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The transition toward sustainable organic food systems in Indonesia: A case study of organic rice

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Abstract— The demand for organic food in Indonesia is increasing annually. Organic rice is one of the most consumed organic foods in Indonesia. Organic rice perceive as healthier than conventional rice; however, in the context of the food system (from farm to fork), is organic rice better than conventional rice? To what extent does the transition contribute to sustainability? We have been investigating organic rice in the context of the food system since 2016. Our experiment reveals that (1) organic rice fits the organic principle in the level of farming where less pesticide, better farmer income and protecting biodiversity (2) lower degree of milling in organic rice resulted in the highest nutritional benefit (3) consumer perception depend on nutritional information From this point of view, we conclude that organic rice would be fit for the organic food principle and sustainable way if the rice has a lower degree of milling.

***Keywords*—organic food systems, organic rice, contaminant, cultivation, processing, consumer preference, Indonesia**

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INTRODUCTION

The development of organic agriculture in Indonesia started in the early 1980s when the campaign of green revolution covers nationwide. Several small communities and non-government organisations (NOGs) were concerned about the overuse of Nitrogen (N) and Phosphorus (P) fertiliser in paddy fields (Brush et al., 2007). At the beginning of the movement, several NGOs reacted to the green revolution because of their belief that it was causing a decline in soil fertility, soil and water pollution, as well as the greenhouse effect. According to David and Ardiansyah (2017), the development of organic agriculture can be divided into three decades:

(1) Early decade (1980–1990), several NGOs were established and were concerned about the overuse of pesticides and fertilisers as well as about farmer freedoms

(2) Network decade (1990–2000), when all the NGOs created a network and collaborations

(3) Regulation decade (2000–2014), when the organic agriculture movement was recognised by the government and established the organic national standard

Since 2014 onwards, the development was enlarged to the competitiveness in the ASEAN Economic Community (AEC). This enlargement and expansion required data and scientific endorsement to capture the potential market in the AEC.

Unlike other agriculture commodities, organic food products are always associated with better health and nutrition and being pesticide-free, as well as with environmental protection (Ibitoye et al., 2014; Mohamad et al., 2014; Annunziata & Vecchio, 2016; David & Ardiansyah, 2017). Organic food perceive as healthier than conventional food, and this is commonly mentioned in several research studies (Chinnici et al., 2002; Harper & Makatouni, 2002; O'Donovan & McCarthy, 2002).

To understand the role of organic principles in the food system, we have to investigate one of the example cases. We have chosen organic rice because of the second most-consumed organic food in Indonesia (Suharjo et al., 2013; Purwasasmita & Sutaryat, 2014; AOI, 2014; David & Ardiansyah, 2017). To deliver the whole principle of organic, we evaluated the entire food system instead of only the cultivation or consumption parts. According to Kahl et al. (2012a), the International Association of Food, Quality and Health (FQH) has given the definition of organic food as well as organic food quality (Kahl et al., 2012a; 2012b) the food and production process as inseparable aspects which can be defined by criteria, indicators, and measurable parameters. To our understanding, production, processing, and consumption are one of holistic system and it inseparable.

David and Kofahl (2017) stated that the purpose of organic rice as an example because this organic product is the most consumed in Indonesian. Therefore, to understand the transition toward a sustainable food system, we comparing organic vs conventional from the farm to the fork as a system through the following aspects: (1) Agrochemical residue (2) Farmers Income (3) Bio-active Compound – whole grain rice and polished rice (4) Consumer perception.

A three-year study performed to identify the potential of organic rice to become a sustainable food system, (1) to identify agrochemical residue during cultivation. Comparative study between five hectares each of organic and conventional rice has been conducted in the similar agroclimatic (tropical) condition in Tasikmalaya, West Java, Indonesia, (2) to identify the degree of milling of organic rice in three different varieties which provides better nutrition and (3) to identify consumer preferences towards organic rice with various degree of milling. Those three years of studies have been published three manuscripts in three different journals.

The objective of this review is to describe the transition of organic rice toward a sustainable food system. We describe organic rice from the farm to fork comparing with conventional rice. The description covers all activities during cultivation, processing, and consumption.

AGROCHEMICAL RESIDUE

According to David et al. (2020c), two sites have been chosen—organic and conventional—in Tasikmalaya, West Java, Indonesia. The distance between the two groups is 7 km. Both areas are located ca. 500 m above sea level and the rate of rainfall is about 2.000 mm/year. The daily average temperature is 18ºC–25ºC. Rapid rural appraisal (RRA) generates information such as dosage, wide-ranged area of usage, type of agrochemical, frequency of usage, the productivity of rice varieties and Focus Group Discussion were applied to understand farmer behaviours covering cost and productivity of farmers. Agrochemical residue has been determined to cover organophosphate, organochlorine, as well as heavy metals. The analysis of agrochemicals was performed using the Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC) method, as described by Cid et al. (2007).

The results showed that agrochemical residues were detected in the soil, water and plants. Diazinon was detected 40% frequencies of occurrence in the plant. The occurrence of Aldrin, Heptachlor and Dieldrin was also detected up to 60%. Mercury and Arsenic were detected in the water with the frequency of about 10-40%. Contrary to that in the organic rice samples, the agrochemical residue was not detected. A review of pesticide residue in rice revealed (Asiah et al., 2019) that the concentration of pesticide residue is generally lower in the final product; however, it is still higher during the processing.

Plant protection cost

In the production cost, David et al. (2020) found the cost of plant protection to be recorded as 0.8±0.43 USD/Ha for organic and 16.17±3.12 USD/Ha. Cost of manure/fertiliser for organic rice is 20.03 USD/Ha and 92.85USD/Ha for conventional rice. Further, the margin of profit for organic rice is 0.32 USD/kg, while it is 0.21 USD/kg for conventional rice, as can be seen in Table 1.

Table .1 Farmer characteristics (David et al., 2020c)

Characteristic	Organic (n=18)	Conventional (n=18)
Farmers age (years)	54.94 ± 9.997	54.64 ±8.85
Education	Elementary School (n=15) Junior High School (n=3) Senior High School (n=0)	Elementary School (n=16) Junior High School (n=1) Senior High School (n=1)
Land (m^2)	1868.13 ± 863.29	2162.35± 959.58
Average no. persons per HH	3	4.5
Farming (years)/Organic (years)	19.83 ± 13.62 / (3.55± 0.78)	13.82 ±7.86
Land ownership	Owner (n=10) sharecroppers (n=8)	Owner (n=8) sharecroppers (n-10)
Cost for plant protection (USD ha^{-1})	0.8 ± 0.43	16.17 ± 3.12
Time spent for plant protection (hours)	4±0.08	1±0.5
Cost for manure/fertilizer (USD ha^{-1})	20.03	92.85
Yield (kg ha^{-1})	4246.03±456.52	6100.05±30.01
Margin of profit (USD kg^{-1})	±0.32	±0.21
Selling price of unhulled rice (USD kg^{-1})	0.41±0.016	0.31±0.010
Selling price of rice (USD kg^{-1})	0.73±0.075	0.52±0.075

Key: HH=Households

From table 1 shows that organic rice has less production cost and high in the margin of profit. According to Luck and Grimm (2018), who researched Tasikmalaya, on an average, households retained around half their harvest for their consumption, while the other half was sold or handed over to their landlord, based on the sharecropping arrangement. This condition was also prevalent in our study, where both organic and conventional farmers sold half their harvest to intermediaries and kept the other half for their consumption.

RICE PROCESSING

According to David et al. (2020a), research was conducted on organic rice samples from Tasikmalaya, Indonesia, which were processed with different degrees of milling. Determination of the degree of whiteness, total phenolic content (TPC), total flavonoid and dietary fibre, as well as water content, was carried out.

The results show that an increase in milling time would increase the degree of milling (Fig. 1). However, TPC, flavonoid, and dietary fibre decreased significantly as milling time increased (Fig. 2 and Fig. 3) (David et al., 2020a). According to David (2017), brown rice has the highest number of bioactive compounds as compared to polished rice, besides also having the lowest cost post-harvest.

Considering the criteria for the bioactive compound for functional food, the degree of milling may be an essential factor in the sustainability of organic rice in Indonesia. This finding proves that even though organic rice has no agrochemical residue when the highest degree of milling is applied, there is a reduction in the nutritional or bioactive content of the organic rice.

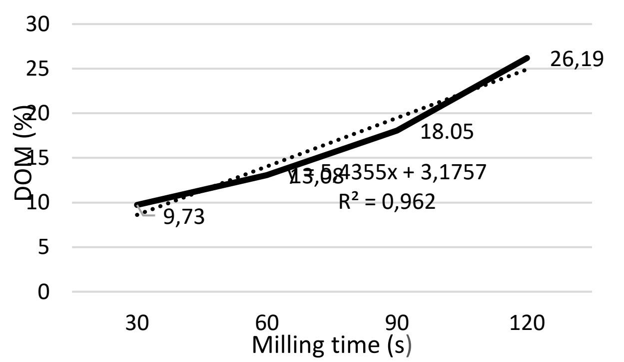

Fig. 1. Degree of milling vs milling time (David et al., 2020a)

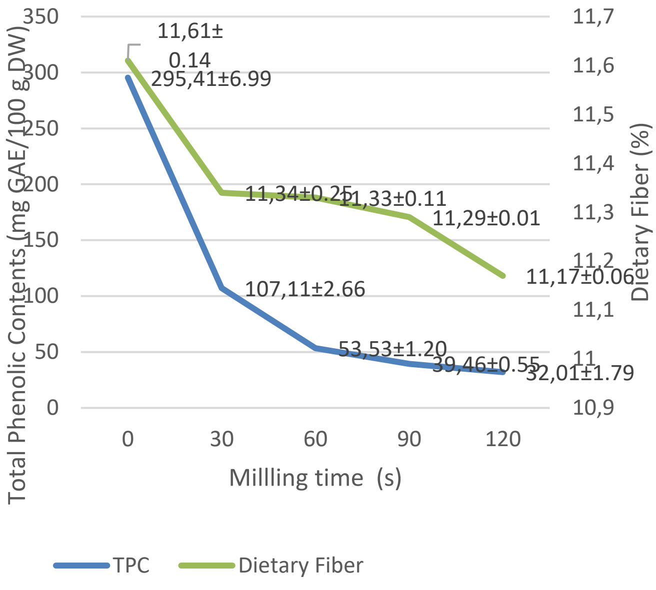

Fig. 2 TPC and dietary fibre levels vs milling time (David et al., 2020a)

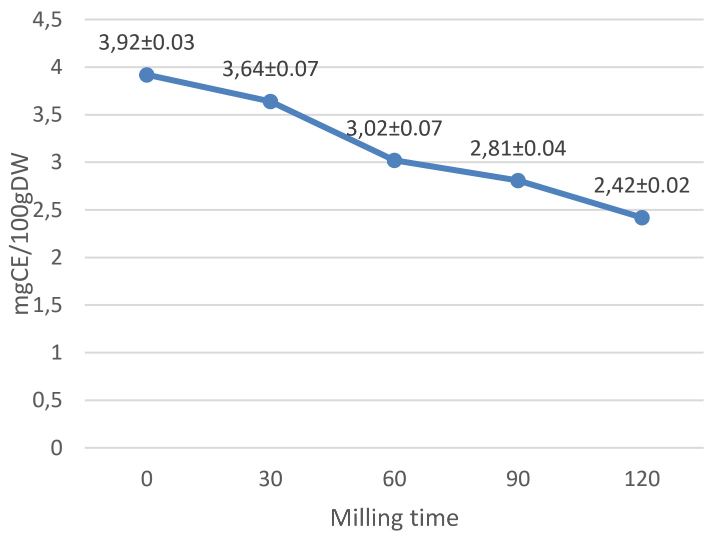

Fig. 3. Flavonoid levels vs milling time (David et al., 2020a)

Milling is a conventional method of rice processing which enhances its stability and sensory qualities. However, during the milling process, a considerable amount of nutrients also get depleted (Finocchiaro et al., 2007; Ha et al., 2006). Brown rice also contains lipids, amino acids, phytosterols, phenolic compounds, dietary fibres, and γ-aminobutyric acid (Cho & Lim, 2016). However, the consumption of brown rice is limited, owing to its rough sensory quality (Ohtsubo et al., 2005).

As our previous study suggested, organic rice in the mode of brown rice is giving a better nutritional composition (David et al. 2020a). Brown rice consists of bran, embryo, and endosperm, and its major nutrient is starch; it also has other nutrients such as protein, fat, ash, fibre, and lignin (Chen et al., 1998). Brown rice has rich vitamin content (folate 16–20 µg; pantothenic acid 1.4–1.6 mg; vitamin E 0.8–25 mg; thiamine 0.4–0.6 mg; riboflavin 0.04–0.14 mg; niacin 3.5–6.2 mg; vitamin B6 0.5–0.7 mg) per 100g (Mir et al., 2016; Juliano, 2016). On the other hand, after the milling process (conversion from brown rice to polished rice), the losses of nutrition and vitamins occurred (dietary fibre 0.7–2.7 g; protein 6.3–7.1 g; fat 0.3–0.6 g; folate 4–9 µg; pantothenic acid 0.8–1.3 mg; vitamin E 0.1–0.3 mg; thiamin 0.07–0.17 mg; riboflavin 0.02–0.06 mg; niacin 1.3–2.5 mg; vitamin B6 0.1–0.4 mg) per 100g (Lambert et al., 2007; Juliano, 2016). In carbohydrate metabolism, which produces energy (in the form of adenosine triphosphate or ATP), loss of thiamine (Vitamin B1) as a coenzyme of thiamine pyrophosphate makes the energy formation incomplete; even consuming enough carbohydrate sources produces insufficient energy.

CONSUMPTION

David et al. (2020b) explained how access to nutritional information shifts the consumer preference toward organic rice. Naïve panellists were recruited for sensory analysis. The panellists were divided into two groups; the first group of panellists were provided with nutritional information, and the second group was provided with no information about the nutritional value of organic brown rice. The protocol of sensory evaluation followed ISO 13299:2016 norms of sensory methodology's general guidance.

A recent study found that the nutritional information intervention of twenty panellists, it was found that the nutritional information of brown rice affected panellist responses on colour and texture. There is a significant difference between the groups with nutritional information and without nutritional information, in particular to the attributes of colour and texture. The intervention of nutritional information may help in increasing the preference for organic brown rice (David et al., 2020b).

In Indonesia, the consumer is familiar with polished rice as the primary source of calories, contributing to high glycemic loads (BPS, 2015). The consumption of polished rice has become a symbol of social status, which is confirmed by Zhang et al. (2010), who state that polished rice is a symbol of higher standards in Asian countries. The popularity of organic polished rice has increased due to the perceptions of the people regarding the premium rice standard.

SUSTAINABILITY OF ORGANIC RICE IN THE FOOD SYSTEM

Unlike conventional rice, organic rice has unique properties. Besides the absence of pesticide contamination, most consumers perceive organic rice as more nutritious as compared to its conventional counterpart. However, numerous studies have confirmed that there is no significant difference between organic and conventional rice in terms of nutritional profiles unless they are in the form of whole grain. From the perspective of organic agriculture, refined rice may not fit in with the principle, particularly with the principle of health. The attribute of healthiness, in terms of the presence of bioactive compounds (TPC, flavonoid, and dietary fibre), decreased during milling.

With this review, we summarised the sustainability of organic rice as a food system in the following table.

Table 2. Organic rice vs conventional rice

Indicators of sustainability	Source of Information	Conventional Rice		Organic Rice	
		Refined	Whole grain	Refined	Whole grain
Agri-chemical residue (Environment)	David et al. (2020c)	ND	Moderate[1]	ND	ND
Post-harvest cost (Farmers income)[2]	David et al. (2020c)	High	Low	High	Low
Bioactive compound (Health attribute)[3]	David et al. (2020a)	Low	High	Low	High
Consumer perception (consumer awareness)[4]	David et al. (2020b)	High	Low	High	Low[5]

Key: ND=not detected

1) Diazinon, Aldrin, Heptachlor, and Dieldrin were detected, including heavy metals
2) Margins of profit can be seen in Table 1.
3) The total phenolic, flavonoid and dietary fibre decreased significantly as milling time increased.
4) Consumer perception in brown rice (where "high" means "high regard" and "low" means "low regard").

5) Nutritional information of organic brown rice affects panellist responses on colour and texture.

We confirm that there is still a need for more research on organic rice, not only regarding the cultivation but also the processing and consumer perception. Attention needs to be paid to the concept of whole grain in organic rice, as otherwise, the attribute of healthiness will not be significantly different in organic and conventional rice. If we consider no chemical residue, minimised degree of milling, and increased consumer awareness as tools for checking the conformity fulfilment of the organic principles in the system, then we could describe the organic value of the food system as in Figure 4 below.

[Insert fig 4]

The strategy to increase the awareness must be accomplished by disseminating information about the benefits of organic rice and taking proactive steps in setting the degree of milling in the national standard. Furthermore, disseminating nutritional information for the consumer is necessary to increase the acceptance of organic rice with a lower degree of milling.

Development of the organic rice standard in Indonesia

The initial standard of organic agriculture in Indonesia was created by Badan Standarisasi Nasional (BSN) with the number SNI 01-6729-2002 covering the definition, labelling, procedure in production, processing, internal audit system, certification, import and audit system in organic food. This standard has three annexures covering the principles of organic production, substances used, and materials permitted during food processing and minimum inspection and certification. In 2010, SNI 01-6729-2010 was revised, and some adjustments were made to the new regulation. The adjustment in regards in which allowed to be used in the production. In 2013, the standard was revised and adjusted according to the new regulations in the food system.

The quality of rice is based on Indonesian rice standard 2015 (SNI 6128:2015), depending on the degree of milling. The highest degree of milling, the more its become premium rice. Based on recent research, the government accommodate organic rice in a particular regulation. This regulation is an attempt to accommodate the special treatment of organic rice in the form of brown rice, and the government launched regulation. No 48/Permentan/ PP.130/12/2017, which stated that organic rice should be in the shape of whole-grain (unpolished rice).

CONCLUSION

With this review, we conclude that organic rice as a food system shows how it needs comprehensive research toward sustainability. We conclude that organic rice has low pesticide residue; however, in the processing, there would be no significant difference between organic and conventional rice if the organic rice follows the conventional degree of milling. In terms of farmer income, organic whole grain gives a lower cost post-harvest. The challenges faced by organic brown rice (lower degree of milling) are mainly consumer perception in Indonesia that it is inferior to polished rice. Research regarding the processing and consumer acceptability would help the system of organic rice to enhance sustainability in the food systems.

Furthermore, this review provides evidence for how the organic food system should consider as an inseparable part of the organic principle itself. A food system comprises of function, interrelationship, as well as modelling. The global food system impacts biodiversity, nutrient cycle, and climate change in profound ways (Springmann et al., 2018).

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