EFFECT OF GAMMA IRRADIATION ON ANTHOCYANIN CONTENT AND RICE GROWTH RATE OF THAI COLORED RICE

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Thai colored rice cultivars can be classified into three types based on the color: Black, Purple or Red. Black and Purple rice cultivars have more anthocyanin content than does Red rice cultivars (Ratanamarno *et al.,* 2005; Pengkumsri *et al.,* 2015). Anthocyanins is the group of flavonoid compounds. In rice grains the anthocyanins content has variation in different variety of rice cultivars (Choi *et al.,* 2007; Shen *et al.,* 2009). Gamma ray is a, technique useful for inducing plant mutation. The reactive oxygen species (ROS) produced by gamma ray can cause DNA damage and create the mutation plant (Roldán-Arjona & Ariza, 2009; Qi *et al.,* 2015). In rice gamma ray caused some high bio-active compounds such as tocopherol content in rice mutant line than in native rice (Hwang *et al.,* 2014). The growth rate of rice is also caused by gamma irradiation (Sasikala & Kalaiyarasi, 2010; Sansenya *et al.,* 2017a). Moreover, in fragrant rice the higher aroma intensities in mutant rice are caused by gamma irradiation compared with native fragrant rice (Sansenya *et al*., 2017a; 2017b). This study was investigated the effect of gamma ray on the anthocyanin and the growth rate of Thai colored rice.

The ten Thai colored rice cultivars including Khao Nieow Gam, Khao Gum, Khao Nieow Dam, Khao Mali Nin, Khao Nieow Daeng, Khao Mali Daeng, Khao Nieow Dam Sakon Nakhon, Khao Glong Nin, Khao Man Bpoo and Khao Sangyod were obtained from a rice field in Thailand. The seed samples of all rice cultivars were subjected to gamma irradiation with the gamma dose at 0 Gy (control, non-irradiated), and 20, 40, 60, 80, 100, 150, 200, 250, 300, 500 and 1000 Gy. The anthocyanin content of non-gamma irradiated rice, and gamma-irradiated rice were determined with some modification method of Ranganna (1977).

The total anthocyanin content of 10 Thai colored cultivars were shown in Table 1. The highest values and lowest values of total anthocyanin content were obtained from Khao Gam (848.6083 ±17.0 mg/g) and Khao Nieow Daeng (4.2430±1.5 mg/g) respectively. The total anthocyanin content of black colored rice cultivars (Khao Nieow Gam, Khao Nieow Dam, Khao Glong Nin, Khao Mali Nin and Khao Gam) had higher than red colored rice cultivars (Khao Man Bpoo, Khao Nieow Daeng, Khao Mali Daeng, Khao Nieow Dam Sakon Nakhon and Khao Sangyod). According to the report of Pengkumsri *et al*. (2015) the Chiang Mai back rice has more anthocyanin content than Chiang Mai red and brown rice. For more observation, the suitable ratio of extraction solution (95% ethanol: 1% HCl) for anthocyanin extraction was varied in different rice cultivars. Among them, the ratio 2.5: 1.0 of 95% ethanol: 1% HCl seem to be more suitable than other ratio. Table 2 shows that the total anthocyanin content of gamma-irradiated rice was increased when compared to non-gamma irradiated rice except for the gamma-irradiated rice treated with 20, 40 and 60 Gy. At the gamma dose of 80 to 300 Gy the total anthocyanin content was increased approximately twice compared with non-irradiated rice. While at the gamma doses of 500 and 1000 Gy the total anthocyanin content was decreased, compared with gamma-irradiated rice treated with 80 to 300 Gy but still higher than in case of non-gamma-irradiated rice. The effect of gamma irradiation has been reported to affect the bio-active compounds of rice. Sansenya *et al*. (2017a; 2017b) reported that the 2-acetyl-1-pyrroline content and

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Table 1. Total anthocyanin content of 10 Thai colored rice cultivars in differences of ratio of 95% ethanol and 1% HCl

Rice cultivars	95% EtOH : 1% HCl	Total anthocyanin content (mg/g)
Khao Nieow Gam	0.5 : 1.0	451.4596±24.1^{j}
	1.0 : 1.0	471.8262±15.0^{j}
	2.5 : 1.0	467.5832±8.2^{j}
	7.0 : 1.0	325.0170±14.5^{k}
Khao Nieow Dam	0.5 : 1.0	571.1134±9.0^{gh}
	1.0 : 1.0	670.4005±28.0^{cd}
	2.5 : 1.0	633.9104±19.9^{ef}
	7.0 : 1.0	543.9579±43.3^{h}
Khao Glong Nin	0.5 : 1.0	23.7610±1.4^{lm}
	1.0 : 1.0	24.6096±1.5^{lm}
	2.5 : 1.0	30.5499±2.5^{lm}
	7.0 : 1.0	18.6694±1.5^{lm}
Khao Gam	0.5 : 1.0	718.7712±39.0^{b}
	1.0 : 1.0	708.5879±44.7^{bc}
	2.5 : 1.0	848.6083±17.0^{a}
	7.0 : 1.0	510.0136±10.6^{j}
Khao Man Bpoo	0.5 : 1.0	15.2749±2.5^{lm}
	1.0 : 1.0	16.9722±1.5^{lm}
	2.5 : 1.0	22.0638±1.5^{lm}
	7.0 : 1.0	18.6694±1.5^{lm}
Khao Nieow Daeng	0.5 : 1.0	5.9403±1.5^{m}
	1.0 : 1.0	4.2430±1.5^{m}
	2.5 : 1.0	9.3347±1.5^{lm}
	7.0 : 1.0	5.0916±1.5^{m}
Khao Mali Daeng	0.5 : 1.0	36.4902±1.5^{lm}
	1.0 : 1.0	35.6415±2.5^{lm}
	2.5 : 1.0	35.6415±2.5^{lm}
	7.0 : 1.0	23.7610±1.5^{lm}
Khao Nieow Dam Sakon Nakhon	0.5 : 1.0	16.1236±1.5^{lm}
	1.0 : 1.0	16.1236±1.4^{lm}
	2.5 : 1.0	16.9722±1.5^{lm}
	7.0 : 1.0	8.4861±1.5^{m}
Khao Sangyod	0.5 : 1.0	22.0638±1.5^{lm}
	1.0 : 1.0	24.6096±1.5^{lm}
	2.5 : 1.0	44.1276±3.0^{l}
	7.0 : 1.0	30.5499±2.5^{lm}
Khao Mali Nin	0.5 : 1.0	656.8228±15.5^{de}
	1.0 : 1.0	622.8785±28.6^{f}
	2.5 : 1.0	716.2254±61.1^{b}
	7.0 : 1.0	583.8425±37.8^{g}

Note: ± indicated the standard deviation of means (n=3). The same letter indicates no significant difference (Duncan, p>0.05).

Table 2. Effect of gamma irradiation on the anthocyanin content of the Thai colored rice cultivars (Khao Gam)

Gamma dose (Gy)	95% EtOH : 1% HCl	Total anthocyanin content (mg/g)
0	2.5 : 1.0	224.37±9.2^{i}
20	2.5 : 1.0	214.91±12.1^{j}
40	2.5 : 1.0	174.81±13.1^{k}
60	2.5 : 1.0	216.57±21.0^{j}
80	2.5 : 1.0	456.55±28.5^{f}
100	2.5 : 1.0	568.91±25.9^{a}
150	2.5 : 1.0	476.84±31.7^{e}
200	2.5 : 1.0	483.03±10.0^{d}
250	2.5 : 1.0	520.71±5.8^{c}
300	2.5 : 1.0	530.89±9.7^{b}
500	2.5 : 1.0	413.51±6.8^{g}
1000	2.5 : 1.0	313.51±6.8^{h}

Note: ± indicated the standard deviation of means (n=3). The same letter indicates no significant difference (Duncan, p>0.05).

Table 3. Effect of gamma irradiation on the rice growth rate of the Thai colored rice cultivars (Khao Gam)

Gamma dose (Gy)	Shoot length (cm)
0	1.83 ± 0.07^{h}
20	2.91 ± 0.20^{g}
40	5.22 ± 0.46^{a}
60	3.51 ± 0.07^{e}
80	3.05 ± 0.14^{f}
100	4.81 ± 0.36^{b}
150	4.07 ± 0.32^{d}
200	5.23 ± 0.29^{a}
250	4.75 ± 0.27^{b}
300	4.53 ± 0.32^{c}
500	0.51 ± 0.05^{i}
1000	0.23 ± 0.01^{j}

Note: ± indicated the standard deviation of means (n=6). The same letter indicates no significant difference (Duncan, $p > 0.05$).

GABA content could be stimulated by low gamma doses, while high gamma doses inhibited both bio-active compounds of rice. Table 3 shows that shoot length of gamma-irradiated rice significantly increased in all gamma doses except for gamma dose at 500 and 1000 Gy. The highest and lowest shoot length of gamma-irradiated rice were obtained from 200 Gy and 100 Gy, respectively. The shoot length of 200 Gy gamma-irradiated rice had approximately 2.9-fold and 22.7-fold higher than shoot length of non-gamma irradiated rice and 1000 Gy gamma-irradiated rice. For more observation, the low gamma doses seem to stimulate growth rate of rice, while the high gamma dose has inhibited the rice growth rate. Sansenya *et al*. (2017a) also reported the higher shoot length of Thai upland rice under low gamma doses. On the other hand, the terminate of growth rate of Thai upland rice has observed under high gamma doses.

The highest total anthocyanin content was obtained from Khao Gam. The total anthocyanin content and the growth rate of Thai colored rice (Khao Gam) were affected by gamma irradiation. The high gamma doses seem to stimulate total anthocyanin content and rice growth rate, while the high gamma doses inhibited the total anthocyanin content and rice growth rate.

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