行政院國家科學委員會專題研究計畫　成果報告

輻射照射糯米對米穀粉及其產品之影響

計畫類別：個別型計畫
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行政院國家科學委員會補助專題研究計畫成果報告

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執行單位：嘉南藥理科技大學餐旅管理系

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Abstract

Milled japonica cultivar, Taichung Waxy 70 (TCW 70), was exposed to gamma radiation with doses ranging from 0 to 2.0 kGy. The effects of gamma irradiation on waxy rice flour pasting properties and the qualities of its food product, mochi, were compared to the effects of storage. Doses ranging from 0.5 to 2 kGy can decrease the flour paste viscosity as those obtained after 6 months of storage. But the effect of gamma irradiation tenderized the texture of mochi was not as those obtained after 6 months of storage. It was shown the effects of gamma irradiation on shorting the waxy rice aging time and improving the processing stability and quality of rice products were not as good as the effects of 6 months storage.

Keywords: waxy rice; storage; gamma irradiation; quality; physical properties

1. Introduction

The food processing industry in Taiwan normally uses aged rice to make food products, such as rice curd, rice noodles, and leaven-rice cake (Huang et al. 1992). They use aged rice, which has been in storage for over half a year in order to improve the processing stability and obtain a better quality final products. This aging process takes up storage space and adds to the cost of ingredients. Besides, it increases the risk of insect or microbial damage to the rice. Gamma irradiation has been proved to be effective in reducing microbial growth (Hayashi, 1991; Kim, 2003; Lee, 2004; Roy et al., 1991; Wang et al., 1983; Wang et al., 1980) and increasing the shelf life of perishable foods (WHO, 1994). The prospects for the radiation disinfestations of rice in Taiwan with 1 kGy are very promising (Fu et al., 1985). Exposure to gamma radiation doses below 3 kGy on rice were found to have no effects on fat, starch, and protein content (Wang et al., 1980; Wu et al., 2004). The microstructure of the starch was modified by gamma irradiation (Wang et al., 2002; Cieśla et al., 1991; Grant and D'Appolonia, 1991; Sabularse et al., 1991). Starch pasting viscosities of wheat, corn and rice were reduced by gamma irradiation (Bao et al., 2001; Kang et al., 1996; Lee et al., 2003; Sabularse et al., 1992; Wu et al., 2002; Yi et al., 2004; Yi et al., 2000a,b). Viscosity measurement is a well established method for analytical identification of irradiated starch containing products (Bao and Xia, 1999; Hayashi, 1996; Hayashi et al., 1996; Yi et al., 2000b; Yi et al., 2004). Storage decreases rice flour pasting viscosity by increasing the disulphide bonds between protein networks (Martin and Fitzgerald, 2002). Although some researchers (Wu et al., 2002) predicted that the texture of cooked rice might be softened by gamma irradiation, its effect on the quality of the processed foods is still unclear. In previous research, gamma irradiation could be used for shortening the indica rice aging time and for improving the processed stability and quality of rice products (Sung, 2005). A hypothesis for this research was assumed that gamma irradiation could also be used to shorten the waxy rice aging process and to improve the processed stability and quality of waxy rice products.

For this research, it was also evaluated effect of gamma irradiation on retrogradation of waxy rice flour. Differences between the irradiated waxy rice and the conventional storage waxy rice have potential to clarify the changes of amylopectin in waxy rice after irradiation and storage.

2. Materials and methods

2.1 Raw material

Milled japonica cultivar, Taichung waxy 70 (TCW 70), were supplied by the

Excellent Farmers Association of R.O.C. They were harvested in the Chang Hua County area in July of 2005. Milled TCW 70 was separately sealed in 1 kg polyethylene (PE) bags. A part of the fresh rice was stored at room temperature for twelve months duration and the other part was used for gamma radiation treatment.

2.2 Gamma irradiation

The waxy rice was irradiated in the 1 kg bags at a 60-Cobalt source at room temperature (25℃) at the China Biotech Corporation (CBC) in TaiChung , Taiwan, R.O.C. The irradiation was carried out at a dose-rate of 1 kGy/hr to five doses (0.1kGy, 0.2kGy, 0.5kGy, 1.0kGy and 2kGy). Ceric-cerous dosimeters were used to measure the exact absorbed dose. All samples were stored at room temperature after irradiation.

2.3 Aerobic plate counts on milled waxy rice were conducted following the dry rehydratable film method (AOAC method 990.12)(AOAC, 1995). Colony forming units (CFUs) were counted to determine the CFUs per gram of milled rice sample following gamma irradiation.

2.4 Physicochemical properties and the composition of waxy rice flour

Waxy rice flour was prepared by wet-milling processes according to the methods of Lu and Lii (1989). TCW 70 was processed to form waxy rice flour after 0, 3, 6, 9, and 12 months storage for storage tested groups. All irradiated rice was made into waxy rice flour immediately for further tests. The lipid content, crude protein content, total starch, and pasting properties of rice flour were determined by following AACC standard methods (30-10, 46-30, 76-13, and 76-21)(AACC, 1995), respectively. Solubility and swelling power of waxy rice flours were evaluated at temperatures of 55, 65, 75, 85, and 95℃ following the method of Leach et al. (1959). Water binding capacities of flours and starch were evaluated at 25℃ by the procedure of Medcalf and Gilles (1965).

Gelatinization temperature and retrogradation of waxy rice flour were determined by a Differential Scanning Calorimeter (DSC 7, Perkin Elmer, Norwalk, Connectict, USA) using the procedure of Bao et al. (2004).

2.5 Preparation of mochi

Waxy rice flour (360g, dry basis) was mixed with 320g of water and 120g of sugar to form slurry. The slurry was covered in a stainless container and left to stand for 10 minutes at room temperature (25℃). The slurry was steamed for 20 minutes and then mixed with small table-model mixer (Habart Corp. Monterey Park, CA) with dough arm attachment at high speed for 5 minutes. The mochi was cooled to room temperature and cut into small pieces (15g each for sensory evaluation and three 55g pieces for the measurement of texture). The processing stability of the gelatinized slurry during mixing and processing was recorded.

2.6 The measurement of mochi texture and the firmness increase during storage

Mochi (55g) was rolled into ball shape. Firmness of mochi was tested by force in compression with the TA.XT 2i (Texture Technologies Corp, Scarsdale, NY) and a 15mm diameter cylinder probe. Texture Profile Analysis was conducted with a test speed of 2.0 mm/s. Calibration distance for the probe was 40.0 mm and the test strain was set at 50%. Stickiness of mochi was recorded from a maximum tension as the probe returned to original height. Three determinations were made per sample. All samples were stored at room temperature (25℃). Firmness data were collected for 3 days duration.

2.7 Sensory Evaluation of mochi

Mochi samples were served to 30 panelists to evaluate color, firmness, stickiness and overall scores. Thirty male and female students between the ages of 18 and 22 were participants on the panel. Panelists were instructed to evaluate each attribute using hedonic rating.

2.8 Statistical Analysis

A completely randomized block design was used with 3 replications per treatment with 3 sub-samples per replication. Data were analyzed by analysis of variance programs using the Statistical Package for the Social Sciences (SPSS Institute, 1999). Partial correlation coefficients were used to determine the relationship between factors at a 1% significance level (solubility swelling power, water binding capacity, parameters of RVA profile, thermal properties of rice flour, firmness and stickiness of mochi samples, sensory evaluation results). Least squares means were used to identify differences between treatments at a 5% significance level ($p<0.05$).

3. Results and discussion

3.1 Approximate composition of waxy rice flours

Table 1 lists the approximate compositions of milled Taichung Waxy 70 (TCW 70) rice flour. Although waxy rice flours have various moisture contents, all experiments were conducted at 14% moisture basis.

3.2 Effect of gamma irradiation on waxy rice

The aerobic plate counts per gram (CFUs/g) of all milled fresh waxy rice were less 100 (Table 2). These results might indicate that all fresh waxy rice is clean. The CFUs/g of fresh milled waxy rice seems not to be affected by gamma irradiation. Table 2 shows that the aerobic plate counts significantly increase within 1 year of storage. Doses ranging from 0.5 to 2.0 kGy seem reduce the aerobic plate counts of aged rice. The pasting viscosities of waxy rice in RVA changed after expose to gamma irradiation (Table 3). The parameters, PV, Break down, setback, and total setback of the RVA profile significantly decreased by 2 kGy of gamma irradiation (Table 3). High doses of gamma irradiation have been proven to decrease the viscosity of starch paste (Kang et al., 1999) and starch containing products (Hayashi, 1996; Hayashi et al., 1996). A dose of 2 kGy can decrease the peak temperature of waxy rice during gelatinization (Table 4). Results of waxy rice flours on water-binding capacity are shown in Table 5. A dose of 1kGy reduces the water-binding capacity of waxy rice flours (Table 5). Waxy rice flour undergoes a restricted swelling at high temperature (Table 5). The irradiated rice with 0.2-2.0 kGy shows to swell less at 95℃ than the untreated sample (Table 5). It seems imply that the associative forces within these irradiated rice represent a much wider range of bond strengths than those in untreated waxy rice flour. Solubility data for all rice flours at different temperature are presented in Table 6. In general, fresh waxy rice flour solubility increased with increasing temperatures (55℃ to 65℃), and the waxy flour rice solubility of the dose above 1kGy increased with increasing temperatures (55℃to 75℃) then all decreased solubility with increasing temperatures to 95℃ (Table 6). A possible reason for the decrease in solubility with increasing temperature in all waxy rice flours is that the coagulated protein matrix and gelatinized starch can prevent leaching of soluble material into water. Waxy rice exposed to gamma radiation had higher solubility than fresh rice. This indicates with gamma radiation more starch fragments will leach into water until those starch fragments are gelatinized.

Partial correlation analysis showed swelling power of irradiated rice significantly ($p<0.01$) related to solubility ($r=-0.91$ and -0.64) at 75℃ and 85℃, respectively. Higher swelling powers of rice flour at 75℃ and 85℃, produced lower solubility for the rice flours. Total setback of RVA profile test is positively related to the solubility of rice flour at 65℃ ($r=0.66$). Peak viscosity ($r=0.70$), breakdown ($r=0.83$), cool paste viscosity ($r=0.64$), total setback ($r=0.69$) of RVA profile test, and swelling power at 55℃ ($r=0.62$), significantly ($p<0.01$) positively related to the firmness increase of 2 days storage mochi. Solubility only significantly negatively ($r=-0.61$) related to onset temperature (To) of gelatinization among the DSC thermal properties of rice flour. Higher solubility of rice flour at 55℃, produced lower onset gelatinization temperature. The firmness increase of 2 days storage mochi is negatively related to the setback viscosity of RVA test ($r=-0.71$), and swell power at 55℃ is negatively related to the firmness of mochi sensory evaluation ($r=-0.69$). Rice flours which have higher water binding capacity will have higher swelling power at 55℃ ($r=0.92$), higher solubility at 65

℃ (r=0.75), and higher total setback (r=0.78) of RVA profile test (p<0.01). The higher water binding of rice flour, the higher its swelling power at 55℃, solubility at 65℃, and higher total setback viscosity of RVA test. Swelling power at 65℃ was strongly correlated to the firmness (r=0.73) and overall scores (r=0.71) of mochi sensory evaluation. The higher swelling power at 65℃, the higher its score of mochi sensory evaluation. This imply that the swelling power at 65℃ could be used as a indicator for mochi quality. Mochi had higher color (r=0.70) and firmness preference of sensory evaluation (r=0.67), and its overall sensory scores were high. This indicates that the parameters of sensory evaluation were strongly correlated to its overall data (p<0.01).

3.3 Effect of storage on rice flour

Aerobic plate counts of rice surface significantly increased after 4 months storage (Table 2), but doses ranging from 0.5 to 2.0 kGy seem could reduce the aerobic plate counts of aged rice.. The waxy rice flour pasting curves in Rapid Visco Analyser (RVA) changed following one year of storage is also shown at Table 3. All parameters increased within the first three months. Those parameters decreased to their lowest viscosity at sixth month and then came back to the original viscosity after one year. Martin and Fitzgerald (2002) also reported that storage decreased the peak height of pasting curves by increasing the disulphide bonds between proteins in the rice. Table 3 shows japonica rice flour paste viscosity was higher in the first three months than other at any other period in the first year. This might be the reason that industry prefers using aged japonica rice to make some food products. Onset and peak temperatures of the sixth month aged waxy rice decrease (Table 4). ΔH_r was unable to be measured in all samples. Six months aged waxy rice had lower water-binding capacity value than the fresh samples (Table 5). It may due to rice aging forms disulphide bonds proteins (Martin and Fitzgerald, 2002). All waxy rice flours had generally higher values than those from wheat starches (Medcalf and Gilles, 1965). The associative forces within aged waxy rice also represent a much wider range of bond strengths than those in untreated waxy rice flour. Hence it might explain the aged waxy rice, which has been stored for over half a year, will be less sticky during mixing and heating. The six months aged japonica rice undergoes a gentle increased swelling above 75℃ (Table 5). And its swelling power is lower than the fresh waxy rice flours (Table 5). Waxy rice at six months storage had significantly higher solubility but lower swelling power value than all samples. This indicates with continuous gluten network during aging in rice, more soluble material will leach into water. The firmness increase of mochi made from fresh rice is higher than that of waxy rice stored for more than six months (Table 7).

This might be due to the increase of disulphide bonds between the protein networks, which will decrease the firmness of the mochi.

Partial correlation analysis showed swelling power at 75℃ of stored rice significantly ($p<0.01$) related to solubility ($r=-0.91$) at 75℃. Higher swelling powers of rice flour at 75℃, produced lower solubility for the rice flours. Total setback viscosity ($r=-0.71$), final viscosity ($r=-0.90$), breakdown viscosity ($r=-0.92$), peak viscosity ($r=-0.93$) of RVA profile test and water binding capacity is negatively related to the solubility of rice flour at 55℃ ($r=-0.76$), but positively related to setback viscosity ($r=0.94$), pasting temperature ($r=0.85$), and peak time ($r=0.90$) of RVA profile test. Setback viscosity ($r=-0.86$), pasting temperature ($r=-0.82$), peak time ($r=-0.90$) of RVA profile test, stickiness of fresh mochi ($r=-0.70$) significantly ($p<0.01$) negatively related to the swelling power at 75℃, but positively related to peak viscosity ($r=0.89$), breakdown viscosity ($r=0.88$), total setback ($r=0.80$), and final viscosity ($r=0.91$) of RVA test, and water binding capacity ($r=0.69$). Pasting temperature ($r=0.72$), peak time ($r=0.83$), setback viscosity ($r=0.82$) of RVA profile test, significantly ($p<0.01$) positively related to the solubility at 75℃, but negatively related to peak viscosity ($r=-0.83$), breakdown viscosity ($r=-0.82$), and final viscosity ($r=-0.82$) of RVA profile test. Water binding capacity ($r=0.81$), peak viscosity ($r=0.89$), breakdown viscosity ($r=0.89$), final viscosity ($r=0.90$), total setback viscosity ($r=0.84$) of RVA profile test, and the firmness of fresh mochi, significantly ($p<0.01$) positively related to the swelling power at 85℃, but negatively related to setback viscosity ($r=-0.85$), peak time ($r=-0.86$), pasting temperature ($r=-0.80$) of RVA test, and the stickiness of fresh mochi ($r=-0.78$). Peak time ($r=0.90$), pasting temperature ($r=0.83$), and setback viscosity ($r=0.89$) of RVA profile test, significantly ($p<0.01$) positively related to the solubility at 85℃, but negatively related to peak viscosity ($r=-0.91$), break down ($r=-0.91$), total setback ($r=-0.80$), and final viscosity ($r=-0.92$) of RVA profile test, water binding capacity ($r=-0.77$), and the stickiness of fresh mochi ($r=0.70$). Setback viscosity ($r=0.70$) of RVA profile test, significantly ($p<0.01$) positively related to the solubility at 95℃, but negatively related to peak viscosity ($r=-0.71$), break down ($r=-0.69$), and final viscosity ($r=-0.69$) of RVA profile test. Peak viscosity ($r=0.80$), breakdown ($r=0.81$), final viscosity ($r=0.79$) of RVA profile test, and the firmness of fresh mochi ($r=0.76$) strongly correlated ($p<0.01$) to water binding capacity of rice flour, but negatively related to setback viscosity or RVA profile test. The higher firmness values of fresh mochi, the higher peak viscosity ($r=0.74$), breakdown viscosity ($r=0.74$), total setback viscosity ($r=0.78$), final viscosity ($r=0.74$) ($p<0.01$) of RVA profile test, and the swelling power at 65℃ ($r=0.74$). The firmness values of fresh mochi are negatively related to the peak time (r=-0.71), pasting temperature (r=-0.76), and total setback (r=-0.69) of RVA profile test. Stickiness values of fresh mochi are positively related to the pasting temperature (r=0.69), peak time (r=0.67) of RVA profile test, but negatively related to peak viscosity (r=-0.70), final viscosity (r=-0.72), and total setback (r=-0.75) of RVA profile test. Mochi firmness increasing values of the first day is positively related to the swelling power at 65℃ (r=0.73). Mochi firmness increasing values of the second day is positively related to the total setback of RVA profile test (r=0.74).

3.4 Effect of gamma irradiation on the quality of waxy rice products

Roy (1997) reported that hedonic scores of cooked or uncooked scented rice varieties decreased, but all sensory scores suggested that the rice irradiated with 1.0 kGy doses are of more acceptable quality (Table 9). Gamma irradiation applied to waxy rice and storage of waxy rice shown to decrease the pasting viscosity of rice flour (Table 3). Gamma irradiation degraded the ordering structure in starch granules (Wang et al., 2002; Cieśla et al., 1991; Grant and D'Appolonia, 1991; Sabularse et al., 1991). Rice aging formed disulphide bonds between proteins (Martin and Fitzgerald, 2002). Both mechanisms cause the decrease of pasting viscosity and tenderize the texture of mochi (Table 3 and Table 7). The mechanisms of storage and gamma irradiation on rice are different. It seems that gamma irradiation could be used for shortening the japonica rice aging time and for improving the processed stability and quality of rice products, but the effects of gamma irradiation is not as good as the effects of storage for japonica rice.

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Table 1. Approximate composition* of milled Taichung Waxy 70 (TCW 70) rice flour

TCW 70	% Protein**	% Fat	% Ash	% Total starch
Control	8.85b	0.61a	0.20a	76.34
100Gy	8.56b	0.70a	0.22a	76.52
200Gy	7.10ab	0.70a	0.16a	78.04
500Gy	8.18b	0.70a	0.21a	76.91
1000Gy	8.11ab	0.59a	0.21a	77.09
2000Gy	8.27b	0.57a	0.19a	76.97
3 months	8.50b	0.94a	0.20a	76.36
6 months	6.96ab	0.87a	0.29b	77.88
9 months	6.35a	0.58a	0.28b	78.69
12 months	6.69b	0.45a	0.22a	77.44

*Mean values with different letters within the same column are significantly different ($p<0.05$).

All values are a mean of 3 replications with 3 sub-samples per replication except total starch is average of 3 sub-samples.

** %N ╳ 6.25

Table 2. Aerobic plate counts of storage Taichung Waxy 70 (TCW 70) rice surface exposed to gamma irradiation

Dose	Aerobic plate counts (CFUs/g)				
(kGy)	0 month	1 month	4 months	7 months	10 months
0	12ab	5,029b	527,333c	1,266,667a	1,982,000d
0.1	93b	88,367b	1,745,733b	2,472,400c	4,602,667d
0.2	7a	96,344b	281,733b	5,233,333c	9,383,333d
0.5	33ab	64,440b	340,000b	305,333c	1,383,333d
1.0	80ab	152,633b	381,733b	774,333c	1,546,667d
2.0	7a	10,398b	373,333b	646,333c	1,250,000d

*Mean values with different letters within the same column row are significantly different ($p<0.05$).

All values are a mean of 5 samples.

Table 3. Effect of gamma irradiation and storage on the pasting properties of waxy rice (TCW 70) flours*

Sample	PV (RVU)	HPV (RVU)	Breakdown (RVU)	Setback (RVU)	Total setback (RVU)	CPV (RVU)	Pasting temperature (℃)
Control	220.47cd	108.67bc	111.80c	-81.17b	30.64c	139.31bc	73.52b
100Gy	267.14ef	129.33d	137.80ef	-105.06a	32.75c	162.09e	73.50b
200Gy	243.06de	120.78d	122.28cd	-96.72a	25.56b	146.33cd	73.23ab
500Gy	211.33bc	118.28cd	93.06b	-74.28bc	18.78a	137.05bc	73.58b
1000Gy	207.42bc	122.61d	84.80b	-64.89c	19.92a	142.53cd	73.47b
2000Gy	163.30a	106.69b	56.61a	-36.78d	19.83a	126.53ab	73.25ab
3 months	253.50e	120.72d	126.86de	-95.94a	34.00c	154.72de	72.77a
6 months	186.43ab	94.29a	92.14b	-65.62c	26.50b	120.81a	74.82c
9 months	251.26e	125.12d	126.14cde	-94.91a	31.23c	156.35de	73.82b
12 months	288.47f	143.58f	144.89f	-103.99a	40.90d	184.49f	72.76a

*PV (peak viscosity); HPV (hot pasting viscosity); Breakdown = PV-HPV; CPV (cool paste viscosity); Setback = CPV-PV; RVU(Rapid Visco Unit)

Table 4. Thermal analysis of gelatinization of waxy rice (TCW 70) flours*

Sample	To (°C)	Tp (°C)	Tc (°C)	ΔH_g (J/g)	ΔH_r (J/g)
Control	65.36c	70.61de	76.51ab	10.65a	NA
100Gy	64.90bc	69.99bc	77.06a	11.16a	NA
200Gy	64.58bc	69.92b	77.00ab	10.61a	NA
500Gy	64.18ab	70.25c	76.97ab	11.06a	NA
1000Gy	65.06bc	70.29cd	76.21a	10.59a	NA
2000Gy	64.85bc	70.26c	77.04ab	10.42a	NA
3 months	64.05ab	70.30ab	76.79ab	11.33a	NA
6 months	65.10bc	70.86e	78.37c	10.87a	NA
9 months	63.16a	69.10a	76.24a	11.91a	NA
12 months	64.58bc	70.59cd	77.80bc	11.69a	NA

To, onset temperature (°C); Tp, peak temperature (°C); Tc, conclusion temperature (°C);
ΔH_g, enthalpy of gelatinization (J/g); ΔH_r, enthalpy of retrogradation (J/g)

Table 5. Mean values for the swelling power and water binding capacity of waxy rice flour *

Sample	Swelling power					Water binding capacity (%)
	55℃	65℃	75℃	85℃	95℃	
Control	2.06b	2.60bc	10.00d	10.03c	11.93c	111.35cd
100Gy	2.08bc	2.25ab	10.04d	10.66cd	10.92bc	113.07d
200Gy	2.06b	2.10a	8.11bc	10.99cd	11.02ab	109.01bcd
500Gy	2.02a	2.37abc	9.08cd	9.97c	10.12ab	105.85abc
1000Gy	2.00a	3.10d	7.94bc	9.87c	10.28ab	103.80ab
2000Gy	2.08bc	2.68c	7.36b	8.32b	10.42ab	112.67d
3 months	2.06b	2.27ab	9.05cd	10.12c	10.30ab	113.67d
6 months	2.07b	2.52bc	5.30a	7.04b	9.61a	101.93a
9 months	2.12cd	3.41d	8.31bc	10.32c	10.93bc	107.50abcd
12 months	2.14d	5.27e	9.96d	11.62d	11.92c	106.83abcd

Table 6. Mean values for solubility of waxy rice flour *

Sample	Solubility				
	55℃	65℃	75℃	85℃	95℃
Control	1.05a	29.22cd	13.33ab	2.28abc	2.36ab
100Gy	1.33ab	31.85cd	14.39abc	2.36abc	1.38ab
200Gy	1.43b	25.51bc	25.27bc	3.02ab	2.90ab
500Gy	1.37ab	21.34ab	17.39abc	6.63cd	2.45ab
1000Gy	1.30ab	17.15a	23.81abc	8.84d	0a
2000Gy	1.41ab	25.72bc	27.51cd	14.41e	0a
3 months	1.10ab	26.85bcd	15.13abc	4.84bcd	4.47b
6 months	1.89c	29.73cd	38.21d	25.90f	9.00c
9 months	1.33ab	30.84cd	15.41abc	6.32bc	0.36ab
12 months	1.41ab	32.79d	10.37a	0a	0a

Table 7. Effect of gamma irradiation and storage on firmness of mochi*

Sample	Firmness (g) of storage mochi			Firmness (g) increase	
	0 day	1 day	2 days	1 day	2 days
Control	210.8ab	847.0ab	4400.6abcd	176.0a	4189.8b
100Gy	276.0b	2108.3bc	5618.9cd	3957.2c	8704.3d
200Gy	258.2ab	1405.6abc	6336.5cd	1482.8b	6556.0c
500Gy	230.3ab	807.6ab	3686.3abc	20.0a	400.1a
1000Gy	214.4ab	512.9ab	3082.3abc	370.9a	3619.3b
2000Gy	221.2ab	2551.1c	7754.4d	453.2a	4121.8b
3 months	278.2b	667.3ab	4832.9bcd	389.1a	4554.7b
6 months	168.3a	365.0a	1599.0ab	196.7a	1430.7a
9 months	217.3ab	270.9a	845.3a	53.7a	628.1a
12 months	254.4ab	944.8abc	3594.9abc	690.5ab	3340.5b

* Mean values with the same letter in the same column were not significantly different ($p \geqq 0.05$).

Table 8. Mean values for the stickiness and the processing stability of mochi *

Sample	Stickiness (g)	Score of processing stability* *
Control	-41.1abc	4.0abc
100Gy	-30.2cde	5.0bcd
200Gy	-37.7abcde	3.3ab
500Gy	-40.6abcd	7.3d
1000gy	-44.0ab	6.0bcd
2000gy	-48.3a	4.3abc
3 months	-40.3abcd	2.0a
6 months	-27.4e	4.0abc
9 months	-28.6de	3.5ab
12 months	-32.1bcde	6.3cd

*Mean values with the same letter in the same column were not significantly different (p≧0.05).

** Dislike extremely=1; Dislike very much=2; Dislike moderately=3; Dislike slightly=4; Neither like nor dislike=5
Like slightly=6; Like moderately=7; Like very much=8; Like extremely=9

Table 9. Mean values for the sensory evaluation of mochi *

Sample	Color	Firmness	Stickiness	Overall
Control	5.96abc	5.72ab	5.77a	5.93abc
100Gy	6.06bc	5.60ab	6.33a	6.17bcd
200Gy	5.95abc	5.19a	6.02a	5.60a
500Gy	5.40a	5.60ab	5.91a	5.66ab
1000gy	6.45c	6.52c	6.22a	6.65d
2000gy	5.40a	5.51ab	5.79a	5.61a
3 months	6.29c	5.93bc	5.80a	6.25cd
6 months	5.99abc	5.99bc	5.84a	5.74abc
9 months	5.62ab	5.68ab	5.65a	5.84abc
12 months	5.72ab	5.44ab	5.41a	5.54a

*Mean values with the same letter in the same column were not significantly different (p≧0.05).

Dislike extremely=1; Dislike very much=2; Dislike moderately=3; Dislike slightly=4; Neither like nor dislike=5

Like slightly=6; Like moderately=7; Like very much=8; Like extremely=9

附件二

可供推廣之研發成果資料表

□ 可申請專利　■ 可技術移轉　日期：95年8月23日

國科會補助計畫	計畫名稱：輻射照射糯米對米穀粉及其產品之影響 計畫主持人：宋文杰 計畫編號：NSC94-2313-B-041-005　學門領域：生物處
技術/創作名稱	以輻射照射糯米加速熟成技術
發明人/創作人	宋文杰
技術說明	中文：糯米以0.5kGy至1.0kGy之輻射照射可加速糯米熟成，並改善其米穀粉加工適性及提升產品品質。
	英文：Milled japonica cultivar, Taichung Waxy 70 (TCW 70), was exposed to gamma radiation with doses ranging from 0.5 to 1.0 kGy. The effects of gamma irradiation on waxy rice flour pasting properties and the qualities of its food product, mochi, were compared to the effects of storage. Doses ranging from 0.5 to 1 kGy can decrease the flour paste viscosity as those obtained after 6 months of storage and improving the processing stability and quality of rice products.
可利用之產業 及 可開發之產品	米穀粉加工業
技術特點	
推廣及運用的價值	

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