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Organic Acids in Potato Tubers: Part 1—The Effect of Storage Temperatures and Time on Citric and Malic Acid Contents of Potato Tubers

G. Lisińska & K. Aniołowski

Department of Storage and Food Technology, Agricultural Academy, Norwida 25, 50-375 Wroclaw, Poland

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ABSTRACT

The effects of storage temperatures and time on citric and malic acid contents of potato tubers (Perkoz, Bliza and Bóbr varieties) are presented. Citric acid content decreased in potato tubers after 6 months' storage while the content of malic acid increased. Changes in citric acid were greatest in potato tubers stored at 7°C whereas those in malic acid proved to be greatest when storage temperature was 13°C.

INTRODUCTION

The basic processes of biochemical and physiological changes in potato tubers occur in a liquid environment, i.e. cellular juice. The acidity (pH) of potato tuber juice is determined by organic acids which are produced during the process of respiration. The organic acids are products of non-total oxidation of sugars and also of deamination of amino acids, ascorbic acid and polyphenolic acids. The acidity ranges from pH 5·25 to pH 6·67 (Schick & Klinkowski, 1961).

The total organic acids found in potato tubers (fresh matter) range from 0·4 to 1·0% (Lisińska & Leszczyński, 1989). The highest amount is citric acid (70–600 mg), then malic (20–150 mg), pyrrolidone carboxylic (14–127 mg), oxalic (8–38 mg), fumaric (0·6–8 mg) and succinic acids (1·4–4 mg) per 100 g of potato tubers (Herrmann, 1974; Thomas & Joshi, 1977). Moreover, such

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acids as ketoglutaric, isocitric, tartaric, malonic and others are present in potato tubers, but in lower quantities.

Potato tuber contents of organic acids undergo some changes during the growing period of potato plants and later, during storage. According to Wieczer and Gonczarik (1977), young tubers exhibit low acidity which progressively increases to reach its maximum within 90–100 days after planting. Next, as the potato tubers start reaching maturity, their total acid content diminishes. It is worth noting that early varieties exhibit lower acidity than late ones (Wieczer & Gonczarik, 1977).

Organic acid content of potato tubers can be affected by cultural factors, such as kind and rate of fertilization (Minina, 1953; Bečka & Miča, 1979), or chemicals applied (Sherman & Ewing, 1982). The impact of these factors is especially prominent during long-term storage (Zgórska & Frydecka-Mazurczyk, 1977).

Storage temperatures and time affect the contents of particular organic acids in potato tubers. The studies conducted by Hyde and Morrison (1964) prove that the pH of juice obtained from potatoes stored at 4°C is lower than that of potatoes stored at 21°C, but it should be noted that reconditioning increases the pH of potato juice. Sweeney *et al.* (1969) found that the citric acid content increased upon potato storage, while the content of malic acid decreased. However, these changes were more conspicuous when the storage temperature was 21°C than at 12·5°C. According to Schwartz *et al.* (1961, 1966) the content of citric acid decreases during the first 2 to 3 months of storage while malic acid content increases. The same authors observed a reverse relationship during prolonged storage when citric acid content increased and malic acid decreased. The decrease in citric acid resulting from long-term storage was also observed by Bečka and Miča (1979).

Additionally, slight amounts of fumaric and succinic acids and trace amounts of malonic acid occur in potato tubers after long-term storage or immediately after planting in May (Wieczer & Gonczarik, 1977). Irradiation used during potato storage has a pronounced influence on organic acid content of potato tubers. Thomas and Joshi (1977) found that irradiated potato tubers stored at 15°C exhibited an increased pH (to almost neutral) as distinct from non-irradiated. The irradiated tubers stored for 7 months were lower in citric but higher in malic and pyrrolidone carboxylic acids in comparison with control samples (Thomas *et al.*, 1979).

The contribution of organic acids to browning reactions occurring in potato flesh (Heisler *et al.*, 1964; Thomas *et al.*, 1979) as well as their indirect influence on the texture of cooked potatoes (Alešina & Volonkovič, 1971) or colour of subsequent fried potato products (Gould & Deppen, 1969; Lisińska, 1981) require attention from technologists selecting the material for processing.

The purpose of the present study, being the first in a series on organic acids in potato tubers, was to examine the effects of storage temperatures and time on citric and malic contents in potato tubers.

MATERIALS AND METHODS

Materials

The material selected for our studies consisted of Perkoz, Bliza and Bóbr potato varieties grown in the fields of Wrocław District in 1988. Potatoes were harvested at full maturity. The experiment started 3 weeks after harvest time. The samples of potato tubers (4 kg each) were packaged in three-layer paper bags and placed in chambers at 7°C and 13°C, humidity 85%. The experiment was carried out in four replications. The samples were subjected to chemical analysis before storage and after 3 and 6 months of storage.

Methods

Dry matter content of potato tubers was determined by the thermogravimetric method. Potatoes were sliced into 6-mm slices and freeze-dried. The dried potato slices were comminuted and next the contents of citric and malic acids were determined by gas chromatography (Kubacka & Kubacki, 1977; Dey *et al.*, 1983). The determinations were done in two laboratory replications. The obtained data were analysed statistically using the method of variance analysis.

RESULTS AND DISCUSSION

The contents of citric and malic acids differed among the potato varieties examined in our study. The early variety of Perkoz was the lowest in these constituents; on average it contained 131 mg of citric acid and 17 mg of malic acid per 100 g of potato tubers. Bliza, a mid-early variety, contained 188 and 23 mg per 100 g, and Bóbr, a late variety, 208 and 26 mg per 100 g, respectively (Table 1).

Six months' storage of potato tubers resulted in significant changes in citric and malic acid contents. The temperature of storage had a marked effect on the changes in organic acid contents, i.e. changes in citric acid were more pronounced in tubers stored at 7°C while malic acid content was more pronounced in the tubers stored at 13°C. After 6 months of storage, potato tubers stored at 7°C lost (on average) 41% of citric acid as compared to the

TABLE 1
Concentration of Citric and Malic Acids in Tubers of Three Potato Varieties Stored Six Months at Temperatures of 7 and 13°C

Potato varieties	*Storage time (months)*	*Storage temperature (°C)*	*Citric acid*		*Malic acid*	
			(mg/100 g (fresh))	*(mg/100 g (dry matter))*	*(mg/100 g (fresh))*	*(mg/100 g (dry matter))*
Perkoz	0		131	740	17	97
	3		84	459	18	94
	6	7	77	411	15	79
	3		115	659	21	113
	6	13	111	623	22	98
Bliza	0		188	779	23	93
	3		130	534	26	107
	6	7	97	398	21	88
	3		175	670	34	130
	6	13	159	582	30	111
Bóbr	0		208	803	26	101
	3		158	578	31	112
	6	7	135	453	29	98
	3		200	702	36	127
	6	13	175	560	37	116
Least significant difference (LSD) at 5% level:						
of storage time			12·8	57	1·1	4·2
of temperatures			10·4	47	0·9	3·4
of varieties			12·1	57	1·1	4·1

initial quantity (Fig. 1), whereas the loss of citric acid in potatoes stored at 13°C averaged only 16%. The highest loss of citric acid after 6 months' storage at 7°C was found in the mid-early variety of Bliza (48%, Table 1), and the lowest loss was observed in the late variety of Bóbr (35%). Thomas *et al.* (1979) observed a 9–65% loss of citric acid in potato tubers stored for a period of 7 months. However, changes in citric acid content depended on potato variety and irradiation rate. Sweeney *et al.* (1969) obtained quite opposite results, i.e. citric acid content of potato tubers stored for 5 months showed a rising tendency.

The increase in malic acid of the potatoes stored at 13°C for 6 months averaged 32% as compared to the initial values (Fig. 2), while potato tubers stored at 7°C for 3 months exhibited a 14% increase in malic acid which, after 6 months of storage, reached the initial value. Some authors (Schwartz *et al.*, 1966) suggest that it is interconversion of citric and malic acids

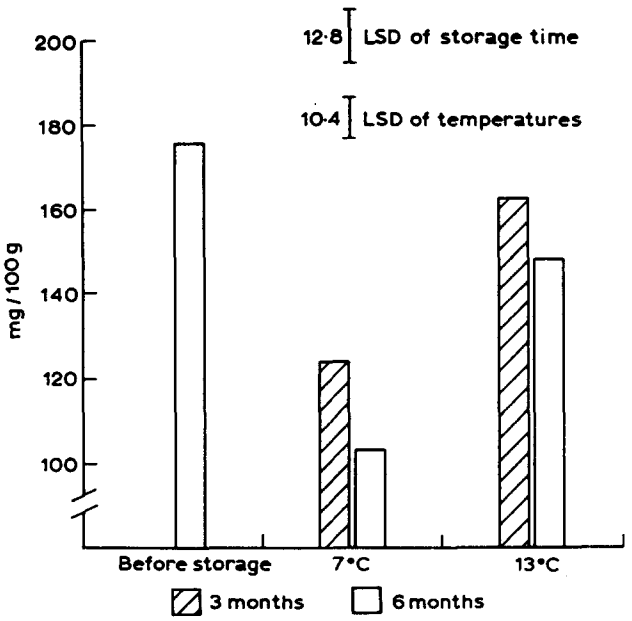

Fig. 1. Changes in citric acid content of potatoes stored 3 and 6 months at temperatures of 7 and 13°C (means of three varieties).

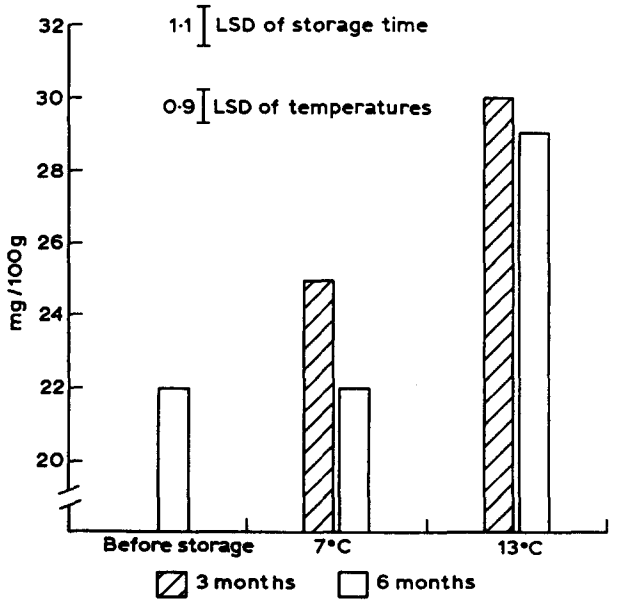

Fig. 2. Changes in malic acid content of potatoes stored 3 and 6 months at temperatures of 7 and 13°C (means of three varieties).

resulting from potato storage that is responsible for these changes, but this does not seem to be the only reaction since the quantitative changes in citric acid content are significantly larger than those of malic acid.

The decreasing content of citric acid in the stored tubers is undoubtedly connected with the increased susceptibility of potatoes to after-cooking darkening, which comparatively increases in tubers as storage is prolonged. The assumption of Hughes and Swain (1962) that citric acid is the factor that plays a major role in decreasing the intensity of colour within the complex of chlorogenic acid and iron, seems to be justified.

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