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# Organic Acids in Potato Tubers: Part 2—The Effect of Gamma Irradiation on Citric and Malic Acid Contents of Potato Tubers

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*ABSTRACT*

*The paper presents the changes in citric and malic acid contents of three potato varieties exposed and non-exposed to gamma irradiation. The changes were observed after 6 months storage at different temperatures. It was found that the irradiated tubers were lower in citric but higher in malic acid than those not exposed to irradiation. In the sixth month of storage, the irradiated tubers exhibited a markedly increased content of the citric acid which was only slightly lower than that observed in the control samples. The tubers exposed to gamma irradiation, stored at 13°C, were higher in citric acid than those stored at 4 and 7°C.*

## INTRODUCTION

Potatoes destined for human consumption and industrial processing require a long term storage under specific conditions. Their freshness can be sustained by delaying the dormancy period and suppression of sprouting which can be achieved using ionizing radiation or chemical sprout inhibitors. In some countries, however, e.g. Poland, the use of sprout inhibitors is prohibited, whereas irradiation is not regarded as hazardous (Lisińska & Leszczyński, 1989). Gamma irradiation used for this purpose delays sprouting of potato tubers (Kubicki, 1961), but does not affect enzymatic processes (Hayashi & Kawashima, 1983) or microbial activity (Bogucka *et al.*, 1984). Moreover, the radiation can affect chemical composition of potato tubers, e.g. sugar (Hayashi & Kawashima, 1982) and



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vitamin C content (Kubicki, 1961), increase susceptibility of the potato flesh to discoloration (Thomas *et al.*, 1979), increase phenolic content, and reduce lipid and phospholipid contents (Mondy & Gosselin, 1989).

In an earlier study, Lisińska and Aniołowski (1990) found that potato tubers stored for 6 months exhibited a decreased citric but increased malic acid content, which in their opinion was due to the storage temperatures. The purpose of the present study was to observe the changes in citric and malic acid contents of the potato tubers exposed to gamma irradiation prior to storage. The control samples selected for this experiment were not exposed to gamma irradiation.

## MATERIALS AND METHODS

### Materials

The material taken for the study consisted of three late potato varieties, i.e. Janka, San and Bóbr, grown in the Wrocław region in the years 1987 and 1988. The potatoes were exposed to gamma irradiation 3 weeks after the harvest date. The dosage applied was 150 Grays (15 000 rads). Next, 6-kg samples were selected from each variety for the analyses which were made: (a) before storage (5 days after exposure to gamma radiation), (b) after 2 months' storage at 4, 7 and 13°C, (c) after 4 months' storage at 4, 7 and 13°C and (d) after 6 months' storage at the above temperatures. The samples of non-irradiated potato tubers were divided likewise. All samples were packaged in three-layer paper bags and then placed in the chambers at 85% relative humidity.

### Methods

Dry matter content of potato tubers was determined by thermogravimetric method. Potatoes were cut 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. The determinations were done in two laboratory replications. The data were analysed statistically using the method of variance analysis.

## RESULTS AND DISCUSSION

Tables 1 and 2 show citric and malic acid contents of the three potato varieties exposed and non-exposed to gamma irradiation. It was found that

**TABLE 1**
Concentrations of Citric Acid (mg/100 g) in Irradiated and Non-irradiated Tubers of Three Potato Varieties Stored for Six Months at Temperatures of 4, 7 and 13°C (means of 2 years' experiments)

| *Storage time (months)* | *Storage temp. (°C)* | *Irradiated* | | | *Control* | | |
|---|---|---|---|---|---|---|---|
| | | *Janka* | *San* | *Bóbr* | *Janka* | *San* | *Bóbr* |
| 0 | — | 126 (614)[a] | 104 (450) | 104 (460) | 155 (695) | 123 (522) | 168 (698) |
| | 4 | 128 (520) | 120 (465) | 114 (454) | 145 (643) | 132 (533) | 142 (545) |
| 2 | 7 | 120 (551) | 121 (471) | 108 (432) | 142 (669) | 133 (553) | 171 (649) |
| | 13 | 130 (596) | 119 (596) | 117 (482) | 162 (696) | 139 (528) | 168 (648) |
| | 4 | 96 (424) | 108 (405) | 84 (344) | 114 (496) | 123 (478) | 111 (437) |
| 4 | 7 | 101 (435) | 105 (413) | 85 (349) | 127 (518) | 135 (485) | 129 (490) |
| | 13 | 157 (483) | 129 (428) | 95 (377) | 128 (530) | 134 (530) | 133 (495) |
| | 4 | 109 (481) | 132 (481) | 120 (466) | 140 (585) | 143 (520) | 134 (541) |
| 6 | 7 | 118 (488) | 129 (494) | 116 (473) | 130 (551) | 145 (523) | 152 (546) |
| | 13 | 120 (539) | 141 (517) | 134 (521) | 143 (561) | 153 (540) | 158 (571) |

Least significant difference (LSD) at 5% level:
of irradiated 3,5 (13,5);
of storage time × temperature 7,7 (29,7);
of varieties 6,0 (16,3).
[a] Values in parentheses—concentration of citric acid in mg/100 g dry matter.

the citric acid content of the irradiated tubers decreased markedly (12–38%) as compared to that observed in the control samples. At the same time, a 10–15% increase in malic acid (Table 2) was observed in the tubers exposed to gamma irradiation. After 2 months storage, the citric acid content decreased in the control samples stored at lower temperatures. At the same time, the irradiated tubers (especially those stored at 13°C) exhibited an increased amount of citric acid in the fresh matter. A marked decrease in citric acid content was observed in the fourth month of storage, both in irradiated and non-irradiated tubers. It was found that in the sixth month of storage, potato tubers were higher in citric acid than those stored for a shorter time. It is worth noting that the San and Bóbr varieties exposed to radiation were higher in citric acid after the storage than before it.

Malic acid (Table 2) showed comparatively smaller changes than citric acid. The malic acid content of potato tubers stored for 2 and 4 months was in the majority of the samples higher than that noted prior to storage. The irradiated potato tubers were in each case higher in malic acid (irrespective of storage temperature and time) than the control samples. The reports of Thomas *et al.* (1979) are in concurrence with the above observations.

**TABLE 2**

Concentrations of Malic Acids (mg/100 g) in Irradiated and Non-irradiated Tubers of Three Potato Varieties Stored for Six Months at Temperatures of 4, 7 and 13°C (means of 2 years' experiments)

| *Storage time months* | *Storage temp. (°C)* | *Irradiated* | | | *Control* | | |
|---|---|---|---|---|---|---|---|
| | | *Janka* | *San* | *Bóbr* | *Janka* | *San* | *Bóbr* |
| 0 | — | 19 (93)[a] | 22 (95) | 19 (83) | 17 (78) | 19 (78) | 17 (71) |
| | 4 | 23 (95) | 21 (84) | 22 (88) | 19 (85) | 18 (72) | 23 (89) |
| 2 | 7 | 23 (107) | 22 (88) | 23 (94) | 20 (90) | 17 (72) | 22 (84) |
| | 13 | 24 (110) | 21 (89) | 26 (102) | 21 (92) | 16 (64) | 19 (75) |
| | 4 | 18 (80) | 24 (89) | 20 (80) | 16 (70) | 21 (81) | 20 (76) |
| 4 | 7 | 21 (90) | 24 (91) | 18 (78) | 17 (67) | 20 (76) | 17 (62) |
| | 13 | 22 (97) | 28 (106) | 20 (79) | 17 (68) | 19 (70) | 17 (60) |
| | 4 | 17 (72) | 23 (83) | 17 (64) | 16 (67) | 21 (77) | 16 (64) |
| 6 | 7 | 20 (82) | 22 (83) | 19 (69) | 16 (67) | 19 (67) | 17 (59) |
| | 13 | 19 (86) | 26 (92) | 18 (68) | 16 (60) | 17 (61) | 16 (56) |

Least significant difference (LSD) at 5% level:
of irradiated 0,7 (2,1);
of storage time × temperature 1,6 (4,8);
of varieties 0,9 (2,6).

[a] Values in parentheses—concentration of malic acid in mg/100 g of dry matter.

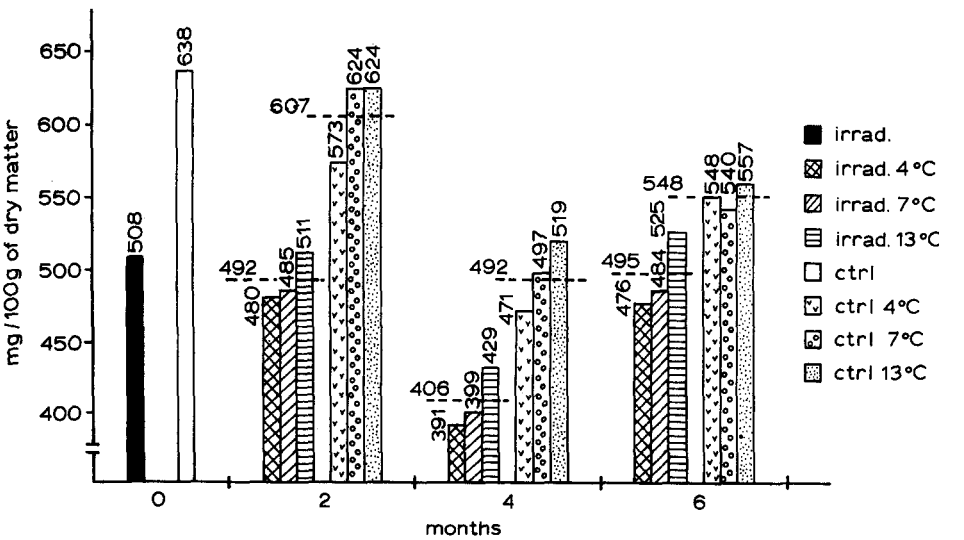


**Fig. 1.** Changes in citric acid content of irradiated and non-irradiated potatoes stored for six months at temperatures of 4, 7 and 13°C (means of three potato varieties).

Figure 1 shows citric acid contents of irradiated and non-irradiated potato tubers stored for 6 months (the means obtained for the three varieties examined). The diagram shows that irradiation reduced the citric acid content, but the difference between citric acid content in irradiated and non-irradiated tubers decreased not earlier than after 6 months of storage. A marked increase in citric acid content of the irradiated potato tubers in the sixth month of storage as compared to that found after 3 months' of storage is associated with reducing susceptibility of potato tubers to after-cooking darkening (Hampson *et al.*, 1986). This fact supports the thesis that citric acid is responsible for reducing the intensity of colour in the chlorogenic acid/iron complex (Hughes & Swain, 1962).

The impact of radiation on citric acid content was smaller in the case of potatoes stored at 13°C than at lower temperatures (4 and 7°C). Different effects of irradiation depending on storage temperatures and time were reported elsewhere. Leszczyński *et al.* (1990) found that sucrose and starch contents of irradiated tubers stored at 13°C for 6 months approximated those observed in the control samples, whereas the effect of irradiation was markedly higher at the storage temperature of 4°C.

The data presented in this paper show that gamma irradiation can be used as a sprout inhibitor provided that, parallely, the storage temperatures are regulated in such a way that the qualitative changes in potato tubers are minimal.

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