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Influence of post-harvest storage temperature and gamma irradiation on potato carotenoids

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Summary

A comparative study of nine Indian potato varieties showed a good correlation between their total carotenoid content and the tuber flesh colour. Regardless of varietal differences, carotenoid level showed an increase during storage at ambient temperature (25–30 C) and to a lesser extent at 2–4 C and 15 C. Tubers exposed to an irradiation dose of 10 krad for sprout inhibition showed decreased levels of carotenoids during storage, particularly at 15 C where 50 % loss was observed after 6 months of storage. Irradiated tubers stored for seven months at 15 C, on reconditioning at 34–35 C for 6 to 12 days showed a 2- to 6-fold increase in their carotenoid content.

Introduction

Carotenes supply approximately three fifths of the vitamin A requirements in the normal diet (Ezell & Wilcox, 1962). Carotenoids impart an aesthetically pleasing pale yellowish flesh colour to many potato varieties, though nutritionally the tubers are not a good source of these pigments. Brunstetter & Wiseman (1947) reported that β-carotene, lutein, ε-carotene and flavoxanthin were the major pigments in cv. Katahdin. Kasim (1967) found that α-carotene, β-carotene-5, 6:5,6-diepoxide, lutein, lutein-5,6-epoxide, violaxanthin and neoxanthin were the major pigments in nine potato cultivars. Pendlingston et al. (1965) have investigated the carotenoid components of several potato varieties at various maturities. They found β-carotene, β-carotene-5,6-monoepoxide, unknown I, cryptoxanthin-5,6-diepoxide, lutein, cis-violaxanthin, cis-anthraxanthin-5,6-monoepoxide and cis-neoxanthin were the most abundant pigments common to all the varieties. According to them, the carotenoid content depended on the variety and maturity, and colour of the flesh ranged from white to pale yellow.

Very little information is available on the changes in carotenoid content of potatoes during storage. Thomas & Joshi (1977) reported a reduction in carotenoid content of gamma-irradiated Kufri Chandramukhi potatoes during storage at 15 C. They found that reconditioning of such tubers at a higher temperature partially restored the carotenoid level. The present work was undertaken to study the changes in carotenoid content of different Indian potato varieties during storage at various temperatures and to confirm the effect of gamma irradiation and reconditioning on carotenoid content.

Materials and methods

Nine varieties of potato were obtained from the Central Potato Research Institute, Simla. Tubers were irradiated within a month after harvest with 10 krad in a Cobalt-60 Package Irradiator in air at 25 C at a dose rate of 0.5 krad/min. Tubers, 20 kg each from irradiated and unirradiated lots were stored in gunny bags for six months at 15 ± 1 C and 25–30 C (room temperature). For comparative purposes, unirradiated tubers were stored at 2–4 C, the conventional cold storage temperature. Cultivars Kufri Chandramukhi, K. Sindhuri, K. Kuber, K. Alankar and K. Sheetman were analysed periodically during storage. Other cultivars were kept untouched for six months and then removed periodically at one month intervals for reconditioning. Reconditioning of 3 kg lots from each variety was carried out for 12 days at 34–35 C and 90–93 % r.h. in a humidity chamber.

Extraction and phase separation of carotenoids were carried out as described previously (Thomas & Janave, 1975). Diced tissue (25 g) pooled from 8 to 10 tubers was used for carotenoid extraction. The concentration of total carotenoids, carotenes and xanthophylls were determined by absorbance at 436 nm in a Bosch and Lomb spectrophotometer. The values reported are averages of two separate estimations.

Carotenes and xanthophylls, after phase separation, were further subjected to thin-layer chromatography by the procedure of Hiyama et al. (1969). β-carotene and xanthophylls were determined by absorbance at 436 nm in a Bosch and Lomb spectrophotometer. The values reported are averages of two separate estimations. thophylls were quantitatively determined spectrophotometrically as above.

Results and discussion

The total carotenoid content of different varieties at harvest varied between 0.6 and 1.75 mg/kg (Table 1). The colour of the tuber flesh ranged from whitish to straw yellow depending on the variety, which could be correlated with the level of carotenoids present. K. Chandramukhi showed the highest amounts, and SLB, K. Kuber and K. Sheetman the lowest.

Changes in total carotenoid content of different potato varieties during storage at various temperatures are shown in Fig. 1. At room temperature (25–30 C), irradiated and unirradiated tubers of K. Chandramukhi and K. Alankar showed an initial decrease (14 to 30 %) during the first month followed by a gradual increase thereafter. After a storage period of 100 days the carotenoid content in K. Chandramukhi and K. Alankar showed 15 and 9 % increase respectively in irradiated tubers as against 35 and 60 % increase in unirradiated tubers. The carotenoid content of K. Kuber, K. Sindhuri and K. Sheetman varieties showed 156, 66 and 82 % increase in unirradiated tubers after 100 days of storage whereas in irradiated tubers the increases were 130, 40 and 15 % respectively. Throughout storage at room temperature, the carotenoid content of irradiated tubers was less than that in unirradiated tubers.

At 15 C, unirradiated tubers of all the varieties generally showed a slight decrease in

Table 1. Relationship at harvest between flesh colour and the content of carotenoids of potatoes.

Variety	Flesh colour	Total carotenoids (mg kg)
K. Chandramukhi	straw yellow	1.75
K. Sindhuri	straw yellow	1.53
K. Alankar	straw yellow	1.30
K. Kuber	whitish to pale yellow	0.75
K. Sheetman	whitish to pale yellow	0.73
SLB	whitish	0.62

their carotenoid content during the initial two months of storage followed by a gradual increase thereafter, reaching the original or even higher levels (10 to 40 % increase over the initial value) at 100 days. At this period the control tubers had long sprouts and were shrivelled and hence could not be used for further analysis. However a random analysis of unirradiated tubers (excluding sprouts) at 6 months showed a decreasing trend in carotenoid content. The increase in carotenoid content in the above tubers after 100 days of storage is attributed to the loss in moisture and consequent high dry matter content. In contrast, irradiated potatoes of all the varieties, generally showed a continued decrease in carotenoid level with advancing storage, the values reaching almost 50 % of the initial levels after 6 months of storage.

At 2–4 C, unirradiated K. Chandramukhi and K. Alankar potatoes showed a 20 % decrease in carotenoid content during the first one month of storage followed by a steady increase reaching the initial levels after 100 days. Thereafter the pigment levels remained constant upto 6 months of storage when the experiment was terminated. In

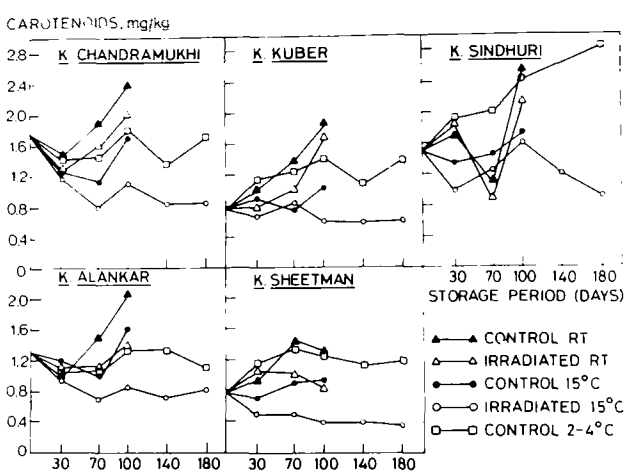

Fig. 1. Changes in total carotenoid content (mg kg) in irradiated and unirradiated potatoes during storage.

the other three varieties the carotenoid content increased by 60 to 80 % after 100 days of storage and remained at that level during further storage except in K. Sindhuri which showed a continued increase.

It is clear from the data that irrespective of varietal differences or storage temperatures, gamma irradiation resulted in a decrease in the tuber carotenoid level during storage, the losses being more at 15 C. Temperature also seems to influence the synthesis of carotenoids during storage, maximal accumulation taking place at room temperature. It has been reported that the carotenoid content of sweet potatoes during storage decreased at low temperatures but increased at higher temperatures (Ezell & Wilcox, 1952).

The effect of reconditioning on the renewed synthesis of carotenoids in irradiated potatoes previously stored at 15 C for seven months is shown in Table 2. Reconditioning for six days at 34–35 C showed a one- to three-fold increase depending upon the variety, maximum carotenoid accumulation was found to occur after 12 days of reconditioning. In three varieties the increase over the initial levels was about six-fold and in others it was about two- to three-fold. The carotene : xanthophyll ratio was found to be approximately 1 : 1 in the reconditioned tubers. Unirradiated potatoes stored at 2–4 C for seven months showed high carotenoid content as compared to irradiated potatoes of the same varieties stored for a similar period at 15 C (see Table 2). The carotene : xanthophyll ratio in unirradiated K. Chandramukhi, K. Jyoti and SLB potatoes was about 1.4 : 1 whereas in K. Dewa and K. Chamatkar it was about 1 : 1.5.

Phase separation of carotenoid pigments of K. Chandramukhi tubers stored for five months at 2–4 C revealed that the carotene : xanthophyll ratio was about 1 : 3 which changed to 1.5 : 1 in tubers stored for 7 to 8 months. Thin layer chromatography of the

Table 2. Carotenoids formation during reconditioning (0, 6 and 12 days) at 34–35 C and 90–93 % r.h. of irradiated potatoes.*

Variety	Total carotenoids (mg/kg)			Carotenes (mg/kg)			Xanthophylls (mg/kg)		
	0 days	6 days	12 days	0 days	6 days	12 days	0 days	6 days	12 days
K. Chandramukhi	0.42	1.10	2.52	–	0.52	0.81	–	0.40	0.88
K. Chamatkar	1.00	1.44	2.10	0.63	0.77	0.70	0.34	0.56	0.84
K. Dewa	0.22	0.42	1.22		–	0.46	–		0.56
K. Jyoti	0.22	0.60	1.52	–	–	0.53	–	–	0.56
SLB	0.68	1.10	1.94	0.42	0.61	0.70	0.30	0.32	0.94

* Irradiated tubers stored for a period of seven months at 15 C were used for these studies.

The content of total carotenoids, carotenes and xanthophylls for unirradiated potatoes stored for seven months at 2–4 C were as follows: K. Chandramukhi 1.84, 0.64, 0.48; K. Chamatkar 4.10, 1.35, 1.60; K. Dewa 1.34, 0.39, 0.56; K. Jyoti 1.40, 0.55, 0.32; SLB 1.92, 0.71, 0.56 mg/kg respectively.

carotene fraction showed that β-carotene accounted for about 60% of the total carotenes in this variety.

The present study shows that gamma irradiation of potato tubers at sprout inhibiting dose level results in increased disappearance of carotenoid pigments during storage especially at cool temperatures (15 C). The flesh colour of such tubers can be improved by reconditioning at higher temperatures. However bacterial soft rot appears to be a serious problem when the reconditioning period exceeds six days.

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