CHANGES IN NUTRITIVE VALUES OF GAMMA IRRADIATED HORTICULTURAL FRUITS DURING DIFFERENT STORAGE PERIODS

By

ABDALLA ABDALLA EL-SAID MAHMOUD
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APPROVAL SHEET

This Thesis, submitted for the M.Sc. Degree,

has been approved by :

A. L. El-Tom

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....

(Committee in charge)

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C O N T E N T S

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1. INTRODUCTION

The maintenance of the adequate food supply for the considerable world-wide increase in the population became a problem specially for the developing countries. Not only that the available food sources are not adequate to meet all needs but also a great portion of the food products is subjected to spoilage and losses which amount to about 30% in some perishable products. There are two approaches to overcome such an inadequacy; first, to increase the food sources and, second, to prevent or reduce the losses of the present available food supplies.

Great attention has been recently devoted to study new means by which it would be possible to limit the deterioration in the quality and quantity of stored food and agricultural products.

In Egypt, potatoes and onions are among the most widely cultivated and exported crops. In 1971, the cultivated area was 66,000 and 36,000 feddans respectively, yielding 451,000 tons of potatoes and 57,000 tons of onions.

Large quantities of potatoes and onions are subjected to undesirable storage conditions. Sprouting, loss of water, dry matter, shrinkage, physiological and pathological disorders took place. The estimated total losses in both crops during storage amount to about 5.7 million pounds per year.

It is well known that some growth regulator treatments prevent sprouting, and produce many undesirable side effects.

Radiation has been recently used to extend the storage period of certain crops among which are the potatoes and onions. The wholesomeness and the acceptability of the irradiated food to the consumers are the two main important questions which occupied for a long time the minds of the investigators. Trials have been performed in order to ascertain the optimal radiation levels which fulfil the preservation requirements, assure no harmful chemical changes in the food and establish the safety for human consumption.

In the present investigation, attempts have been made to set new minimum radiation levels for extending the storageability of Egyptian potatoes and onions under the ordinary storage conditions, and to evaluate the synergistic effect of gamma radiation with certain phenolic chemical compounds.

REVIEW OF LITERATURE

The problem of sprout control in various vegetable crops, particularly potatoes and onions, has recently received great attention.

Most of this effort has been directed towards chemical inhibitors and cold storage conditions which are not sufficiently dependable in many areas, especially in the developing countries.

Irradiation is one method of sprout control that has received considerable attention in recent years.

It is known that the dormant period is the subsequent time when the tubers do not sprout, owing to unfavourable external conditions.

The sprouting tendency varies particularly between varieties but also between years and places of cultivation. The concepts of rest and dormancy are often very practical to use but from a theoretical point of view there may be no reason for separating them. They are two parts of the same physiological process ranging from storage sprout inhibition to vigorous sprout growth. Thus, rest or dormancy does not depend on qualitative but quantitative differences in the endogenous amounts of growth regulating substances; [illegible] (1970).

As early as 1957, investigations have been carried out to utilize ionizing radiation for the inhibition of sprouting in potatoes and onions; BURTON and HANNAN (1957), HEILIGMAN (1957), PATZOLD and WEISS (1957), BROWNELL (1958), OGATA et al. (1959). The problem is still subjected to further investigation.

Many explanations concerning the inhibitory effect of gamma rays on the sprouting of onions and potatoes are given. Sprout inhibiting levels of irradiation usually injures the meristemic tissue causing it to die and this affects the tissue that gradually turns dark during storage; DALLYN & SAWYER (1959), and PATIL (1966). Higher doses over to 15 kilo-reps of irradiation caused blackening fungous infection and other disorders during storage; GUSTAFSON (1957).

1. Radiation Levels Affecting Sprouting Inhibition

It has been found that sprouting of onion bulbs was completely inhibited by 7 k.r. and the storage period was extended by 4-5 months; OGATA et al. (1959).

Gamma radiation doses of 3200, 4700, 6900 and 9500 rad completely inhibited sprouting of Brigham yellow Globe onions for a 300-day-test period; NUTTALL et al. (1961). Similarly, it has been reported that there was complete sprout inhibition with doses of 9, 12, 15 and [illegible] k.r.; NADPURI et al. (1969).

Gamma irradiation of 12,000 rep completely inhibited rooting and external sprouting and greatly reduced the occurrence of internal sprouts. This dosage was effective on bulk units up to 50 pounds, if the package was rotated 180° at the half-time of 20 hours; DALLYN and SAWYER (1959).

Sprouting was completely prevented when irradiating onion bulbs at 8 k rad; ALI et al (1970) and at 15 k rad; CACHIN (1971).

Sprouting was completely prevented by irradiating potato tubers before storage. The inhibition of sprouting of potato tubers was achieved by irradiating with doses ranging from 5000 to 8500 r; BURTON and HANNAN (1957), with 8000 r; PATZOLD and WEISS (1957), with 5000 rep; BROWNELL (1958), with 3000-4000 r; GANTZER and HEILINGER (1969); with 5-20 kilореps not less than 70 days after harvest; SPARKS and IRITANI (1964), with 5-10 kr; TEIXEIRA and BAPTISTA (1968), and by 10 k rad gamma ray; USSUF and NAIR (1971).

It was also found that 2000 r; BURTON and HANNAN (1957), 3000-4000 r; GANTZER and HEILINGER (1964) retarded or delayed the sprouting of potato tubers markedly.

On the other hand, low irradiation promoted sprouting; BOBKOVA (1971), GANTZER and HEILINGER (1964); and FISCHNICH et al. (1961), while medium doses caused the formation of side shoots in the sprout, and therefore also increased their weight; GANTZER and HEILINGER (1964). The effect was only realized when the tubers metabolism was stimulated by conditions before and after irradiation. Low storage temperature prevented this process. The length and number of sprouts formed under low radiation varied with variety and environment; FISCHNICH et al. (1961).

For sprout inhibition in potatoes, gamma irradiation using ^{60}Co sources has been permitted up to the maximum level of 15 k rad in Canada and U.S.A., 10 k rad in USSR, and 10-14 k rad in Egypt. For onions, a level of 15 k rad has been approved in Netherlands and Canada and 8 k rad in Egypt as shown in Table (A).

Table (A)

IRRADIATED FOOD PRODUCTS CLEARED FOR HUMAN CONSUMPTION IN DIFFERENT COUNTRIES
(Quoted from Proc.FAO/IAEA SYMPOSIUM, Karlsruhe 6-10 June, 1966)

Country	Product	Purpose of irradiation	Radiation source	Dose (permissible) (Range) (k rad)	Date of Approval
CANADA	Potatoes	Sprout inhibition	Cobalt 60	10 max.	9 Nov.1960
				15 max.	14 June 1963
	Onions	Sprout inhibition	Cobalt 60	15 max.	25 Mar.1963

Table (A) (cont'd)

Country	Product	Purpose of irradiation	Radiation source	Dose (permissible (Range) (k rad)	Date of Approval
DENMARK	Potatoes	Sprout inhibition	10 mev Electrons	15 max.	27 Jan.1970
HUNGARY	Potatoes (experimental batches)	Sprout inhibition	Cobalt 60	10	23 Dec.1969
ISRAEL	Potatoes	Sprout inhibition	Cobalt 60	15 max.	5 July 1967
	Onions	Sprout inhibition	Cobalt 60	10 max.	25 July 1968
NETHERLANDS	Potatoes	Sprout inhibition	Cobalt 60 4 Mev Electrons	15 max.	23 Mar.1970
	Onions (experimental batches)	Sprout inhibition	Cobalt 60 4 Mev Electrons	15 max.	5 Feb. 1971
SPAIN	Potatoes	Sprout inhibition	Cobalt 60	5-15	4 Nov. 1971
UNION OF SOVIET SOCIALIST REPUBLICS	Potatoes	Sprout inhibition	Cobalt 60	10	14 Mar.1958
	Onions (experimental batches)	Sprout inhibition	Cobalt 60	6	25 Feb.1967
U.S.A.	White potatoes	Sprout inhibition	Cobalt 60 Caesium137 Cobalt 6 & Caesium 137	5-10 5-10 5-15	30 June 1964 2 Oct.1964 1 Nov.1965

2. Effect of Storage Temperature on Sprouting of Irradiated Onions and Potatoes

Irradiation of Ninomiya Globe onion bulbs with total dosages ranging from 5 to 60 kr, applied in small or large daily doses, prolonged storage life at 24°C and reduced shrinkage as compared with untreated controls; PATIL (1966). Sprouting was inhibited in hybrid onions stored at 70°F before and after irradiation with CO^{60} gamma radiation at 2 k rads, 2 weeks after harvest. However, sprouting was not inhibited in bulbs irradiated at 2 to 250 k rads 11 or 17 weeks after harvest; MULLINS and BURR (1961). Irradiation of potato tubers by 8-12 k rads decreased the weight loss and the number of sprouts in the storage within 6 months at 25°C; ROUHANIZADEH (1967). Meanwhile, sprouting was inhibited when potato tubers were irradiated with 6000 and 12000 r and then stored at 12°C; HEILINGER et al. (1958).

Potatoes given more than 1 x 10" rep gamma radiation failed to sprout during 6 months storage at 50°F; MADSEN and SALUNKHE (1958).

Irradiation doses of 5 kilo rep permitted the formation of small abnormal sprouts after storage for 2 months at 13°C; HEILIGMAN (1957). At rates of 10 kilo rep, sprouting occurred only sporadically at 22°C, and no sprouts were formed after storage at 13°C. for 2 months. Rates of

15 kilorep completely inhibited sprouting. Weight losses and decay were lowest in samples which received the lowest doses of irradiation.

At room temperature, irradiated potatoes began to decay sooner than did the controls. In cold storage, there was no decay of irradiated potatoes or controls; LOWIS et al. (1963).

The potato varieties stored at 20°C. and above 90% R.H. required a dose of 5000 r and 7500 r for early and late varieties respectively, to prevent sprouting during 8 months of storage; KUBICKI (1961).

3. Radiation-induced Changes in Morphological and Physiological Characteristics of Onions and Potatoes

Effective sprout inhibition resulted in all cases from irradiation of potatoes with no internal sprouting. The irradiated potatoes remained firmer than the non-irradiated controls. Irradiated potatoes were more resistant to greening in light and the quality of various prepared foods from them was good; HETHERINTON and MACQUEE (1963). Irradiated tubers with 5000-7500 r, that sprouted, had short-thick, branched sprouts emerging from all the eyes.

The doses giving the smallest losses in weight an dry matter were 5000 r and 10,000 r for early and late varieties respectively. Higher doses produced greater losses; KUBICKI (1961).

There were no adverse effects on colour, texture, taste or flavour in boiled irradiated potatoes after 10 months of cold storage; LEWIS and MATHUR (1963).

It has been found that blackening appeared in tubers treated with gamma-rays or sprout inhibitors and stored at 100°F for 36 hours. Blackening increased with increasing radiation dosages. Tubers given low dosages of gamma rays developed hollow centres but did not blacken, SPARKS (1958).

Inner buds of irradiated bulbs were brown and dead but outer buds were not. The larger brown areas may be due to the elongation and/or differentiation occurring during storage, hence early irradiation would be preferable, OGATA et al. (1959).

Size of the area involved varied considerably from bulb to bulb and may have been determined by the size of the growing point at the time of irradiation.

Attempts to solve or minimize the problem were unsuccessful. Normally, the affected area represented a very small fraction of the entire bulb and its appearance might not be objectionable to many types of uses; DALLYN and SAWYER (1959).