Amylase and acid phosphatase activity in potato tubers treated with gibberellic acid and stored at 2°C and 8°C

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Abstract

Amylase activity was higher in tubers stored at 2°C and more marked in the soaked ones (both in water and in GA₃). In the late and difficult-sprouting cv. Uran, soaking resulted in increased amylolytic activity also at 8°C stored tubers. On the contrary, the acid phosphatase activity was a little higher at 8°C than at 2°C stored tubers. At the former temperature two peaks of activity were marked: in November—December and February—March.

INTRODUCTION

The transition from dormancy to sprouting is connected with several important changes in enzymatic activities. Hormonal control of these changes is postulated (Thomas et al. 1965; Amen 1968).

Amylolytic activity (expressed both on fresh or dry weight) in dormant and sprouting potato tubers is much lower than in barley and other cereal seeds (Weichsel 1936; Bailey et al. 191). That is probably why several authors doubt the presence of amylolytic activity in resting potato tubers (Doby and Bürger 1932; Whelan — after Samotus 1969) or they assume that amylase is there in an inactive form (Hanes 1937; Stepanenko et al. 1951). The activity of amylase increases at sprouting (Wright and Peacock 1938; Stepanenko et al. 1951). Compounds which break the dormancy, i.e. ethylene chlorohydrin or thiocyanate, also cause an increase in the amylolytic activity (Denny et al. 1930; Denny 1932).

Arreguin-Lozano and Bonner (1949), investigating the low temperature sweetening of potatoes, suggest that this process is not caused by increased amylolytic activity. On the contrary, Samotus et al. (1974) found a close positive relationship between changes in amy-

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lytic activity and sugar accumulation during cold storage of potato tubers.

The same authors (Arreguin-Lozano and Bonner 1949, Samotus 1974) did not, however, find considerable changes in acid phosphatase activity during storage of potato tubers at low temperature.

The increase of acid phosphatase activity during the end period of dormancy and at germination was observed in apple and rice seeds (Rychter et al. 1971; Rychter et al. 1972; Suzuki and Nisizawa 1974).

In our previous experiments on potato tubers (Bielińska-Czarnecka and Domańska 1969; Bielińska-Czarnecka and Bialek 1972; Bialek and Bielińska-Czarnecka 1975; Engelbrecht and Bielińska-Czarnecka 1972) high abscisic acid (ABA), low gibberellin like substances (GA) and cytokinins (CK) activities were observed during the rest period. With the approach of sprouting, activity the level of ABA decreased, and these of GA and CK increased. All factors hastening sprouting (high temperature, soaking in water or in GA_3 solution, treatment with ethylene chlorohydrin) accelerated the above mentioned changes in the content of active hormones.

It seemed interesting to examine whether amylase and acid phosphatase activities accompany the changes in hormone levels during dormancy and sprouting of potato tubers.

MATERIAL AND METHODS

Experiments were performed at Jadwisin (central Poland) on tubers of two cultivars: Pierwiosnek (early, easily sprouting) and Uran (late, slowly sprouting). Determinations of enzyme activities were carried out during 2-3 storage seasons during the period from 1970 to 1973. The tubers of cv. Pierwiosnek were harvested (depending on the year) from the 10th of September to the 8th of October, those of cv. Uran — from the 15th to the 26th of October. Thereafter, the batches of tubers were divided into three groups: 1) untreated, 2) soaked 24 h in water at room temperature, 3) soaked 24 h in GA_3 solution (Gibrescol preparation, 50 ppm, at room temperature). Then, the tubers were stored at 2°C or at 8°C. During the last experimental season the tubers of cv. Pierwiosnek (treated and untreated) were stored at only 8°C, the tubers of cv. Uran were left untreated and stored at 2°C and 8°C.

Enzyme activities were determined in the cortical part of the tubers (including the eyes), each month till February-March. Extraction and determination of enzyme activities were done as described earlier (Samotus and Leja 1973; Samotus 1974).

RESULTS

1. Amylase activity

The amylase activity was found in tubers of both cultivars and at all dates of investigations. This activity, calculated on fresh or dry weight, was much lower than that found in germinating seeds.

Independent of seasonal variations, tuber of both cultivars manifested a distinctly higher amylolytic activity at 2°C (Fig. 1 A-C) than at 8°C (Fig. 1 B-D). Soaking of the tubers in water markedly stimulated amylolytic activity at 2°C (except samples of cv. Pierwiosnek tubers estimated in December). At 8°C, this stimulation was pronounced in cv. Uran tubers but was negligible in cv. Pierwiosnek tubers. Addition of GA₃ to the solution in which the tubers were soaked had almost the same effect as water alone.

A lower amylase activity was observed in samples analyzed in November or December in plant material of both cultivars.

In Uran tubers a higher amylase activity and stronger reaction to soaking were observed at 8°C in January than in February-March.

2. Acid phosphatase activity

Activity of acid phosphatase was very low but generally a little higher in tubers stored at 8°C than at 2°C.* In tubers stored at 8°C, there were two peaks of acid phosphatase activity: in November-December and in February-March (Fig. 2 A-D). The second peak was very high for Pierwiosnek tubers. Response to the treatments (soaking in GA₃ solution or in water alone) was rather negligible. The tendency of the changes of acid phosphatase activity was similar in both years (Fig. 2 D).

DISCUSSION AND CONCLUSIONS

The storage temperature influence the amylase and acid phosphatase activities in potato tubers.

Amylase activity was higher in tubers stored at 2°C and was pronounced in samples soaked in water. At 8°C the response to soaking was manifested by an increase of amylolytic activity only in difficult-sprouting tubers of cv. Uran.

The influence of GA₃ on amylase synthesis in the barley aleurone layers has well been known (Paleg 1960; Varner and Chandra

* Activity of acid phosphatase, estimated in tubers stored at 2°C are not presented at the figures.

Fig. 2. Acid phosphatase activity of potato tubers stored at 8° C, calculated in mg⁰/₁₀ of P in d.wt.

A — cv. Pierwiosnek 1971/72; B — cv. Pierwiosnek 1972/73; C — cv. Uran 1971/72; D — cv. Uran, untreated tubers, 1971/72 and 1972/73

Solid line — untreated; dashed line — soaked in GA₃; dash-dot line — soaked in H₂O

1964; Chrisspels and Varner 1967 a, b). A similar effect has not so far been proved for potato tubers. In this experiment, GA₃ treatment was not effective in amylase activation and only soaking stimulated the amylase activity.

In contrast to amylase, acid phosphatase activity was generally a lit-

Fig. 1. Amylolytic activity of potato tubers in 1971/1972, Calculated in mg of glucose per 100 g d.wt./1 ha at 36°C (see p. 98)

A — cv. Pierwiosnek, tubers stored at 2°C; B — cv. Pierwiosnek tubers stored at 8°C;
 C — cv. Uran, tubers stored at 2°C; D — cv. Uran, tubers stored at 8°C
 1 — control, 2 — soaked in H₂O, 3 — soaked in GA₃

tle higher at 8°C than at 2°C. No clear response to tuber soaking (in water and in GA₃ solution) was observed.

The changes in acid phosphatase activity in this experiment during the storage period were similar to those observed by Rychter et al. (1971, 1972) in apple seeds during stratification.

The above data may suggest some differences in mechanisms of control for amylase and acid phosphatase activity in potato tubers during dormancy and sprouting.

Determination of the various isoenzymes of amylase and acid phosphatase as well as the use of other than GA₃ gibberellins, endogenous to potato, will probably clarify the influence of gibberellins on the activity of these enzymes in potato tubers.

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SUMMARY

The experiments were performed in 1970-1973. The potato tubers cv. Pierwiosnek (early) and Uran (late) were divided into three groups: untreated, soaked 24 h in water, and soaked 24 h in GA₃ (Gibrescol, 50 ppm) solution and then stored at 2°C or 8°C. Amylase and acid phosphatase activities in the cortical part of the tubers were determined each month till spring.

Amylase activity was higher in tubers stored at 2°C and more marked in the ones soaked (both in water and in GA₃). In the late and difficult-sprouting cv. Uran, soaking resulted in increased amylolytic activity also at 8°C stored tubers.

The acid phosphatase activity was on the contrary, a little higher at 8°C than at 2°C stored tubers. At the former temperature two peaks of activity were marked: in November-December and February-March.

These results suggest different mechanisms of control of amylase and acid phosphatase activities during dormancy and sprouting of potato tubers.

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Aktywność amylazy i kwaśnej fosfatazy w bulwach ziemniaka traktowanych Gibreskolem i przechowywanych w temperaturze 2 i 8°C

Streszczenie

Doświadczenie przeprowadzano w latach 1970-1973. Bulwy ziemniaka średniej wielkości odmian: Pierwiosnek i Uran dzielono po zbiorze na 3 partie: nietraktowane, moczone w wodzie przez 24 godz i moczone w GA_3 (w postaci Gibrescolu, w stężeniu 50 cz./milion), następnie przechowywano w temperaturze 2 i 8°C. Oznaczenia aktywności amylazy i kwaśnej fosfatazy przeprowadzano co miesiąc w liofilizatach korowej części bulw.

Aktywność amylolityczna (fig. 1 A-D) była istotnie wyższa u bulw obu odmian przy przechowywaniu w temperaturze 2°C; w tej też temperaturze uwiódodził się stymulujący wpływ moczenia zarówno w wodzie, jak i w GA_3 . Stymulujący wpływ moczenia u bulw przechowywanych w 8°C był widoczny jedynie u odmiany Uran.

Przeciwnie, aktywność kwaśnej fosfatazy była nieco wyższa u bulw przechowywanych w temp. 8°C; występowały u nich dwa okresy wzmożonej aktywności: w listopadzie—grudniu i styczniu-lutym (Fig. 2A-D). Moczenie, zarówno w wodzie, jak i w GA_3 , nie wywarło istotnego wpływu na aktywność tego enzymu.