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Effect of Gamma Irradiation of Physico-chemical Properties, Proximate Composition and Vitamins of an Underutilized Legume *Mucuna deeringiana* (Bort) Merril

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Abstract : Effect of gamma irradiation on *Mucuna deeringiana* at various doses (2, 5, 10, 15 and 25 kGy) on the physico-chemical properties, proximate composition and vitamins (niacin and ascorbic acid) were analyzed. No significant changes were recorded in the physico-chemical properties of irradiated seeds. Gamma irradiation resulted in a significant increase of crude protein, while the crude lipid, crude fibre and ash contents resulted in a dose-dependent decrease. Gamma irradiated seeds revealed a significant decrease in the ascorbic acid and niacin content. Gamma irradiation seems to be a good procedure to improve the quality of legume seeds from the nutritional point of view.

Key words: Gamma irradiation, hydration capacity, crude proteins, vitamins.

Introduction

Legumes occupy an important place in human nutrition and considered as poor man's meat especially by those who are in developing countries. This is due to the reason that legumes are a good source of protein and slowly digestible carbohydrates. They also contain minerals, vitamins and important health protective compounds (phenolics, inositol phosphates and antioxidants). This advantageous composition of legume seeds, not only make them a meat replacer for vegetarians but also a component of rational nourishment. They are very important in human and animal nutrition. However, several antinutritional factors present in legume seeds are a major limiting factor for the increased consumption of legumes, whose presence degrades the nutritive value of legumes. The removal of the undesirable components from the dry legume seed is essential for improving their nutritional qualities and for effectively utilizing them to their full potential as food.

To achieve this, several processing techniques such as germination, soaking and cooking and dry heat treatment have been used. Radiation processing as an effective means of food preservation, has been shown to decrease antinutritional components in some proteinaceous leguminous seeds, thereby helps to provide food security (Bhat *et al*., 2008; Alothman *et al*., 2009; Tresina and Mohan, 2011).

The genus *Mucuna*, belonging to the family Fabaceae is rich in crude protein, essential fatty acids, starch content, and certain essential amino acids. On the otherhand, it also contains various antinutritional factors and some cyclitols with antidiabetic effects. All parts of the *Mucuna* plant possess medicinal properties and exhibit a wide variety of pharmacological effects, including antidiabetic, antiinflammatory, neuroprotective and antioxidant properties. The seeds are used in traditional medicine to prevent the toxic effects of snake bites (Lampariello *et al*., 2012).

Despite, the literatures on the nutritional and antinutritional properties of *Mucuna deeringiana* seeds is available, information on the effects of processing with gamma irradiation is scanty. Consequently, the present investigation was commenced to explore the impact of gamma irradiation on the nutritional factors of the underutilized legume, *M. deeringiana*.

Materials and Methods

Collection of seeds

The mature seed materials of *Mucuna deeringiana* (Bort) Merril were collected from Chinnamyllaru, Kanyakumari District, Tamil Nadu. Soon after the collection, the seeds were sun dried for 2-3 days and were surface cleaned with muslin cloth and physically damaged, immature and insect infested seeds were eliminated.

Irradiation

Seed samples (each-50g) packed in polyethylene pouches were irradiated at different doses of gamma irradiation (2, 5, 10, 15 and 25 kGy) at room temperature (25±1°C) using a Cobalt -60 Gamma cell 5000 unit at Radiological Safety Division, Indira Gandhi Center for Atomic Research, Kalpakam, Tamil Nadu. Seed samples packed similarly without irradiation served as control. The seed samples were powdered and stored in screw capped bottles for further usage.

Physico-chemical Analyses

100 seed weight, seed density, hydration capacity, hydration index and swelling capacity of *M. deeringiana* seeds were determined by following the method of Sood *et al.* (2002). Swelling index was calculated as per the method given by Williams *et al.* (1983).

Analyses of Proximate Composition and Vitamins (Niacin and Ascorbic acid)

The moisture content (%) was determined by drying 50 transversely cut seed in an oven at 80°C for 24 hours and is expressed on a percentage basis. The

air-dried samples were powdered separately in a Wiley mill (Scientific Equipment, Delhi, India) to 60-mesh size and stored in screw capped bottles at room temperature for further analysis.

The nitrogen content was estimated by the micro-Kjeldahl method (Humphries, 1956) and the crude protein content was calculated (N x 6.25). Crude lipid content was determined using Soxhlet apparatus (AOAC, 2005). The ash content was determined by heating 2g of the dried sample in a silica dish at 600°C for 6hr (AOAC, 2005). Total dietary fibre (TDF) was estimated by the non-enzymatic-gravimetric method (Li and Cardozo, 1994). The nitrogen free extract (NFE) was obtained by difference (Muller and Tobin, 1980). The energy value of the seed (kJ) was estimated by multiplying the percentages of crude protein, crude lipid and NFE by the factors 16.7, 37.7 and 16.7, respectively (Siddhuraju *et al*., 1996)

Ascorbic acid and niacin contents were extracted and estimated as per the method given by Sadasivam and Manickam, 1996.

Statistical Analysis

The above said data were estimated on triplicate determinations. Analysis of variance (ANOVA) and Paired samples –‘t ’test were used for analysis (SPSS software for windows release 17.0; SPSS/Inc., Chicago IL, USA) of any significant difference in chemical compositions among the gamma irradiated legumes. Significance was accepted at $p < 0.05$ and $p < 0.01$.

Results and Discussion

Physico-chemical Analyses

The data related to the physico-chemical characteristics of unirradiated and irradiated *M. deeringiana* seeds are presented in Table 1. A non-significant difference was observed in the seed weight, seed density, seed volume, hydration capacity, hydration index, swelling capacity and swelling index of the gamma irradiated *M. deeringiana* seeds. Hydration capacity, swelling capacity and swelling index values of irradiated seeds were greater than those of the unirradiated seeds. Swelling capacity and swelling index have also increased with increasing irradiation doses. This was not statistically significant ($p>0.01$). Similar results were also reported in *Phaseolus vulgaris* and *Cicer arietinum* (Koksel and Celik, 2001) and *Vigna unguiculata* subsp. *unguiculata* (Tresina and Mohan, 2011).

In this study, the water absorption properties of the *M. deeringiana* seeds as measured both gravimetrically (hydration capacity and hydration index) and volumetrically (swelling capacity and swelling index) might also be related to the degradation of starch (Koksel and Celik, 2001).

Table 1. Physico-chemical properties of *Mucuna deeringiana* seeds untreated and treated with gamma irradiation

Component	Dose					
	Raw	**2 kGy**	**5 kGy**	**10 kGy**	**15 kGy**	**25 kGy**
Seed weight (g 100 seed^{-1})	177.70 ± 2.48	177.54 ± 2.76	177.60 ± 2.50[a]	177.36 ± 1.94	177.51 ± 1.58	177.32 ± 1.36
Seed density (g ml^{-1})	1.42 ± 0.08	1.44 ± 0.07	1.41 ± 0.04	1.40 ± 0.03	1.41 ± 0.04	1.42 ± 0.03
Seed volume (ml 100 seed^{-1})	74.00 ± 1.21	73.81 ± 1.11	73.24 ± 0.96	73.56 ± 0.86	73.94 ± 1.41	73.96 ± 0.81
Hydration capacity (g^{-1} seed)	1.525 ± 0.11	1.568 ± 0.08	1.572 ± 0.04	1.586 ± 0.03	1.594 ± 0.05	2.011 ± 0.03
Hydration index	0.858 ± 0.03	0.876 ± 0.04	0.888 ± 0.05	0.894 ± 0.06	0.902 ± 0.06	0.914 ± 0.08
Swelling capacity (ml seed^{-1})	1.66 ± 0.07	1.84 ± 0.03	1.86 ± 0.05	1.94 ± 0.04	1.01 ± 0.08	2.04 ± 0.06
Swelling index*	0.0111	0.0111	0.0112	0.0113	0.0114	0.0112

Means ± SE (N = 3) *values are means of two determinations. [a] denotes significance at (p<0.01) between untreated and treated seeds

Analyses of Proximate Composition and Vitamins (Niacin and Ascorbic acid)

Table 2 summarizes the proximate composition and vitamins (niacin and ascorbic acid) of gamma irradiated and unirradiated *M. deeringiana* seeds. The moisture content of the *M. deeringiana* seeds decreased significantly (p<0.01), as the dose increased when compared to the unirradiated seeds. Crude protein and carbohydrates constitute the major chemical constituents of the seeds. Gamma irradiation resulted in a increment in crude protein at all the irradiated doses (Raw, 23.76%; 25kGy, 29.40%). The crude protein content of the unirradiated seeds were found to be higher when compared with the earlier report of *Cajanus cajan*

(Kumar *et al*., 1991), *Cicer arietinum* (Khatoon and Prakash, 2006) and *Lablab purpureus* var. Co_{12} (Kala *et al*., 2010), tribal pulses like *Dolichos trilobata*, *Rhyncosia cana, R. suaveolens, Vigna radiata* var. *sublobata* and *V. uniguiculata* subsp. *cylindrica* (Arinathan *et al*., 2009). The crude lipid, crude fibre and ash on irradiation showed a dose-dependent decrease in the present study, which was significant (p<0.05) at 15 and 25kGy. The present results were similar to the earlier report of *Mucuna* seeds (Bhat *et al*., 2007).

Table 2. Proximate composition and Vitamin (niacin and ascorbic acid) content of *Mucuna deeringiana* seeds untreated and treated with gamma irradiation (g 100g^{-1})

Component	Dose					
	Raw	2 kGy	5 kGy	10 kGy	15 kGy	25 kGy
Moisture	8.40 ± 0.06	7.96 ± 0.11^{a}	7.24 ± 0.08^{ab}	6.96 ± 0.07	6.54 ± 0.04^{abc}	6.10 ± 0.01^{abce}
Crude protein	23.76 ± 0.21	24.30 ± 0.17	52.10±0.14	26.48 ± 0.11	27.32 ± 0.21	29.40 ± 0.03
Crude lipid	8.48 ± 0.11	8.10±0.08^{a}	7.68 ± 0.07^{ab}	7.12 ± 0.05^{abc}	6.50 ± 0.21^{abcd}	6.12 ± 0.04^{abcdj}
Total Dietary Fibre	7.12 ± 0.14	6.92 ± 0.12^{a}	6.52 ± 0.23^{ab}	5.94 ± 0.06^{abc}	5.50 ± 0.06^{abcd}	5.06 ± 0.02^{abcde}
Ash	5.24 ± 0.02	4.92 ± 0.10^{a}	4.21 ± 0.09^{ab}	3.98 ± 0.06^{abc}	3.01 ± 0.03^{abcd}	2.54 ± 0.02^{abcde}
Nitrogen Free Extractives	55.40 ± 2.10	55.93 ± 2.01	56.49 ± 1.94	56.48 ± 1.88	57.67 ± 1.88	56.88 ± 1.90
Calorific Values (kJ / 100g DM)	1641.66 ± 1.88	1645.21 ± 2.04	1652.09 ± 2.15	1653.86 ± 2.36	1664.38 ± 2.56	1671.60 ± 1.76
Niacin (mg 100g^{-1})	22.10 ± 0.09	21.08 ± 0.15^{a}	20.36 ± 0.14^{ab}	18.26 ± 0.17^{abc}	16.08 ± 0.21^{abcd}	15.14 ± 0.31^{abcde}
Ascorbic acid (mg 100g^{-1})	42.16 ± 0.17	40.33 ± 0.09^{a}	38.14 ± 0.21^{ab}	37.24 ± 0.19^{abc}	36.08 ± 0.23^{abcd}	35.55 ± 0.30^{abcde}

Means ± SE (N = 3) ^{a} denotes significance at (p<0.01) between untreated and treated seeds; $^{b\text{-}e}$ denotes significance at (p<0.01) between the treated seeds; ^{j} denotes significance at (p<0.05) between the treated seeds

The lipid content of *M. deeringiana* seeds is very high when compared to that of *Cicer arietinum* (Srivastava and Ali, 2004) and *Cajanus albicans* (Murthy and Emmanuel, 2011). The dose-dependent decrease in fibre on irradiation has been attributed to depolymerization and delignification of the plant matrix (Sandev and Karaivanov, 1977). Irradiation did not significantly alter the NFE values and slightly increased at 15kGy (57.67%). The calorific value increased above 5kGy. The calorific value of the present study exceeds the energy values of *Lablab purpureus* varieties Co_1, Co_2, Co_9 and Co_{11} (Kala *et al*., 2010), tribal pulses *Rhynchosia cana, R. suaveolens, Tamarindus indica, Teramnus labialis* and *Vigna radiata* var. *sublobata* (Arinathan *et al*., 2009).

The presently investigated seeds of *M. deeringiana* seeds exhibited the highest level of niacin content which was found to be higher than that of the earlier report in *Cicer arietinum* (Alajaji and El-Adawy, 2006), *Vicia faba, Phaseolus vulgaris* (Vega *et al*., 2010), *Vigna mungo* varieties (Tresina *et al.,* 2010) and *V. radiata* (Tresina *et al*., 2014). The ascorbic acid content of *M. deeringiana* seeds also registered high level when compared to *Phaseolus vulgaris, Cajanus cajan, Vigna radiata, V. mungo* (Kakati *et al*., 2010), *V. mungo* varieties (Tresina *et al*., 2010) and *V. radiata* (Tresina *et al*., 2014). In the present investigation, the contents of niacin and ascorbic acid decreased significantly (p<0.01) at a dose rate of 15 and 25 kGy respectively. In an earlier study, niacin and ascorbic acid content decreased significantly in mung bean and *Vigna unguiculata* subsp. *unguiculata* treated with gamma irradiation (Khattak and Klopfenstein, 1989; Tresina and Mohan, 2011).

Conclusion

The results of the present investigation reveal that *M. deeringiana* seed is a valuable source of nutrition due to high protein and carbohydrate with an adequate quantity of vitamins (niacin and ascorbic acid). Application of gamma irradiation as a method of preservation of *M. deeringiana* seed quality did not show any adverse effect on the nutritional composition.

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