

*Irradiation of shrimp extends their storage life.*

## Low Level Ionizing Radiation and Spice Treatment of Raw, Headless, White Shrimp

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**ABSTRACT**—A study was made to determine the storage life of raw, headless, white shrimp treated with ionizing radiation and shrimp treated with turmeric and salt and ionizing radiation. Sensory assessment of irradiated shrimp and shrimp treated with ionizing radiation and turmeric and salt exhibited a storage life of 2 and 4 weeks longer, respectively, than nonirradiated shrimp. The spice treatment masks off-odors and flavors caused by irradiation and imparts a spicy odor, inhibits melanosis, and produces a more desirable irradiated product.

### INTRODUCTION

A review of the literature of the past decade dealing with low-level irradiation treatment of fish and shellfish shows that the refrigerated storage life is increased (Miyauchi et al. 1967-1968, Slavin et al. 1966, Ronsivalli 1967, Kumta and Sreenivasan 1967). In such studies, irradiation doses ranging from 50 kilorads to 1 megarad followed by refrigerated storage have been used (Coleby 1959). Spoilage bacteria are eliminated effectively and selectively by low-level doses of irradiation, thereby resulting in extension of storage life (Masurovsky et al. 1963, Pelroy and Eklund 1966, Laycock and Regier 1970). Considerable work has also been done to extend the storage life of fishery products even further by irradiation in combination with other chemicals such as sodium benzoate (Lee et al. 1965) and antibiotics (Awad et al. 1965) through synergistic bactericidal effects. Spoilage of the product finally ensues when some bacteria survive such treatment, multiply, and finally degrade fish tissue.

When fish and meat are irradiated at different dose levels, radiation-like odors and flavors are more pronounced at higher dose levels (Urbain 1965, Hannesson and Dagbjartsson 1970), but the intensity of the odors and flavors

diminishes as the storage period lengthens (Scholz et al. 1962).

In India and other far eastern countries, people are accustomed to eating spiced food. Many such spices are known to possess antioxidant and tinctorial properties apart from conferring their characteristic odor and flavor to foods. Thus, Sethi and Aggarwal (1950) found that chili peppers, cinnamon, ginger, turmeric, nutmeg, black pepper, and cloves retarded rancidity in peanut oil.

Although some work has been done on the development of radiation-sterilized fish and fishery products by masking with spices and seasonings (Waters et al. 1969), practically no work has so far been reported on the use of spice in combination with low-level irradiated fishery products for inhibiting bacterial spoilage. Since turmeric is

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popularly used with salt in India for nearly every fish dish, it would be desirable to use it to mask any irradiation off-odor and off-flavor that might be developed during irradiation processing even at low doses. The present investigation was made, therefore, to study the feasibility of combining low-dose ionizing radiation of shrimp with turmeric and salt as a preservative process.

### MATERIALS AND METHODS

Fresh, headless, white shrimp, *Penaeus setiferus*, of commercial size (26 to 30 count) caught in Florida waters were air-shipped in ice in an insulated container to Gloucester, Mass. The shrimp were divided into different lots as control, pretreated control, irradiated, and pretreated and irradiated. The pretreatments were as follows:

- I. 5% suspension of turmeric spice - 15 minute dip.
- II. 5% suspension of turmeric spice - 30 minute dip.
- III. 5% suspension of both turmeric and salt - 15 minute dip.
- IV. 5% suspension of both turmeric and salt - 30 minute dip.

The samples (approximately 100 grams each) were then air-packed and sealed in heat-sealable polyester film bags and irradiated immediately under refrigerated conditions (42°F) at 100, 200, or 300 kilorads and held at 33°F for subsequent storage study. Since detectable irradiation off-odor and off-flavor in shrimp has been established as occurring above 250 kilorads (Kumta et al. 1970), a maximum irradiation dose of 300 kilorads was included so as to determine their occurrence in this study.

Sensory evaluation and bacteriological tests were performed periodically on the refrigerated stored samples. The sensory evaluation test was carried out using a 9-point hedonic scale. The samples were judged on appearance, odor, flavor, and texture by 12 experienced taste panelists composed of staff members of the laboratory. To avoid sensory fatigue, seldom were more than 4 samples served at a time. The shrimp were cooked by steaming 10 minutes and were served hot for evaluation. Panelists judged samples in individual booths and arrived at their scores independently of one another.

The bacteriological analysis of experimental shrimp consisted of total

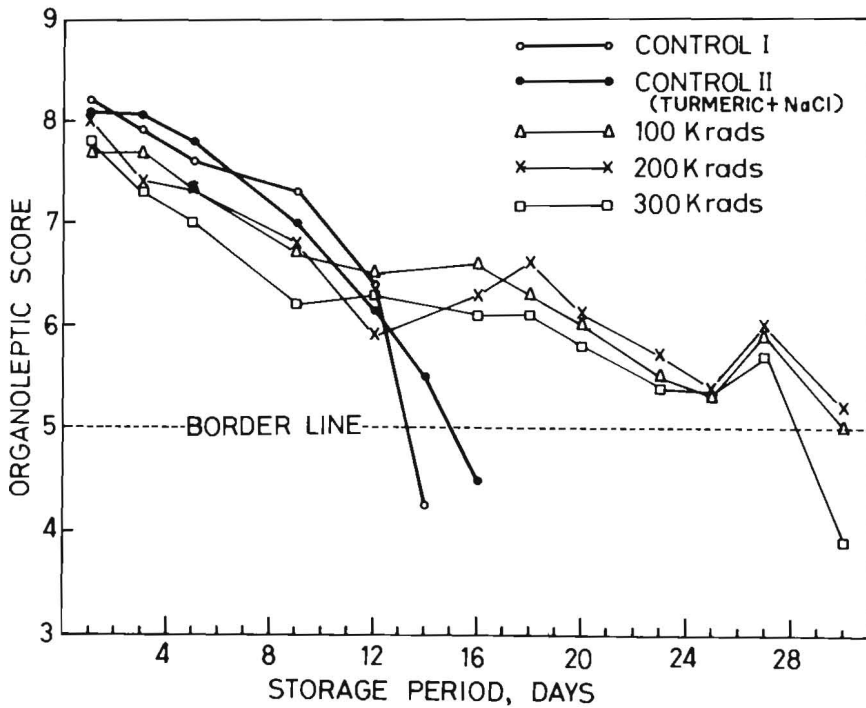


Figure 1.—Overall organoleptic score of control and irradiated shrimp based on hedonic scale with 9 as "like extremely," 1 as "dislike extremely," and 5 as "neither like nor dislike" (on the borderline of acceptability).

aerobic plate counts performed on samples of randomly chosen shrimp of the appropriate sample groups.

Aerobic total bacterial counts were obtained by pour plate techniques using nutrient agar enriched with 0.5 percent yeast extract, coliform groups by using lactose broth, and proteolytic activity by gelatin liquefaction tests on nutrient agar-gelatin media flooded with a solution of 2N HCl containing 15 percent Hg Cl<sub>2</sub>.

## RESULTS AND DISCUSSION

The storage life of samples held at 33°F when judged by experienced taste panelists (see Fig. 1) was as follows: control 13 days, control (treated) 15 days, and all irradiated samples were acceptable up to 28 days. The irradiated samples scored 0.5 to 1.0 point less on the hedonic scale than the controls during early storage. Shrimp irradiated at the 300 kilorad level exhibited greater irradiation off-flavor than 100 and 200 kilorad level irradiated samples, but the difference decreased on subsequent storage (Scholz 1962). The 300 kilorad level samples did not have a longer storage life than those of the 100 and 200 kilorad levels but scored lower and were completely rejected by the 30th day.

The gradual decrease in acceptability of irradiated samples during the first 9-12 days of storage does not correlate with bacterial growth. Figure 2 shows that there is no increase in total bacterial plate count during this period for all the irradiated samples. The decrease in acceptability during this period might be related to changes in chemical constituents affected by endogenous enzymes or bacterial enzymes produced earlier.

It is evident from the work of Ron-sivalli et al. (1965) and Kaylor et al. (1970) that the application of 300 kilorads of ionizing radiation reduces the total bacterial plate count up to 3 log cycles. In this particular experiment the bacterial loads of control samples increased by 3 log cycles at the end of the

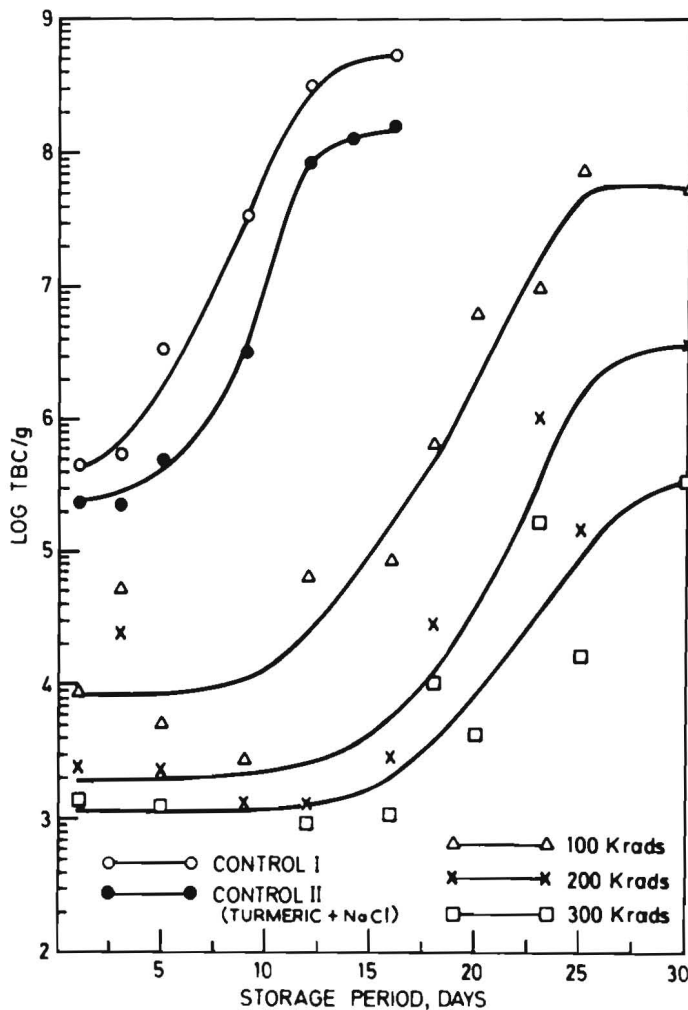


Figure 2.—Bacterial load of control and irradiated shrimp.

storage life. The irradiated samples, however, showed a one log cycle reduction for each additional 100 kilorads of ionizing radiation.

In the case of control samples, there was scarcely any bacterial lag phase. The log phase was steep, leading to less shelf life, whereas in the case of irradiated samples, the lag as well as the log phase was extended. This may be due to a combination of effects: shift in microflora surviving the irradiation treatment (MacLean and Welander 1960), damage inflicted on the bacterial cell (Stapleton 1955), and the retarding effect that irradiated substrates and packaging have on microbiological growth (Solberg and Nickerson 1963). Although the time required for bacterial surviving irradiation to return to their original level increased with dose, the samples at all dose levels spoiled at the same time. This may be due to survival of different microflora at different doses which eventually cause spoilage. Another explanation might be that the spoilage rate is dependent continually on temperature, but dependent on bacteria only until the available enzymes have increased to reach a maximum level of activity on the substrate (Charm et al. 1972).

Table 1.—Spoilage characteristics at the end of storage life of nonirradiated, irradiated, and pretreated plus irradiated shrimp held at 33°F.

Sample	Storage time (days)	Comments of panel	
		Raw	Cooked
Control (raw)	13	Melanosis, odor of decomposition	Melanosis, ammonia odor, inedible
Control turmeric-salt treated <sup>1</sup>	15	Some melanosis, spicy odor and odor of decomposition	Some melanosis, ammonia odor, spicy odor
100 kilorads	28	Melanosis, odor of decomposition	Melanosis, ammonia odor, decomposed
200 kilorads	30	Melanosis, slight irradiation odor, fishy odor	Melanosis, slight irradiation flavor, ammonia odor, stale
300 kilorads	30	Melanosis, some irradiation odor, odor of decomposition	Melanosis, irradiation flavor, ammonia odor, inedible
Pretreatment + 100 kilorads <sup>1</sup>	40	No melanosis, spicy odor, slight incipient spoilage odor	Saffron color, spicy flavor, slight ammonia odor
Pretreatment + 200 kilorads <sup>1</sup>	42	No melanosis, no irradiation odor, spicy odor predominant	Saffron color, spicy flavor, no irradiation flavor
Pretreatment + 300 kilorads <sup>1</sup>	42	No melanosis, no irradiation odor, slight ammonia odor, spicy odor	Saffron color, spicy flavor, no irradiation flavor, slightly sweetish

<sup>1</sup>Pretreatment dip with turmeric spice either alone or in combination with sodium chloride at 5% level each for 15 and 30 minutes followed by irradiation at 100, 200, and 300 kilorads.

Control (raw as well as treated) and irradiated shrimp developed black spots typical of shrimp (melanosis) and developed off-odor and off-flavor at the highest dose level. It will be seen from Table 1 that pretreatment with 5 percent turmeric and 5 percent salt dip for 15 and 30 minutes followed by irradiation

at the three dose levels resulted in a lack of melanosis and a lack of off-odor and off-flavor. When cooked, the pretreated samples developed a somewhat saffron color which enhanced their appearance.

Shrimp treated with turmeric and salt and irradiated at different dose levels exhibited a shelf life of 42 days (Fig. 3)

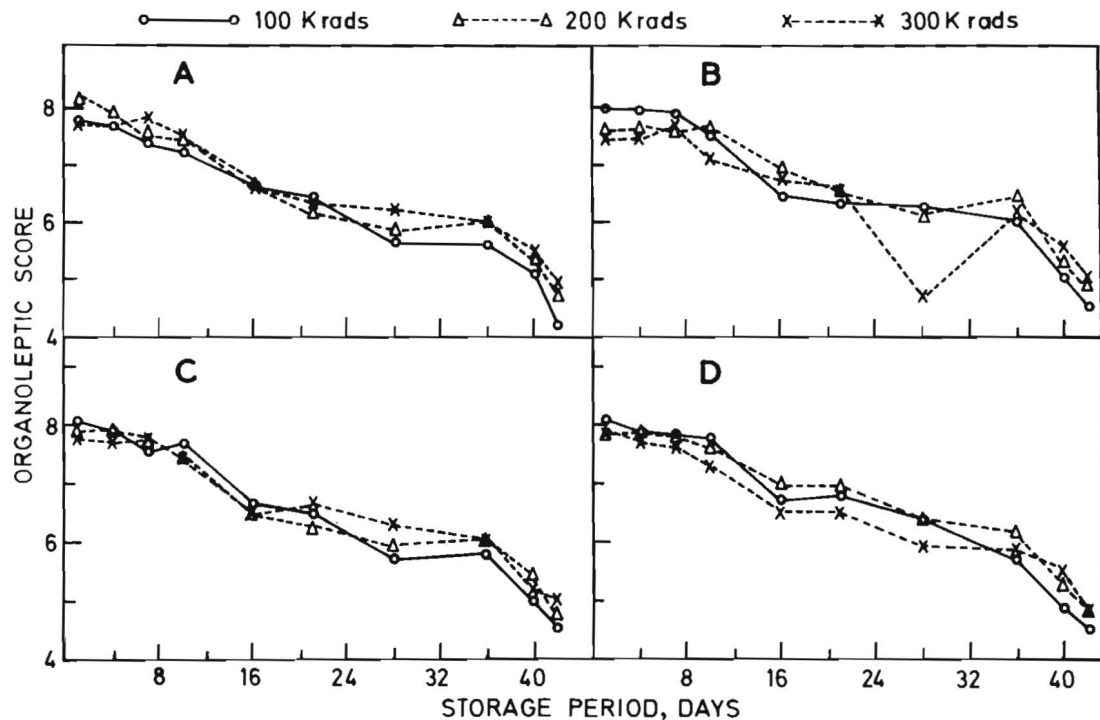


Figure 3.—Overall organoleptic score of combination-treated shrimp based on hedonic scale. A = 5% turmeric predip for 15 minutes. B = 5% turmeric predip for 30 minutes. C = 5% turmeric + 5% NaCl predip for 15 minutes. D = 5% turmeric + 5% NaCl predip for 30 minutes.

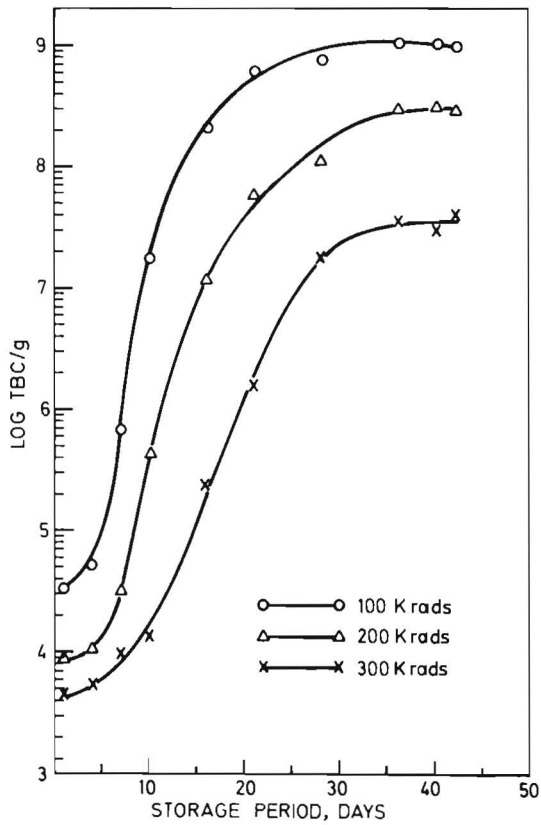


Figure 4.—Bacterial load of 5% turmeric predip for 15 minutes and irradiated (combination-treated) shrimp.

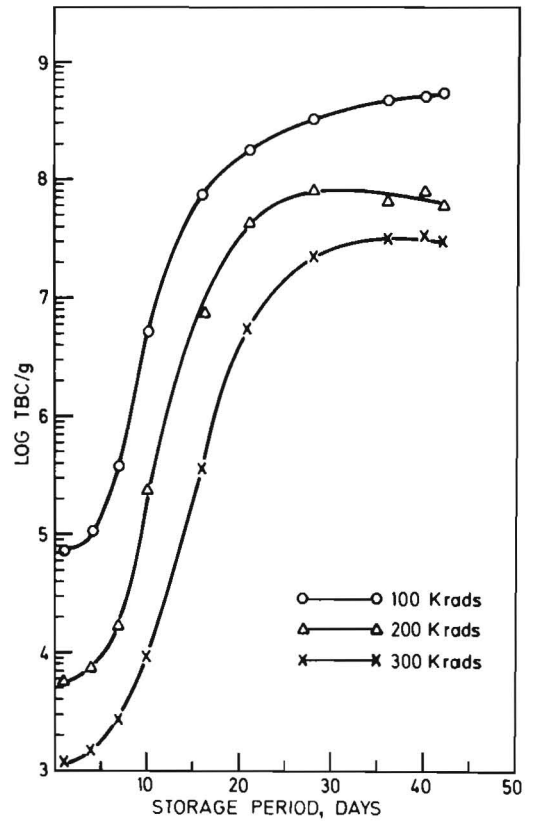


Figure 5.—Bacterial load of 5% turmeric predip for 30 minutes and irradiated.

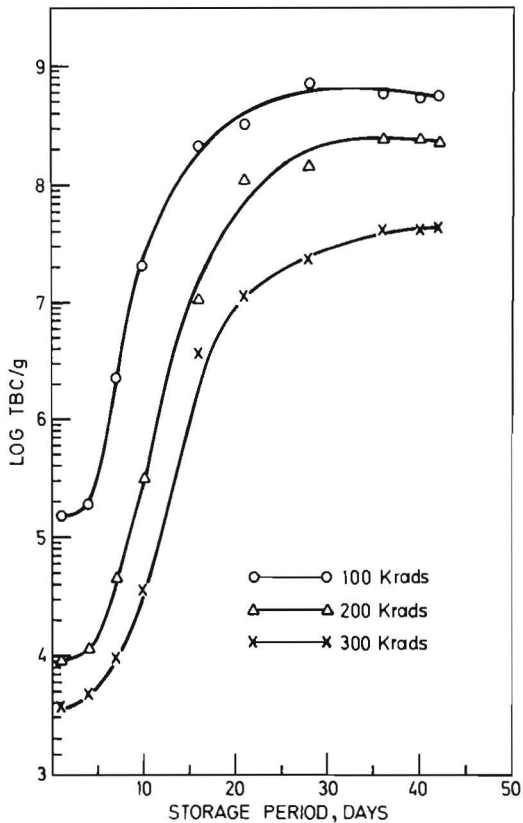


Figure 6.—Bacterial load of 5% turmeric + NaCl predip for 15 minutes and irradiated.

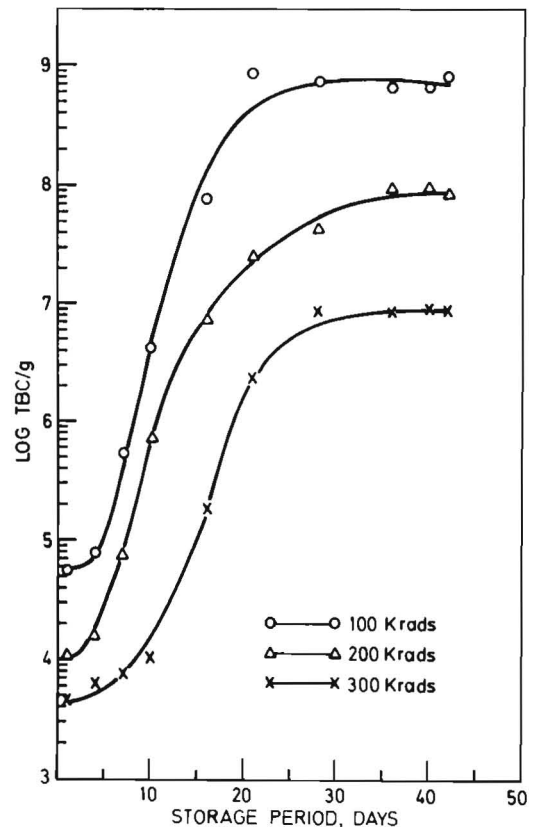


Figure 7.—Bacterial load of 5% turmeric + 5% NaCl predip for 30 minutes and irradiated.

as against 30 days for irradiated shrimp without spice and salt. The difference in storage life of the two control samples is not noteworthy when compared with the difference in the irradiated samples and those receiving the pretreatment plus irradiation. This indicates a complementary effect of the turmeric/salt/radiation combination. The different pretreatments also indicate that salt alone fails to have any contributory effect upon either the extension in storage life or in ameliorating off-odor and off-flavor of the irradiated shrimp. It is also interesting to note that the pretreated and irradiated shrimp consistently scored one-half to one full scale point above irradiated samples without pretreatment. The low point in the 300 kilorad curve, Fig. 3B, is believed to be an inexplicable artifact.

Figures 4 to 7 showed high total bacterial count (TBC) of combination-treated shrimp when compared with control and irradiated samples (Fig. 2) by a factor of 10 to 100 times at the end of their storage lives. Similar observations have been made by other workers (Spinelli et al. 1965, Adams et al. 1964, Kumta et al. 1970). Unlike the irradiated samples, the combination-treated shrimp did not exhibit a bacterial lag phase; the log phase curve is steeper and the count at the end of storage life was  $10^9/g$ . The proteolytic activity of bacteria expressed as percent of TPC did not correlate with organoleptic score. Coliforms were absent in all samples. This is confirmed by Kaylor et al. (1970) in his work with the parent stock of shrimp from which these samples were derived.

Table 2 summarizes the storage life of control, irradiated, and combination-treated shrimp.

## CONCLUSION

It would appear that turmeric in combination with low-dose ionizing radiation exerts a complementary effect in extending the shelf life of shrimp and imparts desirable attributes of flavor and appearance. While all levels of ir-

**Table 2.—Storage life, in days at dose levels, of control, irradiated, and combination-treated shrimp.**

	Description	Kilorads			
		0	100	200	300
I	Control	13			
II	Control turmeric + sodium chloride treated	15			
III	Irradiated samples		28	30	30
IV	5% turmeric dip for 15 minutes + irradiated		40	42	42
V	5% turmeric dip for 30 minutes + irradiated		40	42	42
VI	5% turmeric + 5% NaCl dip for 15 minutes + irradiated		40	42	42
VII	5% turmeric + 5% NaCl dip for 30 minutes + irradiated		40	42	42

radiation studied were effective, the 15-minute turmeric dip and 200 kilorad dose level produced an adequate storage life for shrimp when held at 33°F.

## ACKNOWLEDGMENT

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