EFFECT OF HARVESTING TIME AND STORAGE SYSTEM ON THE QUALITY OF SEED POTATO TUBERS (*Solanum tuberosum* L.)[1] /

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Resumen

Se estudió el efecto de dos épocas de cosecha y de dos sistemas de almacenamiento sobre la calidad de los tubérculos de papa cultivar Spunta destinados a nueva siembra. Las cosechas se realizaron 70 y 100 días después de la muerte natural del follaje y los tubérculos se almacenaron durante cinco meses en un silo refrigerado y ventilado, mantenido a 3°C y 95% de humedad relativa y en pilas a la intemperie cubiertas con paja de maíz. Los tubérculos cosechados a los 70 días de la muerte del follaje se conservaron por un mes en pilas y luego una parte se almacenó en el silo.

Las heladas registradas entre los 70 y 100 días posteriores a la muerte del follaje causaron daños a los tubérculos sin cosechar, pero no a los amontonados en las pilas.

Cuando los tubérculos se almacenaron en el silo inmediatamente después de la cosecha, se produjo una adecuada suberización en el 63% de los tubérculos cuyo parénquima estaba parcialmente helado; esto impidió su pudrición ulterior por bacterias, esto no sucedió con los tubérculos almacenados en las pilas.

Los tubérculos almacenados a 3°C y 95% de humedad relativa no brotaron, y resultaron fisiológicamente más jóvenes que los conservados en las pilas.

Introduction

In Argentina, table potatoes are planted with tubers from the annual multiplication of cultivars of long dormant periods such as cv Huinkul MAG cv Bonaerense La Ballenera MAA, or with those tubers of first or second multiplication from imported cultivars of early sprouting, being cv Spunta and cv Kennebec the principal ones. Nearly all these multiplications are carried out in the South-Eastern area of the province of Buenos Aires, between October and March each year where, 70% of potatoes for consumption is produced.

Potato crops for consumption are planted in the North part of Argentina in June or July and, in the South-East of Buenos Aires in October or November. Due to this fact, seed tubers from the South-East of Buenos Aires to be planted early must be stored for three months just after natural foliage death, and for nearly eight months when used for the medium late production. Almost all seed tubers are stored in outdoors heaps, covered with corn (*Zea mays*) or Stipa (*Stipa* spp.) straw; only a small part is stored in refrigerated stores without ventilation or in less proportion in refrigerated and ventilated store houses.

Seed potato tubers of late sprouting can be perstored in outdoors heaps, but those of early sprouting must be desprouted more than once in this systems, which determines loss of quality, principally during the last months of storage.

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It is also known that harvesting time influence physiological age of the tubers (6, 7), and this according to Van der Zaag (9) determines sprout number, growth rate and duration of crop cycle.

Efficiency of potato storage in outdoors heaps or in cold store houses was already studied for the area by Cavia and Caruso (2) and Radtke and Escande (8). In the present work the influence of harvesting time and storage system on the quality of seed potato tubers cv Spunta is considered.

Materials and methods

This work was carried out at "La Iacinta" settlement district of Coronel Suárez, province of Buenos Aires, located at 37°30' South latitude, 61°57' West longitude and 185 m above sea level.

Potato tubers from the early cv Spunta first multiplication picked at the end in March 1979, were used. The "first harvest" was performed on 22nd May and the "second harvest" on June 18th by means of a disc digger and picked up by hand.

The first harvested tubers were stored in outdoor heaps until the second harvest, and then they were classified in order to remove externally rotted tubers. After classification, some of the tubers were stored in bulk in a refrigerated and ventilated store house and the remainder in outdoor heaps. The "second harvested" tubers, previous elimination of rotted ones were placed either in a store house or in outdoor heaps.

Heavy frosts were registered in April, May and June. In Table 1 the minimum daily outdoor temperatures of soil 5 cm depth and air 5 cm height, were detailed for the period between the first and the second harvest obtained at INTA Agrometheorological Station in Anguil (36° 33' S, 63° 59' W and 165 m above sea level) and in Balcarce (37° 45' S, 58° 18' W and 130 m above sea level).

Outdoor heaps were covered with corn straw 10 cm – thick. As soon as the store house was filled, tubers were dried by blowing cold outdoor air for 24 h. During the following 14 days they were kept at 15°C and at 95% of relative humidity. Then, the temperature was lowered at a rate of 1°C per day until it reached 3°C (storage temperature), keeping the same level of relative humidity. Before the potatoes were taken out from the store house, the temperature was increased at a rate of 1°C per day until it reached 10°C.

Weight losses due to evaporation, respiration and sprouting, as a pool, were studied. Immediately after the second harvest, on June 18th, for each treatment, six open net bags were filled with 20 kg of medium size healthy potatoes (tubers weight range: 100 to 200 g); the number of tubers contained in each bag was counted in order to replace them or estimated their weight in case of rotting. Each bag was considered as an experimental unit. Their content was desprouted and weighed on August 29th, and at the end of storage, on October 29th, for tubers stored in heaps and on November 14th for those in store houses. Tubers and sprouts were weighed separately with a precision of 10 g.

In order to determine frozen tuber weight an "initial" evaluation was done before selecting tubers

Table 1. Minimum daily outdoor temperature of air at 5 cm height and of soil at 5 cm depth in Balcarce and Anguil, between the first and second harvest.

Day	Air temperature at 5 cm above ground (°C)		Soil temperature at 5 cm depth (°C)	
	Anguil	Balcarce	Anguil	Balcarce
May 22	– 2.1	–0.8	7.3	5.5
23	– 2.6	0.1	5.9	6.0
24	3.6	7.3	8.3	9.5
25	8.1	4.0	10.6	9.2
26	– 5.7	4.5	5.1	7.0
27	3.6	7.0	5.2	8.7
28	– 0.6	1.0	6.4	6.5
29	0.3	0.1	5.6	5.0
30	– 5.8	0.0	3.0	4.5
31	– 3.9	–2.0	3.4	3.0
Jun 1	– 3.9	1.8	4.1	3.6
2	5.1	2.6	4.2	5.0
3	– 2.9	2.5	4.5	5.6
4	– 8.4	– 1.0	3.2	3.0
5	– 7.7	–1.5	2.2	2.0
6	– 6.6	–4.5	2.5	1.5
7	– 6.1	–2.0	3.4	1.5
8	– 5.9	0.6	3.8	0.5
9	– 6.4	–2.2	2.7	1.0
10	– 5.4	–3.0	3.2	2.0
11	– 5.6	4.5	3.7	3.5
12	– 5.1	1.0	3.4	3.6
13	– 6.8	1.0	1.5	4.3
14	–14.0	1.0	0.2	0.0
15	–13.0	–5.7	0.3	1.0
16	– 3.9	–2.0	1.6	1.3
17	– 1.9	3.5	3.9	4.8
18	1.9	0.6	5.7	6.0

Source: INTA, E.E.A. Anguil. Agrometheorological monthly bulletin. May and June 1979.

INTA, E.E.R.A. Balcarce. Agrometheorological monthly summary. May and June 1979.

to be stored in store houses. Three samples of 50 kg tubers each, randomly selected were evaluated

Tubers were cut at stolon end and at the affected parts. Frozen tubers were classified into frozen and rotted where their parenchyma was partially frozen and into frozen and suberized with soft rot symptons. Tubers externally affected by frosts or rotted were eliminated before storing them in store houses. Final evaluation similar to the one above described was done when the potatoes were taken out from the store house. In both evaluations, potatoes were weighed with a precision of 10 g.

In order to study physiological age of potatoes their incubation state was determined according to Claver (4) criterion. The number of days that elapsed from the possible planting date to the end of the incubation period were determined. This period included from sprouting till new tuber formation (4). For each treatment 25 tubers randomly taken were used, they were placed in wood trays containing permanently humidified vermiculite and kept in darkness at 21° (± 1°C) and 80-90% relative humidity. Every two days tubers that completed their incubation period were counted

In all determinations, a randomly design with 6, 6, 3 and 25 replications was used, in order to determine weight losses, frost damages and physiological age, respectively. Analysis of variance of the data was done and means were compared according to Tuckey' test, at a probability level of 5%.

Results and discussion

Tuber weight losses are shown in Table 2. Tuber weight losses were significantly lower in the store house, and in this system tubers did not sprout during the storage period.

The effect of harvesting time was only shown by weight losses in potatoes stored in outdoor heaps, and it did not produce any effect on sprouting.

Table 2. Percentage of tuber weight loss and sprout weight at the end of the storage period.

Storage System	Weight loss		Sprout weight	
	1st harvest	2nd harvest	1st harvest	2nd harvest
Outdoor heaps	17.5 a	16.1 a	3 1 a	2 6 a
Store houses	2 5 b	3 1 b	0 0 b	b

Those averages on the same column followed by the same letter do not differ between them ($P < 0.05$); the ones linked by full lines differ between them ($P < 0.05$)

Frosts registered between foliage death and potato storage in store houses caused serious damages on the tuber parenchyma; in some cases due to suberization these damages did not reach soft rot caused by microorganisms. In only a few cases, frost caused necrosis of vascular tissues (Table 3)

Potatoes harvested in the second turn were more damaged by frosts. This fact shows that frost effect was greater upon tubers that remained in the soil and were harvested in "second time", that upon those temporarily stored in outdoor heaps. When potatoes were stored in store houses immediately after harvest like in the case of the second harvested tubers, storage conditions stimulated their quickly suberization. This fact not only reduces evaporation losses, but also prevents from microorganism attacks (1). Even though, frost in the district of Coronel Suárez are more severe than those in the South-East of the province of Buenos Aires, where the potential frost danger is also important for tubers that remained in the soil in this area; in this region for a ten-year period (1969-1978) an average of 55 days with heavy frosts was registered during the potato storage period, from April to October (5).

Results showing the effect of harvesting time and storage systems on the physiological age of the seed tubers are presented in Table 4, the differences found between tubers stored in store houses and in outdoor heaps, were due to the different conditions under which they were subjected to.

Tubers harvested on the first turn and kept in store houses were physiologically younger than those which remained in the soil and suffered heavy frost damages.

Table 3. Percentage of frozen and rotted[1] tubers, frozen and suberized and totally frozen tubers under store house.

Evaluation	Rotted and frozen tubers harvest		Frozen and suberized tubers harvest		Totally frozen tubers in harvest	
	1st	2nd	1st	2nd	1st	2nd
Initial[2]	6 8	4 3	0 0	0 0	6 8	4 3
Final[3]	2 2	4.3	traces	7.4	2 2	11 7
Total	9 0	8 6	traces	7 4	9 0	16 0

Averages linked by full lines differ between them ($P < 0.05$)

1. Tubers with partially frozen parenchyma and symptoms of soft rot
2. Previous storage in store house and before elimination of tubers externally affected by frost and rot
3. When the store house was unloaded.

Table 4. Number of days from possible planting date up to the end of the incubation period.

Storage system	First harvest	Second harvest
Outdoor heaps	40 b	40 b
Store house	61 a	52 a

Averages on the same column with the same letter do not differ between them ($P < 0.05$); averages linked by full lines differ between them ($P < 0.05$).

The effect of harvesting time on the physiological age of the tubers stored in heaps was not significant; this may be due to the fact that in this case the storage system plays a more important role than harvesting time on the physiological age

It must be said that frost caused greater damages on seed potato tubers that remained in the soil without harvest than upon those harvested and stored in outdoor heaps, covered with corn straw.

Suberization was stimulated by storage immediately after harvest, when the potatoes were kept in a refrigerated and ventilated store houses In this way, rotting caused by microorganisms in frosted potato stocks was diminished.

Storage conditions in the store houses maintained seed potatoes physiologically young and without sprouting; being all these important factors to maintain seed potato quality for new plantings.

Summary

The effect of two harvesting times and two storage systems on the quality of seed potato tubers cv Spunta was studied The harvests were done 70 and 100 days after foliage death and tubers were stored during five months in air-cooled and ventilated store houses at 3°C and 95% relative humidity; and outdoor heaps covered with corn (*Zea mays*) straw.

The tubers harvested 70 days after foliage death were stored in outdoor heaps during one month and later a portion of them were stored in a store house, under controlled conditions. Frost registered between the 70th and 10th day after foliage death caused higher damages in the tubers that had not been harvested than in the harvested ones stores in heaps When the tubers were harvested and stored immediately under controlled conditions, adequate suberization occured in 63% on the tubers whose parenchyma was partially frozen, which prevented from later bacterial decay; but this fact did not occure in the heaps.

Seed potato tubers stored at 3°C and 95% relative humidity did not sprout and were physiologically younger than those stored in outdoor heaps.

Literature cited

1 BURTON, W G. The physics and physiology of storage **In:** The Potato Crop. P. M. Harris ed. Chapman and Hall, 1978 547 p.

2 CAVIA, C y CARUSO, S. Conservación de semilla de papa var. Katahdin en la región sudeste de la provincia de Buenos Aires, Argentina Ministerio de Agricultura y Ganadería de la Nación, Dirección de Fomento Agrícola División Hortalizas. Comunicación Técnica No. 5, 1952. 7 p.

3 CLAVER, F. K Influencia de luz, oscuridad y temperatura sobre la incubación de la papa. Phyton 1:3-12 1951.

4. CLAVER, F, K Influence of temperature during the formation of potato tubers and its effect on the first progeny Phyton 33:1-6. 1975

5. COUSILLAS, C y VIDAL, N Análisis de las temperaturas de Balcarce 1. Régimen de heladas. Balcarce, E.E.R.A. Departamento de Ecología y Técnica Cultural. 1981 11 p.

6. HUTCHINSON, R The dormancy of seed potatoes. 1 The effect of time of haulm destruction and harvesting. Potato Research 21:257-265. 1978.

7 O'BRIEN, P. and ALLEN, E Effect of area of seed production and date of lifting of seed crops on the performance of the progeny tubers. E.A.P.R. Conference Papers, Wageningen, The Netherlands, 1975. pp 41-42

8 RADTKE, W. y ESCANDE, A Mermas en papas almacenadas; mermas totales. Rev. Inv. Agr Serie 2 Biología y Producción Vegetal, 10:223-231 1973

9 VAN DER ZAAG, D. Requirements of the user of seed potatoes. Standards of health, grading and physiological age; time and mode of delivery; price. E. A. P. R Procc. 5th Trienn. Conf Norwich, 1972. 38-46. 1973.