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Interrelationship between Secondary Metabolites of Cereals and Agronomic Practice

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Abstract. Rice considered as integral part of diet, however, milled rice beneficial effects in relationship with agronomic practice is yet unclear; for this reason the assessment of antioxidant activities of rice kernel (2 *japonica* cultivars) grown under conventional or organic farming is illustrated. In the present study, a standard method of ethanolic extractant of rice kernel grown under chemical based and organic farming was estimated for various properties of antioxidant contents (phenolic compounds, flavonoid content, reducing power, ferrous chelating activity and DPPH%). The results highlighted the beneficial effects of higher antioxidant levels in organic rice in comparison of conventional farming, though phenolic compounds found insignificant. The DPPH%, flavonoid content and ferrous chelating% of organic rice reported 11, 6 and 31%, respectively higher than conventionally grown rice. These promising results encourage organic rice in regular diet with harmony of ecological balance, although large gene pool studies awaited for further validation of results.

Keywords: organic farming, japonica rice, antioxidants, phenolic compounds

1. Introduction

Phenolic compounds considered as most widely distributed in plant kingdom as secondary metabolic products while many phenolic compounds in fruits and vegetables are also reported in cereals. Rice grains have been used as a staple food and dominant cereal worldwide, where, major production and consumption of rice shared by Asia as the homeland. The major phenolic compound considered in cereals is ferulic acid that exhibits antimutagenic, anti cancer and other antioxidant effects on the human health [1]. Various studies suggested colored rice antioxidant effects are biological activities and values could vary many times higher than white or light brown colors [2], [3]. These functional compounds have free radical scavenging activity which could be generated by metabolic pathways inside body tissues. Recently, environmental protection and food safety (including exposure to synthetic chemicals) draw major attention towards the growing demand of organic foods [4]. So far, few studies correlate antioxidant activities of milled rice and influence of farming system on the secondary metabolites production. Therefore, the objectives of this investigation focused on the effects of different farming system on the secondary metabolites development in *Japonica* rice cultivars.

2. Materials and Methods

Kaohsiung No. 139 and Taikeng No. 16 are one of the recommended rice cultivating in Southern Eastern Taiwan, respectively, purchased from certified Organic Farmers Market in Taichung from 2009 to 2011. Similarly, conventionally grown rice in neighborhood of similar zones collected to minimize variable errors of study. The samples were collected twice a year as First Crop and Second crop season (harvested at

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June/July and November/December, respectively) in Taiwan. The rice kept under storage for 4 months and later analysis conducted to estimate antioxidant properties. The powdered rice was sieved through 20-mesh sieves prior to analysis and rice powder (2 g) was extracted with 80% ethanol (25 ml) which was modified version of Adom and Liu [5] and Zhou *et al.* [6] by varying extraction steps. The extracts obtained were used for the determination of total phenolic compound and antioxidant activities. Total phenolic compound of rice extracts was determined according to the Folin-Ciocalteu method [7]. Antioxidant activities of rice extracts including DPPH radical scavenging activity [8], Reducing power [9], Metal chelating capacity [10] and Flavonoid content [11], were also determined. Gallic acid and Quercetin acid were used as standard and total phenolic content was calculated and expressed as mg Gallic Acid equivalent per 100 g sample (mg GAE/100 g sample).

3. Results and Discussion

In the present study, the phenolic compound and antioxidant activities were not influenced by agronomic practices or environmental factors. It was demonstrated that except DPPH and ferrous chelating activity (Table 1), environmental factors in interaction with genotypes can alter the production of secondary metabolites in crops to a greater extent than a single factor. Some of the studies in other cereal grains, like oat have also described that the secondary metabolites were prominently guided by genetical properties. Also, it shown no differences in phenolic compounds (hydroxycinnamic acids), if there is any changes in cropping systems from conventional to organic farming or in N rates [12].

Table 1: Analysis of variance for total phenolic compounds and antioxidant activities of two rice cultivars grown at organic and conventional agriculture in 2 seasons.

Source	df	Mean squares[a]				
		Total phenolic compound	Reducing power	DPPH	Flavonoid	Ferrous chelating
season (S)	3	478.52c (0)	0.00018 (0)	1026.62 (4.5)	86.69 (0) ns	140.69 (0)
treatment (T)	1	257.15 (0) ns	0.00003 (0) ns	181.74c (1.4)	18.38 (0) ns	1434.45 (13.8)
cultivar (C)	1	8815.63 (40.6)	0.00028 (0)	769.60 (0)	740.26b (25.2)	5808.0 (67.6)
*S*T*	3	2793.44 (23.7)	0.00002 (0) ns	115.36c (6.6)	79.73 (0) ns	333.34 (7.5)
*S*C*	3	1141.69b (10.4)	0.00055(46.1)	866.74 (68.5)	170.82c (0.7)	52.57c (0)
*T*C*	1	50.64 (0) ns	0.00036 (7.2)	2.34(0) ns	106.51 (0) ns	117.19d (0.9)
*S*T*C*	3	405.64c (8.8)	0.00018 (33.7)	44.99 (0) ns	210.55d (24.5)	107.12b (6.3)
Error	32	135.08 (16.5)	0.00001 (12.9)	37.52 (19.0)	50.12 (49.6)	14.02 (4.0)
CV %		7.04	13.19	16.83	37.60	9.11

[a]All mean squares are significant at 0.0001 probability levels, except b, c and d at 0.001, 0.05 and 0.01, respectively. NS-non significant at P ($\leq$ 0.05); values in parentheses are percent variance components.

However, the effect of farming system on rice extraction solvents as total phenolic content and antioxidant activity are shown in Table 2, respectively. Generally, total phenolic compound and reducing power of conventionally grown rice were slightly higher than those extracts of organic rice. But statistically, results found insignificant among the values and TPC content established as genetic trait irrespective of farming system. From the result, the study also demonstrated that organically grown rice cultivars had potential for producing secondary metabolites similar to conventionally grown rice crops. Also, organic rice had highest ferrous chelating%, DPPH radical scavenging activity and flavonoid content among both farming systems ($P \leq 0.5$). Brett *et al.* [13] claims that cinnamic acids are stress metabolites in cereal plants, and thus organic farming has a higher content due to its higher (risk for) stress by nutrient deficiency or pests/pathogens. Smaller kernels caused by lack of available nutrients would give a higher concentration in organic oats also, because there would be a "dilution effect" in larger, conventional oat kernels [12].The total phenolic compound of organic rice was 162.7 mg GAE/100 g and above antioxidant activities can be increased up to 31% when rice cultivated under organic farming.

Table 2: Phytochemicals of rice cultivars (mean values of 2 years) as affected by treatments (conventional or organic).

Properties	Treatment	
	Organic	Conventional
Total phenolic content (mg GAE/100g fw)	162.7a	167.4a
Reducing power (abs. reading)	0.025a	0.027a
DPPH(%)	38.4a	34.5b
Flavonoid (mg QAE/g fw)	19.4a	18.2a
Ferrous chelating (%)	46.6a	35.6b

Values for each parameter followed by a different letter within each row are significantly different, $P \leq 0.05$ (Duncan's Multiple Range Test). Abs. = Absorbance; GAE = Gallic Acid Equivalent; QAE = Quercitin Acid Equivalent.

In another report, it was found that the enzyme activites of peroxidase and catalase increased under organic manure and combined inoculums of N-fixing bacteria compared to control (chemically fertilized plots) [14]. In a study of phenolic content in berries and corn grown under different agronomic practices, the ascorbic acid content (52.4%) and total phenolic compounds were higher (58.5%), in organically produce frozen corn than their corresponding conventionally grown samples [15]. The correlation coefficients among all of the secondary metabolites of the *Japonica* cultivars showed that TPC had a significant ($P \leq 0.0001$) positive correlation with DPPH and chelating activities (Table 3). So, it was determined the high polyphenolic content or any modifications, cause increment in the rice grain antioxidant activity in this study.

Table 3: Correlation coefficient (r) of Total Phenolic Compound and various antioxidant activities in rice grain.

Factors	Correlation coefficient (r)				
	Ferrous chelating	Flavonoid	DPPH	Reducing power	Total phenolic compound
Total phenolic compound	0.58****	0.39**	0.52****	-0.26 (ns)	1.00
Reducing power	-0.26 (ns)	-0.03 (ns)	-0.07 (ns)	1.00	
DPPH	0.52****	0.58****	1.00		
Ferrous chelating	1.00				

ns= values statistically non-significant at P > 0.05.
Probability values ***** = $P \leq 0.05$; ****** = $P \leq 0.01$; ******* = $P \leq 0.001$; ******** = $P \leq 0.0001$

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