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# Effect of gamma-irradiation and extended storage on chemical quality in onion (*Allium cepa* L.)

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The effects of gamma-irradiation and long-term storage on the chemical quality of the *Valenciana sintética 14* onion variety were determined under warehouse conditions in two sets of bulbs grown consecutively in 1988 and 1989. In both years irradiated and non-irradiated bulbs showed similar behaviour in terms of carbohydrate and ascorbic acid contents throughout the 300 days of storage. It was found that the carbohydrate content significantly decreased in irradiated and non-irradiated samples up to 180 days of storage. The storage time was found not to have a significant effect on the ascorbic acid content of bulbs. The carbohydrate and ascorbic acid contents were found to be higher in the irradiated and non-irradiated bulbs grown in 1988. Neither storage time nor gamma-irradiation nor the specific year significantly affected dry matter or acidity. Gamma-irradiation did not significantly affect flavour strength in terms of total pyruvate content.

## INTRODUCTION

Several authors have reported the efficacy of the radioinhibition process in a number of varieties of onion bulbs under different storage and irradiation conditions (Dallyn & Sawyer, 1959; Lewis & Mathur, 1963; Salem, 1974). A previous paper (Curzio & Croci, 1983) described the effects of the irradiation process on the *Valenciana sintética 14* onion, the most marketable variety in Argentina. A dose of 30·0 Gy of $^{60}CO$ gamma rays applied during dormancy was sufficient for sprout inhibition. After up to 300 days of storage, irradiated onion bulbs underwent a loss in weight and marketable bulbs were about 100% smaller than non-irradiated ones. Moreover, once treated, this variety has proved to be suitable for export (Curzio *et al.*, 1985).

Despite the existence of data on the commercial quality of irradiated onion bulbs, little information is available about the pattern of change of the main chemical components of the bulbs during long-term storage. Dallyn and Sawyer (1959) reported that irradiation had no significant effect on the carbohydrate content of Yellow Globe, Sweet Spanish and Texas Grano onion varieties after 6 months of cold storage. Lewis and Mathur (1963) found no modifications in carbohydrates and ascorbic acid as a result of irradiation in the Red Globe variety after 5 months storage at room temperature. However, a noticeably lower level of ascorbic acid compared with that found in non-irradiated bulbs was reported in Egyptian varieties of onion (Salem, 1974).

Kawakishi *et al.* (1971) noted that irradiation treatment made the characteristic flavour of onion milder, whereas Dallyn and Sawyer (1959) claimed that it became stronger. In *Allium*, the cleavage of flavour precursors by enzymatic attack produces thiopropanal S-oxide, sulphenic acid, sulphur volatiles, pyruvate, and ammonia. Among these decomposition products, pyruvic acid is considered to be the most suitable for assessing flavour in onion (Schwimmer & Guadagni, 1962).

The aim of this study was to evaluate the effects of irradiation and long-term storage on the *Valenciana sintética 14* onion variety during two consecutive years in terms of chemical quality. Dry matter, water-soluble carbohydrate, ascorbic acid and pyruvate content — the latter as a measure of flavour strength — and the acidity of aqueous extracts were recorded monthly in bulbs stored under warehouse conditions for 300 days.

## MATERIALS AND METHODS

### Materials

Observations were made on stored bulbs grown in 1988 and 1989. In both years the *Valenciana sintética 14*

onion variety grown in the Southwest of Buenos Aires province was used. Onions harvested by hand were naturally cured in the field for 10 days in the middle of February. Medium-sized (45–60 mm, mean weight 86·5 g) export quality bulbs were selected for the study. In both years about 75 kg of bulbs were packed in nylon string bags containing 5 kg each. The bulbs were stored in commercial warehouse conditions up to and after irradiation treatment. Storing was for 300 days at a temperature ranging from 6 to 32°C and RH of 40–50%.

### Irradiation

The treatment was applied 30 days after harvest as reported by Curzio and Croci (1983). Irradiation was carried out at the facilities of the Comisión Nacional de Energía Atómica in Ezeiza, in an IMO-I Transportable Irradiator. Bulbs were treated in air at 20°C, with a dose of 50 Gy using $^{60}$Co gamma rays. The dose-rate was 0·35 Gy/s as determined by Fricke dosimetry, and the dose uniformity ratio was 1·25.

### Chemical analyses

The chemical assays were carried out monthly on marketable bulbs, subsamples for analysis consisting of composite samples of equal quarter wedges from 17 peeled bulbs. Sprouts were not included in the material for chemical analysis.

The dry matter content (expressed as a percentage of fresh weight) was determined by drying the samples at 90 ± 2°C until a constant weight was obtained. The carbohydrates were extracted by homogenizing the sample with distilled water and measured by the anthrone colorimetric method with glucose as standard (Yemm & Willis, 1954). The photometric assay with 2,6-dichlorophenolindophenol was used to evaluate the ascorbic acid content (Ruck, 1969); the extracts were obtained by homogenizing the tissue with oxalic acid. The acidity was determined from aqueous extracts by using a potentiometric measure. In the samples grown in 1989, the flavour strength was evaluated in terms of total pyruvate content by using 2,4-dinitrophenylhydrazine as described by Schwimmer and Guadagni (1962).

### Statistical analyses

Data from chemical assays were analysed by analysis of variance (ANOVA). The effects of treatment, storage time and crop year and the interaction between these three factors and dry matter, acidity, carbohydrates and ascorbic acid were analysed by three-way analysis of variance. Two-way analysis of variance was used to test the effects of treatment and storage time on the content of pyruvic acid. It was found appropriate to treat the data as the untransformed values. Data presented are the averages of three subsamples analysed in triplicate.

## RESULTS

Figure 1 shows the carbohydrate content in irradiated and non-irradiated onion bulbs during storage for two consecutive years. Carbohydrate behaviour in the two treatments was found to be similar ($P > 0·05$) throughout storage in both years, with a decrease ($P < 0·01$) in carbohydrate content up to 180 days of storage; the decrease was less pronounced in irradiated bulbs. Bulbs from the 1988 crop showed a higher ($P < 0·05$) carbohydrate content than those from the 1989 crop.

The ascorbic acid content was also similar ($P > 0·05$) in irradiated and non-irradiated bulbs from the two consecutive years (Fig. 2). The storage time was not found to have a significant effect ($P > 0·05$) on ascorbic acid content. Up to 180 days of storage, irradiated bulbs on the whole showed a higher ($P < 0·05$) ascorbic acid content than non-irradiated ones. Bulbs from the 1988 crop showed a higher ($P < 0·05$) ascorbic acid content than those from the 1989 crop.

The behaviour of dry matter content was similar ($P > 0·05$) in irradiated and non-irradiated bulbs during storage in two trials. Radiation treatment and the crop year were not found to have any significant ($P > 0·05$) effect on dry matter content. The dry matter in both samples varied between the beginning and the

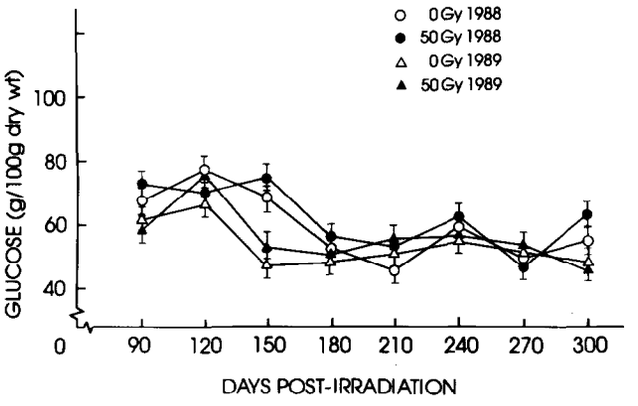


**Fig. 1.** Effect of gamma-irradiation and extended storage on the water-soluble carbohydrate content in *Valenciana sintética 14* onion variety.

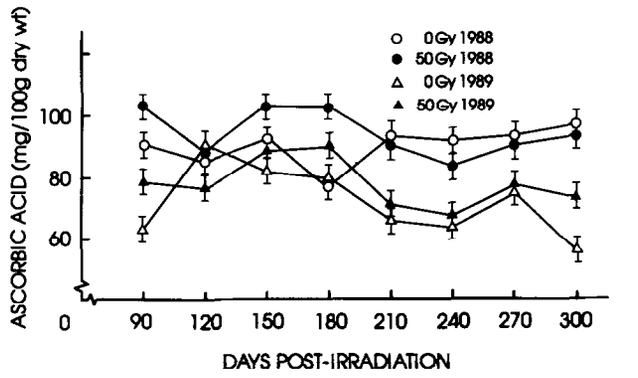


**Fig. 2.** Effect of gamma-irradiation and extended storage on the ascorbic acid content in *Valenciana sintética 14* onion variety.

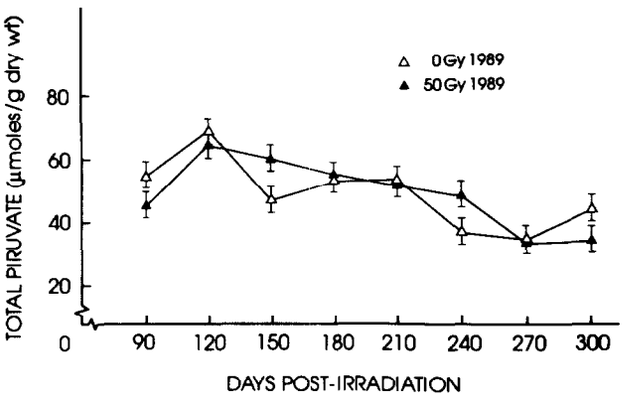


**Fig. 3.** Effect of gamma-irradiation and extended storage on flavour strength in *Valenciana sintética 14* onion variety.

end of the storage period in each year as follows: 7·7–7·3 g/100 g for irradiated bulbs and 7·8–7·2 g/100 g for non-treated ones.

The acidity of aqueous extracts from bulbs was shown to be identical ($P > 0.05$) in irradiated and non-irradiated bulbs during storage. Irradiation treatment and the crop year had no influence ($P > 0.05$) on bulb acidity. The pH 5·5 value remained practically constant during the storage period both in irradiated and non-irradiated bulbs.

The total pyruvate content during storage of marketable bulbs grown in 1989 is shown in Fig. 3. The pyruvate behaviour was similar ($P > 0.05$) in irradiated and non-irradiated bulbs, an overall decrease ($P < 0.05$) being noted for both treatments during the course of storage. Irradiation treatment was found not to have any significant effect ($P > 0.05$) on the bulbs' pyruvate content.

## DISCUSSION

Although the effect of irradiation treatment on carbohydrate and ascorbic acid contents in different onion varieties under different storage conditions has been reported (Dallyn & Sawyer, 1959; Lewis & Mathur, 1963; Salem, 1974), such data has only referred to bulbs from one season, stored for short periods. The results of the present paper show that, for two consecutive seasons, onions of the *Valenciana sintética 14* variety irradiated and stored for 10 months have, on the whole, higher carbohydrate and ascorbic acid contents than non-irradiated ones. These findings can be attributed either to a higher extractability of these components as a result of irradiation (Tobback, 1977) or to a delay in the evolution of the metabolism of these substances as a result of the treatment. The latter possibility is in line with recent research reported by Croci (1988).

Variations found in the chemical components of onion bulbs of individual varieties grown in different years have been attributed to different factors, especially climatic and cultural conditions (Nilsson, 1980; Fendwick & Hanley, 1985). The results show that bulbs of the *Valenciana sintética 14* onion variety grown in 1988 had more carbohydrates and ascorbic acid than those grown in 1989. An incomplete curing process (Dallyn & Sawyer, 1959) or an early harvest (Nilsson, 1980) may have led to these results.

With reference to the dry matter content of bulbs, no variations were found as a result of storage or irradiation for either year. This fact would appear contradictory since it has been stated that dry matter losses take place as sprouting progresses (Brewster, 1987). However, it should be noted that, in the present work, dry matter was determined on scale leaves from non-irradiated bulbs without external sprouting and irradiated ones in which sprouting was absent.

The behaviour pattern of acidity values in bulb extracts is identical to dry matter content, which is in agreement with results reported previously for garlic (Curzio *et al.*, 1986).

The flavour strength in terms of total pyruvate content was investigated only in bulbs grown in 1989. Irradiated and non-irradiated onions exhibited identical variations in total pyruvate content during 10 months of storage. This is corroborated by the fact that irradiation did not cause any alteration in flavour of this variety as measured in terms of the olfactory threshold level (Curzio & Urioste, 1993), and suggests that irradiation treatment has no influence on the metabolism of onion flavour components, which is in agreement with previous observations (Bandyopadhay *et al.*, 1973).

The significance of the findings of the present study is that the irradiation process and long-term storage affects neither the flavour nor the chemical quality of onion bulbs of the *Valenciana sintética 14* variety. Moreover, the process led to an improvement in carbohydrate and ascorbic acid contents, both basic to the human diet. The study provides a useful basis on which to commence the introduction of irradiated bulbs for domestic use and for export.

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