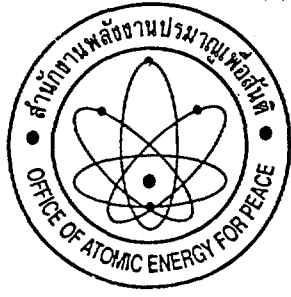




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# การเก็บรักษาในทางการค้า และการทดลองวางตลาด หอมหัวใหญ่ฉายรังสี

โกวิทย์ นุชประมูล เสาวพงศ์ เจริญ ยุทธพงศ์ ประชาสิทธิศักดิ์  
วชิรา พริ้งสุลกะ และ พิทยา อุดลยธรรม

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COMMERCIAL STORAGE AND MARKETING TRIALS OF IRRADIATED ONIONS

โกวิท นุชประมุล เสาวพงศ์ เจริญ สุทนต์ ประชาสิทธิศักดิ์  
วชิรา พริงศ์ลกะ และ นิกยา อุดลยธรรม  
กองวิทยาศาสตร์ชีวภาพ

KOVIT NOUCHPRAMOOL SAOVAPONG CHAROEN  
YUTHAPONG PRACHASITTHISAK VACHIRA PRINGSULAKA PITAYA ADULYATHAM  
BIOLOGICAL SCIENCE DIVISION

2534

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## บทคัดย่อ

การทดลองเก็บรักษาหอมหัวใหญ่ในทางการค้าเพื่อประเมินประสิทธิภาพของการฉายรังสีในการควบคุมการงอกของหอมหัวใหญ่ได้กระทำในปี พ.ศ. 2529 และ 2530 โดยได้รับความร่วมมือจากผู้ประกอบการเก็บรักษาหอมหัวใหญ่ หอมหัวใหญ่ที่ใช้ทดลองมีอายุหลังจากเก็บเกี่ยวระหว่าง 10-50 วัน และมีจำนวนรวมกันมากกว่า 250 ตัน ปริมาณรังสีที่ใช้มีค่าเฉลี่ยเท่ากับ 75 และ 100 เกรย์ หองเย็นที่ใช้เก็บรักษาหอมหัวใหญ่มีอุณหภูมิระหว่าง 1-10 องศาเซลเซียส และความชื้นสัมพัทธ์ร้อยละ 70-90 ผลการทดลองพบว่า การฉายรังสีช่วยลดอัตราการงอกของหอมหัวใหญ่ร้อยละ 11 และ 40 และลดอัตราการสูญเสียน้ำหนักร้อยละ 3 และ 5 เมื่อเก็บรักษาไว้ 5 และ 6 เดือนตามลำดับ การสูญเสียระหว่างการเก็บรักษาจะต่ำสุดเมื่อการฉายรังสีหอมหัวใหญ่กระทำภายใน 2 สัปดาห์ หลังจากเก็บเกี่ยวหอมหัวใหญ่ฉายรังสีสามารถเก็บรักษาในหองเย็นได้นาน 6 เดือน ในขณะที่หอมหัวใหญ่ไม่ฉายรังสีเก็บได้เพียง 5 เดือน นอกจากนี้ เมื่อนำไปเก็บรักษาต่อที่อุณหภูมิห้องหอมหัวใหญ่ฉายรังสีจะเก็บได้นานกว่าหอมหัวใหญ่ไม่ฉายรังสีอีก 1 สัปดาห์ การฉายรังสีเพื่อควบคุมการงอกของหอมหัวใหญ่ได้ผลเป็นที่พอใจทั้งในด้านเทคโนโลยีและด้านเศรษฐกิจ ดังจะเห็นได้จากผลตอบแทนที่ส่งกว่าตลอดช่วงระยะเวลาที่เก็บรักษา การทดลองวางตลาดหอมหัวใหญ่ฉายรังสีปรากฏว่าประสบความสำเร็จ ผู้ขายส่ง ผู้ซื้ปลีก และผู้ซื้อ ชอบหอมหัวใหญ่ฉายรังสีมากกว่าเพราะมีคุณภาพดีและสามารถเก็บรักษาได้นานกว่าหอมหัวใหญ่ไม่ฉายรังสี

## ABSTRACT

Pilot scale storage tests were carried out in co-operation with commercial onions traders in the years 1986 and 1987 to evaluate the efficacy of irradiation for sprout inhibition of onions under actual commercial storage conditions. Slightly over 250 tonnes of onions were irradiated 10-50 days after harvest at average doses of 75 and 100 Gy and stored in commercial cold storage at 1-10° C. and 70-90 % relative humidity. The results show that irradiation reduce sprouting in onions by 11 and 40 per cent and weight loss by 3 and 5 per cent after 5 and 6 months of storage, respectively. Storage losses are minimum when radiation is applied within two weeks of harvest. A maximum storage life of six months as against five months for controls is attained. Post cold storage life at ambient temperature for irradiated onions after withdrawal from cold storage is one week longer than that of non-irradiated controls. The radioinhibition process is technically feasible and economically justified as a profit can be made during the extended storage period. Marketing trials of irradiated onions conducted during and after termination of storage revealed no adverse comments from consumers and retailers /wholesalers. Wholesalers/retailers and consumers preferred irradiated onions because of their better physical quality and longer marketable life.

## 1. INTRODUCTION

Onions are vegetable crops of economic importance to Thailand and are grown locally for domestic consumption. The annual production is estimated to be approximately 30,000-40,000 tonnes. The crops are harvested only once a year from February to April. Thus they have to be stored to ensure the availability of supply before the next harvest. Existing methods for long term storage are not adequate to control deterioration. Approximately 50 per cent of the harvest is lost after a few months of storage. Sprouting, loss in weight and rotting have been the major problems in the deterioration of onions during storage at low temperature<sup>(1)</sup>. As a result, prices rise sharply during the off season in contrast to low prices in season. Although annual production is higher than consumption, Thailand still imports 600-1,000 tonnes of onions valued at approximately Baht 8-12 million during the months of August to December<sup>(2)</sup>. Extension of storage life and reduction of post storage losses by radiation treatment would help to ensure a steady supply, stabilize the price and cut down onions import.

Irradiation treatment of onions inhibits sprouting and reduces weight loss<sup>(3-7)</sup>. Irradiation of onions on both the laboratory and commercial scale has been found to be economically feasible<sup>(8-9)</sup>. Unconditional clearance of irradiated onions has been accorded in Thailand<sup>(10)</sup>. The scope of the work was to demonstrate the efficacy of pilot-scale radiation treatment of onions with the objective of transferring food irradiation technology to onion traders. Commercial storage and marketing trials of irradiated onions were carried out with involvement of onion traders during 1986 and 1987. Quality of irradiated onions stored under commercial conditions, market acceptability of the irradiated bulbs and cost-benefit of the radioinhibition process were evaluated.

## 2. PROCEDURES

### 2.1 collection of samples

Onions grown in Chiang Mai were used in the trials. In 1986 season, onions were cured by hanging in bunches in sheds for 3 weeks. In 1987 onions were cured for 10-50 days. After curing, sound onions only were sorted and packed in slatted wooden crates at 30-36 kg per crate. In 1986 about 10 tonnes of onions were collected from Bak Brothers Limited Partnership, and in 1987 about 243 tonnes of onions were collected from Bak Brothers Limited Partnership and the Government Cold Storage Organization. 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. Crates of onions 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 onion crates. The average dose administered for onions was 75 Gy (uniformity ratio = 1.7) in 1986 and 100 Gy (uniformity ratio = 1.7) in 1987. Each crate of irradiated onions was labelled with a printed statement showing that onions 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

Irradiated and non-irradiated onions were stored in commercial cold storage at Thai Seri Universal Food Company and the Government Cold Storage Organization. Space was left between stacks for ventilation. The period of storage was from May-November in 1986 and from March-November in 1987. The storage temperature and humidity were  $4\pm 3^{\circ}$  C and  $78\pm 10\%$  in 1986 and  $1-5^{\circ}$  C, 70-90 % and  $1-10^{\circ}$  C, 80-90 % in 1987.

## 2.4 Quality evaluation

Onions were inspected 4,5 and 6 months after storage for sprouting, softening, rotting, loss in weight and per cent of good bulbs. Quality inspection of onions during post cold storage at ambient temperature was also done periodically until the commodities reached a total of 50 per cent storage defects. Quality indices for stored onions are as follow:

### 2.4.1 Loss in weight

The difference between the weight of onions at start of storage and the final weight of onions at the time of inspection, was considered the loss in weight.

### 2.4.2 Sprouting

Onions bulbs exhibiting external sprouts were considered sprouting.

### 2.4.3 Rotting

Onions bulbs affected with mold rot and soft rot but without external sprouts were considered rotting.

### 2.4.4 Softening

Onions bulbs without external sprout and rot but showing soft to the touch when gently pressed on the outer surface, were considered softening.

### 2.4.5 Good bulbs

Good bulbs were bulbs without external sprouts, rot and soft.

## 2.5 Market test

Market testing of irradiated onions was done in the months of September-November, 1986 covering the lean period during 4 to 6 months' storage. Irradiated onions were periodically withdrawn from cold storage. On withdrawal, they were removed from crates and spread on cement floors to dry the surface moisture. After drying, decayed bulbs were sorted out, sprouts were trimmed and the marketable bulbs were repacked in crated with net weight of 30 kg and in polyethylene bags of 0.5 and 1 kg per bag. The packed onions with indicator label as mentioned earlier were supplied at the wholesale price prevailing at the time to five shops and one department store in different parts of Bangkok. A poster on onion irradiation was displayed at the sales area to inform consumers about irradiation, safety and wholesomeness of irradiated product. Each shop/store was given a



number of questionnaires to be supplied to the consumers for recording quality assessment and making comment. In 1987 marketing of irradiated onions was carried out by Bak Brothers Limited Partnership and the Government Cold Storage Organization in Bangkok through normal trading channel at competitive market price.

### 2.6 Cost-benefit analysis

The profit on sale of irradiated and non-irradiated onions were calculated based on 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 onions.

## 3. RESULTS AND DISCUSSION

### 3.1 Marketable quality and storage losses

The percentage of good bulbs, sprouting, softening, decay and loss in weight of irradiated and control bulbs stored up to 6 months in commercial cold storage at  $4 \pm 3^{\circ}$  C and  $78 \pm 10$  % relative humidity is shown in Table 3.1.1. The results showed that immediately after 5 and 6 months in cold storage only 68.6 and 26.0 percent good bulbs were recovered from the controls versus 83.2 and 70.5 per cent for irradiated lots. Loss due to sprouting was effectively controlled in irradiated samples. Eleven and 40 per cent less sprouts after 5 and 6 months were obtained by irradiation treatment. Loss in weight has also been reduced by irradiation treatment. Similar results were obtained with storage trials in 1987 (Table 3.1.2). Irradiated onions always had a higher percentage of good bulbs. The lower percentage of good bulbs obtained by the Government Cold Storage Organization can be attributed to higher variation in storage temperature and lower physical compactness of onions at the time of irradiation. Figure 3.1.1 shows results of losses due to sprouting and softening of onions irradiated at various time periods after harvest and stored for different times at  $1-5^{\circ}$ C. Our results do not confirm the observation that sprouting was inhibited completely only in those onions irradiated not later than 4 weeks after harvest. However, losses from sprouting and softening were lowest when irradiation was carried out within 2-4 weeks of harvest.

### 3.2 Quality deterioration in onions after transfer from cold storage to ambient temperature

The rate of quality deterioration at ambient temperature in previously cold stored irradiated and non-irradiated onions is shown in Tables 3.2.1, and 3.2.2. Marketable irradiated onions when transferred to ambient conditions after 5 and 6 months in cold storage at  $4\pm 3^{\circ}\text{C}$  and  $78\pm 10\%$  relative humidity deteriorated at a much lower rate than the non-irradiated onions. Non-irradiated bulbs took 4 days or less while irradiated bulbs took 11-16 days for the level of good bulbs to fall to 60 per cent. The additional 7 days marketable life will be important in the ambient temperature distribution of the commodity to retailers and consumers in distant areas. The high degree of softening during subsequent post storage at ambient temperature was probably due to the formation of hollow center surrounding a sprout. This hollow center enlarged when surrounding tissues dehydrated and caused the onion to lose its hardness.

### 3.3 Market test

Approximately 9 tonnes of irradiated onions were put on sale at the prevailing wholesale price during the lean months of September to November 1986 (Table 3.3.1). Irradiated onions were supplied to five shops and one department store in Bangkok at regular intervals, the quantity depending on the rate of sale. The shops and department store were requested to keep a record of the number of consumers purchasing irradiated onions and to note the reaction or comment made by the consumers.

Test marketing revealed no adverse comments on the sale of irradiated onions labelled as irradiated. Most consumers were unconcerned and refrained from making any comments or returning a questionnaire. Comments when made were positive. Consumers preferred the irradiated onions because their appearance and would buy them again. Some consumers asked whether onions imported from the Netherlands had been irradiated. Only a few consumers asked about the safety of irradiated onions. Ninety nine per cent of irradiated onions offered at the normal off-season high price were sold. Shop keepers noted that irradiated onions kept longer than non-irradiated onions. Wholesalers in Pakklong market, the center for onions distribution in Thailand, were informed of irradiation technology and

supplied with irradiated and non-irradiated bulbs for quality assessment. They are now aware of this technology and willing to obtain supplies of irradiated onions .

In 1987, 160 tonnes of irradiated onions were put on sale by Bak Brothers Limited Partnership through normal marketing channel in Bangkok. About 4-10 tonnes of irradiated onions were supplied to 14 shops each day during October to November (Table 3.3.2). Customers purchased irradiated onions without any hesitation even at a price of one Baht per kg higher than the prevailing price. The marketing trials were therefore considered successful.

#### 3.4 Cost-benefit analysis of onion irradiation and storage

The monetary benefit derived from sale of irradiated and non-irradiated onions is shown in Tables 3.4.1-3.4.3. The tables show that when onions harvested in April are irradiated and sold in September, October and November, the benefits are Baht 2,157 , 2,743 and 89 per ton compared to Baht 2,903, 1,369 and -5,284 per ton for non-irradiated onions. This result clearly indicates that non-irradiated onions cannot be profitably held in storage for a period of 6 months. The large difference in profits during October to November, combined with the higher consumers acceptability of irradiated onions and their longer marketable life at ambient temperature are appropriate for the implementation of irradiation in the local marketing system.

#### 4. CONCLUSIONS

Commercial storage and marketing trials of irradiated onions as a means of evaluating the commercial viability of the radioinhibition process are valuable. They provide better loss control data based on actual conditions of handling, temperature and relative humidity to which the commodities are exposed as well as information on consumers reactions towards irradiated foods which are necessary in evaluating the acceptability of the process.

Our pilot scale storage tests clearly demonstrated that irradiation of onions (75-100 Gy) to inhibit sprouting and reduce weight loss during commercial storage (1-7° C) was technically feasible and commercially practical. Optimum results were obtained with onions irradiated within 2-4

weeks after harvest. Irradiated onions can be stored for 6 months which is long enough to bridge the time until the new harvest, compared with 5 months' storage for unirradiated bulbs. The radioinhibition process is economically justified as a profit can be made during the extended storage period.

Encourage responses were obtained on marketing irradiated onions. Wholesalers, retailers and consumers preferred irradiated bulbs because of their better visual appearance, reduced shrivelling and longer marketable life. No adverse comments were received during the trials in spite of the label "irradiated".

The irradiation process for sprout inhibition of onions has now come to the stage of commercialization as evident by the increased number of onions traders utilizing the process and the increased quantity of irradiated onions irradiated from 10 tonnes in 1986 to 560 tonnes in 1988. It can be concluded that the objective of the Co-ordinated work aiming towards the transfer of food irradiation technology to traders and industry has been attained.

#### ACKNOWLEDGEMENT.

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Table 3.1.1 Quality of irradiated <sup>1</sup>(irr) and non-irradiated (non-irr) onions during storage at refrigerated temperature <sup>2</sup>

Storage time (months)	Treatment	Quantity inspected (kg)	Good bulbs %	Sprouting %	Softening %	Decay %	Weight loss %
4	Non Irr.	134	89.9	4.0	1.6	0.6	4.0
	Irr.	134	90.2	1.4	3.8	1.0	3.6
5	Non Irr.	134	68.6	15.3	5.3	2.6	8.2
	Irr.	134	83.2	4.4	5.4	2.3	4.8
6	Non Irr.	134	26.0	57.1	2.2	3.1	11.6
	Irr.	134	70.5	16.6	4.0	2.2	6.7

1) 75 Gy    2) 4±3° C, 78±10 % RH

Table 3.1.2 Per cent marketable bulbs of irradiated <sup>1</sup> (irr) and non-irradiated (non-irr) onions during 4.5 to 6 months' cold storage

Company	Storage time (months)	Treatment	Quantity stored (kg)	% Marketable bulbs	
				Good	Sprouted and Soft
A	4.5 - 5	Non Irr.	80,406	27.5	41.7
A	5 - 6	Irr.	60,044	56.8	25.6
B	6	Irr.	182,880	68.8	18.8

1 100 Gy

A The Government Cold Storage Organization : 1-10° C, 80-90 % RH

B Bak Brothers Limited Partnership : 1-5° C, 70-90 % RH

Table 3.2.1 Quality of irradiated <sup>1</sup> (irr) and non-irradiated (non-irr) onions <sup>2</sup> during post cold storage at ambient temperature <sup>3</sup>

Post cold storage time (day)	Treatment	Good bulbs %	Sprouting %	Softening %	Decay %	Weight loss %
1	Non Irr.	100				
	Irr.	100				
4	Non Irr.	74.8	12.2	4.9	6.0	2.2
	Irr.	96.0	0.2	1.7	0.2	2.0
9	Non Irr.	40.2	40.2	8.8	6.4	4.2
	Irr.	88.8	1.4	6.0	1.2	2.8
11	Irr.	76.2	1.8	13.0	5.0	4.2
16	Irr.	60.2	2.2	20.6	11.4	5.8

1 75 Gy

2 After 5 months in cold storage at  $4 \pm 3^\circ \text{C}$ ,  $78 \pm 10\% \text{ RH}$

3  $29-34^\circ \text{C}$ .

Table 3.2.2 Quality of irradiated <sup>1</sup> (irr) and non-irradiated (non-irr) onions <sup>2</sup> during post cold storage at ambient temperature <sup>3</sup>

Post cold storage time (day)	Treatment	Good bulbs %	Sprouting %	Softening %	Decay %	Weight loss %
1	Non Irr.	100				
	Irr.	100				
4	Non Irr.	52.0	39.0	3.5	2.6	3.0
	Irr.	91.8	3.7	1.7	1.0	1.8
9	Irr.	78.3	4.5	10.2	4.6	2.2
11	Irr.	64.5	6.4	21.1	5.2	3.0

1 75 Gy

2 After 6 months in cold storage at  $4 \pm 3^\circ \text{C}$ ,  $78 \pm 10\% \text{ RH}$

3  $26-33^\circ \text{C}$

Table 3.3.1 Quantity of irradiated onions sold and wholesale market price during the lean period in 1986

1 US \$ = 25.5 Baht

DATE	Quantity (kg)		Price (Baht/kg)	
	good bulbs	sprouted and soft	good bulbs	sprouted and soft
17 Sept.86	123.0	5.5	16	6
24 Sept.86	314.5	8.0	17	6
26 Sept.86	269.0	21.0	18	6
29 Sept.86	230.0	20.0	18	6
1 Oct.86	239.0	16.0	19	6
3 Oct.86	291.0	20.0	20	6
6 Oct.86	296.0	25.5	20	6
8 Oct.86	285.0	28.0	20	6
10 Oct.86	350.0	50.0	20	6
13 Oct.86	346.0	45.0	19	6
14 Oct.86	116.5	8.0	19	6
15 Oct.86	230.0	25.5	19	6
17 Oct.86	375.0	35.0	20	7
20 Oct.86	410.0	58.0	20	7
21 Oct.86	220.0	33.0	20	7
22 Oct.86	214.0	36.0	20	7
23 Oct.86	558.5	57.5	20	7

Table 3.3.1 (continued)

1 US \$ = 25.5 Baht

DATE	Quantity (kg)		Price (Baht/kg)	
	good bulbs	sprouted and soft	good bulbs	sprouted and soft
24 Oct.86	427.0	36.0	20	7
27 Oct.86	410.0	54.0	20	7
28 Oct.86	109.0	16.5	20	7
29 Oct.86	267.0	48.0	20	7
30 Oct.86	551.5	63.0	20	7
31 Oct.86	406.0	62.0	20	7
3 Nov.86	350.0	84.5	20	7
4 Nov.86	352.0	79.5	20	7
5 Nov.86	310.0	112.0	20	7
7 Nov.86	309.0	112.0	20	7
11 Nov.86	95.5	27.0	20	7
TOTAL	8,454.5	1,186.5		



Table 3.3.2 Quantity of irradiated onions sold and wholesale market price during the lean period in 1987

1 US \$ = 25.5 Baht

DATE	Quantity (kg)		Price (Baht/kg)	
	good bulbs	sprouted and soft	good bulbs	sprouted and soft
11 Oct.87	6,685	1,120	18.6	8.3
12 Oct.87	7,175	770	18.6	8.4
13 Oct.87	7,595	1,015	18.3	8.1
14 Oct.87	4,970	910	18.8	8.5
18 Oct.87	7,140	2,590	18.6	8.2
19 Oct.87	5,775	1,470	17.5	7.1
20 Oct.87	5,915	1,400	17.5	6.4
23 Oct.87	6,895	595	17.3	5.9
25 Oct.87	9,100	1,190	17.3	6.6
27 Oct.87	4,760	840	18.1	6.3
28 Oct.87	6,020	945	18.7	7.1
29 Oct.87	6,685	770	19.3	7.7
30 Oct.87	4,060	735	20.6	7.4
31 Oct.87	3,080	805	20.6	9.6
1 Nov.87	4,025	2,940	20.8	9.0
2 Nov.87	3,325	735	23.0	9.2

Table 3.3.2 (continued)

1 US \$ = 25.5 Baht

DATE	Quantity (kg)		Price (Baht/kg)	
	good bulbs	sprouted and soft	good bulbs	sprouted and soft
3 Nov.87	3,430	1,400	22.0	9.2
4 Nov.87	4,165	2,590	22.9	9.7
5 Nov.87	5,250	840	22.5	9.0
6 Nov.87	4,515	2,520	22.7	9.4
8 Nov.87	7,280	2,380	24.8	8.3
9 Nov.87	4,900	2,555	21.3	8.5
10 Nov.87	3,115	3,220	21.0	8.3
TOTAL	125,860	34,335		

Table 3.4.1 Cost analysis of onions irradiation and storage in 1986

1 US \$= 25.5 Baht

	Cold storage period (month)			
	4 (Sept.)	5 (Oct.)	6 (Nov.)	Total
1. Quantity stored (kg)	1,038.5	7,336.5	2,010	10,385
2. Quantity sold (kg)				
good bulbs	936.5	6,101.5	1,416.5	8,454.5
sprouted and soft	54.5	717.0	415.0	1,186.5
3. Wholesale price (Baht/kg)				
good bulbs	17.40	19.85	20.00	
sprouted and soft	6.00	6.70	7.00	
4. Revenue, 2x3 (Baht)	16,622	125,918	31,235	172,775
5. Cost of onions <sup>1</sup> (Baht)	8,308	58,692	16,080	83,080
6. Irradiation fee <sup>2</sup> (Baht)	779	5,502	1,508	7,789
7. Cold storage fee <sup>3</sup> (Baht)	4,206	33,014	10,854	48,074
8. Interest <sup>4</sup> (Baht)	419	3,870	1,326	5,615
9. Labour cost <sup>5</sup> (Baht)	517	4,035	1,106	5,712
10. Transportation cost <sup>6</sup>	99	682	183	964
11. Profit (Baht/Tonne)	2,157	2,743	89	2,170
	(4-5-6-7-8-9-10)			

- (1) 8 Baht/kg including cost of crate, packing, transportation from Chiangmai to Bangkok (2) 0.75 Baht/kg including cost of transportation to cold storage room (3) 0.90 Baht/kg/month (4) 12 % per year on 5,6,7 (5) 0.55 Baht/kg (6) 0.10 Baht/kg

Table 3.4.2 Cost analysis of onions and storage in 1986

1 US \$ = 25.5 Baht

	Cold storage period (month)			Total
	4 (Sept.)	5 (Oct.)	6 (Nov.)	
1. Quantity stored (kg)	134	268	134	536
2. Quantity sold (kg)				
good bulbs	120.5	183.8	34.9	339.2
sprouted and soft	7.4	55.3	79.5	142.2
3. Wholesale price (Baht/kg)				
good bulbs	17.40	19.85	20.00	
sprouted and soft	6.00	6.70	7.00	
4. Revenue, 2x3 (Baht)	2,141	4,019	1,255	7,415
5. Cost of onions <sup>1</sup> (Baht)	1,072	2,144	1,072	4,288
6. Cold storage fee <sup>2</sup> (Baht)	543	1,206	724	2,473
7. Interest <sup>3</sup> (Baht)	50	131	82	263
8. Labour cost <sup>4</sup> (Baht)	74	147	74	295
9. Transportation cost <sup>5</sup> (Baht)	13	24	11	48
10. Profit (Baht/tonne)	2,903	1,369	-5,284	90
(4-5-6-7-8-9)				

(1) 8 Baht/kg including cost of crate, packing, transportation from Chiangmai to Bangkok

(2) 0.90 Baht/kg/month

(3) 12 % per year on 5 and 6      (4) 0.55 Baht/kg      (5) 0.10 Baht/kg

Table 3.4.3 Cost analysis of onions irradiation and storage in 1987

1 US \$ = 25.5 Baht

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Cold storage period (month)

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6 (Oct. - Nov.)

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1. Quantity stored (kg)	182,880
2. Quantity sold (kg)	
good bulbs	125,860
sprouted and soft	34,335
3. Wholesale price (Baht/tonne)	
good bulbs	19,540
sprouted and soft	8,310
4. Revenue, 2x3 (Baht)	2,744,628
5. Cost of onions <sup>1</sup> (Baht)	1,463,040
6. Irradiation fee <sup>2</sup> (Baht)	115,214
7. Cold storage fee <sup>3</sup> (Baht)	941,832
8. Interest <sup>4</sup> (Baht)	105,822
9. Labour cost <sup>5</sup> (Baht)	86,505
10. Transportation cost <sup>6</sup> (Baht)	14,418
11. Profit (Baht/tonne) (4-5-6-7-8-9-10)	97

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(1) 8 Baht/kg including cost of crate, packing, transportation from Chiangmai to Bangkok

(2) 630 Baht/tonne including cost of transportation to cold storage room

(3) 900 Baht/tonne for first month and 850 Baht/tonne for each subsequent month (4) 12 % per year (5) 540 Baht/tonne (6) 90 Baht/tonne

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