PT024
To improve postharvest handling, storage and processing quality of atlantic and cadima potatoes

Dr S C Tan
Western Australian Department of Agriculture

Know-how for Horticulture™

PT024

This report is published by the Horticultural Research and Development Corporation to pass on information concerning horticultural research and development undertaken for the potato industry.

The research contained in this report was funded by the Horticultural Research and Development Corporation with the financial support of Smiths Snackfoods Pty Limited.

Cover Price $20.00

HRDC ISBN 1 86423 490 3

Published and Distributed by:

Horticultural Research and Development Corporation
Level 6
7 Merriwa Street
Gordon NSW 2072

Telephone: (02) 9418 2200
Fax: (02) 9418 1352

HORTICULTURAL RESEARCH AND DEVELOPMENT CORPORATION

FINAL REPORT

Project title: To improve postharvest handling, storage and processing quality of Atlantic and Cadima potatoes.

Project No.: HRDC P/0024

Organisation:
Western Australian Department of Agriculture
3 Baron-Hay Court
South Perth WA 6151

Project Chief Investigator:
Dr Soon Chye Tan
Research Officer (Postharvest)
Phone: (09) 368 3647
Fax: (09) 368 2625

Commencement date: January 1991

Completion date: June 1993

Funding sources:
1990/91 - $7,600
1991/92 - $16,300
1992/93 - $7,600

HRDC and Smith's Snack Foods Pty Ltd

CONTENTS

1. Summary

(a) Industry summary

Atlantic is a preferred crisping variety in Western Australia as it has high specific gravity (around 1.085) and normally produces desirable crisp colour. However, experimental results indicated that there were more blemishes, shrivelling and sprounting in Atlantic compared to Cadima in medium (4-6 weeks) to long term (> 3 months) storage. The blemish problem was due to the fact that Atlantic has tender skin and texture. Atlantic also has severe sprouting problem if not stored properly as it is a short dormancy cultivar. The high level of dehydration/water loss in Atlantic tuber was partly due to excessive sprouting. Atlantic harvested late in the season (i.e. more mature) seemed to sprout more severely than those harvested earlier (i.e. less mature).

In order to maintain good visual external quality and crisping/processing quality, Atlantic can only be stored at 10° or 15°C for about 6 weeks. Atlantic should not be stored at 20°C or higher temperatures.

Cadima that had been stored for 3 months at 10° or 15°C and 2 months at 20°C still produced acceptable crisping quality. There were no sprouting problems in Cadima in long term storage but the crisping quality deteriorated due to dehydration and changes in texture.

The crisping/processing quality seemed to be influenced by the ways the potatoes were grown including growers' farm management and how they were handled during and after harvesting. Maturity seemed to have little effect on the processing quality and therefore the growers could plan harvesting date two to three weeks before or after the calculated optima harvesting date as long as they practised proper postharvest management.

Application of maleil hydrazide of 8 L/ha or higher doses at 6 weeks before harvesting was effective in reducing sprouting during storage. Generally the sprouting was more severe when the potatoes were stored at 20°C compared to 10°C. Protective coating with Ausgloss and gelatin solution reduced the degree of greening and hence improved the visual external quality of potatoes.

The maturity of the tubers based on the harvesting dates seemed to have no effects on the development of greening in Atlantic and Cadima potatoes. However, greening was more severe in Atlantic than in Cadima.

The levels of glycoalkaloids in the samples were well below the toxic level of 200 mg/kg fresh weight. No apparent trend was observed when comparing potatoes harvested at different maturity and exposed to light after various coating treatments. Some green potatoes contained less glycoalkaloids than ungreen potatoes. There was no direct relationship between visual greeness and glycoalkaloid levels. The white-skinned Atlantic appeared to produce more glycoalkaloid than Cadima under the same treatment and some experimental conditions.

Our results confirmed literature claims that the glycoalkaloids concentrate in the stem and layer just under stem (< 5 mm). The results showed that glycoalkaloids were much higher in the sprouts. However, the relationship between visual greeness and glycoalkaloid levels needs further investigation.

(b) Technical summary

In order to retain good visual external and processing/crisping quality. Atlantic potatoes can only be stored at 10 or 15°C for about 6 weeks and no more than 2 months. Storage at ambient (20°C) should not be carried out for Atlantic. Cadima potatoes can be stored for 3 months at 10 or 15°C and 2 months at 20°C.

Atlantic has severe sprouting problems as it is a cultivar with very short dormancy. Atlantic harvested late in the season (i.e. more mature) seemed to sprout more severely than those harvested earlier. There were no sprouting problems in Cadima in long term storage but the processing quality deteriorated due to dehydration and changes in texture.

Application of Maleic hydrazide at rates of 8 L/ha or higher 6 weeks before harvesting was effective in reducing sprouting in Atlantic and Cadima potatoes.

The levels of glycoalkaloids in all the samples are well below the toxic level of 200 mg/kg fresh weight. There is no direct relationship between visual greeness and glycoalkaloid levels. Some green potatoes contained less glycoalkaloids than ungreen ones. However, the white-skinned Atlantic appeared to produce more glycoalkaloid than the Cadima under the same treatment and same experimental conditions. There is a varietal difference in the production and accumulation of glycoalkaloid levels. It is necessary to quantify glycoalkaloids in several common potato varieties/cultivars grown in various regions in Australia. To study the relationship between the levels of glycoalkaloid and the degree of green (to measure chlorophyll content) under different environment conditions and different handling methods need to be carried out in future. As new cultivars are created, either through traditional plant breeding or bio-engineering, those responsible should be aware of the possibility that new cultivars may be toxic due to excessive glycoalkaloids.

The experimental results confirm literature claims that the glycoalkaloids concentrate in the skin and the layer just under the skin. Glycoalkaloids concentrate even more in the sprouts. Protective coating with Ausgloss and gelatin solution reduced the degree of greening and hence improved the visual external quality of potatoes. The effectiveness of Ausgloss and gelatine in reducing greening should be studied in a commercial scale to investigate the feasibility and the economical aspects of usage in the industry.

2. RECOMMENDATIONS

(a) Extension/adaptation by industry of research findings

(i) In order to maintain good visual external and processing/crisping quality, Atlantic potatoes should only be stored at 10 or 15°C in darkness for about 6 weeks and definitely not more than 2 months.

(ii) Storage of Atlantic at ambient or temperature higher than 20°C should not be carried out due to excessive sprouting and dehydration.

(iii) Cadima potatoes can be stored in darkness at 10 or 15°C for 3 months, and at 20°C in darkness for 2 months. There were no severe sprouting problems in Cadima but the processing quality deteriorated due to dehydration in long term storage.

(iv) Maturity seemed to have little effect on the processing quality of both Atlantic and Cadima potatoes. The growers can plan to harvest their crops two to three weeks before or after the optimal harvesting date as long as they practise proper pre and post-harvest management.

(v) Apply maleic hydrazide at 6 weeks before harvesting to reduce sprouting during storage.

(vi) Measures to reduce postharvest greening would include the following practices:

- Farm — Farmers should cover bins with plastic tarpaulins immediately after harvest and place inside a dark well ventilated shed as soon as possible after harvesting.
- Transport — Trucks should be covered with light proof tarpaulins for transporting potatoes.
- Processors — Processors should keep stored potatoes at 10-15°C in the dark in well ventilated rooms.

(b) Directions for future research and/or activities supported by the HRDC

(i) Atlantic has severe sprouting problems as it is a cultivar with very short dormancy. Atlantic harvested late in the season (more mature) seemed to sprout more easily than those harvested earlier. Further work needs to be done to control the sprouting in Atlantic potatoes if they have to be stored for considerable periods of time.

(ii) There is varietal differences in the production and accumulation of glycoalkaloids in potatoes. It is necessary to quantify glycoalkaloid levels in several common potato varieties/cultivars grown in various regions in Australia to study the relationship between the levels of glycoalkaloid and the levels of chlorophyll in

greening potatoes under different growing conditions and handling methods. If a statistically valid relationship is found then a greening index could be developed.

(iii) Our experimental results confirm literature claims that glycoalkaloids concentrate in the skin and the layer just under the skin.

(iv) Glycoalkaloids concentrate even more in the sprouts.

(v) Since the glycoalkaloids concentrate in the potato skin it is recommended that skins only be analysed in future studies.

(vi) Protective coating with Ausgloss and gelatin solution reduced the degree of greening and hence improved the visual external quality of potatoes. The effectiveness of Ausgloss and gelatin in reducing greening should be studied in a commercial scale to investigate the feasibility and the economical aspects of usage in the industry.

(vii) Continuation of studies to reduce the amount of greening in potatoes. In particular, potato handling techniques and retail display practices. Potato greening is a serious marketing problem.

(viii) Extension program should be developed by the industry and department s of agriculture directed to farmers, transporters and processors.

(c) Financial/commerical benefits of adoption of research findings

(i) To extend the storage life and to maintain the processing/crisping quality of Atlantic and Cadima potatoes.

(ii) To reduce postharvest loss of potatoes during storage.

(iii) To reduce sprouting and greening of potatoes.

(iv) The growers can plan for the harvesting time more effectively.

3. Technical Report

To improve postharvest handling, storage and processing quality of Atlantic and Cadima potatoes.

S.C. Tan
Division of Plant Industries
Department of Agriculture
South Perth, Western Australia 6151

Introduction

Australia's annual potato crop is usually 1,000,000 tonnes with a gross value of approximately $320 million. Annual potato production in Western australia is approximately 100,000 tonnes from 2,940 ha worth a gross value of $35 million. Potatoes are the most important horticultural crop in Western Australia and constitute 35% of the area of vegetables. About 38% of the crop undergoes value adding processing (crisps, french fries). The total number of growers is 350 and production is supplied from 8 growing areas between Gingin in the north and Albany in the south of the State.

Atlantic and Cadima are the preferred varieties for crisp manufacture (Gratte and Paust, 1990). Cadima is also a French fry variety. Poor handling methods during harvesting, in-field storage and transportation have greatly reduced the storage and keeping quality of Atlantic and Cadima potatoes. Common storage diseases and disorders associated with poor handling are water loss due to skin damage, black spot, soft rot caused by *Erwinia* spp. and dry rot caused by *Fusarium* spp. (Hide *et al.* 1969, Logan *et al.* 1975, Hamilton *et al.* 1981, Carnegie *et al.* 1984, Carnegie *et al.* 1990 and Foister *et al.* 1952).

Better handling methods and more efficient storage conditions need to be developed in order to reduce postharvest losses of Atlantic and Cadima. Poor handling methods are particularly damaging to Atlantic potatoes as they have very tender skins, bruise and crack easily.

Light causes the tubers to turn green (Conner 1937, Howard *et al.* 1957). Chemicals involved are chlorophyll (Larson, 1949), α-solanine (Hilton, 1951) and α-chaconine. As well as being poisonous (e.g. too much α-solanine), green tubers result in unacceptably dark and coloured crisps and chips. There has been little previous work on the level of glycoalkaloids in potatoes in Australia.

There is a need to examine the possible usage and the effectiveness of maleic hydrazide and to develop other methods for the inhibition of sprouting during long term storage (Smith, 1968).

The objective of this project was to improve postharvest handling and storage conditions for Atlantic and Cadima potatoes for processing. The project aimed to study the effect of maturity, temperature and the period of storage on the storage and processing quality of potatoes. The project also investigated the effects of maleic hydrazide on sprouting and the effects of handling (such as modified atmosphere packaging and application of protective layers) in reducing greening.

Objectives for each year of the project:

Year 1:

To investigate the relationship between maturity and the time of storage, the specific gravity (SG), dry matter (DM), visual quality and processing quality of Atlantic and Cadima. Initial study on the effects of poor management on the development of postharvest disorders. Studies on the control of sprouting and greening, including modified atmosphere storage.

Year 2:

To continue study on the effects of maturity and storage conditions on processing quality of potatoes. To further study on the control of sprouting and greening. Further refine the results obtained and to prepare reports and recommendations.

Materials and methods

(a) Effects of maturity and the time of storage on the specific gravity (SG), dry matter (DM), visual quality and processing quality of Atlantic and Cadima potatoes

1991

Atlantic and Cadima potatoes were grown at Medina Research Station, Department of Agriculture as well as at the growers' properties in Manjimup-Pemberton areas and Old Coast Road area, Western Australia. Five samples, # 1, 2, 3, 4, 5; each one or two week apart were harvested at the Medina Research Station and at each growers property. Sample #1 was the most immature one, sample #3 was harvested at the optima time and sample #5 was the over mature one. The harvesting dates of the six growers engaged in this trial of Atlantic potatoes are shown in Table 1 and Cadima in Table 2. Growers No. 1, 2 and 3 were from Manjimup-Pemberton area and growers No. 4, 5 and 6 were from Old Coast Road (Myalup area).

Table 1. The location and harvesting date of Atlantic potatoes in 1991

Location	Harvesting date				
	#1	#2	#3	#4	#5
Medina Research Centre	23/10	6/11	20/11	4/12	18/12

Plate 1. The greening index for potatoes.

Range	SCORE	Descriptive Terms
Too Light	1	White
	2	Very light yellow
	3	Light yellow
Desired colour		
	4	Yellow
	5	Light gold
Borderline	6	Gold
	7	Dark gold
	8	Brown
Too dark		
	9	Dark brown
	10	Black

(b) The effectiveness of maleic hydrazide in controlling of sprouting during storage

1991

Atlantic and Cadima potatoes were grown at Medina Research Centre, Department of Agriculture. Maleic hydrazide with concentrations of 5, 8, 11 and 14 litre/ha were sprayed on different plots (3 plots per concentration) at 6 and 4 weeks before the crop was ready for harvest. The spraying dates were 7 October and 21 October 1991 respectively. A total of 24

plots for each variety. Both Atlantic and Cadima were harvested at 20 November 1991. The concentration recommended by the manufacturer was 11 L/ha.

1992

Atlantic and Cadima potatoes were also grown at Medina Research Centre, Department of Agriculture. Maleic hydrazide with concentrations of 5, 8, 11 and 14 L/ha were sprayed on different plots (3 plots per concentration) at 6 and 4 weeks before the crop was ready for harvest, and also at 2 weeks after full bloom. A total of 36 plots for each variety. Both Atlantic and Cadima were harvested at 18 November 1992.

Afterharvesting, all the samples were transported to the Postharvest Laboratory at South Perth by a utility. On arrival at the Laboratory, they were randomly divided into lots and stored at 10, 15 and 20°C for a period of 0, 1, 3 and 6 months. They were then assessed for tuber weight, sprout weight, sprouting capacity and visual quality. The sprouting capacity was defined as:

$$\text{Sprouting capacity} = \frac{\text{Sprout weight}}{\text{Tuber weight (after removing the sprout)}} \times 100\%$$

(c) Reduction of greening in Atlantic and Cadima potatoes

Atlantic and Cadima potatoes harvested from Medina Research Centre were used in the trial. They were hard washed before treatment.

Experiment A.

Potatoes (10 tubers per replicate, 5 replicates per treatment) were dipped separately in the following solutions:

(i) control (without dipping)
(ii) 3% sweet potato flour
(iii) 3% tapioca flour
(iv) 3% arrow root flour
(v) 3% gelatin
(vi) 1.5% Semperfresh
(vii) Ausgloss
(viii) no dipping, stored in sealed low density polyethlene bags (modified atmosphere storage).

After drying in air, they were placed at a 20°C constant temperature room under constant light of about 25 ft candle. The degree of greening and the visual quality were assessed daily. Any tuber with greening score and visual quality score of more than 3 was not suitable for marketing/processing.

Experiment B.

Two maturity stages of potatoes were used in this experiment to study the effects of maturity on greening. The potatoes were harvested at 29 October 1992 (immature) and 24 November 1992 (optimal maturity). Potatoes (10 tubers per replicate, 5 replicates per treatment) were treated as follows:

(i) control (without dipping, opened tray)
(ii) dipped in 3% gelatin solution
(iii) dipped in Ausgloss solution
(iv) no dipping, stored in sealed low density polyethylene bags (modified atmosphere storage)

After drying in air, they were placed at a 20°C constant temperature room with 10 hours light (about 40 ft candle) and 14 hours darkness. The arrangement was aimed to simulate supermarket display conditions. The potatoes were assessed from day to day for the degree of greening and visual quality. The levels of 0_2 and CO_2 in the sealed polyethylene bags were determined from time to time. The contents of α-chaconine, α-solanine and total glycoalkaloid in the potatoes were also analysed from time to time. The analysis was done by using whole potatoes, skins and sprouts separately.

Determination of CO_2 and 0_2 concentration

The concentration of CO_2 was determined with an ADC CO_2 analyser (The Analytical Development Co. Ltd, England) and the concentration of 0_2 was determined with a Servomex 0_2 analyser (Series 1400, Servomex Ltd., U.K.). One millilitre air samples from the bags were injected into CO_2 and 0_2 free gas streams.

Determination of glycoalkaloids (in collaboration with the Chemistry Centre, Western Australia)

To obtain a representative sample, 4-6 potato tubers from each sample were selected, washed, wiped dry and cut into small pieces. The sample was then placed in a food processor dish and blended until a smooth potato paste was obtained (3 minutes approx.).

A 5 g sample of potato paste was weighed into a 50 mL cylinder and 30 mL methanol added. Shaked well and placed in an ultrasonic bath for 15 minutes.

Filtered sample and washed residue with methanol. Filtrates were collected in a 50 mL cylinder and brought final volume to 50 mL with methanol.

A 5 mL aliquot of the extract was then mixed with 8 mL of water and applied to a Sep-Pak C_{18} cartridge previously conditioned with 5 mL of methanol.

The C_{18} cartridge was then washed with 5 mL of 40 percent methanol. The glycoalkaloids were then eluted with 15 mL methanol and collected in a 100 mL round-bottom flask. The methanol was then evaporated to dryness on a rotary evaporator. The residue formed was dissolved in 2 mL of methanol and 20 µL injected in the HPLC system.

Results and discussion

(A) Effects of maturity, temperature and the time of storage on Atlantic and Cadima potatoes

Effects of maturity/harvesting date, time of storage and temperature of storage on the degree of blemishes, shrivelling, greening and the visual external quality of Atlantic and Cadima potatoes grown in Medina Research Centre in 1991 are shown in Table 5; on sprout number and sprout weight in Table 6; and on specific gravity, dry matter and crisp colour in Table 7. The results of the potatoes grown in Medina research Centre in 1992 are shown in Table 8, 9 and 10.

Effects of maturity/harvesting date and time of storage on the visual external quality, specific gravity and crip colour of Cadima potatoes grown by the six growers in Manjimup-Pemberton area and the Old Coast Road (Myalup area) in 1991 are shown in Table 11 (storage temperature 10°C), Table 12 (storage temperature 15°C) and Table 13 (storage temperature 20°C).

The results of the effects of maturity/harvesting date, time of storage and temperature of storage on the visual external quality, specific gravity and crisp colour of Atlantic potatoes grown by the two growers in Manjimup-Pemberton area are shown in Table 14, 15 and 16.

Table 5. Effects of harvesting date (Harvest), time of storage (Time), and temperature of storage (Temp) on the degree of blemishes, shrivelling, greening and the visual external quality of Atlantic (A) and Cadima (C) potatoes grown in Medina Research Centre 1991

Harvest	Time (month)	Temp (°C)	Blemishes		Shrivelling		Greening		Quality	
			A	C	A	C	A	C	A	C
23/10/91	0	10	1.1	1.0	1.0	1.0	1.0	1.0	1.1	1.0
	1	10	1.3	1.0	1.0	1.0	1.0	1.0	1.2	1.0
	2	10	1.7	1.1	1.0	1.0	1.0	1.0	1.7	1.1
	3	10	1.9	1.4	1.3	1.0	1.0	1.0	2.1	1.4
	4	10	2.2	1.5	4.1	2.5	1.0	1.0	5.0	3.5
	6	10	2.3	2.4	5.0	5.0	1.0	1.0	5.0	5.0
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.0
	1	15	1.6	1.0	1.0	1.0	1.0	1.0	1.3	1.0
	2	15	1.9	1.1	1.0	1.0	1.0	1.0	1.6	1.1
	3	15	2.1	1.3	2.7	1.0	1.0	1.0	3.0	1.3
	4	15	2.1	1.5	4.7	4.0	1.0	1.0	5.0	4.2
	6	15	2.4	1.7	5.0	5.0	1.0	1.0	5.0	5.0
	0	20	1.1	1.0	1.0	1.0	1.0	1.0	1.1	1.0
	1	20	1.4	1.0	1.0	1.0	1.0	1.0	1.7	1.0
	2	20	1.9	1.1	1.0	1.0	1.0	1.0	2.0	1.1
	3	20	1.9	1.1	2.8	1.1	1.0	1.0	3.1	1.2
	4	20	2.1	1.2	4.5	3.3	1.0	1.0	5.0	3.8
	6	20	2.4	1.7	5.0	4.7	1.0	1.0	5.0	4.9

Table 5 cont'd.

Harvest	Time (month)	Temp (°C)	Blemishes		Shrivelling		Greening		Quality	
			A	C	A	C	A	C	A	C
6/11/91	0	10	1.0	1.1	1.0	1.0	1.0	1.0	1.0	1.1
	1	10	1.2	1.2	1.0	1.0	1.0	1.0	1.6	1.2
	2	10	1.6	1.2	1.0	1.0	1.0	1.0	1.7	1.2
	3	10	1.9	1.4	1.0	1.0	1.0	1.0	2.0	1.4
	4	10	2.1	1.9	2.5	1.0	1.1	1.0	3.0	1.9
	6	10	2.2	1.9	4.9	3.5	1.2	1.0	5.0	4.3
	0	15	1.0	1.2	1.0	1.0	1.0	1.0	1.0	1.2
	1	15	2.0	1.2	1.0	1.0	1.0	1.0	2.0	1.2
	2	15	2.0	1.2	1.0	1.0	1.0	1.0	2.0	1.2
	3	15	2.0	1.3	1.0	1.3	1.0	1.0	2.0	1.5
	4	15	2.2	1.3	3.4	1.5	1.0	1.0	4.0	2.0
	6	15	2.2	1.4	4.8	4.0	1.0	1.0	5.0	4.7
	0	20	1.1	1.1	1.0	1.0	1.0	1.0	1.2	1.1
	1	20	1.5	1.2	1.8	1.0	1.0	1.0	2.1	1.2
	2	20	1.8	1.3	2.4	1.4	1.0	1.0	2.7	1.5
	3	20	2.2	1.3	2.7	1.9	1.0	1.0	3.5	2.1
	4	20	2.5	1.3	4.1	2.4	1.0	1.0	4.9	3.2
	6	20	2.8	1.3	4.9	4.0	1.0	1.0	5.0	5.0
20/11/91	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	10	1.1	1.2	1.0	1.0	1.0	1.0	1.1	1.2
	2	10	1.1	1.2	1.0	1.0	1.0	1.0	1.1	1.2
	3	10	1.4	1.2	1.6	1.0	1.0	1.0	1.6	1.2
	4	10	1.8	1.2	2.0	1.0	1.3	1.0	2.5	1.2
	6	10	1.8	1.3	4.2	2.4	1.3	1.0	5.0	3.4
	0	15	1.1	1.1	1.0	1.0	1.0	1.0	1.2	1.3
	1	15	1.3	1.1	1.0	1.0	1.0	1.0	1.3	1.3
	2	15	1.3	1.1	1.0	1.0	1.0	1.0	1.5	1.3
	3	15	1.5	1.2	2.1	1.1	1.0	1.0	2.4	1.4
	4	15	1.9	1.4	2.8	1.3	1.0	1.0	2.8	1.7
	6	15	1.9	1.6	5.0	4.1	1.0	1.0	5.0	4.7
	0	20	1.1	1.1	1.0	1.1	1.0	1.0	1.2	1.3
	1	20	1.4	1.1	1.0	1.1	1.0	1.0	1.5	1.3
	2	20	1.6	1.2	1.5	1.2	1.0	1.0	1.7	1.5
	3	20	1.6	1.3	2.0	1.4	1.0	1.0	2.3	2.0
	4	20	1.6	1.5	3.0	1.6	1.0	1.0	3.5	2.0
	6	20	1.6	1.5	4.2	3.7	1.0	1.0	5.0	4.7

Table 5 cont'd.

Harvest	Time (month)	Temp (°C)	Blemishes		Shrivelling		Greening		Quality	
			A	C	A	C	A	C	A	C
4/12/91	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	10	1.3	1.0	1.0	1.0	1.0	1.0	1.3	1.0
	2	10	1.6	1.1	1.0	1.0	1.0	1.0	1.6	1.2
	3	10	1.6	1.2	2.2	1.0	1.0	1.0	2.9	1.2
	4	10	1.6	1.4	3.8	2.1	1.0	1.0	4.7	2.8
	6	10	1.6	2.0	5.0	5.0	1.1	1.0	5.0	5.0
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	15	1.2	1.0	1.0	1.0	1.0	1.0	1.2	1.0
	2	15	1.5	1.0	2.2	1.0	1.0	1.0	2.6	1.0
	3	15	1.5	1.0	2.9	1.0	1.0	1.0	3.2	1.0
	4	15	1.5	1.1	4.0	3.9	1.0	1.0	5.0	4.9
	6	15	1.7	1.3	5.0	5.0	1.0	1.0	5.0	5.0
	0	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	20	1.2	1.0	1.0	1.0	1.0	1.0	1.2	1.0
	2	20	1.3	1.0	2.2	1.0	1.0	1.0	2.4	1.0
	3	20	1.3	1.1	3.1	1.1	1.0	1.1	3.9	1.1
	4	20	1.4	1.2	4.0	3.5	1.0	1.0	5.0	3.6
	6	20	1.7	1.5	5.0	5.0	1.0	1.0	5.0	5.0
18/12/91	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	10	1.1	1.0	1.0	1.0	1.0	1.0	1.2	1.0
	2	10	1.3	1.1	1.0	1.0	1.0	1.0	1.3	1.1
	3	10	1.4	1.3	2.8	1.9	1.0	1.0	2.1	2.2
	4	10	1.5	1.9	4.0	2.5	1.0	1.0	4.3	3.0
	6	10	1.6	2.8	5.0	4.4	1.0	1.0	5.0	4.9
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	15	1.0	1.0	1.0	1.0	1.0	1.0	1.4	1.0
	2	15	1.1	1.2	2.2	1.0	1.0	1.0	2.2	1.2
	3	15	1.1	1.3	3.2	2.4	1.0	1.0	2.8	2.6
	4	15	1.1	1.4	4.6	4.0	1.0	1.0	4.7	4.3
	6	15	1.1	2.1	5.0	5.0	1.0	1.0	5.0	5.0
	0	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	20	1.0	1.1	1.5	1.0	1.0	1.0	1.6	1.1
	2	20	1.1	1.2	2.1	1.0	1.0	1.0	2.3	1.2
	3	20	1.1	1.4	3.0	2.3	1.0	1.0	3.4	2.7
	4	20	1.1	1.6	3.9	3.4	1.0	1.0	4.8	4.3
	6	20	1.1	1.6	5.0	4.9	1.0	1.0	5.0	4.9

Table 6. **Effects of harvesting date (Harvest), time of storage (Time), and temperature of storage (Temp) on the sprout number and sprout weight of Atlantic (A) and Cadima (C) potatoes grown in Medina Research Centre, 1991**

Harvest	Time (month)	Temp (°C)	Sprout No.		Sprout weight (gm)	
			A	C	A	C
23/10/91	0	10	0	ND	0	0
	1	10	0	ND	0	0
	2	10	3.8	ND	0.5	0
	3	10	4.2	ND	4.4	0
	4	10	3.8	ND	4.6	0.3
	6	10	3.9	ND	5.2	0.8
	0	15	0	ND	0	0
	1	15	0	ND	0	0
	2	15	1.9	ND	1.0	0
	3	15	3.1	ND	7.1	0.1
	4	15	3.9	ND	7.6	0.4
	6	15	4.3	ND	7.4	0.9
	0	20	0	ND	0	0
	1	20	0	ND	0	0
	2	20	1.6	ND	1.2	0
	3	20	2.8	ND	4.4	0.1
	4	20	5.8	ND	5.8	0.3
	6	20	4.7	ND	6.9	0.9
6/11/91	0	10	0	ND	0	0
	1	10	0	ND	0	0
	2	10	2.1	ND	0.8	0
	3	10	2.3	ND	0.5	0
	4	10	2.8	ND	4.2	0
	6	10	3.2	ND	5.6	0.7
	0	15	0	ND	0	0
	1	15	0	ND	0	0
	2	15	1.2	ND	1.3	0
	3	15	2.1	ND	1.9	0
	4	15	4.8	ND	7.4	0.1
	6	15	5.3	ND	8.1	0.9
	0	20	0	ND	0	0
	1	20	0	ND	0	0
	2	20	1.8	ND	2.7	0
	3	20	2.6	ND	4.1	0
	4	20	3.9	ND	4.7	0.1
	6	20	5.9	ND	7.3	0.5

Table 6 cont'd.

Harvest	Time (month)	Temp (°C)	Sprout No.		Sprout weight (gm)	
			A	C	A	C
20/11/91	0	10	0	ND	0	0
	1	10	0	ND	0	0
	2	10	3.3	ND	0.5	0
	3	10	3.9	ND	3.8	0
	4	10	3.4	ND	5.7	0
	6	10	3.8	ND	6.3	0.4
	0	15	0	ND	0	0
	1	15	0	ND	0	0
	2	15	2.3	ND	1.4	0
	3	15	3.7	ND	3.9	0
	4	15	4.2	ND	7.9	0.1
	6	15	4.0	ND	8.3	0.7
	0	20	0	ND	0	0
	1	20	0	ND	0	0
	2	20	1.8	ND	0	0
	3	20	4.3	ND	4.2	0
	4	20	5.1	ND	6.2	0
	6	20	9.0	ND	8.1	0.1
4/12/91	0	10	0	ND	0	0
	1	10	0	ND	0	0
	2	10	3.7	ND	1.4	0
	3	10	3.4	ND	2.1	0
	4	10	3.5	ND	4.6	0.5
	6	10	3.4	ND	4.8	0.7
	0	15	0	ND	0	0
	1	15	2.8	ND	0.9	0
	2	15	4.2	ND	3.4	0
	3	15	3.9	ND	4.3	0.1
	4	15	4.2	ND	5.8	0.3
	6	15	5.3	ND	6.9	0.9
	0	20	0	ND	0	0
	1	20	1.6	ND	0.9	0
	2	20	2.8	ND	3.1	0
	3	20	3.7	ND	4.3	0
	4	20	4.3	ND	5.1	0.4
	6	20	7.5	ND	7.3	1.2

Table 6 cont'd

Harvest	Time (month)	Temp (°C)	Sprout No.		Sprout weight (gm)	
			A	C	A	C
18/12/91	0	10	0	ND	0	0
	1	10	0	ND	0	0
	2	10	2.8	ND	3.8	0
	3	10	3.4	ND	3.2	0
	4	10	4.4	ND	4.3	0.4
	6	10	4.8	ND	5.4	0.6
	0	15	0	ND	0	0
	1	15	0	ND	0	0
	2	15	2.8	ND	5.5	0
	3	15	3.7	ND	4.8	0
	4	15	4.3	ND	6.2	0.6
	6	15	4.6	ND	7.1	1.1

Table 6 cont'd

Harvest	Time (month)	Temp (°C)	Sprout No.		Sprout weight (gm)	
			A	C	A	C
	0	20	0	ND	0	0
	1	20	0	ND	0	0
	2	20	2.7	ND	4.3	0
	3	20	3.8	ND	4.9	0.1
	4	20	5.2	ND	6.7	0.3
	6	20	5.4	ND	8.3	0.7

ND = not determined

Table 7. Effects of harvesting date (Harvest), time of storage (Time), and temperature of storage (Temp) on dry matter (DM), specific gravity (SG) and crisp colour (Colour) of Atlantic (A) and Cadima (C) potatoes grown in Medina Research Centre, 1991

Harvest	Time (month)	Temp (°C)	DM		SG		Colour	
			A	C	A	C	A	C
23/10/91	0	10	20.8	20.8	1.089	1.078	3.3	3.7
	1	10	21.7	21.3	1.086	1.082	3.3	4.0
	2	10	20.9	20.6	1.090	1.087	3.7	5.0
	3	10	21.3	20.9	1.091	1.082	5.3	5.4
	4	10	21.6	23.9	1.091	1.089	4.2	6.7
	0	15	20.8	20.8	1.089	1.078	3.3	3.7
	1	15	21.3	21.3	1.090	1.090	3.6	4.0
	2	15	21.8	20.9	1.092	1.087	4.7	6.0
	3	15	23.1	22.6	1.094	1.086	5.0	5.6
	4	15	22.7	23.1	1.092	1.079	5.2	6.9
	0	20	20.8	20.8	1.089	1.078	3.3	3.7
	1	20	20.7	21.9	1.090	1.084	3.2	4.0
	2	20	22.6	20.6	1.092	1.087	2.0	6.0
	3	20	22.5	22.8	1.091	1.076	3.0	5.0
	4	20	21.9	23.4	1.092	1.091	3.7	6.8
6/11/91	0	10	20.4	21.2	1.078	1.082	3.3	3.3
	1	10	20.8	22.1	1.083	1.077	5.3	4.0
	2	10	21.3	21.9	1.090	1.080	4.7	5.2
	3	10	22.4	21.9	1.092	1.079	5.0	6.3
	4	10	19.7	22.4	1.087	1.087	6.0	7.3

Table 7 cont'd.

Harvest	Time (month)	Temp (°C)	DM		SG		Colour	
			A	C	A	C	A	C
	0	15	20.4	21.2	1.078	1.082	3.3	3.3
	1	15	21.2	22.2	1.081	1.078	4.7	4.3
	2	15	21.3	21.9	1.082	1.083	4.2	4.7
	3	15	22.4	22.0	1.081	1.080	4.3	5.6
	4	15	21.5	22.0	1.083	1.080	4.9	6.7
	0	20	20.4	21.2	1.078	1.082	3.3	3.3
	1	20	25.2	23.0	1.090	1.084	3.7	4.2
	2	20	22.7	21.9	1.087	1.077	3.6	4.0
	3	20	21.9	21.6	1.082	1.081	3.3	6.7
	4	20	22.0	21.1	1.080	1.092	4.2	6.3
20/11/91	0	10	21.0	21.4	1.082	1.081	4.3	3.0
	1	10	20.6	20.8	1.080	1.079	5.6	3.6
	2	10	23.7	21.3	1.092	1.084	5.2	4.2
	3	10	20.3	21.4	1.084	1.078	4.6	4.6
	4	10	20.1	20.5	1.089	1.082	5.6	4.7
	0	15	21.0	21.4	1.082	1.081	4.3	3.0
	1	15	21.2	21.3	1.082	1.079	4.6	3.6
	2	15	20.8	22.7	1.084	1.080	5.7	5.0
	3	15	21.9	21.9	1.087	1.080	5.2	6.0
	4	15	20.6	21.7	1.085	1.084	6.3	6.0
	0	20	21.0	21.4	1.082	1.081	4.3	3.0
	1	20	23.7	20.8	1.091	1.084	4.0	4.2
	2	20	22.4	22.7	1.086	1.089	4.3	4.3
	3	20	23.1	21.9	1.084	1.082	4.9	3.0
	4	20	24.2	22.0	1.088	1.084	4.0	6.2
4/12/91	0	10	20.3	20.9	1.083	1.079	4.0	4.3
	1	10	20.8	20.2	1.083	1.083	4.6	4.8
	2	10	20.6	20.8	1.085	1.076	3.9	5.2
	3	10	21.7	21.9	1.088	1.086	6.0	5.3
	4	10	21.3	22.7	1.084	1.082	5.6	6.0
	0	15	20.3	20.9	1.083	1.079	4.0	4.3
	1	15	21.3	20.9	1.085	1.079	4.2	4.3
	2	15	22.1	12.6	1.086	1.081	3.7	5.2
	3	15	21.4	21.4	1.087	1.082	4.8	5.0
	4	15	22.9	22.4	1.090	1.082	5.9	6.2

Table 7 cont'd.

Harvest	Time (month)	Temp (°C)	DM		SG		Colour	
			A	C	A	C	A	C
	0	20	20.3	20.9	1.083	1.079	4.0	4.3
	1	20	21.6	21.0	1.086	1.080	4.2	5.7
	2	20	22.2	21.3	1.088	1.082	3.6	6.2
	3	20	21.8	21.2	1.084	1.086	4.6	5.7
	4	20	24.1	21.7	1.091	1.090	6.0	6.9
18/12/91	0	10	20.4	21.8	1.083	1.080	3.3	3.3
	1	10	21.3	21.4	1.090	1.079	4.6	4.6
	2	10	19.9	21.0	1.082	1.082	5.7	5.3
	3	10	22.4	21.7	1.091	1.084	5.9	6.2
	4	10	24.2	22.6	1.095	1.085	6.2	5.9
	0	15	20.4	21.8	1.083	1.080	3.3	3.3
	1	15	19.9	20.6	1.081	1.076	3.9	3.8
	2	15	21.3	20.9	1.086	1.081	4.7	4.2
	3	15	21.8	21.8	1.089	1.082	5.2	5.6
	4	15	22.4	23.0	1.092	1.089	6.4	5.7
	0	20	20.4	21.8	1.083	1.080	3.3	3.3
	1	20	21.4	20.8	1.090	1.079	4.6	4.3
	2	20	18.8	20.0	1.085	1.082	6.0	5.0
	3	20	22.6	21.9	1.092	1.084	5.9	5.3
	4	20	22.0	22.7	1.092	1.089	6.7	6.7

Table 8. Effects of harvesting dates (Harvest), time of storage (Time), and temperature of storage (Temp) on the degree of blemishes, shrivelling, greening and the visual external quality of Atlantic (A) and Cadima (C) potatoes grown in Medina Research Centre, 1992

Harvest	Time (month)	Temp (°C)	Blemishes		Shrivelling		Greening		Quality	
			A	C	A	C	A	C	A	C
29/10/92	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0
	1	10	1.0	1.0	1.1	1.0	1.0	1.0	1.2	1.2
	2	10	1.0	1.1	1.2	1.1	1.0	1.0	1.4	1.4
	4	10	3.3	3.9	3.9	2.2	1.0	1.0	5.0	4.8
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0
	1	15	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2
	2	15	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2
	4	15	3.7	3.8	4.0	3.0	1.0	1.0	5.0	5.0

Table 8 cont'd.

Harvest	Time (month)	Temp (°C)	Blemishes		Shrivelling		Greening		Quality	
			A	C	A	C	A	C	A	C
	0	20	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0
	1	20	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0
	2	20	1.0	1.0	1.2	1.3	1.0	1.0	1.3	1.8
	4	20	3.7	3.3	5.0	3.6	1.0	1.0	5.0	5.0
10/11/92	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	4	10	2.2	2.7	3.7	1.0	1.0	1.0	5.0	3.7
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	4	15	2.2	3.3	3.2	2.0	1.0	1.0	5.0	3.8
	0	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	20	1.0	1.0	1.2	1.0	1.0	1.0	1.4	1.0
	2	20	1.0	1.0	1.5	1.0	1.0	1.0	1.6	1.0
	4	20	2.4	2.3	4.0	3.0	1.0	1.0	5.0	5.0
18/11/92	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
	1	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
	2	10	1.0	1.0	1.2	1.1	1.0	1.0	1.4	1.3
	4	10	2.3	2.6	3.9	2.0	1.0	1.0	5.0	3.0
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
	2	15	1.0	1.0	1.4	1.3	1.0	1.0	1.6	1.4
	4	15	2.7	2.5	3.6	2.0	1.0	1.0	5.0	3.4
	0	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	20	1.0	1.1	1.0	1.0	1.0	1.0	1.1	1.2
	2	20	1.4	1.3	1.5	1.3	1.0	1.0	1.8	1.8
	4	20	2.3	2.0	4.0	2.0	1.0	1.0	5.0	4.0
26/11/92	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	10	1.1	1.0	1.2	1.1	1.0	1.0	1.3	1.2
	4	10	1.9	1.9	3.0	2.0	1.0	1.0	5.0	2.4
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	15	1.0	1.0	1.3	1.2	1.0	1.0	1.4	1.4
	4	15	2.1	1.9	4.0	1.4	1.0	1.0	5.0	2.1

Table 8 cont'd.

Harvest	Time (month)	Temp (°C)	Blemishes		Shrivelling		Greening		Quality	
			A	C	A	C	A	C	A	C
	0	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	20	1.0	1.0	1.1	1.1	1.0	1.0	1.2	1.1
	2	20	1.0	1.0	1.3	1.2	1.0	1.0	1.7	1.3
	4	20	1.6	1.7	3.0	1.9	1.0	1.0	5.0	3.9
10/12/92	0	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	4	10	2.0	1.8	2.7	2.0	1.0	1.0	5.0	2.3
	0	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	15	1.0	1.0	1.1	1.0	1.0	1.0	1.2	1.0
	2	15	1.0	1.0	1.3	1.2	1.0	1.0	1.4	1.3
	4	15	1.2	1.8	3.0	1.0	1.0	1.0	5.0	1.8
	0	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1	20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	20	1.3	1.1	1.4	1.2	1.0	1.0	1.9	1.6
	4	20	2.6	1.8	4.0	1.5	1.0	1.0	5.0	3.2

Table 9. Effects of harvesting date (Harvest), time of storage (Time), and temperature of storage (Temp) on the sprout number and sprout weight of Atlantic (A) and Cadima (C) potatoes grown in Medina Research Centre, 1992

Harvest	Time (month)	Temp (°C)	Sprout No.		Sprout weight (gm)	
			A	C	A	C
29/10/92	0	10	0	0	0	0
	1	10	0	0	0	0
	2	10	0	0	0	0
	4	10	1	1.0	3.9	0.5
	0	15	0	0	0	0
	1	15	0	0	0	0
	2	15	0	0	0	0
	4	15	1.2	1.0	8.4	0.6
	0	20	0	0	0	0
	1	20	0	0	0	0
	2	20	1.6	0.4	1.0	0.1
	4	20	1.2	4.1	12.3	2.1

Table 9 cont't

Harvest	Time (month)	Temp (°C)	Sprout No.		Sprout weight (gm)	
			A	C	A	C
10/11/92	0	10	0	0	0	0
	1	10	0	0	0	0
	2	10	0	0	0	0
	4	10	1.9	0.8	3.3	0.4
	0	15	0	0	0	0
	1	15	0	0	0	0
	2	15	0	0	0	0
	4	15	1.4	0.7	4.2	0.4
	0	20	0	0	0	0
	1	20	0	0	0	0
	2	20	0.9	0	0.4	0
	4	20	1.0	2.8	7.2	1.1
18/11/92	0	10	0	0	0	0
	1	10	0	0	0	0
	2	10	0	0	0	0
	4	10	1.0	0.3	5.0	0.1
	0	15	0	0	0	0
	1	15	0	0	0	0
	2	15	0	0	0	0
	4	15	1.2	0.5	5.5	0.1
	0	20	0	0	0	0
	1	20	1.9	0	0.8	0
	2	20	1.2	0.	1.3	0
	4	20	1.7	1.5	7.9	0.4
26/11/92	0	10	0	0	0	0
	1	10	0	0	0	0
	2	10	0	0	0	0
	4	10	1.2	0.2	5.7	0.1
	0	15	0	0	0	0
	1	15	0	0	0	0
	2	15	0	0	0	0
	4	15	1.1	0.2	5.1	0.1
	0	20	0	0	0	0
	1	20	0.1	0	0.4	0
	2	20	0.2	0	0.7	0
	4	20	1.2	1.2	6.7	0.3

Table 9 cont'd

Harvest	Time (month)	Temp (°C)	Sprout No.		Sprout weight (gm)	
			A	C	A	C
10/12/92	0	10	0	0	0	0
	1	10	0	0	0	0
	2	10	0	0	0	0
	4	10	1.4	0.1	3.3	0.1
	0	15	0	0	0	0
	1	15	0	0	0	0
	2	15	0	0	0	0
	4	15	1.1	0	4.6	0
	0	20	0	0	0	0
	1	20	0.1	0	0.2	0
	2	20	0.1	0	1.0	0
	4	20	1.0	0.5	6.1	0.2

Table 10. Effects of harvesting date (Harvest), time of storage (Time), and temperature of storage (Temp) on dry matter (DM), specific gravity (SG) and crisp colour (Colour) of Atlantic (A) and Cadima (C) potatoes grown in Medina Research Centre, 1992

Harvest	Time (month)	Temp (°C)	DM		SG		Colour	
			A	C	A	C	A	C
29/10/92	0	10	20.8	18.3	1.071	1.082	4.3	6.0
	1	10	21.8	18.8	1.085	1.075	5.7	5.0
	2	10	21.1	17.9	1.084	1.076	4.9	5.2
	4	10	ND	17.4	ND	1.073	ND	5.0
	0	15	20.8	18.3	1.071	1.082	4.3	6.0
	1	15	21.7	18.4	1.087	1.082	3.7	4.7
	2	15	19.8	17.5	1.084	1.071	4.9	5.9
	4	15	ND	18.9	ND	1.077	ND	4.7
	0	20	20.8	18.3	1.071	1.082	4.3	6.0
	1	20	22.8	18.3	1.088	1.072	4.0	4.0
	2	20	20.2	19.0	1.091	1.076	4.8	4.9
	4	20	ND	18.4	ND	1.073	ND	4.3
10/11/92	0	10	23.5	19.0	1.100	1.081	5.3	5.7
	1	10	22.9	18.7	1.099	1.079	5.7	4.9
	2	10	23.2	18.5	1.110	1.079	6.0	4.7
	4	10	ND	18.1	ND	1.082	ND	7.0
	0	15	23.5	19.0	1.100	1.081	5.3	5.7
	1	15	23.3	19.0	1.103	1.080	4.8	6.0
	2	15	23.1	18.9	1.108	1.073	5.4	6.0
	4	15	ND	19.1	ND	1.080	ND	6.7

Table 10 cont'd

Harvest	Time (month)	Temp (°C)	DM		SG		Colour	
			A	C	A	C	A	C
	0	20	23.5	19.0	1.100	1.081	5.3	5.7
	1	20	22.9	19.0	1.100	1.081	5.4	6.0
	2	20	24.9	18.8	1.109	1.079	5.7	5.4
	4	20	ND	20.2	ND	1.079	ND	6.0
18/11/92	0	10	23.9	20.3	1.095	1.087	5.7	5.0
	1	10	23.5	19.9	1.097	1.082	4.9	4.7
	2	10	23.7	20.6	1.111	1.084	5.7	5.6
	4	10	ND	20.8	ND	1.086	ND	6.0
	0	15	23.9	20.3	1.095	1.087	5.7	5.0
	1	15	23.0	17.4	1.097	1.080	4.9	5.6
	2	15	23.7	18.9	1.100	1.086	6.3	4.9
	4	15	ND	20.1	ND	1.087	ND	6.0
	0	20	23.9	20.3	1.095	1.087	5.7	5.0
	1	20	22.5	19.3	1.103	1.082	4.9	6.0
	2	20	22.8	19.8	1.107	1.084	7.2	5.2
	4	20	ND	20.1	ND	1.088	ND	5.7
26/11/92	0	10	22.7	20.4	1.095	1.082	3.0	5.7
	1	10	22.7	19.5	1.089	1.080	4.2	5.2
	2	10	23.1	19.8	1.101	1.084	4.7	5.6
	4	10	ND	18.4	ND	1.083	ND	6.3
	0	15	22.7	20.4	1.095	1.082	3.0	5.7
	1	15	21.7	18.2	1.098	1.079	3.8	5.2
	2	15	22.9	18.0	1.103	1.080	4.7	6.2
	4	15	ND	17.4	ND	1.080	ND	6.5
	0	20	22.7	20.4	1.095	1.082	3.0	5.7
	1	20	23.0	19.4	1.087	1.080	4.3	5.2
	2	20	23.2	18.9	1.105	1.080	4.9	6.0
	4	20	ND	19.1	ND	1.083	ND	5.2
10/12/92	0	10	23.6	19.7	1.094	1.080	2.0	5.3
	1	10	23.0	18.5	1.096	1.080	3.1	5.6
	2	10	23.1	19.1	1.111	1.082	4.7	5.6
	4	10	ND	20.1	ND	1.078	ND	6.0
	0	15	23.6	19.7	1.094	1.080	2.0	5.3
	1	15	23.3	17.7	1.098	1.079	3.9	5.9
	2	15	22.9	18.9	1.106	1.081	5.0	5.2
	4	15	ND	18.6	ND	1.082	ND	6.0

Table 10 cont'd

Harvest	Time (month)	Temp (°C)	DM		SG		Colour	
			A	C	A	C	A	C
	0	20	23.6	19.7	1.094	1.080	2.0	5.3
	1	20	23.4	18.9	1.098	1.082	3.6	5.2
	2	20	23.7	18.9	1.103	1.080	4.9	5.0
	4	20	ND	18.0	ND	1.079	ND	4.9

ND = NOT DETERMINED

Table 11. Visual external quality (Quality), specific gravity (SG) and crisp colour (Colour) of Cadima potatoes after storage for various time at 10°C in 1991

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 1									
Grower 1	1.2	1.080	4.0	1.2	1.090	4.7	2.8	1.079	4.7
Grower 2	1.4	1.100	3.0	1.7	1.087	2.8	3.2	1.075	4.0
Grower 3	1.6	1.081	3.6	1.8	1.091	4.7	2.5	1.082	4.0
Grower 4	1.4	1.081	4.0	1.6	1.098	4.3	2.5	1.086	4.7
Grower 5	1.1	1.079	2.8	1.3	1.086	3.6	2.0	1.086	4.0
Grower 6	1.3	1.082	3.4	1.6	1.084	4.0	2.6	1.082	4.5
Harvest 2									
Grower 1	1.3	1.081	3.7	2.0	1.080	5.0	3.3	1.077	3.7
Grower 2	2.0	1.077	3.0	2.1	1.076	2.7	3.0	1.078	4.3
Grower 3	1.2	1.081	3.7	1.8	1.083	5.0	2.5	1.083	5.3
Grower 4	1.7	1.085	3.3	2.2	1.081	5.0	3.4	1.084	4.5
Grower 5	1.0	1.082	3.4	1.5	1.084	3.8	2.1	1.082	4.2
Grower 6	1.4	1.082	3.6	1.7	1.086	4.2	2.5	1.086	4.6
Harvest 3									
Grower 1	1.3	1.080	2.7	2.0	1.079	4.7	3.4	1.080	4.0
Grower 2	1.5	1.076	3.0	2.6	1.082	3.7	3.1	1.075	4.7
Grower 3	1.6	1.081	3.8	2.6	1.084	4.4	3.5	1.082	4.9
Grower 4	1.5	1.082	3.0	2.0	1.076	5.0	3.6	1.079	4.7
Grower 5	1.2	1.084	2.9	1.5	1.078	3.6	2.4	1.083	3.8
Grower 6	1.4	1.089	3.6	2.2	1.080	4.3	2.9	1.078	5.2

Table 11. **Visual external quality (Quality), specific gravity (SG) and crisp colour (Colour) of Cadima potatoes after storage for various time at 10°C in 1991**

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 4									
Grower 1	1.0	1.083	4.3	1.3	1.083	4.0	2.8	1.079	4.7
Grower 2	1.5	1.080	2.3	2.1	1.074	4.0	3.2	1.079	4.0
Grower 3	1.0	1.083	3.7	1.4	1.082	4.0	3.3	1.082	4.0
Grower 4	1.0	1.084	4.0	1.6	1.078	4.2	3.2	1.074	5.3
Grower 5	1.0	1.082	2.4	1.4	1.076	2.9	2.4	1.078	4.2
Grower 6	1.2	1.085	3.0	1.5	1.085	3.6	2.6	1.083	4.8
Harvest 5									
Grower 1	1.9	1.080	2.7	2.4	1.081	4.3	2.8	1.081	4.5
Grower 2	1.5	1.091	2.0	2.1	1.087	3.3	3.4	1.080	4.5
Grower 3	1.9	1.080	2.3	2.3	1.081	4.3	3.2	1.084	4.2
Grower 4	1.7	1.083	2.0	2.0	1.080	4.0	2.8	1.081	5.0
Grower 5	1.4	1.078	2.4	2.2	1.080	2.9	2.9	1.083	4.0
Grower 6	1.6	1.084	2.9	2.6	1.079	3.8	3.0	1.080	4.2

Table 12. **Visual external quality (Quality), specific gravity (SG) and crisp colour (Colour) of Cadima potatoes after storage for various time at 15°C in 1991**

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 1									
Grower 1	1.2	1.080	4.0	1.1	1.093	4.0	2.8	1.080	3.0
Grower 2	1.4	1.100	3.0	1.4	1.082	2.0	3.1	1.078	3.6
Grower 3	1.6	1.081	3.6	1.5	1.091	4.3	2.7	1.086	3.3
Grower 4	1.4	1.081	4.0	1.4	1.095	3.7	2.9	1.082	4.3
Grower 5	1.1	1.079	2.8	1.3	1.094	3.2	2.6	1.089	3.4
Grower 6	1.3	1.082	3.4	1.4	1.083	4.0	3.0	1.084	4.0
Harvest 2									
Grower 1	1.3	1.081	3.7	1.5	1.085	4.0	1.8	1.083	3.7
Grower 2	2.0	1.077	3.0	1.7	1.080	3.0	2.4	1.078	3.3
Grower 3	1.2	1.081	3.7	2.2	1.081	3.7	2.5	1.082	4.2
Grower 4	1.7	1.085	3.3	1.8	1.080	3.3	1.8	1.084	3.5
Grower 5	1.0	1.082	3.4	1.5	1.084	3.3	2.2	1.080	3.5
Grower 6	1.4	1.082	3.6	1.7	1.082	3.5	2.8	1.082	3.6

Table 12. **Visual external quality (Quality), specific gravity (SG) and crisp colour (Colour) of Cadima potatoes after storage for various time at 15°C in 1991**

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 3									
Grower 1	1.3	1.080	2.7	1.5	1.081	5.0	1.8	1.078	4.3
Grower 2	1.5	1.076	3.0	1.7	1.086	3.0	2.4	1.079	4.0
Grower 3	1.6	1.081	3.8	1.9	1.080	3.6	2.6	1.081	4.0
Grower 4	1.5	1.082	3.0	1.8	1.078	4.0	1.8	1.080	4.3
Grower 5	1.2	1.084	2.9	1.6	1.079	3.6	1.8	1.079	4.2
Grower 6	1.4	1.089	3.6	1.7	1.082	3.4	2.4	1.082	4.1
Harvest 4									
Grower 1	1.0	1.083	4.3	1.8	1.086	3.0	2.5	1.082	3.6
Grower 2	1.5	1.080	2.3	2.4	1.091	3.0	2.6	1.077	3.3
Grower 3	1.0	1.083	3.7	1.7	1.080	4.0	2.5	1.078	4.7
Grower 4	1.0	1.084	4.0	2.2	1.076	3.7	3.0	1.072	4.3
Grower 5	1.0	1.082	2.4	1.5	1.083	3.0	2.4	1.084	3.2
Grower 6	1.2	1.085	3.0	1.7	1.082	2.9	2.8	1.083	3.2
Harvest 5									
Grower 1	1.9	1.080	2.7	2.9	1.080	3.7	3.0	1.081	4.0
Grower 2	1.5	1.091	3.0	2.5	1.086	3.3	3.0	1.084	3.9
Grower 3	1.9	1.080	2.3	2.4	1.084	3.7	3.2	1.083	4.1
Grower 4	1.7	1.083	2.0	2.3	1.076	3.7	3.9	1.085	4.2
Grower 5	1.4	1.078	2.4	2.0	1.084	3.0	2.8	1.084	3.8
Grower 6	1.6	1.084	2.9	2.6	1.085	3.0	4.0	1.085	3.7

Table 13. **Visual external quality (Quality), specific gravity (SG), and crisp colour (Colour) of Cadima potatoes after storage for various time at 20°C in 1991**

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 1									
Grower 1	1.2	1.080	4.0	1.2	1.087	4.3	3.0	1.081	5.3
Grower 2	1.4	1.100	3.0	1.7	1.082	2.0	2.9	1.079	3.3
Grower 3	1.6	1.081	3.6	1.8	1.095	3.6	2.7	1.089	4.2
Grower 4	1.4	1.081	4.0	1.4	1.087	3.7	2.6	1.084	4.0
Grower 5	1.1	1.079	2.8	1.5	1.082	2.8	2.4	1.084	3.4
Grower 6	1.3	1.082	3.4	1.6	1.084	3.6	2.8	1.083	4.2
Harvest 2									
Grower 1	1.3	1.081	3.7	1.5	1.084	4.7	3.2	1.080	3.7
Grower 2	2.0	1.077	3.0	1.4	1.082	2.3	3.3	1.082	4.3
Grower 3	1.2	1.081	3.7	1.9	1.086	4.7	3.1	1.085	4.9
Grower 4	1.7	1.085	3.3	1.7	1.084	4.7	3.8	1.084	3.8
Grower 5	1.0	1.082	3.4	1.5	1.085	3.2	3.0	1.085	3.9
Grower 6	1.3	1.082	3.6	1.6	1.084	3.8	3.6	1.086	4.2
Harvest 3									
Grower 1	1.3	1.080	2.7	1.1	1.083	4.7	3.1	1.079	4.3
Grower 2	1.5	1.076	3.0	2.0	1.085	3.0	3.1	1.080	4.0
Grower 3	1.6	1.081	3.8	1.6	1.082	4.0	2.8	1.082	4.0
Grower 4	1.5	1.082	3.0	1.3	1.084	4.3	3.0	1.083	4.0
Grower 5	1.2	1.084	2.9	1.4	1.086	3.2	2.7	1.084	4.2
Grower 6	1.4	1.089	3.6	1.7	1.088	3.9	3.4	1.088	4.5
Harvest 4									
Grower 1	1.0	1.083	4.3	1.9	1.084	3.3	2.9	1.082	3.8
Grower 2	1.5	1.080	2.3	2.2	1.088	4.0	2.8	1.083	4.0
Grower 3	1.0	1.083	3.7	2.0	1.078	5.0	3.1	1.084	5.2
Grower 4	1.0	1.084	4.0	1.8	1.083	3.7	3.1	1.084	4.9
Grower 5	1.0	1.082	2.4	1.6	1.080	3.8	3.0	1.086	4.3
Grower 6	1.2	1.085	3.0	1.9	1.087	3.5	3.4	1.087	4.5
Harvest 5									
Grower 1	1.9	1.080	2.7	2.7	1.082	3.7	3.4	1.084	5.2
Grower 2	1.5	1.091	2.0	2.1	1.076	4.0	3.0	1.082	4.9
Grower 3	1.9	1.080	2.3	1.9	1.084	3.7	3.1	1.079	4.7
Grower 4	1.7	1.083	2.0	2.7	1.084	4.7	3.8	1.089	5.3
Grower 5	1.4	1.078	2.4	1.9	1.083	4.2	2.9	1.082	5.4
Grower 6	1.6	1.084	2.9	2.0	1.087	3.8	3.1	1.086	4.7

Table 14. Visual external quality (Quality), specific gravity (SG) and crisp colour (Colour) of Atlantic potatoes after storage for various time at 10°C in 1992

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 1									
Grower 1	1.3	1.079	3.0	1.6	1.082	3.2	4.0	1.084	4.5
Grower 2	1.2	1.083	2.4	1.7	1.084	2.6	3.8	1.084	4.2
Harvest 2									
Grower 1	1.2	1.080	2.8	1.5	1.080	3.0	4.2	1.082	4.2
Grower 2	1.3	1.085	2.2	1.5	1.082	2.6	3.6	1.079	3.8
Harvest 3									
Grower 1	1.2	1.082	3.7	1.4	4.085	3.0	4.0	1.082	3.7
Grower 2	1.4	1.083	3.0	1.4	1.071	2.0	4.0	1.075	4.7
Harvest 4									
Grower 1	1.2	1.077	3.0	1.8	1.082	3.3	4.5	1.080	4.5
Grower 2	1.3	1.075	3.0	1.3	1.073	3.0	4.0	1.077	4.3
Harvest 5									
Grower 1	1.5	1.080	2.3	2.0	1.086	3.0	4.2	1.083	3.7
Grower 2	1.2	1.075	3.2	2.2	1.088	3.6	4.0	1.079	4.3

Table 15. Visual external quality (Quality), specific gravity (SG) and crisp colour (Colour) of Atlantic potatoes after storage for various time at 15°C in 1992

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 1									
Grower 1	1.3	1.079	3.0	1.8	1.082	3.4	4.2	1.084	3.8
Grower 2	1.2	1.080	2.4	1.5	1.082	2.8	3.9	1.082	4.0
Harvest 2									
Grower 1	1.2	1.080	2.8	1.6	1.080	3.2	4.3	1.084	3.6
Grower 2	1.3	1.085	2.2	1.6	1.078	3.0	3.6	1.082	3.7
Harvest 3									
Grower 1	1.2	1.082	3.7	1.4	1.085	2.7	3.8	1.087	3.0
Grower 2	1.4	1.083	3.0	1.4	1.080	2.0	4.2	1.074	4.0
Harvest 4									
Grower 1	1.2	1.077	3.0	2.6	1.083	3.3	4.2	1.091	3.7
Grower 2	1.3	1.075	3.0	1.4	1.074	2.7	4.3	1.085	4.0
Harvest 5									
Grower 1	1.5	1.080	2.3	2.2	1.079	3.0	5.0	1.089	4.3
Grower 2	1.2	1.075	3.2	2.6	1.086	3.3	4.7	1.076	4.7

Table 16. Visual external quality (Quality), specific gravity (SG) and crisp colour (Colour) of Atlantic potatoes after storage for various time at 20°C in 1992

Sample	Time of storage (month)								
	0			1			3		
	Quality	SG	Colour	Quality	SG	Colour	Quality	SG	Colour
Harvest 1									
Grower 1	1.3	1.079	3.0	1.9	1.082	3.2	4.0	1.084	4.4
Grower 2	1.2	1.083	2.4	1.8	1.086	2.6	3.8	1.080	3.9
Harvest 2									
Grower 1	1.2	1.080	2.8	1.7	1.084	3.4	4.2	1.079	4.7
Grower 2	1.3	1.085	2.2	2.0	1.090	2.4	4.4	1.086	4.2
Harvest 3									
Grower 1	1.2	1.080	3.7	1.6	1.086	2.7	4.0	1.084	5.0
Grower 2	1.4	1.083	3.0	2.0	1.079	2.0	4.0	1.077	4.7
Harvest 4									
Grower 1	1.2	1.077	3.0	2.3	1.074	3.0	5.0	1.080	6.2
Grower 2	1.3	1.075	3.0	1.9	1.078	2.3	4.0	1.073	4.7
Harvest 5									
Grower 1	1.5	1.080	2.3	3.4	1.083	3.0	4.4	1.088	4.0
Grower 2	1.2	1.075	3.2	3.1	1.075	3.7	4.2	1.068	3.8

Degree of blemishes, shrivelling, greening and visual external quality

The assessments of visual external quality of the tubers were based on the combined effects of blemishes, shrivelling, sprouting, greening. Potatoes with the visual external quality more than 3.0 were not suitable for crisping as they have problems such as extended blemishes including bruises, shrivelling and sprouting. Generally there were more blemishes, shrivelling and sprouting in Atlantic compared to the Cadima. Atlantic has more blemish problems due to its texture and tender skin. Atlantic is known to have sprouting problems as it is a cultivar with very short dormancy. Besides dehydration, Atlantic also lost water through sprouting. Some of the water loss from Atlantic was converted to weight gain in the sprouts.

There were no greening problems during the storage of Atlantic and Cadima potatoes as they were stored in complete darkness.

In the trials, we found out that Grower No. 2 and No. 5 produced better quality crops compared to Growers No. 1, 3, 4 and 6.

From the trial results, in order to maintain good external quality, Atlantic could only be stored at 10° or 15°C for about 6 weeks and definitely less than 2 months. Storage of Atlantic at ambient (20°C) should not be carried out. However, Cadima that had been stored for

3 months at 10 or 15°C and 2 months at 20°C still maintained an acceptable quality, i.e. scores less than 3.0. There were no sprouting problems with Cadima but the processing quality into crisp deteriorated due to dehydration and change in texture.

Sprouting

Sprouting was not significant in Atlantic after 1 month storage at 10°C. However, it increased with the increase in storage temperature, i.e. at 15° and 20°C. All the Atlantic stored for 3 months and longer at 10, 15 or 20°C sprouted badly.

Atlantic harvested late in the season (i.e. more mature) seemed to sprout more severely than those harvested earlier (i.e. less mature).

Sprouting was not a problem in Cadima even after 3 months storage at 20°C.

Specific gravity (SG), dry matter (DM) and crisp colour

Specific gravity and dry matter were generally higher in Atlantic than in Cadima. There were no differences in SG and DM among various growing conditions (growers, locations, time of the year, maturity) and storage conditions (temperature and time of storage).

Crisp colour varied with the time and temperature of storage. Grower No. 2 and No. 5 produced better quality potatoes and therefore generally better colour crisps. Crisps with best colour were produced by fresh potatoes and potatoes that had been stored in suitable conditions for a desirable period of time, e.g. less than a month. Crisp colour assessment scores were summarised as follows:

Crisp colour

10°C Atlantic:	Fresh sample - crisp colour was between	2.3-3.7
	1 month storage - crisp colour was between	2.0-3.6
	3 months storage - crisp colour was between	3.7-4.7
Cadima:	Fresh sample - crisp colour was between	2.0-4.0
	1 month storage - crisp colour was between	2.0-5.0
	3 month storage - crisp colour was between	3.7-5.3
15°C Atlantic:	Fresh sample - crisp colour was between	2.3-3.7
	1 month storage - crisp colour was between	2.0-3.3
	3 month storage - crisp colour was between	3.0-4.7
15°C Cadima:	Fresh sample - crisp colour was between	2.0-4.0

	1 month storage - crisp colour was between	2.0-5.0
	3 month storage - crisp colour was between	3.0-4.7
20°C Atlantic:	Fresh sample - crisp colour was between	2.3-3.7
	1 month storage - crisp colour was between	2.0-3.7
	3 month storage - crisp colour was between	3.8-4.7
20°C Cadima:	Fresh sample - crisp colour was between	2.0-4.0
	1 month storage - crisp colour was between	2.0-5.0
	3 month storage - crisp colour was between	3.3-5.3

The processing quality seemed to be influenced by the way the potatoes were grown and how they were handled during harvesting and post-harvest management (handling, transportation and storage). Maturity seemed to have little effect on the processing quality, therefore the growers can plan to harvest Atlantic and Cadima for processing two to three weeks before or after the optimal harvesting date provided they practise proper post-harvest management.

(B) The effectiveness of maleic hydrazide (MH) in controlling of potato sprouting during storage

The maleic hydrazide used in the trial was Agslo MH. It contained 250 g of maleic hydrazide per litre. The rate of application recommended by the manufacturer was 11 litres per ha in 500-1000 litres of water. The application time recommended was 4-6 weeks before the potato is ready for harvest.

Sprouting capacity

After storage of the potatoes at various temperature for various periods of time, the weight of the tubers and the weight of the sprouts were determined separately. They were then expressed as the sprouting capacity.

The sprouting capacity of the Atlantic and Cadima potatoes grown in 1991 is shown in Table 17 and 18 respectively.

Generally the sprouting was more severe when stored at 20°C compared to 10°C. Application rates of 8 L/ha or higher were effective in reducing sprouting. The recommended rate by the manufacturer of 11 L/ha was effective. The suitable time to apply maleic hydrazide was found to be at 6 weeks before harvesting. The patterns in response to maleic hydrazide was similar between Atlantic and Cadima potatoes.

The results of 1992 were not presented as the results obtained from the application of maleic hydrazide at 6 and 4 weeks before harvesting were similar to those of 1991. The results from the application at 2 weeks after full bloom were not reliable as the date of full bloom could not be determined accurately.

Table 17a. Effects of malic hydrazide on sprouting capacity of Atlantic potatoes after storage at various temperatures for different periods of time.

Application time *	Application rate (L/ha)	Temperature stored (oC)	Time stored (months)	Tuber wt. (gms)	Sprout wt. (gms)	Sprouting capacity (%)
6	5	10	0	140.5	0.09	0.06
6	5	10	1	177.2	2.20	1.24
6	5	10	3	168.7	10.57	6.26
6	5	15	0	137.8	0.26	0.19
6	5	15	1	178.1	2.83	1.59
6	5	15	3	167.2	11.03	6.60
6	5	20	0	141.5	0.00	0.00
6	5	20	1	193.0	2.53	1.31
6	5	20	3	160.3	9.37	5.85
6	8	10	0	165.5	0.12	0.07
6	8	10	1	188.8	0.66	0.35
6	8	10	3	157.8	2.08	1.32
6	8	15	0	151.5	0.13	0.09
6	8	15	1	189.0	1.50	0.80
6	8	15	3	158.8	2.77	1.74
6	8	20	0	159.8	0.00	0.00
6	8	20	1	188.8	2.39	1.26
6	8	20	3	176.0	7.40	4.21
6	11	10	0	165.9	0.06	0.04
6	11	10	1	183.7	0.18	0.10
6	11	10	3	169.1	0.92	0.54
6	11	15	0	162.2	0.08	0.05
6	11	15	1	183.9	0.44	0.24
6	11	15	3	175.9	2.48	1.41
6	11	20	0	166.3	0.00	0.00
6	11	20	1	174.7	1.24	0.71
6	11	20	3	161.9	3.18	1.96
6	14	10	0	152.5	0.13	0.09
6	14	10	1	198.1	0.28	0.14
6	14	10	3	157.9	0.44	0.28
6	14	15	0	140.0	0.06	0.05
6	14	15	1	202.0	0.64	0.32
6	14	15	3	173.2	2.74	1.58
6	14	20	0	153.1	0.00	0.00
6	14	20	1	172.5	1.05	0.61
6	14	20	3	172.4	2.66	1.55

* Application time: 6 = 6 weeks before harvesting

Table 17b. Effects of malic hydrazide on sprouting capacity of Atlantic potatoes after storage at various temperatures for different periods of time.

Application time *	Application rate (L/ha)	Temperature stored (oC)	Time stored (months)	Tuber wt. (gms)	Sprout wt. (gms)	Sprouting capacity (%)
4	5	10	0	164.5	0.01	0.01
4	5	10	1	206.9	1.94	0.94
4	5	10	3	162.2	6.96	4.29
4	5	15	0	152.1	0.00	0.00
4	5	15	1	216.3	2.15	1.00
4	5	15	3	170.1	9.64	5.67
4	5	20	0	149.2	0.00	0.00
4	5	20	1	210.8	2.76	1.31
4	5	20	3	161.1	10.40	6.46
4	8	10	0	177.2	0.00	0.00
4	8	10	1	220.2	1.72	0.78
4	8	10	3	184.2	3.61	1.96
4	8	15	0	170.3	0.00	0.00
4	8	15	1	197.3	2.01	1.02
4	8	15	3	177.9	5.94	3.34
4	8	20	0	181.9	0.00	0.00
4	8	20	1	201.9	2.43	1.20
4	8	20	3	191.0	8.89	4.65
4	11	10	0	163.4	0.00	0.00
4	11	10	1	221.5	1.32	0.59
4	11	10	3	176.8	2.14	1.21
4	11	15	0	168.3	0.00	0.00
4	11	15	1	222.0	2.26	1.02
4	11	15	3	189.3	4.99	2.64
4	11	20	0	166.9	0.00	0.00
4	11	20	1	219.4	2.04	0.93
4	11	20	3	193.2	7.96	4.12
4	14	10	0	187.4	0.00	0.00
4	14	10	1	186.9	0.78	0.42
4	14	10	3	172.9	0.97	0.56
4	14	15	0	160.6	0.00	0.00
4	14	15	1	202.2	0.93	0.46
4	14	15	3	166.8	2.89	1.73
4	14	20	0	167.7	0.00	0.00
4	14	20	1	215.8	2.20	1.02
4	14	20	3	189.9	5.70	3.00

*-Application time: 4 = 4 weeks before harvesting

Table 18a. Effects of malic hydrazide on sprouting capacity of Cadima potatoes after storage at various temperatures for different periods of time.

Application time *	Application rate (L/ha)	Temperature stored (oC)	Time stored (months)	Tuber wt. (gms)	Sprout wt. (gms)	Sprouting capacity (%)
6	5	10	0	143.2	0.00	0.00
6	5	10	1	168.6	0.00	0.00
6	5	10	3	158.3	1.46	0.92
6	5	10	5	118.2	0.94	0.80
6	5	15	0	152.5	0.00	0.00
6	5	15	1	164.4	0.12	0.08
6	5	15	3	138.9	1.93	1.39
6	5	15	5	128.9	3.11	2.42
6	5	20	0	141.2	0.00	0.00
6	5	20	1	143.2	0.17	0.12
6	5	20	3	154.5	1.37	0.88
6	5	20	5	128.9	4.08	3.17
6	8	10	0	133.5	0.00	0.00
6	8	10	1	157.3	0.00	0.00
6	8	10	3	151.6	0.05	0.03
6	8	10	5	142.3	0.48	0.34
6	8	15	0	130.0	0.00	0.00
6	8	15	1	149.6	0.07	0.05
6	8	15	3	136.8	0.37	0.27
6	8	15	5	116.1	1.15	0.99
6	8	20	0	121.0	0.00	0.00
6	8	20	1	164.9	0.31	0.19
6	8	20	3	142.2	0.78	0.55
6	8	20	5	126.6	0.91	0.72
6	11	10	0	124.5	0.00	0.00
6	11	10	1	175.2	0.00	0.00
6	11	10	3	152.4	0.00	0.00
6	11	10	5	130.6	0.10	0.08
6	11	15	0	121.3	0.01	0.01
6	11	15	1	184.2	0.01	0.01
6	11	15	3	143.9	0.02	0.01
6	11	15	5	124.8	0.32	0.25
6	11	20	0	116.9	0.00	0.00
6	11	20	1	173.0	0.20	0.12
6	11	20	3	168.6	0.17	0.10
6	11	20	5	122.9	0.30	0.24

* Application time: 6 = 6 weeks before harvesting

Table 18b. Effects of malic hydrazide on sprouting capacity of Cadima potatoes after storage at various temperatures for different periods of time.

Application time *	Application rate (L/ha)	Temperature stored (oC)	Time stored (months)	Tuber wt. (gms)	Sprout wt. (gms)	Sprouting capacity (%)
6	14	10	0	135.3	0.00	0.00
6	14	10	1	177.1	0.00	0.00
6	14	10	3	140.7	0.07	0.05
6	14	10	5	132.2	0.08	0.06
6	14	15	0	138.9	0.00	0.00
6	14	15	1	159.5	0.03	0.02
6	14	15	3	145.6	0.19	0.13
6	14	15	5	114.5	0.21	0.18
6	14	20	0	126.7	0.00	0.00
6	14	20	1	155.8	0.10	0.07
6	14	20	3	131.2	0.14	0.11
6	14	20	5	136.8	0.25	0.18
4	5	10	0	161.8	0.00	0.00
4	5	10	1	157.9	0.04	0.02
4	5	10	3	157.2	1.32	0.84
4	5	10	5	124.8	2.93	2.35
4	5	15	0	151.4	0.00	0.00
4	5	15	1	167.5	0.07	0.04
4	5	15	3	144.8	2.49	1.72
4	5	15	5	111.6	6.08	5.45
4	5	20	0	164.5	0.00	0.00
4	5	20	1	153.1	0.02	0.02
4	5	20	3	128.5	1.65	1.28
4	5	20	5	116.1	5.63	4.85
4	8	10	0	154.3	0.00	0.00
4	8	10	1	164.0	0.00	0.00
4	8	10	3	130.0	0.33	0.25
4	8	10	5	121.9	1.08	0.88
4	8	15	0	150.0	0.00	0.00
4	8	15	1	161.6	0.03	0.02
4	8	15	3	152.4	1.58	1.03
4	8	15	5	118.0	2.23	1.89
4	8	20	0	146.7	0.00	0.00
4	8	20	1	176.0	0.13	0.07
4	8	20	3	143.8	1.43	0.99
4	8	20	5	112.4	1.37	1.22

* Application time: 4 = 4 weeks before harvesting
6 = 6 weeks before harvesting

Table 18c. Effects of malic hydrazide on sprouting capacity of Cadima potatoes after storage at various temperatures for different periods of time.

Application time *	Application rate (L/ha)	Temperature stored (oC)	Time stored (months)	Tuber wt. (gms)	Sprout wt. (gms)	Sprouting capacity (%)
4	11	10	0	153.7	0.00	0.00
4	11	10	1	167.7	0.00	0.00
4	11	10	3	149.3	0.24	0.16
4	11	10	5	131.4	0.95	0.72
4	11	15	0	154.4	0.00	0.00
4	11	15	1	162.9	0.05	0.03
4	11	15	3	145.1	0.30	0.21
4	11	15	5	125.5	1.87	1.49
4	11	20	0	158.7	0.00	0.00
4	11	20	1	154.3	0.11	0.07
4	11	20	3	141.1	0.65	0.46
4	11	20	5	128.2	1.82	1.42
4	14	10	0	155.4	0.00	0.00
4	14	10	1	153.5	0.01	0.00
4	14	10	3	149.3	0.10	0.07
4	14	10	5	125.8	0.66	0.52
4	14	15	0	147.6	0.00	0.00
4	14	15	1	159.1	0.03	0.02
4	14	15	3	168.0	1.13	0.67
4	14	15	5	121.0	1.20	0.99
4	14	20	0	137.9	0.00	0.00
4	14	20	1	155.1	0.08	0.05
4	14	20	3	137.2	0.79	0.58
4	14	20	5	137.7	1.00	0.72

* Application time: 4 = 4 weeks before harvesting
6 = 6 weeks before harvesting

(C) Reduction of greening in Atlantic and Cadima potatoes

Experiment A

The effects of light on greening and the visual external quality of Atlantic and Cadima potatoes which were coated with various protective coating solutions are shown in Table 19. Protective coating with Ausgloss and gelatin solution reduced the degree of greening and hence improved tuber quality when the potatoes were placed under constant light of about 25 ft candle. Owing to their effectiveness in reducing greening, Ausgloss and gelatin solution were used again in Experiment B to study their effects on the content of glycoalkaloids and chlorophyll in greening potatoes.

The experimental results also indicate that Atlantic is more prone to greening than Cadima.

Table 19. The effects of protective coatings on the degree of greening (Green) and the visual external quality (Quality) of Atlantic (A) and Cadima (C) potatoes which were exposed to constant light

Treatments	Green						Quality					
	A			C			A			C		
	2*	4	7	2	4	7	2	4	7	2	4	7
Control	1	3	4	2	3	3	2	3	5	2	3	5
3% Sweet potato flour	2	3	4	1	2	3	2	4	5	2	2	4
3% Tapioca flour	2	4	4	1	2	3	2	4	5	2	2	4
3% Arrowroot flour	2	3	4	1	2	3	2	3	5	2	2	4
3% Gelatin	1	2	2	1	1	1	2	2	3	2	2	3
1.5% Semperfresh	2	3	4	1	2	3	2	3	5	2	2	4
Ausgloss	1	1	2	1	1	1	2	2	4	2	2	3
LPDE bag	1	2	3	1	1	2	2	3	4	2	2	3

* Days of exposure to light.

There was no greening and the visual external quality score was 1 at the beginning of the experiment.

Experiment B.

The effects of protective coating and light on the degree of greening and visual external quality of Atlantic potatoes are shown in Table 20 and Cadima potatoes in Table 21. Once again, it was shown that 3% gelatin solution and Ausgloss were effective in reducing greening in the potatoes. The beneficial effect of modifed atmosphere packaging in reducing greening was not shown in this trial. Schouten also concluded that low oxygen conditions (2.1% and 1.4%) at 6 °C did not deliver a possibility for controlled atmosphere storage or potatoes.

The maturity of the tubers based on the harvesting dates seemed to have no effects on the development of greening in Atlantic and Cadima potatoes. However, the degree of greening was more severe in Atlantic than in Cadima.

The changes in carbon dioxide and oxygen concentrations during the storage of Atlantic and Cadima potatoes in sealed LDPE bags are shown in Figure 1. The gas composition profiles were very similar for Atlantic and Cadima. The carbon dioxide concentrations during storage of Atlantic and Cadima potatoes in sealed bags which were harvested on 29 October 1992 were stabilized between 1.8%-3.2%, and between 2.8%-3.7% for those harvested on 24 November 1992. The oxygen concentrations were between 12.7%-16.5% for harvesting on 20 October 1992 and between 8.0%-12.3% for harvesting on 24 November 1992.

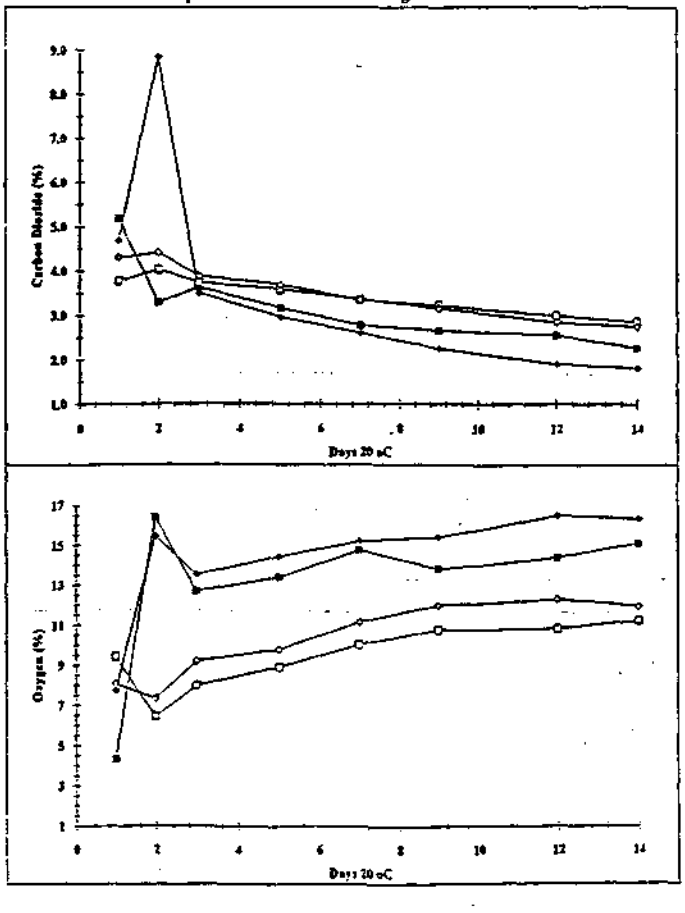
Table 20. The effects of protective coating on the degree of greening (G) and visual external quality (Q) of Atlantic potatoes

Treatment	Harvest date	Days exposed to light at 20°C											
		0		5		7		9		12		14	
		G	Q	G	Q	G	Q	G	Q	G	Q	G	Q
Control	29/10/92	1.0	1.3	3.1	4.0	4.2	5.0	4.0	5.0	4.4	5.0	4.5	5.0
Gelatin	29/10/92	1.0	1.3	2.9	3.8	3.2	4.2	3.8	4.8	4.0	5.0	4.2	5.0
Ausgloss	29/10/92	1.0	1.3	1.6	2.4	2.0	2.4	2.4	3.3	2.6	3.8	2.9	4.3
LDPE bags	29/10/92	1.0	1.3	2.7	3.5	2.3	3.3	3.5	4.5	3.8	4.8	4.0	5.0
L.SD (0.05)		0	0.3	0.5	0.6	0.6	0.5	0.4	0.6	0.5	0.4	0.5	0.4
Control	24/11/92	1.0	1.2	2.9	3.9	3.8	4.8	3.9	4.9	3.9	4.9	4.1	5.0
Gelatin	24/11/92	1.0	1.2	2.3	2.8	2.8	3.5	3.2	4.0	3.4	3.9	3.4	4.3
Ausgloss	24/11/92	1.0	1.2	2.3	2.8	2.8	3.5	3.8	4.7	4.0	5.0	3.4	5.0
LDPE bags	24/11/92	1.0	1.2	1.9	2.1	2.7	3.4	3.6	4.6	3.8	5.0	3.4	5.0
LSD (0.05)		0	0.2	0.4	0.5	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3

Table 21. The effects of protective coating on the degree of greening (G) and visual external quality (Q) of Cadima potatoes

Treatment	Harvest date	Days exposed to light at 20°C											
		0		5		7		9		12		14	
		G	Q	G	Q	G	Q	G	Q	G	Q	G	Q
Control	29/10/92	1.0	1.3	2.9	3.9	3.3	4.3	3.6	4.6	3.7	4.7	3.9	4.9
Gelatin	29/10/92	1.0	1.3	2.3	3.0	2.3	3.3	2.8	3.8	3.3	4.3	3.7	4.7
Ausgloss	29/10/92	1.0	1.3	1.7	1.9	1.6	2.1	1.7	2.6	2.0	2.3	2.4	3.0
LDPE bags	29/10/92	1.0	1.3	1.8	2.6	2.4	3.3	3.2	4.2	2.6	3.2	3.4	4.4
LSD (0.05)		0	0.2	0.3	0.4	0.4	0.5	0.6	0.5	0.4	0.5	0.5	0.4
Control	24/11/92	1.0	1.2	2.1	2.4	3.2	4.2	3.5	4.5	3.7	4.7	4.0	5.0
Gelatin	24/11/92	1.0	1.2	1.8	2.0	2.6	3.3	2.2	2.7	3.0	3.8	3.7	4.6
Ausgloss	24/11/92	1.0	1.2	1.4	1.4	2.3	2.7	2.7	3.6	2.4	2.8	2.9	3.9
LDPE bags	24/11/92	1.0	1.2	1.8	1.8	2.2	2.7	2.4	3.2	3.1	4.1	3.3	4.3
LSD (0.05)		0	0.2	0.3	0.4	0.4	0.5	0.3	0.5	0.3	0.5	0.3	0.5

Figure 1. Changes in CO2 and O2 concentrations during the storage of Atlantic and Cadima potatoes in sealed LDPE bags



The content of α-solanine α-chaconine and total glycoalkaloids in Atlantic potatoes is shown in Table 22 and in Cadima potatoes in Table 23. Although the exact toxic dose in humans has not been established, potatoes with total glycoalkaloid not exceeding 200 mg/kg fresh weight, are generally regarded as being safe for human consumption. The level of glycoalkaloids found in the samples is well below this limit.

No apparent trend was observed when comparing potatoes harvested at different maturity and stored under light after different coating treatments. Since it is generally believed that the glycoalkaloid concentrate in the skins of green-coloured potatoes the level of glycoalkaloids in the potato skins of some selected samples was determined. The results are shown in Table 24. Some trends are clear here. The white-skinned Atlantic appeared to produce more glycoalkaloids than the Cadima under the same treatment and storage conditions. There seemed to be little conclusive evidence of trends in the effects of various coating and storage treatments on the production of glycoalkaloids. This trend is expected since the white-skinned varieties such as Atlantic, Delaware, Sebago and Kennebei tend to green rapidly. As being discussed earlier, processing quality of potato can be improved by following suitable postharvest handling and storage methods. It can also be improved by introducing a better processing cultivar. Since there is cultivar differences in the accumulation and production of glycoalkaloids, care should be taken not to introduce a cultivar with high glycoalkaloid levels (WHO 1992). In order to investigate glycoalkaloid levels in different layers of potatoes, the sprouts were removed and the skin and the successive layers of the tubers were analysed. The results are as follows.

Layers	Total glycoalkaloids mg/kg
Sprouts from large potato	3080
Sprouts from small potato	8340
Skin and layer just underneath	154
5 mm under skin	< 30
10 mm under skin	< 30
20 mm under skin	< 30
30 mm under skin	< 30
Centre of potato	< 30

The results confirm literature claims that the glycoalkaloids concentrate in the skin and the layer just under the skin. The results show that glycoalkaloids concentrate even more in the sprouts.

Table 22. The effects of protective coating on the content of chaconine (Ch), Solanine (So) and total glycoalkaloids (To) of Atlantic potatoes

t Treatmen	Harvest date	Days exposed to light at 20°C														
		5			7			9			12			14		
		Ch	So	To	Ch	So	To	Ch	So	To	Ch	So	To	Ch	So	To
		mg/kg														
Control	29/10/92	39	21	60	47	24	71	72	40	112	113	35	148	71	38	109
Gelatin	29/10/92	35	18	53	40	24	64	53	32	85	69	27	96	39	18	57
Ausgloss	29/10/92	39	24	63	39	24	63	46	26	72	56	24	80	40	20	60
LDPE bags	29/10/92	53	32	85	32	23	55	60	32	92	61	29	90	35	16	51
Control	24/11/92	68	44	112	50	30	80	47	27	74	37	22	59	42	24	66
Gelatin	24/11/92	44	28	72	38	22	60	47	27	74	32	20	52	35	22	57
Ausgloss	24/11/92	47	30	77	38	22	60	44	27	71	37	24	61	27	16	43
LDPE bags	24/11/92	36	14	50	35	22	57	41	24	65	29	18	47	37	24	61

The content of α chaconine, α solanine and total glycoalkaloids at 0 day was 64, 35 and 99 mg/kg respectively for the potatoes harvested on 29/10/92, and 60, 36 and 96 mg/kg respectively for those harvested on 24/11/92.

Table 23. The effects of protective coating on the content of chaconine (Ch), Solanine (So) and total glycoalkaloids (To) of Atlantic potatoes

Treatment	Harvest date	Days exposed to light at 20°C														
		5			7			9			12			14		
		Ch	So	To	Ch	So	To	Ch	So	To	Ch	So	To	Ch	So	To
		mg/kg														
Control	29/10/92	23	12	35	21	13	34	28	16	44	41	12	53	26	17	43
Gelatin	29/10/92	25	21	46	25	18	43	22	10	32	49	16	65	26	15	41
Ausgloss	29/10/92	28	25	53	32	23	55	28	14	42	27	15	42	26	16	42
LDPE bags	29/10/92	26	20	46	24	16	40	18	12	30	28	16	44	31	18	49
Control	24/11/92	31	16	47	21	10	31	20	10	30	31	14	45	18	10	28
Gelatin	24/11/92	29	14	43	20	10	30	19	10	29	26	14	40	24	14	38
Ausgloss	24/11/92	21	14	35	20	10	30	20	10	30	24	13	37	18	10	28
LDPE bags	24/11/92	52	35	87	23	10	33	23	10	33	24	12	36	13	8	21

The content of α chaconine, α solanine and total glycoalkaloids at 0 day was 30, 14 and 44 mg/kg respectively for the potatoes harvested on 29/10/92, and 27, 6 and 33 mg/kg respectively for those harvested on 24/11/92.

Table 24. The effects of protective coating on the content of chaconine (Ch), solanine (So) and total glycoalkaloids (To) in the skin of Atlantic and Cadima potatoes

Treatment	Days exposed to light at 20°C								
	0			5			7		
	Ch	So	To	Ch	So mg/kg	To	Ch	So	To
Atlantic									
Control	521	246	766/7	435	186	621/766	527	225	752
Gelatin	521	245	766	366	174	540	380	204	585
Ausgloss	521	245	766	391	185	576	275	130	405
LDPE bags	521	245	766	404	226	630	412	271	629
Cadima									
Control	164	65	229	266	110	376	298	129	427
Gelatin	164	65	229	113	57	170	170	79	249
Ausgloss	164	65	229	151	55	206	171	59	230
LDPE bags	164	65	229	252	103	355	201	79	280

The potatoes used in the experiment were harvested on 29/10/92.

The experimental results indicated that green Atlantic and Cadima potatoes did not appear to contain higher glycoalkaloid levels than normal potatoes when whole potato was analysed (Table 22). It is possible that the dilution effect of analysing the whole potato may have obscured the skin-greeness effect. To test this the skins of two potatoes that were green on one side and normal on the other were analysed.

Sample	Chaconine	Solanine	Total glycoalkaloid
	mg/kg		
Normal half	328	144	472
Green half	270	129	399
Normal half	339	153	492
Green half	277	137	414

These results indicate that there is no direct relationship between visual greeness and glycoalkaloid levels.

References

Carnegie, S.F., Hamilton, G.A., Lindsay, D.A., Ruthven, A.D. and Gray, W.J. (1984). Control of gangrene, skin spot and silver scurf on potatoes by a new fungicide formulation of thiabendazole and 2-aminobutane. Proceedings of Crop Protection in Northern Britain Conference, pp. 138-143.

Carnegie, S.F., Ruthven, A.D., Lindsay, D.A. and Hall, T.D. (1990). Effects of fungicides applied to seed potato tubers at harvest or after grading on fungal storage diseases and plant development. Annals of Applied Biology 116, 61-72.

Connor, H.W. (1937). Effects of light on solanine synthesis in the potato tuber. Plant Physiology 12, 79-98.

Foister, C.E., Wilson, A.R. and Boyd, A.E.W. (1952). Dry rot disease of potato. 1. Effect of commercial handling methods on the incidence of the disease. Annals of Applied Biology 39, 29-37.

Gratte, H. and Paust, G. (1990). Potato varieties for Western Australia. Potato Grower, April-May issue, 1990, pp. 21-28.

Hamilton, G.A., Lindsay, D.A., Quinn, C.E., Ruthven, A.D., Shipton, P.J. and Gray, W.J. (1981). Comparison of the fungicides thiabendazole and 2-aminobutance used for the control of gangrene and skin spot of potatoes grown under Scottish conditions. Proceedings of the 1981 British Crop Protection Conference - Pests and diseases, pp. 355-362.

Hide, G.A., Hirst, J.M. and Griffith, R.L. (1969). Control of potato disease with systemic fungicides. Proceedings of the 5th British Insecticide and Fungicide Conference 1, 310-314.

Hilton, R.J. (1951). Factors in relation to tuber quality in potatoes. II. Preliminary trials on bitterness in Netted Gem potatoes. Scientific Agriculture 31, 61-70.

Howard, F.D., Yamaguchi, M. and Timm, H. (1957). Effects of illumination and waxing on the chlorophyll development in scrubbed White Rose potato tubers. American Potato Journal 34, 424-329.

Larson, E.C. (1949). Investigations on cause and prevention of greening in potato tubers. Idaho Agricultural Experimental Station Bulletin No. 16, 1-32.

Logan, C., Copeland, R.B. and Little, G. (1975). Potato gangrene control by ultra low volume sprays of thiabendazole. Annals of Applied Biology 80, 199-204.

Schouten, S.P. (1993). Influence of low oxygen conditions during long term (CA) storage of ware potatoes. Proc. 6th International Controlled Atmosphere Research Conference.

Smith, O. (1968). Potatoes: Production, storing, processing. AVI publishing, Westport, Conn. 642 p.

W.IO (1992). Technical report Series 828, 39th report of the joint FAO/WHO Expert Committee on Food Additives.

Appendix

SHELF LIFE AND COOKING QUALITY OF ATLANTIC POTATOES

S.C. Tan and J. Berston
Division of Horticulture
Western Australian Department of Agriculture

Introduction

Atlantic is a potato cyst nematode (PCN) resistant potato but has the major faults of skinning, bruising and cracking which lead to postharvest storage and cooking problems. Poor handling methods during harvesting, in-field storage, washing and transportation have greatly reduced the storage and keeping quality of Atlantic. CCA Snack Foods Ltd has reported that black spots and rots represents the main problems during the production of crisps. Potato Marketing Authority was interested in the poor cooking quality of Atlantic when boiled.

The objective of this experiment is to study the effects of washing, bruising and mechanical injury on the keeping and cooking quality of Atlantic when compared to Delaware.

Materials and Methods

Fresh Atlantic and Delaware potatoes were obtained from CCA Snack Foods Ltd and Potato Marketing Authority respectively. Eight treatments were carried out on both cultivars. They are summarized in Table 1.

Table 1. Summary of treatments

Treatment no.	Description*
1	Washed with hand in tap water and packed into perforated potato bags after drying.
2	Washed with hand in tap water and packed into perforated potato bags while still wet.
3	Injured the potatoes by dropping them to a flat cement floor from one metre above the floor, washed them with hand in tap water and then packed into perforated potato bags after drying.
4	Injured the potatoes by dropping them to a flat cement floor from one metre above the floor, washed them with hand in tap water and then packed into perforated potato bags while still wet.
5	Unwashed potatoes were packed into perforated potato bags.
6	Unwashed potatoes were wet with tap water and then packed into perforated potato bags.
7	Unwashed potatoes were injured by dropping them to a flat cement floor from one metre above the floor, they were then packed into perforated potato bags.
8	Unwashed potatoes were injured by dropping them to a flat cement floor from one metre above the floor, they were then wet with tap water and packed into perforated potato bags.

* Perforated potato bags were supplied by Sumich Group Ltd. Each bag contained 10 potatoes.

Eighteen bags of Atlantic (10 potatoes/bag) and six bags of Delaware were packed for each treatment as described in Table 1. Six bags of Atlantic of each treatment were kept at ambient temperature (average night temperature was 11 ± 3°C, average day temperature was 25 ± 6°C). The other six bags of Atlantic of each treatment were kept at 20 ± 1°C with 8 hr light (light intensity was 40 ± 5 ft candles) and 16 hr darkness together with six bags of Delaware. The remaining six bags of Atlantic of each treatment were kept at Woolworths supermarket, Dianella, Western Australia. The light intensity in Woolworths Supermarket during the period of experiment was between 20 to 50 ft candles, with temperature at 21 ± 3°C. The weight loss, % marketability (the combined effects of the degree of greening, shrivelling, sprouting and rottening), total soluble solids (TSS), specific gravity (SG) and boiling quality was assessed weekly for a period of three weeks. Ten potatoes of each cultivar for each treatment were used every week for the assessment.

Boiling test

Ten medium sized potatoes of about 200 g each were peeled and boiled whole. The potatoes were put in cold water which was then heated to boiling and then simmered until the potatoes were cooked as shown by testing each cultivar with a metal skewer (Mr Roger P. Kirkham, personal communication). The colour and disintegration of the potatoes immediately after boiling were rated as described in Table 2. The potatoes were also cut through with a fork and a softness score was recorded. The potatoes were left for 24 hr and then scored for after cooking darkening.

Table 2. Boiling test

Test	Score	Descriptive terms
Basic Colour A	1	White
	2	Creamy White
	3	Cream
	4	Deep Cream
	5	Yellow
Greying And After Cooking Darkening B	1	Nil
	2	Slightly Grey
	3	Moderate, greyish black
	4	Marked blackening around eyes and/or stem end
	5	General blackening
Disintegration And Sloughing C	1	Nil, surface smooth and translucent
	2	Slight, surface dull but mainly intact
	3	Moderate, major part of surface sloughed off but mainly intact
	4	Severe, floury mass
	5	Severe, soupy
Softness D	1	Firm, do not readily break up when tested with fork
	2	Fairly firm, can be broken in large lumps which retain a strong mutual cohesion
	3	Fairly soft, can be broken apart easily
	4	Soft, breaks easily up into mass of glistening crumbs with little cohesion
	5	Very soft, breaks easily up and mashed into a slurry

Results and Discussion

The weight loss of the potatoes from different treatments and stored in different conditions are shown in Table 3. The Atlantic lost about 3% of weight after stored for 21 days in supermarket and in simulated supermarket conditions (21°C, 8 hr light and 16 hr darkness). Delaware at 21°C also lost the same amount of weight. The weight loss was basically caused by transpiration. There seemed to be no differences in weight loss among the treatments between two cultivars.

The % marketability of the potatoes from different treatments and stored in different conditions are shown in Table 4. When the potatoes were stored at 21°C with 8 hr light and 16 hr darkness for 7 and 14 days there was no difference in marketability between the two cultivars tested. However, Delaware appeared to have a better quality than that of Atlantic after 21 days of storage. The lower quality in Atlantic was due to the rots occurring in washed and mechanically injured potatoes. Some rots were also found in unwashed and mechanically injured Atlantic when packed in wet condition. Delaware also rot but to a lesser extent. Mechanical injuries, especially at the wet condition, encouraged the entry of pathogen. This is particularly severe in Atlantic because their skin is more fragile when compared to Delaware.

Table 3. Weight loss of potatoes during storage in various conditions

Storage condition and treatment*	% Weight loss after days of storage					
	7		14		21	
	A**	D**	A	D	A	D
21°C, 8 hr light and 16 hr darkness						
1	0.8	0.8	1.9	1.3	2.4	1.8
2	1.1	1.0	2.4	1.4	2.4	2.6
3	1.3	0.9	1.9	1.7	2.9	2.1
4	1.7	1.4	3.2	1.7	4.6	2.4
5	0.8	0.7	1.5	1.5	2.3	1.8
6	1.3	2.0	2.3	2.2	3.2	2.9
7	0.9	0.9	1.8	1.8	3.2	2.2
8	1.7	1.1	2.0	1.9	3.2	2.7
Ambient						
1	1.2	-	2.3	-	2.7	-
2	1.1	-	1.8	-	2.5	-
3	1.4	-	2.1	-	3.1	-
4	2.4	-	3.2	-	3.7	-
5	1.1	-	2.4	-	2.9	-
6	1.5	-	2.0	-	3.0	-
7	0.9	-	2.3	-	4.8	-
8	1.9	-	3.7	-	5.5	-
Woolworths Supermarket						
1	0.4	-	1.8	-	2.2	-
2	0.9	-	2.0	-	2.6	-
3	1.2	-	1.8	-	2.7	-
4	2.0	-	3.1	-	3.9	-
5	1.0	-	1.7	-	2.2	-
6	1.4	-	2.4	-	3.0	-
7	0.8	-	1.6	-	2.9	-
8	1.8	-	2.4	-	3.4	-

* Refer to Table 1 for treatments.
** A = Atlantic, D = Delaware, - = not determined.

Table 4. Marketability rating of potatoes during storage in various conditions

Storage condition and treatment*	Marketability rating** of potatoes after days of storage					
	7		14		21	
	A	D	A	D	A	D
21°C, 8 hr light and 16 hr darkness						
1	2	2	2	2	3	2
2	2	2	3	3	3	3
3	3	2	3	2	5	2
4	2	2	3	2	4	3
5	2	2	2	2	2	2
6	2	2	3	3	3	3
7	2	3	3	3	3	3
8	2	3	2	3	4	3
Ambient						
1	2	-	2	-	2	-
2	2	-	2	-	3	-
3	2	-	3	-	3	-
4	3	-	3	-	3	-
5	2	-	2	-	2	-
6	2	-	2	-	2	-
7	3	-	3	-	4	-
8	3	-	3	-	5	-
Woolworths Supermarket						
1	2	-	2	-	2	-
2	2	-	2	-	2	-
3	3	-	3	-	3	-
4	2	-	3	-	4	-
5	2	-	2	-	2	-
6	2	-	2	-	3	-
7	2	-	3	-	3	-
8	2	-	3	-	3	-

* Refer to Table 1 for treatments.

** Marketability rating of potatoes was based on the combined effects of degree of greening, shrivelling, sprouting and rottening.

Rating: 1 - excellent, 2 - good, 3 - average, 4 - unsaleable, 5 - unusable
A = Atlantic
D = Delaware
- = not determined.

The marketability rating of both fresh Atlantic and Delaware potatoes before storage was 2.

However, if washed carefully without any mechanical injury and packed after drying, the marketability of Atlantic stored at 21°C for 21 days was as good as that of Delaware. In addition, Atlantic also contain a higher amount of sugars which can be used as substrate for the growth of micro organism. The degree of rottening was also higher in the Atlantic which were stored at ambient and at Woolworths Supermarket (Table 4) when compared to Delaware.

The percentage of total soluble solids (TSS) (Table 5) and specific gravity (SG) (Table 6) were generally higher in Atlantic when compared to Delaware. Higher % TSS and SG not only promote the growth of microorganism, they also partially responsible for the poor boiling quality (greying and after cooking darkening) in Atlantic (Table 7). Reducing sugars cause the darkening of the potato tissues due to chemical reactions, especially Maillard reaction. It is a non-enzymatic browning reaction between the aldehyde groups of reducing sugars and the free amino groups of amino acids and, perhaps to a lesser degree of proteins. A higher concentration of sugars apparently enhanced darkening of chips (Beale et al., 1966).

The specific gravity of potatoes used for processing is of great importance. High specific gravity potatoes (e.g. Atlantic) are preferred for potato chips and French fries. However, potatoes of low specific gravity are preferred for boiling because they slough or fall apart less during boiling process than potatoes of higher specific gravity. The effects of specific gravity on the boiling quality of potatoes are shown in Table 7 and Table 8.

Table 5. Total soluble solids (TSS) of popatoes during storage in various conditions

Storage condition and treatment*	% TSS of potatoes after days of storage					
	7		14		21	
	A	D	A	D	A	D
21°C, 8 hr light and 16 hr darkness						
1	4.9	4.8	5.0	4.2	5.0	4.9
2	5.0	4.6	5.0	4.6	5.0	4.9
3	5.2	4.8	5.0	4.6	5.1	4.6
4	5.0	4.8	5.0	4.8	5.0	4.9
5	5.0	4.8	5.0	4.8	5.0	4.8
6	4.9	4.6	5.0	4.8	5.0	4.2
7	4.9	4.6	5.0	4.8	5.1	4.8
8	5.0	4.6	5.0	4.8	5.0	4.2
Ambient						
1	4.8	-	5.0	-	5.0	-
2	5.0	-	5.0	-	5.0	-
3	5.2	-	5.0	-	5.2	-
4	5.0	-	5.0	-	5.1	-
5	5.4	-	5.2	-	4.8	-
6	5.0	-	5.2	-	5.0	-
7	5.4	-	5.2	-	5.4	-
8	5.1	-	5.2	-	5.0	-
Woolworths supermarket						
1	5.0	-	5.0	-	5.0	-
2	5.0	-	5.0	-	4.9	-
3	5.0	-	5.0	-	5.0	-
4	5.0	-	5.0	-	5.0	-
5	5.0	-	5.0	-	5.0	-
6	4.8	-	5.0	-	4.8	-
7	5.2	-	5.0	-	5.0	-
8	5.0	-	5.0	-	5.0	-

* Refer to Table 1 for treatment.
A = Atlantic, D = Delaware, - = not determined.

The % TSS of fresh Atlantic and Delaware potatoes before storage was 5.0% and 4.8% respectively.

Table 6. Specific gravity (SG) of potatoes during storage in various conditions

Storage condition and treatment*	SG of potatoes after days of storage					
	7		14		21	
	A	D	A	D	A	D
21°C, 8 hr light and 16 hr darkness						
1	1.091	1.071	1.095	1.058	1.094	1.068
2	1.085	1.068	1.093	1.061	1.091	1.066
3	1.088	1.075	1.100	1.064	1.083	1.064
4	1.082	1.072	1.092	1.066	1.080	1.066
5	1.088	1.076	1.095	1.063	1.088	1.058
6	1.084	1.066	1.090	1.066	1.087	1.061
7	1.080	1.071	1.096	1.066	1.088	1.063
8	1.087	1.075	1.091	1.062	1.087	1.062
Ambient						
1	1.095	-	1.083	-	1.096	-
2	1.092	-	1.101	-	1.093	-
3	1.078	-	1.095	-	1.082	-
4	1.080	-	1.087	-	1.093	-
5	1.087	-	1.097	-	1.093	-
6	1.088	-	1.103	-	1.095	-
7	1.086	-	1.090	-	1.093	-
8	1.081	-	1.093	-	1.094	-
Woolworths Supermarket						
1	1.090	-	1.094	-	1.086	-
2	1.093	-	1.094	-	1.088	-
3	1.091	-	1.091	-	1.086	-
4	1.084	-	1.088	-	1.088	-
5	1.096	-	1.089	-	1.085	-
6	1.090	-	1.086	-	1.088	-
7	1.086	-	1.090	-	1.091	-
8	1.088	-	1.089	-	1.087	-

* Refer to Table 1 for treatment.
A = Atlantic
D = Delaware
- = not determined.

The specific gravity of fresh Atlantic and Delaware potatoes before storage was 1.090 and 1.067 respectively.

Table 7. Boiling quality of Atlantic potatoes during storage in various conditions

Storage condition and treatment*	Score** of boiling test after days of storage											
	7				14				21			
	A	B	C	D	A	B	C	D	A	B	C	D
21°C, 8 hr light and 16 hr darkness												
1	2	4	3	3	2	4	3	2	2	4	3	2
2	2	4	3	3	2	4	3	2	2	4	3	2
3	2	4	3	3	2	4	3	2	2	4	3	2
4	2	4	3	3	2	4	3	2	2	4	3	2
Ambient												
1	2	4	3	3	2	4	3	2	2	4	2	2
2	2	4	3	3	2	4	3	2	2	4	2	2
3	2	4	3	3	2	4	3	2	2	4	2	2
4	2	4	3	3	2	4	3	2	2	4	2	2
Woolworths Supermarket												
1	2	4	3	3	2	4	3	2	2	4	3	2
2	2	4	3	3	2	4	3	2	2	4	3	2
3	2	4	3	3	2	4	3	2	2	4	3	2
4	2	4	3	3	2	4	3	2	2	4	3	2

* Refer to Table 1 for treatment.
** Refer to Table 2 for the descriptions of boiling test.

The score of boiling rest of fresh Atlantic potatoes before storage was A = 2, B = 4, C = 3, and D = 3.

Table 8. Boiling quality of Delaware potatoes during storage at 21°C

Treatment*	Score** of boiling test after days of storage											
	7				14				21			
	A	B	C	D	A	B	C	D	A	B	C	D
1	2	2	1	2	2	2	1	2	2	3	2	2
2	2	2	1	2	2	2	1	2	2	3	2	2
3	2	2	1	2	2	2	1	2	2	3	2	2
4	2	2	1	2	2	2	1	2	2	3	2	2

* Refer to Table 1 for treatment.
** Refer to Table 2 for the descriptions of boiling test.

The score of boiling test of fresh Delaware potatoes before storage was A = 2, B = 2, C = 1, and D = 2.

The degree of disintegration and sloughing (Test #B) was higher in Atlantic than in Delaware. The disintegration and sloughing score was 4 for the Atlantic and 2-3 for the Delaware. This might be due to the higher SG in Atlantic (Table 6). It has been noted that potatoes of SG 1.080 or higher sloughed, but those below these figures did not (Nutting, 1950).

Boiling quality of Atlantic seemed to improve during storage for a period of time. The score of softness (Test #D) was 3 in fresh potatoes and those potatoes which have been stored for 7 days. The score improved to 2 after 14 and 21 days of storage (Table 7). This might be due to the loss of water and the occurring of some chemical reactions which in turn altered the chemical compositions and hence the texture of the tuber. Barmore (1938) showed that there was less disintegration of peeled, diced pieces when cooked if tubers had been stored at 18°C for a period of time.

Conclusions and Future Works

1. The Atlantic potatoes kept reasonably well after washing carefully with hand without any injuries and packed after drying. However, due to its fragile skin and texture, washing of Atlantic by commercial washer should be carried out to test the effects of washing on their qualities and marketability.

2. Atlantic have higher SG than Delaware. They are good processing potatoes (for crisps and chips) but tend to slough when boiled soon after harvest. Due to their texture, they may be more suitable for steaming, roasting and microwaving purposes as it takes less time to cook.

3. Because of Maillard reaction, probably due to higher % TSS, do not store peeled Atlantic potatoes, and consume them as soon as possible after cooking (e.g. boiling, roasting).

4. Further works have to be carried out to test the effects of maturity, time of harvesting, postharvest handling, time of storage and ageing on the texture of Atlantic potatoes in order to improve their storage and cooking quality, especially boiling quality.

Reference

Barmore, M.A. (1938). The sloughing of potatoes. Amer. potato J. 15, 170-171.

Beale, W.L., Hunger, D. and Stevenson, F.J. (1966). Potato chip colour reversion. Amer. Potato J. 43, 355-360.

Nutting, G.C. (1950). Sloughing of potatoes. Amer. Potato J. 27, 117-118.

Acknowledgement

We thank CCA Snack Foods Ltd and Potato Marketing Authority for the supply of Atlantic and Delaware potatoes respectively, and the Sumich Group Ltd for the supply of potato bags.