SOME FACTORS INFLUENCING THE KEEPING QUALITY OF POTATOES [1] [2]

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Introduction

Anyone who has anything to do with the storage of potatoes knows that not all potatoes are equally easy to keep. By potatoes which are "easy to keep" we mean those in which sprouting does not readily take place and in which disease does not readily occur in the tubers. When sprouting and rotting do not occur, the quality is best preserved. By substituting storage in buildings with through-cooling for storage in pits the keeping quality of the potatoes is considerably improved, firstly because it is easier to reach so low a temperature that sprouting can be countered, and secondly because the spreading of tuber diseases such as *Phytophthora* and wet rot in the potatoes stored can be prevented by drying the latter by forced ventilation at the beginning of the storage period. Nevertheless, it is a fact that one variety is much easier to store than another, and even within each variety considerable differences may occur from batch to batch.

The two characteristics of good keeping quality mentioned above may be described most simply as the physiological and the microbiological keeping quality.

The physiological keeping quality

The physiological keeping quality is determined – at any rate, very largely – by the readiness of the potatoes to sprout, for sprouting means accelerated decay. One of the properties of the tubers which plays a part in this readiness to sprout is the length of the dormancy period. There are two aspects to this. In the first place earlier sprouting does in itself mean earlier deterioration, but it is also probable that potatoes which sprout quickly will also display an increased readiness to sprout in the further storage period; and this, as stated above, impairs the keeping quality.

The most important factor which determines the end of the dormancy period [3] is temperature. This emerges from the figures given in Table 1, which shows the end of the dormancy period, at various constant temperatures, of potatoes of the size 35/45 mm and of different varieties, lifted on 10th July, 1954, and coming from one trial field. The tubers were originally stored in a fairly cold shed at 12–15° C, after which, ou 24th July, the (constant) temperatures shown in Table 1 were applied.

Although the length of the dormancy period at different temperatures is, to a considerable extent, a varietal property, there are various external factors which may modify this length.

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1) Received for publication September 5, 1955.

2) Lecture given during the Twentieth Agriculture Week at Wageningen, and the Informal Potato Conference, which was held at Wageningen, 8–10 August, 1955.

3) By definition the dormancy period is considered to have ended when at least 80 % of the tubers display sprouting in one or more eyes.

One such factor is probably the soil temperature at which the tubers have grown, possibly combined with the moisture content of the soil. By covering part of a trial field with straw in 1953, as a result of which lower maximum

Table 1. End of the dormancy period.

Variety	Constant storage temperature in °C							
	20°	16°	13°	10°	7°	5°	4°	3°
Eigenheimer	20/9	4/10	18/10	1/11	29/11	6/1	16/2	5/5
IJsselster	15/10	1/11	15/11	1/12	30/12	8/2	26/3	26/5
Noordeling	8/12	23/12	5/1	17/1	23/2	27/3	7/5	13/6

temperatures occurred in the soil during sunny periods, the dormancy period of the lifted tubers of the variety Bintje was some weeks longer during storage at 20° C than that of potatoes from the uncovered part of the field. Owing to the bad weather in 1954 no differences in soil temperature occurred during repetition of the trial, nor were there any differences in the length of the dormancy period.

A similar climatic influence was also found in trials with potatoes (including the variety Bintje) from lifting-time trials in various parts of Holland [4]). The potatoes planted in these trial fields came from one batch. They had therefore all been subject to the same storage conditions, and were also planted on the same dates. From 24th June part of each field was lifted every week, and when the potatoes were stored at a constant temperature of 20° C it was found that those from the field in Limburg in all cases sprouted a week earlier than those of the corresponding lifting dates from the field in West Brabant, and three weeks earlier than those of the corresponding lifting dates in Groningen. After storage at 5° C, too, a similar difference proved to exist, but the difference was greater than after storage at 20° C. The potatoes from Limburg sprouted in all cases two and a half weeks earlier than those from West Brabant. It is probable that differences in soil temperature played an important part here.

A second point, which must be touched upon, is the following. The later the tubers were lifted, the later the dormancy period terminated. However, it was noticed that potatoes lifted on 24th August and stored at 20° C (constant) did not sprout one month later than those lifted on 24th July, but only three weeks later. We have here the well-known phenomenon that riper tubers (harvest 24th August), stored under the same circumstances, have a shorter dormancy period than unripe ones (harvest 24th July). During storage at 5° C this shortening of the dormancy period could be less clearly observed, in particular because the slower and irregular sprouting made judgment far more difficult. For instance, the potatoes from Groningen sprouted so irregularly that comparison with the potatoes from the other two trial fields was impossible.

4) These trial fields were laid out by Mr. F. J. H. van Hiele of the Laboratory of Field Crop Husbandry of the Agricultural University, who kindly made the yield of the fields available to the Institute for Potato Storage for further investigation.

Besides the conditions during growth of the crop, the circumstances at the beginning of storage also have an obvious influence on the time of sprouting. The influence on the length of the dormancy period and the rate of sprout-growth, exercised by the temperature just after lifting – i.e. at a time when the potatoes, despite optimum conditions for sprouting, are not able to sprout – has been investigated. For this purpose potatoes of eight varieties were subjected partly to fluctuating and partly to constant temperatures for three weeks after harvest (19th August–9th September), after which they were stored at 20° C (constant). At a fixed time, the percentage of tubers of each sample that had sprouted was ascertained, and a few weeks later the sprouts were weighed. This led to some very surprising results, which can be most easily illustrated by giving the data for the two varieties which exhibited the extremes of behaviour (Table 2). The variety Alpha behaved exactly in conformity with the view prevailing in the literature of the subject, viz. that greatly fluctuating temperatures tend to interrupt dormancy. On 19th November 10% of the tubers of the control sample, which had always been kept at 20° C, had sprouted. The samples which had been kept for 3 weeks at 10° C and 13° C displayed moderate sprouting, viz. 30%, and the samples which had been exposed to a temperature change of 13–20–13° C and of 10–20–10° C (see table) had sprouted to the extent of 20 and 15% respectively. However, as soon as 2° C was involved in the temperature change, the percentage of sprouted tubers was much higher and, in fact, the greater the differences in temperature, the higher the percentage. Storage for three weeks at 2° C or 5° C also had the effect of interrupting dormancy.

The results from the variety Voran were quite different, however. In the case of this variety, only 3 samples had fully sprouted on 8th October, viz. the control and the two samples which had been stored for 3 weeks at 2° C and 30° C respectively. The degree of sprouting of the remaining subjects varied from 10 to 45%.

Table 2. Percentage of sprouted tubers after treatment for three weeks and storage at 20° C (constant).

Treatment		Alpha	Voran
For three weeks:			
Alternate days at 2° C and 30° C	Then at 20° C (constant)	100	30
,, ,, ,, 2° C and 20° C		90	10
,, ,, ,, 2° C and 13° C		65	35
,, ,, ,, 2° C and 10° C		60	25
,, ,, ,, 20° C and 13° C		20	25
,, ,, ,, 20° C and 10° C		15	45 [5]
,, ,, ,, 20° C and 5° C		70	20
Three weeks constant: 30° C		55	100
,, ,, ,, 20° C		10	100
,, ,, ,, 13° C		30	40
,, ,, ,, 10° C		30	20
,, ,, ,, 7° C		55	30
,, ,, ,, 5° C		90	40
,, ,, ,, 2° C		90	100

[5] The percentages were observed when the differences were the greatest. In the case of Alpha, a slowly sprouting variety, this was after 92 days; with the more rapidly sprouting variety Voran it was 49 days after commencement of the treatment.

It may logically be assumed that those potatoes which sprout first will, in the course of the time, also yield the greatest weight of sprouts. To investigate this a correlation calculation was made, and the results show that this correlation is in fact present in most cases. The correlation coefficients of the various varieties (with 30 pairs of observations) were, namely, as follows:

Libertas	0.83 ± 0.11	Alpha	0.62 ± 0.15
Noordeling . . .	0.80 ± 0.15	IJsselster	0.51 ± 0.18
Eigenheimer . .	0.71 ± 0.13	Bevelander . . .	0.45 ± 0.18
Bintje	0.62 ± 0.16	Voran	0.15 ± 0.17

According to current mathematical views, reliable correlation is present in every one of these cases except that of Voran. As regards the latter variety, a short dormancy period is not bound up with an accelerated growth of sprouts after the dormancy period.

The microbiological keeping quality

The microbiological keeping quality has been ascertained by storing the potatoes either at a constant temperature of 2° C, or in an unventilated, insulated shed in which the temperature follows that of the outside air, and by counting the number of rotten tubers at set times.

The first method requires much more time than the second (one to two years), but the differences revealed are very distinct. Application of the second method takes less than a year, but the differences are sometimes vague. In the case of the first method no sprouting occurs; but in the case of the second, sprouting does occur. Evidently sprouting takes place when rotting makes its appearance.

The rot which predominantly occurs has proved to be *Fusarium* rot. In this connection the following points must be borne in mind:

a when the potatoes are stored at 2° C this rot manifests itself as a disease of age;

b when the potatoes are stored in the uncooled shed, sprouting occurs, with loss of sprouts, during the counts. Loss of sprouts means accelerated deterioration in the condition of the potato, and consequent greater susceptibility to attack by *Fusarium* (Dr. Mooi).

Various circumstances during the growth of the crop have been investigated in connection with the occurrence of rotting, sooner or later, during storage of the harvested potatoes. It has been known for some considerable time now that it is not uncommon for potatoes grown on clay to be easier to keep than potatoes grown on sand – a fact which, in our determination of keeping quality, manifests itself in earlier rotting on the part of the latter. But potatoes from different sandy soils may also vary strongly in microbiological keeping quality. This has emerged from the results of trial fields which were laid out for many years in Drente, an essential feature being that the trial fields were on the same piece of land every year and that the seed potatoes all came from the same batch and had been stored in the same manner. The potatoes were on every occasion planted on the same date, and lifted on the same date. Important results which came to the fore were that certain plots always yielded potatoes which kept well, whilst other plots always produced poor keepers, and that, in the case of the potatoes from the remaining plots, rotting fluctuated to a fairly considerable extent from year to year. Various growth factors may be indicated which influence the keeping quality of the potatoes (measured in terms of earliness of rotting), such as the acidity and the humus content of the soil and the amount of potash applied thereto. These are illustrated in Table 3.

Table 3.

Harvest year	Number of fields	% rotting in June of following year	Soil investigation		
			humus %	$pH\text{-}H_2O$	potash number
1950	9	2–8	5.7	5.5	34.3
	4	20–30	7.4	5.2	19.0
	3	50–65	7.7	5.2	16.3
				pH-KCl	
1952	3	3–10	4.5	4.5	20.3
	4	13–20	7.0	4.3	20.0
	3	90–100	10.0	3.6	12.7

Here, poor keeping quality is accompanied by a high content of humus, a low pH value and a low potash number. The extent to which these features exert their influence independently of each other or in co-operation with each other cannot be deduced from this investigation.

Besides these factors, presence of loam in the soil proved to have a favourable influence, but the infection of the soil by *Fusarium* was also of great importance.

The influence of potash was also strongly apparent from the results of an investigation of the storage of samples of potatoes from fertilizer trial fields which belonged to various bodies such as the Agricultural Experiment Station and Institute for Soil Research (T.N.O.), Groningen, the Netherlands Potash Import Company, the Advisory Office of the Netherlands Superphosphate Industry, and others (Table 4).

Table 4. Harvest year 1952 % rotting October 1953.

Fertilizer/Variety	Voran	Thorma	Rode Star	Noordeling
No potash	37.3	14.0	55.7	34.6
225 kg K_2O on 9/4 [6])	23.3	5.3	41.0	12.6
225 kg K_2O on 16/6 [6])	21.3	7.6	41.3	12.0

A noteworthy fact is that the effect on keeping quality of the application of potash on 16th June was as good as that of application of the same quan-

[6]) Potash applied in the form of sulphate of potash and expressed in kgs per hectare.

tity of potash to potatoes on planting. The same favourable influence of late manuring with potash was seen in results from another trial field, likewise laid out in 1952. There two lots of potatoes of the variety Noordeling were fertilized with 225 kg of potash (K_2O), as sulphate of potash, on 16th June and 4th July, respectively. The percentages of rotting found after storage till October 1953 were 16.3 and 14.7% respectively, whereas the potatoes from the field to which no potash had been supplied exhibited 45.7% rotting. However, full account must be taken of the fact that ripe-lifted potatoes only were involved in the above fertilization trials. These potatoes therefore had ample opportunity of profiting from the late application of potash; and it is to be presumed that potatoes lifted early would have had far less chance of doing this.

These are thus results of the 1952 harvest, which results were already available in the autumn of 1953. That the microbiological keeping quality may vary strongly from year to year emerges from the fact that the rotting of potatoes of the 1953 harvest from fertilization trial fields only occurred at the end of June 1955 to an extent sufficient to enable differences between the potatoes under trial to be observed for certain.