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Effect of temperature on shelf life and ascorbic acid content of broccoli produced with different combinations of nitrogen level and spacing

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Key words: Shelf life, temperature, ascorbic acid and broccoli.

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Abstract

The experiments were carried out in the research field and laboratory of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur, during October 2011 to April 2012 to determine optimum temperature and combined nitrogen dose and spacing for ensure storage condition as well as increasing shelf life of broccoli. There were two factors temperature (24°C, 10° C, 4°C) and nitrogen fertilizer and spacings combinations (15) in the experiment. The maximum shelf life (16.51 days) was recorded from ST_3 (4°C) and minimum shelf life (5.79) recorded from ST_1 (24°C). Similar trend was observed in case of ascorbic acid content. The maximum shelf life (12.70 days) recorded from the $S_{60\times60}$ N_0 and ascorbic acid content was maximum (27.11 mg/100g) in $S_{60\times30}$ N_0. The maximum shelf life (19.67 days) was recorded from $S_{60\times60}$ N_0 at 4°C and maximum ascorbic acid content (37.33 mg/100g) was recorded from $S_{60\times30}$ N_0 at 4°C.

Keywords:

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Introduction

Broccoli (*Brassica oleracea* L. var. italica) is one of the non-traditional and relatively new cole crops in Bangladesh. It is a biennial and herbaceous crop belonging to the family Cruciferae. Morphologically, broccoli resembles cauliflower. The terminal curd is rather loose, green in colour and flower stalks are larger than cauliflower. Broccoli is originated from west Europe (Prasad and Kumer, 1999). Broccoli is a very popular vegetable in the United States of America, and very recently Japan has occupied a respectable position in the production of this crop. The crop is also considered as a commercial crop in India (Nonnecke, 1989).

Vegetables play an important role in human nutrition. It provides carbohydrates, fat, minerals, vitamins and roughages, which constitute the essentials of a balanced diet. The total vegetable production is far below the requirement. In 2009-2010, total vegetable production area was 358148.20 hectares with a production of 2.99 million tons (Anon., 2010). To fulfill the nutritional requirement of people, total production as well as number of vegetables should be increased. Broccoli is a nutritious vegetable than any other cole crops (Nieuwhof, 1969). Vitamin C content in fresh broccoli is almost twice that in cauliflower (Lisiewska and Kmiecik, 1969). According to Thompson and Kelly (1985) broccoli is more nutritious than any other cole crops (such as cabbage, cauliflower). Devouring broccoli enriched in antioxidants can reduce the risk of some forms of cancer and heart disease. Thus broccoli can play a vital role in improving the nutritional status of the people of Bangladesh.

Since vegetables are living biological systems, they deteriorate after harvest. Flower vegetables (such as broccoli, cauliflower etc.) are deteriorated very quickly in post-harvest (Yahia and Audit-Oubahou, 2001). Broccoli is an important vegetable having short shelf life, which hasten the post-harvest losses and make the crop unpopular; even it has greater potential to improve the nutritional situation of our country.

Researchers on many countries of the world have paid due attention towards developing variety with good shelf life of broccoli (Anon., 1992). Nath *et al.* (2011) reported the effect of ambient and refrigerated storage temperature on post-harvest qualities of broccoli and mention low temperature increase the shelf life and nutritional quality and Magd *et al.* (2010) reported that effect of different levels of nitrogen and application of high inorganic fertilizer increase the vegetative growth but nutritional quality was reduced. Nath *et al.* (2011) reported the effect of ambient and refrigerated storage temperature on post-harvest qualities of broccoli and mention low temperature increase the shelf life and nutritional quality and Magd *et al.* (2010) reported that effect of different levels of nitrogen and application of high inorganic fertilizer increase the vegetative growth but nutritional quality was reduced.

There is an ample scope to prevent the post-harvest losses of broccoli under Bangladesh condition by determine the appropriate storage temperature as well as by using judicial nitrogen fertilizer and management by determine the appropriate storage temperature as well as by using judicial nitrogen fertilizer and management practices..practices. It has a great export potential and nutritionally rich vegetable and nutritionally rich vegetable- as a result, its popularity is increasing day by day in our country. Considering the above facts, our present study aimed to investigate the optimum storage temperature and combination of nitrogen dose and spacing for increasing the nutritional quality of broccoli.

Materials and method

Experimental place

The experiment was conducted in the laboratory of the Department of Horticulture Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the period from January to April, 2012.

Plant materials

The materials used for the experiment were freshly

harvested curd of broccoli from the experimental field of Horticulture Research Farm, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur. The curds were placed in laboratory to determine shelf life and ascorbic acid content under different storage conditions.

Treatments of the experiment

The experiment consisted of two factors:

Factor A: Storage Condition (3)

a. Control (Room temperature) 24°C with polythene bag

b. Refrigerated condition 4°C with polythene bag

c. Moderate condition 12°C with polythene bag

Factor B: Combination of nitrogen levels and plant spacing (15)

$S_{60\times60}$ N_0	$S_{60\times60}N_{160}$	$S_{60\times45}$ N_{80}	$S_{60\times45}N_{200}$	$S_{60\times30}N_{120}$
$S_{60\times60}$ N_{80}	$S_{60\times60}N_{200}$	$S_{60\times45}N_{120}$	$S_{60\times30}$ N_0	$S_{60\times30}N_{160}$
$S_{60\times60}N_{120}$	$S_{60\times45}$ N_0	$S_{60\times45}N_{160}$	$S_{60\times30}N_{80}$	$S_{60\times30}N_{200}$

The two factor experiment was laid out in completely randomized design with three replications. A single curd was assigned for each treatment representing one replication.

Collection of data

Fresh curds were collected from field for shelf life determination under different storage conditions and curds were packed with polyethylene bag and then kept at different temperature keeping the packs unsealed.

Shelf life

Visual and sensory quality was observed in daily basis. Shelf life (days) of broccoli curd under different temperatures (4°C, 10°C, 24°C) were measured by the change of florets color (just started to yellowing) was recorded by eye estimation.

Estimation of Ascorbic acid

Preparation of the extract for the determination of ascorbic acid:

A sample of 50g sample was taken in a warring blender. The sample was homogenized with warring blender by adding 50 ml distilled water. The homogenized solution was transferred into a 250 ml volumetric flask and its volume was made up to the mark with distilled water and then centrifuged at 0°C for 20 minutes at a speed of 4000 rpm. The supernatant liquid was collected in the 250 ml volumetric flask. This was the extract solution for the determination of ascorbic acid.

Ascorbic acid determination

The ascorbic acid content was determined as per the procedure described by Pleshkov (1976). For estimating free ascorbic acid 10 ml of prepared extract was taken in a conical flask. Five ml 5% KI, 2 ml of 2% starch solution, 2 ml glacial acetic acid was added to the extract. Finally it was titrated with 0.001N KIO_3 solution. Free ascorbic acid was quantified by using the following formula:

$$\text{Ascorbic acid content (mg/100 g)} = \frac{TF}{\quad} \quad 100$$

Where,

T = Titrated volume of KIO_3 (ml)

F = 0.088 mg of ascorbic acid per ml of 0.001N KIO_3

V = Total volume of sample extracted (ml)

v = Volume of the extract (ml) taken for titration

W = Weight of the sample taken.

Statistical analysis

The collected data on various parameters were statistically analyzed using MSTAT-C program and the significance was tested by ANOVA. The means of different parameters were compared by Duncan's Multiple Range Test (DMRT) at 1% or 5% level of probability (Gomez and Gomez, 1984).

Results and discussion

Shelf life

Different temperature had the significant influence on the shelf life of broccoli (Figure 1). The maximum shelf life (16.51 days) was recorded from the lowest storage temperature ST_3 (4°C) which was followed by ST_2 (10°C) and minimum shelf life (5.79) was recorded at highest storage temperature ST_1 (24°C). From the result it was observed that shelf life was

highest in low temperature and minimum in high temperature may be due to low temperature reduced the physiological activities like respiration and increased the shelf life. Roura *et al.* (2000) reported that shelf life reduced with increase in temperature.

Nitrogen and spacing combination also had a significant effect on shelf life of broccoli (Table 2). The maximum shelf life (12.70 days) was recorded from $S_{60\times60}N_0$ which was statistically identical to $S_{60\times60}N_1$ (12.33 days), $S_{60\times45}N_0$ (12.00 days) and $S_{60\times30}N_0$ (11.56 days). Minimum shelf life (9.66 days) was recorded from $S_{60\times45}N_{160}$.

Table 1. Interaction effect of temperature, nitrogen and spacing on shelf life of broccoli.

Treatment combination (S×N)	Shelf life		
	Stored at 24°C with polythene bag	Stored at 10°C with polythene bag	Stored at 4°C with polythene bag
$S_{60\times60}$ N_0	6.77 l	11.67 ijk	19.67 a
$S_{60\times60}$ N_{80}	6.33 l	12.00 ijk	18.67 abc
$S_{60\times60}$ N_{120}	5.93 l	10.67 jk	16.33 c-g
$S_{60\times60}$ N_{160}	5.33 l	9.33 k	18.00 a-d
$S_{60\times60}$ N_{200}	4.83 l	11.67 ijk	16.00 d-h
$S_{60\times45}$ N_0	5.67 l	11.33 ijk	19.00 ab
$S_{60\times45}$ N_{80}	6.00 l	10.67 jk	16.67 b-f
$S_{60\times45}$ N_{120}	6.33 l	10.00 jk	17.33 a-f
$S_{60\times45}$ N_{160}	5.30 l	9.66 jk	14.00 ghi
$S_{60\times45}$ N_{200}	5.50 l	12.33 ij	14.00 ghi
$S_{60\times30}$ N_0	5.33 l	11.67 ijk	17.67 a-e
$S_{60\times30}$ N_{80}	5.83 l	11.00 jk	16.33 c-g
$S_{60\times30}$ N_{120}	6.00 l	10.33 jk	15.33 e-h
$S_{60\times30}$ N_{160}	6.33 l	9.33 k	15.00 fgh
$S_{60\times30}N_{200}$	5.33 l	11.67 ijk	13.67 hi
Level of significance	**		
CV(%)	6.58		

Means bearing same letter (s) in a column do not differ significantly at 1% level of probability by DMRT.

Table 2. Effect of nitrogen and spacing combination on shelf life and ascorbic acid content of broccoli.

Treatment combinations (S X N)	Shelf life	Ascorbic acid
$S_{60\times60}$ N_0	12.70 a	23.15 b
$S_{60\times60}$ N_{80}	12.33 ab	23.15 b
$S_{60\times60}$ N_{120}	10.98 bc	21.87 bc
$S_{60\times60}$ N_{160}	10.89 bc	15.32 f
$S_{60\times60}$ N_{200}	10.83 bc	13.50 f
$S_{60\times45}$ N_0	12.00 abc	24.07 b
$S_{60\times45}$ N_{80}	11.11 bc	22.53 bc
$S_{60\times45}$ N_{120}	11.22 bcd	21.16 bcd
$S_{60\times45}$ N_{160}	9.656 e	16.33 ef
$S_{60\times45}$ N_{200}	10.61 cde	13.64 f
$S_{60\times30}$ N_0	11.56 a-d	27.11 a
$S_{60\times30}$ N_{80}	11.06 bc	23.22 b
$S_{60\times30}$ N_{120}	10.56 cde	20.24 cd
$S_{60\times30}$ N_{160}	10.22 de	18.62 de
$S_{60\times30}$ N_{200}	10.22 de	16.00 ef
Level of significance	**	**
CV (%)	6.58	5.72

Means bearing same letter (s) in a column do not differ significantly at 1% level of probability by DMRT.

The interaction effect of temperature with combination of nitrogen fertilizer and spacing on the shelf life of broccoli was found statistically significant (Table 1). The maximum shelf life (19.67 days) was recorded from $S_{60\times60}$ N_0 at 4°C which was statistically similar to $S_{60\times45}$ N_0 (19.00 days), $S_{60\times60}$ N_{80} (18.67 days), $S_{60\times60}$ N_{160} (18.00 days), $S_{60\times30}$ N_0 (17.67 days) and $S_{60\times45}$ N_{120} (17.33 days) at same temperature (4°C). Minimum shelf life (4.83 days) was recorded from $S_{60\times60}$ N_{200} at 24°C.

Table 3. Interaction effect of temperature, nitrogen and spacing on ascorbic acid content of broccoli.

Treatment Combinations (S X N)	Ascorbic acid content		
	Stored at 24°C with polythene bag	Stored at 10°C with polythene bag	Stored at 4°C with polythene bag
$S_{60\times60}$ N_0	13.80 n-q	21.92 ghi	33.73 ab
$S_{60\times60}$ N_{80}	14.84 k-o	20.91 ghi	33.71 ab
$S_{60\times60}$ N_{120}	13.92 n-q	19.68 h-k	32.03 bc
$S_{60\times60}$ N_{160}	8.37 rst	13.39 n-r	24.19 e-h
$S_{60\times60}$ N_{200}	6.060 t	12.36 n-s	22.09 ghi
$S_{60\times45}$ N_0	17.46 i-n	22.76 fgh	31.99 bc
$S_{60\times45}$ N_{80}	15.54 j-o	21.94 ghi	30.12 bcd
$S_{60\times45}$ N_{120}	13.16 n-r	20.24 hij	30.09 bcd
$S_{60\times45}$ N_{160}	8.683 q-t	14.34 l-o	25.98 d-g
$S_{60\times45}$ N_{200}	7.373 st	13.35 n-r	20.18 hij
$S_{60\times30}$ N_0	19.48 h-l	24.53 e-h	37.33 a
$S_{60\times30}$ N_{80}	14.22 m-p	22.94 fgh	32.50 ab
$S_{60\times30}$ N_{120}	12.52 n-r	19.33 h-l	28.86 b-e
$S_{60\times30}$ N_{160}	11.70 o-s	16.84 i-o	27.31 c-f
$S_{60\times30}N_{200}$	9.473 p-t	15.35 j-o	23.18 fgh
Level of significance	**		
CV%	5.72		

Means bearing same letter(s) in a column do not differ significantly at 1% level of probability by DMRT.

Ascorbic acid content

Different temperature condition had the significant influence on the ascorbic acid content of broccoli (Fig. 1). The maximum ascorbic acid content (28.89 mg/100g) was recorded from the lowest storage temperature ST_3 (4°C) which was followed by ST_2 (10°C) and minimum ascorbic acid content (12.44 mg/100g) was recorded from highest storage temperature ST_1 (24°C). From the result it was observed that ascorbic acid content was highest in low temperature and minimum in high temperature may be due to heat destroyed the ascorbic acid rapidly. Similar result also reported by Wang *et al.* (2001).

The interaction effect of temperature, nitrogen fertilizer and spacing on the ascorbic acid content of broccoli was found statistically significant (Table 3). The maximum ascorbic acid content (37.33 mg/100g) was recorded from $S_{60\times30}$ N_0 at 4°C which was statistically similar to $S_{60\times60}$ N_0 (33.73 mg/100g), $S_{60\times60}$ N_{80} (33.71 mg/100g) and $S_{60\times30}$ N_{80} (32.50 mg/100g) at same temperature (4°C). The minimum ascorbic acid content (6.06 mg/100g) was recorded from $S_{60\times60}$ N_{200} at 24°C.

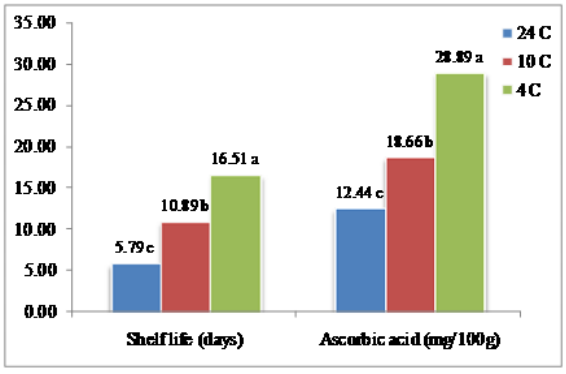

Fig. 1. Effect of temperature on shelf life and ascorbic acid content of broccoli**.** Combination of nitrogen and spacing also had a significant effect on ascorbic acid content of broccoli (Table 2). The maximum ascorbic acid content (27.11 mg/100g) was recorded from the $S_{60\times30}$ N_0 which was followed by $S_{60\times45}$ N_0 (24.07 mg/100g), $S_{60\times30}$ N_{80} (23.22 mg/100g), $S_{60\times60}$ N_0 (23.15 mg/100g), $S_{60\times60}N_{80}$ (23.15 mg/100g), and $S_{60\times45}$ N_{80} (22.53 mg/100g). The minimum ascorbic acid content (13.50 mg/100g) was recorded from $S_{60\times60}$ N_{200}.

Conclusion

On the basis of the results of the present study it can be concluded that broccoli produced maximum shelf life (19.67 days) at 4°C whereas maximum ascorbic acid (37.33 mg/100g) after 4 days of storage at 4°C. That means low temperature and low nitrogen fertilizer produce higher shelf life and high ascorbic acid.

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