SPROUT SUPPRESSION OF WARE POTATOES BY MEANS OF CARVONE

RESULTS OF STORAGE EXPERIMENTS ON SEMI-PRACTICAL SCALE (15 TONS STORES) CONDUCTED ON THE ATO-DLO EXPERIMENTAL FARM "DE EEST" (NOP) IN THE STORAGE SEASON 1991-1992

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CONTENT

1. INTRODUCTION

Sprouting control is very important when potato tubers must be stored for a long period. Good storage practice is in particular important, when tubers have to be stored for processing into crisps and French fries later in the season.
Whenafter the curing period the temperature is lowered to 2-4°C, followed by storage at constant temperature, sprouting will be kept within acceptable limits. However, in this temperature range the so-called low temperature sweetening will develop, leading to a high reducing sugar content which, depending on cultivar and growth circumstances will in turn cause a brownish, bitter product when processed(Maillard reaction).
In this case storage at higher temperatures (6-8°C) combined with a sprout inhibiting treatment is necessary. Worldwide isopropyl N-phenylcarbamate (IPC or Propham) and isopropyl N- (3-chlorophenyl) carbamate (CIPC or chlorpropham) are most used as sprout inhibitors for potatoes. In the Netherlands IPC and CIPC are normally applied together as a sprout inhibiting mixture, during storage.

Since long there is a demand for other sprout inhibiting components, instead of both carbamates.
There are several essential plant oils which are now applied in the food and cosmetic industry as fragrancing and flavouring substances, which have promissing inhibiting properties (Beveridge et al., 1981).
Small scale as well as semi-practical scale experiments within 15 tons stores with an outside air cooling system, has shown that sprout growth can be inhibited with the monoterpene Carvone (1-menthyl-4-isopropyl-6-cyclohexene-2-one) from the essential oil of caraway seed (Carum carvi) or dill seed (Anethum graveolens). (Hartmans and van Es, 1988; Buitelaar and Hartmans 1991; Hartmans and Buitelaar, 1992 a and b). During the season 1991/1992 different Carvone dosages and application methods were tested at the ATO-DLO experimental farm "de Eest" in 15 tons stores.
Reported is here the influence of different Carvone treatments on sprout suppression and quality aspects of the potatoes during the whole storage season 1991/1992.

2 MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 Potatoes

The research was conducted on one potato cultivar, i.e. 'Bintje'. The required potatoes were cultivated on clay soil, 38% elutriation, on the ATO-experimental farm 'de Eest' at Nagele (NOP).

The following plant protection treatments were carried out:

Type	number of treatments	Name	dosage/ha
- herbicide	1 x	Mirabo	8.5 l
- fungicide (phytophthora)	13 x	Topper	3 to 4 l
- insecticide	3 x	Dimethoate	1 l
- „	2 x	Pirimor	0.5 kg

The haulm was killed in the beginning of September by using 3 l Reglone/ha. The potatoes were lifted on September 23th and 24th. Harvesting was done under dry soil conditions (nearly no soil remained on the potatoes) which caused some damages due to handling.

2.1.2 Sprout inhibitors

The sprout inhibitors involved in the research were:

- a liquid sprout inhibitor used for ware potatoes, containing the active ingredients IPC (15 g/l) + CIPC (285 g/l). This agent is available on the market, as AA servo liquid SF (charge no. 877082 MC).

  IPC, Propham, isopropyl-N-phenylcarbamate, MW: 179.2.

  CIPC, Chlorpropham, N-(3-chlorophenyl)-isopropylcarbamate, MW: 213.63.

- a powder sprout inhibitor used for ware potatoes, containing the active ingredients 0,5% IPC and 0,5% CIPC. This agent is available on the market as (B.V. Luxan - charge no. 3107).

- d-Carvone, derived from caraway seed. Carvone was purchased on the market. Production of Carvone is based on steam distillation of caraway seed followed by fractional distillation of the steam distillate(95% d-Carvone).

  d-Carvone, 1-methyl-4-isopropyl-6-cyclohexene-2-on, MW:150.21.

- l-Carvone, chemically synthesized from the essential oil d-Limonene(94% l-Carvone).

2.1.3 Sampling for quality control

Sampling.

During the entire storage season, all stores were sampled every six weeks in order to make various

quality analyses and chemical analyses. To that end, representative potato samples were each time taken from the top of every store; subsequently, the potatoes were divided up at random to assess flavour, residue, chips quality, internal sprouting, external damages and sprouting and to make analyses on sugar and glycoalkaloid.
When unloading the stores, one representative sample was taken from the entire store and from the stack heights 0.5, 1.5 and 2.5 m. A sufficient number of potatoes of the desired size were collected from the conveyor belt and divided up in order to make various analyses.

2.2 METHODS

2.2.1 Storage time and storage conditions

The 'Bintje' potatoes, to be put down in stores No. 1 to 10, were harvested and storage in bulk started on September 23th and 24th. The unloading time of the stores was partly determined by the sprout suppression effects of the agents and varied from the 25th of May till the 16th of June (244 to 266 days).

The research was conducted on the ATO-experimental farm 'de Eest'. Use was made of ten 15 tons stores cooled with outside air. The ventilation system was controlled by microprocessors, with the exception of the curing and drying period and the period required for heating the potatoes prior to delivery. After the liquid sprout inhibitors had been dosed, a ventilation-free period of 2 x 24 hours was inserted.
In the drying and curing period, a storage temperature of 12 - 15°C was kept. After this period, the true storage periods followed, starting on October 8th.
The automatic ventilation system was programmed in such a way, that, the outside air permitting, a storage temperature of about 5 - 7°C was reached in the stores.
It turned out that from some weeks after the curing period until about May, the average storage temperature properly remained within the required range of 5 - 7°C.
The research programme also stated that in periods in which ventilation with outside air was not possible for a long time, a number of hours of internal air circulation would automatically be supplied so as to level the temperature in the stacked potatoes. Each ventilation-free period of 4 x 24 hours was followed by one hour of internal air circulation. Prior to delivery, the temperature of the potatoes was increased to about 20°C, by internal ventilation combined with antificial heating or by outside air ventilation.

Within the stores no. 7 and 8 Carvone was dosed automatically after every outside air ventilation period. The short Carvone dosage period was combined with an internal ventilation period of 30 minutes.
Furthermore in these two stores internal ventilation was started when there was a temperature difference of ≥ 2°C between two temperature sensors; one at a stack height of 0,5 m and one at 2,5 m.
In all stores, temperature and the number of internal and external ventilation hours were registered daily. In each store an electronic temperature sensor was installed 50 cm below the surface.

2.2.2 Dose rates of sprout inhibitors

During this investigation, the agents, number of treatments and dosing time varied. A survey of the test variants is to be found in Table 2.2.2.

To spread the liquid agents, use was made of a swingfog apparatus, (nozzle 0,9 for propham/chlorpropham and nozzle 1.2 for Carvone) and of the internal air circulation system which continued another 15 min. after the application.

Within the stores no.7 and 8, Carvone was automatically applied (Table 2.2.2) 5 min after every outside air ventilation period, by the use of a compressed air fogging equipment (Dofra - The Netherlands). The fogging was combined with internal air ventilation, which continues another 15 min. after the application.
The Gro Stop powder was spread by hand during loading.

Table 2 2.2.2. A survey of the experimental applications used to investigate the sprout suppressant activity of Carvone during storage of ware potatoes of the cv. Bintje in 1991/1992.

Store nr.	Sprout inhibitors	Application per 1000 kg potatoes			Application times
		number of applications	dosage per application	Total amount	
1	Gro Stop S.C. (30%)	3	22 ml	66 ml	16 Oct., 27 Nov., 11 March
2	D-Carvone D-Carvone	3 3	50 ml 100 ml	450 ml	from 16 Oct. 1 x per 6 weeks from 19 Febr. 1 x per 6 weeks
3	D-Carvone	34	12 ml	408 ml	from 16 Oct. 1 x week
4	D-Carvone	34	8.5 ml	289 ml	from 16 Oct. 1 x per week
5	D-Carvone	4	100 ml	400 ml	from 16 Oct. 1 x per 9 weeks
6	L-Carvone L-Carvone	3 3	50 ml 100 ml	450 ml	from 16 Oct. 1 x per 6 weeks from 19 Febr. 1 x per 6 weeks
7	D-Carvone D-Carvone	54 5	* x 3.86 ml * x 13.71 ml	277 ml	from 24 Oct. automatical dosing (average 1.8 x per week)
8	D-Carvone D-Carvone D-Carvone	53 5 1	* x 4.29 ml * x 14.29 ml 100 ml	399 ml	from 24 Oct. automatical dosing (average 1.8 x per week) 25 Febr.
9	Gro Stop powder (1%) D-Carvone	1 34	0.55 kg 8.5 ml	0.55 kg 289 ml	24 Sept. during loading from 16 Okt. 1 x per week
10	Gro Stop powder (1%) D-Carvone D-Carvone	1 2 1	0.54 kg 50 ml 100 ml	0.54 kg 200 ml	24 Sept. during loading from 19 Febr. 1 x per 6 weeks

* x = average values

2.2.3 Carvone determination in the storage atmosphere (headspace)

The Carvone content in the storage atmosphere (head space) was determined by means of absorption of Carvone onto the Tenax absorbent, followed by thermal desorption cold trap injection on GC.
During the storage season, air samples were taken in the stores at regular intervals. An amount of air of 1 ml $sec.^{-1}$ was sucked trough glass tubes filled with 100 mg of Tenax TA (20-35 mesh) for 15-60 seconds, depending on the Carvone concentration to be expected.

The air samples were taken in the upper part of the stores. The first samples were take one hour after treatment.
Carvone was analysed with GC, as described in 2.2.4.2.

2.2.4 QUALITY ASPECTS OF POTATOES DURING STORAGE

2.2.4.1 Sprout suppression and tuber defects

<u>Sprout suppression</u>

Sprout suppression during storage

During the storage period, a regular assessment was made of the degree of sprouting in the potatoes: this could only be done in the upper part of the store.
To simulate the effect of a short storage period in small quantities at higher temperatures (super market situation), samples from the bulk store at regular intervals of six weeks were taken and stored for an additional period of three weeks at 15°C in perforated plastic bags. Two representative samples of 20 tubers (size ± 40 - 60 mm; weight ± 100 g) were used therefore. After one and three weeks all sprouts of one sample were removed, counted and weighed.

Sprout suppression at unloading time

When unloading the store, the degree of sprouting in the entire lot was visually assessed and the mean sprout suppression effect was determined and expressed on a sliding scale with the following scale indications: excellent, good, amply sufficient, almost sufficient, sufficient, insufficient, bad.

The above-mentioned values can be expressed in figures, ranging from 1 to 7.
The following classification can be made:

1 = bad
2 = insufficient
3 = almost sufficient
4 = sufficient
5 = amply sufficient
6 = good
7 = excellent

If the sprout suppression effect is considered to be 'excellent', this means that no or hardly any sprouts were found in the lot. If the sprout suppression effect is regarded as 'bad', this means that a lot of potatoes were heavily sprouted. A sprout suppression effect which is sufficient is only just effective enough not to create problems with the customer.
Furthermore a representative sample of 30 to 40 kg was collected form the entire store, sprouts and tubers weighed separately and the number of tubers per sample counted.
Four small samples of 20 tubers from the entire store were collected and stored in plastic bags for an additional period at 15°C. The number of sprouts and the sprout weight was determined from two samples after one and three weeks respectively.

<u>Tuber defects</u>

Internal and external defects

In order to determine internal sprouting and any damage to potatoes as a result of agents used, two mixed samples of 100 tubers were collected from each store during unloading of the stores.
The samples were washed and an assessment was made of any external damage due to the agent used; subsequently, the samples were cut and the degree of internal sprouting and any other defects were determined.

Blackspot susceptibility

The blackspot susceptibility was determined of two representative samples of 100 tubers (size ± 40 - 70 mm) collected at unloading time from the entire stores. After two extra days of conditioning at 15°C, samples were shaken for 30 sec. on an approximately 1 m^2 shaker plate (at a rotational speed of 290 rev./min.). After 48 hours storage at 15°C the blackspot index of the tubers was determined after peeling. The tubers were visually inspected and divided in four classes, based on the area of the tuber surface with blackspots.

susceptibility class	**blackspot area of the tuber surface in %**
no	0
light (L)	0 - 2%
moderate (M)	2 - 10%
severe (S)	> 10%

The blackspot index was calculated by using the formula:

$$\text{Blackspot index} = \% \ \frac{(L + 2M + 3S)}{6}$$

2.2.4.2 Residue Analysis

Residue content of IPC/CIPC

IPC/CIPC was extracted from fresh potatoes by means of an organic solvent, pre-purified with aluminium oxide and analysed by means of a GC fitted with a nitrogen phosphorus detector (NPD) (Hartmans and Buitelaar 1992a). For the determination of IPC-CIPC, the NPD type of detector is more sensitive than the FID type.

Residue content of Carvone

Carvone was extracted from fresh potatoes by means of an organic solvent, suitable for lipid extraction (Bligh and Dyer, 1959); subsequently, it was analyzed by means of a GC fitted with a thermodesorption cold trap injection system (Hartmans, 1992).
An internal standard was added to the extract, which was injected straight onto a Tenax column.

The method used was described by Hartmans 1992, although there were some modifications. The thermodesorption injections with Tenax traps were carried out now with a Thermodesorption autosampler TDAS-5000 from Carlo Erba.

Thermodesorption - Gaschromatografic Procedure

- Thermodesorption Cold Trap injection of Tenax traps.

- Tenax traps - standard glass tubes filled with 100 mg Tenax TA (20-35 mesh)
- desorption gas Helium
- desorption flow 10 ml. min. $^{-1}$
- desorption temp. 255°C
- desorption time 10 min.
- temp. cold trap -70°C
- injection temp. 240°C
- injection time 1 min.

- GC procedure
  Detection level: 0.1 ppm
  Recovery limit: 90%

Detector:	Type	- FID
	Temp.	- 240°C
	Air flow	- 350 ml min^{-1}
	H2 flow	- 35 ml min^{-1}
Column:	Type	- chemically bounded fused silica capillar
	Length	- 25 m
	Diameter	- 0.32 mm (ID)
	Coating	- CP-SIL 19 CB
	Thickness of the film	- 0.2 µm
	Carrier gas	- He (70 KPa)
	He flow	- 2.5 ml min $^{-1}$

Oven temperature programme: start 76°C ----> 10°C min $^{-1}$ to 106°C ----> 10 min. 106°C ----> 30°C min $^{-1}$ to 200°C ----> 3 min. 200 °C ----> cool 5 min. ----> heat to 76°C.

2.2.4.3 Sensory quality of steam cooked potatoes and French fries

Sensory research into steam cooked potatoes by means of a panel

Method/composition of the panel.

The method chosen was that of an ordinal comparison in pairs of potatoes with a number of relevant characteristics. Each pair was checked and treated, after which the panel was forced to make a choice.
The method is described by Hartmans and Buitelaar 1992b.

Sensory research into French fries by means of product specialist

The chips to be assessed were pre-fried in frying fat for 4 minutes at a temperature of 140°C; subsequently, the pre-fried chips to be assessed were fried in frying fat for 2 minutes at a temperature of 180°C; subsequently a sensorial assessment was made. A classification into smell and taste was made, containing four groups:

- good
- reasonable
- moderate
- bad

2.2.4.4 Processing quality (sugar content and French fry colour)

Determination of sugar (glucose, fructose)

The sugars were extracted from freeze-dried potato samples by means of water. The extract is filtrated several times and is subsequently 'cleaned up' by means of a small Sep-pack column. The solution is now ready for injection into the HPLC.
Separation of the sugars on the SUGAR pack column is based on a combination of mechanisms, such as hydrophilic and hydrophobic adsorption and separation on the basis of particle size. Detection takes place by means of a refractometer (Brons and Olieman, 1983; Anon. 1980).

Frying colour index

For the system of 'paying according to potato quality', a system in which both trade and grower are paid on the basis of the quality of the supplied potatoes, a quality determination was developed for the chips (French fries) industry based on the frying colour of the potato chips (Ludwig, 1989).

2.2.4.5 Glycoalkaloid analysis

Determination of glycoalkaloids

The glycoalkaloids α-solanine and α-chaconine were extracted from freeze-dried potato samples by means of an organic solvent; subsequently, they were pre-purified on a Sep-pack C-18 column and analysed by means of HPLC according to Saiko et al., 1990.
During storage the total glycoalkaloid content (α-solanine + α-chaconine) was determined of freeze-dried samples of whole (unpeeled) potatoes. The potatoes were sampled only from the

IPC/CIPC treated store 1, the Carvone treated stores no.2, 4, 6 and 7 and of the IPC/CIPC + Carvone treated store no. 9.

3. RESULTS AND DISCUSSION

3.1 STORAGE CONDITIONS

3.1.1 Temperature

From the daily registered temperatures, the average weekly values were calculated per store. The average weekly values from all stores over the whole season are shown in Fig. 3.1.1. With exception of the beginning of the storage season (cooling period) and the end (too high outside air temperature), the storage temperature could be kept rather constant within the 5-7°C range.
Store nr. 8 registered until march a higher average temperature of about 0.8°C, probably caused by an incorrect sensor. After correction, the temperature was from then on more equal with the temperature of the other stores.

3.1.2 Ventilation

From the daily registered external and internal number of ventilation hours, the average weekly values were calculated per store. The average weekly values for all stores over the whole season are shown in Fig. 3.1.2 A and B., the total number of ventilation hours during the curing, storage and heating periods in Table 3.1.2. The variation in internal ventilation hours was rather constant over the whole season (Fig.3.1.2.B). The number of external ventilation hours varied more at the beginning and end of the storage season, due to the cooling period and higher outside air temperatures (Fig.3.1.2.A).

Tabel 3.1.2. A survey of the number of ventilation hours during the storage season 1991/1992.

Store nr.	External ventilation during			Internal ventilation during	
	curing period	storage period	heating period	storage period	heating period
1	9	220	16	41	0
2	9	222	16	44	0
3	9	228	16	51	0
4	9	231	24	53	0
5	9	281	16	49	0
6	9	267	16	46	0
7	9	289	14	32	0
8	9	196	9	31	0
9	9	279	16	45	0
10	9	281	16	39	0

3.1.3 Carvone concentration in the atmosphere (head space) during storage.

Fig. 3.1.3 en Table 3.1.3 (Appendix) shows the changes in Carvone concentration in the headspace of the stores during the storage period, due to the different Carvone treatments. The Carvone measurements were carried out once a week.

Periodical treatments with high dosages (stores no. 2, 5, 6 and 10) showed high Carvone concentrations just after the treatments every 6 weeks. This high concentrations decreased within a few weeks to low levels. In a few cases just after dosing the Carvone concentration approached the saturated vapour pressure at 6°C (± 125 µg. L^{-1} air).
Regular treatments with low dosages (stores no.3, 4 and 9) showed after dosing lower concentrations of Carvone in the atmosphere and this decreased within a week to low levels. In these cases measurements were carried out three times a week.
Automatical treatments (stores no.7 and 8) showed a more or less constant low level of Carvone in the head space during storage. Because of inadequate sprout inhibition (partly caused by a somewhat higher storage temperature due to technical problems) an extra Carvone dosage was applied (100 ml. ton^{-1}) after about 150 days in store no.8. This caused higher values in the head space.
Except in the automatically dosed stores, the lowest Carvone values were higher in the other stores between about 125 en 225 days. This was probably due to the fact that there was less external ventilation (Fig. 3.1.2 A) during this period, which means less Carvone losses.

The concentration of Carvone in the storage atmosphere depends in general on:
a. the administered dose
b. the time after dosing
c. amount of ventilation between dosing times.

Fig. 3.1.1

Average storage temperature per week of 10 experimental stores ("De Eest" storage season 1991/1992, stores 1/10)

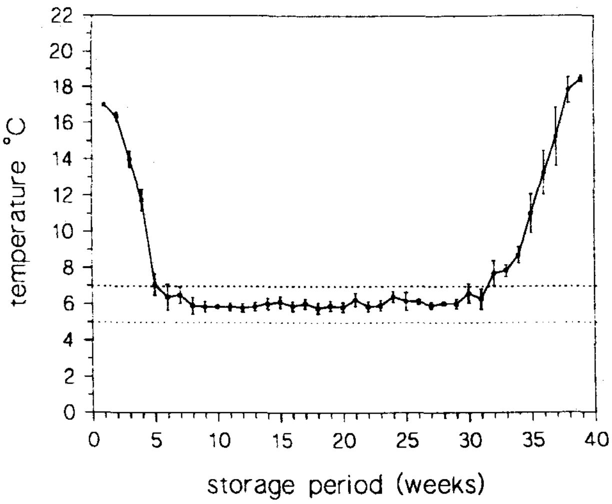


Fig. 3.1.2.A

Average number of ventilation hours per week of 10 experimental stores. ("De Eest" 1991/1992, stores 1/10)

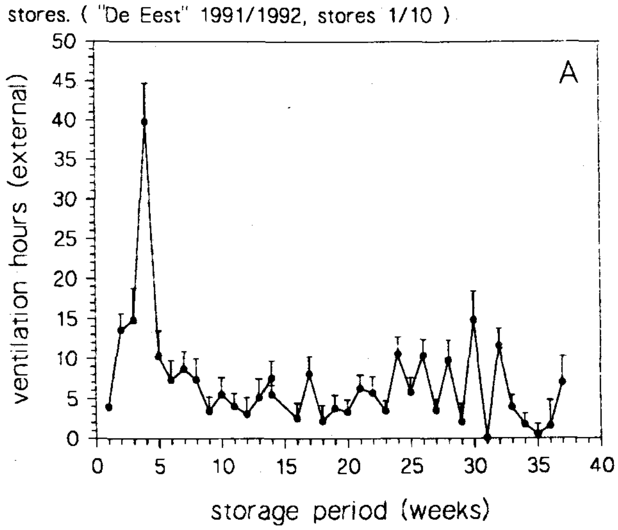
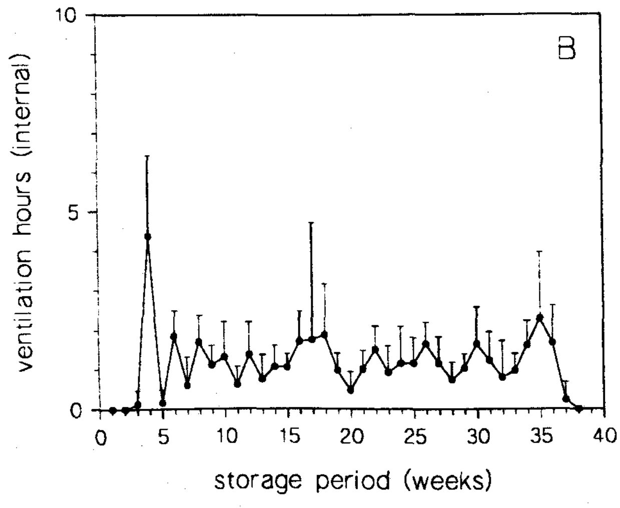


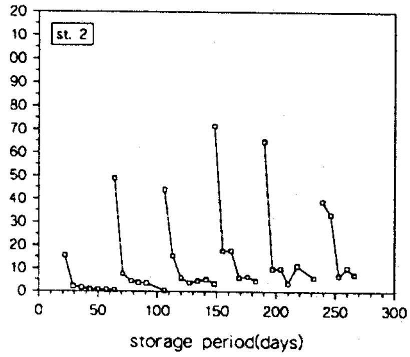
Fig. 3.1.2.B

Average number of ventilation hours per week of 10 experimental stores. ("De Eest" 1991/1992, stores 1/10)

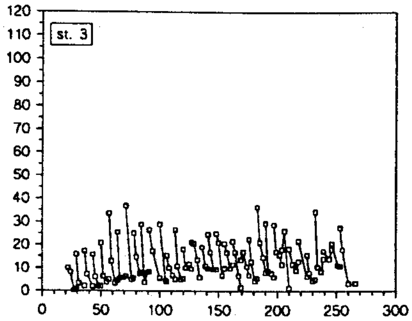


. 3.1.3

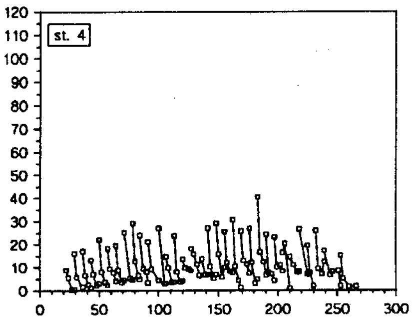
ıce of different carvone treatments during storage
e carvone concentration of the storage atmosphere.
carv. appl. day 22)



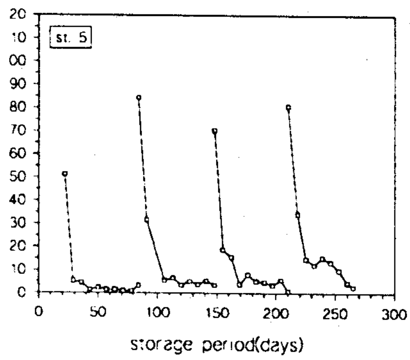
-carvone; 3 x 50 ml + 3 x 100 ml/t/6 weeks



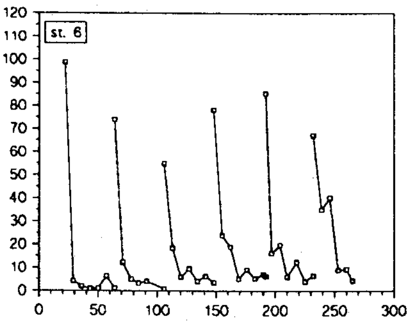
d-carvone; 12 ml/t/week



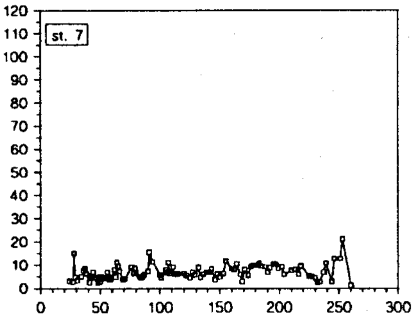
d-carvone; 8.5 ml/t/week



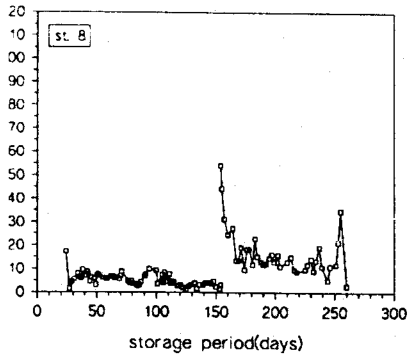
-carvone; 4 x 100ml/t/9 weeks



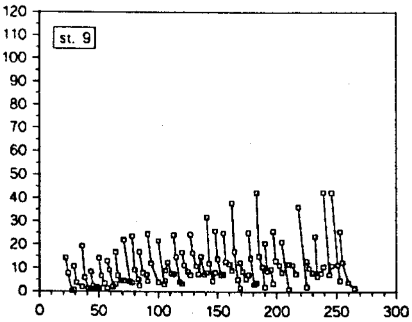
l-carvone; 3 x 50 ml + 3 x 100 ml/t/6/weeks



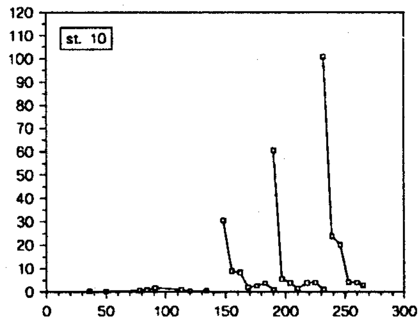
d-carvone; aut. ± 2 x 4 ml/t/week



-carvone; aut. ± 2 x 4 ml/t/week +
1 x 100 ml/t at day 154



0.5 kg ipc/cipc powder(1%)/t +
d-carvone; 8.5 ml/t/week



0.5 kg ipc-cipc powder(1%)/t +
d-carvone; 2 x 50 ml + 1 x 100 ml/t/6 weeks

3.2 QUALITY ASPECTS

3.2.1 Sprout suppression and tuber defects

Sprout suppression

3.2.1.1 Sprout suppression during storage

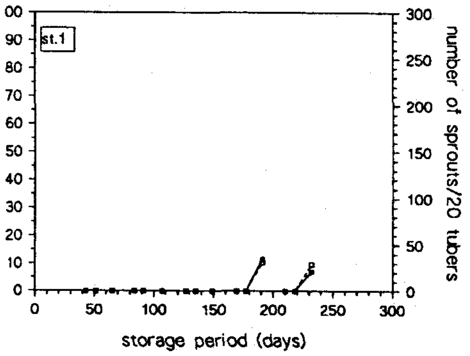
The sprout growth of small potato samples which were at regular intervals removed from the bulk stores and subsequently stored for one or three weeks at 15°C is shown in Fig. 3.2.1.1.
The sprout suppression after one week was in general still sufficient. After three weeks in some cases the potatoes were heavily sprouted, especially during the bulk storage period between about 120 and 220 days. Potatoes could obtain then sprouts of 3 to 11 cm.
The sprout weight and number of sprouts varied during the season and depended of the sprout suppression treatment. Less sprouting was shown when the potatoes were treated with a liquid (store no. 1) or powder IPC/CIPC formulation combined with Carvone (store no. 9).
Although Carvone applications can control sprout growth during bulk store very efficient, as soon as the potatoes were removed from the Carvone containing stores, there will be in general a regrowth of the sprouts within a couple of weeks when the storage conditions allowed the tubers to sprout again.

3.2.1.2 Sprout suppression at unloading time

The start of sprout growth in the 15 ton air-cooled stores was mainly determined by the extent of sprouting of the potatoes stored in the upper part of the store. In principle, the potatoes were stored as long as possible. The moment that sprouting made continued storage no longer sensible, the potatoes were heated to a temperature of 18 - 20.5°C (in case of sprout growth) and transported. The first orientation on the sprout suppression effect of the agents applied is therefore determined by the moment of unloading the stores.
The average sprout suppression effects for each store or variant on the day of unloading the stores are presented in Tables 3.2.1.2 A and B. Some Carvone variants produced a better sprout suppression effect than IPC-CIPC liquid, which was dosed as directed.
Sprout suppression with only IPC/CIPC (store no.1) was insufficient, because the store had to be unloaded already in May.
Where Carvone was dosed, the best results were produced in stores No. 2 and 6, in which the highest dose rates of d- or l-Carvone were administered. Regular treatments with lower Carvone dosages showed poorer sprout suppression effects (stores no.3, 4, 7 and 8). The potatoes from store no.8 showed already in February a certain amount of sprouting, probably due to the somewhat higher storage temperature (mentioned in 3.1.1). An additional amount of 100 ml Carvone/1000 kg at that time was applied. Within one week the already existed sprouts became complete necrotic and could be decided to another storage period. When IPC/CIPC powder was combined with a regular low dose Carvone treatment (store no.9), this seemed to be the most efficient sprout suppression treatment. Combination of IPC/CIPC powder with a delayed treatment (when potatoes had sprouts of about 2mm) of few batches of high Carvone dosages (store no.10) had a good sprout suppressing effect as well.

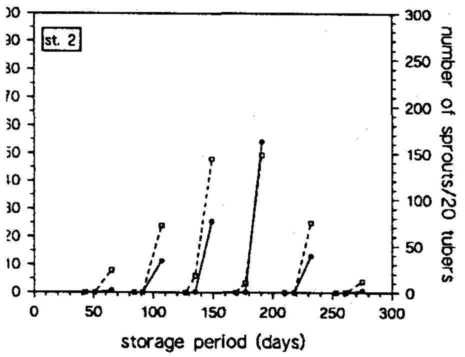
3.2.1.1

ce of sproutinhibitor treatments on sproutgrowth during storage and
an additional storage period of 1 or 3 weeks at 15°C. (1991/1992)

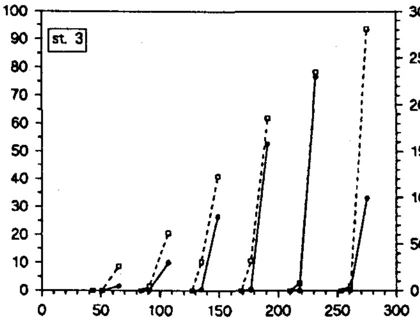


ipc/cipc: 3 x 22 ml (30%)

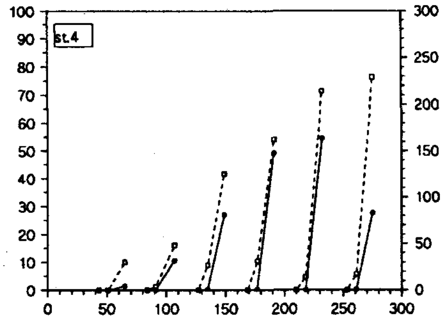
sproutweight
number of sprouts



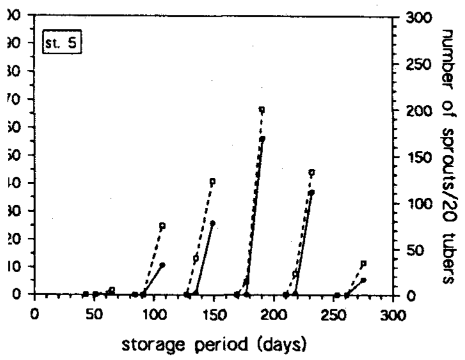
l-carvone: 3 x 50 ml + 3 x 100 ml/t/6 weeks



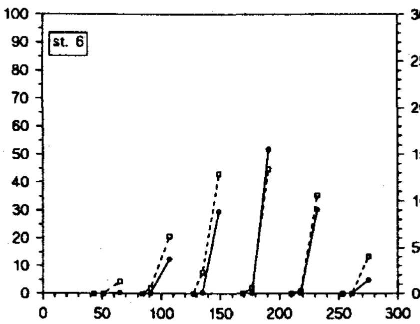
d-carvone: 12 ml/t/week



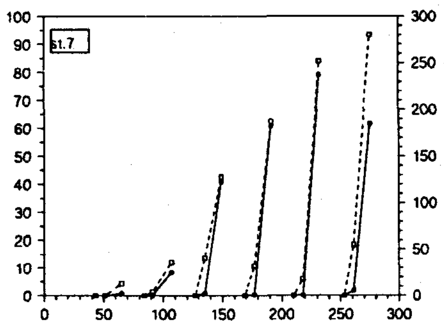
d-carvone: 8.5 ml/t/week



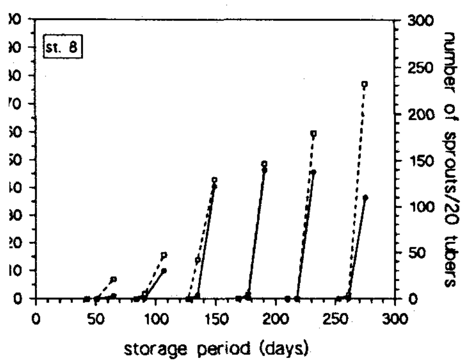
l-carvone: 4 x 100 ml/t/9 weeks



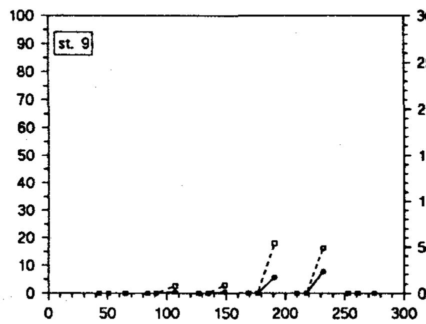
l-carvone: 3 x 50 ml + 3 x 100 ml/t/6 weeks



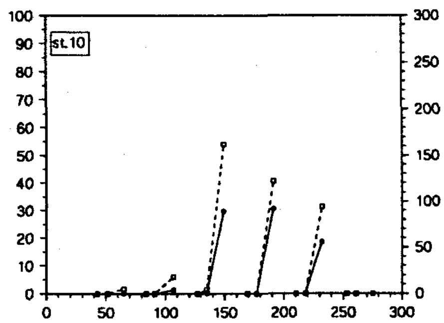
d-carvone: aut. ± 2 x 4 ml/t/week



l-carvone: aut.± 2 x 4 ml/t/ week



0.5 kg ipc/cipc powder (1%)/ t +
d-carvone: 8.5 ml/t/week



0.5 kg ipc/ccipc powder (1%) / t +
d-carvone: 2 x 50 ml + 1 x 100 ml/t/6weeks

Fig. 3.2.1.2

Influence of sprout inhibitor treatments on sprouting after unloading and an additional storage period of 1 or 3 weeks at 15°C. (cv. Bintje, season 1991/1992)

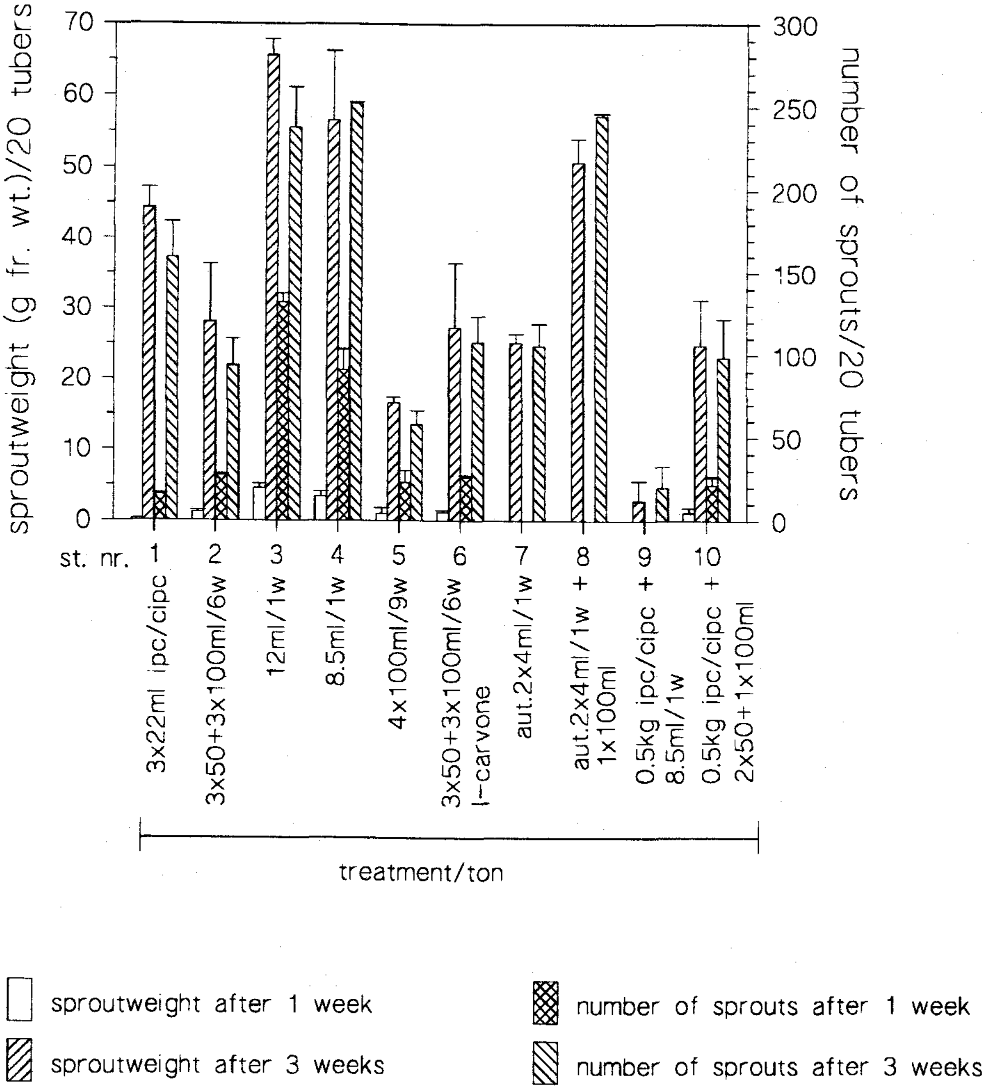


Table 3.2.1.2 A A survey of the storage periods and sprout suppression indications at unloading time (cv. Bintje, season 1991/1992).

Store nr.	Sprout inhibitor	number of applications	date of unloading	storage period (days)	Sprout suppressing indication	Scale 1 to 7
1	Gro Stop liquid (66 ml) **)	3	25 May	244	amply sufficient till good	5½
2	D-Carvone (450 ml)	6	16 June	266	amply sufficient till good	5½
3	D-Carvone (408 ml)	34	16 June	266	almost sufficient	3
4	D-Carvone (289 ml)	34	16 June	266	insufficient	2
5	D-Carvone (400 ml)	4	16 June	266	sufficient	4
6	L-Carvone (450 ml)	6	15 June	265	good	6
7	D-Carvone (277 ml)	59	10 June	260	bad	1
8	D-Carvone (399 ml)	59	10 June	260	insufficient	2
9	Gro Stop powder 0.55 kg D-Carvon (289 ml)	1 34	15 June	265	excellent	7
10	Gro Stop powder 0.54 kg D-Carvone (200 ml)	1 3	15 June	265	amply sufficient till good	5½

**) total dosage/1000 kg potatoes/season

Table 3.2.1.2 B A survey of the average sproutweight (fresh) at unloading time (cv. Bintje, season 1991/1992).

Store nr.	date of unloading	Sprout weight (g) per 10 kg potatoes	Sprout weight (g) per 100 tubers
1	25 May	12	18
2	16 June	24	36
3	16 June	47	66
4	16 June	100	144
5	16 June	35	47
6	15 June	10	15
7	10 June	235	357
8	10 June	163	256
9	15 June	0.3	0.5
10	15 June	11	15

After unloading, small tuber samples were stored in perforated plastic bags at 15°C, for an additional period of three weeks. After one week all samples were sprouted except from store no.9 (Fig. 3.2.1.2). There were no measurements from stores no.7 and 8 after one week. After three weeks all potato samples were sprouted with the smallest sprouts (± 3 cm) on potatoes originating from store 9 and the largest sprouts (till ± 13 cm) on potatoes from store no.8. Regrowth of sprouts after unloading was most suppressed by the combination of IPC/CIPC powder application with regular low dosages of Carvone (store no.9). The results of previous high Carvone application dosages (stores no.5, 2 and 6) showed however less sprout regrowth than the liquid IPC/CIPC treatment (store no.1).

Tuber defects

3.2.1.3 Skin damages and internal sprouting at unloading time

- Minor skin damages were determined when a combination of IPC/CIPC powder and Carvone was used. Potatoes from stores no. 9 and 10 showed also a small amount of cracks. The damages were caused by the IPC/CIPC powder treatment during loading, wich is a well known fact in practice ,because IPC and CIPC are mitose inhibitors and have an effect on wound healing and periderm formation.

- Internal sprouting was shown in the tubers from all stores (Table 3.2.1.3) at unloading time, probably due to the long storage period and far too high storage temperature at the end.
  The slightest amount of internal sprouting had the potatoes treated at the time of loading with a powder application of IPC/CIPC followed by Carvone treatments later on. Next best was the liquid application with IPC/CIPC (store no.1) but these potatoes were unloaded earlier when the storage temperature before heating up artificially, was about 10°C.
  All treatments with Carvone only suffered at unloading time from a too high percentage of internal sprouting. The storage conditions at the end were however very unfavourable, due to a quick rise in storage temperature (to 18°C, Fig. 3.1.1) and low Carvone concentrations in the headspace (Fig. 3.1.3). This resulted in a quick decrease of the Carvone residue of the potatoes in all stores (Fig. 3.2.2.1) and the possibility of sprout regrowth and internal sprouting.
  Also potatoes stored in practice in the Netherlands in 1991/1992 (and all treated with IPC/CIPC) showed a lot of internal sprouting at that time, because of exceptional temperature conditions.

Table 3.2.1.3 A survey of the amount of skin damages and internal sprouting at unloading time (cv. Bintje, season 1991/1992).

		Sprout inhibitor		Percentage of tubers with	
Sampling date	Store nr.		Total dosis/1000 kg	Internal sprouts	Skin damages
25 May	1	Gro Stop liquid	66 ml	3	0
16 June	2	D-Carvone	450 ml	11	0
16 June	3	D-Carvone	408 ml	14	0
16 June	4	D-Carvone	289 ml	8.5	0
16 June	5	D-Carvone	400 ml	9.5	0
15 June	6	L-Carvone	450 ml	11	0
10 June	7	D-Carvone	277 ml	12	0
10 June	8	D-Carvone	399 ml	13.5	0
15 June	9	Gro Stop powder + D-Carvone	0.55 kg + 289 ml	~~0.5~~	5
15 June	10	Gro Stop powder + D-Carvone	0.54 kg + 200 ml	2	2,5

3.2.1.4 Blackspot susceptibility at unloading time

The blackspot susceptibility at the time of unloading was lower (Fig. 3.2.1.4), when the sprout suppression effect was better, which was a well known phenomenon.

3.2.2 Sprout inhibitor residue contents

Carvone residue content during storage

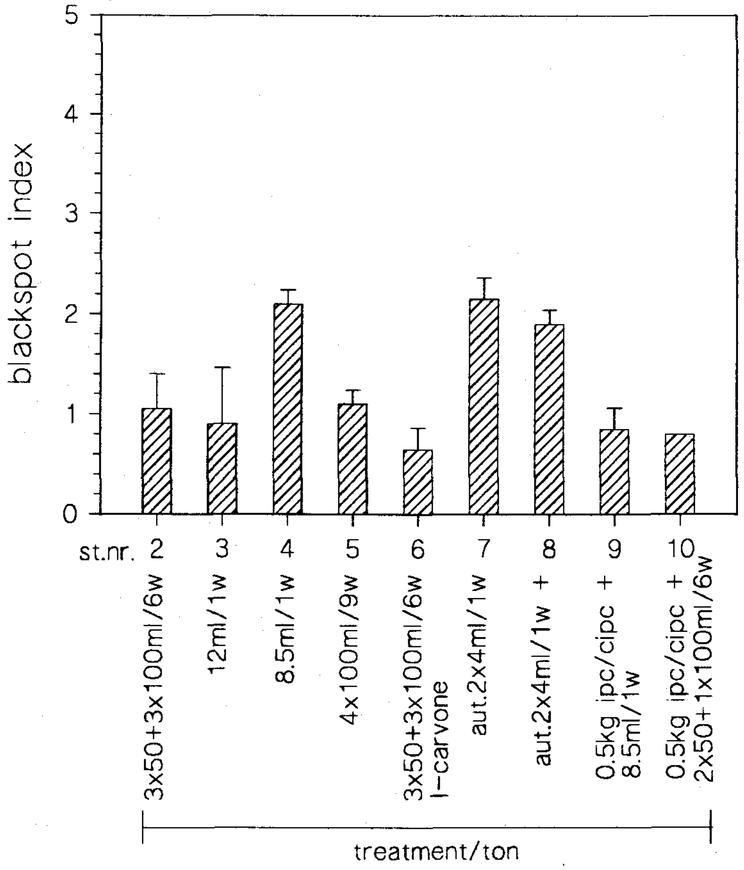
Samples from each Carvone treated store were analysed every 6 weeks during storage (Fig. 3.2.2.1 and Table 3.2.2.1 Appendix). The Carvone residue contents found, were more or less related to the dose rate applied although in general there was not much difference between the different treatments.
The lowest residue content existed in the constant automatically dosed store (store no.7).
Due to inefficient sprout inhibition, additional Carvone of 100 ml/t was applied at day 154, within the other automatically dosed store (store no.8). This provided for an increase in Carvone residue.
In all stores, there was an increase in Carvone residue during the storage season, followed by a substantial decrease to average values of ± 1 ppm, when the potatoes were heated and the stores unloaded. The increase was probably due to less ventilation half way the season and the decrease due to more ventilation at the end.
The Carvone residue concentration was also influenced by the time between application and sampling (Fig. 3.2.2.2 and Table 3.2.2.1 Appendix). Two stores applied every 6 weeks with equal amounts of d- or l-Carvone were sampled three or six weeks after application. Residue values three weeks after application were always higher then after six weeks. Most Carvone was found in the peelings (Fig. 3.2.2.3 A and B; Table 3.2.2.2 Appendix) and only a very small amount in the peeled tubers. Increase of the Carvone concentration during storage was mainly an increase of Carvone concentration in the peelings (Fig. 3.2.2.3 A and B; Fig. 3.2.2.4 A and B), probably due to absorption of most Carvone at the suberized potato periderm. This explains also the rather quick decrease in residue level at the end of the storage season.

IPC/CIPC and Carvone residue contents at unloading time

When the stores were unloaded IPC/CIPC and Carvone residues were measured from every store at three different stack heights and from an average subsample of the whole store (Fig. 3.2.2.5 and Table 3.2.2.1 Appendix). The d-Carvone residue's were in all cases lower than the IPC/CIPC residues and equal or smaller than ± 1.5 ppm. The d-Carvone residue content from store 6 was somewhat higher for unknown reasons.
Potatoes from the lowest stack heights had higher IPC/CIPC residue contents, than from the higher stack height. This could be expected while application took place as a fog application during ventilation from the bottom to the top of the stack.
Between different stack heights, there were also differences in Carvone concentration, however the differences in general were small (≥ 0.5 ppm) and without a clear trend. Although in six out of nine stores, the potatoes from the lowest stack height had also the highest Carvone residue content. It seems that Carvone being more volatile was more equal supplied over the whole store than IPC/CIPC.

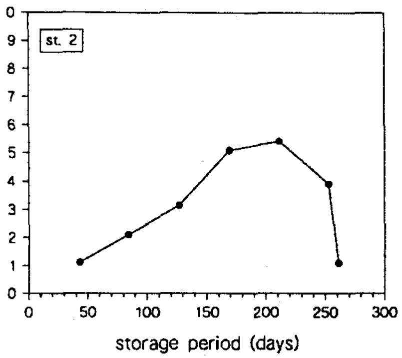
Fig. 3.2.1.4

Influence of sprout inhibitor treatments on the blackspot index at unloading time of 15 ton stores.
(cv. Bintje, season 1991/1992))

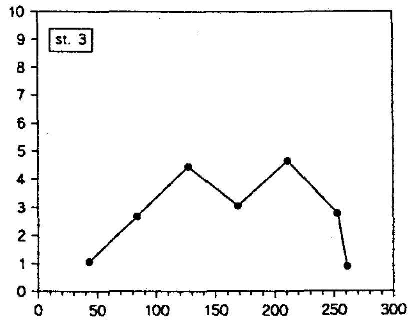


. 3.2.2.1

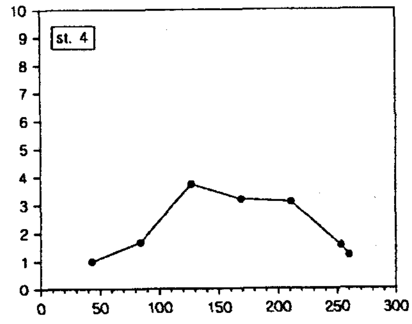
nce of different carvone treatments during
ge on the carvone residue of the potatoes.
: carv. appl. day 22)



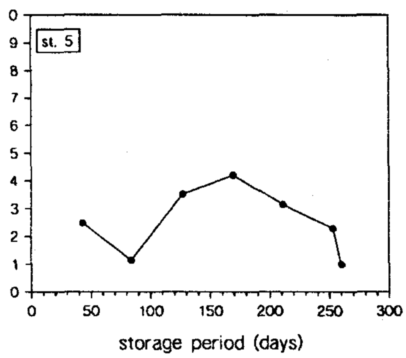
vone; 3 x 50 ml+ 3 x 100 ml/t/6 weeks



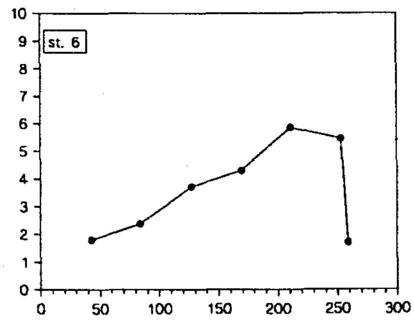
d-carvone; 12 ml/t/week



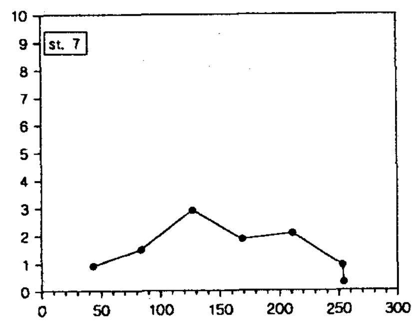
d-carvone; 8.5 ml/t/week



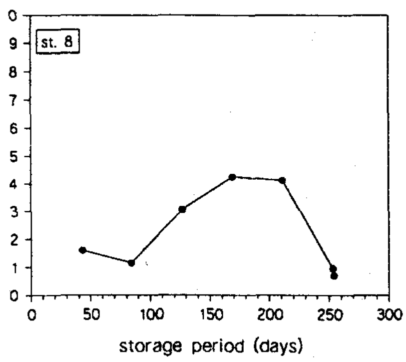
vone; 4 x 100 ml/t 9 weeks



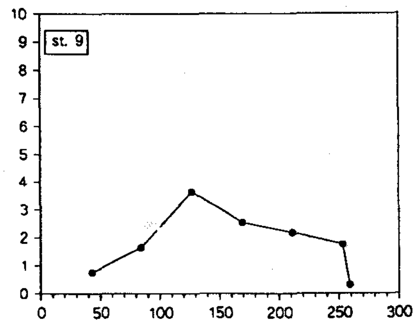
l-carvone; 3 x 50 ml + 3 x 100 ml /t/6 weeks



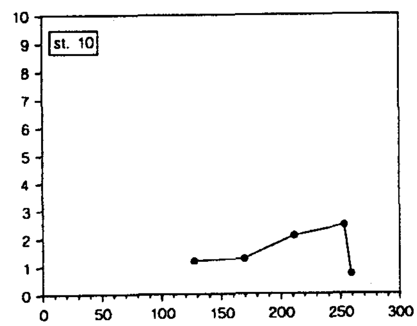
d-carvone; aut. ± 2 x 4 ml/t/week



; aut. ± 2 x 4 ml/t/week + 1 x 100 ml/t at d 154



0.5 kg ipc-cipc powder(1%)/t +
d-carvone; 8.5 ml/t/week



0.5 kg ipc-cipc powder(1%)/t +
d-carvone; 2 x 50 ml + 1 x 100 ml/t/6 weeks

Fig. 3.2.2.2

Influence of repeated d– or l–carvone applications in 15 ton stores on the residue level of whole potatoes 3 or 6 weeks after application.

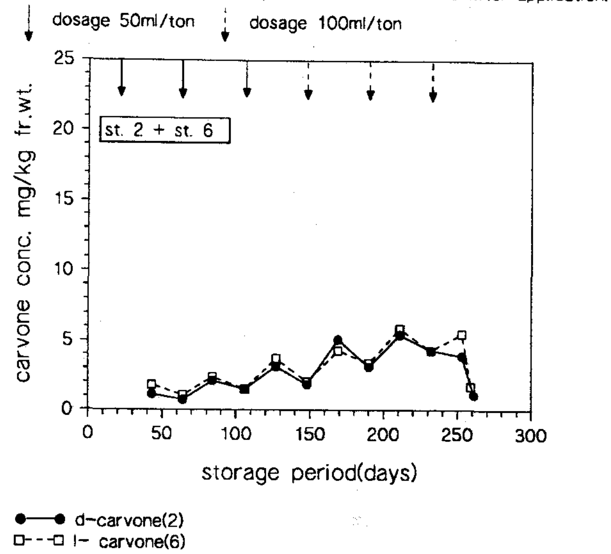


Fig. 3.2.2.3

Influence of carvone application on the carvone residue in whole tubers, peelings and peeled tubers 6 weeks after application.

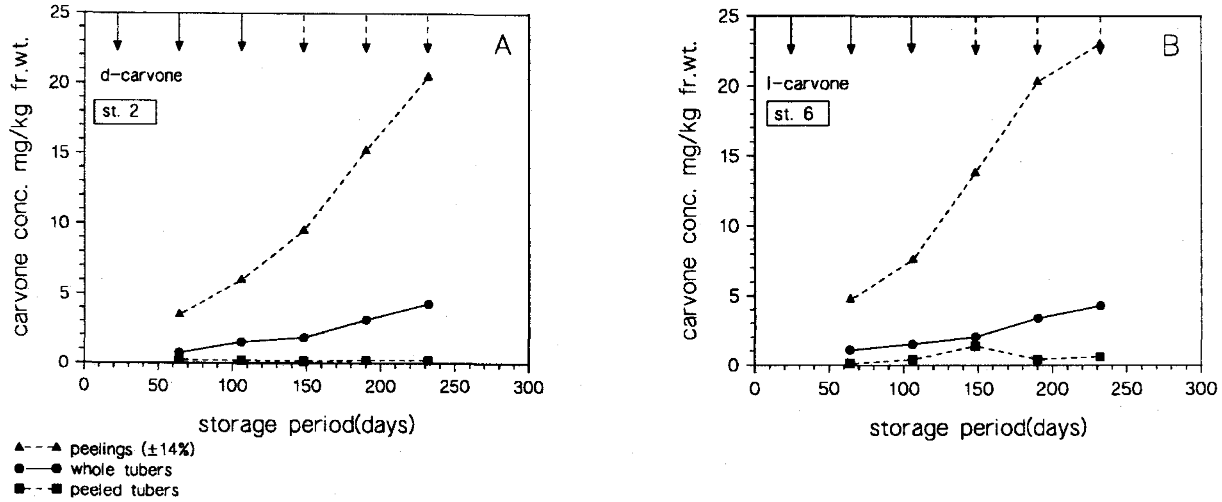


Fig. 3.2.2.4

Influence of carvone application on the % of carvone residue in peelings or peeled tubers, 6 weeks after application.

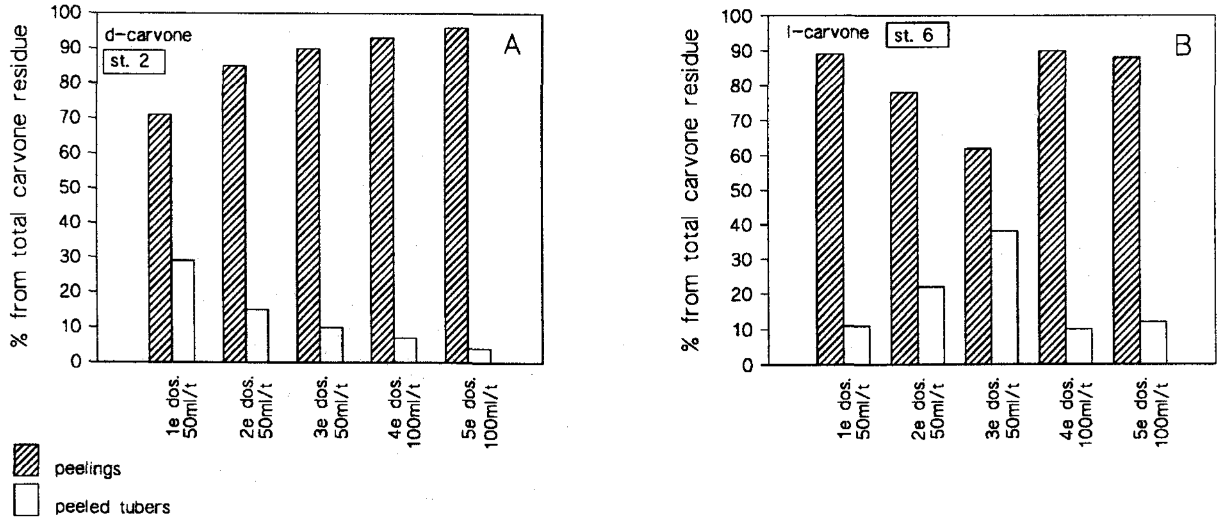
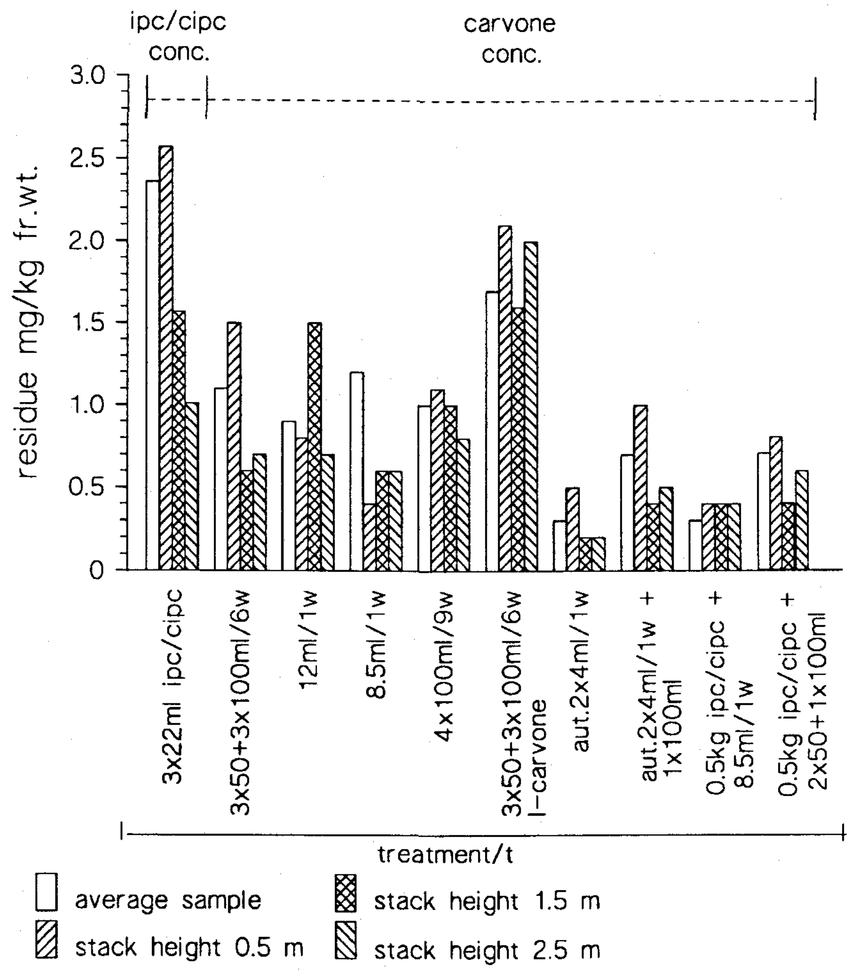


Fig. 3.2.2.5

Influence of different sprout inhibitor treatments on the residue content of potatoes of three stack heights at unloading time (unloading time between 244 and 266 days).



3.2.3 Sensory quality of steam cooked potatoes and French fries (chips).

Sensory evaluation of steam cooked potatoes

Off flavour

By 'off-flavour' is meant any 'unpotato-like' characteristic. Actually, unpotato-like characteristics - e.g. 'fishy' or 'metallic' - are not unknown occuring during storage; especially with Bintje cultivar. So IPC/CIPC treated as well as Carvone treated samples were assessed individually for off-flavour. Comparison of frequencies of off-flavour detection gives a good idea of positive or negative effects due to Carvone treatment.

No significant effect -neither positive nor negative - due to Carvone treatment were found concerning steam cooked potatoes (Bintje) during storage or at unloading time, summarized over all assessments (Fig. 3.2.2).
Occasionally the number of off-flavour responses for individual assessments reached the significant 50% detection level (Table 3.2.3.1). Especially at unloading time nearly all Carvone treated samples gave a relatively high number of off-flavour responses, of which 2 were significant. A reason could be found in the phenomenon of about 20 days longer storage period of the Carvone treated potatoes, with quickly rising temperatures up till 18°C (Fig. 3.1.1). These high temperatures can undoubtedly influence the flavour quality negatively.
On the otherhand IPC/CIPC treated potatoes were unloaded earlier and kept at 6°C. Because of the used paired comparison method for quality evaluation both treatments were needed at the same time.

Flavour quality

Because Carvone treatment could have a positive as well as a negative effect on flavour quality of potatoes, the ordinal paired comparison method (IPC/CIPC >< Carvone treated) was used for quality evaluation.
Although Carvone has a very specific flavour of its own, the panelists very seldom labelled an off-flavour as 'Carvone-like'.
Actually penalists did not label the off-flavour responses of Carvone treated samples otherwise than those of the IPC/CIPC treated samples. Nevertheless, there still may be positive and/or negative effects.
As Table 3.2.3.2. shows, for ± 16% of the pairs was found a significant difference in flavour quality in favour of the IPC/CIPC treated sample. However 10% of those differences came from the assessments at unloading time with the unfavourable storage conditions of Carvone treated potatoes mentioned before.
The remaining significant different pairs match approximately the pairs in favour of the Carvone treated sample.

In general the conclusion can be made that no significant positive or negative effects of Carvone treatment on flavour quality of steam cooked potatoes were found. With the exception of Carvone treated samples at unloading time the significant different pairs were scattered over treatments, favourable for IPC/CIPC as well as Carvone treated samples. This can be due to the original within sample variation.

By checking the differences between per mutations (A-B/B-A) and the order number of the pair

presented, a slight impression exists that there was a tendency that Carvone treated potatoes have a slightly less outspoken flavour. However this could never be proved within the used method, being a 'difference' method.
Such effects could only be found by applying Quantitative Descriptive Analysis.

Sensory quality of French fries (chips)

Sensory quality for chips of samples of potatoes from all stores was tested during storage 4 times at regular intervals and at unloading time. In all cases there was no effect of Carvone neither on off-flavour nor on flavour of the chips.

Fig. 3.2.3

% number of off-flavour responses for ipc/cipc and carvone treated samples, summarized over all presentations during storage.

significance: 50% detection level

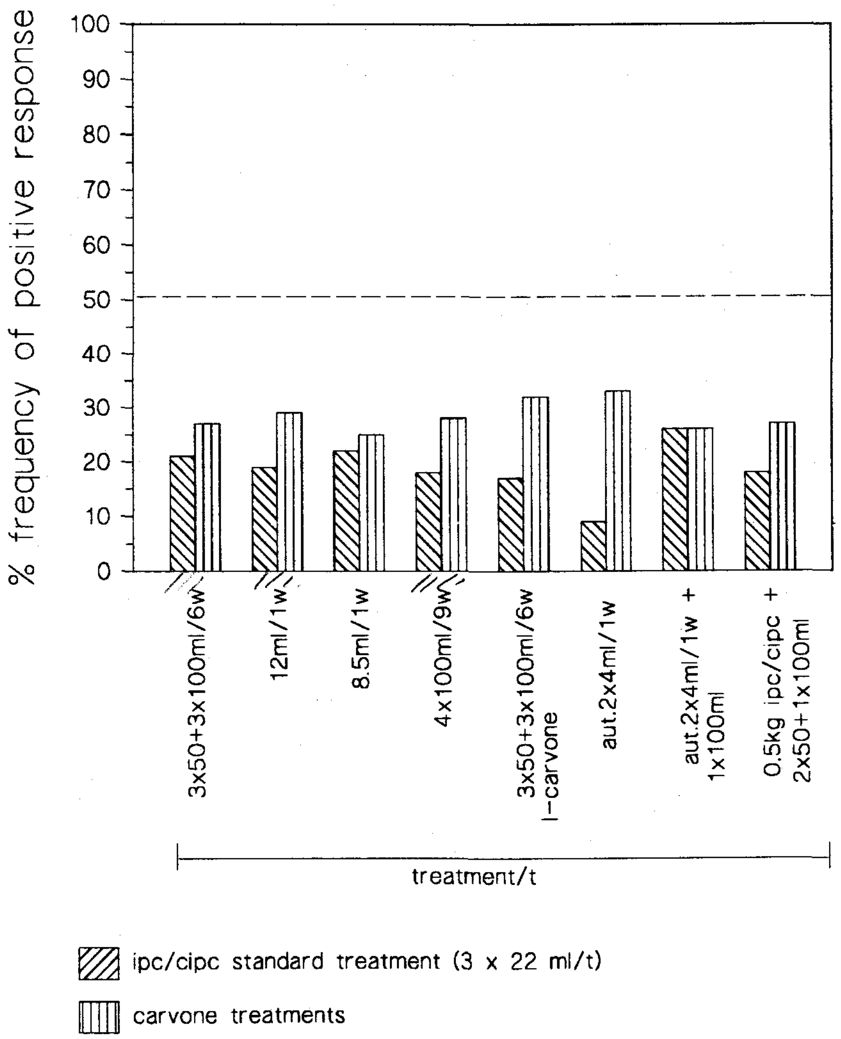


Table 3.2.3.1: Number of assessments, total responses and off-flavour responses of IPC/CIPC and Carvone treated potatoes, summarized over the storage period (cv. Bintje, season 1991/1992).

Store nr.	2		3		4		5		6		7		8		9	
Treatment/1000kg	D-Carvone 3 x 50 + 3 x 100 ml/6w		D-Carvone 12ml/w		D-Carvone 8,5 ml/w		D-Carvone 4 x 100 ml/9w		L-Carvone 3 x 50 + 3 x 100 ml/6w		D-Carvone Aut. ± 2 x 4 ml/w		D-Carvone aut. ± 2 x 4 ml/w + 1 x 100 ml		IPC/CIPC + d-Carvone 0,5 kg (1%) + 8,5 ml/w	
Total number of assesments during storage	12		6		6		6		12		6		6		6	
Total number of responses during storage	192		96		96		96		192		96		96		96	
*	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C
% off-flavour responses	21	27	27 ?	19 ?	22	25	18	28	17	32	9	33	26	26	18	27
Number of assessments with high off-flavour responses	-	1	-	1	-	-	-	1	-	2	-	1	-	-	-	-

Significance: 50% detection level.

Table 3.2.3.2 Number of pairs (IPC/CIPC and Carvone treated) with significant differences in flavour quality of steam cooked potatoes during storage (cv. Bintje, season 1991/1992)

Store nr.	2		3		4		5		6		7		8		9			
Treatment /1000kg	D-Carvone 3 x 50 + 3 x 100 ml/6 w		D-Carvone 12 ml/w		D-Carvone 8,5 ml/w		D-Carvone 4 x 100 ml/9 w		L-Carvone 3 x 50 + 3 x 100 ml/6 w		D-Carvone aut. ± 2 x 4 ml/w		D-Carvone aut. ± 2 x 4 ml/w 1 x 100 ml		IPC/CIPC + D-Carvone 0,5 kg (1%) + 8,5 ml/w		Total	
Total number of assessed pairs during storage	12		6		6		6		12		6		6		6		60	
	Number of sign. different pairs (p≤ 0.05)																	
	R > C	C > R	R > C	C > R	R > C	C > R	R > C	C > R	R > C	C > R	R > C	C > R	R > C	C > R	R > C	C > R	R > C	C > R
More potatoflavour	1	-	1	1	1	-	-	-	1	-	-	-	-	-	-	-	4	1
Purer flavour	1	-	1	1	1	-	-	-	2	-	-	-	-	-	-	-	6	1
																Total	10	2
																%	16.5	3.5

* R = reference (IPC/CIPC treatment)
C = Carvone treatment

3.2.4 Processing quality

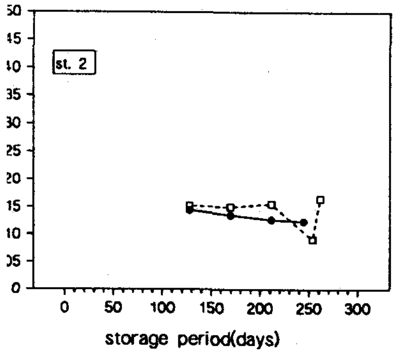
During the storage season the potatoes treated with Carvone, Carvone and IPC/CIPC and IPC/CIPC treated potatoes had comparable reducing sugar contents (Fig. 3.2.4.1) and chips frying colour (Fig. 3.2.4.2).
The Carvone treated tubers were stored about 10 to 15 days longer than the IPC/CIPC treated. There was a sudden substantial increase in reducing sugar content and therfore also in fry colour during this short period. This was however caused by the high storage temperature (up to 18°C) during this period and not by the Carvone treatment.

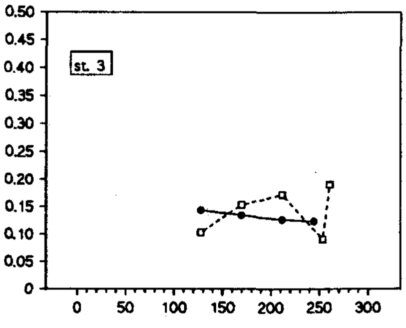
3.2.5. Total Glycoalkaloid content

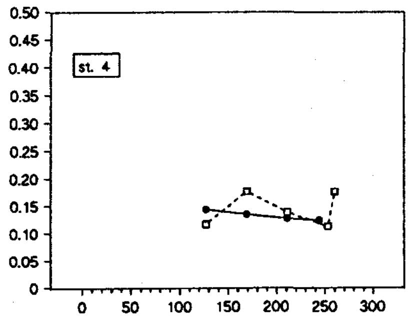
Although whole unpeeled potatoes were analysed and most glycoalkaloids are located in the parenchym tissue just underneath the skin, the glycoalkaloid contents were low. The total glycoalkaloid contents during storage of the Carvone treated potatoes, were comparable with the IPC/CIPC treated potatoes (Fig. 3.2.5).

3.2.4.1

on between the influence of IPC/CIPC and different CARVONE
ts during storage on the reducing sugar content of potatoes.



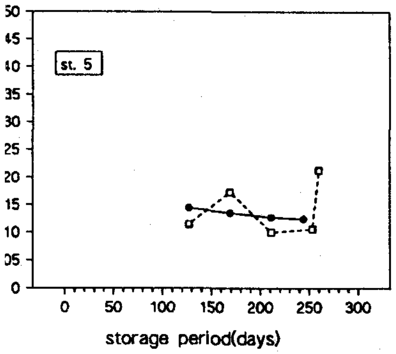


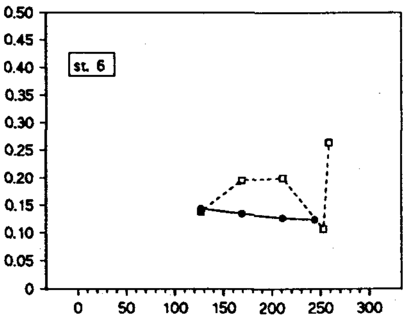


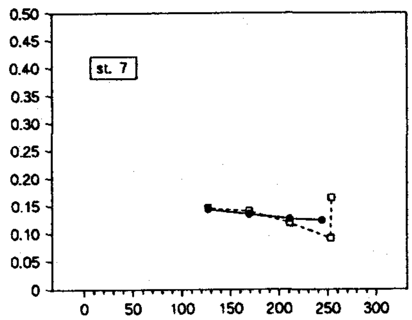
st. 1(ipc/cipc; 3 x 22 ml/t)
st. 2(d-carvone; 3 x 50 ml + 3 x 100 ml/t/6 weeks)

□--□ st. 3 (d-carvone; 12 ml/t/week)

□--□ st.4(d-carvone; 8.5 ml/t/week)



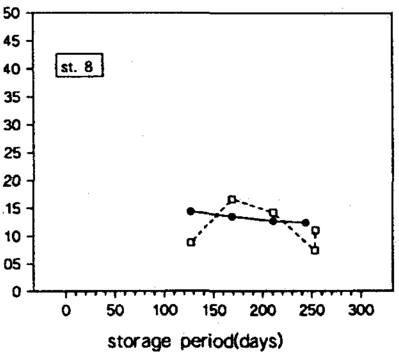


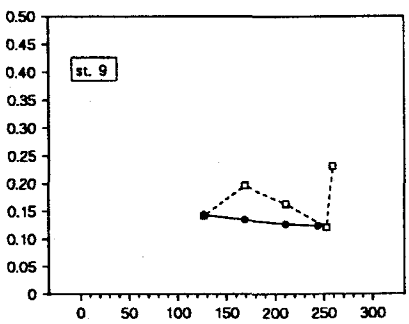


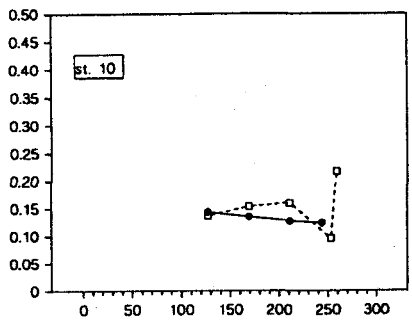
. 5(d-carvone; 4 x 100 ml/t/9 weeks)

□--□ st. 6()-carvone; 3 x 50 ml + 3 x 100 ml/t/6 weeks)

□--□ st.7(d-carvone; aut. ± 2 x 4 ml/t/week







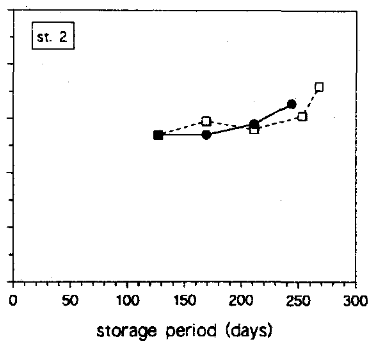
st. 8(d-carvone; aut. ± 2 x 4 ml/t/week +
1 x 100 ml/t at day 154)

□--□ st.9(0.5 kg ipc/cipc powder(1%)/t +
d-carvone; 8.5 ml/t/week)

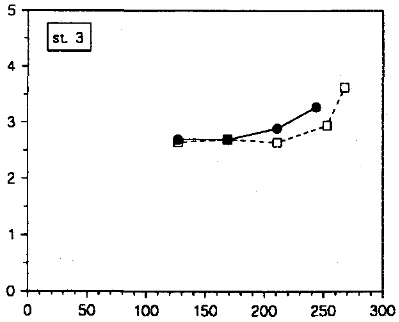
□--□ st.10(0.5 kg ipc/cipc powder(1%)/t +
d-carvone; 2 x 50 ml + 1 x 100 ml/t/6 weeks)

3.2.4.2

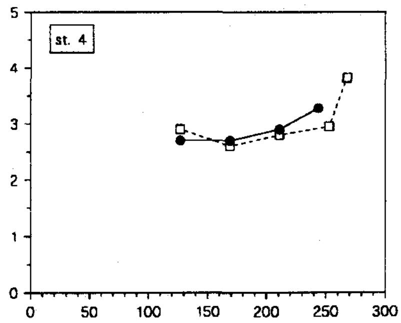
n between the influence of IPC/CIPC and different CARVONE
; during storage on the fry colour index of potatoes.



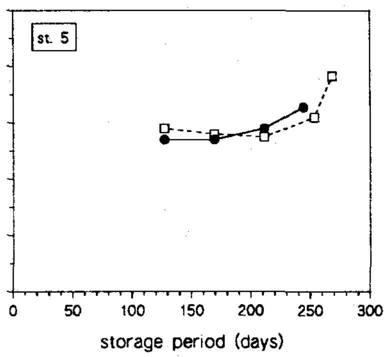
● st. 1(ipc/cipc; 3 x 22 ml/t)
□ st. 2(d-carvone; 3 x 50 ml + 3 x 100 ml/t/6 weeks)



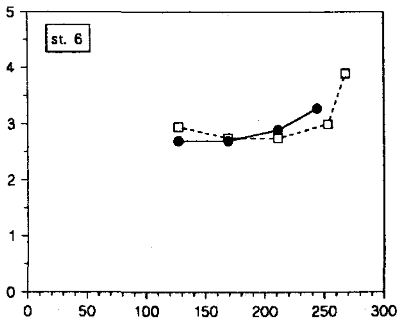
□- - -□ st. 3(d-carvone; 12 ml/t/week)



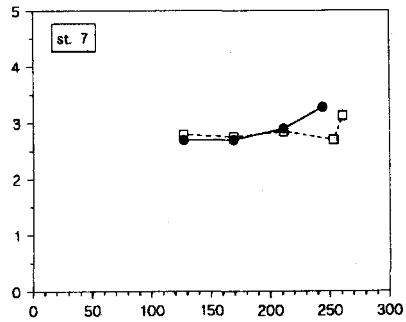
□- - -□ st. 4(d-carvone; 8.5 ml/t/week)



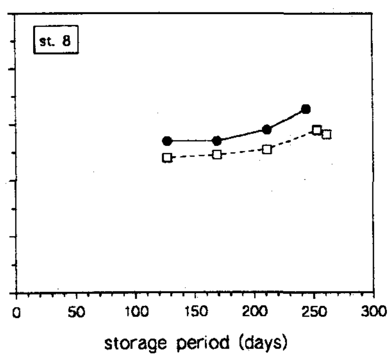
t. 5(d-carvone; 4 x 100 ml/t/9 weeks)



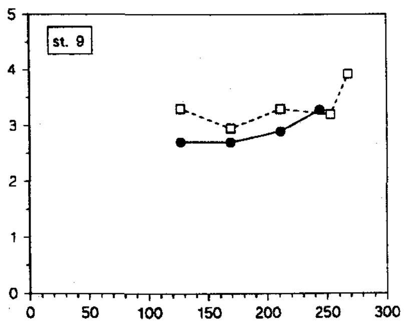
□- - -□ st. 6(l-carvone; 3 x 50 + 3 x 100 ml/t/6 weeks)



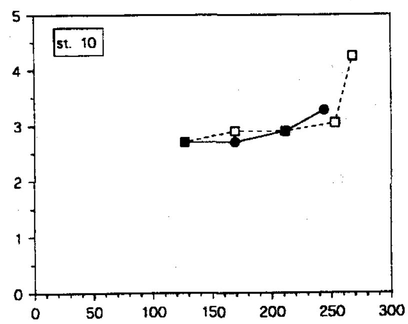
□- - -□ st. 7(d-carvone; aut. ± 2 x 4 ml/t/week)



□ st. 8(d-carvone; aut. ± 2 x 4 ml/t/week +
1 x 100 ml/t at day 154)



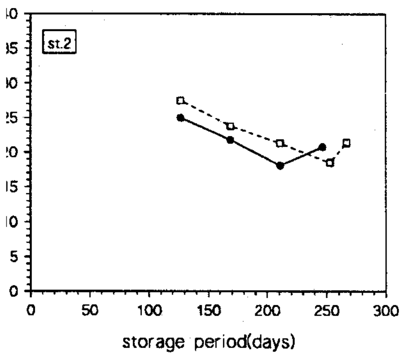
□- - -□ st. 9(0.5 kg ipc/cipc powder(1%)/t +
d-carvone; 8.5 ml/t/week)



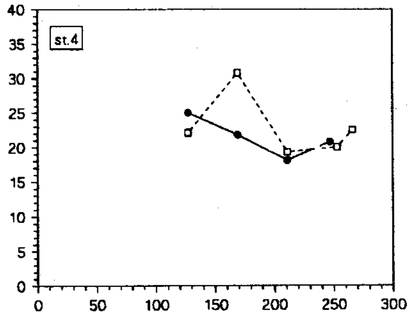
□- - -□ st. 10(0.5 kg ipc/cipc powder(1%)/t +
d-carvone; 2 x 50 ml + 1 x 100 ml/t/6 weeks)

g. 3.2.5

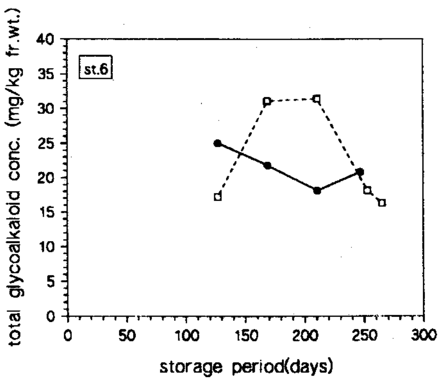
arison between the influence of IPC/CIPC or different CARVONE
ents during storage on the total glycoalkaloid content of potatoes.



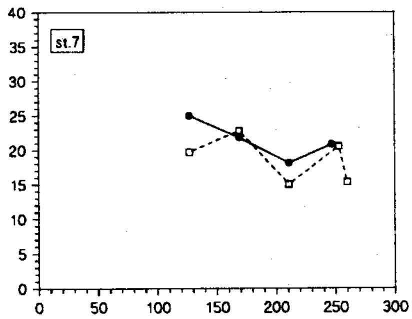
st. 1(ipc/cipc; 3 x 22 ml/t)
st. 2(d-carvone; 3 x 50 ml + 3 x 100 ml/t/6 weeks)



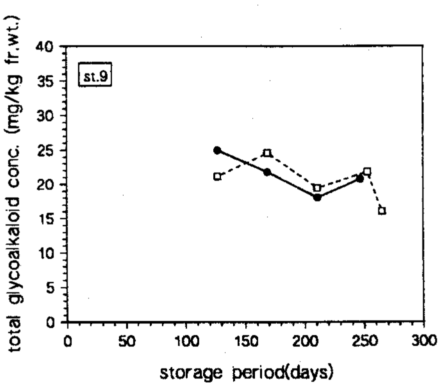
st. 1(ipc/cipc; 3 x 22 ml/t)
st. 4(d-carvone; 8.5 ml/t/week)



st. 1(ipc/cipc; 3 x 22 ml/t)
st. 2(l-carvone; 3 x 50 ml + 3 x 100 ml/t/6 weeks)



st. 1(ipc/cipc; 3 x 22 ml/t)
st. 7(d-carvone; aut. ± 2 x 4 ml/t/week)



st. 1(ipc/cipc; 3 x 22 ml/t)
st. 9(0.5 kg ipc/cipc powder(1%)/t +
d-carvone; 8.5 ml/t/week)

4. SUMMARY AND GENERAL CONCLUSIONS

In the storage season of 1991/1992, practical research was conducted into the sprout suppression effect of Carvone. Also Carvone application technologies were tested. The research was carried out in 10, 15 ton air-cooled stores on the ATO experimental farm 'de Eest' in Nagele. The ventilation system of these stores was computer-controlled; the storage temperature required was 5 - 7°C. The research was carried out on the Bintje potato cultivar which was grown on 'de Eest'.
Table 4.1 gives a survey of the applied agents, the dose rates and the various dosing times.

During the research period, the following items were dealt with:

<u>Storage</u>

- storage conditions;
- Carvone content in the storage atmosphere.

<u>Quality aspects</u>

- sprout suppression;
- tuber defects;
- residue content;
- sensorial characteristics;
- processing quality;
- glycoalkaloid content.

The results of the research can be represented in the following way:

<u>Storage</u>
- Storage conditions;
  * From some weeks after the curing peiod to about the mid of May, the average storage temperature lay well within the range of 5 - 7°C.
  * The average number of hours of external ventilation for the Bintje potatoes that were treated with Carvone and stored for a long time was ± 250. The highest number of ventilation hours lay at the beginning and at the end of the storage period.
- Carvone content in the storage atmosphere;
  * The concentration of Carvone in the storage atmosphere depended on the different dose rates of Carvone applied: as a result of external ventilation, this concentration strongly decreased after dosing.

  In periods of lower ventilation, the Carvone concentrations in the storage atmosphere increased.

<u>Quality aspects</u>
- Sprout suppression
  * Carvone applied in higher dose rates per 6 weeks on bulk-stored potatoes, produced a sprout inhibiting effect better than that of IPC-CIPC liquid dosed as directed.
  * A combined application of IPC/CIPC powder during loading, with Carvone applied later on showed the best sprout suppression effect.
  * Although Carvone applications can control sprout growth during bulk store very efficient, as soon as the potatoes were removed from the Carvone containing stores there will be in general a regrowth of sprouts within a couple of weeks when the storage temperature is favourable for sprout growth.

- Tuber defects
  * Minor skin damages were determined when a combination of IPC/CIPC powder with Carvone was used.
  * Internal sprouting especially occurred in the potatoes that were unloaded in June (when high storage temperatures existed) and had been treated with Carvone solely. At the same moment the combined IPC/CIPC and Carvone treatment showed little internal sprouting.
  * There was a negative relation between the blackspot susceptibility and sprout suppression.
- Residue content
  * The Carvone residue content was positively influenced by the dose rate and negatively by the number of external ventilation hours in a certain period (more hours-less Carvone). During storage there was an increase in Carvone residue.
    The Carvone residue values measured 3 weeks after dosing were max. 5 to 6 ppm during the storage period. When the stores were heated, ventilated and unloaded, the Carvone content of the tubers was low to very low (≤ 1.7 ppm) and comparable with the IPC/CIPC content.
    Most Carvone was located in the peelings (± 80-90%).
- Sensorial characteristics
  * During storage and when unloading the stores, the Carvone treatment had neither a positive nor a negative effect of significance on the sensorial off-flavour and flavour characteristics of steam cooked potatoes.
  * Both during the storage season and when unloading the stores, the use of Carvone did not give rise to any deviations in the smell and taste of fried chips that were specifically related to the Carvone treatment.
- Processing quality
  * During storage and when unloading the stores, the potatoes treated solely with Carvone yielded a reducing sugar content comparable to that of potatoes treated with IPC/CIPC.
  * During the storage season and when unloading the stores, the potatoes treated with Carvone yielded a frying colour comparable to that of potatoes treated with IPC/CIPC.
- Glycoalkaloid content
  * The use of Carvone did not influence the glycoalkaloid content of the potatoes during storage.

Final conclusion

D-Carvone, which was derived from the essential oil of Caraway seed, as well as L-carvone which was a synthetical product, properly inhibited sprout growth of Bintje potatoes that were stored on a semi-practical scale (15 tonnes stores) for a long period, preserving the quality of both fresh potatoes and processed ones. In these experiments the highest dose rates of Carvone administered at larger intervals turned out to be the optimum quantities. Even better sprout suppression results were obtained when IPC/CIPC powder was used as a starting treatment combined with a Carvone treatment later on.

Table 4.1

ATO-DLO/LUXAN RESEARCH "DE EEST" 1991/1992

STORE NR.	SPROUT INHIBITOR TREATMENTS/TON POTATOES	
1	IPC/CIPC	3 X 22 ML
2	D-CARVONE	3 X 50 +3 X 100 ML/6W
3	D-CARVONE	12 ML/1W
4	D-CARVONE	8.5 ML/1W
5	D-CARVONE	100 ML/9W
6	L-CARVONE	3 X 50 + X 100 ML/6W
7	D-CARVONE	4 ML/AUT. DOSAGE
8	D-CARVONE	4 ML/AUT. DOSAGE + 1 X 100 ML
9	IPC/CIPC + D-CARVONE	0.5 KG(1%) + 8.5 ML/1W
10	IPC/CIPC + D-CARVONE	0.5 KG(1%) + 2 X 50 + 1 X 100 ML/6W

5. ACKNOWLEDGEMENTS

We thank the ATO-DLO co-workers K. Groenewoud and J. Sinke for carrying out the storage experiments at the experimental farm "de Eest", Sara Hertog and Janny Slotboom for the chemical analysis, Riek de Gooijer and Dinie Slotboom for measuring the processing quality, Ria van de Vuurst de Vries for measuring the sensoric quality, Truke Ebbenhorst-Seller for the sugar analysis and the BV-Luxan co-workers dr.ir. P. Diepenhorst and J.M. Lenssen for their valuable discussions and comments.

6. APPENDIX

The appendix contains the tables

Table 3.1.3
Table 3.2.2.1
Table 3.2.2.2

Table 3.1.3

ATO-DLO/LUXAN Research "DE EEST" Storage-season 1991-1992

Influence of different carvone applications on the carvone conc. of the storage atmosphere. Exp.stores 2 untill 10 "de Eest" '91-92

Airsamples

Beginning storage season 24-9-91

Carvone conc. ug/L air

store no / storage period days	2	3	4	5	6	7	8	9	10
22	*27.1	*10.1	*8.8	*51.2	*98.8			*14.4	
24		8.2	5.6			3.0	17.3	7.7	
27		0.3	0.3			2.7	1.5	0.2	
28						15.0	4.1		
29	2.1	0.7	0.7	5.3	4.2	4.7	4.4	0.6	
29		*15.9	*16.0					*10.7	
31		3.3	5.7			3.3	5.6	3.8	
34						4.8	8.0		
36	1.7	2.1	1.7	4.6	2.0	7.4	6.4	1.94	0.2
36		*17.4	*16.9					*19.3	
37						8.6	5.9		
38		7.2	6.5			6.2	9.6	6.0	
41			2.5			2.5	7.1	1.4	
42						5.0	8.7		
43	1.0	1.9	1.2	1.5	1.0	4.4	7.6	1.1	
43		*15.7	*13.2					*8.4	
44						6.8	4.4		
45		6.0	7.0			4.3	6.4	2.4	
48		2.2	2.2			2.4	5.9	1.8	
49						4.8	3.2		
50	0.9	2.0	3.1	2.4	1.0	2.8	7.3	1.5	0.1
50		*20.9	*22.2					*14.2	
51						4.8	7.7		
52		6.3	8.0			4.0	7.1	6.6	
55		3.7	3.7			4.2	6.2	3.5	
56						6.8			
57	0.8	4.9	4.9	1.6	6.4	4.9	6.2	1.3	
57		*33.5	*18.2					*13.1	

* carvone dosage time

Carvone conc. ug/L air

store no storage period days	2	3	4	5	6	7	8	9	10
58						3.6	5.7		
59		13.0	9.4			4.0	5.8	9.2	
62		3.3	4.7			7.9	7.0	2.1	
63						4.8	6.7		
64	0.7	4.4	4.1	1.6	1.2	11.1	6.5	3.2	
64	*48.9	*25.5	*19.5		*73.9			*16.8	
65						9.5	5.8		
66		5.4	8.7			7.2	6.4	6.8	
69		5.7	3.6			3.7	5.6	4.7	
70						4.0	6.8		
71	7.6	6.3	4.5	1.0	12.3	4.1	8.7	4.5	
71		*36.7	*4.4					*22.1	
72									
73									
76		4.8	5.3			7.9	4.9	4.4	
77						9.0	4.5		
78	4.5	5.5	4.8	0.8	5.0	6.2	3.9	3.8	0.6
78		*25.0	*29.2					*23.7	
79						8.6	5.0		
80		14.7				6.7	3.8	9.2	
83		7.4	6.4			4.9	3.1	5.2	
84	3.8	8.0	4.9	3.2	3.3	4.4	2.6	2.6	0.7
84		*28.8	*24.0	*84.4				*16.9	
85						4.7	3.5		
86						5.4	3.0		
87		3.7	9.4			5.9	4.4	7.9	
90		8.2	8.0			7.2	6.8	7.2	
91	3.6	8.3	3.4	31.5	4.1	15.4	7.7	4.4	1.8
91		*26.4	*21.1					*24.7	
94		17.3	9.2			11.3	9.9	12.0	
100		5.6	4.5			5.6	9.4	4.0	
100		*28.9	*27.0					*21.7	
101						4.6	3.5		
105		4.4	3.0			8.0	7.5	3.2	
106	0.5	4.0	3.1	5.5	1.0	6.7	4.1	4.6	
106	*44.0	*15.3	*14.8		*55.0			*8.9	
107						11.0	8.5		
108		10.1	9.7			6.1	4.5	12.5	
111		6.7	3.6			9.2	7.7		
112						5.8	3.6		
113	15.4	5.1	3.7	6.6	18.6	6.2	3.6	7.3	1.0

* carvone dosage time

Carvone conc. ug/L air

storage period days	2	3	4	5	6	7	8	9	10
114						5.9	4.6		
115		10.9	8.0			6.1	4.3	14.8	
118		4.8	3.8				2.7	4.2	
120	5.9	5.2	4.2	3.5	6.0	6.1	3.3	3.3	0.4
120		*18.1	*13.5					*16.7	
122		10.0	9.7			5.4	2.1	11.3	
125		11.8	9.3			4.4	1.4	8.5	
127	3.7	9.6	8.5	5.2	9.6	6.8	2.6	7.0	
127		*21.1	*18.0					*24.4	
129		20.7	15.8			5.6	3.4	16.4	
132		13.4	11.3			8.9	3.9	10.8	
134	4.6	5.8	6.5	3.7	4.2	4.6	1.6	7.4	0.5
134		*8.6	*10.1					*9.5	
136		19.0	13.7			6.0	3.2	15.0	
139		10.9	6.7			6.6	3.0	7.2	
141	5.2	9.7	6.8	5.4	6.3	6.7	3.9	8.0	
141		*24.6	*27.1					*32.0	
143		16.8	10.4			8.2	4.1	12.0	
146		9.5	5.3			3.6	3.9	4.6	
148	3.4	9.4	6.8	3.5	3.6	6.0	4.6	8.1	
148	*71.5	*24.9	*29.1	*70.4	*78.3			*26.0	*30.5
150		21.1	15.7			4.8	2.4	14.0	
153		6.7	5.7			6.2	1.4	7.1	
154							3.1		
154							*54.2		
155	17.6	9.9	9.9	18.8	24.0	11.7	44.2	7.3	8.9
155		*20.6	*25.5					*25.2	
157		16.6	12.1				31.2	12.7	
160		9.9	8.2			8.3	24.4	11.9	
162	17.8	11.4	7.8	15.6	19.0	7.9		8.9	8.2
162		*21.7	*30.6				38.1		
164		16.7	10.4			10.5	27.2	17.1	
167		6.5	4.3			5.8	13.5	5.2	
169	6.0	1.5	1.2	3.9	5.2	2.8	13.4	1.6	2.0

* carvone dosage time

Carvone conc. ug/L air

storage period days \ store no	2	3	4	5	6	7	8	9	10
169		*13.6	*25.7					*12.5	
171		16.9	13.0			7.8	19.0	8.6	
174		10.6	11.4			5.4	9.6	5.5	
176	6.5	6.8	7.3	8.1	9.4	9.3	18.3	7.2	2.7
176		*22.6	*26.9					*25.2	
178		12.8	12.2			9.9	18.3	14.2	
181		4.3	3.1			9.9	11.8	3.2	
183	4.7	5.5	4.9	5.2	5.3	10.6	22.9	3.7	3.7
183		836.4	*40.3					*42.6	
185		21.2	16.6			9.3	15.2	15.1	
188		14.6	12.4			9.1	12.9	10.5	
190		8.0	6.7	4.8	7.3	6.6	11.9	2.0	0.9
190	*64.9	*29.4	*24.3					*20.6	*60.5
192		8.9	7.7		6.4	6.3	12.2	8.7	
192					*85.3				
195		7.7	7.1			10.5	14.6	9.6	
197	9.9	5.9	4.3	3.6	16.3	10.2	16.0	3.5	5.5
197		*28.8	*23.2					*25.8	
199		17.0	10.1			12.9	13.3		
202		15.6	11.0			9.1	15.8	11.3	
204	10.1	11.6	8.2	5.7	19.9	5.8	11.0	8.1	3.9
204		*18.1	*16.3					*21.3	
206		16.1	20.3						
210	3.5	1.4	0.9	1.0	6.2	7.5	13.0	1.1	1.4
210		*18.3	*14.5	*80.8				*11.8	
213		11.7	11.0			8.0	14.9	11.4	
216		8.9	7.8			5.7	9.5	7.6	
218	11.3	12.9	8.0	34.2	12.5	9.5	8.6		3.9
218		*21.7	*26.5					*36.3	
225		6.2	6.9	14.8	4.1	5.0	9.7	2.0	4.0
225		*15.6	*19.5					*13.0	
227		7.7	7.6			4.9	11.7	10.0	
230		4.4	2.0			4.2	14.1	8.0	
232	6.0	5.0		12.1	6.6	2.5	9.1		1.0

* carvone dosage time

Carvone conc. ug/L air

store no / storage period days	2	3	4	5	6	7	8	9	10
232		*34.2	*25.9		*67.3			*23.7	*100.8
234		10.5	9.2			2.7	13.4	6.4	
237		8.4	7.0			6.7	19.2	7.8	
239	39.0	13.9	12.5	15.3	35.0	10.8	10.8	10.6	23.7
239		*17.3	*17.2					*42.7	
244		13.8	6.7			2.8	5.0	7.2	
246	33.3	18.1	8.1	13.3	40.2	12.8	11.0	11.1	20.0
246		*20.6	*25.9					*42.5	
251		11.2	8.5			12.7	11.7	11.4	
253	6.9	10.9	1.9	9.9	9.1	21.2	21.3	4.8	4.2
253		*27.5	*15.2					*25.6	
255		17.9	5.1				34.8	12.5	
260	10.3	3.2	1.7	4.5	9.4	1.1	2.6	3.9	4.1
265				3.1	4.5			1.4	2.8
				2.2	4.3			1.5	
266	7.4	3.4	1.9						
	7.5	3.2	1.8						

Table3.2.2.1

Influence of different carvone treatments during storage on the carvone residue of the potatoes.
Exp. ('91/92) in 15-ton bins. Storage at 6°C.

Carvone concentration in mg/kg fresh weight.
Carvone treatment in ml/ton. (..) treatment interval in weeks.

storage period days / store->	3x50 + 3x100 (6) 2	12 (1) 3	8.5 (1) 4	100 (9) 5	3x50 + 3x100 (6)** 6	aut.2x (1) 7	aut.2x (1) 8	0.5kg IPC/CIPC + 8.5 (1) 9	0.5kg IPC/CIPC + 2x50 + 1x100 (6) 10
43	1.1	1.1	1.0	2.5	1.8	0.9	1.6	0.8	
64	0.7				1.1				
84	2.1	2.7	1.7	2.1	2.4	1.5	1.2	1.6	
106	1.5				1.5				
127	3.2	4.5	3.7	3.5	3.7	2.9	3.1	3.7	1.2
148	1.8				2.0				
169	5.1	3.1	3.2	4.2	4.3	1.9	4.2	2.5	1.3
190	3.1				3.4				
211	5.4	4.7	3.1	3.1	5.9	2.1	4.1	2.2	2.1
232	4.3				4.3				
253	3.9	2.8	1.5	2.3	5.5	0.9	1.0	1.8	2.5
Carvone concentration at unloading time									
stack height									
0.5 m	1.5	0.8	0.4	1.1	2.1	0.5	1.0	0.4	0.8
1.5 m	0.6	1.5	0.6	1.0	1.6	0.2	0.4	0.4	0.4
2.5 m	0.7	0.7	0.6	0.8	2.0	0.2	0.5	0.4	0.6
average sample	1.1	0.9	1.2	1.0	1.7	0.3	0.7	0.3	0.7

** L-carvone treatment

IPC/CIPC concentration at unloading time
mg/kg fresh weight

store->	1		9		10	
treatment/ton	3x 22 ml		0.5 kg(1%)		0.5 kg(1%0)	
	IPC	CIPC	IPC	CIPC	IPC	CIPC
stack height						
0.5 m	0.05	2.57				
1.5 m	-	1.57				
2.5 m	-	1.01				
average sample	-	2.36	0.19	1.04	0.08	0.52

unloading time	store		day ->
	store	1	244
	store	7/8	260
	store	5/6/9/10	265
	store	2/3/4	266

Table 3.2.2.2

Influence of carvone application on the carvone residue in whole tubers, peelings and peeled tubers 6 weeks after application.

Treatment 50 ml/ton on day 22, 64 and 106
100 ml/ton on day 148, 190 and 232

Carvone residue store 2 and store 6

mg carvone/kg fresh weight

day	store 2 (d-carvone) whole tuber	peeled tuber	peelings	store 6 (l-carvone) whole tuber	peeled tuber	peelings
64	0.7	0.2	3.5	1.1	0.1	4.7
106	1.5	0.2	6.0	1.5	0.4	7.6
148	1.8	0.2	9.5	2.0	1.4	13.8
190	3.1	0.2	15.2	3.4	0.4	20.3
232	4.3	0.2	20.5	4.3	0.6	23.0

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