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Physicochemical properties of organic and inorganic Phatthalung Sungyod rice

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Abstract: Rice from different cultivation systems, organic and inorganic rice, were growth and harvested from Phatthalung province, the Southern Thailand. The difference in their physicochemical properties was determined. Inorganic rice (1.44 g/100 grains) showed significant higher ($P<0.05$) in rice grain weight compared with organic rice (1.42 g/100 grains). Different cultivation system has profound effects on physicochemical properties of rice. Inorganic rice showed significantly higher ($P<0.05$) in protein, lipid and amylose content than organic rice. Protein, lipid, amylose and anthocyanin content of organic rice were 5.64% (db), 2.48% (db), 15.32% (db) and 14.66 mg cyanidin-3-glucoside/100 g (db), respectively. Protein, lipid, amylose and anthocyanin content of inorganic rice were 7.02% (db), 2.59% (db), 16.27% (db) and 15.60 mg cyanidin-3-glucoside/100 g (db), respectively. Both of organic and inorganic rice showed type-A of X-ray diffraction pattern. In addition, the small difference in crystallinity of organic and inorganic rice was observed. The swelling power of organic and inorganic rice was 13.14 and 13.02 g/g (db), respectively. Peak viscosity of inorganic rice (118.62 RVU) is significant higher ($P<0.05$) than organic rice (116.88 RVU) when studied with RVA. The enthalpy of gelatinisation of organic and inorganic rice was 8.08 and 8.01 J/g, respectively.

Keywords: Organic rice, Phatthalung Sungyod rice, physicochemical

Introduction

Recently, organic agricultural practices have grown considerably as an alternative to conventional agriculture and related use of chemical pesticides. It was expected that the organic agriculture has benefits with respect to food safety (Champagne *et al*., 2007). Many consumers prefer organic food to inorganic foods because they are perceived healthier. In addition, organic practices are thought to reduce the risk of plant infection by pathogens. However, there is some evidence that the reduced use of fungicides may lead to a greater contamination by mycotoxins in organic food (Finamore *et al.*, 2004). The organic rice cultivation system is a production of rice without the use of chemicals to control pests, moreover, no chemical fertilisers are used. These are inversely with inorganic rice cultivation system. The difference in cultivation systems affected on physicochemical properties and sensory quality of rice as reported by Champagne *et al.* (2007).

Phatthalung Sungyod rice is a local rice variety and has long been known in Phatthalung province, Southern part of Thailand. It is mostly cultivated in Phatthalung province (Phatthalung Rice Research Centre, 2005). The cultivation systems of Sungyod rice in Phatthalung province can be seen in both organic and inorganic systems. By using of different types of fertiliser and agricultural practices will be affected the amylose, protein and mineral contents in rice. Protein content in rice is markedly influenced by time and rate of nitrogen fertiliser applied and type of fertiliser used (Champagne *et al*., 2007). Therefore, the present study was to determine the difference in physical, chemical and physicochemical properties between organic and inorganic Phatthalung Sungyod rice.

Materials and Methods

Materials

Two different rice cultivation systems, organic and inorganic rice, were growth and harvested in Phatthalung province, in the Southern Thailand, in the 2008/2009 growing season. After harvested, paddy rice was dehydrated by sun light approximately 7 days as the commercial method. Before analysis, rice grain was ground to give rice flour able to pass a 40-60 mesh sieve (420-250 µm).

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Grain size

Ten of rice grain were collected randomly and measured for the length and the breadth in each replicate. The L/B ratio was calculated as the length divide by the breadth. The measurement of rice grain size was performed in triplicates (Wadsworth *et al*., 1982).

Grain weight

In each replicate, one hundred of rice grain was counted randomly and weighed. The measurement of rice grain weight was performed in triplicates (Wadsworth *et al*., 1982).

Colour

Rice grain was placed in a clear petri dish and measured colour by colourimeter (Hunter Lab Reston, VA, USA) in CIE L*, a*, b* colour space.

Chemical properties

Proximate analysis of organic and inorganic rice samples, such as, moisture, lipid, protein, ash contents and including free fatty acid (FFA) were determined according to A.O.A.C. method (A.O.A.C., 2000). Amylose content was determined by iodine colourimeter at 620 nm using amylose from potato starch as a standard mixture (Juliano *et al*., 1985). Thiobarbituric acid (TBA value) was determined as described by Woods and Aurand (1977). Anthocyanin content of brown rice was determined according to the method of Nollet (1996). Water activity (a_w) was determined using a water activity meter (Novasina, Thermostanter).

Swelling power and water solubility

Rice flour (0.5 g, db) was weighed directly into a centrifuge tube and added 15 ml distilled water. Swelling power and solubility of rice starch were determined at different temperatures (55, 65, 75, 85 and 95°C) by placed the centrifuge tube in water bath for 30 min. The tube was then centrifuged at 2,200×g for 15 min at room temperature. The supernatant was removed and sediment was weight. The supernatant from swelling power determination was dried to get a constant weight in a hot air oven at 105°C. The swelling power and water solubility index of rice starch were calculated as described by Schoch (1964).

Pasting properties

The pasting properties of the rice flour were determined with a rapid visco-analyser (Scientific Newport, RVA 4D, Australia) as described by Zhou *et al*. (2003). Rice flour sample (3.0 g, db) was mixed with 25 ml of distilled water in a RVA canister, then, the mixture was stirred at 960 rpm and changed to 160 rpm. The mixture was held at 50°C for 1 min and then heated to 95°C at the rate of 12°C/min. The sample was subsequently held at 95°C for 2.5 min. This was followed by cooling down to 50°C at the rate of 12°C/min and kept at this temperature for 5 min. A plot of the pasting viscosity in arbitrary RVA unit (RVU) versus time was used to determine the peak viscosity (PV), temperature at peak viscosity (P_{temp}), trough final viscosity (FV) and setback viscosity (SBV).

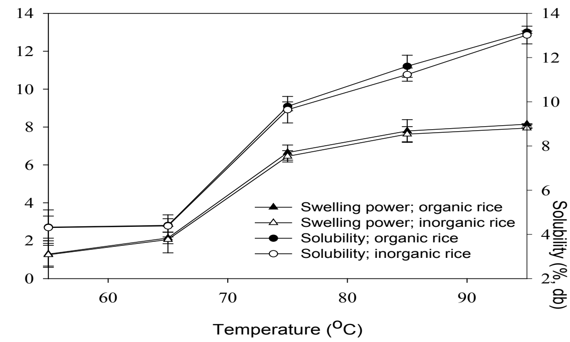

Figure 1. Swelling power and solubility of organic and inorganic rice

Thermal properties

The thermal characteristic of the rice flour was studied using a differential scanning calourimeter (DSC) model DSC 7 (Perkin Elmer, USA). Two milligrams of rice starch (dry basis) was weighed into aluminum pan and 6.0 mg of distilled water was added using micro-syringe. The aluminum pan was sealed and equilibrated at room temperature for 2hr, then, heated from 30 to 100°C at the heating rate 10°C/min to determine the gelatinisation enthalpy and temperature. Onset temperature (T_o), peak temperature (T_p), conclusion temperature (T_c) and enthalpy of gelatinisation (ΔH_{gel}) was calculated automatically (Teo *et al*., 2000).

X-ray diffraction by XRD

Rice starch sample was subjected to the X-ray diffractometer to determine the crystalline peaks. The operation conditions are CuKα radiation (λCu = 1.5406), voltage 40 kV, and current 30 mA. The scanning angular (2θ) is ranges between 4.0-40.0° at a scan rate 0.5°/min (Kim *et al*., 2001).

Statistical analysis

Data was subjected to analyse of variance. Comparison of means was carried out by Duncan's multiple-range test. Analysis was performed using a SPSS package (SPSS 11.0 for windows, SPSS Inc, Chicago, IL).

Table 1. Physical properties of organic and inorganic Phatthalung Sungyod rice

Physical properties	Rice cultivation system	
	Organic rice	Inorganic rice
Grain size		
Length (cm)	0.61±0.01[a]	0.62±0.01[b]
Breadth (cm)	0.16±0.01[a]	0.17±0.01[b]
Length/Breath (L/B)	3.68±0.12[a]	3.60±0.14[b]
Grain weight (g/100 grains)	1.42±0.01[a]	1.44±0.01[b]
L*	37.22±0.05[a]	37.46±0.08[b]
a*	12.32±0.04[a]	12.16±0.11[a]
b*	20.04±1.11[a]	20.07±0.18[a]

Means with the same letter in the same row are not significantly different ($P \geq 0.05$).
Data are reported as means ± SD (standard deviation) for 3 determinations

Table 2. Chemical properties of organic and inorganic Phatthalung Sungyod rice

Chemical properties	Rice cultivation system	
	Organic rice	Inorganic rice
Moisture (%)	11.27±0.03[a]	11.26±0.03[a]
a_w	0.68±0.01[a]	0.69±0.01[a]
Ash (%, db)	1.88±0.03[a]	1.86±0.02[a]
Lipid (%, db)	2.48±0.08[a]	2.59±0.08[b]
Protein(%, db)	5.64±0.08[a]	7.02±0.04[b]
FFA (%, db)	3.69±0.05[a]	3.67±0.03[a]
TBA (mg/kg, db)	0.33±0.03[a]	0.38±0.02[a]
Amylose (%, db)	15.32±0.03[a]	16.27±0.04[b]
Anthocyanin (mg cyanidin-3-glucoside/ 100g, db)	14.66±0.53[a]	15.60±0.07[b]

Means with the same letter in the same row are not significantly different ($P>0.05$).
Data are reported as means ± SD (standard deviation) for 3 determinations.

Results and Discussion

Physical properties

The difference in physical properties of rice grain between organic and inorganic Phatthalung Sungyod rice, such as, rice grain size, weight and colour was observed. The results are shown in Table 1. Inorganic rice grain gave the higher in grain length and breadth than organic rice. The length and breadth of organic rice grain are 0.613 and 0.167 cm, respectively. The length and breadth of inorganic rice grain are 0.623 and 0.173 cm, respectively. There was a significant difference ($P<0.05$) in rice grain weight between organic and inorganic rice. A hundred grain weight of organic and inorganic rice after dehydrated was 1.4226 and 1.4437 g, respectively. It related with the study of the difference between conventional and organic paddy fields in irrigated rice ecosystem was reported by Lawanprasert *et al*. (2007). They have reported that rice yield of conventional method was the highest followed by the organic and the natural methods. The rice yield of the organic method was lower than that of conventional method, the difference in rice yield between these two methods appeared to be relatively small (Lawanprasert *et al.*, 2007).

Organic and inorganic Phatthalung Sungyod rice show a similarly grain colour. By using colourimeter, L*, a* and b* values of organic rice grain are 37.22, 12.32 and 20.04, respectively. L*, a* and b* values of inorganic rice grain are 37.46, 12.16 and 20.07, respectively.

Chemical properties

Chemical compositions of organic and inorganic Phatthalung Sungyod rice grain are shown in Table 2. The inorganic rice showed significantly higher in protein, lipid, amylose and anthocyanin content than the organic rice cultivar ($P<0.05$). Rice lipids, which are predominantly triacylglycerides, are usually divided into free and bound lipids. It is most concentrated in the aluerone layers. The endosperm contains only a fraction of the total lipid content (Juliano, 1985). From this study, inorganic rice showed a significant higher in lipid content than organic rice ($P<0.05$). Lipid content of organic and inorganic rice was 2.48 and 2.59% (db), respectively. Protein is an important source of nutrition. Rice protein has significant influence on the structural, functional and nutritional properties of rice. It is a major factor in determining the texture, pasting and sensory characteristic of rice (Juliano, 1985; Teo *et al.*, 2000). From this study, organic rice showed lower in protein content when compared with inorganic rice. The total protein content of organic and inorganic rice was 5.64 and 7.02% (db), respectively. The amylose content of organic and inorganic rice is approximately 15 and 16% (db), respectively. FFA and TBA values had significantly affected by rice cultivation systems ($P<0.05$). Inorganic rice showed considerably higher in FFA and TBA values than organic rice. From these results, FFA and TBA values were responded from lipid hydrolysis. The lipid hydrolysis is initiated by the action of lipases. The reactions occur principally in the outer layer of the rice kernel where lipids are concentrated. Dehulling rice disrupts these outer layers, lipids diffuse and makes contact with the lipases and hydrolysis of lipids to fatty acids begins. Microbial also produced lipases located on the kernel surface also come in contact with kernel lipids (Dhaliwal *et al.*, 1991; Deka *et al.*, 2000; Nishiba *et al.*, 2000). Inorganic rice showed significantly higher in anthocyanin content when compared with organic rice. Anthocyanin content of organic and inorganic rice was 14.66 and 15.60 mg cyanidin-3-glucoside/100 g (db), respectively ($P<0.05$).

Swelling power and water solubility

Swelling and solubility are phenomenon when starch is heated in excess water, the crystalline structure is disrupted due to the breakage of hydrogen bond, and water molecule become linked by hydrogen bonding to the exposed hydroxyl group of amylose

Table 3. Pasting properties of organic and inorganic Phatthalung Sungyod rice

Pasting properties	Rice cultivation system	
	Organic rice	Inorganic rice
PV (RVU)	116.88±0.93[a]	118.62±0.58[b]
P_{temp}(°C)	82.40±0.90[a]	82.92±0.36[a]
FV (RVU)	243.61±1.38[a]	247.72±0.90[b]
SBV (RVU)	123.65±3.16[a]	129.93±0.61[b]

Means with the same letter in the same row are not significantly different (P≥0.05).
Data are reported as means ± SD (standard deviation) for 3 determinations.

Table 4. Thermal properties of organic and inorganic Phatthalung Sungyod rice

Thermal properties	Rice cultivation system	
	Organic rice	Inorganic rice
T (°C)	73.61±0.23[a]	75.29±0.05[b]
T^{o}(°C)	79.33±0.18[a]	79.16±0.07[a]
T^{p}(°C)	83.69±0.21[a]	83.83±0.21[a]
ΔH_{gel}(J/g, db)	8.08±0.04[a]	8.11±0.03[b]

Means with the same letter in the same row are not significantly different (P≥0.05).
Data are reported as means ± SD (standard deviation) for 3 determinations

and amylopectin (Yeh and Li, 1996). Swelling power and solubility of rice flours were determined by heating rice flour slurry at 55, 65, 75, 85 and 95°C for 30 min. The results are shown in Figure 1. Swelling power of both organic and inorganic rice increased as increasing heating temperature. Nevertheless, organic rice showed significantly higher in swelling power as compared with inorganic rice flour (P<0.05). Champagne *et al*. (2004) reported that protein in rice flour plays a significant role in determining the functional properties of the starch and protein bring about an inhibitory effect on the swelling of rice starch granules. The solubility of organic and inorganic rice showed the same trend as swelling power. It was increased as increasing temperature.

Pasting properties

Pasting properties for both organic and inorganic rice cultivation system are shown in Table 3. There was a significant different effect on RVA pasting properties of both rice cultivation systems (P<0.05). Organic rice showed the lower in peak viscosity when compared with inorganic rice. Peak viscosity of organic and inorganic rice was 116.88 and 118.62 RVU, respectively. Pasting, gelatinisation may be influenced by the presence, orientation and nature of surface lipids and proteins. Proteins are rich in basic amino acid and are intrinsically hydrophilic. For instant, changes at the granule could contribute to a decrease in hydrophilicity that would affect granule hydration and swelling (Sowbhagya and Bhattacharya, 2001).

Thermal properties

Thermal properties of organic and inorganic rice are shown in Table 4. They showed the difference in onset temperature (T_o), peak temperature (T_p), conclusion temperature (T_c) and enthalpy of gelatinisation (ΔH_{gel}) as measured using DSC.

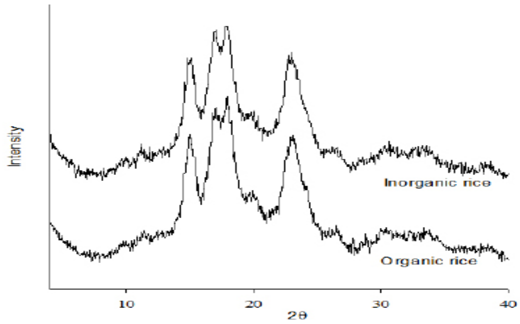

Figure 2. X-ray diffractogram of organic and inorganic rice

Inorganic rice showed higher in transition temperature, such as, onset temperature, conclusion temperature and enthalpy of gelatinisation than organic rice. The enthalpy of gelatinisation of organic was higher than inorganic rice. Sodhi *et al*. (2003) suggested that the difference in thermal properties of rice flour might be attributed to the differences in composition in rice starch and rice flour as well as environmental conditions. The higher in gelatinisation enthalpy of rice after ageing may also be due to the differences in amylose, lipid and protein contents. The formation of intermolecular covalent disulphide crosslinks made the proteins less soluble and less prone to bind with other flour constituents such as starch.

X-ray diffraction

X-ray diffraction pattern of starch from organic and inorganic rice cultivars are shown in Figure 2. They showed the same pattern of diffractogram, type-A pattern, which it is a typical of cereal starches. Their diffractogram showed the peaks at 15.2, 17.0, 17.9 and 22.9 Å. Organic and inorganic rice showed a small difference in their crystallinity. The crystallinity of organic and inorganic rice starch was 38.74 and 39.93%, respectively. A higher degree of crystallinity provides structural stability and makes the granule more resistant toward gelatinization. The high transition temperature is mainly resulted from this reason (Barichello *et al*., 1990; Yang *et al.*, 2005). Moreover, Tester (1997) has postulated that the extent of crystalline is reflected in the gelatinization temperatures, and amylopectin plays a major role in crystallinity.

Conclusion

There are differences in some properties of both rice cultivation systems, organic and inorganic rice. Inorganic rice gave greater in rice grain size and weight. It showed higher value of some chemical compositions, such as, protein, lipid, amylose and anthocyanin contents. For physicochemical properties, inorganic rice showed a slightly difference in swelling power and solubility with organic rice at all heating temperatures. The gelatinisation temperature and enthalpy of inorganic rice was higher than organic rice. Both organic and inorganic rice showed the same pattern of X-ray diffraction, type-A starch. The significantly higher protein content of inorganic rice is a major factor affected the difference in rice quality.

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