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Effect of radiation processing on bioactive components of finger millet flour (*Eleusine coracana* L.)

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Abstract

Finger millet *(Eleusine coracana)* is an important staple food in eastern and central Africa, Asia as the same some of regions in India. Finger millet is an important food grain to treat malnutrition because it contains typical bioactive components like amino acids, iron, calcium, phosphorus, fibre and vitamins, may undergo several changes at molecular level when subjected to different types of processing and preservation methods/techniques. The present research was carried out to study the effect of Radiation process on nutritional changes of bioactive components such as calcium, Iron, and fibre in finger millet flour at the dose rate of 1 kGy. In present study total two samples were prepared and among two, one sample was treated with 1kGy of radiation and the other one kept as control. The impact of radiation on the Iron, calcium, and fibre content was assessed. The results shows that there is no significant loss of any nutrients after samples have been irradiated. Some extent of nutrients lost, similar to the amount lost during other food processing methods like canning, drying .etc was observed. After irradiation the crude fibre content was decreased in flour, iron and calcium content of irradiated samples was more when compared to non irradiated samples. Radiation process doesn't show any predominant negative changes in calcium, iron, and fibre content of finger millet flour. Above observations denoted that radiation processing of foods has proven to be an effective technology to improve the nutritional quality and to extend the shelf life of the foods.

Introduction

India is the world's second largest producer of food grains next to china and has the potential of being the biggest with the food and agricultural sector. The total food production is likely to be doubled in the next ten years. The countries population estimated to reach1.3 billion by 2017 and serious shortage of capacity to store food grains, the country will be short of food grains. Increased crop production as well as lack of appropriate processing, preservation methods and storage capacity with Food Corporation of India (FCI) results, 25 million tonnes of food grain stored outside the warehouses. There is urgent need to emerge novel food processing and preservation techniques and effective storage capacity to prevent wastage of food grains. A growing population and climatic change have emphasized the need to meet the sufficient levels of food grains by improving India's crop productivity through innovations in agriculture sector. Cereal grains form a major source of dietary nutrients for human beings. Among the cereals, finger millet is one of the principle cereal grain which contains major source of nutrients and also is a traditional staple food in India and other regions of the world, particularly Asian and African countries (Rotimi, 2011). Finger millet belongs to grass family, originally native to the Ethiopian high lands and was introduced into India approximately four thousand years ago. Finger millet is the main food grain for many people, especially in dry areas of India and Srilanka. It is rich in proteins, iron, calcium, phosphorus, fibre, and vitamin content (Karel *et al*., 2000). Calcium content is higher than all cereal grains and iodine content is said to be highest among the food grains (Barbeau and Hilu, 1993). Finger millet has best quality proteins along with essential amino acids like tryptophan; cysteine and methionine (Sawaya *et al*., 1984). All of these are crucial to the human health and deficient in other food grains. Because of these qualities finger millet became good source of diet for growing children, women, old age people, and the people suffering from malnutrition, diabetes, obesity (Veenu and Patel, 2013). The term food preservation

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refers to a number of techniques used to prevent food from spoilage by giving increased shelf life with good quality attributes (Desrosier *et al*., 1977). Canning, pickling, drying, freeze drying, pasteurisation, smoking, addition of chemical additives, advanced food processing methods like PEF, HPP, HIL, microwave processing, radiation.etc are the some common methods employed in preservation of foods (Siva Shankar, 2005). Among the preservation techniques and innovations in food preservation, radiation is the future depended, potential novel preservation technique in foods associated with several misunderstandings and confusions in related to human health (Miller, 2005). But several researchers proved that radiation is an efficient, potential preservation tool in food processing and preservation sector (Salunkhe, 1961). Over 42 countries in the world including USA, UK, Canada and France have given clearance for use of radiation in food processing and preservation. The government of India also have permitted the use of radiation technology in preservation of foods such as potatoes, onions, rice, semolina, wheat flour or Maida, mango, raisins, dried dates, ginger, garlic, shallots (small onions) as well as meat and meat products including chicken. Irradiation is a process in which foods either packed or in bulk subjected to the controlled ionising radiation in the form of X-rays, alfa, beta, and gamma rays (Loannis, 2010). Among these, gamma rays are extensively used in food irradiation process because of its high penetration efficiency (Xeutong *et al*., 2013), these radiation process needs radioactive compound usually cobalt-60 (Machi, 1995). Present study was designed to observe the effect of radiation processing at a dose rate of 1kGy on nutritional composition of finger millet with special reference to calcium, iron and fibre.

Materials and Methods

Finger millet *(Eleusine coracana)* is also known as African millet, is an annual plant widely grown as a cereal in the arid areas of Africa and Asia (Hilu *et al*., 1997). The present study has been planned to increase the shelf life and to identify the nutritional and organoleptic changes in the irradiated and non irradiated finger millet flour.

Selection and procurement of samples

Finger millets which are clean, good coloured, without dust and foreign matter, without foreign grains, and de infested were purchased from local market.

Preparation of finger millet flour and samples

Finger millets were brought to the laboratory and cleaned to separate dust, pebbles, stones and other foreign materials. One kilogram (1000 g) of finger millets were washed and cleaned in cold water to remove the dust and other foreign materials adhered to grains. After cleaning, excess water was drained and the grains were spread on a clean cotton cloth. The grains were sun dried about six hours and ground into flour, cooled and stored in air tight polythene covers. Two samples, each consists of 400 g of finger millet flour were prepared for experimental observation. One sample was treated as experimental sample and subjected to irradiation, and the other sample was kept as control which was not irradiated.

Irradiation of the sample

Finger millet samples were Prepared and aseptically transferred into polythene packs, sealed tightly and labelled. Sample Packets were examined to ensure that there will be no leakages and stored in a dry chamber until to use. Samples were subjected to gamma-radiation, at the dose rate of 1kGy (Aziz *et al*., 2006). The irradiation process was carried out in gamma radiation chamber in irradiation unit (Gamma chamber GC-5000 is a compact self shielded cobalt-60 gamma irradiator providing an irradiation volume of approximately 5000 cc) at Acharya N. G. Ranga Agricultural University, Hyderabad, India. For the irradiation of samples, Cobalt-60 was used as a radioactive compound.

Shelf life or storage studies

Irradiated and non-irradiated samples were stored at ambient temperatures in the laboratory and subjected to storage studies for a period of one month. Nutrient analysis and sensory evaluation of the samples were carried at 1st and 30th day of the storage period. During the storage studies the nutrient analysis was carried out in terms of calcium, iron and crude fibre content and sensory evaluation was carried out couple of times i.e., initial day and after completion of one month to observe the quality and storage changes in the finger millet flour.

Chemical analysis

Proximate analysis was carried out to estimate calcium, iron, and crude fibre content of both control and experimental samples during the storage/shelf life studies.

Estimation of iron by Wong's method

Iron content was estimated both in control and experimental samples by using spectrophotometer

(Systronics. India/model no: 106). In this method, aliquot (6.5 ml or less) mineral solution was taken and to this enough water was added to makeup to a volume of 6.5 ml fallowed by 1.0 ml of 30% H_2SO_4, 1.0 ml potassium per sulphate solution and to this mixture 1.5 ml 40% KCNS solution was added. The red colour that develops was measured within 20 minutes at 510 nm (Raghuramulu *et al*., 2003).

Estimation of calcium by titrimetric method

Calcium content was estimated in both irradiated and non-irradiated samples by titrimetric methodology (Phillip *et al*., 1954). 5 ml of mineral solution was taken in 15ml centrifuge tube, 2 ml distilled water and a drop of methyl red indicator was add ed, ammonium hydroxide was added drop wise until the pink colour was disappeared, then acetic acid was added drop wise until faint pink colour was appeared. Solution was agitated well, 1ml of 6% ammonium oxalate was added and mixed thoroughly, allowed it to stand for 1 hour. Solution was centrifuged and inverted on a blotting paper for 5 minutes. Precipitate was collected and washed thoroughly with 4ml of dilute ammonia to remove ammonium oxalate, centrifugation was repeated. Washed precipitate was dissolved in 2 ml of 1N sulphuric acid, heated in water bath up to 70-75^{0}c and titrated against 0.01N potassium permanganate(while the solution was hot) up to faint pink colour was observed as end point. Titre value of 1 ml of 0.01 potassium permanganate = 0.2004 mg of calcium.

Estimation of crude fibre content

Crude fibre was estimated both in control and experimental samples. In this method the sample is allowed to boil with dilute hydrogen sulphide (1.25%), dilute sodium hydroxide (1.25%) and the sample was transferred to weighed crucible (W1), the crucible with sample was heated at 6000c for 2-3 hours in muffle furnace, cooled in desiccator and again crucible weight (W2) was taken and the crude fibre content was calculated by means of ash (Olof *et al*., 1986).

Statistical analysis

All the data was recorded, tabulated, and subjected to statistical analysis. ANOVA, t-test techniques were used to observe significant difference between irradiated and non-irradiated finger millet flour.

Results and Discussion

Present study was planned with the prime objective to examine the impact of radiation at the rate of 1 kGy on the nutritional components like iron, calcium, and crude fibre of finger millet flour. The impact of radiation on the flour was examined through the assessment of changes observed by the nutrient composition and sensory evaluation at appropriate storage periods after irradiation i.e., 1st day and 30th day respectively. The results were tabulated and discussed below.

Table 1. Bio active components in irradiated and non irradiated finger millet flour upon storage

Bioactive component	Irradiated finger millet flour	Non- irradiated finger millet flour	t-value	Significance
Iron(mg/100g)	10.243±0.104	9.960±0.100	3.4	0.027*
Calcium(mg/100g)	495.817±0.199	418.724±0.199	474.46	0.000**
Crude fibre(mg/100g)	2.823±0.095	3.050±0.090	2.999	0.040*

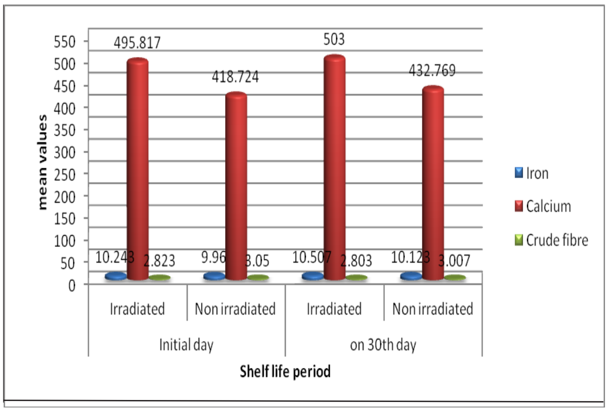

Figure 1. Mean values of iron, calcium and fibre content in Irradiated and non-irradiated finger millet flour during storage

Iron, calcium, and crude fibre bioactive components of irradiated and non irradiated finger millet flour during storage

Iron content was analysed in both irradiated and non irradiated finger millet flour samples on the 1st day and the results were tabulated in Table 1, Figure 1 revealed that the mean values of iron content in irradiated and non irradiated finger millet flour were 10.243±0.104 mg/100 g, 9.960± 0.10 mg/100g respectively. The results indicate that the iron content in finger millet flour was increased after irradiation. Iron content was significantly increased at 0.05 levels in between irradiated and non irradiated flour samples. The reason for the increase in iron content was due to the removal or reduction of tannins either by extraction with solvent or by grain maturation (Mamiro *et al*., 2001). These results were in accordance with the results of the study conducted by Shashi *et al*. (2007), where removal or reduction of tannins either by solvent extraction or grain maturation, increase the iron levels in the finger millet flour.

Calcium content of the finger millet flour was determined by titrimetric method. The results obtained during the analysis were given in Table 1, Figure 1. The data in the table revealed that the mean value of calcium content in irradiated and non-irradiated finger millet flour were 495.817±0.199 mg/100 g, 418.724±0.199 mg/100 g respectively. The results indicated that, calcium content was increased in finger millet flour at a significance level of $p<0.01$after irradiation.

Crude fibre content in finger millet flour, both in irradiated and non irradiated samples were analysed and tabulated in Table 1, Figure 1. The results in the table state that the mean values of crude fibre in irradiated and non irradiated finger millet flour were 2.823±0.095 mg/100 g, 3.050±0.090 mg/100 g respectively. The results justified that, after irradiation a little reduction in crude fibre content was observed (Khanzadi *et al.*, 2009). The differences between irradiated and non irradiated samples were significant at 0.05 levels.

Effect of irradiation on nutritional quality of finger millet flour during storage

Analysis of bio active components such as iron, calcium and fibre content for irradiated and non irradiated finger millet flour were carried out during storage i.e., 1st day (after treatment) and 30th day. The results obtained for iron, calcium, and crude fibre were tabulated in Table 1.

Nutritional quality of flour upon storage

Iron content of the irradiated and non irradiated finger millet flour during the storage was given in Table 2 and Figure 2. The results in the table that the mean values for the iron content of irradiated and non irradiated finger millet flours were 10.243±0.104 mg/100g, 9.960±0.100 mg/100g for 1st day and 10.507±0.155 mg/100g, 10.155±0.152 mg/100g for 30th day. The t-value obtained between first day and 30th day for iron content of irradiated and non irradiated samples were 2.439, 1.557 respectively. According to the results, there was no significant difference was observed in iron content at 0.01significance level. The results clearly showed that the irradiated finger millet flour doesn't under go any predominant changes during the storage and present study clearly concluded that irradiation doesn't effect the iron content on storage.

The obtained results for calcium during storage were given in Table 2, Figure 2. The results in the table indicated that the mean values for the calcium

Table 2. Impact of irradiation on bio active components of finger millet flour on storage

Bioactive components		Shelf life		t- value	Significance
		Initial day	30th day		
Iron(mg/100g)	Irradiated	10.243±0.104	10.507±0.155	2.439	0.071[NS]
	Non-irradiated	9.964±0.100	10.123±0.152	1.557	0.195[NS]
Calcium (mg/100g)	Irradiated	495.617±0.199	503.894±0.100	62.808	0.000**
	Non-irradiated	418.734±0.199	432.769±0.299	67.73	0.000**
Crude fibre(mg/100g)	Irradiated	2.823±0.095	2.803±0.095	0.258	0.809[NS]
	Non-irradiated	3.050±0.038	3.007±0.215	0.769	0.485[NS]

*Significance at 0.05 levels
**Significance at 0.01 levels
NS non-significance

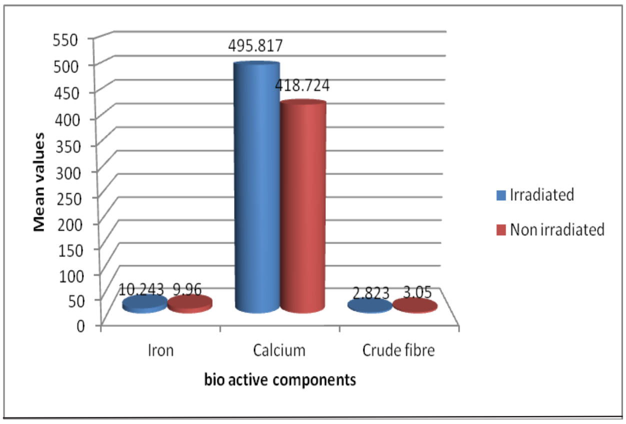

Figure 2. Mean values of iron, calcium and fibre content in irradiated and non irradiated finger millet flour

of irradiated and non irradiated finger millet flour for 1 month of storage, the t-value obtained between 1st day and 30th day for calcium of irradiated and non irradiated samples were 62.808 and 67.730 respectively. The results indicate that the calcium content was significantly increased during the shelf life period of one month on both irradiated and non irradiated samples. The difference between 1st day and 30th day for calcium content was significant at 0.01 levels.

Crude fibre content in irradiated and non-irradiated finger millet flour were analyzed during the storage .The obtained results were presented in the Table 2, Figure 2. The data in the table indicated that the mean values for the crude fibre of irradiated and non-irradiated flour were 2.823±0.095mg/100g, 3.050±0.038mg/100g on 1st day and 2.803±0.095mg/100g, 3.007±0.215mg/100g on 30th day. The t-value obtained between initial day and 30th day for crude fibre of irradiated and non irradiated finger millet flour was not significant, but crude fibre content was slightly decreased on storage which was negligible (Ikemefuna *et al.*, 1994).

Conclusion

Food irradiation is the treatment of food by using a certain type of radiation energy. The process involves exposing the food, either packaged or in bulk, to carefully controlled amount of ionizing radiation. Throughout the world, several experiments proved that there is no significant loss of any nutrients after food has been irradiated. A small amount of some vitamins are lost, similar to the amount lost during other food processing methods such as canning, drying, sterilization etc. The present study was carried out to examine the impact of irradiation on bio active components such as iron, calcium and crude fibre of finger millet flour on 1st day as well as on 30th day of storage, the analysis process was carried out both in irradiated and non-irradiated finger millet flour. During storage periods, calcium and iron content was increased significantly in irradiated finger millet flour, at the same time slight decrease in crude fibre was observed. The study was revealed that radiation processing of finger millet flour doesn't show any predominant changes in the iron, calcium, and crude fibre composition.

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