A SUMMARY OF INVESTIGATIONS ON CLAMP STORAGE OF POTATOES IN ENGLAND

Met een samenvatting: Overzicht van onderzoekingen in Engeland betreffende het bewaren van aardappels in kuilen

BY

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The major part of the potato crop in England is still stored during the winter in clamps. It is true that in recent years an interest has been developing in the storage of potatoes in buildings, but so far very few permanent potato stores have been erected. This is partly because of restrictions on building due to shortage of materials, but mainly because the climate in the main potato-growing areas is very suitable for clamping, so that serious losses from frost and waterlogging are exceptional.

The current interest in problems of storage has focussed attention on how little scientific knowledge is on record about conditions in potato clamps. The only quantitative work published appears to be in an early paper by GAUT (10) on the use of lime in clamps; in short papers by BARKER (1,2) in the Reports of the Food Investigation Board for 1933 and 1936, from an extended series on the metabolism of potatoes in storage; in a paper by BARKER and WALLACE (3) on temperatures in clamps and their influence on sprouting and sugar content; and in a recent paper by CROOK and WATSON (7) on changes in composition of the tubers. Other investigations, the results of which have not yet been published, were carried out during the war by WATSON, CROOK, WILSON and others. Even though so little quantitative work has yet been done, it may be of value to review it briefly to direct attention to some of the problems. Permission has kindly been given by DR WATSON and DR CROOK to refer to some of their unpublished results, and the notes are amplified in places by some further results of our own.

LIME IN CLAMPS

GAUT (10) carried out experiments on the effect of dusting potatoes with quicklime and slaked lime, his object being to determine whether either of these treatments would lessen the losses in clamps in years when potato blight was prevalent. His results showed that lime in either of the forms used, while not preventing the blighted tubers from going rotten, did prevent infection of the surrounding tubers with the „wet rot" which so often spreads if substantial quantities of blighted tubers are present. Of the two kinds of lime used, quicklime was considered the preferable. Potatoes dressed with slaked lime turned out so sticky that they could not be cleaned, whereas those dressed with quicklime had a dry flaky covering which easily fell away leaving the tubers clean and bright. Notwithstanding this early work, the use of lime in clamps, even in seasons when blight is known to be prevalent, has not been adopted in practice.

TEMPERATURES IN CLAMPS

BARKER and WALLACE (2,3) investigated the distribution of temperatures in clamps of King Edward potatoes in Lincolnshire from November to February 1934–35 and 1935–36. The clamps were on an 8 ft. (2.4 m) base and were of three kinds: (1) *Ordinary*, with 8 in. (20 cm) covering of soil, (2) *Shaded*, being the same as (1), but shaded from the sun on the south side by a wooden screen 20 in. (51 cm) from the clamp face, and (3) *Double-earthed*, with 14 in. (36 cm) covering of soil.

The mean temperatures in the clamps were found to be a degree or two Centigrade higher than the mean temperature of the surrounding air. The clamp coverings had an insulating effect, the variations in temperature of the potatoes being much smaller than those of the air (Fig. 1). Increasing the thickness of the soil covering raised the mean temperature of the potatoes a degree or two and also reduced the variations in temperature within the clamp.

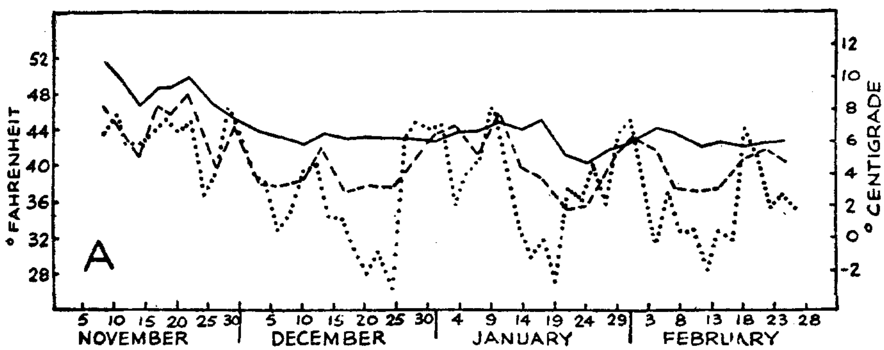

Fig. 1. Graph showing temperatures in King Edward potato clamp in Lincolnshire, England, in the winter of 1935–36.
Grafische voorstelling aangevend temperaturen in een kuil met King Edward aardappels in Lincolnshire, Engeland, gedurende de wintermaanden 1935–'36.
——— Bottom, centre of clamp. *Onder in de kuil in het midden.*
- - - - - South face, in the potatoes. *Zuidkant, in de aardappels.*
.... Air temperature. *Luchttemperatuur buiten.*
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Contrary to expectation, the mean temperature in the shaded clamp was slightly higher than in the ordinary clamp, possibly due to restriction of air movement over the clamp by the shading screen.

Distinct differences in average temperatures were found between various positions in the clamps. These may be summarized as follows:

	1934–'35		1935–'36	
	°F	°C	°F	°C
South side (30 cm below surface)	45,5	7,5	40,5	4,7
North side (30 cm below surface)	45,5	7,5	44,5	6,9
Top (30 cm below ridge)	43,0	6,1	41,5	5,3
Bottom, centre	45,5	7,5	44,5	6,9

It is interesting to note that in the 1935–36 season the average temperature on the south side was lower than that on the north side. It was considered that the sun during the winter had little direct effect on temperature (though it was recognised that after the beginning of March it might have been otherwise), and it was suggested that the relative temperatures on the north and south sides were influenced more by other factors, such as the direction of the wind.

Another point of interest was that the temperatures at the top, where sprouting was most advanced, were lower than those at the bottom of the clamp. Evidently factors other than temperature had a marked effect on sprouting.

In the investigations carried out by Watson and Crook at Rothamsted Experimental Station, it was found that when the soil covering was applied at the beginning of December there was an immediate rise in temperature of a few degrees; that the temperature then remained fairly steady until the end of February, after which a marked variability set in. Watson and Crook have suggested that the onset of this variability may have been due to drying out of the moisture in the soil casing, allowing greater penetration of wind.

The characteristic feature of this variability was that the temperature at the two surfaces of the potatoes tended to vary in opposite senses, i.e. a fall at one face was accompanied by a rise at the other face, and vice versa. It was found that these fluctuations were closely correlated with changes in the component of wind velocity normal to the clamp faces, suggesting that they were caused by the movement of air through the clamp towards the side remote from the wind. On one occasion when a strong wind normal to the clamp face persisted for more than 24 hours, the temperature fell thoughout the potatoes. In this instance, apparently, all the warm air was displaced by cold air.

As regards high temperatures, Watson and Crook noted a temperature of 104 °C (40 °C) in a clamp of Majestic which collapsed in April owing to the spread of rots from blighted tubers. Still higher temperatures in collapsing clamps have at times been noted by other observers, without published record.

A few further data on temperatures are given below in the section *Extra-long Keeping*.

THE ATMOSPHERE IN CLAMPS

Barker and Wallace (3) mention that the carbon dioxide content of the atmosphere in clamps was found in earlier unpublished work to be between 0.1 and 0.3 %. Watson and Crook studied the changes in rather more detail and were able to detect a rise from 0.03 % the day before earthing up to 0.18 % the following day. Thereafter, there was a gradual rise in concentration, with irregular fluctuations which could again be correlated with variations in the direction and velocity of the wind. Owing to the inclusion of blighted tubers, the temperature in the experimental clamp rose considerably in March and April, and in April the clamp collapsed, but even under these conditions the concentration of carbon dioxide did not reach 1 %.

SPROUTING

Barker and Wallace (3) noted a general correlation between temperature and sprouting, and also that other factors could at times obscure this relation. For example, the mean temperature in the double-earthed clamp in 1934–35 was 6 °F (3.3 °C) above that in the ordinary one, and this higher temperature was reflected in a doubling of the sprouting; also in all the experimental clamps sprouting was most vigorous in the outside 3 in. (7.6 cm) layer of potatoes, especially along the ridge, notwithstanding the fact that in these situations the temperatures were lower than at the centre. Although no investigations have been carried out to determine the reasons for the greater sprouting at the outside, it would seem likely that increased moisture in these layers may play an important rôle.

It is well known that sprouting varies greatly according to variety, locality and season, but no figures have yet been published showing the progressive loss from sprouts during the season. In experiments at Sutton Bonington and at Rothamsted in 1943, with clamps divided into weighed sections of one ton, the progress of sprouting, expressed in percentages of the original weights of tubers, for clamps of three varieties, was found to be as follows:

	Jan.	Feb.	Mar.	Apr.	May	Jun.
Arran Peak (S. Bonington)	0,3	0,6	1,7	3,4	4,4	6,1
King Edward (S. Bonington)	0,1	0,3	0,4	1,0	1,3	1,8
Majestic (Rothamsted) . .	0,0	0,0	0,0	0,7	3,7	7,5

It will be seen that whereas sprouting started slowly in the Majestic at Rothamsted, the sprouts grew quickly and eventually exceeded in amount those in the clamps of other varieties at Sutton Bonington. In some further experiments with Majestic carried out by workers in another locality, a much smaller amount of sprouting was determined. The figures illustrate the differences that may be met with in rate and degree of sprouting, and no doubt investigations on a wider range of varieties, carried out in different localities and in different seasons, would serve to focus attention on still further differences of interest.

NET WEIGHT LOSS

This may be defined as the figure obtained by subtracting the total weight of all material recovered from the original weight clamped, and is considered to be due to evaporation and respiration. The figures for the same three clamps as above were as follows:

	Jan.	Feb.	Mar.	Apr.	May	Jun.
Arran Peak	8,4	5,5	6,5	7,6	16,9	14,3
King Edward	8,3	4,1	4,3	4,7	12,8	12,2
Majestic.	6,5	4,6	6,0	7,8	11,2	17,8

It will be noted that the net weight loss (mainly loss of water) considerably exceeded the loss due to sprouts. The high values at the first sampling date seem anomalous, and may have been due to the fact that they were obtained from the end sections of the sectional clamps.

REMOVING THE SOIL COVER

It is a common practice for growers to remove the soil cover in spring, either in whole or in part, with the object of keeping down the temperature and minimizing sprouting. The effect of this practice was examined at Sutton Bonington in 1943, when the following figures (% loss by weight) were obtained (The soil cover was removed from the test clamp in April).

	Soil cover	Feb.	Mar.	Apr.	May	Jun.
Sprout losses						
Arran Peak	removed	0,6	1,7	3,4	4,4	6,1
Arran Peak	retained	0,6	1,6	4,5	6,4	8,4
Net weight loss						
Arran Peak	removed	5,5	6,5	7,6	16,9	14,3
Arran Peak	retained	5,9	5,4	5,0	9,5	9,3

It is seen that although removal of the soil cover did check sprouting somewhat, it resulted also in the moisture loss rising substantially, probably owing to the freer passage of air through the clamps. Any saving in sprout growth was thus more than offset by increased loss of weight. These data are insufficient to permit any generalization; obviously further work of this kind is needed.

EXTRA-LONG KEEPING

The figures already quoted give information about the losses to be expecteed until the end of June, which is about as long as commercial potatoes can be satisfactorily stored in clamp. The only further information on record is in an article by FURLONG (9), in which mention is made of a clamp of Majestic potatoes at East Malling which was kept until the end of August to serve as a control to an experiment in cool store. The figures given were as follows:

	Apr.	May	Jun.	Jul.	Aug.
Sprouts (% by wt.) . . .	1,9	5,0	12,1	20,0	Clamp collapsing; many new potatoes
Max. temperatures: °F	54,9	69,8	69,8	83,3	86,0
°C	12,7	21,0	21,0	28,5	30,0

It was recorded also that the temperatures at the top of the clamp were higher than those at the bottom, which is in contrast to what was noted above for a Lincolnshire clamp in winter.

CHANGES IN COMPOSITION

BARKER and WALLACE (3) estimated total sugars in the samples taken from different positions in the Lincolnshire King Edward clamps previously mentioned. As was to be expected, they found the sugar content inversely correlated with temperature. For example, in 1934–35, in the ordinary and double-earthed clamps the average temperatures were 45,0 ° and 50,0 °F, whereas the average sugar contents of the tubers were 0,69 % and 0,46 % respectively. In the ordinary clamps sugar content approached 1 % in some samples, and the authors raised the question whether poor culinary quality might not in some instances be due to too low temperatures in the clamps.

CROOK and WATSON (7) studied the changes in sugar content (both sucrose and reducing sugars) throughout the season, showing that there was a slow decrease until April, and then a rise coincidental with active sprout growth. Loss of fresh weight was determined mainly by loss of water. Thus in losses ranging from 12 to 25 %, no more than 3 % was due to dry matter loss. Although there was up to 10 % loss of nitrogen from the tubers, all was recovered in the sprouts. There was a gradual reduction of starch in the tubers, and an increase in residual dry matter in late winter. Ascorbic acid increased slightly to a maximum at the time sprouts began to appear (in February) and then fell to a very low value at the end of the storage season.

SPROUT DEPRESSANTS

Sprout depressants in clamps are not yet used commercially in England. In an early experiment BARKER (1) passed ethylene into small clamps of King Edward potatoes at Cambridge, through metal pipes inserted when the clamps were built. The stronger dosage (1650 cc per hr) reduced sprouting early in April, but no retarding effect could be seen 3 weeks later, nor at either date in the clamp treated with a weaker dosage (560 cc per hr). Sprouting varied greatly in different positions in the clamps.

Small scale experiments with methyl-alpha-naphthalene-acetate in talc were carried out by LUCKWILL (12), who showed that application in March of 14 g of active substance per ton (in a 1 % dust) halved the weight of sprouts formed by June. This corresponded with similar results in Holland. However, in England clamps are never opened and worked over in spring, as they are in Holland, so that unless satisfactory results are given by application at the time the clamps are built in autumn, the outlook for commercial use of a sprout depressant in clamps is not promising. WILSON and MCKEE (14) gave the results of a fairly large clamp experiment in which they applied methyl-alpha-naphthalene-acetate (2 % in gypsum) to King Edward potatoes in October at 45,3 g per ton, and found that in May sprouting was reduced from 1,8 % by weight in the controls to 0,9 % in the treated clamps. Unfortunately sprouting was less than usual in the control clamps that year. The treated tubers with their shorter sprouts could be graded rather more quickly than could the untreated, but even so, it is doubtful whether use of the dust was economic. BROWN (4) reported small-scale experiments with pentachlornitrobenzene and tetrachlornitrobenzene, both of which depressed sprouting and prevented injury to the sprouts by *Rhizoctonia*. Tetrachlornitrobenzene is now being marketed as a 3 % dust on china-clay carrier, under the proprietary name „Fusarex". GLASSCOCK (11) reported an experiment with tetrachlornitrobenzene, methyl-alpha-naphthalene-acetate and methyl-alpha-naphthyl-methyl-ether, but none of these substances gave completely satisfactory inhibition of sprouting in very small clamps opened in late May. Further experiments to determine the value of sprout depressants in clamps are in progress.

This brief survey of quantitative work on potato clamps has been restricted to work done in England. It does not take account of the much more extensive work on the storage life of potatoes available from *laboratory* studies of physiology, metabolism, cooking quality, blackening on cooking, etc. The literature on these aspects of storage has recently been well summarized by BURTON (5). Nor does it take account of wastage in clamps due to disease, which may vary greatly from season to season and from place to place. Brief discussions of the various factors concerned in wastage from disease have been given by COTTON and TAYLOR (6) and by WILSON and BOYD (13). Mention should also be made of some detailed figures on losses in experimental clamps, published by DREW and DEASY (8) in Ireland.

Although the main outlines of the storage life of potatoes in clamps are now known, there is obviously opportunity for much more quantitative work to establish ranges and means of the factors concerned, as related to different varieties, localities and seasons. The reason why so little work has been done with clamps is almost certainly the large amount of labour required for weighing in and out. For this reason the development of an adequate sampling method is a pressing need. Experimental work at present in progress indicates that the labour may be considerably lessened by the use of weighed samples (preferably in bags made of plastic string) embedded in the clamps. These give the added advantage over total weighing that positional effects can also be ascertained.

SAMENVATTING

Ondanks het feit dat het grootste deel van de aardappeloogst in Engeland op het veld wordt ingekuild, zijn er betrekkelijk weinig quantitatieve gegevens bekend over de condities in de kuilen. Er wordt een overzicht gegeven van de literatuur betreffende het gebruik van kalk in de kuilen, temperaturen in de kuilen, percentage koolzuur, spruitvorming, gewichtsverlies, chemische veranderingen in de knollen, en het gebruik van anti-spruit middelen. Tevens worden enige gegevens uit eigen niet gepubliceerd werk en dat van collega's medegedeeld. Volgens de schrijvers is veel meer quantitatief onderzoek betreffende het inkuilen vereist ter vaststelling van de variatiebreedte en het gemiddelde van de verschillende factoren, zoals deze door rassen, groeistreek en seizoenen beinvloed worden. Zij zijn van mening, dat het mogelijk zou zijn de belangrijke hoeveelheid arbeid nodig om dit soort onderzoek te verrichten te vereenvoudigen, door in de kuilen te werken met afgewogen monsters, bij voorkeur in zakken gemaakt van draden van plastic.

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ENKELE WAARNEMINGEN OVER BLADLUIZEN IN DE HERFST

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Some observations have been made on the migration of aphids in autumn.

In de herfst vieren de bladluizen hoogtij. Immers in deze tijd van het jaar ontstaan de geslachtsdieren (sexuales), waarvan de steeds ongevleugelde wijfjes (oviparae), na de paring, één of enkele eieren afzetten, welke overwinteren (wintereieren). Geldt het soorten, die migreren, d.w.z. die 's zomers op een verscheidenheid van kruidachtige planten (zomerplanten) leven en die in de herfst zich verplaatsen naar verschillende houtige gewassen (winterplanten), dan worden de eieren op de houtige delen afgezet, b.v. op de dunnere takken in de nabijheid van knoppen of andere eventueel aanwezige oneffenheden. Zo kan men b.v. op *Euonymus*, *Viburnum* e.a. de eieren van verschillende zgn. zwarte bladluizen vaak in grote getale aantreffen. Bepaalde groepen van bladluizen zetten hun eieren niet op dunne takken, maar in oneffenheden van de schors van dikkere takken en stammen af, hiertoe behoren de verschillende galluizen op iep (*Eriosomatinen)* en de hieraan verwante galluizen op populier (*Pemphiginen*). De in het voorjaar uitkomende jonge larven moeten zich dan van de stam naar de knoppen begeven.

Het tijdstip der migratie en van het hierop volgende afzetten van eieren is bij de verschillende soorten nogal uiteenlopend. Het vroegst zag ik een zwarte luis, *Doralis saliceti* KLTB. op wilg eieren afzetten, nl. al in Juli. Ongeveer op hetzelfde tijdstip, zo niet al eerder, produceert een luis (*Mindarus*) op Abies haar wintereieren. Ook de populieren-galluizen zijn vroeg, zij migreren nl. al in de tweede helft van Augustus. Eens nam ik waar, dat de stammen van enkele Italiaanse