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Studies on the Preservation of Korean Rice by Gamma-radiation (V)

Effects of low temperature storage of gamma-irradiated rice

by

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감마선 조사에 의한 쌀저장에 관한 연구 (제 5 보)

—— 감마선 조사 쌀에 대한 저온 저장의 영향 ——

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요 약

경기도 김포지방에서 수확한 농림 6 호를 1970 년 3 월에 현미와 백미로 표준도정하여 kraft paper bag 에 포장하고 Co-60 irradiator 로 30, 50, 600, 및 800 Krad 의 감마선을 조사한후 저온(10°C, 75% RH)에 저장하면서 fat acidity, amylase activity, 백미가루와 그 전분의 amylogram 에 의한 viscosity 및 식미시험등의 시험 결과는 다음과 같다.

1) Fat acidity 의 증가는 30~50 Krad 조사미에 있어서 대조구에 비해서 근소한 차이였으나, 600~800 Krad 조사구에서는 현저하게 증가하였고, 상온저장에 비해서는 그 증가율이 낮았다.
2) Amylase activity 는, 30~50 Krad 조사구에서 대조구와 차이가 없고, 모두 감소경향이며, 600~800 Krad 조사구는 그 감소경향이 현저하다.
3) Brabender amylogram 에 의한 viscosity 는 백미분의 경우 30~50 Krad 조사구는 대조구와 차이없이 저장중 약간 감소경향이고, 600~800 Krad 조사구는 현저하게 그 viscosity 가 감소하였다.
4) 식미시험 결과는 30~50 Krad 조사구가 대조구와는 차이가 없고, 600~800 Krad 조사구는 색갈에서만 대조구와 유의차를 나타났다.

I. Introduction

In the previous reports[1] [2] [3], the efficacies of the low levels of irradiation for the disinfestation was reported, confirming not any critical and biological changes of the sampled Korean polished and brown rice treated with gamma-ray irradiator and stored at the room temperature.

In this investigation, the changes of the fat acidity, amylase activity, viscosity by amylogram and organoleptic tests would be investigated when the sample was stored at the condition of the low temperature of 10°C

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and 75 % relative humidity after gamma-ray irradiation of the rice samples.

Generally the rice stored at the low temperature acquires a sort of sterilizing effect against the disinfestation and disinfection and preserves its qualities as the fact was assured by Kano[4] and many investigators since 1939.

Tani et al.[5] in 1964 and Chikubu et al.[6] in 1965 having stored the polished rice and brown one at 10° ~13°C with 70~80% RH, they found the lower decreasing rate of amylase activity and viscosity by amylogram, but the higher increasing rate of fat acidity in the first year in comparison with the room temperature lot. This was the only exceptional case, nevertheless, the low temperature lot generally conveyed less changes of the contents than the room temperature one.

II. Materials and Methods

1) Sampling and Packing

Nonglim #6, the sampled rice variety, was harvested at Kimpo area of the central Korea and was milled into the 92% polished rice and brown one by the common method of the Agricultural Products Inspection of Korea. Each 2kg of the sample was then packed in the three fold kraft paper bags.

2) Irradiation and storage of the samples

The packed samples were irradiated with the irradiator, 455 Ci Co-60, at 13±2°C in dosage variation such as 30, 50, 600 and 800 Krad and the treated samples were stored at 10°C and 75% RH.

3) Determination of fat acidity

Fat acidity was expressed in mg of potassium hydroxide used to neutralize the free fatty acids contained in 100g of the sample by the previous method[7].

4) Determination of amylase activity

Each 5g of the polished rice and the brown one was placed in 20ml of cold tris-buffer solution at pH 7.3, at 3°C of a refrigerator for overnight. The soaked rice was ground in an ice jacket and the homogenate was centrifuged at 800×G and 0°C for 15 minutes and the supernatant fraction was taken for enzyme assay. Amylase activity was measured by Bern-feld method[8], one millilitter of the enzyme preparation and 1ml of 1% soluble starch solution were mixed and controlled to pH 4.6. The mixture was incubated at 25°C for 5 minutes and the increase in reducing power was measured by the addition of 2ml of 1% dinitrosalycylic acid solution.

The amylase activity was expressed in mg of the maltose by Bern-feld method[8] with some modification. The colored mixture was diluted with 5ml of distilled water and the optical density was read at 380 mμ of Coleman spectrophotometer. The mg % of the maltose was ultimately obtained from the standard curve.

5) Estimation of viscosity

The viscosity of the starch and that of the polished rice were estimated by Brabender amylography[9].

First, fifty five grams of the grind rice were passed through 60 mesh sieve which contained 14% moisture. It was suspended in 100ml of distilled water and then diluted to 350ml by distilled water, pouring into the amylography container. To make the paste carefully and completely, especially in the case of rice powder, all of the paste was kept being stirred for 20 minutes. Heating slurry was then started at 25°C and went up uniformly at the rate of 1.5°C per minute.

Second, fourty five grams of the rice starch contained 14% moisture was also made to slurry by the same method as above. In detail, the rice starch was prepared as follows[10]: Three hundred of the ground rice were added to 1,500ml of 2% sodium dodecylbenzenesulfonate solution in the 2,000ml beaker. The above SDBS solution was the SDBS solution proper plus 2% of fresh sodium sulfite solution, the pH being controlled to 7.6 with diluted sodium hydroxide solution. The mixture in the breaker was stirred gently at some intervals. After 36 hours, the supernatant was decanted and the residues were crushed with glass bar adding some of the SDBS solution.

The paste of starch was passed through a sieve of 150 mesh to seperate off the big particles and cellulose, with the addition of some distilled water. The seperated particles and cellulose were crushed again with SDBS solution and then they were sieved again. All the starch suspended solution was collected, centrifuged and the supernatant fraction was decanted.

The SDBS solution 5 times as much as the starch layer was mixed with the starch and the mixture was placed for 6 hours and this procedure was repeated 3 times to remove protein and free fatty acids. The

starch was next washed with distilled water until it didn't react with SO_3^{--} ion, being suspended in distilled water and placed at 4°C at a refrigerator for one day. The starch was centrifuged after rewashed and only the intermediate layer was taken as the purified starch. At last the starch was ground and sieved to 150 mesh after the starch was dried in an incubator for about 24 hours.

6) Organoleptic test[11]

The organoleptic test of the boiled rice was performed to evaluate the taste, oder, viscosity and color of it in October, 8 months after irradiation. The rice was boiled under the same condition as that of usual cookery. The score scales were graduated 0 to 5 and the standard was 3 point which was allotted to the usual boiled rice.

III. Results and discussion

1) General components of samples

The general chemical components of sample rice (Nongim #6 variety), in their polished and brown forms, were as follows.

Table I. General chemical composition of rice

Sample	Moisture	Crude protein	Crude fat	Crude ash	N-free extract
Brown rice	14.50%	8.05%	2.81%	1.34%	73.30%
Polished rice	14.20%	6.56%	0.94%	0.62%	77.68%

2) Changes in fat acidity

The irradiated polished and brown rice in the kraft paper bags underwent some changes, and the changes through the storage, under the conditions of 10°C and 75% RH, are in the fig. 1 and 2.

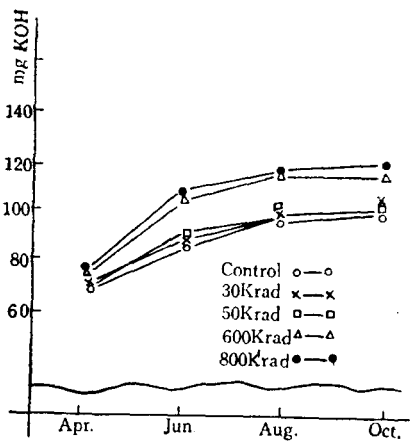

Fig. I. Changes in fat acidity in brown rice after irradiation for storage

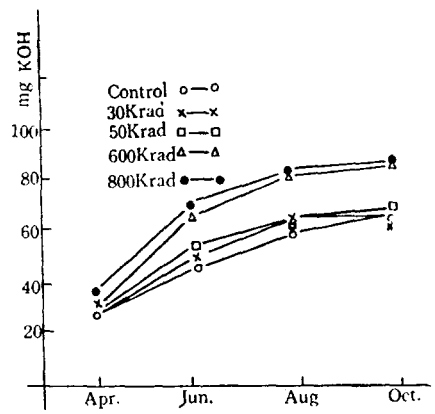

Fig. II. Changes in fat acidity in polished rice after irradiation for storage.

The fat acidity of the brown rice marked 75mg, and 35mg for the polished one in April, that is, after one month. After 3 months (in June), the values increased to 90mg for the low dose and 105mg for the high dose in the brown rice and their counterparts in the polished rice were 50mg and 65mg. In October 110mg and 130mg appeared as the respective values for the two dose levels in the brown rice and the polished rice had 70mg and 85mg.

As was stated in the previous reports[2][3], the low dose lot of 30-50 Krad had slight increased in the fat acidity over those of the control lot and the high dose lot of 600 or 800 Krad manifested higher discrepancies over the curves for the control lot. However, the increasing rate of the fat acidity is low in the low temprature storage than in the room temperature storage.

3) Changes in amylase activity

When the polished rice and brown one were irradiated and stored at low temperature (10°C and 75% RH) till October, the changes of the amylase activities were shown in the fig. 3 and 4.

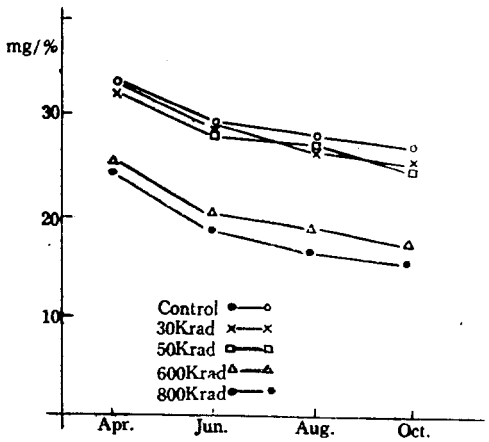

Fig. III. Changes in amylase activity during storage in brown rice after irradiation.

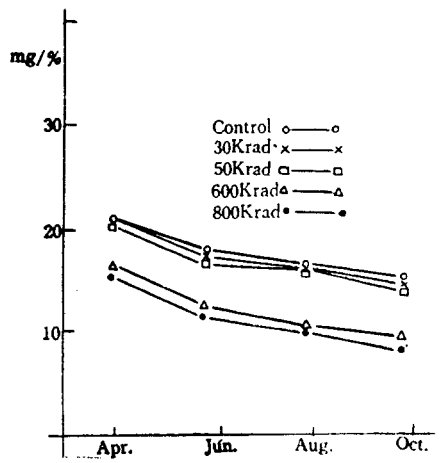

Fig. IV. Changes in amylase activity during storage in polished rice after irradiation.

The amylase activities in the brown rice were 33mg for low dose lot and 24mg for high dose one month after irradiation in April, but they decreased to 25mg and 17mg respectively in October. On the other hand, the polished rice group had the same tendencies and changed from the initiating levels of 21mg and 16mg in April to the decreased levels of 15 and 9mg in October.

In comparing the control lot and the irradiated lot, the low dose group kept close with the control lot and decreased for both forms of rice, but the amylase activities in the high dose group seemed to have undertaken a sudden decrease at the irradiation and had a same decreasing curves for both forms of the rice.

Columbi and Davis[12] found the amylase activity wasn't affected by 175Krad gamma-ray irradiation, which fact was concordant with this experiment.

It was reported[13] also that the catalase activity relevent to the respiration of rice was decreased at low temperature but by far the less degree comparing with the case of the room temperature.

The changes of amylase activity and catalase activity seemed to be a good index[13] to the quality of rice, so it appears that the significant decrease of the amylase activity in the high dose lot of 600 or 800 Krad meant a low quality of the rice.

4) Changes in viscosity

For the polished rice power and rice starch, Brabender amylogram was made; the sampled polished rice was ground into power and it was refined to rice starch by the aid of sodium-dodecyl-benzene-sulfonate (SDBS) solution as a surface active agent.

The maximum points of gelatinization and the increased viscosity during the cooling were measured in the amylogram and the results are in table 2.

Table 2. Changes of specific value of amylogram of polished rice

		Max-point of gelatinization(B.U)			Increased viscosity during cooling(B.U)		
	dose \ time of test	Jun.	Aug.	Oct.	Jun.	Aug.	Oct.
Rice powder	0 Krad	720	680	630	700	600	800
	30	710	680	650	720	650	750
	50	720	650	600	680	800	770
	600	350	300	230	430	220	270
	800	220	130	100	200	70	30
Rice starch	0	450	430	460	520	560	540
	30	430	420	440	480	460	480
	50	450	440	450	470	470	470
	600	240	200	230	200	190	220
	800	170	140	160	50	60	40

Of the rice powder, the low dose lot had nearly the same maximum points of gelatinization with the control lot but the high dose lot marked less than the

half values of the control lot. Although Chikubu et al.[6] reported a slight increase in the control lot, all lots including the control lot showed the decreasing tendencies through the storage. The increased viscosity during the cooling revealed no plain indications but the high dose lot had a notable decreased viscosity comparing with the control lot.

Except the almost constant value during the storage, a same description could be allowed in the maximum points of gelatinization of the purified rice starch. In examing the increased viscosity values during the cooling, any clear drift was not found, nevertheless, the high dose lot also showed the low values against the control lot.

The high doses of 600-800 Krad must have had some effects[14] on the particles of starch and consequently on the decrease of their viscosities, and that is why the maximum points of gelatinization were far below at the amylogram of the high dose lots of the rice powder and rice starch.

By Suzuki and Chikubu[9], both the maximum points of gelatinization and the break-downs for the rice powder were higher than for the rice starch, and this observation agreed with author's experiment.

5) Results of organoleptic test

Nonglim #6 variety is famous for its deliciousness in Korea, and the sample harvested in 1969 was milled in the next March to 92% milling. Each 2kg was packed into the kraft paper bags for the irradiation with 30, 50, 600 and 800 Krad doses. After 7 months' storage under 10°C and 75% RH, the rice was cooked by the usual method and then the organoleptic test was performed. The tests were grouped into two, high dose lot and low dose one, and were examined in the difference analysis[11] about the taste, odor, color and viscositly.

1) Low dose group (30, 50 Krad)

a) Taste

Analysis of varience

Source of varience	df	SS	MS	F
Sample	2	0.8	0.4	0.74<3.23
Penelist	14	6.6	0.55	
Error	28	15	0.54	
Total	44	22.4		

b) Order

Analysis of vraience

Source of varience	df	SS	MS	F
Sample	2	0.40	0.22	0.79<3.23
Penelist	14	5.66	0.40	
Error	28	7.90	0.28	
Total	44	14.0		

c) Color

Analysis of varience

Source of varience	df	SS	MS	F
Sample	2	0.4	0.2	1.0<3.23
Penelist	14	7.2	0.5	
Error	28	5.6	0.2	
Total	44	13.2		

d) Viscosity

Analysis of varience

Source of varience	df	SS	MS	F
Sample	2	1.5	0.75	0.85<3.23
Penelist	14	6.3	0.45	
Error	28	16.8	0.6	
Total	44	24.6		

As pointed in the previous report[2] of the series of this investigation, there was no significant difference between the low dose lot and the control lot in the organoleptic test.

2) High dose group (600, 800 Krad)

a) Taste

Analysis of varience

Source of varience	df	SS	MS	F
Sample	2	2.1	1.05	2.33<3.23
Penelist	14	6.5	0.46	
Error	28	12.6	0.45	
Total	44	21.2		

b) Order

Analysis of varience

Source of varience	df	SS	MS	F
Sample	2	2.2	1.1	2.90<3.23
Penelist	14	10.1	0.72	
Error	28	10.5	0.38	
Total	44	22.8		

c) Color

Analysis of varience

Source of varience	df	SS	MS	F
Sample	2	5.0	2.5	6.6>3.23
Penelist	14	5.6	0.4	
Error	28	10.6	0.38	
Total	44	21.2		

d) Viscosity

Analysis of varience

Source of varience	df	SS	MS	F
Sample	2	1.8	1.9	1.64<3.23
Penelist	14	66.1	0.44	
Error	28	15.3	0.55	
Total	44	23.2		

Of the taste, odor and viscosity, no significant differences were found in the results of the difference analysis for the high dose group, but, in 5% level and even in 1% level, there occured significant differences of the color. Duncan's multiple range tast manifested, however, no significance between 600 Krad and 800 Krad.

The results somewhat disagreed with those of the report[3] of this investigation series; At the room temperature, the color and oder of the high dose lot displayed the significant differences with those of the control lot. The low temperature storage was decisively effective to remove the off-flavor affect of the high dose irradiation. There was no significant difference of the odor between high dose lot and the control in the case of low temperature storage.

IV. Summary

The Korean rice, Nonglim #6 was milled into brown rice and 92% polished one and packed with the kraft paper bags. The sample bags were irradiated with the respective doses of 30, 50, 600 and 800 Krad and then were stored at 10°C and 75% RH. Changes of fat acidity, amylase activity, viscosity of thus irradiated rice were examined during storage. The results were as follows.

1) Fat acidity increased slightly in the range of 30 ~50 Krad but remarkably in the range of 600~800 Krad. However, the rate of increase was low in comparison with the storage under the room temperature.

2) The amylase activity of both the low dose lot and the control decreased in the same rate during the storage. However the high dose lot had more remarkable decrease of the amylase activity from the beginning.

3) The viscosity by Brabender amylogram showed the slightly decreasing tendency in both the low 30~ 50 Krad lot and the control lot of the polished rice powder during storage. On the other hand, the high dose lot of 600 or 800 Krad marked the similar decreasing rate but by far the lower values of the viscosity.

4) The results of the organoleptic test presented no differences between the low dose lot and the control lot, but the high dose lot and the control lot differed significantly only in the color.

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