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Effect of γ – ray irradiation on storage behaviour in garlic (*Allium sativum* L.)

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Abstract

Experiments conducted at Rajgurunagar (Maharashtra) to study the effect of γ-ray irradiation and cold storage on storage losses in garlic (*Allium sativum*) indicated that cold storage of garlic reduced physiological weight loss and infection due to diseases. These losses were lower than ambient stored garlic even after 5 months of storage. Un-irradiated cold stored garlic showed rapid sprouting during post cold storage period but this low temperature induced sprouting was not noticed in γ-ray irradiated cold stored garlic after storage period. Overall, γ-ray irradiation followed by cold storage minimized the storage losses by 15% to 20% and increased the shelf life of garlic.

Keywords: *Allium sativum,* cold storage, gamma irradiation, garlic.

Introduction

Garlic (*Allium sativum* L.) is cultivated in India in the plains from October to March, while in the northern hills from September to June and May to October in the southern hills. Garlic is used every day in various culinary preparations but freshly harvested garlic is available from March to May only; during remaining part of the year stored garlic is used. Thus, about 80% of garlic harvested, is to be stored for 6 to 8 months. Garlic is usually stored in hessian cloth bags under room temperature. The major storage losses in garlic are physiological weight loss (12%–15%) and also due to various diseases such as soft rot, blue mould, grey mould and black mould (10%–25%). Total losses during storage for 5 to 6 months are as high as 30% – 40% (Maini & Chakravatri 2000). Internal sprouting in cloves of garlic is common after November, which results in rapid weight loss and reduction in quality. Irradiation is effective in controlling sprouting and pathogens in many crops such as onion, potato and garlic (Thomas *et al*. 1975; Curzio 1982; Croci & Curzio 1983). Treatment of garlic bulbs with γ-ray irradiation within 6 weeks of harvesting inhibits sprouting, reduces weight loss and prolongs storage life (Curzio 1982; Curzio & Urioste 1994; Warade & Shinde 1998).

Storage losses in garlic can be reduced by storing in ventilated storage structures but the physiological weight loss during summer and infection by *Aspergillus* spp. and other pathogens in rainy season remains high. These losses can be minimized under controlled temperature and relative humidity regimes. Low temperature storage provides ample opportunity to control storage losses. The beneficial effect of low temperature storage has been successfully used in many vegetable crops (Hardenburg 1986). In tropical conditions, low temperature induced sprouting is the major problem in cold stored garlic. γ-Ray irradiation, which is known for sprout inhibition, may be helpful in reducing post cold storage sprouting. Therefore, an experiment was conducted to study the effect of irradiation and cold storage on storage losses in garlic.

Materials and methods

The trials were carried out at National Research Centre for Onion and Garlic, Rajgurunagar (Maharashtra) during 2002 and 2003. Well-cured and dried bulbs of garlic (cv. G-41) were irradiated with 75 Gy dose of a cobalt-60 package irradiator in air for fraction of second at ambient temperature at Bhabha Atomic Research Centre, Mumbai. The irradiated and un-irradiated garlic bulbs were packed in hessian cloth bags and stored from May to October under two storage conditions, namely ambient condition in modified bottom ventilated storage structure; and in cold store at $0–2^{0}$C and 65%–70% relative humidity. The cold stored garlic lots were taken out from store after 5 months and observations on weight loss, disease infection and sprouting were recorded. These cold stored and ambient stored treatments were kept under room temperature from October to December to study post cold storage behaviour. Observations on weight loss, disease infection and sprouting were recorded at 20 days intervals. The temperature and humidity conditions during storage are given in Figs. 1 and 2. The data were statistically analysed using randomized block design.

Fig. 1. Temperature and relative humidity conditions in bottom ventilated storage structure during experimentation in garlic

Fig. 2. Temperature and relative humidity conditions in cold store during experimentation in garlic

Results and discussion

Loss during storage

Effect of temperature

Total loss in cold storage was significantly lower (11.2%) than bottom ventilated storage structure namely, ambient condition (33.8%) after 5 months. Physiological weight loss was 14.7% in ambient stored garlic, while it was only 4.9% in cold stored garlic. Diseases such as blue mould and grey mould causing softening and drying of cloves was significantly higher (16.3%) in ambient stored treatments, while it was only 5.2% in cold stored treatments. Similarly, black mould infection was significantly lower in cold stored bulbs than ambient stored ones. No sprouted bulb was found in any of the treatments (Table 1). The lower weight loss in cold storage was due to low temperature, which reduces the respiration rate and slows

Table 1. Effect of irradiation and storage environment on storage loss in garlic

Treatment	Physiological weight loss (%)		Disease incidence (%)		Black mould (%)		Total loss (%)	
	UI	I	UI	I	UI	I	UI	I
Ambient stored	14.7	15.0	16.3	16.7	2.8	2.4	33.8	34.1
Cold stored	4.9	6.1	5.2	4.8	1.1	1.0	11.2	11.9
CD (P=0.05)	2.5		2.3		0.7		3.5	

Period of storage: May– October ; UI=Un-irradiated; I= Irradiated

down metabolic activities. Further, the constant optimum humidity level (65%–70%) minimized moisture loss from bulbs. Similarly, the low incidence of diseases may also be attributed to low temperature and moderate humidity conditions (Hadenburg 1986).

Effect of γ–ray *irradiation*

There was no effect of γ–ray irradiation on total storage losses during 5 months of storage. Physiological weight loss and disease infection were statistically on par in both irradiated and un-irradiated bulbs. There were no sprouted bulbs in all the treatments (Table 1).

Post storage behaviour

Physiological weight loss

Physiological weight loss increased rapidly in cold stored treatments during first 20 days after taking out from cold store. Thereafter, the rate of weight loss was low in irradiated bulbs but it remained high in un-irradiated cold stored bulbs. The rate of weight loss was lower in ambient stored treatments. The highest weight loss (38.9%) after 80 days was recorded in un-irradiated ambient stored bulbs which was on par with un-irradiated cold stored treatment. Lower weight loss was recorded in irradiated cold store (29.3%) and irradiated ambient stored bulbs (29.4%) and these were significantly lower than the un-irradiated treatments (Table 2).

The rapid weight loss in cold stored garlic after taking from cold store was due to increase in respiration rate. The reduction in rate of weight loss after 20 days might be due to moderate temperature and humidity conditions during November and December. The increased rate of weight loss in un-irradiated ambient stored bulbs after 60 days of taking out from store may be correlated to internal sprouting of cloves, which is the normal tendency in garlic after the onset of winter. The lower rate of weight loss in irradiated bulbs in post cold storage period may be due to inhibition of internal sprouting. Lower weight loss and firmness in irradiated onion bulbs have been reported by Curzio & Urioste (1994).

Disease incidence

The incidence of diseases particularly *Fusarium* rot and neck rot in cold stored irradiated and

Table 2. Physiological weight loss during post cold storage period in garlic

Treatment	Weight loss after taking out from cold storage (%)			
	20 days	40 days	60 days	80 days
Un-irradiated, ambient stored	17.9	20.3	25.0	38.9
Un-irradiated, cold stored	17.3	21.4	29.8	37.8
γ-Irradiated, ambient stored	20.3	23.9	27.0	29.4
γ-Irradiated, cold stored	16.5	19.7	24.2	29.3
CD (P=0.05)	3.4	3.7	4.0	5.3

Period of observation: October–December

Table 3. Incidence of diseased garlic bulbs during post-cold storage period in garlic

Treatment	Disease incidence (%)			
	20 days	40 days	60 days	80 days
Un-irradiated, ambient stored	16.8	22.5	28.9	31.8
Un-irradiated, cold stored	8.7	15.3	21.8	27.7
γ-Irradiated, ambient stored	23.7	27.3	31.6	34.1
γ-Irradiated, cold stored	9.2	16.4	20.1	24.2
CD (P=0.05)	3.8	4.4	4.8	5.2

Period of observation: October–December

un-irradiated bulbs increased rapidly after taking out from cold store and this rate of increase was almost the same up to 80 days. Significantly lower incidence of diseased bulbs was recorded in irradiated cold stored treatment (24.2%) and un-irradiated cold stored treatment (27.7%). The highest incidence of diseased bulbs (34.1%) was found in γ−ray irradiated ambient stored bulbs which was on par with un-irradiated ambient stored bulbs (Table 3). The infection of black mould was less than 5% in all the treatments and there was no significant difference among various treatments (Table 4). The higher disease infection in cold stored bulbs during post cold storage period may be due to wetting of outer scales of bulbs by condensation of water on bulbs just after taking out from cold store.

Sprouting

There was no sprouting of bulbs in irradiated treatments and the un-irradiated bulbs stored under ambient condition during post storage period. Rapid sprouting (13.3%) was recorded in un-irradiated cold stored garlic bulbs during the first 20 days of post cold storage period which was constant up to 80 days. Internal sprouting of cloves was noticed in un-irradiated garlic after 190 days of storage but there was no sprouting in the irradiated garlic even after 230 days of storage and the bulbs remained firm (Table 5). The rapid sprouting of cloves in un-irradiated cold

Table 4. Incidence of black mould during post-cold storage period in garlic

Treatment	Black mould incidence (%)			
	20 days	40 days	60 days	80 days
Un-irradiated, ambient stored	2.9	3.8	3.8	3.8
Un-irradiated, cold stored	4.6	4.9	4.9	4.9
γ-Irradiated, ambient stored	1.1	1.3	1.3	1.3
γ-Irradiated, cold stored	1.1	1.4	1.4	1.4
CD (P=0.05)	NS	NS	NS	NS

Period of observation: October–December

Table 5. Sprouting of garlic bulbs during post-cold storage period

Treatment	Sprouted garlic bulbs (%)			
	20 days	40 days	60 days	80 days
Un-irradiated, ambient stored	0	0	0	0
Un-irradiated, cold stored	13.3	13.3	13.3	13.3
γ-Irradiated, ambient stored	0	0	0	0
γ-Irradiated, cold stored	0	0	0	0
CD (P= 0.05)	1.6	1.6	1.6	1.6

Period of observation: October–December

Table 6. Total loss during storage of garlic

Treatment	Total loss (%)				
	150 days	170 days	190 days	210 days	240 days
Un-irradiated, ambient stored	33.8	37.6	46.5	57.7	74.5
Un-irradiated, cold stored	11.2	43.6	54.9	69.9	77.4
γ-Irradiated, ambient stored	34.1	45.3	52.5	59.7	64.8
γ-Irradiated, cold stored	11.9	26.8	37.5	45.7	54.8
CD (P=0.05)	3.5	4.9	2.5	5.7	5.9

stored bulbs after taking out from store was due to low temperature exposure, which activated the hormonal level in cloves breaking dormancy.

The highest total losses (77.4%) were recorded in un-irradiated cold stored garlic bulbs after 240 days of storage which was on par with un-irradiated ambient stored bulbs. The lowest storage losses (54.8%) were found in γ–ray irradiated cold stored bulbs, which was significantly lower than all other treatments (Table 6).

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References

Croci C A & Curzio O A 1983 The influence of gamma irradiation on storage life of red variety of garlic . J. Food Proc. Preser. 7:17.

Curzio O A 1982 Sprout inhibition in garlic (*Allium sativum*) and onion (*Allium cepa* L.) by gamma irradiation. In: Final Report, Coordinated Programme on Pre-commercial Scale Radiation Treatment of Food, November 1980–October 1981. (p. 26). International Atomic Energy Agency, Vienna.

Curzio O A & Urioste A M 1994 Sensory quality of irradiated onion and garlic bulbs. J. Food Proc. Preser. 18 (2): 149–158.

Hardenburg R E 1986 The Commercial Storage of Fruits, Vegetables and Florist and Nursery Stocks. United States Department of Agriculture, ARS, Agriculture Handbook No. 66, USA.

Maini S B & Chakravatri A K 2000 Post harvest management of onion and garlic. In: Souvenir, National Symposium on Onion and Garlic: Production and Post Harvest Management. Challenges and Strategies (pp. 24–32). National Horticultural Research Development Foundation, Nasik.

Thomas P, Srirangarajan A N & Lirnaye S P 1975 Studies on sprout inhibition of onions by gamma irradiation. Influence of time interval between harvest and irradiation doses and environmental conditions on sprouting. Radiation Bot. 15 : 215.

Warade S D & Shinde K G 1998 Garlic In: Salunkhe D K & Kadam S S (Eds.) Hand Book of Vegetable Science and Technology (pp. 397–413), Marcel Dekker Inc., New York.