CHAPTER 5
EFFECT OF ELECTRON BEAM IRRADIATION ON SENSORIAL PROPERTIES AND SHELF LIFE OF AMLA VARIETIES

5.1 Introduction

Sensorial evaluation is a scientific field to measure, analyze and interpret reactions of food and food material characteristics and its major application involves in developing the new product, check the effect of raw materials and technological processing of final product, marketing test adopted for new products (Paula et al., 2007). Instrumental measurement techniques play a vital role to overcome the sensorial analysis and have been studied, good linkage between mechanical techniques and sensorial firmness, crispness and crunchiness (Chen and Opara, 2013). Sensory evaluation of vegetables gets very worthful on their quality characteristics. In a sensory attributes of vegetables main factor is a determining the consumer’s satisfaction (Abbott, 1999). The content of micronutrients, sugars and acids in these fruits determines their sensory quality. The phenolic acids contribute to the some sensorial properties of dark colour, bitter taste and objectionable flavour of some fruits and leaves (Ayaz et al., 2000). Several studies evidenced that gamma irradiation at low levels improve the shelf life of mango fruits by slowing the rates of ripening and ageing (Thomas, 1986).

5.2 Materials and Methods

5.2.1 Sensory evaluation in electron beam irradiated amla varieties

Sensory quality attributes such as colour, taste, odour, firmness and overall acceptability were evaluated for irradiated and control samples with a panel of five judges
from the Department and using nine point hedonic scales for scoring (Score 1- dislike extremely, score 2- dislike very much, score 3- dislike moderately, score 4- dislike slightly, score 5- neither like nor dislike, score 6- like slightly, score 7- like moderately, score 8- like very much and score 9 - like extremely).

5.2.2 Organoleptic Studies

5.2.2.1 Hedonic score rating for irradiated and control amla varieties

Sensory analysis must be used to assess the sensory attributes of foods that were subjected to irradiation process. In Banarasi, Chakaiya and Francis variety the sensory attributes such as colour, taste, odour, firmness and overall acceptability were studied in control and irradiated samples (El-Samahy, 2000).

5.3 Analysis of shelf life in fruit samples

Three varieties (Banarasi, Chakaiya and Francis) of irradiated and control fruit samples were packed in polypropylene bags (4×4 cm) and stored at room temperature (±25°C). Quality of the fruit was examined for each 10 days until 30th day. Shelf life in the form of firmness etc.,

5.4 Statistical Analysis

The data were subjected to analyse the variance (ANOVA) using the SPSS software package. Tukey’s significance difference was used to analyse the data. P value was <0.05 considered to be significant.

5.5 Results

5.5.1 Hedonic score rating for whole fruit of amla in irradiated and control samples

In this study, the sensorial properties were studied in irradiated and control samples of whole fruit of amla. The colour of fruit was observed as whitish green to straw
Figure 5.1 Hedonic score of electron beam irradiation on organoleptic properties of whole fruit of Banarasi

a. Colour

b. Taste

c. Odour

d. Firmness

e. Over all acceptability
yellow and light green. After 20 days, it was changed into blackish in colour due to fungal
growth appeared on the surface. Normally the amla fruit has astringent in taste. The slight
changes were observed in the taste of irradiated samples. The colour values were found
to be 8.78 in non irradiated, mean time irradiated samples have 8.56, 8.43, 8.45, 8.24 and
8.18 at 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 7.33, 7.67,
7.00, 7.33, 6.67 and 6.33 and in 20th day it was 7.30, 6.66, 6.54, 7.28, 6.67 and 5.35,
respectively. The colour of 30th day scored 5.34, 6.45, 6.07, 5.38, 4.67 and 4.35,
respectively (fig. 5.1 (a)). The hedonic score of taste value was 7.12, 7.23, 7.23, 7.10 and
7.10 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (fig 5.1 (b)). In 10th day it
was 6.67, 6.33, 6.31, 6.19, 6.00 and 5.06 and in 20th day it was 5.64, 6.21, 6.14, 6.16, 6.06
and 5.05, respectively. The taste value of 30th day was found to be 5.47, 6.23, 5.11, 4.16,
4.04 and 4.03, respectively. The hedonic score of odour was illustrated in fig. 5.1 (c). and
its score values were found to be 8.12, 8.56, 8.20, 8.15, 8.20 and 8.23 in control, 0.05,
0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 6.77, 6.63, 6.53, 6.43, 6.29
and 5.60 and in 20th day it was 6.10, 6.08, 6.01, 6.00, 5.04 and 5.32, respectively. In 30th
day score was observed as 4.47, 5.23, 4.11, 4.16, 3.04 and 3.01, respectively. The
hedonic score of firmness value was illustrated in fig. 5. 1(d), the values were 8.75, 8.76,
8.60, 8.56, 8.43 and 8.20 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In
10th day it was 7.33, 7.33, 7.00, 6.76, 6.67 and 6.10 and in 20th day it was 6.33, 7.12, 6.98,
6.56, 6.47 and 6.10, respectively. The firmness value of 30th day was recorded as 5.13,
6.10, 5.90, 5.45, 4.32 and 4.01, respectively. The hedonic score of overall acceptability
value was illustrated in fig. 5. 1(e), the values were 8.56, 8.67, 8.56, 8.67, 8.55 and 8.43
in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 7.67, 7.33,
7.21, 7.12, 6.67 and 6.45 and in 20th day it was 6.99, 6.65, 6.53, 6.32, 6.12 and 5.79,
Figure 5.2 Hedonic score of electron beam irradiation on organoleptic properties of whole fruit of Chakaiya

a. Colour

b. Taste

c. Odour
d. Firmness

e. Overall acceptability

0 day 10th day 20th day 30th day

0 0.05 0.1 0.15 0.2 0.25
respectively. The overall acceptability value of 30th day was measured as 5.47, 5.43, 5.11, 5.13, 4.04 and 4.03, respectively.

Whole fruit of Chakaiya variety obtained following colour values such as 8.79, 8.79, 8.75, 8.54, 8.10 and 8.76 for non irradiated, 0.05, 0.10, 0.15, 0.20 and 0.25kGy respectively. In 10th day it was 7.35, 7.66, 7.54, 7.38, 6.67 and 6.35 and in 20th day it was 7.30, 7.54, 7.32, 7.36, 6.67 and 5.35, respectively. The colour of 30th day it was 5.34, 7.65, 6.67, 5.38, 4.43 and 4.12, respectively (fig. 5.2 (a)). The score values of Chakaiya was illustrated in fig.5.2 (b). The taste values were found to be 7.43, 7.40, 7.35, 7.31, 7.27 and 7.20 for control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy respectively. In 10th day it was 6.65, 6.63, 6.44, 6.27, 6.12 and 5.96 and in 20th day it was 5.64, 6.21, 6.14, 6.16, 6.06 and 5.04, respectively. The score value for taste in 30th day was 5.47, 6.17, 5.11, 5.16, 5.04 and 4.03, respectively. The hedonic score of odour was illustrated in fig. 5.2 (c). The hedonic score of odour was 8.89, 8.67, 8.56, 8.45, 8.23 and 8.23 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 6.57, 6.13, 6.03, 6.09, 6.80 and 5.60 and in 20th day it was 5.12, 6.20, 6.10, 6.08, 6.01 and 5.04, respectively. The taste value of 30th day was 4.47, 5.23, 4.11, 4.16, 3.06 and 3.01, respectively. The hedonic score of firmness was illustrated in fig. 5.2(d), the values were 8.90, 8.78, 8.70, 8.65, 8.54 and 8.45 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 7.13, 7.08, 7.00, 6.76, 6.47 and 6.21 and in 20th day it was 7.13, 7.12, 6.98, 6.55, 6.31 and 6.09, respectively. The firmness value of 30th day was 4.13, 6.09, 5.09, 5.10, 5.02 and 4.03, respectively. The hedonic score of overall acceptability value was illustrated in fig. 5.2(e), the values were 8.67, 8.77, 8.65, 8.60, 8.56 and 8.47 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 7.11, 7.41, 7.21, 7.32, 6.47 and 6.33 and in 20th day it was 6.09, 6.45, 6.43, 6.10, 5.12 and 5.79, respectively. The overall
Figure 5.3 Hedonic score of electron beam irradiation on organoleptic properties of whole fruit of Francis

a. Colour

b. Taste

c. Odour

d. Firmness

e. Overall acceptability
acceptability score value of 30th day was 5.57, 5.83, 5.61, 5.13, 4.20 and 4.13, respectively.

Figure 5.3 (a) illustrated the score value for colour in whole fruit of Francis variety. In initial day of observation the values were found to be 8.85, 8.71, 8.63, 8.21, 8.02 and 8.17 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 7.40, 7.66, 7.54, 7.38, 6.20 and 6.25 and in 20th day it was 7.30, 7.05, 7.54, 7.38, 5.67 and 5.35, respectively. The colour of 30th day scored 5.34, 7.35, 6.08, 5.12, 4.10 and 4.01, respectively. The score values for taste of Francis variety of amla was compared in fig 5.3 (b) with all treated and untreated fruit. The taste values were found to be 7.54, 7.43, 7.39, 7.28, 7.19 and 7.10 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy respectively. In 10th day it was 6.67, 6.33, 6.33, 6.19, 6.00 and 5.00 and in 20th day it was 5.64, 6.21, 6.19, 6.12, 6.06 and 5.44, respectively. The taste value of 30th day it was 5.47, 6.13, 5.15, 4.27, 4.04 and 4.03, respectively. The odour values were found to be 8.79, 8.70, 8.67, 8.45, 8.39 and 8.35 for non irradiated, 0.05, 0.10, 0.15, 0.20 and 0.25kGy respectively. In 10th day it was 6.57, 6.13, 6.03, 6.09, 6.80 and 5.60 and in 20th day it was 5.32, 6.10, 6.08, 6.01, 6.00 and 5.14, respectively. The taste value of 30th day was scored as 4.47, 5.23, 4.11, 4.16, 3.06 and 3.01, respectively (fig. 5. 3 (c). The hedonic score of firmness value were 8.60, 8.76, 8.54, 8.44, 8.30 and 8.28 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 7.40, 7.56, 7.50, 7.36, 6.12 and 6.13 and in 20th day it was 6.40, 7.56, 6.50, 5.36, 5.14 and 5.10, respectively. The firmness value of 30th day was observed 5.34, 6.35, 5.08, 5.12, 4.10 and 4.01, respectively which was showed in fig. 5.3(d). The hedonic score of overall acceptability were 8.78, 8.56, 8.67, 8.78, 8.45 and 8.56 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day it was 7.91, 7.75, 7.67, 7.43, 7.21 and 6.33 and in 20th day it was 7.74, 7.31, 7.24, 7.16, 6.00 and 6.17,
Figure 5.4  Hedonic score of electron beam irradiation on organoleptic properties of cut pieces of Banarasi

a. Colour

b. Taste

c. Odour

d. Firmness

e. Overall acceptability
respectively. The overall acceptability value of 30th day was 6.57, 6.53, 5.42, 5.13, 5.24 and 4.13, respectively fig. 5.3(c).

5.5.2 Hedonic score rating for irradiated and non-irradiated cut pieces

The cut pieces of Banarasi, colour showed changes during the storage period. Figure 5.4 (a) showing the colour value of cut pieces of Banarasi. The colour value was recorded as 6.65, 6.29, 6.20, 5.34 and 5.28 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy respectively at initial day of experiment. In 10th day the values were 6.12, 6.54, 6.21, 6.10, 5.22 and 5.19 and in 20th day it was 5.30, 5.11, 5.22, 5.62, 4.57 and 4.35, respectively. On 30th day of storage the colour value was 3.34, 4.65, 3.67, 3.38, 3.67 and 3.35 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Figure 5.4 (b) showing the taste values of cut pieces of Banarasi. The taste value was recorded as 7.56, 7.49, 7.45, 7.39, 7.26 and 7.13 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy at initial day of experiment, respectively. In 10th day the values were 6.54, 6.33, 6.21, 5.19, 5.04 and 5.06 and in 20th day it was 5.84, 5.21, 5.14, 4.16, 4.06 and 4.95, respectively. On 30th day of storage the taste value was 3.47, 3.23, 3.11, 3.13, 3.04 and 3.03 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Figure 5.4 (c) showing the odour values for cut pieces of Banarasi. The odour value was recorded as 6.88, 6.56, 6.43, 6.27, 6.12 and 6.09 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy respectively at initial day of experiment. In 10th day the values were 6.77, 6.63, 5.53, 5.43, 4.29 and 4.60 and in 20th day it was 5.10, 5.08, 3.01, 4.06, 3.04 and 2.32, respectively. On 30th day of storage the odour value was 2.57, 2.10, 2.11, 2.05, 2.06 and 1.01 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Fig 5.4 (d) showing the hedonic scores of firmness in cut pieces of Banarasi variety of amla. The values were 8.75, 8.78, 8.69, 8.50, 8.00 and 8.01 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 7.31, 7.54, 7.04, 6.61, 6.53 and 6.22 and in 20th day it was 5.33, 6.12, 5.98, 5.56, 4.47 and 4.12, respectively. On 30th day of storage the
Figure 5.5 Hedonic score of electron beam irradiation on organoleptic properties of cut pieces of Chakaiya

a. Colour

b. Taste

c. Odour
d. Firmness

e. Overall acceptability
value was found to be 4.13, 5.10, 3.90, 3.45, 3.32 and 3.01 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Initial day of observation the values were 7.67, 7.65, 7.50, 7.43, 7.15 and 7.08 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 6.59, 6.57, 6.21, 6.02, 6.69 and 6.35 and in 20th day it was 6.43, 5.30, 5.49, 4.64, 4.45 and 4.19, respectively. On 30th day of storage the overall acceptability value was 3.47, 3.22, 3.11, 2.13, 2.19 and 2.03 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (fig. 5.4 (e)).

Cut pieces of Chakaiya variety colour values were plotted in fig. 5.5 (a). The values were 7.45, 7.40, 7.32, 7.23, 7.10 and 7.08 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 7.35, 6.66, 6.44, 6.32, 6.43 and 6.35 and in 20th day it was 7.24, 5.56, 5.31, 5.30, 4.22 and 3.35, respectively. On 30th day of storage the colour value was 4.34, 4.65, 4.67, 3.38, 3.10 and 3.35 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Figure 5.5 (b) showing the score values for taste in cut pieces of Chakaiya. The taste value was recorded as 7.78, 7.56, 7.45, 7.32, 7.22 and 7.08 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy respectively at initial day of experiment. In 10th day the values were 6.75, 6.63, 6.54, 6.37, 6.12 and 5.99 and in 20th day it was 5.74, 5.01, 5.14, 5.16, 4.00 and 4.04, respectively. On 30th day of storage the taste value was found to be 3.47, 3.97, 3.11, 3.56, 2.52 and 2.03 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Figure 5.5 (c) showing the cut pieces of Chakaiya odour value. The odour value was recorded as 6.78, 6.65, 6.43, 6.21, 6.10 and 6.10 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy at initial day of experiment, respectively. In 10th day the values were 6.37, 6.23, 6.17, 6.09, 5.80 and 5.60 and in 20th day it was 5.12, 5.20, 4.10, 3.86, 3.01 and 2.04, respectively. On 30th day of storage the taste value was recorded 2.47, 2.23, 2.11, 2.16, 1.06 and 1.01 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. The hedonic scores of firmness observed as 8.67, 8.56, 8.43, 8.23, 8.10 and 7.86 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy,

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Figure 5.6 Hedonic score of electron beam irradiation on organoleptic properties of cut pieces of Francis

a. Colour

b. Taste

c. Odour
d. Firmness

e. Overall acceptability
respectively. In 10\textsuperscript{th} day the values were 7.13, 7.33, 7.08, 6.76, 6.47 and 6.21 and in 20\textsuperscript{th} day it was 7.13, 7.12, 6.99, 6.55, 6.31 and 6.09, respectively. On 30\textsuperscript{th} day of storage the firmness value was found to be 4.13, 6.09, 5.09, 5.11, 5.02 and 4.03 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.5 (d). The hedonic scores of overall acceptability values were 7.60, 7.59, 7.45, 7.32, 7.10 and 7.07 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10\textsuperscript{th} day the values were 7.15, 7.38, 7.21, 6.32, 6.47 and 6.33 and in 20\textsuperscript{th} day it was 6.69, 5.45, 5.43, 5.10, 4.12 and 4.70, respectively. On 30\textsuperscript{th} day of storage the overall acceptability value was 3.57, 3.83, 3.61, 2.13, 2.24 and 2.13 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.5 (e).

Cut pieces of Francis varieties colour values were plotted in fig. 5.6 (a). The values were 7.67, 7.56, 7.43, 7.30, 7.25 and 7.15 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10\textsuperscript{th} day the values were 7.40, 6.66, 6.54, 6.38, 6.20 and 6.25 and in 20\textsuperscript{th} day it was 5.30, 6.15, 5.38, 6.11, 5.67 and 5.35, respectively. On 30\textsuperscript{th} day of storage the colour value was recorded as 4.34, 4.35, 4.08, 4.12, 4.10 and 3.01 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. The taste of Francis variety amla cut pieces were elaborated in fig. 5.6 (b). The values were registered as 7.65, 7.54, 7.34, 7.20, 7.12 and 7.04 in control, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10\textsuperscript{th} day the values were 6.67, 6.33, 6.33, 6.27, 6.00 and 5.89 and in 20\textsuperscript{th} day it was 5.64, 6.21, 5.14, 5.16, 4.06 and 4.04, respectively. On 30\textsuperscript{th} day of storage the taste value was 5.47, 4.19, 3.11, 3.16, 2.04 and 2.03 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Score values for odour in cut pieces of Francis variety during storage were elaborated in fig. 5.6 (c). The values were 6.98, 6.56, 6.43, 6.21, 6.11 and 6.09 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10\textsuperscript{th} day the values were 6.57, 6.13, 5.24, 5.39, 5.80 and 4.60 and in 20\textsuperscript{th} day it was 5.32, 5.10, 5.08, 4.01, 3.00 and 2.04, respectively. On 30\textsuperscript{th} day of storage the odour value was 2.47, 2.23, 2.11, 1.16, 1.13 and 1.01 in 0.05, 0.10, 0.15, 0.20
Figure 5.7 Hedonic score of electron beam irradiation on organoleptic properties of dried pieces of Banarasi

a. Colour

b. Taste

c. Odour
d. Firmness

e. Overall acceptability
and 0.25kGy, respectively. The hedonic scores of firmness values were 8.79, 8.57, 8.40, 8.29, 7.89 and 7.68 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 7.40, 7.56, 7.50, 7.36, 6.12 and 6.13 and in 20th day it was 6.40, 7.56, 6.50, 5.36, 5.14 and 5.01, respectively. On 30th day of storage the firmness value was 5.34, 6.35, 5.08, 5.12, 4.10 and 4.01 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.6 (d). The hedonic scores of overall acceptability values were 7.67, 7.59, 7.50, 7.45, 7.32 and 7.12 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 6.91, 7.87, 6.78, 6.48, 6.29 and 6.33 and in 20th day it was 5.74, 5.31, 5.24, 4.05, 4.67 and 4.17, respectively. On 30th day of storage the overall acceptability value was 3.57, 3.53, 3.40, 2.13, 2.10 and 2.03 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.6 (e).

5.5.3 Hedonic score rating for irradiated and non-irradiated dried pieces

In dried pieces of amla the colour was observed as whitish black at initial day of storage whereas after 30 days, it was appeared as black. Cut pieces of Banarasi variety showed colour changes during the storage period. Figure 5.7 (a) showing the score value for colour in dried pieces of Banarasi. The colour value was recorded as 7.13, 7.10, 7.10, 6.67 and 6.10 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy at initial day of experiment, respectively. In 10th day the values were 6.12, 6.54, 5.21, 5.10, 5.22 and 5.19 and in 20th day it was 6.12, 6.54, 5.21, 5.10, 5.22 and 5.19, respectively. On 30th day of storage the colour value was found to be 5.34, 5.65, 4.67, 4.38, 4.67 and 3.45 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. The score values for tastes were found to be 6.89, 6.76, 6.57, 6.43, 6.34 and 6.23 in control to 0.25kGy, respectively at initial day (fig. 5.7 (b). In 10th day the values were 6.10, 6.29, 5.25, 5.20, 5.19 and 5.08 and in 20th day it was 6.30, 6.12, 6.02, 5.99, 5.14 and 4.96, respectively. On 30th day of storage the taste value was 5.84, 6.01, 5.44, 5.16, 5.06 and 4.55 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Odour
Figure 5.8 Hedonic score of electron beam irradiation on organoleptic properties of dried pieces of Chakaiya

a. Colour

b. Taste

c. Odour

d. Firmness

e. Overall acceptability
values were found to be 7.89, 7.77, 7.59, 7.43, 7.32 and 7.20 in control to 0.25kGy, respectively (fig. 5.7(c)). In 10th day the values were 6.77, 6.60, 6.55, 6.21, 6.29 and 5.60 and in 20th day it was 5.10, 6.08, 5.11, 5.03, 5.09 and 5.32, respectively. On 30th day of storage the odour value was registered as 4.57, 5.10, 4.18, 4.05, 4.04 and 4.01 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. The hedonic scores of firmness were 7.88, 7.85, 7.76, 7.70, 6.87 and 6.54 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 6.44, 6.10, 6.29, 5.25, 5.20 and 5.19 and in 20th day it was 5.10, 5.04, 6.17, 5.25, 5.10 and 5.15, respectively. On 30th day of storage the firmness value was 4.12, 5.12, 5.65, 4.67, 4.38 and 4.67 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.7(d)). The hedonic scores of overall acceptability values were 7.89, 7.67, 7.00, 7.45, 7.34 and 6.20 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 6.69, 6.57, 6.11, 6.09, 5.69 and 5.35 and in 20th day it was 5.43, 6.03, 5.87, 5.64, 5.45 and 5.19, respectively. On 30th day of storage the overall acceptability value was 4.47, 5.57, 5.00, 5.13, 4.59 and 4.03 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.7(e)).

Dried pieces of Chakaiya variety colour values were plotted in fig. 5.8(a). The values were 7.67, 7.34, 7.23, 6.89, 6.75 and 6.34 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 6.35, 6.66, 5.44, 5.32, 5.43 and 5.35 and in 20th day it was 6.12, 6.54, 5.21, 5.10, 5.22 and 5.19, respectively. On 30th day of storage the colour value was 5.34, 5.70, 5.67, 5.38, 4.43 and 4.12 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Taste values were found to be 6.56, 6.77, 6.63, 6.51, 6.42 and 6.31 in control to 0.25kGy, respectively. In 10th day the values were 6.35, 6.66, 5.44, 5.32, 5.43 and 5.35 and in 20th day it was 6.79, 6.74, 6.64, 6.37, 6.24 and 5.99, respectively. On 30th day of storage the taste value was 5.72, 6.01, 5.14, 6.16, 6.06 and 5.04 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (fig. 5.8(b)). Odour values were
Figure 5.9 Hedonic score of electron beam irradiation on organoleptic properties of dried pieces of Francis

a. Colour

b. Taste

c. Odour
d. Firmness

e. Overall acceptability
found to be 7.86, 7.65, 7.43, 7.32, 7.21 and 7.10 in control to 0.25kGy, respectively. In 10th day the values were 6.60, 6.40, 6.17, 6.09, 5.80 and 5.68 and in 20th day it was 5.12, 6.20, 6.10, 5.86, 5.01 and 5.14, respectively. On 30th day of storage the taste value was 4.47, 5.23, 4.11, 4.16, 3.06 and 3.00 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (fig. 5.8 (c). The hedonic scores of firmness were 7.60, 7.56, 7.45, 7.32, 6.57 and 6.49 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 5.08, 6.35, 6.66, 5.44, 5.32 and 5.43 and in 20th day it was 5.00, 6.12, 6.54, 5.21, 5.10 and 5.22, respectively. On 30th day of storage the firmness value was 3.45, 5.34, 5.70, 5.67, 5.38 and 4.43 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.8 (d). The hedonic scores of overall acceptability values were 7.68, 7.65, 7.59, 7.50, 7.45 and 7.29 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 7.15, 7.38, 7.19, 7.32, 6.47 and 6.33 and in 20th day it was 6.79, 6.75, 6.73, 6.10, 5.34 and 5.79, respectively. On 30th day of storage the overall acceptability value was 5.57, 5.83, 5.61, 5.13, 4.04 and 4.10 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.8 (e).

Dried pieces of Francis variety colour values were plotted in fig. 5.9 (a). The values were 7.67, 7.54, 7.32, 6.65, 6.31 and 6.12 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10th day the values were 6.40, 6.66, 5.54, 5.38, 4.20 and 4.25 and in 20th day it was 6.40, 6.66, 5.54, 5.38, 4.20 and 4.25, respectively. On 30th day of storage the colour value was 5.34, 5.32, 5.03, 5.12, 4.15 and 4.08 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Taste values were found to be 6.54, 6.70, 6.45, 6.33, 6.25 and 6.30 in control to 0.25kGy, respectively (fig. 5.9 (b). In 10th day the values were 6.40, 6.66, 6.37, 6.27, 6.06 and 5.89 and in 20th day it was 6.60, 6.31, 6.14, 6.16, 6.00 and 5.04, respectively. On 30th day of storage the taste value was 5.64, 6.21, 5.44, 5.38, 4.20 and 4.15 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. Odour values were found to be 7.68, 7.54, 7.43, 7.32, 7.20 and 7.11 in control to 0.25kGy, respectively (fig. 5.9 (c).
10\textsuperscript{th} day the values were 6.57, 6.13, 6.24, 6.39, 6.80 and 5.78 and in 20\textsuperscript{th} day it was 5.32, 6.10, 6.08, 6.01, 6.66 and 5.20, respectively. On 30\textsuperscript{th} day of storage the odour value was 4.47, 5.23, 5.21, 4.38, 3.41 and 3.00 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. The hedonic scores of firmness were 7.65, 7.58, 7.40, 7.30, 6.75 and 6.55 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10\textsuperscript{th} day the values were 5.35, 6.40, 6.66, 5.54, 5.38 and 4.20 and in 20\textsuperscript{th} day it was 5.19, 6.40, 6.66, 5.54, 5.38 and 4.20, respectively. On 30\textsuperscript{th} day of storage the firmness value was 4.12, 5.34, 5.32, 5.10, 5.03 and 4.15 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.9 (d). The hedonic scores of overall acceptability values were 7.67, 7.65, 7.50, 7.43, 7.39 and 7.23 in 0, 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively. In 10\textsuperscript{th} day the values were 7.81, 7.77, 7.65, 7.54, 7.32 and 6.46 and in 20\textsuperscript{th} day it was 7.76, 7.57, 7.44, 7.35, 6.87 and 6.37, respectively. On 30\textsuperscript{th} day of storage the firmness value was 6.97, 6.83, 5.62, 5.53, 5.43 and 4.63 in 0.05, 0.10, 0.15, 0.20 and 0.25kGy, respectively (Fig 5.9 (e).

5.6 Shelf life of Amla Varieties

Irradiation can delay ripening of some tropical fruits and resulted in the shelf life of fruits are extended (Kader, 1986). The whole fruit of Banarasi, shelf life has increased to 43 days at 0.05kGy irradiation. In other doses like 0.10 and 0.15kGys the shelf life were recorded to be 38 and 32 days respectively. During the storage it was in good condition when compared to control. In control sample, the shelf life has retained only for 27 days. In 0.20 and 0.25kGy, the fruit was found in good condition for 29 and 22 days, respectively.

The whole fruit of Chakaiya, shelf life has increased to 46 days at 0.05kGy irradiation. In other doses like 0.10 and 0.15kGys the shelf life were recorded as 38 and 28 days when compared to the control samples. In 0.20 and 0.25kGy the fruit was found in good condition for 26 and 20 days, respectively. On 20 days after irradiation, the
fungal growth was observed on the surface of fruit. In the control, the shelf life was recorded as for 35 days. Francis varieties the shelf life was found to be 40, 33, 29, 20, 15 and 28 days in 0.05, 0.10, 0.15, 0.20, 0.25 and control sample, respectively. The radiation dose, above 1kGy affect the shelf life and it was found as less than 10-15 days, since the fruit does not tolerate to higher doses.

In cut pieces of amla, the entire samples were damaged within 6 to 10 days. The self life was reduced in cut pieces. Fungi grow easily on the surface of cut pieces due to increased level of moisture content. 0.05kGy the shelf life was 17, 20 and 18 at 0.10kGy the shelf life was 12, 13 and 12 in Banarasi, Chakaiya and Francis varieties of amla, respectively. In 0.15kGy the shelf life was 13, 13 and 10 and 0.20kGy the shelf life was 10, 9 and 7 in Banarasi, Chakaiya and Francis varieties of amla, respectively. 0.25kGy of all the three varieties of amla, shelf life was very less, the shelf life was just 5, 6 and 6 days only.

In dried pieces, the shelf life was retained for upto 60 days because the absences of moisture but in same manner nutrient content and antioxidant properties will be decreased according to the doses level. In all the samples studies shelf life has been extended except of cut pieces amla.

Table 5.1 Shelf life of electron beam irradiated amla varieties in whole fruit stored at room temperature

<table>
<thead>
<tr>
<th>Doses (kGy)</th>
<th>Banarasi</th>
<th>Chakaiya</th>
<th>Francis</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>27 ± 2</td>
<td>35±2</td>
<td>28±2</td>
</tr>
<tr>
<td>0.05</td>
<td>43±1</td>
<td>46±2</td>
<td>40±2</td>
</tr>
<tr>
<td>0.10</td>
<td>38±2</td>
<td>38±1</td>
<td>33±2</td>
</tr>
<tr>
<td>0.15</td>
<td>32±2</td>
<td>28±2</td>
<td>29±1</td>
</tr>
<tr>
<td>0.20</td>
<td>29±1</td>
<td>26±2</td>
<td>20±2</td>
</tr>
<tr>
<td>0.25</td>
<td>22±2</td>
<td>20±2</td>
<td>15±1</td>
</tr>
</tbody>
</table>
Table 5.2 Shelf life of electron beam irradiated amla varieties in cut pieces stored at room temperature

<table>
<thead>
<tr>
<th>Doses (kGy)</th>
<th>Banarasi (days)</th>
<th>Chakaiya (days)</th>
<th>Francis (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6±2</td>
<td>10±2</td>
<td>8±2</td>
</tr>
<tr>
<td>0.05</td>
<td>17±2</td>
<td>20±2</td>
<td>18±2</td>
</tr>
<tr>
<td>0.10</td>
<td>12±2</td>
<td>13±2</td>
<td>12±2</td>
</tr>
<tr>
<td>0.15</td>
<td>13±1</td>
<td>13±2</td>
<td>10±2</td>
</tr>
<tr>
<td>0.20</td>
<td>10±2</td>
<td>9±2</td>
<td>7±2</td>
</tr>
<tr>
<td>0.25</td>
<td>5±2</td>
<td>6±2</td>
<td>6±2</td>
</tr>
</tbody>
</table>

Table 5.3 Shelf life of electron beam irradiated amla varieties in dried pieces stored at room temperature

<table>
<thead>
<tr>
<th>Doses (kGy)</th>
<th>Banarasi (days)</th>
<th>Chakaiya (days)</th>
<th>Francis (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>55±2</td>
<td>59±2</td>
<td>56±2</td>
</tr>
<tr>
<td>0.05</td>
<td>65±2</td>
<td>67±2</td>
<td>60±2</td>
</tr>
<tr>
<td>0.10</td>
<td>48±2</td>
<td>54±2</td>
<td>52±2</td>
</tr>
<tr>
<td>0.15</td>
<td>42±1</td>
<td>42±2</td>
<td>47±2</td>
</tr>
<tr>
<td>0.20</td>
<td>44±2</td>
<td>43±2</td>
<td>48±2</td>
</tr>
<tr>
<td>0.25</td>
<td>46±2</td>
<td>51±2</td>
<td>49±2</td>
</tr>
</tbody>
</table>

5.7 Discussion

The sensorial properties such as colour, taste, odour, firmness and overall acceptability showed no significant statistical difference among the aspects analyzed (Hardar et al., 2009). This finding was agreed with Song et al., 2007 for their previous studies in sensorial properties of gamma irradiated tamarind juice and fresh vegetable juices. Studies with Gala and Fuji apples irradiated with quarantining dosages showed that 0.6kGy was enough for this purpose, did not cause physical-chemical damages, and did not alter sensory quality of the fruit (Dionisio et al., 2004). The sensorial properties such as colour and taste were not affected during the gamma irradiated cashew nut at the
dose level of 7kGy and taste was assigned than odour (Mexis and Kontominas, 2009). Electron beam irradiated amla varieties, the sensorial properties were slightly decreased during the storage period, these results was agreed with Ju Woon et al., (2009) by gamma irradiated turmeric juice. Electron beam irradiated whole fruit of amla varieties sensorial properties of colour was decreased in the hedonic score with increased doses, this results was agreed by Fan et al. (2003a) reported that visual appearance of fresh cut lettuce surface in fresh cut lettuce, where decrease in surface colour with increased doses. After the irradiation burdock extracts colour value was decreased (Lee et al., 2010).

Lacroix (1992) reported that mango irradiated at 0.60 and 0.90kGy of gamma rays showed a significant difference in the loss of texture when compared with control fruits. Irradiated feta cheese sample texture and flavor was increased due to the irradiation doses (Spyros et al., 2009). Eshan et al., 2003, who reported the decrease in texture of grape fruit apple marmalade after irradiation. Irradiation treatment was affected the organoleptic properties of almonds (Paloma et al., 2008). Irradiated amla varieties, the taste score was slightly changed in experimental period. This result was fully accepted by Fenfen et al., 2012, they were studied the gamma irradiated cashew nut taste and appearance and reported slight changes during the storage period.

El-Samahy et al. (2000) reported that the reduction of firmness of mango when exposed to gamma irradiation at dose levels between 0.5 and 1.5kGy. Sensory firmness was significantly decreased with shelf life in LeM H1-H2 apples. CP apples had little changes in sensory properties (Maristella et al., 2013). The irradiation dose of 2.0kGy was found to be effective in maintaining the textural property of carrots for 14 days (Chaudry et al., 2004). The texture, odour and appearance score value of irradiated packaged products was significantly lower compared to the control sample (Al-Bachik, 2005). In the present study irradiated samples hedonic score points for all the sensorial
properties such as colour, taste, odour, firmness and overall acceptability were not significantly changed.

Shelf life of fruit was altering due to cell was ripped by cutting during the processing and wound caused the biochemical reactions (Cantwell and Suslow, 2002). Singh et al., 2005, suggested that amla fruit is a highly spoilage fruit and its shelf life is poor. Hence, preservation is very important for storing long period. Fresh fruits and vegetables preserved under some chemical preservatives used to improve the storability and reduce the decay (Sethi and Maini, 2000). Respiration rate was decreased in modified atmosphere packaging in irradiation, it was extends the shelf life (Habibunnisa et al., 2001a). Electron beam irradiated amla varieties shelf life was decreased in cut pieces of irradiated samples compared to the non irradiated samples. This data was agreed by Maristella et al., 2013, for those tested in LeM H1-H2 apples. It appears that 8th day of storage in shelf life of apples were perceived less firm, less crispy and mealier than at day 1 and day 14 of storage time. Whole fruit of electron beam irradiated amla varieties, shelf life was increased, this data agreed with several authors such as gamma irradiation was used to extend the shelf life of fresh ginger (Mishra et al., 2004), sliced carrot (Chaudry et al., 2004), carrot and kale juice (Song et al., 2005), liquorice root (Al-Bachir and Lahham, 2003) and dried potato (Wang and Chao, 2003). Irradiation of blueberries and mango at doses up to 3.2 and 1.5kGy does not affect the parameters such as water activity of the fruits and may increase their shelf-life (Maria, 2005). Combination treatment with irradiated fresh-cut pears optimum shelf life was extended (Swailami et al., 2007). The pasteurized pulps of passion fruit shelf life period were increased to 60-90 days (Natalia et al., 2012). Radiation treatment of litchi fruit extended the shelf life up to 28 days less than 4°C. The storage condition of litchi fruit was not affected due to irradiation (Satyendra et al., 2010).