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International Journal of Food Science, Nutrition and Dietetics (IJFS)
ISSN:2326-3350

Sensory Evaluation of Gamma Irradiated Shrimp (*Penaeus notialis*) from Three Different Water Sources in Ghana

Research Article

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Abstract

Shrimp is one of the world's most popular shellfish. It is cherished in Ghana due to a wide range of culinary applications such as its usage as food as well as food condiments in some local foods such as kenkey (local food prepared from fermented corn dough), pepper sauce (locally called shito), fast foods etc. The influence of gamma irradiation on the sensory and acceptability attributes of dried shrimp was evaluated. Sensory evaluation was carried out using steamed shrimp samples irradiated at doses 0 (control), 4, 8 and 10 kGy at a dose rate of 2.71 kGy/hr from a Cobalt 60 source (SLL 515, Hungary) batch irradiator and stored in polypropylene packs for 4 months at 28-30°C. Using a structured questionnaire, 30 male and female panelists independently assessed the samples for sensory attributes. Organoleptic scores were made according to a seven-point hedonic scale and a mean score of 4 used as the acceptable limit.

Results of investigated parameters of colour, aroma, texture and taste recorded were of ranges of 1.04 ± 0.05 - 2.0 ± 0.05, 1.0 ± 0.04 - 2.16 ± 0.17, 1.08 ± 0.05 - 2.12 ± 0.17 and 1.64 ± 0.17 - 2.2 ± 0.17 respectively showed some statistical differences ($p<0.05$) among the treatments of samples. The overall the most accepted samples were shrimps from the sea and river sources pretreated with dose 10 kGy scored similarly. Sensory evaluation of the gamma irradiated shrimps showed acceptability for samples from non-irradiated shrimps with taste and texture influencing selection of preferred choice.

Keywords: Sensory Evaluation; Texture; Gamma Radiation; *Paneausnotalis*; Hedonic Scale.

Introduction

The shrimp is an excellent source of protein and essential High-Unsaturated Fatty Acids (HUFA) such as eicosapentaenoic (20: 5n3, EPA) and docosahexaenoic (22: 6n3, DHA) acids [1, 2]. Furthermore, the shrimp is also a good source of minerals and vitamins such as calcium, iron, zinc, copper, vitamin B12, essential amino acids [1, 3] as well as astaxanthin, a fat-soluble carotenoid which has antioxidant properties. Its biochemical composition may be affected by several factors as the species, environmental factors, size, age, natural diet and feed composition [4, 5].

In Ghana and most parts of the world, drying remains one of the best options of preprocessing this seafood. It is one of the oldest means of food preservation and is applicable to a wide range of food products [6-8] including shrimps. Dried shrimps are popular and widely acceptable. They are used (in whole or powdered form) in soups and sauces as a major protein source and as food condiments owing to their delectable flavor [9]. In addition to drying, it is imperative to further enhance the shelf life of this product by a process which will impart minimal or no effects on its wholesomeness.

Gamma irradiation although a recent acceptable technology, is one of the few processes that can help attain this goal. The use of irradiation as a preservation process without loss of sensory and organoleptic qualities, is well documented for various foods [10-13]. There are however, conflicting data regarding the effect of irradiation on the sensory properties of foods [14]. This likely results from the fact that the development of off-odors and off-flavours in irradiated foods can be affected by a number of factors, including temperature, environment within the package,

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Received: February 19, 2018
Accepted: March 26, 2018
Published: March 27, 2018

Citation: Akuamoah F, Odamtten GT, Kortei NK. Sensory Evaluation of Gamma Irradiated Shrimp (*Penaeus notialis*) from three Different Water Sources in Ghana. *Int J Food Sci Nutr Diet.* 2018;7(3):383-386. **doi:** http://dx.doi.org/10.19070/2326-3350-1800068

packaging material, radiation dose, post irradiation storage time, and the condition of the food before irradiation [15]. According to Spoto et al., [16] sensory alterations in irradiated foods, more specifically in the texture, color, rancidity, and odor can be eliminated with low temperatures at the time of irradiation, with the application of absorbent substances and the use of condiments.

This paper therefore sought to investigate the effect of gamma irradiated dry shrimps on its sensory and acceptability attributes.

Materials and Methods

Shrimp Sample

Dehydrated-smoked shrimps from the sea, lagoon and river were purchased from three different areas, "Faana", "Tsokome" and "Bortiano" respectively; all located at the coastal areas of Ghana. The samples were dominated mainly by *P. notialis* although there were other few varieties found in the population, which were identified as *P. monodom* and *P. kerathucus*. The samples were them carefully sorted to ensure a homogenous population of *P. notialis*. They were then wrapped in a brown paper and then placed in a black polyethylene bag, (main mode of packaging by the local producers) and then transported to the Department of Botany laboratory of the University of Ghana. The shrimps were poured into dense polypropylene containers and kept at a temperature (6-8°C) appropriate for storage. These were considered the population from which the samples were collected for further analysis.

Irradiation of Shrimp Samples and Dosimetry Method

Irradiation was done according to [17] and [18] with modifications. The samples were packaged in dense polypropylene bowls which was able to satisfy this condition (packaging material which is strong enough to resist piercing/puncture by the antenna of the shrimp was considered) in accordance to the East African Standard (EAS, CD/K/512:2010: ICS 67.120.30) for dried shrimp packaging. The samples were treated with gamma irradiation (Cobalt-60 irradiator) in a Category Four (4) Wet Storage Irradiator at the Radiation Technology Centre at the Ghana Atomic Energy Commission. Doses applied were 0 kGy (control), 4 kGy, 8 kGy and 10 kGy within the range used by for dried shrimp in East Asia. The dosimeter used was the Ethanol chloro benzene (ECB) Dosimetry system, which comprise of the Ethanol Chloro benzene Dosimeter and the High Frequency Dosimeter Reader (HFDR). The dosimeter was calibrated against an International standard set by the International Atomic Energy Agency and read using the HFDR. To minimize variations in radiation dose absorption, the bags were turned at different angles half way through the procedure. Samples were analysed in triplicates for each source. The dose rate used was 2.17 kGy/hour in air.

Sample Preparation

The dried *P. notialis* samples were grouped according to their source (river, lagoon and sea) as well as method of pretreatment (non-irradiated and irradiated). Equal amounts (18.76g) of all samples were cooked by steaming in a pressure cooker (Binatone®, Japan) in a slightly saline water medium without spicing for a period of 30 minutes and used in the study. The maximum temperature, which occurred about 30s after the shrimps exited the pressure cooker was recorded as the final internal cooked temperature. The mean cooked temperature was 83.4°C with a SD of 2.9. Temperature rise was monitored with a handheld thermometer (Cole-Parmer, Vernon Hills, IL).

Sensory Analysis

Sensory analysis was carried out to compare the irradiated shrimp from different water sources (river, lagoon and sea) with control samples. The objective was to find out how the product will create perceived changes to human observers and how they would be accepted after irradiation is carried out. The discriminating or difference testing method, which tells whether there is a perceptible difference between two types of product, was used. The paired comparison procedure was used. The head of the shrimp was removed in order not to mask the actual taste attribute. Irradiated and control samples were served separately in an air-tight clear polyethylene material. Thirty (30) untrained panelists were selected for each analysis. They were composed of students from Graduate School of Nuclear and Allied Sciences (GSNAS) and staff from Ghana Atomic Energy Commission (G.A.E.C.). Panelists were selected based on their familiarity with the procedure and their knowledge about the test samples. During the process, an analytical frame of mind was adopted. Panelists were made to focus on specific attributes (colour, aroma, texture and taste) as directed by the scales on the questionnaire. They were to specify what attributes are present in the product and to what level of sensory intensity. Panel members scored all factors on a 7-point Hedonic scale and a mean score of 4 was used as the acceptable limit. Panelists were given the chance to make additional comments. The number of samples accessed at one sitting was limited to five to minimize sensory fatigue. Ordinary water was provided to each panelist to rinse mouth after tasting one sample before doing so to the others.

Organoleptic scores were made according to a seven point hedonic scale in which 7 = Like very much, 6 = Like moderately, 5 = Like slightly, 4 = Neither like nor dislike, 3 = Dislike slightly, 2 = Dislike moderately and 1 = Dislike very much, which showed the degree of likeness.

Statistics Analysis

The data was analyzed using Microsoft excel and analysis of variance (two way ANOVA) using Stat graphics software (centurion XVI.I) to assess whether the 2 independent variables thus radiation dose at the different levels and sources of shrimps had any effect on the variable been measured (various parameters). Differences among mean values were processed by Fisher's Least Significant Difference (LSD) procedure. Mean difference values were reported and significance was defined at $P < 0.05$. Each analysis was subjected to its own unique experimental design in a randomized complete block.

Results and Discussion

Table 1 shows a summary of treatment means of the multiple comparison tests. Panelists did not find any significant differences ($p < 0.05$) in the colour, aroma and texture of the riverine shrimp owing to radiation treatment although they found differences in taste between control and the irradiated shrimp. The colour attribute of shrimps obtained from riverine, lagoon and sea, ranged between 1.04 ± 0.05 - 2.0 ± 0.05. Samples treated with 4 and 8 kGy from the lagoon source statistically differed ($p < 0.05$) from the rest of the samples. Presumably, this result is in accordance with loss of total carotenoids [19], which was delayed by keeping the shrimp in ice.

Aroma ranged between 1.0 ± 0.04 - 2.16 ± 0.17 and showed statistical differences ($p < 0.05$) among the treatments of samples. The flavour experienced from eating mushrooms, or any other food, comes from a combination of taste, texture, temperature, spiciness, and aromatic qualities [20]. Effects of irradiation on odour and flavour have been studied with sensory panels of varying degrees of training; however, few consumer studies have been conducted.

Texture ranged between 1.08 ± 0.05 - 2.12 ± 0.17 and also showed some significant differences ($p < 0.05$) among the treatments of samples. The observed high score of non-irradiated *P. notialis* for hardness might be due to the ability of high doses of gamma radiation to cause a weakening of covalent bonds to cause depolymerisation [21-23]. Texture is a sensory attribute which greatly influences taste perception and the marketability of a product.

Taste ranged between 1.64 ± 0.17 - 2.2 ± 0.17 and also showed some significant differences ($p < 0.05$). Variation could probably be due to the diversity of preference of different shrimp species, method of cooking etc. by the consumers.

Generally, the panelist also found no difference in colour and taste after increasing doses up to 10 kGy in the sea shrimp (Table 1). However, they found difference in aroma and texture between the control and the irradiated samples (4-10 kGy) (Table 1). Also, irradiation at 4-10 kGy had no effect on colour, aroma, texture and taste of the lagoon shrimp (Table 1).

Table 2 is a summary of ranking of the shrimp in order of preference in relation to overall acceptability after irradiation. It was obvious from the statistical analysis that consumers preferred irradiated shrimp to a greater extent. For example, significant differences ($p \leq 0.05$) existed between irradiated lagoon shrimp at the different levels of irradiation dose; lagoon shrimp irradiated with 4 kGy was the most preferred and ranked highest whereas the same sample treated with 10 kGy were the least preferred. In the case of the riverine shrimp, samples treated with 10 kGy were the most preferred followed by 8 kGy and 4 kGy respectively. In the case of the sea shrimp, samples irradiated with 10 kGy were the most preferred while the control was the least preferred (Table 2). Taken together, one could conclude that the panelist preferred irradiated shrimp obtained from the different sources more than their parallel untreated control samples.

Table 1. Mean values of multiple comparison and ranking of overall acceptability of color, aroma, texture and taste of dehydrated-smoked shrimp (*Penaeus notialis*) after irradiation with 0, 4, 8 and 10 (kGy) doses.

Sources	Doses (kGy)	MULTIPLE COMPARISON (mean ± standard error)			
		Colour	Aroma	Texture	Taste
Lagoon	0	1.04 ± 0.05^a	2.0 ± 0.04^b	2.04 ± 0.05^b	2.04 ± 0.03^b
	4	1.96 ± 0.05^b	1.0 ± 0.04^a	1.08 ± 0.05^a	2.0 ± 0.03^{ab}
	8	2.0 ± 0.05^b	1.04 ± 0.04^a	2.0 ± 0.05^b	1.96 ± 0.03^a
	10	1.08 ± 0.05^a	1.08 ± 0.04^a	1.96 ± 0.05^b	2.0 ± 0.03^{ab}
River	0	1.88 ± 0.14^a	1.72 ± 0.15^a	2.12 ± 0.17^a	2.08 ± 0.17^{ab}
	4	1.84 ± 0.14^a	1.96 ± 0.15^a	2.16 ± 0.17^a	2.2 ± 0.17^b
	8	1.92 ± 0.14^a	1.72 ± 0.15^a	1.88 ± 0.17^a	1.64 ± 0.17^a
	10	1.64 ± 0.14^a	1.8 ± 0.15^a	2.04 ± 0.17^a	1.68 ± 0.17^a
Sea	0	1.96 ± 0.16^a	1.76 ± 0.17^{ab}	1.92 ± 0.15^b	2.04 ± 0.16^a
	4	1.92 ± 0.16^a	1.8 ± 0.17^{ab}	2.0 ± 0.15^b	1.76 ± 0.16^a
	8	1.96 ± 0.16^a	1.64 ± 0.17^a	1.44 ± 0.15^a	2.12 ± 0.16^a
	10	1.96 ± 0.16^a	2.16 ± 0.17^b	1.72 ± 0.15^{ab}	1.96 ± 0.16^a

Means within each column with different letters are significantly different ($P \leq 0.05$).

Table 2. Ranking According to Sample Most Preferred.

Sources	Doses (kGy)			
	0	4	8	10
Lagoon	-0.98 ± 0.05a^3	0.95 ± 0.05b^1	0.33 ± 0.05c^2	-0.3 ± 0.05b^4
River	-0.24 ± 0.15a^4	-0.09 ± 0.15ab^3	0.02 ± 0.15ab^2	0.30 ± 0.15b^1
Sea	-0.24 ± 0.15a^4	0.10 ± 0.15a^2	-0.04 ± 0.15a^3	0.18 ± 0.15a^1

Means within each column with different letters are significantly different ($P \leq 0.05$)

$^{(1-4)}$→ Ranking of shrimp (from highest (1) to lowest (4).

In the concluding experiment, the sensory evaluation of shrimp from different water sources before and after irradiation was carried out. Panelist did not find any significant differences ($p \pm 0.05$) in the colour, aroma and texture of the riverine shrimp owing to radiation treatment, although they found differences in taste between the control and irradiated shrimp (Table 1). The panelists also found no differences in colour and taste after increasing doses up to 10 kGy in the sea shrimp. However, they found differences in aroma and texture (Table 1). Irradiation at 4 -10 kGy did not affect colour, aroma, texture and taste of lagoon shrimp. It was obvious from the statistical analysis that the consumer panel preferred irradiated shrimp to a greater extent. Taken together, one can conclude that irradiated shrimp would be accepted by the consumer. Presumably, irradiation sensory qualities of shrimp are acceptable at low doses as stipulated by Wang et al., [18].

This observation is in agreement with findings of some researchers [24, 25] who carried out analysis to assess consumer attitudes to irradiated foods. Niemira and Fan [26], observed that treatment up to 0.5 kGy did not change the texture of different types of iceberg lettuce. Studies by [27] and [28] also demonstrated that doses of 0.5 kGy did not induce alterations on visual attributes or softening in iceberg lettuce. Recently [29], have shown the minimal to no effects of gamma irradiation on sensory, acceptability and descriptive textural properties of steamed dry mushrooms stored in two different packaging materials.

Results obtained have consistently shown that many consumers have misconceptions about the technology and believe that it makes food radioactive. When consumers are given information about the process and a chance to try irradiated products for themselves they are much more likely to accept the technology such as in this case reported in this paper.

Conclusion

Sensory evaluation of the gamma irradiated dry smoke shrimps showed acceptability for samples from irradiated shrimps with taste and texture influencing selection of preferred choice. Two other attributes, colour and aroma did not contribute significantly to the preferred option of sensory panelists.

Acknowledgement

Authors are grateful to all staff of the Food Science Department of the Biotechnology and Nuclear Agricultural Research Institute, Ghana Atomic Energy Commission for making available the equipment and materials for the analysis.

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