investigate the nutrients compositions and the presence of residual pesticides from rice cultivated from converted-to-organic paddy fields in Lombok Island. The nutrients being investigated were macronutrients (carbohydrates, fat, and proteins), micronutrients (beta-carotene), metal ions, and minerals, whereas pesticides being investigated were organo-chlorides residues such as endrin, delta-BHC, dieldrin, etc. The chemical analysis results were compared to those from rice cultivated from conventional farming, which uses chemical pesticides. It was revealed that there is no difference in the nutrients compositions of rice produced from converted-to-organic paddy fields to those from conventional farming. Moreover, it was shown that both rice samples from converted-to-organic and conventional farming paddy fields have no detectable residual pesticides. This finding suggests that the absence of residual pesticides from rice samples does not necessarily correspond to the application of organic farming in the converted-to-organic land. There is not robust evidence that the application of organic alters the nutrient composition of rice. This result also underlines the need to further investigate the real benefits of organic rice farming products in terms of nutritional composition and safety.

Keywords: Residual pesticide, converted-to-organic paddy field, chemical analysis, organic rice

INTRODUCTION

The growing need for a healthy lifestyle is now frequently manifested in the consumption of organic products. In addition to their safety claims, organic products are perceived to have nutritional superiority (Barański, Rempelos, Iversen, & Leifert, 2017; Prada, Garrido, & Rodrigues, 2017; Sharma & Singhvi, 2018). The increasing demand for organic products has broadened organic agriculture. The trend is considered good practice in terms of consumer health and the ecological perspective, i.e., the decrease in the use of chemical fertilizers and pesticides may significantly cut the chemical load to the environment.

The reluctance among farmers to adopt organic farming lies in the lower harvest they obtain and the shorter shelf life of their products. Moreover, the stringent requirements for organic labeling and the high cost of chemical analysis have prevented the farmers from adopting organic farming. On the other hand, established farmers and traders have enjoyed market share once they passed the organic label requirement. They are additionally grey areas where producers claim their product as 'organic' by showing a laboratorium report indicating the absence of residual pesticides. Unlike other crops that are planted in newly opened land, such as coffee and sugar palm (*aren*), rice plantation has long used chemical fertilizer and pesticide (Yargholi & Azarneshan, 2014). The practice has prevented rice farmers from creating organic products as it is not easy to open new land for paddy fields. Nevertheless, there is a current initiative by a small group of rice farmers in Lombok Island to adopt an organic cultivation style. They cultivate rice from the so-called converted-to-organic paddy field. The paddy field has at least undergone ten harvest cycles, i.e., neither chemical fertilizer nor pesticides were used, a practice defined here as conventional rice cultivation.

So far, there is no data on the chemical composition and nutrient content of the rice produced in the converted-to-organic paddy field. Hence, this study has been undertaken to compare the chemical composition and possible residual pesticides from rice cultivated from a converted-to-organic paddy field in

Lombok Island with those from conventional rice cultivation. Analysis has been performed to investigate the major nutrients (total fat, carbohydrates, and proteins), micronutrients (beta-carotene), and metal ions (Fe^{2+}, Ca^{2+}, etc.), as well as the residual pesticides. The research results are expected to promote eco-friendly cultivation and yet economically for the farmers.

METHODOLOGY

Rice samples were obtained from converted-to-organic paddy fields that have been undergone at least ten cultivation-harvesting cycles without chemical fertilizer or pesticides in Kuripan Regency, West Lombok. The paddy field acquired a regular irrigation system. One sample was rice from conventional cultivation in Lombok Island, and organic labeled rice from the supermarket was used as a reference.

Water, ash, and major nutrients were analyzed by standard analysis (Amagliani, O'Regan, Kelly, & O'Mahony, 2017; Bijang, Latupeirissa, & Ratuhanrasa, 2018). Metal ions were determined by atomic absorption spectrophotometry (AAS) (de Oliveira, Antunes, Vieira, Medina, & Ribeiro, 2016; Hamzah & Yusuf, 2019; Wasim, Naz, Khan, & M., 2019), whereas residual pesticides were determined simultaneously by gas chromatography-mass spectrometry (GC-MS) (Amagliani et al., 2017). A certified reference material EPA 8080 (Sigma), which contained 17 different pesticides was used as the standard for residual pesticide analysis.

RESULTS AND DISCUSSION

The Rice sample used in this study was obtained from farmers who grew their paddy without chemical fertilizers or pesticides for at least ten cycles. Such cultivation practice is hereby referred to as converted-to-organic paddy fields. Instead of using chemical fertilizers, they use a consortium of microbes as bio-fertilizer and natural pesticides such as neem trees (*Azadirachta indica)* (Kumar et al., 2012; Mondal & Chakraborty, 2016).

To minimize cross-contamination from neighboring cultivation areas that share irrigation, irrigating water was initially contained in an adsorption pond loaded with active carbon or charcoal (Figure 1). This containment practice is justified by several reports (Gupta, Gupta, Rastogi, Agarwal, & Nayak, 2011; Jusoh, Lam, Hartini, & Ali, 2014). The composition of the rice produced in this way is compared to those from conventional cultivation and organic-certified product. The macronutrient composition of rice from the converted-to-organic paddy field was similar to those produced in conventional cultivation and organic labeled rice (Table 1).

Figure 1. Adsorption pond loaded with active carbon to adsorb potential cross-contaminating pesticides from neighboring paddy-fields watering from the same irrigation stream (shown by yellowish water spinach, left). Rice product from converted-to-organic paddy field and fertilized with bio-fertilizer (right).

However, the total fat content of rice produced in converted-to-organic paddy field was dramatically reduced from 0.72% obtained by conventional farming to 0.37% on average from CtO fields, which is close to 0.25% found in organic certified rice (Table 1). Metal ions and minerals content of the three sources of rice sample shows no difference. The conserved composition of rice grown in various treatments is by far noticeable, and other extreme treatments such as salt exposure may lead to the alteration of composition and quality of rice (Razzaq et al., 2020). A plausible explanation would be to consider the rice bran (the more rigid outer shell of rice) in the analysis since the shell might prevent pesticides' intrusion.

Table 2. Chemical composition of rice product in converted-to-organic paddy field. Metal ions were determined by AAS

No	Parameter	Unit	Sample			
			CtO.1	**CtO.2**	**Conv**	**Ref**
1	Water content	%	13.05	10.73	13.31	12.82
2	Ash	%	0.47	0.53	0.32	0.25
3	Protein	mg/100g	6.98	7.84	7.99	7.99
4	Carbohydrate	%	79.14	80.51	77.65	78.71
5	Fat	%	0.35	0.39	0.72	0.25
6	Beta-Caroten	mg/100g	0.01	0.01	0.03	0.02
7	Calcium	ppm	3.44	3.37	4.31	2.49
8	Kalium	ppm	612.6	606.97	467.13	430.58
9	Magnesium	ppm	223.6	262.45	206.2	122.36
10	Natrium	ppm	53.59	37.23	27.12	58.37
11	Iron	ppm	7.16	6.42	8.79	8.15

CtO: converted-to-organic, Conv: conventional agriculture, Ref: Organic-labeled product obtained from market

Table 1. Chemical analysis of residual pesticide from rice produced in converted-to-organic paddy field as determined by GC-MS. The detection limit of the analytes were in the range of 0.2 to 2 ppm.

No	Analyte	Sample			
		CtO.1	CtO.2	Conv	Ref
1	alpha-BHC	nd *	nd	nd	nd
2	gamma-BHC (Lindane)	nd	nd	nd	nd
3	Heptachlor	nd	nd	nd	nd
4	Aldrin	nd	nd	nd	nd
5	beta-BHC	nd	nd	nd	nd
6	Heptachlorepoxide Isomer B	nd	nd	nd	nd
7	delta-BHC	nd	nd	nd	nd
8	4,4’-DDE	nd	nd	nd	nd
9	Dieldrin	nd	nd	nd	nd
10	Endrin	nd	nd	nd	nd
11	4,4’-DDD	nd	nd	nd	nd
12	Endosulfan II (beta isomer)	nd	nd	nd	nd
13	4,4’-DDT	nd	nd	nd	nd
14	Endrin Aldehyde	nd	nd	nd	nd
15	Endosulfan Sulfate	nd	nd	nd	nd
16	Metoxychlor	nd	nd	nd	nd

*nd: not detected

CtO: converted-to-organic; Conv: conventional agriculture; Ref. organic labeled product obtained from supermarket

This result may also lead to a reverse consequence, i.e. the growing claim of organic rice merely based on contents and residual analysis, without legal certification, is not based on stringent control since the rice produced in traditional farming also does not contain detectable residual pesticides.

An alternative scenario to investigate the real benefits of organic rice over those produced in conventional farming is to assess the potential accumulation of residual pesticides, up to the detectable figure, within the animal model consumer. It is supported by a recent report that organochlorine pesticides were accumulated within loaches fish grown in paddy fields (Zhang et al., 2016), or fish caught in the offshore zone in Taiwan (Chang, 2018).

Accordingly, this conclusion may not be generalized for other crops such as vegetables and fruits. The report shows that vegetables are more prone to contain residual pesticides, such as Heptachlor, Aldrin, and Lindane (Tuhumury, Leatemia, Rumthe, & Hasinu, 2018). A more recent report also revealed the accumulation of organochlorine in Melliferous plants, bee pollen, and honey (Kasianchuk, Berhilevych, Negay, Dimitrijevich, & Marenkova, 2020). However, the contents still meet national standards (Anonim, 2008). Therefore, additional study is required to investigate potential residual pesticides in vegetables and fruits to evaluate the implementation of organic farming for vegetables and fruits. In the longer term, aplant may also accumulate metals, such is reported for nipah (*Nypa* fruticans) plant (Nafie, Liong, & Arifin, 2019). In the case of rice, the rice bran might also be investigated.

CONCLUSION

The introduction of organic farming did not lead to drastic chemical composition alteration of rice, except for the lower fat and beta carotene contents. These two nutrients were also low in certified organic rice in comparison to rice produced in conventional agriculture. The absence of detectable residual pesticides in the rice cultivated from converted-to-organic fields may add the benefit of the product, at least for marketing strategy. However, since conventional farming also produces rice with comparable nutrition and safety in terms of the absence of residual pesticides, our result might challenge the benefits of organic rice claims. Nevertheless, further research to investigate a possible accumulation of pesticides in animal models fed with rice from different cultivation (conventional, converted-to-organic, and organic) is deemed necessary to reveal the benefit of organic rice.

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