Impact of Production Practices on Organoleptic Intensity Scale of Different Rice Cultivars

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Abstract: The purpose of this research was to relate mean organoleptic scores of organically and conventionally grown rice (n = 5) in *japonica* cultivars (Taikeng No. 16 and Kaohsiung No. 139). The 0-7 organoleptic scale is used in trials to measure the agronomic practices impact on sensory attributes of rice cultivars. However, the precise relationship between farming system and organoleptic analysis of rice remains independent variables. Judges (n = 10) used a common 0-7 scale to report the 6 sensory attributes *viz.* appearance, aroma, flavor, cohesion, hardness and overall acceptability while keeping cultivar Taikeng No. 9 as control. The scale ranges from – 3 to + 3 as very poor to excellent. The study demonstrates sensory attributes as inherited trait of rice; while no improvement found in cooking and eating quality under seasonal or agronomic variations. Interestingly, the aroma was reported as only better parameter when grown under organic farming compared to conventional farming (– 0.49 and – 0.62 over control, respectively). Also, the positive co-relationship exists between amylose content and organoleptic analysis while antagonistic link to crude protein content. The study cleared that management method, per se, did not influence any flavory attributes and detected no changes by the sensory panel. Further descriptive analysis needed with different conditions such as variety, degree of milling, growing location and moisture content which also played significant role in determining flavor and eating quality of rice cultivars.

Keywords: organic farming, sensory evaluation, cooked rice, eating quality.

INTRODUCTION

The rice grain qualities are measurable factors which indirectly indicated the crop growth environment and nutrient status of soil. Amylose, crude protein content and grain chalkiness are the participatory factors which in turn may influence the sensory properties of cooked rice also. The protein content of rice grains derived from translocation of accumulated plant nitrogen at flowering [1]. Hence, the rate and time of fertilizer application play crucial role in protein content of rice, nevertheless, the type of fertilizer use [2, 3]. It was timely reported that, organically grown rice cultivars found less protein content than conventionally grown rice grains due to lower nitrogen content of organic inputs. Low protein content of cooked rice found softer and difficult to chew than high protein rice [4, 5]. Sometimes, similar cultivar rice samples are also reported tasteful than those with high protein. However, a decrease in amylose content has been observed concurrent with an increase in protein content with nitrogen application or uptake [6]. Amylose, a predictor of cooked rice texture, is generally directly correlated with hardness or firmness [7-14].

The perceptions of sensory quality only by individual properties can biased or misclassify the rice classification. Therefore, the proper assessment and actual judgment could be only possible by a combination of sensory, physical and eating qualities. Consumers' acceptability of rice likely remains on the choice of hardiness and stickiness [15]. However, the overall acceptance of any rice largely varies geographically based on the preferences. Abundant information available on the influence of organic or mineral fertilization on the biological and nutritional quality of rice, however, few studies has been conducted for the comparative analysis of specific rice cultivars grown locally under these agronomic practices.

Among organic treatments, farmyard manure contributed the least in terms of protein content. The

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ISSN: 2223-3806 / E-ISSN: 1927-5951/15

study suggested that organic nutrient sources can perform comparatively well in terms of chemical and physico-chemical properties, and cooking quality of rice [3]. Also, higher amylose content and similar eating quality in organic Thai rice is possible despite of conventional practice [16].

Rice has an ability to utilize other N sources also as an advantage under competitive available N pool in the soil. The protein content of rice grains in organic practices increasingly develop, which attributed to the alternate availability of nitrogen supply as organic N that increases uptake [17, 18]. Keeping this view, our study focused on elaboration of relationship of different agronomic farming on the sensory properties of *japonica* rice.

MATERIALS AND METHODS

Rice Samples

Commercial milled rice Taikeng No. 9 (TK9) and Kaoshiung No. 139 (KSH139) available locally was purchased based on the specific agronomic practice (organic or conventional farming) from year 2009 to 2011. Cultivar TK9 and KSH139 are coarse grains rice popularly grown in Central Taiwan (Chiayi County) and Eastern Hualien County (Taiwan, ROC), respectively (*Appendix* 2 and 3). The procured organic rice samples were collected from established Organic Farmers market in National Chung Hsing University, Taichung. However, the conventional rice collected from the nearest neighboring farmers of similar location of organic farms. Rice cultivation taken twice a year during February to June (first crop) and August to November (second crop) in Taiwan and study included both seasons crop for 2 years.

No physical or biological contaminations were noticed during procurement and samples were stored in refrigerator at 4 degree centigrade in vacuum-packaged polyethylene pouches until further analysis.

General Chemical Analysis

Moisture, protein, fat, crude fiber and ash were determined by American Association of Cereal Chemists [19] approved methods. Total carbohydrates were determined by difference.

Sensory Analysis of Cooked Rice

For analysis, rice grains of 20 g each sample rinsed three times thoroughly with water. Later, mixed with 42 g of water (in a ratio of 1:2.1) in 100 cc beaker and it was sealed with thin aluminum foil retaining at room temperature (22±2°C) for soaking. Thirty minutes later, randomly 4 samples were kept in an automatic rice cooker (TAC-IOH Tatung Co.), followed by 10-min holding period [20]. Rest of the samples were treated same. For sensory analysis, cooked rice samples (including Taikeng No.9 used as the control) were served in a plate, and results recorded in specially designed data sheet by 10 experienced panelists who were trained in the principles and concepts of descriptive sensory analysis [20]. Degree scales of 7 points range from +3 to -3 were used to evaluate the

Table 1: F-Values of Sensory Panel Score of Rice Cultivars Influenced by Agricultural Practice in Two Crop Seasons

Parameter	Appearance	Aroma	Flavor	Cohesion	Hardness	Overall
Organic	-0.72b	-0.49a	-0.59a	-0.64a	0.40a	-0.66a
Conventional	-0.58a	-0.62b	-0.55a	-0.59a	0.49a	-0.60a
F-values						
Properties	****	****	****	****	****	****
season (S)	ns	ns	ns	*	ns	ns
treatment (T)	****	***	ns	ns	ns	ns
cultivar (C)	****	****	****	****	****	****
*S*T*	****	****	****	****	**	****
*S*C*	****	****	****	****	****	****
*T*C*	ns	****	***	**	****	ns
*S*T*C*	****	****	****	****	****	****

Values for each parameter followed by a different letter within each row are significantly different, $P \leq 0.05$ (Duncan's Multiple Range Test). Rating evaluated by sensory panelists in comparison with rice cultivar Taikeng No.9 which cultivated in chemical farming, as a Control. Where '+, 0 and –' denote ratings higher, equal to, and lower than the control, respectively. ns = values statistically non-significant ($P > 0.05$). * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$; **** = $P \leq 0.0001$.

intensity of each sensory attributes (very poor = -3, excellent = +3) (*Appendix* 1).

RESULTS AND DISCUSSION

It was concluded from the findings that cooking and eating quality of rice is inherited property and significantly influenced among rice cultivars (Tables **1** to **3**) only. No changes reported under different agronomic practices or cultivation period (Tables **1** & **2**). However, an improvement in aroma is quite possible if rice grown under organic farming (Table **1**).

Earlier long term study suggested better eating quality as much stickier if rice grown under organic farming. Also the pasting properties such as peak viscosity and breakdown can improve eating qualities [21]. Our research findings had contrary results, as organic rice has no changes in breakdown and cohesiveness values (data not shown) but reported lower than their conventional counterparts.

Except the grain hardness, the analysed cultivars categorized as 'poor quality' comparatively to Taikeng No.9 (control) as average scores was found inferior (Tables **1** to **3**). But, among the cultivars Kaohsiung No. 139 (KSH-139) had better eating quality than Taikeng No. 16. The grain hardiness influenced positively under TK-16 cultivar, spring crop as well as conventionally grown rice. It has been attributed by amylose, as indirect precursor of cooked rice texture, which is directly related to hardness and grain firmness [22], which was in agreement to our studies also. The pasting properties such as setback values and cooked rice hardiness have negative interaction in our study, which on contrary to earlier agreements [23, 24]. Negative interaction between two properties might be attributed to growing conditions and genotypic difference of cultivars. Significant higher protein content was reported in our further studies in conventionally grown rice than organic rice [25] which might attributed to overall hardness in conventional produce, whereas high temperature during grain filling stage cause the low moisture content of rice that increase hardness of spring crop than fall season. Lower content of amylose in organic rice and higher springiness brings the soft

Table 2: Sensory Panel Score of Rice Cultivars (Mean Values of 2 Years) in Two Different Crop Seasons

Properties	Seasons	
	Summer	Winter
Appearance	-0.74a	-0.55a
Aroma	-0.62a	-0.50a
Flavour	-0.69a	-0.45a
Cohesion	-0.74a	-0.49a
Hardness	0.46a	0.43a
Overall	-0.75a	-0.52a

Rating evaluated by sensory panelists in comparison with rice cultivar Taikeng No.9 which cultivated in chemical farming, as a Control. Where '+, 0 and –' denote ratings higher, equal to, and lower than the control, respectively. Values for each parameter followed by a different letter within each row are significantly different, $P \leq 0.05$ (Duncan's Multiple Range Test).

Table 3: Sensory Panel Score of Rice Cultivars (Mean Values of 2 Years) as Affected by Treatments (Conventional or Organic)

Properties	Cultivars	
	TK-16	KSH-139
Appearance	-0.99b	-0.31a
Aroma	-0.93b	-0.18a
Flavor	-0.85b	-0.29a
Cohesion	-0.91b	-0.32a
Hardness	0.58a	0.32b
Overall	-0.95b	-0.31a

Rating evaluated by sensory panelists in comparison with rice cultivar Taikeng No.9 which cultivated in chemical farming, as a Control. Where '+, 0 and –' denote ratings higher, equal to, and lower than the control, respectively. Values for each parameter followed by a different letter within each row are significantly different, $P \leq 0.05$ (Duncan's Multiple Range Test).

Table 4: Correlation Coefficients between Chemical Properties of Milled Rice and Palatability after Various Fertilization Methods on the First and Second Crop in 2009-10

Factors	Correlation coefficient (r)					
	Appearance	Aroma	Flavor	Cohesion	Hardness	Overall
Spring.	-0.09 (ns)	0.03 (ns)	-0.04 (ns)	- 0.10 (ns)	-0.38**	-0.09 (ns)
Amyl.	0.52***	0.48***	0.49***	0.53***	-0.30*	0.52***
C.P.	-0.26*	-0.28*	-0.34*	-0.36**	0.46***	-0.31*
G.C.	-0.13 (ns)	-0.22 (ns)	-0.23*	-0.27*	0.11 (ns)	-0.24*

Amylose = Amyl; Crude Protein = C.P.; Gel consistency = G.C.; ns= values statistically non-significant at P ≤0.05. ***** = P ≤0.05; ******* = P ≤0.0001; ****** = P ≤0.001.

starch of rice compared to conventional samples. Higher content of protein tends to less swelling of starch grain by forming a gel layer surrounding the grain and let absorb less water for swelling, while comparatively enhanced the hardness. Other studies have contrary results, higher cohesiveness and hardness of conventionally grown rice with better score for eating quality compared to organic rice [26]. It was found that cultivars grown in organic have low overall acceptability as compared to conventional practice that in agreement with previous studies of rice [27], but contrast results found in our study related to seasonal and genotypic analysis.

Chemical compositions of rice grain affect the cooking quality and found high amylose cultivars are basically firmer and less sticky when cooked than low-amylose cultivars [28]. However, our study shown contrary results that higher amylose content in different parameters of study as conventional farming, second crop and KSH-139 presented higher cohesiveness than above theory. It might be attributed to milling degree of collected samples in different practices. Higher milling degree increase the amylose content but decrease the protein content as removal of bran layer which attributed the restriction of moisture migration in rice kernels during cooking [29].

Overall acceptance of tested samples were not significantly different (P>0.05) due to external factors (season and farming). This parameter may be influenced by other quality parameters, as solely changes in any eating quality parameters may not provide significant impact on the overall acceptance [24].

Experimental results revealed that the amylose content of milled rice was negatively correlated with cooked rice hardness but positively correlated with overall sensory score of palatability (Table **4**). Positive correlation of amylose content with aroma and flavor was also finding in earlier studies of various rice genotypes [30]. The crude protein content of milled rice was negatively correlated with cohesiveness, aroma and overall palatability of cooked rice, but found positive correlation with hardness of cooked rice. Results are in agreements with previous studies of physicochemical properties of rice under organic farming [22, 31]. Similarly, protein content was weakly, negatively correlated with stickiness, and positively correlated with roughness of rice [32]. Also, higher N content of rice grain can influence the sensory characteristics and cause inverse relation with the aroma, stickiness and softness of cooked aromatic rice [33, 34]. Also, gel consistency and springiness have found negative correlation with sensory parameters which was in contrary findings to the Lee *et al.* [31].

In general, differences in pasting and physicochemical properties of diverse cultivars grown conventionally and organically were attributed to differences in protein content. However, it was clear from results that management method, per se, did not influence any flavory attributes and detected no changes by the sensory panel. Further descriptive analysis needed with different conditions such as variety, degree of milling, growing location and moisture content which also played significant role in determining flavor and eating quality of rice cultivars [35]. Thus, processors who purchase organic rice can be assured that there will be no negative impact on functionality but higher aroma content will be find which associated with reduced protein content, presumably due to reduced nitrogen uptake [22].

ACKNOWLEDGEMENT

We are so grateful to Dr. Madhu Sharma and Dr. Sachin Kumar Vaid for developing the article and suggestions to improve the article. Also like to thanks Professor Chen for contributing their valuable suggestions and guidance during research.

APPENDIX

Appendix 1: Taste Panel Test Score for Rice Grading

Item	Scale[1]						
	+3	+2	+1	0	-1	-2	-3
Appearance	excellent	better	good	as control	poor	poorer	Very poor
Aroma	excellent	better	good	as control	poor	poorer	Very poor
Flavor	excellent	better	good	as control	poor	poorer	Very poor
Cohesion	excellent	better	good	as control	poor	poorer	Very poor
Hardness	excellent	better	good	as control	poor	poorer	Very poor
Overall in sensory evaluation	excellent	better	good	as control	poor	poorer	Very poor

[1]Where +, 0 and – denote ratings higher, equal to, and lower than the control (Taikeng No. 9), respectively.

Appendix 2: Detail of Physiochemical Properties of Cultivar TK-16 Rice Collected from Farmer's Market and Field

Properties of white rice	Taikeng No. 16	
Nutritional value (per 100 g)	Conventional	Organic
Calories (kcal)	355	354
Protein (g)	5.2	4.9
Fat (g)	1.3	1.2
a. saturated (g)	0.5	0.4
b. unsaturated (g)	0	0
Carbohydrate (g)	78.6	80.9
Sodium (mg)	4	4

Appendix 3: Detail of Physiochemical Properties of Cultivar KSH-139 Rice Collected from Farmer's Market and Field

Properties of white rice	Kaohsiung No. 139	
A. permissible limit	Conventional	Organic
Shape	Short and bold	Short and bold
Moisture (%)	14.5	14.5
Foreign particles (%)	0.2	0.1
Bran (%)	0	0
Brown rice (%)	0	0
Heat damaged kernels (%)	0.3	0.1
Damaged kernels (%)	2	1
Off-type kernel (%)	3	1
Broken kernel (%)	10	5
Chalky kernel (%)	10	5
Non-opaque waxy kernel (%)	-	-
B. Nutritional value (per 100 g)		
Calories (kcal)	356	349.7
Protein (g)	6.8	5.3

Fat (g)	1.3	0.5
a. saturated (g)	0.3	-
b. unsaturated (g)	0	-
Carbohydrate (g)	75.5	81.1
Sodium (mg)	4	12.3

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Received on 23-03-2015 Accepted on 13-04-2015 Published on 12-05-2015

DOI: http://dx.doi.org/10.6000/1927-5951.2015.05.02.3