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Gamma Irradiation for Aflatoxin Decontamination in Peanut Samples

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Abstract: These days, more people are becoming aware of the use of radiation to reduce the quantity of aflatoxin in food products. Aflatoxin, a potent carcinogen, has been related to human illnesses like hepatitis B and tuberculosis by compromising the immune system. Mycotoxin contamination in agricultural products has significant negative economic effects. Aflatoxin is a very serious issue for food insecurity in developing countries because of climate elements, farming methods, and storage conditions that promote fungal development and toxin generation. This study used high-performance liquid chromatography to separate and identify different chemical compounds. Randomly chosen peanut samples from the Ethiopian Conformity Assessment store were placed in plastic bags and prepared for testing and analysis. For peanut samples, radiation dosages of 4, 6, and 8 kGy were used. Gamma-cell 220 research irradiator (GC-220) from MDS Nordion, a Co-60 gamma irradiator, was utilized by the National Institute for the Control and Eradication of Tsetse and Trypanosomiasis to irradiate the samples at a dose rate of 1.5 kGy/h. The samples were inspected after irradiation, and encouraging results were discovered. For 4, 6, and 8 kGy, respectively, it was found that there had been reductions in aflatoxin of 7.6%, 17.3%, and 23.25 percent. The results of this study make it abundantly clear that one strategy for addressing the problem of global food insecurity is irradiation technology, which should be promoted by stakeholders, policymakers, food storage facility providers, food packaging companies, food preservation facility providers, warehouse providers, and food item exporters.

Keywords: Aflatoxin, Contamination, Irradiation Treatment, Radiation Dose, Peanut, Food Preservation

1. Introduction

Aflatoxin, one of the most dangerous human carcinogens, is produced as a byproduct of secondary fungal metabolism. The most harmful mycotoxins are aflatoxins, which are produced by four species of the Aspergillus fungus. Some of these species are Aspergillus pseudotamarii, Aspergillus nomius, Aspergillus parasiticus, and Aspergillus flavus. Aflatoxins are known to harm 25% or more of the world's food crops annually [1], endangering both human and animal health and burdening farmers financially.

Aflatoxin contamination is one of the main challenges with food safety in Africa. Sorghum, maize, and groundnuts are just a few of the cash and basic crops that are affected. Aflatoxin-related product standards violations prevent African farmers from selling their goods in regional and international markets. Aflatoxin poisoning is thought to cost Africa $670 million annually in lost export revenue [2].

Peanuts can develop mold and are very susceptible to aflatoxin contamination, depending on the temperature, relative humidity, drying, and processing conditions [3]. Although the market for groundnuts is contracting and the product is no longer exported, the crop has a lot of potentials to raise farmers' and dealers' incomes across Ethiopia. The crop was rejected due to its aflatoxin contamination and the difficulty food processors and importers had in conforming to tolerance norms, which reduced market demand [4].

Mycotoxins are a very important issue in developing countries because their climatic conditions, agricultural practices, and storage conditions are conducive to the growth of fungi and the production of toxins [5]. Due to their ability to impair the immune system, aflatoxins are potent carcinogens that have also been connected to human ailments like hepatitis B and tuberculosis. Poor collecting conditions, uncontrolled production methods, and lengthy drying times expose spices to various fungal contamination, allowing mycotoxin development to happen at any stage of spice production, from pre-harvest to storage [6, 7].

Depending on the temperature, relative humidity, and drying and processing conditions, peanuts can grow mold and are extremely sensitive to aflatoxin contamination [8, 9, 10]. Up to 25% of agricultural goods around the world may contain mycotoxins, according to estimates from the Food and Agricultural Organization (FAO), which has a significant detrimental impact on the economy [11]. Decontamination is required before using such materials for food and feed because it is not always possible to stop the contamination of materials with aflatoxin before harvest or during post-harvest and storage [11-13].

Mycotoxin contamination in agricultural products has significant negative economic effects. Due to losses from rejected shipments and lower prices for subpar quality, mycotoxin contamination may completely ruin export markets in underdeveloped nations [1]. The problem was made worse by the fact that exported agricultural products and commodities did not meet the international standards for minimal quality. Some of the exported spices, mostly chili peppers, were sent back home due to a greater level of aflatoxin contamination [14].

Hot pepper powder worth $10 million was discovered to contain dangerous amounts of ochratoxin A and ochratoxin B when tested at entry laboratories in European countries. As a result, it was sent back to Ethiopia from European markets. After Ethiopian hot pepper was banned in the UK in 2017 until it could pass quality-control testing, Ethiopian hot pepper importers and the Ethiopian Embassy in London began working together to enhance the product. A lot of hot pepper was also prohibited from entering Germany [15].

Peanuts are the food item that this study has most dramatically affected. The irradiation technique was used in this study to disinfect the food samples. Food packaging and products are irradiated using ionizing radiation. It entails presenting food with a particular kind of low-energy radiation. The procedure gets rid of the bacteria, insects, molds, and fungus that cause foodborne illnesses or food spoilage. Irradiated food retains all of its flavor, texture, aroma, and nutritional content while being more safety-proof and resistant to degradation [16].

The goal of the current investigation was to evaluate how gamma radiation doses affected the total fungal burden. To lower mold and aflatoxin levels, 4, 6, and 8 kGy of gamma radiation were applied to peanut samples packaged in polyethylene. The level of aflatoxin in products derived from peanuts might be greatly reduced as a result of the study's findings.

2. Methods

In this study, we used the irradiation technique approach to treat the contamination of the peanut samples. Food that has been irradiated receives an effective dose of carefully controlled ionizing radiation [16]. High-Performance Liquid Chromatography (HPLC) was used for the separation and quantification of aflatoxin [17].

The HPLC method uses a stationary phase that is confined inside either a glass or plastic tube and an aqueous/organic mobile phase that runs through the solid adsorbent. The sample for analysis will flow through and disperse between the stationary and mobile phases when it is layered on top of the column [18].

Typically, the sample to be examined is injected into the stationary phase. The mobile phase then moves the analytes through the stationary phase under high pressure created by a pump. Two methods for finding aflatoxins in food are reversed-phase and normal-phase high-pressure liquid chromatography processes. Reversed-phase HPLC is the most widely used method for separating and identifying aflatoxins [18].

The three samples were randomly selected, bagged in plastic, and prepared for the examination. Peanut samples were acquired from the Ethiopian Conformity Assessment shop. The dosages of radiation applied to the peanut samples were 4, 6, and 8 kGy. The aflatoxins were extracted and cleaned using the LCTech sample preparation and analysis procedure and the AOAC official method 2005-08.

The samples were irradiated at the National Institute for the Control and Eradication of Tsetse and Trypanosomiasis using a Gammacell 220 research irradiator (GC-220) from MDS Nordion that emits 60-Co gamma radiation at a dose rate of 1.5 kGy/h. The aflatoxin and mold count for the peanut samples before and after irradiation were calculated at the Ethiopian Conformity Assessment Laboratory.

3. Result and Discussion

As indicated in Tables 1 and 2, we have the following findings from this study. Table 1 shows the total mold counts and total aflatoxins before and after irradiation in the three samples of peanut, whereas Table 2 shows the total aflatoxins and average aflatoxins present before irradiation, and the average aflatoxin reduction after irradiation in the three peanut samples.

Table 1. *Total Mold Counts and Total Aflatoxins before and after Irradiation in Three Samples.*

Dose (kGy)	Before Irradiation			After Irradiation	
	Total Mold Counts (CFU/g)	Aspergillus Detection	Total Aflatoxins (µg/kg)	Mold Reduction (%)	Aflatoxin Reduction (%)
0 (Control)	2.7×10^4	ND	98	-	-
0 (Control)	4.1×10^4	ND	164.5	-	-
0 (Control)	1.6×10^6	80%	584.5	-	-
4	2.2×10^2	ND	89.1	99.20%	9.08%
4	1.1×10^3	ND	127.1	98.44%	22.74%
4	1.3×10^3	ND	566.1	99.90%	3.15%
6	1.1×10^2	ND	62.8	99.59%	35.92%
6	3.0×10^2	ND	108.7	99.27%	33.92%
6	1.1×10^2	ND	529.3	99.95%	9.44%
8	<10	ND	36.4	99.98%	62.86%
8	<10	ND	107.1	99.98%	34.89%
8	1×10^2	ND	506.6	99.99%	13.33%

ND: Not Detected.

It is evident from Table 1 that mold populations are particularly sensitive to gamma radiation dosages of 6 kGy. Similar similarities to our findings have been observed by other researchers who have used gamma radiation to ionize matter. According to Aziz and Mahrous [19], agricultural seeds need a treatment rate of 4 to 6 kGy to completely eradicate the fungus. According to Iqbal, Q., et al. [8], radiation at 4 kGy reduced the levels of total mold and Aspergillus by 99 and 97 percent, respectively.

According to Aziz et al. [20], who similarly observed significant decreases in total mold counts in grains subjected to radiation from 2 to 4 kGy, molds were eliminated at 6 kGy. Similar conclusions were reached by Qumar et al. [3], who found that a dose of gamma radiation of up to 10 kGy was sufficient to destroy microorganisms from commonly used herbal remedies. The overall mold count pattern seen during our analysis was in line with the patterns observed during packed peanut sample mold and aflatoxin elimination by gamma radiation.

Table 2. *Total Aflatoxins and Average Aflatoxins before Irradiation, and Average Aflatoxin Reduction after Irradiation in Three Peanut Samples.*

Dose (kGy)	Before Irradiation		After Irradiation
	Total Aflatoxins (µg/kg)	Average Aflatoxin (µg/kg)	Average Aflatoxin Reduction (%)
0 (Control)	98 164.5 584.5	282.33	0%
4	89.1 127.1 566.1	260.77	7.6%
6	62.8 108.7 529.3	233.6	17.3%
8	36.4 107.1 506.6	216.7	23.25%

A positive outcome for the aflatoxin treatment after irradiation has been found based on the samples tested. It was found that an average 7.6%, 17.3%, and 23.25 percent reduction in aflatoxin was seen in the peanut sample for 4, 6, and 8 kGy, respectively.

Aflatoxin B1 was sufficiently destroyed by dosages of 15, 20, 25, and 30 kGy by 55–74 percent, according to another source [21], which is consistent with the findings of the current investigation. The proportion of AFB1 degradation at 10 kGy was 58 percent [22], following peanut oil content percentages of 38 percent. The most recent studies for the same radiation exposure range support this conclusion as well.

4. Conclusion

A condition of food security exists when all people have constant physical and financial access to affordable, nutritious food that meets their needs for an active and healthy life. These four food pillars are availability, access, consumption, and stability. When one of these four pillars deteriorate, a society's capacity to secure its food supply is put in jeopardy. Human health and welfare as well as social, economic, and political elements of society are impacted by malnutrition and food insecurity-related concerns.

This study looked at how pathogen and aflatoxin contamination in peanut products could be treated using irradiation technology. Irradiation technology is unquestionably the most effective way to combat global food insecurity, and stakeholders, policymakers, food storage facility providers, food packaging companies, food preservation facility providers, warehouse providers, and food item exporters should all work to promote its use.

The study can guarantee both the export standard for such goods and the safety of peanut products for human consumption. The information gained from this study, which is the first of its kind in Ethiopia, will serve as the basis for creating a way to reduce aflatoxin. The study's conclusions can serve as a roadmap for further investigation on the topic by academics and researchers.

The results of this study will, in general, improve food preservation, which will significantly increase the export trade of food products derived from peanuts and contribute significantly to Ethiopia's growth of food security and safety.

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