Results of project 04-042

Contract TSD-A-188

Report 87.24

Title of project: Application of food irradiation processes to developing countries.

Head of project: D.Is.Langerak

Scientific staff: Th.C.Wolters; H.Stegeman

RIKILT,

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Content

A. TUBER, BULB AND ROOTPRODUCTS

ABSTRACT

The losses in potato tubers during storage are mainly due to sprouting and rotting. Gamma irradiation effectively inhibits sprouting and extends the storage life of potatoes. Rotting can not be controlled within the sprout inhibition dose range, but irradiation increases, however, the rot by disturbing the resistance mechanism.
For this reason storage experiments were carried out with combination treatments of heat, calcium salicylate, salicylic acid and irradiation. Before treatment the potatoes were artificially damaged and infected with Fusarium sulfurium. After the combined treatments the potatoes were stored at 10 ^{o}C, 85% RH in order to study the mould growth.

It appeared from the results that irradiation with 1 kGy has some effect on the delay of rot. The best results were obtained with a combined treatment of heat with 50 ^{o}C and irradiation of 1 kGy. A treatment with different concentrations of salicylic acid or calcium salicylate alone or in combination with irradiation has hardly an effect on the prevention of rot caused by Fusarium sulfurium. The results obtained with the combination of chemicals and irradiation are not in agreement with previous research.

1 INTRODUCTION

In many developing countries the production of potatoes is large and increasing (Islam, 1985). The annual losses are about 15 to 20% due to sprouting and rotting (Rahman, 1971).

Prevention of sprouting is technically feasible by irradiation (Godordhun, 1978). It is a non-chemical method of sprout inhibition in potatoes and onions. But an increase of rot in irradiated stored potatoes is a problem in the practical application (Shrif, 1983). This rot is mainly caused by Phytophtora infestans, Phoma and Fusarium spp. producing potato blight, gangrene and dry rot respectively A sprout inhibition dose is enough to prevent Phytophtora (Langerak, 1982).

In order to control moulds, usually high doses are required, resulting in tissue damage and unacceptable change of the sensoric properties (Langerak, 1982). It is known that the low dose (80 to 100 Gy) used for potato sprout inhibition irradiation, inhibits the development of meristem tissue. The reduced capacity of cell division however, has also an effect on the suberization of damaged tissue (Langerak, 1986). Woundhealing is virtually suppressed and a greater susceptibility to Fusarium may be the result (Sparenberg, 1975; Islam, 1985).

For that reason an irradiation treatment does not always have a positive effect on the marketable weight of potatoes because of higher percentage of decay, induced by the irradiation treatment (Shrif, 1983).

In the framework of contract SD-A-188 research has been carried out, to reduce decay in potatoes, using low-dose treatment after a woundhealing period (Langerak 1986).

In order to avoid the undesirable changes often caused in food by a high irradiation level, the synergistic effect of heat and irradiation or the combination of the phenolic compound salicylic acid with irradiation can also be been utilized. The results obtained have indicated so far promising possibilities (Roushdy, 1972; Langerak 1982; Shrif, 1983; Islam, 1985). Using such combined effects, better storage ability has been attained.

The aim of this experiment was to investigate the effect of different combined treatments on the prevention of rot in potatoes infected by Fusarium sulfurium.

2 MATERIALS AND METHODS

2.1 The potatoes

Potatoes were purchased directly from a farm near Wageningen. The variety of the potatoes was "Bintje". The potatoes were selected on reasonable uniformity of size and shape. Potatoes which showed signs of disease or damage were removed. The selected potatoes were stored for 6 months at 4 °C, 85% RH.
For each treatment 5 replicates of 25 potatoes were used.

2.2 Mould species collection

The mould species of Fusarium sulfurium were collected from the Reseach Institute for Plant Protection (IPO), Wageningen, The Netherlands. The spores were purchased from the stock by shaking a vew gram of the material with approximately 100 ml water. The spore suspension was counted and diluted to a concentration of 20000 spores/ml by diluting with water.

2.3 Inoculation and incubation

On two sides of the potatoes holes were made of 5 mm diameter and 2 mm deep using a cork borer. Into the holes 0.05 ml spore suspension was added using a micropipet. The infected potatoes were incubated for 20 hours at 10 °C, 85% RH.

2.4 Combined treatment of heat and irradiation

The infected potatoes were dipped for 5 min into a waterbath of 20 (control), 45 and 50 °C respectively. After drying by an air-dryer the treated potatoes were placed in plastic bags and transported to the Pilot Plant for Food Irradiation. The samples were treated with doses of 0 (control), 0.1 and 1 kGy respectively. The applied dose rate was 0.1 kGy/hour for the 0.1 kGy samples and 1.3 kGy/hour for the 1 kGy samples.

2.5 Combined treatment of salicylic acid and irradiation
The infected potatoes were dipped for 5 min into a waterbath containing a solution of 0 (control), 0.2 and 0.4% salicylic acid respectively. After drying by an air-dryer the treated potatoes were placed in plastic bags. The samples were irradiated similar to the combined treatment of heat and irradiation (2.4).

2.6 Combined treatment of calcium salicylate and irradiation
Because of the very bad solubility of salicylic acid an experiment was also carried out using calcium salicylate in water with concentrations of 0.2 and 0.4 % with a pH of 1.8 and 1.5 respectively (same level as salicylic acid).
The infected potatoes were dipped for 5 min into a waterbath containing 0 (control), 0.2 and 0.4% calcium salicylate respectively. After drying by an air-dryer the treated potatoes were placed in plastic bags. The samples were irradiated similar to the combined treatment of heat and irradiation (2.4).

2.7 Storage and inspection
After the irradiation treatment the samples were placed in wooden boxes and per box packed in a polyethylene bag. The samples were stored at 10 ^{o}C, 85% RH.
During the storage period the samples were regulary inspected individualy on the presence of rot in and around the holes. To determine the rot percentage the number of rotten spots per box were counted.

3 RESULTS AND DISCUSSION

3.1 Combined treatment of heat and irradiation
The average rot percentage of 5 samples of 25 potatoes +/- SE (standard error of the mean) treated at different temperatures and with different irradiation doses are presented in table 1 and figure 1.

It proved from the results that a heat treatment of 50 °C shows a delay of mould development. A heat treatment of 45 °C alone does have only a minor effect on the prevention of mouldgrowth. An irradiation treatment of 1 kGy has also effect. An irradiation treatment of 0.1 kGy has only effect when it is combined with a heat treatment. The best results were reached with a combined treatment of 50 °C and 1 kGy.

Table 1: Average rot incidence +/- SE of 5 samples of 25 potatoes inoculated with Fusarium sulfurium, heat treated at different temperatures, irradiated and non-irradiated and stored at 10 °C, 85% RH.

heat temp. [°C]	irr. dose [kGy]	storage time [days] 3	6	9	11	14	20
20	0	0.0	23.6±3.4	95.2±1.4	98.9±0.5	99.6±0.4	99.6±0.4
	0.1	0.0	13.2±0.8	97.2±1.4	99.2±0.5	100.0±0.0	100.0±0.0
	1.0	0.0	0.4±0.4	63.6±2.8	96.0±1.1	99.6±0.4	99.6±0.4
45	0	0.0	5.2±1.4	93.2±1.2	97.6±0.4	99.6±0.4	99.6±0.4
	0.1	0.0	0.4±0.4	55.8±4.7	96.0±2.1	99.2±0.8	99.6±0.4
	1.0	0.0	0.0	0.4±0.4	10.8±2.3	80.0±4.0	96.0±1.1
50	0	0.0	0.0	28.0±3.0	62.8±5.4	79.2±4.1	86.0±3.3
	0.1	0.0	0.0	3.2±0.5	48.4±5.3	94.0±0.9	97.2±0.5
	1.0	0.0	0.0	0.0	2.0±0.6	22.4±1.2	44.8±3.6

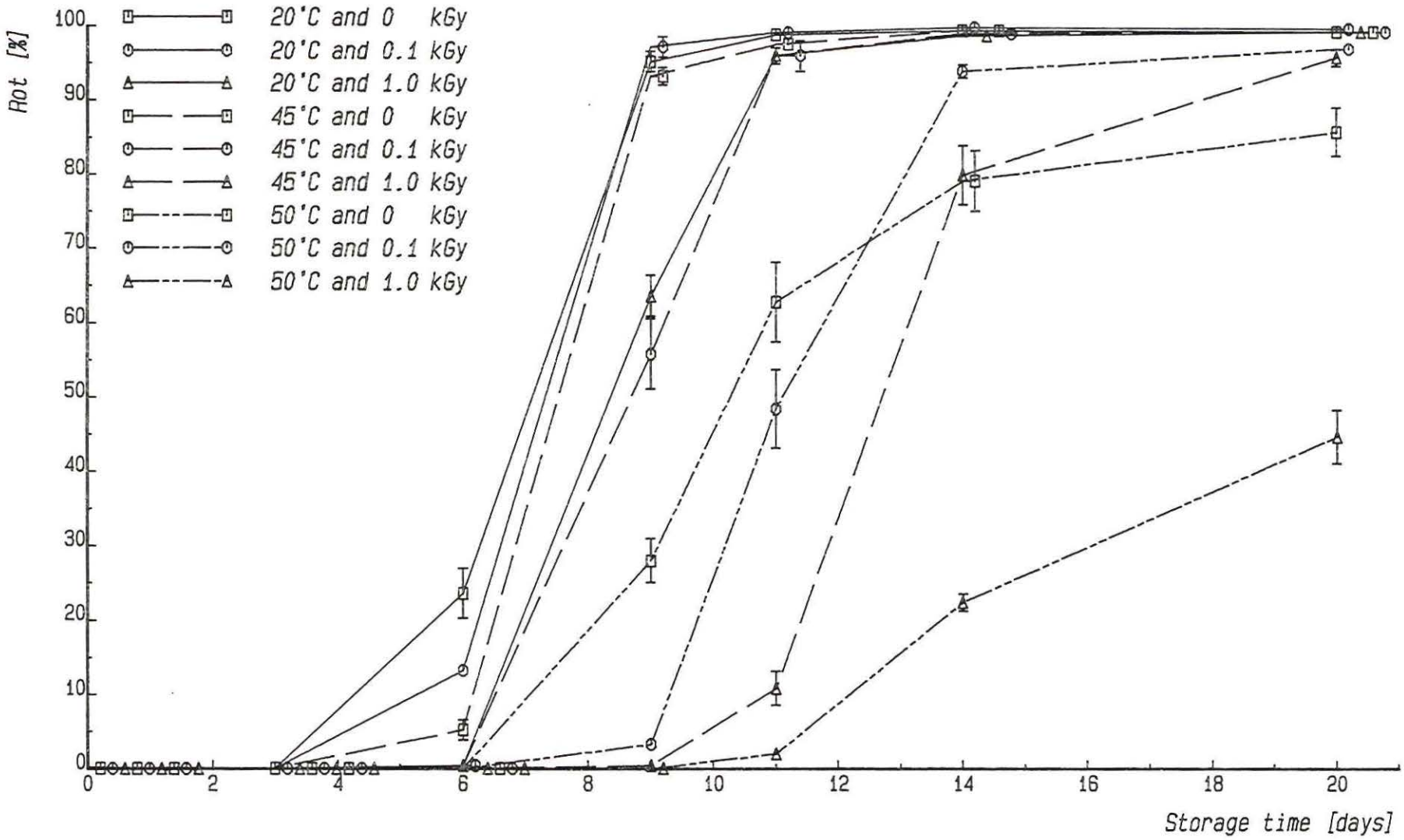

Figure 1 : Average rot percentage of 5 samples of 25 potatoes inoculated with Fusarium Sulfurium, treated with different temperatures, irradiated and non-irradiated, stored at 10°C and 85% RH.

3.2 Combined treatment of salicylic acid and irradiation

The avarage rot percentage of 5 samples of 25 potatoes +/- SE treated with different concentrations of salicylic acid and with different irradiation doses are presented in table 2 and figure 2.

During the preparation it proved that the solution of 0.4 % salicylic acid was saturated because crystals were formed when the solution was cooled to room temperature (20 °C). These crystals remained on the potatoes after the treatment.

It shows from the table that the salicylic acid treatment did not have a positive effect on the reduction of rot. Irradiation with 1 kGy delayed in the beginning but showed an increase of rot later on, probably due to disturbance of the resistance meganism. The combined treatment of salicylic acid and irradiation with 1 kGy showed a longer delay of rot development but did not prevent it.

Table 2: Average rot incidence +/- SE of 5 samples of 25 potatoes inoculated with Fusarium sulfurium, treated with different concentrations of salicylic acid, irradiated and non-irradiated and stored at 10 °C, 85% RH.

conc. acid [%]	irr. dose [kGy]	storage time [days] 3	5	7	10	12	14
0	0	0.0	5.0±0.9	14.8±2.7	15.2±2.7	19.2±3.7	25.2±3.9
	0.1	0.0	8.4±1.6	37.6±1.6	42.8±3.0	52.0±3.6	57.6±2.6
	1.0	0.0	0.0	42.5±5.8	72.6±6.1	89.2±3.0	92.2±2.3
0.2	0	0.0	0.0	19.6±2.9	43.2±3.4	54.4±3.0	60.0±2.8
	0.1	0.0	0.8±0.5	28.0±3.2	81.2±2.6	88.8±3.2	93.6±2.7
	1.0	0.0	0.0	3.6±0.7	60.8±2.6	86.4±2.6	90.4±2.3
0.4	0	0.0	3.2±2.1	44.0±2.0	62.0±3.3	71.6±3.5	77.2±2.1
	0.1	0.0	1.6±0.7	50.0±3.6	84.4±1.2	94.4±1.3	95.6±0.7
	1.0	0.0	0.0	4.8±1.0	50.0±7.3	78.8±3.4	80.4±3.2

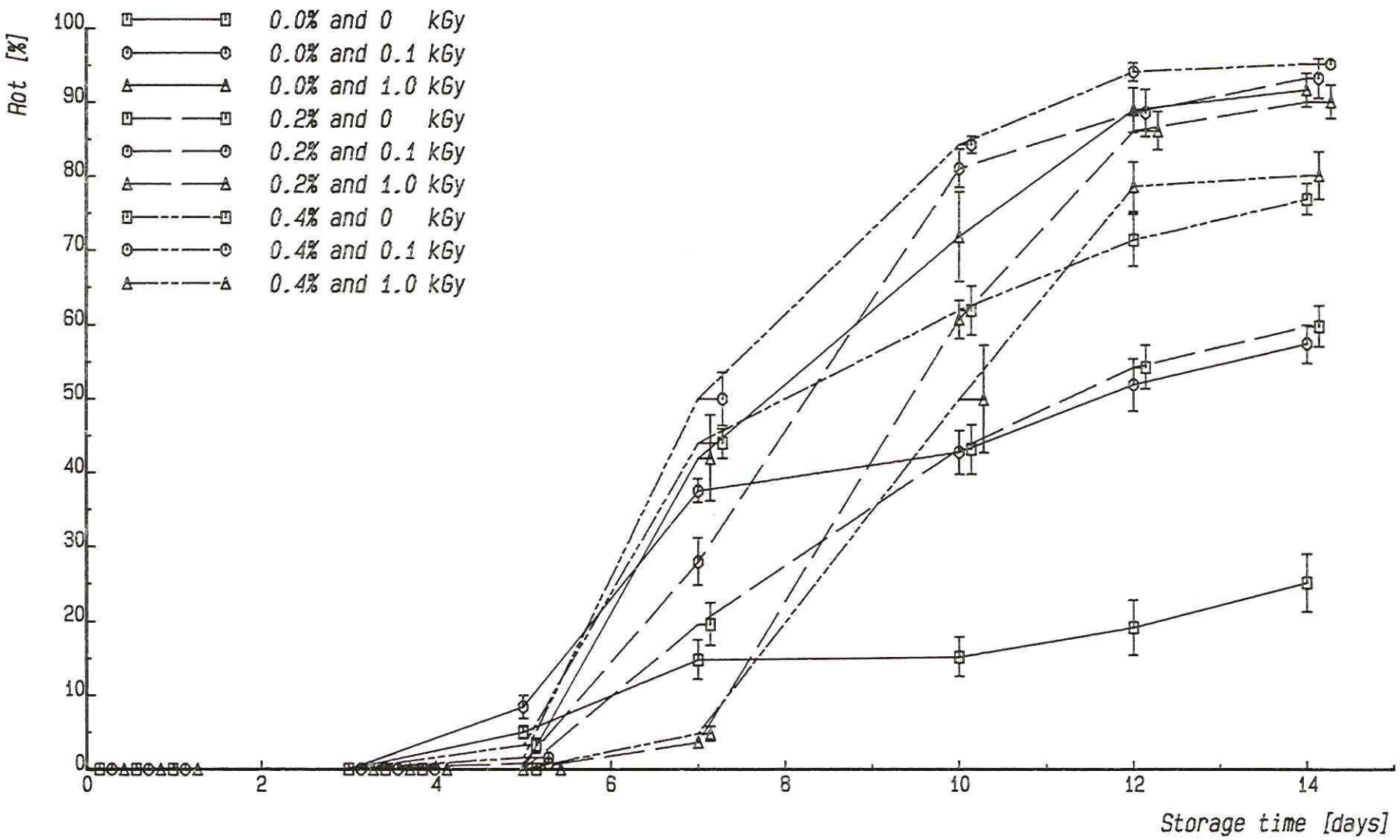

Figure 2 : Average rot percentage of 5 samples of 25 potatoes inoculated with Fusarium Sulfurium, treated with different salicylic acid concentrations, irradiated and non-irradiated, stored at 10'C and 85% RH.

3.3 Combined treatment of calcium salicylate and irradiation

The avarage rot percentage of 5 samples of 25 potatoes +/- SE treated with different concentrations of calcium salicylate and with different irradiation doses are presented in table 3 and figure 3.

During the adjustment of the pH of the 0.4 % calcium salicylate it proved that the solution was saturated because crystals were formed. This saturation resulted in remaining particles on the potatoes after the treatment. The results show that in the beginning of the storage period a dose of 1 kGy delayed the rot development. A treatment with calcium salicylate, however, increased the percentage of rot. A combination of calcium salicylate with irradiation did not improve the control of rot.

Table 3: Average rot incidence +/- SE of 5 samples of 25 potatoes inoculated with Fusarium sulfurium, treated with different concentrations of calcium salicylate, irradiated and non-irradiated and stored at 10 °C, 85% RH.

conc. salt [%]	irr. dose [kGy]	storage time [days] 3	6	13	17	20
0	0	0.0	0.0	30.4±4.3	56.4±4.8	56.8±4.9
	0.1	0.0	0.0	39.2±4.8	80.0±3.8	80.8±3.3
	1.0	0.0	0.0	0.0	37.6±3.5	62.8±2.4
0.2	0	0.0	0.0	52.0±4.5	90.8±3.7	90.8±3.7
	0.1	0.0	0.0	36.0±1.7	98.0±0.6	98.0±0.6
	1.0	0.0	0.0	0.0	40.0±3.0	52.8±3.5
0.4	0	0.0	0.0	80.8±2.4	94.0±1.5	95.2±2.1
	0.1	0.0	0.0	62.8±1.6	96.4±1.0	96.8±0.8
	1.0	0.0	0.0	8.0±1.1	58.4±5.2	62.8±5.4

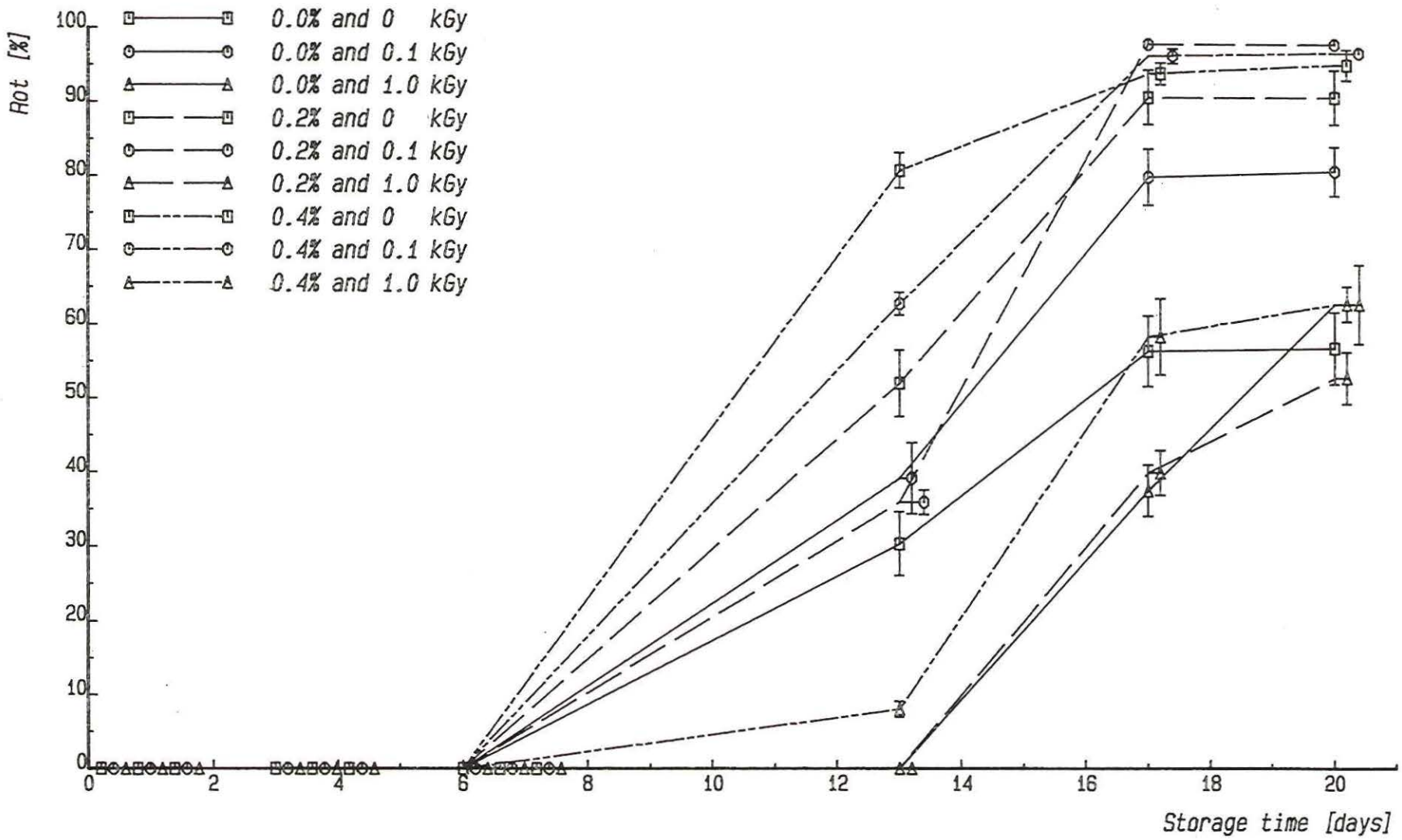

Figure 3 : Average rot percentage of 5 samples of 25 potatoes inoculated with Fusarium Sulfurium, treated with different calcium salicylate concentrations, irradiated and non-irradiated, stored at 10°C and 85% RH.

3.4 General conclusions

- It appeared from this experiment that a combination of heat (50 °C) and irradiation with 1 kGy gives the best results in prevention of rot in potatoes.
- A treatment of salicylic acid in combination with 1 kGy gives a short delay of rot development.
- A treatment of calcium salicylate alone or in combination with irradiation has no positive effect on the prevention of rot.

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B. INGREDIENTS

In the period of july to december 1986 a systematic storage study on the quality of irradiated spices was started. In this study irradiated samples will be compared with fumigated and untreated samples. Three kinds of spices, onion powder, fenugreek and cumin were selected. After the irradiation and fumigation treatment the samples were packed in cans and stored at ambient temperature for 1 year. Untreated reference samples are stored under deep frozen conditions. The main purpose is to study the effect of storage (0, 6 weeks, 12 weeks, 6 months and 12 months) on the sensory quality of radiation and fumigation processed spices. Besides the sensory analyses, chemical (volatile oils) and microbiological analyses wil be carried out. The experiment will be finished in december 1987.

C. INTERNATIONAL COOPERATION

1 INTRODUCTION

The establishment of the International Facility for Food Irradiation Technology (IFFIT) was initiated by the Duch Government to speed up progress in the practical introduction of food irradiation. The IFFIT project was set up in November 1978 at the Pilot Plant for Food Irradiation, Wageningen, The Netherlands, under an Agreement between FAO, IAEA and the Ministery of Agriculture and Fisheries of the Government of The Netherlands.

Under this Agreement the Pilot Plant for Food Irradiation puts at the disposal of the project its radiation and related facilities. In the years of 1979-1983 the closely located Research Institute ITAL and since January 1984 the State Institute for Quality Control of Agricultural Products (RIKILT), Wageningen, made available, on behalf of the Pilot Plant and without cost to the project, administrative facilities and services of their laboratories as required for the Project activities.

2 OBJECTIVES AND ACTIVITIES OF IFFIT

The purpose of the IFFIT-Agreements are:

a) To offer training and to assist in international coordination of development and research in the field of the technology, economics and implementation of food irradiation;
b) To assist national and international agencies in their assessment of the feasibility of applying radiation preservation techniques to foods;
c) To develop and facilitate the dissemination of information on the above topics without proprietary restrictions.

Special attention is paid in the IFFIT programme to the training of scientists from developing countries in various aspects of technology and practical applications of food irradiation.

3 APPLIED RESEARCH TRAINING AND FEASIBILITY STUDIES

IFFIT provides also applied research training for longer-term research fellows in the frame of the IAEA Research Felloships Programme. The felloship holders are accepted to work under the guidance of the RIKILT staff on specific technological problems of food irradiation. This is of great concern to their national food programme. Those selected for this type of IFFIT training are usually actively involved in or have responsibility for food irradiation in their country and are therefore able to apply, upon return, their increased knowledge for the practical benefit of their country.

The types of feasibility studies are defined in close cooperation with the visiting scientists by exchange of information, which usually takes place after the felloship has been awarded, and prior to the start of the work at IFFIT. These feasibility studies are recorded in IFFIT reports. The publication of their new results in scientific meetings and periodicals is encouraged. Since september 1979 thirty-one scientists from twenty-one countries have obtained guided research training for 3 to 15 months duration at the project.

4 TRAINING COURSES

From time to time IFFIT organizes general or special training courses on food irradiation. So far, seven general inter-regional training courses of four to six weeks duration were held in Wageningen, in the fall of 1979, 1980, 1981, 1982, 1984, 1985 and 1986 respectively, for

English speaking participants. About 200 scientists from 50 countries have already been trained. The objective of the general training couses is to pass on a broadly based knowledge covering the main aspects of the introduction and use of food irradiation. The courses consist of lectures, laboratory exercises, roud table disussions, national reports and visits to radiation plants and research facilities. Emphasis is placed on understanding the principle of food irradiation as a method of food preservation and minimizing postharvest losses, as well as improving the safety of food supply. Present technological and economic feasibility, wholesomeness and legislative aspects are discussed. Practical training in food irradiation technology and techniques, including dosimetry and operation of a pilot food irradiator is provided.

5 BILATERAL COOPERATION

IFFIT's cooperation and advice can be requested on feasibility studies which are initiated and to be carried out by institutes in developing countries. The project assisted its partners occasionally by arranging short-term consultancy missions, by sending samples of packaging material or providing irradiation services for those institutes which wanted to evaluate their own materials after irradiation but are still lacking radiation sources of needed capacity.

A well appreciated IFFIT activity of increasing importance is the evaluation of the quality of trial shipments of food samples coming from developing countries, which have already research on pilot irradiators. Small scale shipments of irradiated onions and garlic from Egypt and Argentina, Spices from Indonesia, papayas and frozen shrimps from Thailand, dates from Iraq, avocadoes from Chile, mangoes from the Philippines and strawberries from Yugoslavia are the examples of a broading network of such cooperation. The products of above mentioned trial shipments are stored and evaluated on RIKILT.

In the framework of the IFFIT project two scientific fellows from the Food Irradiation Department of the Centre d'Etudes Nucleares et Solaire in Alger and one fellow from the Vietnam National Atomic Energie Institute in Hanoi join the potato EEG project for training and to set up similar experiments under local conditions in their own countries. An expert of RIKILT is asked for supervising the Food Irradiation programme in Algeria. A bilateral cooperation on food irradiation between the Irradiation Centre in Hanoi and RIKILT is in study.