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THE PHYSIOLOGICAL EFFECTS OF GAMMA IRRADIATION
ON THE STORAGEABILITY OF GARLIC.

by

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INTRODUCTION

Garlic (Allium sativum L.) is one of the major vegetable crops in the United Arab Republic for local consumption and export. In 1969, the garlic production area was more than 15,097 feddans. Total production was approximately 100,000 tons, of which 13,410 tons were exported. The value of garlic exports is expected to exceed two million Egyptian pounds in 1970.

A large percentage of the total garlic production is wasted each year due to sprouting, which is usually followed by decay. Several chemicals have been tested for sprout control, and maleic hydrazide has been used on a commercial scale as a preharvest spray on onions and, to a lesser extent, on garlic.

During the past twenty-five years, much consideration has been given to the use of ionizing radiation for food preservation. The types of radiation used have included cathode, beta, x, and gamma rays. Although they are similar in their effects on living tissues, they differ in their penetrating power, with gamma rays being the most penetrating.

Irradiation of fruits and vegetables has been directed to problems of :

- a) Morphology : sprout inhibition in root, bulb, and tuber crops, control of elongation, and other morphological changes that affect quality and shelf-life;
- b) Pathology : control of decay organisms ; and
- c) Physiology : slowing life processes during storage, and inhibition of fruit ripening.

The scope of this work is primarily concerned with the first problem area (i.e., morphology). Sprout inhibition is among the most promising application of gamma radiation. Studies on sprout inhibition of vegetables by gamma irradiation have concentrated previously on potatoes, onions and carrots while such studies on garlic have been much more limited. After evaluating the effects of gamma irradiations on, fruits and vegetables, Sommer and Maxie (1966) concluded that : 1) there is no significant loss in nutritive value after radiation doses that living fruits and vegetables can tolerate; 2) there is no induced radioactivity; 3) animal feeding trials have indicated that irradiated foods are safe; 4) irradiation cannot in any degree substitute for refrigeration; 5) highly perishable commodities harvested near full-ripe generally best tolerate irradiation and show greatest benefits; and, 6) irradiation doses the commodities can withstand are often insufficiently fungicidal unless combined with other treatments to provide a synergistic effect.

Sprout inhibition in garlic has been achieved by means of preharvest application of maleic hydrazide. Thus, it is essential to compare both methods of sprout control.

The work reported in this dissertation compares the effects of gamma irradiation with the preharvest application of maleic hydrazide on garlic. The comparison includes several physical and chemical parameters, i.e., weight loss , sprouting , shelf-life , sugars , organic acids , amino nitrogen , and amino acid content during storage at 0°C and at room temperature (common storage).

PART I : COMPARATIVE EFFECTS OF GAMMA IRRADIATION
AND MALEIC HYDRAZIDE TREATMENT ON THE
STORAGEABILITY OF GARLIC

Review of Literature

Since 1950, when Wittwer and Sharma reported the success of maleic hydrazide to control sprouting. Consideration has been given to maleic hydrazide as a method for inhibiting sprouting in onions. Recently, irradiation has been reported as an effective sprout inhibitor for both potatoes (Sparrow and Christensen, 1954) and onions (Brownell et al , 1954).

Data on garlic has been rather scant , though since garlic and onions belong to genus Allium , they are discussed together. When Abdel-Al (1967) exposed cured Egyptian garlic cloves and bulbs to gamma irradiation doses of 0 , 4000 , 6000 , 8000 , and 12,000 roentgen, he found that 12,000 R was very effective in the inhibition of sprouting and reduced the percentage of empty cloves. Tewfic (1960) treated field grown Egyptian garlic of the "Baladi" variety with maleic hydrazide two weeks before harvest with concentrations of 0 , 500 , 1000 , and 2500 ppm. Two weeks after harvest , garlic was stored at 50 or 37° F and at room temperature (90 or 89° F). The most effective concentration

was 2500 ppm; storage at cold storage temperature resulted in reducing the weight loss during storage and increasing the percentage of sprouting bulbs more than did storage at room temperature.

Mann (1952) reported that a lot of 172 cloves of "Late" garlic variety stored at 32° F was dissected 189 days after harvest and showed an average of 7.35 (range 6-9) leaves within the storage leaf, while a lot of 197 cloves stored at 50° F had an average of 8.32 (range 7-11) leaves.

Mann and Lewis (1956) studied the influence of storage of garlic bulbs at 0, 5, 10, 15 and 20°C for periods of up to 24 weeks on subsequent sprouting of cloves in the field and on sprouting of cloves in moist conditions at controlled temperatures. They concluded that storage at intermediate temperatures favoured early sprouting when compared to storage at 0 or 20°C. Cloves from bulbs stored at 20°C generally sprouted last followed by those stored at 0°C. Mann and Minges (1958) found that after sprouting, the vigor of growth as measured by plant height is greatest in plants from cloves stored at 0°C and least in plants from cloves exposed to 20°C.

1 - Sprouting :

The early work of Dallyn et al (1955) using different gamma irradiation doses showed that pre-storage irradiation of cured onions proved effective in controlling sprouting over a period of several months. Dallyn and Sawyer (1959 a) found that using fast electrons was effective in controlling sprouting and rooting of onions only when directed to the base of the bulbs. On the other hand , Koay and Langerak (1961) reported that 7.5×10^5 rad fast electrons inhibited sprouting in onions only during the first thirty days of storage.

Dallyn and Sawyer (1959 b), Blinc (1959), Nuttal et al (1961) , Korableva and Metlitskii (1963), Lewis and Mathur (1963) , and Solanas and Darder (1963) , reported that gamma irradiation effectively inhibited the sprouting of onions. The effective dose in controlling sprouting in onion bulbs ranged from 2000 R (Hori et al, 1965) to 12,000 R (Dallyn and Sawyer, 1959 a), depending on variety , time of exposure , storage conditions and the physiological state of the bulbs. Ogata et al (1959) found that sprouting was completely inhibited even at 3000 R when the onions were irradiated soon after harvest and at the pre-sprouting period. Ojima et al (1963) treated onion bulbs with total dosages of 3000 , 6000 ,

9000 , 12,000 and 15,000 roentgen 57, 86, and 114 days after harvest. Sprouting was completely inhibited with all total dosages in the bulbs irradiated 57 and 86 days after harvest , but not inhibited at 114 days after harvest.

Maleic hydrazide was used early in controlling onions sprouting (Wittwer and Sharma , 1950). Paterson (1952) , Ciferri (1953), Rao (1954) , Rehm (1954) , Van Beekom et al (1954) , Gongalez-Kepfer (1955). Isenberg (1956) , Ninoniya (1956) , Acosta and York (1957) , Tabing et al (1957) , Aquilà-Saneho (1959) , Tewfic (1960) and Dhesi et al (1966) reported that spraying with maleic hydrazide at a rate of 2000 to 3000 ppm , 1 to 3 weeks before harvest inhibited sprouts of onion bulbs during storage.

Javela and Rodriguez (1966) found that spraying 1, 2 or 3 weeks before harvest with maleic hydrazide at concentrations of 1500 , 2500 or 3500 ppm , reduced the sprouting of onions stored at 4°C and 85 % relative humidity or at ordinary atmospheric conditions. The same workers also mentioned that the effect was directly related to the concentration. The weight of shoots produced was least when the treatment was applied 2 or 3 weeks before harvest.

2- Weight loss :

Solanas and Darder (1963) found that a dose of 3000 rads prevented sprouting in onions and weight loss at the end of 8 months was 15 %. Ojima et al (1963) mentioned that the weight loss during storage was less in irradiated onion bulbs than in unirradiated ones.

Anonymous (1953) reported a net gain after 172 days storage of about 10 % in plants treated ^{with} 0.25 % maleic hydrazide 2 to 3 weeks before harvest. Acosta and York (1957) reported that application of maleic hydrazide two weeks prior to harvest reduced the combined losses due to sprouting and rotting in onions more in common storage than in cold storage , regardless of concentration and method of application. Kepkova (1966) , working on maleic hydrazide treated onions at 2500 to 5000 ppm, reported that maleic hydrazide reduced the weight loss.

3- Shrinkage , Discolouration and Disease :

Ellis (1958) treated tubers of different varieties of potatoes with gamma irradiations at levels from 0 to 15 krep and were stored at 41° F up to 380 days. He found that the nonirradiated check tubers of all varieties underwent some shrivelling. Irradiated tubers of the varieties Sebago , Red Pontiac , and Katahdin shrivelled to various degrees , whereas identically treated Russet

Burbanks were still quite turgid. Blinc (1959) concluded that onion bulbs irradiated beyond 7000 rep remained firm during storage.

Nuttal et al (1961) exposed Brigham Yellow Globe onion variety to various gamma irradiation doses and stored at controlled temperatures. The incidence of internal discolouration of the growing point was suggested with the highest radiation dose (9500 rad). He also mentioned that irradiated onions were milder in flavour.

Lewis and Mathur (1963) irradiated bulbs of Red Globe onions with 6000 rad and stored them at different controlled temperatures. No differences occurred in decay percentage between the control and irradiated onions at room temperature. However, in cold storage no decay occurred in either of the two lots of onions.

Paterson (1952) used maleic hydrazide as a foliar spray at different concentrations on onions. Foliar sprays at 2500 ppm applied three weeks or more before harvest caused an increase in storage breakdown of onions. On the other hand, Isenberg (1956) found that the keeping quality of a "poor keeping" variety like Early Yellow Globe or of varieties grown under poor conditions was improved to a greater degree by the maleic

hydrazide sprays than was the keeping quality of a "good keeping" variety grown under optimum conditions.

Tabing et al (1957) , Aquilá-Saneho (1959) , and Kepkova (1966) reported that sprayed onion plants with maleic hydrazide at different concentrations had significantly more marketable bulbs. The treatment with maleic hydrazide reduced disease incidence and did not affect the colour , flavour or odour of bulbs.

Materials and Methods

The field experiments were carried out at Kaluob during the 1966/1967 season. The area (one - third feddan) was divided into three parts for three replications. The three treatments-- control , maleic hydrazide , and gamma radiation-- were administered at random within each replication. "Baladi" variety garlic cloves were planted on both sides of the row at 20 cm spacings on September 11, 1966. Ridges were 71 cm apart.

Irrigation , manuring , fertilizer application , and other cultivation treatments were applied as the common commercial methods. Every plant was labeled to facilitate identification of field treatments and replications during handling, curing, and the storage period.

Seven months after planting (April 5, 1967) maleic hydrazide plots were sprayed with diethanoline salt of 6, hydroxy-3-(2H) - pridazonone (MH-30) , produced by Naugatuck Chemical Division , United States Rubber Co. A concentration of 2500 ppm was applied at a rate of 280 litres per feddan.

Separate plots were harvested 13 days later (April 18, 1967). Injured , unhealthy , small , and off-type

plants were discarded. Roots of the selected plants were cleaned from clay and then slightly trimmed. The plants were transported to the greenhouse on the same harvest day , to represent the curing zero time.

Curing :

Plants were placed in the greenhouse (temperature 25-35°C and 60-75 % relative humidity) and sorted at intervals of 4-7 days. Two months after harvest (June 22, 1967) when foliage and bulbs were dried , plants were resorted and prepared in small bundles (4-5 plants), using the dry foliage as a tie.

Radiation treatment :

On June 23, 1967 plants were irradiated at the U.A.R. Atomic Energy Establishment at Inshas. Cured plants of the replication field which were assigned for gamma radiation were irradiated with 12 Krad at 480 rad per hour using a 254 - curie CO^{60} gamma irradiation open system source (Agromat Engineering Limited Co., England). The small bundles were arranged with bulbs towards the source in a one-layer circle with a 85 - cm radius around the source tube.