169
Arab Univ.
J. Agric. Sci.,
Ain Shams Univ.,
Cairo, 25(1), 169-178, 2017

MINIMIZING POSTHARVEST LOSSES IN POTATO (*Solanum tuberosum* L.) TUBER USING GAMMA IRRADIATION, MINT OIL AND PACLOBUTRAZOL UNDER UNREFRIGERATED STORAGE CONDITION

[11]

Soha. M. El-Sherbiny[1]; M.E. Ragab[2]; M.S. Abd-El-Moula[2] and E.A. Ragab[1]

1- Natural Products Dept., National Center for Radiation Research and Technology, Atomic Energy Authority, Cairo, Egypt

2- Horticulture Dept., Faculty of Agriculture, Ain Shams University, Cairo, Egypt

Keywords: Potato tubers, Gamma irradiation, Mint oil, Paclobutrazole, Unrefrigerated, Storability, Weight loss

ABSTRACT

This experiment was carried out on potato tubers during the two successive seasons of 2013/2014 and 2014/2015 at the Department of Natural Products Research, National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt. The research aims to reduce losses resulting from the storage at room temperature and to reduce cold storage costs of potato tubers using gamma radiation, mint oil and paclobutrazole treatments.

Potato tubers cv. Sponta were treated with 100 Gy of gamma radiation, 5% of mint oil and 100 ppm of paclobutrazole during the two successive seasons of 2013/2014 and 2014/2015. Results showed that, tubers irradiated with 100 Gy and soaked in 100 ppm paclobutrazole scored the lowest percentage of weight loss, sprouting, shrinkage, decay and total lost percentage. As for the effect of soaking tubers in 5% mint oil, results showed a higher percent of shrinkage than other treatments. On the other hand tubers irradiated with 100 Gy of gamma irradiation then soaked in 100 ppm of paclobutrazole had higher contents of starch than other tested treatments.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important vegetable crops of the family solaneceae. It occupies the fourth place in food crop production worldwide after wheat, maize and rice. The production of potato crop takes the second rank in 2012 after tomato by 4758040 ton According to the Agricultural statistics of Ministry of Agriculture 2013**.** In Egypt**,** one of the most important problems which face potato during storage is sprouting especially under unrefrigerated storage conditions. Preventing potato sprouting during storage could be used through different methods i.e., cold storage, dipping in hot water, modified atmosphere storage, chemical materials and physical methods **(Daniels-Lake et al 2011).** One of these physical methods is ionizing radiation. Ionizing radiation like gamma radiation produced from the sources like Co-60 or Cs-137 preserve potato against sprouting and postharvest disease **Asha et al (2011). Ivanesa et al (2016)** studied the effect of 100, 150 and 200 Gy of gamma radiation on budding, rot, loss of weight, texture, flesh color, moisture, external and internal appearance, aroma, soluble solids, titratable acidity, vitamin C, protein, starch and glucose of potato cultivar Ágata and indicated that 150 Gy of gamma radiation was the most effective dose to reduce sprouting and post-harvest losses. Also, **Abdullah et al (2015)** found that 150 Gy proved to be most effective in retarding the sprouting of potatoes stored at ambient conditions and enhancing the shelf life up to 14 days. The results obtained by **Mahto and Das (2014**) indicated that low doses up to 120 Gy did not increase the susceptibility of potato tubers to rotting. The same authors **(2015)** found that 50 Gy scored the lowest concentrations of reducing and total sugars of potato tubers. In addition, **Rezaee et al (2013)** studied the effect of 50 and 100 Gy of gamma rays after harvest using Agria and Marfona

(Received 4 January, 2017)
(Revised 12 January, 2017)
(Accepted 18 January, 2017)

varieties and found that 100 Gy inhibited sprouting decreased weight loss and specific gravity. The results obtained by **Lu et al (2007)** showed that starch content of sweet potato increased at 100 and 500 Gy than the higher doses of gamma radiation**. Nouri and Toofanian (2001)** indicated that 100 Gy increased total sugars, in onion and potato. Also there are some organic compounds (essential oils) of some herbs which retard sprouting of potato tubers like mint oil and spearmint oil (**Coleman, 2001; Elbashir et al 2011).** Some chemical compounds may be used to retard sprouting and prolonging dormancy period. Paclobutrazol is a triazole compound categorized as plant growth retardant, and is mainly used to control vegetative growth of plants in various species. Paclobutrazol was reported to retard sprout elongation **(Ranney et al 1994; Wiesman and Lavee, 1994). Nakasha et al (2012)** studied the effect of different concentrations of paclobutrazole (0, 100, 200, and 300 mg/l) on sprouting of safedmusli (*Chlorophytum borivilianum*) and concluded that tuber treated with paclobutrazole had lower sprout percent than untreated tubers.

Therefore, the aim of this study was to investigate the effect of gamma irradiation, mint oil, paclobutrazole and their interactions on storability of potato tubers under unrefrigerated storage condition.

MATERIALS AND METHODS

This experiment was carried out during the two successive seasons of 2013/2014 and 2014/2015 at the Department of Natural Products Research, National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt.

The tubers of potato cv. Sponta were cultivated in clay soil during the first and second seasons respectively, at Kaliobeya Governorate, all agricultural practices included soil preparation, fertilization, irrigation, pest management; harvesting and handling were done according to the recommendation of the Ministry of Agriculture and Land Reclamation. Tubers were harvested at 90 days after planting in both seasons then tubers were cured at 29ºC and 90-95% relative humidity for 10 days for skin maturity and healing cuts and injuries occurred during harvesting**.**

After transportation of tubers to the laboratory, defected tubers and dissimilar in size were eliminated , then tubers were washed and surface was sterilized in 200 ppm sodium hypochlorite solution for 5 minutes, rinsed and dried in well-ventilated room. The tubers were divided into 7 treatments in addition to the control treatment, in 4 replicates, each treatment composed from 2 Kg of potato tubers placed in mesh plastic bags for each treatment.

Gamma irradiation unit is held at the National Center for Radiation Research and Technology-Nasr City. Using Indian unit of Cobalt-60, the radiation dose was 100Gy at the dose rate of 28.5 Gy/h and 27.9 Gy/h in the two successive seasons. Tubers were soaked in 5% of mint oil, of paclobutrazole and a mixture of 5% mint oil plus 100ppm paclobutrazole, 5% mint oil plus 100 Gy of gamma radiation, 100 ppm paclobutrazole plus 100Gy of gamma radiation and mixture of mint oil 5% plus 100ppm paclobutrazole 100ppm plus 100 Gy of gamma radiation for 2 minutes for each treatment and the control treatment(without treatment). During storage period the fallowing parameters were recorded.

1- Physical characters

1-1 Weight loss: Weight loss was recorded at the start of the experiment and at two weeks intervals during the storage period (12 weeks).

1-2 Sprouting: This was determined by weighing the sprouted tubers and the percent was calculated.

1-3 Shrinkage: It was determined visually according to the personal evaluation.

1-4 Decay percent: It was determined according to personal evaluation, where rotted tubers were weighted and the percentage was calculated.

1-5 Total loss: It is the overall consideration of weight loss, sprouting, shrinkage and. It was calculated as follow:
Total loss = weight loss% + Sprouting% + shrinkage% + decay%

1-6 Specefic gravity: The specific gravity of the stored tubers was determined using the following equation

$$\textit{Specific gravity} = \frac{\text{weight of tubers in air}}{\text{weight of tubers in air} - \text{weight of tubers in water}}$$

2-Chemical analysis

2 -1- Total sugars: It was determined according to **Dubois et al (1966).**
2-2- Starch content: It was determined according to **A.O.A.C. (1956).**

3 – Statistical analysis

Data were recorded every 2 weeks, and then were statistically analyzed according to **SAS (2006**), comparisons among means were evaluated by Duncan ´s Multiple Range Test at 5% level of probability.

RESULTS AND DISCUSSION

1- Weight loss %

It is noticed that the weight loss was started at the fourth storage week in all treatments. Data in **Table (1)** show that after 12 weeks of storage, the highest weight loss percentage was observed. As for the effect of different treatments data show that tubers irradiated with 100 Gy and tubers soaked in paclobutrazole 100 ppm scored the lowest weight loss percent, without significant difference among them. On the other hand, the highest weight loss was recorded in the control, and mint oil at 5 % plus paclobutrazole at 100 ppm treatment. The same trend was observed in the second season. Similar result was obtained by **Rezaee et al (2013)** in potato tubers irradiated with 100 Gy**.**

2- Sprouting %

Sprouting percentage as affected by gamma irradiation, mint oil, paclobutrazole and their interaction was presented in **Table (2)** Sprouting was started at eighth week in some treatments. Data show that at 12 weeks after storage, sprouting percent was increased. Regarding the effect of gamma rays, the irradiation of tubers with 100 Gy only and soaking tubers in the paclobutrazole at 100 ppm plus gamma irradiation with 100 Gy led to the lowest sprouting percent without differences among them in both seasons. On contrast, treatment the tubers with mint oil at 5 % only and treatment of tubers with mint oil combined with other tested treatments reflect the highest values of sprouting percentage compared with the control and other tested treatment during the two seasons of study . These results agree with those obtained by **Ivanesa et al (2016) and Rezaee et al (2013).** Sprouting delaying in potato using gamma irradiation was found by **Abdullah et al (2015)**.

3- Shrinkage %

Shrinkage started in the tenth week in all treatments except the irradiated tubers, paclobutrazole + irradiated and paclobutrazole treatments. Regarding the effect of gamma irradiation, mint oil, paclobutrazole and their interaction on shrinkage percentage of tubers, data in **Table (3)** indicate that at 12^{th} week of storage, shrinkage percent was increased with increasing in storage period. The treatment of tuber with gamma rays at 100 Gy, paclobutrazole at 100 ppm or their combination showed the lowest shrinking percent in both seasons followed by the mixture of gamma irradiation and paclobutrazole in the second season. The noticed shrinkage was increased by extending the storage period, regardless of the tested treatments**.**

4- Decay %

This study recorded that decay was noticed in the sixth week in tubers treated with mint oil + paclobutrazole. The effect of gamma irradiation, mint oil, paclobutrazole and their interactions on decay percentage was presented in **Table (4)**. It was found that at 12^{th} week after storage, the decay percent was higher than that at the beginning of the experiment, untreated tubers also soaked in mint oil and the mixture between mint oil and paclobutrazole led to the highest decay percentage, while no rotting was recorded in the irradiated tubers. Those results obtained by **Mahto and Das (2014).** Other treatments recorded the lowest decay percentage in both seasons and there was no significant difference between them. These Results are comparable to those of **Ivanesa et al (2016)** who recorded 15% rot after the first seven days in the control samples and 5% rot after 14 days for samples receives 100 Gy of gamma radiation.

5- Total loss %

Total loss of potato tubers was started from the fourth week of storage in all treatments. In **Table (5),** the effect of gamma irradiation, mint oil, paclobutrazole and their interaction on total lost percent such data show that the total lost was observed in a high percent at 12^{th} weeks of storage. Tubers irradiated with 100 Gy, soaked in paclobutrazole and irradiated and soaked in paclobutrazole had

the lowest total lost percent and there was no significant difference between these treatments in both seasons. **Mahto and Das (2014)** concluded that low dose gamma radiation (0.05 – 0.15 kGy) developed as an effective post-harvest method for potato storage which was successfully controlled the storage losses.

6- Specific gravity %

Data in **Table (6)** show that the increase in specific gravity was linked to the increasing storage period especially at 12th week post- storage. The untreated tubers scored the highest specific gravity in both seasons, while the interaction between gamma irradiation and paclobutrazole, paclobutrazole only scored the highest specific gravity in the first and the second seasons, respectively. This result agrees with that obtained by **Rezaee et al (2013)** who found that 100 Gy increases specific gravity of potato tubers.

From previous results, it could be concluded that with an increase in storage period an increase in weight loss, sprouting, shrinkage, decay percentage and total lost was held. This result may be attributed to the high temperature and the increase in respiration which is the major cause as reported by **Picha (1986c).** Some researchers found that irradiation resulting in a complete loss of growth hormone known as indol acetic acid (IAA) in cell tissues of the buds on the potato tuber **(Sharabash, 1995)**. Paclobutrazole results obtained in this study may be attributed to its role in preventing the production of growth hormone gibberelic acid GA3 (**Arteca, 1996**). The essential oils probably delays metabolic changes in potato tubers (**Paula et al 2010**), also the presence of monoterpenes in essential oils often serves as a defense mechanism, against insects and microorganism (**Vaughn and Spencer, 1991**).

7- Total sugars %

The percentage of total sugars in tubers as affected by gamma irradiation, mint oil, paclobutrazole and their interactions is presented in **Table (7)** It was concluded from the data presented that tubers soaked in mint oil solution, paclobutrazol and the combination of three tested treatment, irradiated with 100 Gy and soaked in paclobutrazole and tubers soaked in the solution of mint oil and paclobutrazole scored the highest percent of total sugars in both seasons. The same results were detected by **Mahto and Das (2015**). In addition, **Nouri and Toofanian (2001)** indicated that 100 Gy increased total sugars in potato tuber and onion bulbs.

8- Starch content

As for the effect of gamma irradiation, mint oil, paclobutrazole and their interaction on starch content, results in **Table (8)** showed that tubers soaked in mint oil with gamma irradiation and mint oil with gamma irradiation followed by irradiated tubers had higher percent of starch content compared with the other treatments. The obtained results are in agreement with those of **Ivanesa et al (2016),** who mentioned that tubers subjected to 0.15 kGy of gamma radiation showed a higher percentage of starch than the control ones.

REFERENCES

Abdullah, R., Athar, U., Iqtedar M., Kaleem A., M. Aftab M. and Naz, S., 2015. Reducation of Microflora and frequency of sprouting in Gamma Irradiated Potatoes. **Fuuast J. Biol., 5(2), 213-217.**

A.O.A.C. 1956. Official Methods of Analysis 12. the 3rd editon. **Assoc. of Anal. Chem., 39, 423.** Washington D.C., USA.

Arteca, R.N. 1996. Plant growth substances: Principles and applications. Chapman & Hall, International Thomson Publishing, New York. USA, **pp. 16 – 68.**

Asha, P., Vadivu, S.K. and Rajeswari, N. 2011. Effect of gamma radiation on flexible food packagingmaterial. **International Journal of Advanced Engineering Technology. 2, 151-156.**

Coleman, W.K., Lonergan G. and Silk. P. 2001. Potato sprouts growth suppression by menthone and neomenthol, volatile oil components of *Minthostachys*, *Satureja*, *Bystropogon*, and *Mentha Species*. **American Journal of Potato Research. 78, 345-354.**

Daniels-Lake, Pruski, B.J. and Prange, R.K. 2011. Using ethylene gas and chlorpropham potato sprout inhibitors together. **Potato Research, 54, 223-236.**

Dubois, M., Smith, F., Gilles, K.A., Hamilton J.K. and Rebers, P.A. 1966. Colorimetric method for determination of sugars and related substance. **Anal. Chem., 28(3), 350-356.**

Elbashir, H.A., Ahmed, R.A. and Yousif, K.S. 2011. Effect of spearmint oil on sprouting and processing quality of Diamant and Sinora Potato Varieties. **Journal of biological Scienes. 3(5), 530 – 534.**

Ivanesa, G.M., Silva, E.B., Amaral, A.J., Machado, E.C. and Silva, J.M. 2016. Physicochemiocal and sensory evaluation of potato (*Solanum tuberosum* L.) after irradiation. Anais de Academia Prasileire de Ciencias. **Annals of the Brazilian Academy of Sciences. 88(2), 941- 950.**

LU, J.Y., White, S., Akubu, P.Y. and Loretan, P.A. 2007. Effects of gamma radiation on nutritive and sensory qualities of sweet potato roots. **Journal of Food Quality 9(6), 425 - 435.**

Mahto, R. and Das, M. 2014. Effect of gamma irradiation on the physic-mechanical and chemical properties of potato (*Solanumtuberosum* L.), cv."Kufri Sindhuri" in non-refrigerated storage conditions. **Postharvest Biology and Technology. 92, 37-45.**

Mahto, R. and Das M. 2015. Effect of γ irradiation on the physico-mechanical and chemical properties of potato (*Solanum tubersum* L.), cv. "Kufri Chandramukhi" and: Kufri Jyoti", during storage at 12°C. **Radiation Physics and Chemistry. 107, 12 - 18.**

Nakasha, J.J., Sinniah U.R., Puteh, A. and Hassan, S.A. 2012. Longivity of safed Musli (*Chorophytum borivilianum*) tubes under different storage Temperatures and Concentrations of Paclobutrazol. **Journal of Medical Plants Research. 6(41), 5439 - 5446.**

Nouri, J. and Toofanain F. 2001. Extension of Storage of Onions and Potatoes by Gamma Irradiation.Pakisan. **Journal of Biological Sciences. 4 (10), 1275-1278.**

Paula, T.B., Nativa, D., Ravit, F., Nita, Z., Oded, S. and Dani, E. 2010. Mint essential oil can induce or inhibit potato sprouting by differential alteration of apical meristem. **Planta. 232, 179 - 186.**

Picha, D.H. 1986c. Weight loss in sweet potatoes during curing and storage: Contribution of transpiration and respiration. **J. Amer. Soc. Hort. Sci., 111(6), 889-892.**

Ranney, T.G., Bir, R.E., Conner, J.L. and Whitman, I.E. 1994. Use of Paclobutrazol to Regulate Shoot Growth and Flower Development of 'RoseumElegans' Rhododendron. **J. Environ. Hort. 12(3), 174-178.**

Rezaee, M., Almassi, M., Minaei S. and Paknejad, F. 2013. Impact of post-harvest radiation treatment timing on shelf life and quality characteristics of potatoes. **J. Food. Sci. Technol . 50(2), 339-345.**

SAS. 2006. Statistical Analysis System, SAS User´s Guide: Statistics. SAS. Institute Inc. Editors, Cary, NC.

Sharabash, M.T.M. 1995. Potatoes. In: radiation technology in food and agriculture. Arabian Organization for Agriculture Development and Atomic Energy Authority Pub., Egypt, **pp. 306 – 328.**

Vaughn, S.F. and Spencer, G.F. 1991. Volatile monoterpenes inhibi potato tuber sprouting. **Amercian Potato Journal. 68(12), 821 – 831.**

Wiesman, Z. and Lavee, S. 1994. Vegetative growth retardation, improved rooting and viability of olive cuttings in response to application of growth retardants. **Plant Growth Regul.14, 83-90.**