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Effect of Gamma Irradiation on Functional Properties of Finger Millet and Foxtail Millet Flour

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ABSTRACT

Millets are traditional grains having superior nutritional values and health benefits. γ-irradiation is an emerging and secure food preservation technique that may enhance various properties of food which improves the cooking quality, storage period and handling. The functional properties of finger millet and foxtail millet flour were determined and the study performed for the effects of irradiation doses on water absorption capacity and oil absorption capacity. The water absorption capacity and oil absorption capacity of finger millet and foxtail millet flour were significantly increased as irradiation dose increased. The peak values of finger millet and foxtail millet flour were found at 4 kGy and 8 kGy irradiation dose, respectively.

Keywords : Finger millet, Foxtail millet, Gamma irradiation, Functional properties

MILLETS are traditional food crops and grass grain with high nutritive values. The worldwide cumulative production of millets was noted about 30,752 MT in the year 2023. Wherein, India is the largest producer of millets having 12,200 MT holding 40 per cent share in the world in the year 2023 followed by Niger (11%), China (9%) and Nigeria (7%) (FAS, 2023). Millets are rich in micronutrients, phyto-chemicals and antioxidants (Singh *et al.*, 2012 and Reddy *et al.*, 2019). Millets have high nutritional value and are associated with several health benefits, including prevention of cancer and cardiovascular disease, reduced tumor incidence, lower blood pressure, cholesterol management, slower fat absorption and providing gastrointestinal bulk (Truswell, 2002 and Gupta *et al.*, 2012).

Millets offer a wealth of nutrients; however, their full potential remains untapped. A significant hindrance is the inability to conduct post-harvest procedures on a commercial or residential level due to lack of availability of equipments or practices. Understanding the physical and engineering characteristics of millets is essential to develop and implement appropriate post-harvest machinery (Gaurav *et al.*, 2021). Moreover, these properties play a pivotal role in various issues related to machine design and product behavior analysis throughout agricultural process operations such as handling, planting, harvesting, threshing, washing, sorting and drying.

In the evolving landscape of global trade and technology, transitioning to irradiation for food preservation holds significant importance. Food material can be disinfected using irradiation to get rid of pests and organisms that cause diseases (Kalyani and Manjula, 2014). Many researchers have studied the effects of gamma irradiation on various properties of millets including, physico-chemical properties, functional properties, textural and pasting properties, etc. The presented research highlights the physico-chemical properties and the effects of γ-irradiation doses on the functional properties, specifically water absorption capacity and oil absorption capacity of finger millet and foxtail millet flour.

Material and Methods

Finger millet (*CFMV 2*) and Foxtail millet (*SiA 3088*) were procured from Hill Millet Research Station, Navsari Agricultural University and Me2millet Pvt. Ltd., Anand. The grains were thoroughly cleaned and packed in low density polyethylene (LDPE) pouches for further analysis.

Physical Properties

Various physical properties including, size, sphericity, geometric mean diameter, bulk density, true density, porosity, angle of repose, coefficient of friction and hardness was measured using equipments and methods available at College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand.

Proximate Composition

Proximate composition such as moisture content, crude fat, crude fiber, ash content, protein content, carbohydrate content was determined using the standard methods (AOAC, 1996 and Ranganna, 1986).

Gamma Irradiation Treatment

Finger millet and foxtail millet grains were packed in LDPE pouches and placed into the sample holder of

Fig. 1(a) : Finger millet grains

Fig. 1(b) : Foxtail millet grains

Fig. 1(c) : Finger millet flour

Fig. 1(d) : Foxtail millet flour

γ-irradiation chamber (GIC 5000) available at College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand under the guidance of authorized person. The samples were irradiated at various dose levels (2, 4, 6, 8, 10 kGy) and non-irradiated sample was taken as control. After the completion of irradiation treatment, the samples were grounded, sieved (60 mesh sieve) and stored for further analysis.

Water Absorption Capacity (WAC)

Water absorption capacity (WAC) of finger millet and foxtail millet flour was measured according to the procedure described by Kamaliya and Kamaliya (2001). Weighed flour was placed in porcelain bowl and 25 mL of water at 26.5 °C was poured into the bowl from burette. Flour and water were mixed with a spatula. Water was added until well-kneaded dough of medium soft consistency is formed. The dough was prepared and amount of water required was recorded. If the finally kneaded dough is too soft, repeat the process and make new dough with less water.

Oil Absorption Capacity (OAC)

Oil absorption capacity (OAC) of flour samples were measured according to method described by Thilagavathi *et al.*, 2015. 1g of flour was added to the pre-weighted centrifuge tube and 6 mL of sunflower oil was then added. The contents were stirred for 1 min with a thin brass wire to disperse the sample in oil. After a holding period of 30 min, the tubes were centrifuged for 25 min at 3000 rpm. The supernatant was discarded using pipette and tubes were inverted for 25 min to drain oil prior to re-weighting. The oil absorption capacity was calculated using the following equation:

$$\text{OAC}\left(\frac{\text{mL}}{100\text{ g}}\right) = \frac{\text{ml of oil absorbed}}{\text{weight of sample}} \times 100$$

Statistical Analysis

The descriptive statistics of physico-chemical properties of finger millet and foxtail millet was carried out. Other samples were statistically analyzed using one factor completely randomized design (CRD) at Department of Statistics, B. A. College of Agriculture, Anand Agricultural University, Anand.

Results and Discussion

Physico-Chemical Properties

Various physical properties and proximate composition of finger millet and foxtail millet were determined and shown in Table 1 and 2, respectively. The spatial dimensions represent the structural size of grains in terms of largest (L), medium (B) and smallest (T) interceptor. The size of finger millet was ranged from (L: 1.67-1.75 mm; B: 1.353-1.66; T: 1.38-1.46 mm). Similarly, the size of foxtail millet grains ranged from (L: 1.760-1.793 mm; B: 1.399-1.463; T: 1.028-1.067 mm). The sphericity was in the range of 0.89-0.92 and 0.76-0.78 for finger millet and foxtail millet, respectively. The bulk density and true density of both millets were ranged from 0.63-0.64 g/cc, 1.18-1.25 g/cc and 0.75-0.77 g/cc, 1.37-1.54 g/cc, respectively.

Table 1

Physical properties of finger millet and foxtail millet

Parameters	Finger Millet	Foxtail Millet
Size, L (mm)	1.72 ± 0.05	1.77 ± 0.01
Size, B (mm)	1.58 ± 0.07	1.43 ± 0.03
Size, T (mm)	1.42 ± 0.04	1.05 ± 0.01
Sphericity (ř)	0.91 ± 0.02	0.78 ± 0.01
Geometric mean diameter (mm)	1.55 ± 0.07	1.38 ± 0.08
Bulk density (g/cc)	0.64 ± 0.01	0.76 ± 0.01
True density (g/cc)	1.22 ± 0.03	1.45 ± 0.08
Porosity (%)	47.39 ± 0.05	47.52 ± 0.48
Hardness (N)	11.57 ± 0.11	10.50 ± 0.10
Angle of repose (°)	26.25 ± 0.41	32.09 ± 0.22
Coefficient of friction (wooden plate)	0.46 ± 0.02	0.47 ± 0.02

The finger millet flour was high in carbohydrate content while the foxtail millet flour was rich in protein and fiber content as well. The studies conducted by Shobha *et al.*, 2021 and Shobha *et al.*, 2023 had similar results.

Table 2

Proximate composition of finger millet and foxtail millet

Parameters	Finger Millet	Foxtail Millet
Moisture content (%)	9.06 ± 0.06	7.01 ± 0.03
Crude fat (%)	2.04 ± 0.06	4.69 ± 0.20
Crude fiber (%)	3.89 ± 0.04	8.86 ± 0.08
Protein content (%)	6.76 ± 0.13	8.11 ± 0.13
Ash content (%)	2.25 ± 0.12	1.14 ± 0.10
Carbohydrates (%)	79.87 ± 0.29	79.02 ± 0.02

Descriptive analysis of physical properties and proximate composition of both the millets was carried out for all the samples under investigation and are shown in Fig. 2 and 3.

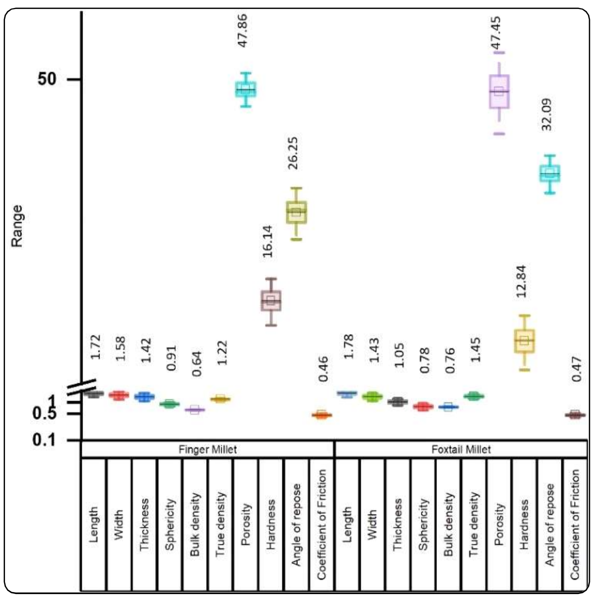

Fig. 2 : Descriptive statistics for physical properties of finger millet and foxtail millet

Functional properties, such as water absorption capacity and oil absorption capacity of both irradiated and non-irradiated samples of finger millet and foxtail millet flour were assessed and the obtained results shown in Table 3 and 4.

Effect of Gamma Irradiation Dose on Water Absorption Capacity

Water absorption capacity (WAC) of irradiated and non-irradiated finger millet and foxtail millet flour at various dose level was determined. The WAC of control samples were ranged from 63.33 mL/100 g for finger millet flour and 34.67 mL/100 g for foxtail millet flour. Furthermore, the dramatic change in WAC of finger millet and foxtail millet flour was observed as irradiation dose increased. The highest values of WAC were measured at 4 kGy for finger millet flour (71.00 mL/100 g) and at 8 kGy for foxtail millet flour (44.68 mL/100 g).

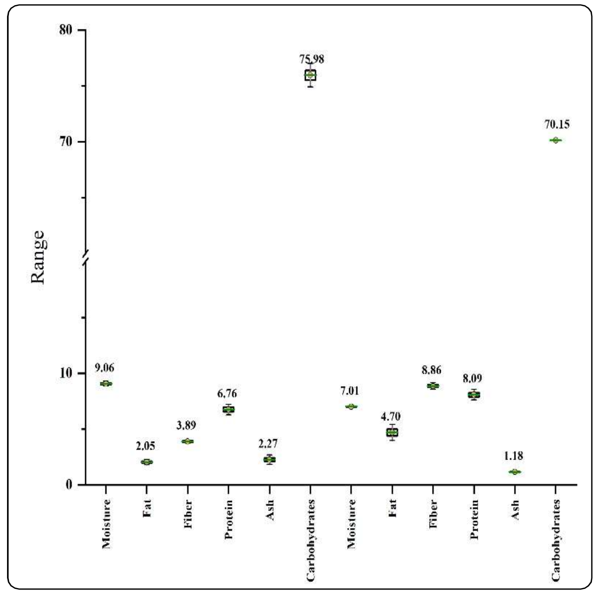

Fig. 3 : Descriptive statistics for proximate composition of finger millet and foxtail millet

Table 3

Water absorption capacity of finger millet and foxtail millet flour

Parameters	Finger Millet	Foxtail Millet
Control	63.33 ± 0.58	34.67 ± 1.15
2 kGy	66.33 ± 1.15	41.33 ± 1.15
4 kGy	71.00 ± 1.00	44.00 ± 1.00
6 kGy	64.67 ± 0.58	41.00 ± 2.00
8 kGy	67.67 ± 0.58	44.67 ± 0.58
10 kGy	68.33 ± 0.58	36.33 ± 0.58
S.Em ±	0.47	0.68
C.D. (%)	1.48	2.15
CV (%)	1.21	2.85

(All values are expressed in Mean ± SD (n=3), CD @5% level of significant)

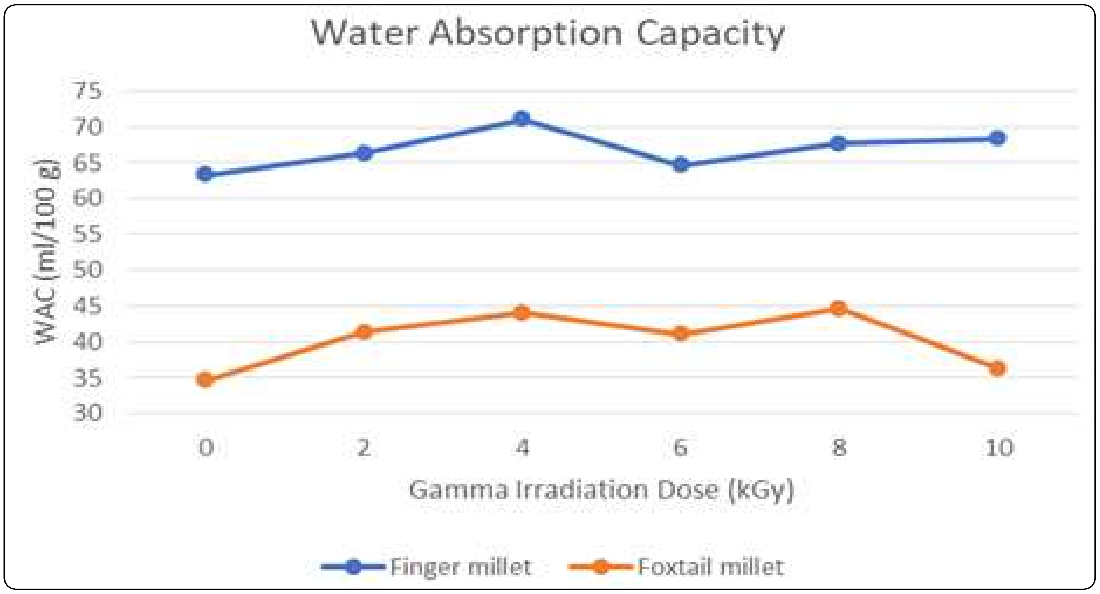

Fig. 4 : Water absorption capacity of finger millet and foxtail millet flour

Table 3 shows one factor CRD of water absorption capacity of irradiated and non-irradiated finger millet and foxtail millet flours. WAC of finger millet and foxtail millet showed no specific trend as irradiation dose increased. From the Fig. 4, it is clearly evident that as irradiation dose increased, the WAC increased up to 4 kGy further it decreased and again increased. The treatments were found significant having 1.21 per cent CV for finger millet and 2.85 per cent CV for foxtail millet.

Effect of Gamma Irradiation Dose on Oil Absorption Capacity of Finger Millet and Foxtail Millet Flour

Oil absorption capacity (OAC) of irradiated and non-irradiated finger millet and foxtail millet flour at various dose level was measured. The OAC of control samples were ranged from 43.72 mL/100 g for finger millet flour and 66.27 mL/100 g for foxtail millet flour. Further more, it was observed that as irradiation dose increased, the OAC of both millet flours increased up to 4 kGy, then decrease up to 6 kGy and suddenly increases. The highest values of OAC were measured at 4 kGy for finger millet flour (77.85 mL/100 g) and at 8 kGy for foxtail millet flour (77.67 mL/100 g).

Table 4 shows one factor CRD of oil absorption capacity of irradiated and non-irradiated finger millet and foxtail millet flours. The OAC of finger millet and foxtail millet change dramatically as irradiation dose increase and at 4 kGy and 8 kGy irradiation dose, the OAC of finger millet and foxtail millet flour was found maximum, respectively. The treatments were found significant having the CV of 0.92 per cent for finger millet and 1.09 per cent for foxtail millet. However, no specific trend was observed upon irradiation.

TABLE 4

Oil absorption capacity of finger millet and foxtail millet flour

Parameters	Finger Millet	Foxtail Millet
Control	43.72 ± 1.80	66.27 ± 3.31
2 kGy	62.43 ± 0.98	71.24 ± 0.62
4 kGy	77.85 ± 0.46	73.82 ± 0.40
6 kGy	68.24 ± 0.73	72.88 ± 0.75
8 kGy	75.81 ± 0.61	77.67 ± 1.29
10 kGy	76.60 ± 0.37	73.15 ± 0.66
S.Em. ±	0.38	0.46
CD (%)	1.21	1.44
CV (%)	0.92	1.09

(All values are expressed in Mean ± SD (n=3), CD @5% level of significant)

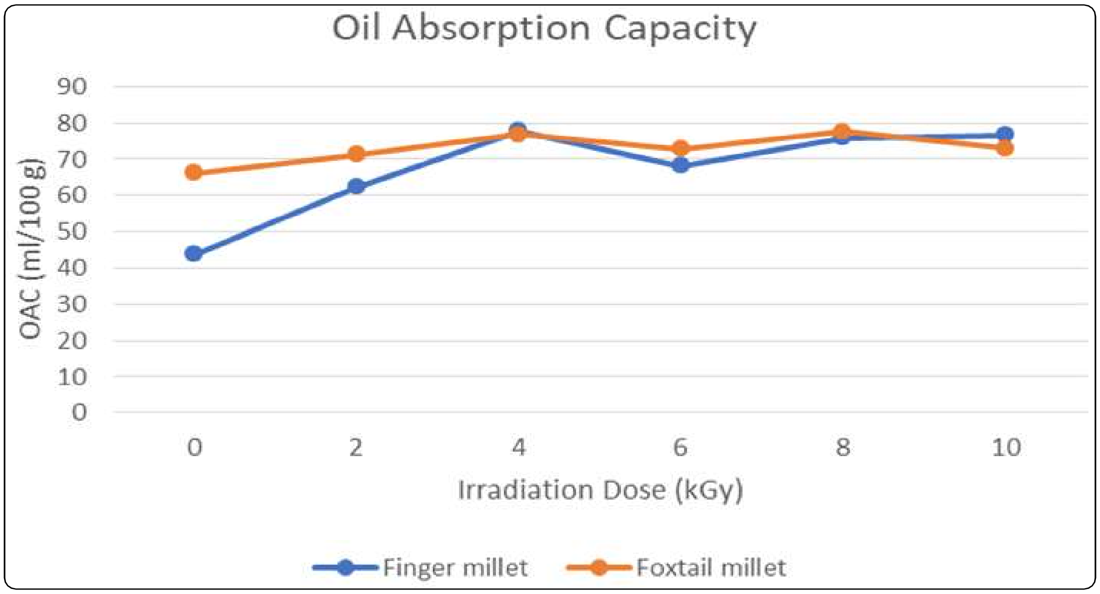

Fig. 5 : Oil absorption capacity of finger millet and foxtail millet flour

People have been consuming millets since ancient times and it has emerged as a primary staple food in many developing countries. Understanding and assessing physico-chemical characteristics is crucial for optimizing equipment and machinery to boost efficiency and precision, leading to cost reduction and improved processing, storage and handling. This strategy also ensures adherence to proper practices for secure packaging, transportation and storage. Millets are traditional food known for their exceptional nutritional value and health benefits, consumed in various countries. Gamma irradiation is an emerging technology utilizing gamma rays, that may help extend the shelf life of millets. The effects of irradiation on functional properties of finger millet and foxtail millet flours were studied. Results indicated significant change in water absorption capacity and oil absorption capacity for both millet flours as irradiation dose increases up to certain limits.

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