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Application of ionizing radiation in the "licuri" (*Syagrus coronata* (Mart.)) as phytosanitary treatment of the *Pachymerus nucleorum* beetle (Fabricius, 1792)

Nogueira [a] A. G., Negrão[a] B. G., Arthur[b] V., Villavicencio[a], A. L. C. H.

[a] *Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN – SP), 05508-000, São Paulo, São Paulo, Brasil.*

[b] *Centro de Energia Nuclear na Agricultura (CENA / USP), 13416-000, Piracicaba, São Paulo, Brasil.*

nogueirazon@hotmail.com

ABSTRACT

***Pachymerus nucleorum* (Fabricius, 1792), is a pest of economic importance it causes direct damages to the "licuri" almonds. The objective of this study was to determine the lethal doses of gamma radiation for stages egg, larvae, and pupae of this insect as a phytosanitary treatment in "licuri". The samples were irradiated in a Cobalt 60 irradiator, Gammacell-220 type, installed at the Institute of Energy and Nuclear Research - IPEN / CNEN at a dose rate of 748 Gy / h. Each treatment consisted of 3 replicates, so 180 licuri were irradiated in the doses of 50, 75, 100, and 125 Gy. After irradiation, the samples were stored at a temperature of 25 ± 5°C and relative humidity of 70 ± 5%. The evaluation of the fruits was performed by the emergence of insects. It is concluded that the dose of 125 Gy was sufficient to inhibit the development of insect life stages. Therefore, this dose of radiation can be used for control of the immature stages of the P. nucleorum.**

Keywords: **food irradiation, insects, life stage.**

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1. INTRODUCTION

The fruit from "licuri" palm (Syagrus coronata) is extracted from palm trees in native forests. It is scientifically named as Syagrus coronata (Martius) Beccari and is a member of the Arecaceae family, Arecoideae subfamily [1]. The regional communities, agro-extractives, and family farmers know it in different names such as adicuri, iricuri, licuri, and licurizeiro. There are 36 popular name forms at least [2] (Figure 1).

Figure 1: *"Licuri" palm tree and fruit.*

Source: author' collection

Infestation by insect pests is the most problems related to the cultivation of the "licuri" palm tree, that not only affect the development stages of the palm but also damages the fruit. There are about 80 species of insects that deteriorate the "licuri" [3] what limit the production and cause significantly low crop as beetle named Pachymerus nucleorum. [4]

P. nucleorum (Fabricius, 1792) is a beetle of the Bruchinae subfamily and Chrysomelidae family, known as vegetable seed borers, one of the greatest pests of fruits stored [5], is a natural predator that causes many damages on palm trees. The beetle is a common insect throughout the north of Brazil has a dark gray color, striated elytra measuring 12 mm to 15 mm length and 5 mm to 7 mm width [6].

The beetle life stage starts with the oviposition on fruits or seeds. Commonly, the females leave their eggs, in the fallen ground fruits, so the larvae hatch and penetrate through the channels of sap or yarn of the coconut. Then, its feed on the almonds by absorbing oil and protein and weave a cocoon where they stay until they become adults [7, 8].

On average, these larval period lasts three months, and the pupal period lasts two months. Before the emergence of adult beetles, they remain inside the coconuts for more two weeks. After this period, they break through the 5 mm diameter hole made by the larva and emerge. [9]

The study of Coleoptera biology allows understanding the behavior insect life stage and their ecological importance [10]. Indeed, some pests seriously affect the quantitative and qualitative aspects of products. The quantitative damage is the loss of weight and degree of hygiene of the product due to the presence dropping of beetles [11] and qualitative loss is associated with the consumer acceptance or fruit appearance [12].

The phytosanitary treatment aim is the prevention and propagation of regulated pests from infested for non-infested areas, for example, when a production area is infestation by a regulated pest and their products exported are capable entry other areas. [13]

In this case, the application of irradiation for food preservation is a prospective field of food science and technology [14]. This processing consists of exposing food to controlled doses of ionizing radiation for the sanitary, phytosanitary, and technological purposes [15].

It is a physical process applied to food with several practical advantages [16] such as reduce storage losses, improve food safety, increase shelf-life also reduces the pathogenic microorganism load, or inhibits the insects' life stage possibly present in food [17]. Also, the process of food irradiation is quite safe for the environment, as it does not produce residuals as pesticides [18].

Given this point, the objective of the work was to determine the lethal doses of gamma radiation for the phases of egg, larvae, and pupae of *P. nucleorum* aiming at its control in almonds of the “licuri”.

2. MATERIALS AND METHODS

2.1. Licuri irradiated samples.

The samples of "licuri" almonds infested by the *P. nucleorum* beetle stages of egg, larvae, pupae (Figure 2) were obtained from Iramaia, Bahia, Brazil. A Cobalt 60, type Gammacell-220 irradiator, installed at the Institute of Energy and Nuclear Research - IPEN / CNEN at a dose rate of 748 Gy / hr. located in São Paulo (Brazil) was used to perform the radiation.

Each treatment for the insect stages inside almonds consisted of 3 replicates with 12 a total of 180 "licuri" per test that was irradiated in the doses of 50 Gy, 75 Gy, 100 Gy, and 125 Gy of gamma radiation. Non-irradiated fruits were used as control samples.

2.2. *P. nucleorum* beetle assays.

After irradiation, the "licuri" infested were placed in 250 ml glass pots with caps punctured for oxygen exchanges. The samples were stored in a controlled environment with a temperature of 25 ± 1 ° C and relative humidity of 70 ± 5%. The doses' effectiveness was evaluated through the counting of the emergence of adults. So, the mortality of immature stages was evaluated from July to December/2020. Data were analyzed by the statistic program (SAS) by the Tukey test ($p < 0.05$).

3. RESULTS AND DISCUSSION

Table 1 shows the results obtained from "licuri" infested by eggs, larvae, pupae, and the doses of cobalt-60 gamma radiation applied. As can be seen, the effects of the gamma radiation on *P. nucleorum* were relative to the increase of radiation doses applied. Moreover, fewer adults emerged when compared to non-irradiated samples.

The lethal dose for the eggs was at 75 Gy where there was no adult emergency. For the larvae stage, no emergence was noticed at 100 Gy and assays pupae showed that 125 Gy is the lethal dose. At the dose of 50 Gy, 58.3% of pupae and larvae survived. Only 16.7% pupae and none larvae survived at dose 100Gy. These results agreement with those found by Arthur et.al, in studies about insect tolerance radiation [19,20,21,22,23,24].

Table 1: Tables are numbered with Roman numerals.

Life stage**	Doses (Gy)*				
	non-irradiated	50	75	100	125
Eggs	10^{a}	3^{b}	-	-	-
Larvae	9^{a}	7^{a}	8^{a}	-	-
Pupae	8^{a}	7^{a}	5^{b}	2^{c}	-

* Equal letters in the same column do not differ statistically at the 5% level of significance in the Tukey test.
**Number of emerged adults insects

The *P. nucleorum* is considered a pest important because of the serious damages the insect cause in all fruit parts. During the experiment it was possible to observe the stages and its consequences (Figure 2).

Firstly, the females beetle lay eggs in the fallen fruits of the "licuri" palm tree. The egg develops up to the larvae stage, then hatches and penetrates the fruit through the sap channels (or hilum of the coconut). Secondly, it is developing inside the almonds feeding of the oil and proteins. Once inside, it weaves a cocoon where they stay up to the pupae stage finally leave the fruit as adults. [7, 24]

Figure 2. *Life stages of the Pachymerus nucleorum.*

Source: author's collection

According to Hallman, the generic phytosanitary irradiation treatments are 300 Gy for all insects (except Lepidoptera pupal and adults), 400 Gy for Lepidoptera pupal, 250 Gy for mealybugs,

150 Gy for weevils (Curculionidae), 70 Gy for the fly genus of Anastrepha fruit, 250 Gy for all Lepidoptera eggs. [26]

Besides, ISPM 18 (Guidelines for the use of irradiation as a phytosanitary measure) establishes ionizing radiation dose ranges for groups of insects. Regarding the Coleoptera group, the range is 50 to 400 Gy to sterilize adults in active reproduction. [27]

Additionally, the International Plant Protection Convention studied some pests and established a dose of 150 Gy is sufficient to prevent the development of F1 adults of Euscepes postfasciatus, 92 Gy to prevent reproduction in adults of Conotrachelus nenuphar and 165 Gy to prevent the development of adult F1 Cylas formicarius elegantulus [27].

In contrast to other treatments used commercially, phytosanitary treatment through irradiation attend an essential aspect that affects the regulation of the process. While other methods only must result in dead pests soon after the end of treatment; insects irradiated in the doses used (current minimum target doses are 150 and 500 Gy) will live days after irradiation, but will no longer develop or reproduce. [28, 9]

As expected, the ionizing radiation does make pests unable to complete development and reproduction. Also, phytosanitary irradiation does not have an independent measure of effectiveness (dead pests on inspection), as the case with any other commercial phytosanitary treatment.

4. CONCLUSION

In conclusion, the dose of 125 Gy is effective in inhibiting the development of the *Pachymerus nucleorum* life stages. This study corresponds to the International Standards for Phytosanitary Measures and also achieves a specific dose of ionizing radiation for an insect that causes a considerable impact on the “licuri” losses production.

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