EFFECT OF IRRADIATION ON QUALITY, SHELF LIFE AND CONSUMER ACCEPTANCE OF TRADITIONAL NIGERIAN MEAT AND FISH PRODUCTS*

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Abstract

The effect of low dose irradiation, up to 6 kGy, on quality, shelf life and consumer acceptance of three traditional Nigerian meat and fish products was investigated. Irradiation inhibited microbial growth in 'suya' and 'kilishi' with substantial reduction in total aerobic counts, yeasts and molds and *Staphylococcus aureus*. Non-irradiated smoked-dried catfish (*Clarias gariepinus*) had a shelf life of less than one week at tropical ambient temperature (21–31°C) due to insect infestation. Irradiated 'kilishi' and smoked dried catfish packed in sealed polyethylene bags (0.04 mm thick) were shelf stable for a period of 4–6 months and remained free from moldiness, infestation and were considered acceptable in sensory quality by a consumer panel of 32 assessors. There was a slight increase in TBA values of irradiated 'kilishi' stored for 4 months relative to non-irradiated controls.

1. INTRODUCTION

'Suya' or 'tsire', 'kilishi' and dried fish are important food products that provide valuable animal protein in the diet of millions of Nigerians. 'Suya'and 'kilishi' are made by roasting the spiced, salted slices/strips of meat (usually beef). 'Kilishi' differs from 'suya' in that the two-stage sun-drying process precedes roasting. Consequently, 'kilishi' has a much lower moisture content (6–14%) than 'suya' (25–35%). Smoking and sun drying are used to preserve a wide variety of Nigerian fresh water species of fish including Clarias, Gymnarchus, Chrysicthys, Citharinus, Alestes, Hydrocynus and Tilapia.

The unhygienic conditions under which meat and fish products are often processed and retailed in Nigeria are of grave concern, from a public health standpoint, as revealed by consumer surveys [1]. In the case of 'suya' and 'kilishi' processing, a variety of spices that are potentially sources of microbial contamination are used. Total viable and coliform counts exceeding acceptable limits for ready-to-eat meat products and the presence of a wide spectrum of pathogenic bacteria have been reported in retail 'suya' [2]. In the case of dried fish, insects, especially blowflies and beetles, are responsible for considerable losses during processing, storage and distribution.

Whilst it is well known that irradiation reduces spoilage and pathogenic microflora in meat and fish products, and destroys insects that damage dried fish, there is some concern regarding lipid stability [3] and consumer acceptance of irradiated foods in Nigeria [4]. The objective of this study was to investigate the effect of irradiation on microflora, shelf life and consumer acceptance of 'suya', 'kilishi' and smoked-dried fish.

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2. MATERIALS AND METHODS

'Suya' and 'kilishi' were purchased on several occasions in 1997 and 1998 from a local processor at the Bodija area of Ibadan, Nigeria. The products were prepared by the traditional method from portions of beef and a variety of spices and other dried ingredients including peanut (*Arachis hypogea*) cake powder, ginger (*Zingiber officinale*), chillies (*Capsicum frutescens*), melegueta pepper (*Aframomum melegueta*), onion (*Allium cepa*), *Piper guineense*, *Thonningia sanguinea*, *Fagara santhoxyloides*, 'Maggi' (trade name of a food condiment containing monosodium glutamate) and salt [1, 5]. Smoked-dried catfish (*Clarias gariepinus*) was purchased from local producers at Aleshinloye market in Ibadan. The product was prepared by gutting *Clarias gariepinus* and bending it into a horse-shoe shape, retained by means of a sharp stick that pierces through the caudal and head regions, before hot smoking by the traditional method with firewood as source of heat and smoke [6].

2.1. Packaging and Irradiation

2.1.1. Pilot studies

Small quantities of 'suya' and 'kilishi' (approximately 20 g) were packed in heat-sealed polyethylene bags (0.04 mm thick). The products were transported by road, inside an ice chest covered with ice in the case of 'suya', from Ibadan to Ile-Ife, over a distance of approximately 90 km for irradiation. Batches of 'suya' and 'kilishi' were irradiated at doses of 1 to 5 kGy (dose rate, 1.5 kGy per h) at ambient temperature (27°–30°C) in a cobalt-60 source Gammacell 220 high dose rate research irradiator at the Centre for Energy Research and Development, Obafemi Awolowo University, Ile-Ife, Nigeria. The irradiated samples together with the non-irradiated controls were transported back to Ibadan by road on the same day. 'Suya' samples were held in an ice chest covered with ice during transportation back to Ibadan.

2.1.2. Scaled-up studies

Individual whole smoked-dried catfish (*Clarias gariepinus*) with an average weight of 170 g each and strips of 'kilishi' were packed in heat-sealed polyethylene bags (0.04 mm thick). The products were transported by road from Ibadan, Nigeria to Accra, Ghana over a distance of approximately 1000km over a period of two days at tropical ambient conditions. The samples were randomly divided into four lots. Three lots were irradiated at estimated doses of 2, 4 and 6 kGy respectively (dose rate 7.3 kGy per h) at ambient temperature in a cylindrical cobalt-60 source gamma irradiator (initial loading capacity, 50 kCi) at the Ghana Atomic Energy Commission, Legon-Accra. The irradiated samples together with the non-irradiated controls were transported back to Nigeria by road and held at ambient conditions, 21°–31°C (mean daily minimum and maximum temperatures).

2.2. Proximate Analysis

Moisture in 'suya', 'kilishi' and smoked-dried catfish (*Clarias gariepinus*) samples was determined by drying to constant weight in an air oven at 103°C. Protein, fat, and ash contents of irradiated and non-irradiated 'suya' were determined by standard procedure [7]. The semi-automated Tecator kjeltec digestion and distillation system was used for the determination of protein by the Kjeldahl procedure, with selenium as catalyst. Protein was

estimated as total N × 6.25. Fat was determined by extraction with petroleum ether in a Soxhlet apparatus. Ash was determined by incineration in a muffle furnace at 500°C.

2.3. *Bacterial Counts*

Irradiated and non-irradiated meat products were examined microbiologically by standard procedures [8]. Representative samples were macerated and serially diluted in ¼ strength Ringer's solution. Total aerobic count, yeasts and molds, intestinal pathogens (*Salmonella* and *Shigella*) and *Staphylococcus aureus* were determined on plate count agar (Difco), potato dextrose agar (Difco), desoxycholate citrate agar (Biolife) and mannitol salt agar (Amershan) respectively. Plates were incubated at 35°C for total aerobic count, 37°C for intestinal pathogens and *Staphylococcus aureus*, and 27°C for yeasts and molds.

2.4. *Lipid Oxidation*

The 2-thiobarbituric acid (TBA) test was used to measure the development of oxidative rancidity in irradiated and non-irradiated meat products. Distillates from 'suya' and 'kilishi' samples were heated with TBA reagent in glass-stoppered tubes. Following cooling, the absorbance at 538 nm was measured against a water/TBA reagent blank [9]. TBA numbers were expressed as mg of malonaldehyde/kg sample.

2.5. *Preliminary Sensory Evaluation*

Preliminary sensory evaluation of smoked-dried fish irradiated at 2, 4 or 6 kGy and stored for 3 weeks at tropical ambient temperature was carried out by a semi-trained panel of 9 assessors drawn from students and staff of the Department of Food Technology, University of Ibadan using the multiple comparison difference analysis [10]. The irradiated smoked-dried fish samples were rated twice relative to freshly procured non-irradiated controls for appearance, flavor, texture and overall acceptability on a nine-point scale where 1=extremely inferior to control, 5=same as control and 9=extremely superior to control.

2.6. *Consumer Acceptability*

Consumer acceptance of irradiated 'kilishi' and smoked-dried catfish was evaluated by a randomly selected consumer panel of 32 members consisting of people of diverse background, familiar with the products. Two types of tests were used; the hedonic rating and paired preference tests.

2.6.1. *Hedonic rating test*

The effect of radiation dose on some specified sensory quality attributes was determined by the hedonic rating test. Samples of 'kilishi' irradiated at a dose of 4 or 6 kGy and stored at tropical ambient temperature for 4 months were rated for appearance, texture, flavor and overall acceptability on a 5-point scale where 1= dislike very much, 3= neither like nor dislike, and 5= like very much.

2.6.2. *Paired preference test*

The paired preference test was used to determine which, if any, of the following four treatments was preferred when compared with each other, one on one.

(i) Freshly purchased non-irradiated smoked-dried catfish.
(ii) Smoked-dried catfish irradiated at 2 kGy and stored for 6 months at tropical ambient temperature.
(iii) Smoked-dried catfish irradiated at 4 kGy and stored for 6 months at tropical ambient temperature.
(iv) Smoked-dried catfish irradiated at 6 kGy and stored for 6 months at tropical ambient temperature.

At each testing session, two samples were presented simultaneously to the assessors who were asked to state, which of the two samples was preferred. The assessors were asked to so indicate if both samples were liked equally. Properly coded samples were used and the order of presentation was randomized to eliminate the effect of sample sequence on food preference.

2.7. *Statistical analysis*

Scores of hedonic rating and multiple comparison difference analysis tests were averaged to obtain mean scores, which were subjected to analysis of variance. The results of the paired preference tests were expressed as levels of significance calculated from the table of Roessler et al. [11].

3. RESULTS AND DISCUSSION

'Suya', 'kilishi' and smoked-dried catfish (*Clarias gariepinus*) had mean moisture contents of 25.90%, 12.98% and 9.23% respectively. Irradiation of 'suya', up to 6 kGy, had no significant effect on moisture (25.90%), protein (44.82%), fat (21.50%) and ash (5.21%).

3.1. *Effect of Irradiation on Shelf Life, Insects and Microbiological Quality*

Smoked-dried catfish had a shelf life of less than 1 week at tropical ambient temperature due to infestation with *Dermestes maculatus* and another insect, with features similar to *Korynestes analis*, which could not be completely identified from pictorial charts. Both larvae and adult insects were present in non-irradiated fish. Irradiated smoked-dried fish were free from infestation even after 6 months at 21°–31°C.

Rather high levels of contaminating microorganisms were present in 'suya' with aerobic counts, yeasts and molds exceeding 10^6. This is consistent with previous reports on the microbiological quality of 'suya' [1, 2]. Unsanitary processing environment and poor quality ingredients, especially the spices used for 'suya' preparation, contribute to the high microbial load of 'suya'. Microbial populations were lower in 'kilishi' presumably because of its lower moisture content. Irradiation of 'suya' up to a dose of 5 kGy significantly reduced microbial populations with a progressive decline in total aerobic count, yeasts and moulds with increase in radiation dose. The greatest reduction in microbial populations (2 –3 log cycles) occurred in the dose range of 0 to 2 kGy. Irradiation increased shelf life and inhibited microbial growth in 'kilishi' stored under tropical ambient conditions (Table I). *Staphylococcus aureus* decreased by at least 2 log cycles in 2 kGy irradiated 'kilishi' stored for 4 months at 21°–31°C. There

was visible mold growth in non-irradiated 'kilishi' stored at 21°–31°C for 4 months whilst corresponding samples irradiated at 2 to 6 kGy showed no visible signs of moldiness.

Irradiation had no significant effect on TBA number of 'suya' and 'kilishi' immediately after treatment. However, irradiated 'kilishi' had slightly higher TBA values than non-irradiated controls when stored for 4 months at tropical ambient temperature. 'Kilishi' irradiated at 2, 4 and 6 kGy had TBA values of 3.74, 4.84 and 6.08 respectively after 4 months at 21°–31°C while corresponding non-irradiated samples had TBA values of 3.12. It has been reported that with the exception of turkey breast, low dose irradiation up to 10 kGy had no significant effect on lipid oxidation in fresh trimmed meats, possibly because the samples had minimum amount of fat and were analysed within the induction period for free radical chain reactions [3].

Table I. Effect Of Irradiation On Microbial Populations In 'Kilishi'[a]

Radiation dose (kGy)	Aerobic count (cfu/g)	Yeasts and molds (cfu/g)	Intestinal pathogens (cfu/g)	*Staphylococcus aureus (cfu/g)*
0	5.0×10^5	2.3×10^3	<10	1.5×10^3
2	2.0×10^4	<10	<10	<10
	2.0×10^2	<10	<10	<10
4				
6	<100	<10	< 10	< 10

[a]Samples stored in sealed polyethylene bags for four months at 21°–31°C.

3.2. *Effect of Irradiation on Sensory Quality and Consumer Acceptance*

Preliminary sensory evaluation by a semi-trained panel of nine assessors revealed that there were no significant differences in the appearance, flavor, texture and overall acceptability of smoked-dried catfish irradiated at 2, 4 or 6 kGy and stored for 3 weeks at tropical ambient temperature. The irradiated samples were comparable to freshly procured non-irradiated controls in sensory quality (Table II). 'Kilishi' irradiated at 4 or 6 kGy and stored at 21°–31°C for 4 months were highly rated (>4.0 on a scale of 1= dislike very much to 5= like very much) for appearance, flavor, texture and overall acceptability by a consumer panel of 32 assessors. Table III gives the results of the paired preference tests by 32 assessors in which smoked-dried catfish irradiated at 2, 4 or 6 kGy and stored for 6 months at tropical ambient temperature were compared with freshly procured non-irradiated controls and with one another. Even though there was a definite preference for fresh, non-irradiated smoked-dried catfish over irradiated samples stored for 6 months at 21°–31°C, panelists still considered the irradiated samples acceptable even after 6 months at tropical ambient temperature. Whilst there were no statistically significant differences between 2, 4 and 6 kGy irradiated samples, there was a slight preference (> 60% positive responses) for smoked-dried catfish irradiated at 4 or 6 kGy compared to those irradiated at 2 kGy after storage for 6 months at 21°–31°C (Table III).

TABLE II. Results of a multiple comparison difference test where irradiated smoked-dried fish stored for 3 weeks under tropical ambient conditions were compared with freshly procured non-irradiated control.[a]

Radiation dose (kGy)	Appearance	Flavor	Texture	Overall acceptability
2	4.5	6.3	6.1	6.1
4	5.5	5.3	5.8	6.3
6	4.7	6.4	5.5	5.7

[a]Rated on a scale where 1=extremely inferior to control, 5=same as control and 9=extremely superior to control.

TABLE III. Results of paired preference tests for irradiated and non-irradiated smoked-dried fish

Pair	Treatment	No. of assessors preferring each sample	Positive responses (%)	Significance
1	Fresh, non-irradiated	31	97	*
	2 kGy, stored for 6 months	1	3	
2	Fresh, non-irradiated	29	91	*
	4 kGy, stored for 6 months	3	9	
3	Fresh, non-irradiated	29	91	*
	6 kGy, stored for 6 months	3	9	
4	2 kGy, stored for 6 months	10	31	NS
	4 kGy, stored for 6 months	22	69	
5	2 kGy, stored for 6 months	12	38	NS
	6 kGy, stored for 6 months	20	62	
6	4 kGy, stored for 6 months	17	53	NS
	6 kGy, stored for 6 months	15	47	

*Significant at the 1% level. NS, no significant difference.

3. CONCLUSION

Low dose irradiation, up to 6 kGy, inhibited microbial growth, infestation and extended the shelf life of traditional Nigerian meat and fish products. Irradiated 'kilishi' and smoked-dried catfish were found acceptable in sensory qualities by a consumer panel after storage for 4 to 6 months at 21°–31°C. By inhibiting microbial growth and increasing shelf life, irradiation offers a practical means of minimizing outbreaks of food borne illnesses associated with 'suya' and similar products and reducing storage and distribution losses of smoked-dried fish, 'kilishi' and, possibly, other traditional Nigerian meat and fish products.

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