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สำนักงานพลังงานปรมาณูเพื่อสันติ
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PRE-COMMERCIAL SCALE PRESERVATION OF GARLIC BY GAMMA RADIATION IN COMBINATION WITH COLD STORAGE

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การทดลองฉายรังสีกระเทียมและการเก็บรักษาในห้องเย็นในระดับก่อนอุตสาหกรรม ได้กระทำในปี พ.ศ.2529-2530 โดยได้รับความร่วมมือจากผู้ประกอบการ กระเทียมที่ใช้ทดลองเป็นพันธุ์ท้องถิ่นซึ่งแขวนผึ่งไว้ 7 สัปดาห์หลังเก็บเกี่ยว ปริมาณรังสีที่ใช้มีค่าเฉลี่ยเท่ากับ 70 เกรย์ ห้องที่ใช้เก็บรักษามีอุณหภูมิระหว่าง 1-7 และ 25-34 องศาเซลเซียส ตลอดระยะเวลาการเก็บนาน 9 เดือน ผลการทดลองพบว่าการฉายรังสีสามารถควบคุมการงอกของกระเทียมได้อย่างสมบูรณ์ และยังช่วยลดการสูญเสียน้ำหนักและการเน่าอีกร้อยละ 18 และ 13 เมื่อเก็บรักษาไว้ 9 เดือน ที่อุณหภูมิ 1-7 องศาเซลเซียส การฉายรังสีเพื่อควบคุมการงอกของกระเทียมนั้นเป็นวิธีที่เป็นไปได้ทางเทคนิคและมีความเหมาะสมทางเศรษฐกิจ ดังจะเห็นได้จากผลตอบแทนที่สูงกว่าตลอดช่วงเวลาที่เก็บรักษา การทดลองวางตลาดกระเทียมฉายรังสีก็ได้ผลเป็นที่พอใจ

ABSTRACT

Irradiation of garlic on a pilot scale and storage in cold room under commercial condition was carried out in co-operation with garlic trader in 1986-1987. Garlic bulbs from local cultivars were irradiated seven weeks after harvest with average dose of 70 Gy and stored for nine months at low (1-7°C) and ambient (25-34°C) temperatures. The treatment proved to be effective in controlling sprouting and in reducing weight loss and rotting. Affer 9 months of cold storage the weight loss and rotting of irradiated bulbs were reduced by 18 and 13 per cent. The radioinhibition process is technically feasible and economically justified as a profit can be made during the extended storage period. Small scale marketing trials of irradiated garlic conducted during and after termination of storage revealed no adverse comments from consumers.

1. INTRODUCTION

Garlic is vegetable crops of economic importance to Thailand and is grown locally for their culinary and medicinal uses. It is also extensively employed as a flavor in sauces and cooking. The annual production is estimated to be approximately 110,000-125,000 tonnes.[1] A great part of the crops is wasted annually due to rotting, weight loss and sprouting, which are usually followed by a loss of quality in the product. Since the crops are harvested only once a year from March to April, they have to be stored to ensure the availability of supply before the next harvest. Garlic is traditionally stored at ambient conditions. Although low temperature storage can control weight loss and weevil infestation, it is not practiced, because of the tendency of the bulbs to sprout.

Gamma irradiation has proved to be a potent tool for controlling sprouting in garlic.[2-4] A number of countries have given approval for the radiation preservation of food based on the wholesomeness of the irradiated products and feasibility of the technology.[5] Unconditional clearance of irradiated garlic has been accorded in Thailand.[6] Since the objective of irradiation is to control sprouting, it provides a means for bringing about reduced storage losses through the application of low temperature. The scope of this work was to demonstrate the efficacy of radiation treatment of garlic aiming toward the transfer of food irradiation technology to traders. The objective of this experiment was to evaluate the quality of irradiated gralic stored under commercial conditions at low temperature. Market acceptability of the irradiated garlic and cost-benefit of the radioinhibition process were also evaluated.

2. PROCEDURE

2.1 Collection of sample

Garlic grown in Lampoon was used in the experiment. It was cured by hanging in bunches in sheds for 7 weeks. After curing, sound garlic bulbs only were sorted and packed in nylon string bags at 20 kg per bag. A total of 400 kg of garlic was collected from Bak Brothers Limited Partnership. Transportation was by covered truck with slatted sides to the Office of Atomic Energy for Peace in Bangkok which required about 16 hours.

2.2 Irradiation

A gammabeam-650 with initial source strength of 1.8 PBq Co-60 (April, 1980) was used for irradiation treatment. The crates of garlic were stacked two level high around the source. Altogether 12 crates could be irradiated at a time. Each crate was manually turned 180° horizontally and also moved vertically at half the total irradiation time. A Fricke dose meters were used to measure the absorbed dose at different positions in the garlic crates. The average dose administered was 70 Gy (uniformity ratio = 1.8). Each crate of irradiated garlic was labelled with a printed statement showing that garlic had been irradiated by gamma rays to inhibit sprouting; name and address of the distributor and facility operator; date of irradiation; a symbol indicating the radiation treatment and registration number assigned by the Ministry of Public Health.

2.3 Storage

The irradiated and non-irradiated garlic were stored in commercial cold storage at Thai Seri Universal Food Company. Spaces were left between stacks for ventilation. The period of storage was from May 1986 to February 1987. The storage temperature and humidity were 4 ± 3°C and 78 ± 10%. Non-irradiated garlic was also stored at ambient condition for comparison.

2.4 Quality evaluation

The garlic was inspected after 5, 6, 7, 8 and 9 months of storage for sprouting, rotting, loss in weight and per cent marketable bulbs. Inner sprouting was checked on cloves of marketable bulbs. The criterion adopted for inner sprouting was the presence of a green coloration in the growth center.

2.5 Market test

Irradiated garlic was marketing tested in Bangkok from October, 1986 to February, 1987. Irradiated garlic was monthly withdrawn from cold storage. On withdrawal, it was removed from crates and spread on cement floors to dry the surface moisture. After drying, decayed and sprouting bulbs were sorted out and the marketable bulbs were repacked in crates with net weight of 20 kg per crate. The packed garlic labelled to indicate that it had been irradiated was supplied at the wholesale price prevailing at the time to one shop in a public market at Klong Toei and retailed to the public. A poster on garlic irradiation was displayed at the sales area to inform comsumers about irradiation, safety and wholesomeness of irradiated product.

3. RESULTS AND DISCUSSION

3.1 Marketable quality and storage losses

The percentage of marketable bulbs, sprouting, rotting and loss in weight of irradiated and non-irradiated garlic stored up to 9 months at ambient temperature and in commercial cold storage at $4 \pm 3^\circ C$ and $78 \pm 10\%$ relative humidity is shown in Table 3.1.1. The table shows that irradiation effectively controlled sprouting at low temperature and caused a large decrease in weight loss. Thirteen, 14 and 18 per cent less loss in weight after 6, 8 and 9 months in cold storage were obtained by irradiation treatment. Our observations that less weight was lost in irradiated garlic bulbs than in the control are in line with the findings of other investigators.[2,7] These results may have been due partially to the radiation effects on the respiration and sprouting of the bulbs. Irradiated garlic always had a higher percentage of marketable bulbs, 90 and 87 per cent for irradiated lots versus 64 and 56 per cent for controls after 6 and 9 months. Non-irradiated garlic stored at ambient temperature for 9 months did not show sprouting but had a higher percentage of weight loss and rotting. This indicates that irradiation in combination with low temperature storage, could be a promising alternative method for storing the crop for longer periods.

The external inspection of the cloves from non-irradiated and irradiated marketable bulbs (Table 3.1.2) revealed a higher percentage of marketable cloves for irradiated garlic. As high as 60 per cent of the cloves from non-irradiated bulbs stored at low temperature was sprouted. Irradiated bulbs stored at low temperature showed complete inhibition of sprouting up to 9 months. Inner sprouting was absent in the cloves from irradiated bulbs but present in 100 per cent of the cloves from non-irradiated bulbs at the end of storage at ambient temperature.

3.2 Market test

Irradiated garlic (336 kg) was put on sale from October, 1986 to February, 1987 at the prevailing wholesale price. About 70 kg was supplied each month to one shop in a public market in Bangkok. It was sold out, at the retail price, within two weeks of delivery. Most buyers were unconcerned and refrained from making any comments. It was indicated by the shop keeper that some buyers had heard about the use of irradiation to preserve food and bought because of the better physical quality. No adverse comment on the sale of labelled irradiated garlic bulbs was received during the trial.

3.3 Cost-benefit analysis of garlic irradiation and storage

From the quantity of marketable bulbs obtained in this study, the prevailing wholesale market price and the total expenses relating to irradiation, storage and sale of garlic, the profit on sale of irradiated and non-irradiated garlic was calculated. The monetary benefit derived from the sale of irradiated and non-irradiated garlic is shown in Table 3.3.1 and 3.3.2. The tables show that when garlic harvested in April are irradiated in May and sold after 6, 8 and 9 months of cold storage, the benefits are Baht 1,370, 5,170 and 1,900 per ton compared to Baht -2,145, 90 and -3,129 per ton for non-irradiated ambient stored garlic. This result clearly indicates that non-irradiated garlic cannot be profitable held in storage for a period of 9 months. Irradiation however makes a 9 month storage period feasible, with a benefit of Baht 1,900 per ton. Although irradiation in combination with low temperature storage showed a large increase in profit compared with non-irradiated ambient storage controls, wholesalers did not show much interest in this radioinhibition process partly because of uncertainty about price fluctuations and the high cost of cold storage fee.

4. CONLUSIONS

Our pilot scale storage tests clearly demonstrated that irradiation of garlic (70 Gy) to inhibit sprouting and reduce weight loss during storage in cold room (1-7°C) was technically feasible. In a developing country such as Thailand where production of garlic is seasonal and certain amonut of garlic has to be wasted and imported each year, gamma irradiation could play an important role to prevent unnecessary losses. Together with chill storage, irradiated garlic could well be kept for 9 months which is long enough to bridge the time until the new harvest. The radioinhibition process is economically justified as a profit of Baht 1,900 per ton can be made at the end of the extended storage period. Preliminary results on market testing indicates that the irradiated garlic bulbs, distinctly labelled as "processed by gamma irradiation", were purchased by consumers without any adverse comments.

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Table 3.1.1 Quality of irradiated[1] (irr) and non-irradiated (non-irr) garlic during storage at different temperatures.

Storage time (months)	Treatment	Marketable (%)	Sprouted (%)	Rotted (%)	weight loss (%)
5	Non Irr. (1-7°C)	74.0	12.9	2.1	11.0
	Irr. (1-7°C)	91.2	0.0	1.2	7.5
6	Non Irr. (25-34°C)	64.6	0.0	14.1	21.4
	NOn Irr. (1-7°C)	63.8	20.0	0.4	15.8
	Irr. (1-7°C)	90.0	0.0	1.2	8.7
7	Non Irr. (1-7°C)	48.1	33.2	1.4	17.3
	Irr. (1-7°C)	87.5	0.0	1.0	11.5
8	Non Irr. (25-34°C)	59.6	0.0	14.5	25.8
	Non Irr. (1-7°C)	33.0	41.5	5.0	20.5
	Irr. (1-7°C)	87.5	0.0	1.0	11.5
9	Non Irr. (25-34°C)	55.6	0.0	14.5	29.9
	Irr. (1-7°C)	86.7	0.0	1.3	12.0

Table 3.1.2 Quality of cloves derived from marketable non-irradiated and irradiated[1] garlic bulbs stored at ambient and low temperatures

Storage time (months)	Treatment	Marketable (%)	Sprouted (%)	Rotted (%)
6	Non Irr. (25-34°C)	89.5	0.0	10.5
	Non Irr. (1-7°C)	33.1	63.4	3.5
	Irr. (1-7°C)	98.9	0.0	1.1
8	Non Irr. (25-34°C)	88.0	0.0	12.0
	Non Irr. (1-7°C)	22.4	64.0	13.5
	Irr. (1-7°C)	93.7	0.0	6.3
9	Non Irr. (25-34°C)	87.4	0.0	12.6
	Irr. (1-7°C)	91.0	0.0	9.0

(1) 70 Gy

Table 3.3.1 Expected profit[1] from sale after storage for irradiated garlic at low temperature[2] and non-irradiated garlic at ambient temperature[3]

Storage time (months)	Non-irradiated	Irradiated
6	-2,145	1,370
8	90	5,170
9	-3,129	1,900

(1) Baht/tonne

(2) 4 ± 3°C

(3) 25-34°C

Table 3.3.2 Cost analysis of garlic irradiation and storage

1 US $ = 25.5 Baht

Storage period (month)	5 (Oct.)	6 (Nov.)	7 (Dec.)	8 (Jan.)	9 (Feb.)
1. Market price[1] in May (Baht/tonne)	21,000	21,000	21,000	21,000	21,000
2. Per cent losses	8.75	10.5	12.5	12.5	13.33
3. Quantity sold (tonne)	0.91	0.90	0.88	0.88	0.87
4. Wholesale price (Baht/tonne)	33,000	34,000	34,000	42,000	40,000
5. Revenue 3x4 (Baht)	30,112	30,600	29,750	36,750	34,667
6. Irradiation fee[2] (Baht)	750	750	750	750	750
7. Cold storage fee[3] (Baht)	4,500	5,400	6,300	7,200	8,100
8. Interest[4] (Baht)	1,177	1,440	1,711	1,992	2,280
9. Labour cost[5] (Baht)	550	550	550	550	550
10. Transportation cost[6]	91	90	88	88	87
11. Profit (Baht/tonne) (5-1-6-7-8-9-10)	2,044	1,370	-649	5,170	1,900

(1) including cost of nylon string bags, packing, and transportation from Chiengmai to Bangkok.

(2) 750 Baht/tonne including cost of transportation to cold storage room

(3) 900 Baht/tonne/month

(4) 12% per year

(5) 550 Baht/tonne

(6) 100 Baht/tonne

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