Journal of Crop and Weed, 17(1): 136-142 (2021)

ISSN- O : 2349 9400 ; P : 0974 6315

http://cwssbckv.org
www.cropandweed.com

Effect of different packaging methods in storability of broccoli var. Aishwarya in refrigerated condition

***CH. CHANBISANA AND A.K. BANIK**

Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal-741252

Received : 12.12.2020 ; Revised : 30.12.2020 ; Accepted : 05.01.2021

DOI : https://doi.org/10.22271/09746315.2021.v17.i1.1416

ABSTRACT

Research work was conducted within the laboratory of Post Harvest Technology of Horticultural Crops Department, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur after harvesting broccoli which was grown within the Horticulture Research Station, Mondouri to determine the effect of different packaging materials on the post harvest life of broccoli stored in refrigerated condition(5±1ºC) and 90-95%relative humidity. Freshly harvested broccolies were trimmed and packed in polypropylene (100 gauge), polyethylene bags(150 gauge) with and without perforation, corrugated fibreboard boxes with inside laminated, stress wrap (50 gauge) and in control to determine the difference in post harvest life of broccoli. During the storage period, samples were taken at regular interval to determine the physiological loss in weight, chlorophyll loss, yellowing %, fungal decay or bacterial decay, sensory evaluation for colour, smell, texture and browning along with marketability. The loss in weight was least in polypropylene bag with no perforation and in stretch wrapped broccoli. Chlorophyll content was high in polypropylene bag with no perforation and polyethylene bag with 1% perforation while yellowing occurred in all packaging where perforation was given and the maximum was in unpacked broccoli. On sensory analysis, best visual colour was in stretch wrapped broccoli, with good smell score in polypropylene and polyethylene bag with no perforation.

Keywords: Ascorbic acid, broccoli, chlorophyll, polyethylene, polypropylene, yellowing

India ranks second position in broccoli production in the world after China (Anon., 2013). In West Bengal, broccoli is grown in hilly region of Darjeeling, Kalimpong while in plains it is cultivated in some sub urban areas of Kolkata but the area and production of broccoli in West Bengal is in trace due to limited production even though it has been scientifically shown and can be successfully cultivated in the place. Due to its delicious taste, flavour and nutritive value, it gains popularity. It is rich in vitamins, antioxidants, anticarcinogenic compounds (Nestle, 1998) and health promoting phytochemicals (Yuan *et al.*, 2010). 1.20-6.24µmol of glucosinolates/g fresh weight (Song and Thornalley, 2007) is present in broccoli. Quality loss in broccoli during storage is usually due to wilting, buds and florets yellowing, head loosening or opening and decay (Toivonen and Forney, 2004). Due to high perishable nature, there are problems of bruising in post harvest management during handling. Colour and texture are two important quality attributes of vegetables affected by storage conditions, such as temperature, relative humidity, light and the composition of the surrounding atmosphere. Green-coloured florets of broccoli (looking fresh) are preferred by consumers. The quality of broccoli is highly reduced after harvesting due to loss of green colour and the consequent sepals yellowing.

Broccoli reaches the retail markets at least one or two days after harvest and, by the time it reaches market, the quality begins to deteriorate. The deterioration in quality of this vegetable is very rapid in both ambient and refrigerated conditions. Yellowing due to loss of chlorophyll is the most important problem for successful marketing of broccoli. Weight loss was significantly higher in non packaged broccolis compared to packaged ones with increase in temperature and storage time. Being extremely sensitive to ethylene, floret yellowing is the most prevalent symptom. Costa *et al*. (2005) confirmed that an increment in activities of some enzymes (chlorophyllase and Mg-dechelatase) is responsible for chlorophyll catabolism and as a result yellowing of florets. Longer storage is undesirable because leaves discolor, buds may yellow and drop off, and tissues soften. Now-a-days, many of the exotic erstwhile less known high value vegetables like lettuce, bean sprouts, spinach are becoming popular in the plains of India and broccoli is one of the most important among them. Though it is grown abundantly in the foothills of the Himalayas, in the terai regions of West Bengal, now-a- days it is gaining popularity among the vegetable growers in the Gangetic plains of West Bengal mainly due to its rich nutritional values but the information on post harvest technology aspect of the crops suitable for this region is scanty. Consumers prefer to keep broccoli under ambient or common refrigerated conditions (at 4°C) with or without packaging if it is not consumed immediately. Regardless of packing method, broccoli heads need to be packed to retain a turgid, fresh, and

Email: chanbi.sana44@gmail.com

attractive condition. Taking into consideration the problem of short shelf life of broccoli, the research work was carried out with different packaging materials to compare the extension of postharvest life of broccoli in refrigerated condition.

MATERIALS AND METHODS

Broccoli variety 'Aishwarya' cultivation was carried out in the Horticulture Research Station, Mondouri in 2014 and harvested from field in the end of December,2014 and storage studies was carried out in the laboratory of the department of Post Harvest Management of Horticultural Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur in January, 2015 in order to study the effect of packaging in refrigerated condition. They were brought immediately to the laboratory, cooled in room for 3 hours. Then they were trimmed and packed in different packaging materials as follows:

T_1 - Polypropylene bag without perforation
T_2 - Polypropylene bag with perforation (1%)
T_3 - Polypropylene bag with CFB box
T_4 - CFB box with inside plastic laminated
T_5 - Polyethylene bag without perforation
T_6 - Polyethylene bag with perforation (1%)
T_7 –Stress wrap
T_8 – Control (without any packaging material)

Polypropylene bags (100 gauge), polyethylene bag (150 gauge) and stretch wrap (50 gauge) were used for packing during the experiment. After each type of packaging, the broccoli heads were stored in refrigerated condition (5±1ºC with 90-95%RH) for the storage study.

Statistical design: Completely Randomised Design (CRD)

Number of replication :3

Physical and chemical analysis:

1. Physiological loss in weight (PLW)

PLW was calculated as total weight loss %, based on the initial weight (before storage) and weight loss at the day of sampling during storage (Nath *et al*., 2011).

$$PLW = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100$$

1. Ascorbic acid

Volumetric method of ascorbic acid determination (2,6-Dichlorophenol-Indophenol Visual Titration Method) was done using 2, 6-dichlorophenol indophenols. The dye is a blue coloured compound but the end point was appeared of pink colour. The dye is pink coloured in acid medium (Ranganna, 2017).

$$\text{Ascorbic acid } (\text{mg}/100\ \text{g}) = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot of extract taken for estimation} \times \text{Wt : or vol : of the sample taken for estimation}} \times 100$$

2. Chlorophyll

Total chlorophyll content was determined by spectrophotometric method (A.O.A.C,1990). A known amount of tissue sample by weight was taken and chlorophyll was extracted in 80% acetone until the residue had no more green colour. The filtrate or supernatant was made upto known volume with 80% acetone and the Optical Density (OD) value was then measured through 660nm and 642.5nm wavelength in a colorimeter against blank. Using the adsorption coefficients, the amount of chlorophyll was calculated as follows

Total chlorophyll (a+b), µg/ ml = (7.12 × OD at 660nm) + (16.8 × OD at 642.5nm)

3. Total soluble solids (TSS) °Brix

TSS was determined by Hand Refractometer. ºBrix is used as an indicator of total soluble solids in the juice of fruits and vegetables (Varnam and Sutherland, 1994), broccoli juice was dropped on the prism (Erma Hand RefractrometerI.S.O 2173) and the percentage of dry substance in it was read directly.

4. Yellowing percentage

Whole green broccoli head was divided into four parts out of 100 per cent. The area which become yellow was recorded visually according to the four parts divided. There were two conditions of yellowing, one where there was gradual yellowing while the other was with the patchy development of colour.

5. Sensory evaluation

Sensory quality indices such as colour, texture, smell and browning were evaluated. The intensity of the attributes evaluated was quantified on a scale from 1 to 5point hedonic scale.

Rating on fresh broccoli were rated as follows:

Colour

5 = dark green, uniform colour
4 = slightly yellow
3 = moderately yellow
2 = very yellow

1 = extreme yellow

Browning

5 = no browning
4 = some browning
3 = moderate browning
2 = very much browning
1 = extreme browning

Texture

5 = crispy
4 = little rubbery
3 = rubbery
2 = soft
1 = extremely soft

Smell

5 = no off-odour
4 = slight off-odour
3 = moderately off-odour
2 = severe off-odour
1 = extreme off-odour

6. Fungal decay(%)

Observation on visual appearance of white growth on fresh broccoli which is mainly caused by fungus was recorded areawise on the whole head of broccoli on percentage basis and respective value in percentage was given for respective amount of decay.

7. Marketability (%)

The marketability of broccoli was determined on the basis of colour, texture or crispiness, flavour and defects like yellowing, browning and decay and expressed in percentage (%). Upto an amount of 50% was considered to be marketable.

RESULTS AND DISCUSSION

1. Physiological loss in weight (%) : In Table 1, physiological loss in weight varied markedly in storage among all the types of packaging and the loss was maximum in unpacked broccoli (T_8) ranging from 7.44 to 40.67% followed by CFBB + inside laminated (T_4) with 6.33 to 18.23% during the storage period while the minimum loss in weight was reported in stress wrap (T_7) broccoli showing 0.16 to 0.89% weight loss throughout the storage period. The increase in PLW among all the treatments during the period of study with the least loss in weight in T_1(PP+ no perforation) was recorded and Esturk *et al*. (2014) also concluded that high quality broccoli can be kept upto 20 days if it is packed with LDPE films. Packing operation was done to slow the respiration and transpiration of a produce thus altering the natural process of ripening and

Table 1: Effect of packaging on PLW (%), marketability (%) and yellowing (%) of broccoli var. Aishwarya in refrigerated condition

Treatment	Physiological loss in weight (%)			Market-ability on 15th day	Yellowing (%)		
	Days in storage				Days in storage		
	5	10	15		5	10	15
T_1(PP+ no perforation)	0.44 (3.82)	0.70 (4.79)	0.89 (5.40)	75	*	*	*
T_2(PP+1% perforation)	4.90 (12.78)	6.53 (14.80)	7.03 (15.37)	63	*	2.67 (9.36)	20.33 (26.77)
T_3(PE +CFBB)	1.27 (6.46)	2.23 (8.59)	3.13 (10.19)	70	*	*	*
T_4(CFBB+inside laminated)	6.33 (14.57)	15.37 (23.07)	18.23 (25.27)	68	*	*	11.67 (19.96)
T_5(PE+ no perforation)	1.53 (7.10)	2.83 (9.69)	3.97 (11.48)	75	*	*	*
T_6(PE+1% perforation)	2.80 (9.63)	4.40 (12.10)	5.57 (13.64)	65	*	*	16.67 (24.04)
T_7(Stress wrap)	0.16 (2.31)	0.18 (2.38)	0.89 (5.40)	70	*	*	*
T_8(Control)	7.44 (15.80)	17.17 (24.46)	40.67 (39.55)	50	*	1.67 (7.33)	51.67 (45.94)
SEm(±)	**0.19**	**0.26**	**1.84**			**0.17**	**0.99**
CD(P=0.05)	**0.58**	**0.79**	**5.56**			**0.50**	**2.99**

Note: values inside brackets denote angular transformed data

Table 2: Effect of packaging on ascorbic acid (mg/100g), total soluble solids(°B), chlorophyll content(µg/g) and fungal decay(%) of broccoli var. Aishwarya in refrigerated condition

Treatment	Ascorbic acid (mg/100g)				Total soluble solids				Chlorophyll(µg/g)				Fungal decay(%)		
		Days in storage				Days in storage				Days in storage					
	At harvest	7	14	21	At harvest	5	10	15	At harvest	5	10	15	5	10	15
T_1(PP+ no perforation)	135	122.33	103.33	86.67	7.5	6.90	6.93	7.07	311	303.33	279.33	256.67	*	*	2.67 (9.36)
T_2(PP+1% perforation)		125.33	122.67	79.67		6.50	7.60	8.03		262.00	207.33	196.67	*	*	*
T_3(PE +CFBB)		136.33	110.00	104.00		7.43	6.87	6.87		273.00	250.00	220.00	*	*	10 (18.43)
T_4(CFBB+inside laminated)		140.67	126.67	126.33		7.90	6.97	6.97		270.00	236.67	206.67	*	*	3.67 (10.52)
T_5(PE+ no perforation)		127.67	122.67	99.83		7.00	6.90	6.47		280.00	268.67	235.00	*	*	*
T_6(PE+1% perforation)		122.33	96.67	77.67		7.13	7.03	6.70		273.33	260.00	256.67	*	*	5.00 (12.92)
T_7(Stress wrap)		131.00	123.33	123.00		7.33	7.67	7.93		298.00	280.00	245.00	*	*	*
T_8(Control)		121.00	112.67	76.67		7.03	10.33	12.83		273.33	220.00	183.33	*	*	3.67 (11.01)
SEm(±)		**2.57**	**2.25**	**4.05**		**0.11**	**0.14**	**0.08**		**9.43**	**8.05**	**6.65**			**1.51**
CD(P=0.05)		**7.76**	**6.79**	**12.23**		**0.32**	**0.42**	**0.25**		**NS**	**24.36**	**20.10**			**0.50**

Note:NS= non significance and * denotes no visible fungal decay

Table 3: Effect of packaging on sensory characteristics of broccoli var. Aishwarya in refrigerated condition

Treatment	At harvest	Sensory score for colour Days in storage			Smell score Days in storage			Texture score Days in storage			Browning Days in storage		
		1	2	3	1	2	3	1	2	3	1	2	3
T_1(PP+ no perforation)	5	4.37	4.07	3.80	4.13	3.80	3.03	4.67	4.60	4.20	5.00	5.00	5.00
T_2(PP+1% perforation)		4.33	3.70	3.47	4.67	4.43	3.80	4.53	4.47	4.10	4.93	4.90	4.93
T_3(PE +CFBB)		4.57	3.83	3.67	4.47	3.87	3.83	4.77	4.17	4.10	4.77	4.40	4.27
T_4(CFBB+inside laminated)		4.37	3.87	3.57	4.67	4.10	3.77	4.43	3.53	3.43	4.50	4.40	4.27
T_5(PE+ no perforation)		4.80	4.40	3.90	4.30	3.40	3.03	4.57	3.40	3.53	5.00	4.43	4.57
T_6(PE+1% perforation)		4.73	4.47	3.37	4.13	3.53	3.20	4.53	3.70	3.23	4.97	4.67	3.53
T_7(Stress wrap)		4.77	4.20	4.03	4.77	4.53	4.23	4.73	4.30	3.87	4.93	4.70	4.30
T_8(Control)		4.20	3.17	3.07	4.87	4.63	4.37	4.67	4.07	3.37	4.97	4.73	4.67
SEm(±)		**0.13**	**0.12**	**0.11**	**0.18**	**0.10**	**0.09**	**0.05**	**0.09**	**0.13**	**0.12**	**0.11**	**0.36**
CD(P=0.05)		**0.39**	**0.35**	**0.33**	**NS**	**0.29**	**0.26**	**0.15**	**0.29**	**0.40**	**NS**	**0.33**	**NS**

*Score for colour: 5 = dark green, uniform colour; 4 = slightly yellow; 3 = moderately yellow; 2 = very yellow; 1 = extreme yellow
Score for smell:5 = no off-odour; 4 = slight off odour; 3 = moderately off odour; 2 = severe off-odour;1 = extreme off-odour
Score for texture: 5 = crispy; 4 = little rubbery; 3 = rubbery; 2 = soft; 1 = extremely soft
Score for browning: 5 = no browning; 4 = some browning; 3 = moderate browning; 2 = very much browning;1 = extreme browning

senescence. Wrapping gave the highest firm texture and minimum loss of water, independent of storage temperature. Increased weight loss during storage with lesser weight loss in packed broccoli was similar with the findings of Giovanelli *et al.* (2014) in raspberries.

2. Ascorbic acid (mg 100g^{-1}) : Ascorbic acid content of broccoli was decreased throughout the period in storage but the ascorbic content was maximum in broccoli packed in CFBB with inside laminated (T_4) followed by broccoli packed in stress wrapped during the entire period of storage while the unpacked broccoli packed recorded minimum ascorbic acid content during storage period (Table 1). As storage duration lengthened, the amount of ascorbic acid was decreased in wrapped broccoli (Reddy *et al.*, 2010).

3. Total soluble solids : Packaging gave significant effect on total soluble solids content (Table 1) of broccoli during the storage period. Total soluble solids was decreased gradually with increase in the duration of storage in all types of packaging however in unpacked broccoli (T_8) and stress wrapped broccoli (T_7), it was gradually increased with the advance in storage duration. Maximum TSS content was recorded in unpacked broccoli (T_8) with 7.33 to 7.93ºB during the storage period while least TSS content was recorded in broccoli packed in PE with no perforation(T_5). The decreasing trend of TSS may be correlated with the finding of Shyam *et al.*(2012).

4. Chlorophyll (µg/g): From Table 1, the decrease in chlorophyll content was non significant on ^{5th} day but after which it became significant till the end of the period of study. So far as the different types of packaging were concerned the chlorophyll content of broccoli was decreased with the increase in days of storage period. T_8 was found to have the least chlorophyll content while the crop packed in PP with no perforation(T_5) and those packed in PE with 1% perforation showed maximum content of chlorophyll followed by broccoli packed in stress wrap during the storage period. Higher loss of chlorophyll compared to packed broccoli was also reported by Sabir (2012) in cold storage.

5. Yellowing percentage: Table 2 showed no yellowing till day 5 in refrigeration. On day 10, yellowing started: 2.67% in broccoli packed in PP with 1% perforation (T_2) and 1.67% in unpacked broccoli (T_8). On day 15, there was no yellowing in broccoli packed in PP with no perforation (T_1), PE packaging with CFBB (T_3), PE packaging with no perforation (T_5) and stress wrapping (T_7) while yellowing was increased to 20.33% in PP packaging with 1% perforation, 11.67% in CFBB packaging with lamination inside (T_4), 16.67% in PE packaging with 1% perforation (T_6) and 51.67% in unpacked broccoli. Yellowing was first started in

perforated packages and unpacked broccoli with greater value in perforated pack which was gradually increased with the advance of storage period and the unperforated one gave better green colour during the storage period.

6. Fungal decay (%): From Table 2, no fungal decay was evident till day 10. Some decay was started from day15 showing highest decay of 10% in PE packaging with CFBB (T_3) followed by 5.00% in PE packaging with 1% perforation (T_6). On day 15, there was still no growth on PE packaging with no perforation and stress wrap while the highest decay was 30.43% in CFBB packaging with inside laminated and the least was 10.04% in PE packaging with CFBB. Beer and Crouch (2013) reported that at 0°C no decay was visible during 35 day storage. So the present storage study at 5°C, have shown that temperature lower than this, is necessary to prevent any decay for longer period.

7. Sensory evaluation

a. Colour : Data presented in Table 3 showed significant effect of packaging on colour score of broccoli during the storage period. Though colour score was reduced with the progress of storage period, the highest score was observed in stress wrapped broccoli (T_7) with scores of 4.77 and 4.03 on 5 and 15th day followed by those packed in PP with no perforation while mimimum colour score was noted in unpacked broccoli throughout the storage period. Packed broccoli tends to have better colour than the control *i.e*., without any packaging. While among the pack broccoli, the non perforated ones gave greener colour compared to the perforated ones. Costa *et al*. (2005) confirmed that floret yellowing was mainly due to an increment in activities of chlorophyllase and Mg-dechelatase by destruction of chlorophyll catabolism.

b. Smell : So far as the different types of packaging were concerned, smell score of broccoli were more in unpacked broccoli compared to the packaged broccoli. Highest smell score was recorded in unpacked broccoli with scores of 4.87 to 4.37 throughout the storage period while the minimum smell score during the storage period was noted in broccoli packed in PP with no perforation and those packed in PE with no perforation. Unpacked broccoli gave better smell score followed by perforated one and non perforated packaging in Table 3.

c. Texture : It is evident from Table 3 that the texture of broccoli was reduced from the progress of storage till the end of the period of study. Texture score was considerably higher in the broccoli packed without perforation. Maximum score during the storage period was recorded in broccoli packed with PP with no perforation (T_5) with scores 4.67 to 4.20 throughout the storage followed by those packed in PP with 1% perforation (T_6) and PP packaging with CFB boxes (T_3) while the least score was recorded in unpacked broccoli(T_8) with scores ranging from 4.67 to 3.37 throughout the storage period. Broccoli packed in polypropylene gave the best texture followed by stress wrapped and polyethylene packing compared to the control which is supported by Jacobsson and Nielson (2003) who had revealed that broccoli kept without any pack at a higher temperature will be less green, fresh and compact compared to the unpackaged broccoli kept at 4 or 10ºC .

d. Browning: Browning (In Table 3) was not occurred in Polyethylene bag without perforation ,T_5 while maximum amount of browning was occurred in Polyethylene bag with perforation(1%),T_6. Wild rocket freshness is determined by its green colour and texture. Occurrence of browning may be correlated with the finding of Lokke *et al*. (2013) who reported that aging and yellowing of green leafy vegetables can be delayed by packaging with a possibility of anaerobic respiration with loss in texture and discolouration.

8. Marketability : Highest marketability (75%) was observed in polypropylene bag with no perforation (T_1) as well as polyethylene with no perforation (T_5) in Table 1. PP and PE with no perforation gave similar effect on marketability on 15th day of storage followed by stress wrap (T_7). Lowest marketability was recorded in unpacked broccoli with 50% marketability on day 15.

Conclusion : Packaging is very essential in increasing the longivity of broccoli. More perforation in package leads to more moisture loss from the produce but the rate of moisture loss is reduced in refrigeration. At the last day of storage period, ascorbic acid remained at acceptable level even though yellowing started. Considering all the parameters, broccoli packed in stress wrap had better post harvest quality in almost all parameters with maximum moisture retension and ascorbic acid content for 15 days.

REFERENCES

Anonymous, 2013. Published on January 3, 2013 in The Telegraph, Calcutta. Front page. https://www.telegraphindia.com/1130103

A.O.A.C. 1990. Official Methods of Analysis. 15thEdn., Association of Official Methods of Analytical Chemists, Washington, DC., Arlington, Virginia, USA., ISBN: 0935584-42-0.

Costa, M. L., Civello P M, Chaves, A. R. and Martinez, G.A. 2005. Effect of ethephon and 6-benzylaminopurine on chlorophyll degrading enzymes and a peroxidase-linked chlorophyll bleaching during postharvest senescence of broccoli (*Brassica oleracea* L.) at 20°C. *Postharvest Biol. Technol.,* **35:**191-99.

Esturk, O., Ayhan, Z. and Gokkurt, T. 2014. Production and application of active packaging film with ethylene adsorber to increase the shelf life of

broccoli (*Brassica oleracea* L. var. *italica*). *Packag. Technol. Sci.,* **27**(3): 179-191.

Giovanelli, G., Limbo, S. and Buratti, S. 2014. Effects of new packaging solutions on physico-chemical, nutritional and aromatic characteristics of red raspberries (*Rubus idaeus* L.) in postharvest storage. *Postharvest Biol. Technol*., **98**: 72–81.

Jacobsson, A. and Nielsen, T. 2003. Influence of packaging material and storage temperature on the texture, colour, and weight of broccoli. Proc. 8th Int. CA Conference. *Acta Hortic.,* **600**: 323-26.

Lokke, M. M., Seefeldt, H. F., Thomas, S. and Edelenbos, M. 2013. Color and textural quality of packaged wild rocket measured by multispectral imaging. *Postharvest Biol. Technol*., **75**: 86-95

Nath, A., Bagchi, B., Misra L.K. and Bidyut, C. D. 2011. Changes in post-harvest phytochemical qualities of broccoli florets during ambient and refrigerated storage. *Food Chem.,* **127**: 1510-1514.

Nestle, M. 1998. Broccoli sprouts in cancer prevention. *Nutri. Rev*., **56**:127–130.

Ranganna, S. 2017. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd Edition, Tata McGraw Hill Publication Co. Ltd, New Delhi, 2017.

Reddy,Y. V. R., Marcy, J. E., Bratsch, A. D., Williams, R. C. and Waterman, K. M. 2010. Effects of packaging and postharvest treatments on the shelf-life quality of crown-cut broccoli. *J. Food. Qual,*. **33**(5): 599-611.

Sabir, F.K. 2012. Postharvest quality response of broccoli florets to combined application of 1-methylcyclopropene and modified atmosphere packaging. *Agric. Food Sci*., **21**: 421-429.

Shyam, N. J., Rai, D.R. and Rajiv, S. 2012. Physico-chmeical quality parameters and overall quality during storage. *J. Food Sci. Technol*., **49**(5): 594-600.

Song, L., and Thornalley, J. 2007. Effect of storage, processing and cooking on glucosinolates contents of Brassica vegetables. *Food Chem. Toxicol*., **45**: 216-224.

Toivonen, P.M.A. and Forney, C. 2004. Broccoli. In: The Commercial Storage of Fruits, Vegetables and Florist and Nursery Stock. USDA, ARS Agriculture Handbook . p.66.

Varnam, A.H. and Sutherland, J.P. 1994. Beverages: Technology, Chemistry and Microbilogy. London, Chapman and Hall.

Yuan, G., Sun, B., Yuan, J. and Wang, Q. 2010. Effect of 1 methylcyclopropene on shelflife, visual quality, antioxidant enzymes and health-promoting compounds in broccoli florets. *Food Chemistry*. **118**: 774-781.