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Comparative Quality Analysis of Cucumber Grown Under Polyhouse and in Open Condition

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Authors' contributions

This work was carried out in collaboration between all authors. Authors TD and LS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors TD and VK managed the analyses of the study. Author VK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Cucumber is one of the important cucurbitaceous vegetable grown in Assam and its neighbouring states. Although a large number of F_1 varieties are available in the market, their comparative quality assessment has not been made for their suitability to be grown under polyhouse. So, the present experiment involves cultivation of six different F_1 hybrids namely Malini, Don, NS 404, Noori, Alisha and Sedona under polyhouse and in open condition having a wide variation in terms of quality characters. During the experiment, various quality parameters or characters were investigated for each of the genotypes. All the genotypes had a wide range of variation for most of the characters under investigation. The highest moisture content per fruit under polyhouse condition was observed in genotype Malini (96.75%) while in open condition Noori recorded the highest moisture content. Highly significant differences were also observed with respect to ascorbic acid, TSS, reducing sugar and non reducing sugar for the conditions of cultivation. The highest TSS content (4.06 ºB), highest total sugar 3.46% and reducing sugar 0.58 % was observed in Malini under polyhouse. However, Sedona was found to have highest maximum TSS content (4.22 ºB), total sugar 3.51% and reducing sugar 0.61% in open condition. The ascorbic acid content (6.38 and 6.25) and SOD activity (28.47 and 26.94) expressed as mg 100 g^{-1} and µ mg^{-1} protein were observed highest in Alisha under both

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polyhouse and in open condition, respectively. The result revealed that cucumber cultivated under polyhouse condition significantly differ in various quality aspects than the ones cultivated in open condition and are found to be superior in terms of quality. Thus we may say that growing environment is an important factor that could reflect on the quality characters of the cucumber.

Keywords: Cucumber; F_1 varieties; quality; ascorbic acid; TSS.

1. INTRODUCTION

Cucumber (*Cucumis sativus*) is an important cucurbitaceous vegetable commercially grown throughout the country. It is considered as fourth most important vegetable crop after tomato, cabbage, and onion in Asia [1]. In India, it is mainly grown as a summer warm season vegetable crop. It is cultivated in an area of 41,000 hectares in India with the total estimated production of 6.10 lakh MT [2].

Cucumber is a commonly used salad vegetable and a source of a variety of conventional nutrients and antioxidants. It is widely used for various skin problems including swelling under the eyes and sunburn, as it promotes refreshing, cooling, healing, soothing, and anti-itching effect to irritated skin [3]. Several pharmacological activities including the antioxidant, antiwrinkle, antimicrobial, antidiabetic, and hypolipidemic potentials have been reported with this plant. One of the antioxidants found in cucumber has been identified as an essential component in organisms defence mechanisms against oxidative stress [4]. Superoxide dismutase is found in all cells of the human body. It breaks down superoxide radicals which are toxic to living cells and cause DNA mutations into harmless components consisting of oxygen and hydrogen peroxide. SOD is an important factor improving tolerance to environmental stresses in organisms, there is a desire to introduce SOD as an ingredient of medicine, food, cosmetic, etc. It has been reported that SOD is effective for the prevention and cure of various human diseases, such as arthritis, rheumatism, ischemic heart disease and radiation hazard [5].

Cucumber is a rich source of silica, triterpene phytonutrients called cucurbitacins. Cucumber is also a good source of iodine, and contains a total of 4-6% of dry substances, approximately 2% sugars, 1% albuminous substances, 0.7% cellular tissue and 0.1% fat [6]. The flavour of cucumber has two compounds, 2,6-nonadenal and 2,6-nonadenol. The pleasant aroma of cucumber is said to derive mainly from the 2, 6-nonadienal, with assistance from 2-hexenal.

The growing environment plays a major role in determining the quality aspects of the fruits. The microclimate present under the polyhhouse condition resulted in the development of a congenial environment especially with respect to the temperature that helped them to flourish well with increase in moisture content and TSS content. Also in the present scenario of increased demand for vegetables having superior quality and drastically shrinking land holdings, protected cultivation of vegetable crops suitable for domestic consumption is found to be the best alternative for using land and other resources more efficiently [7]. Therefore, the present investigation was undertaken to evaluate the quality characters of six different F_1 hybrids of cucumber under Jorhat condition of Assam (India).

2. MATERIALS AND METHODS

2.1 Geographical Location of the Experimental Site

The experimental site was situated at 26º47´N latitude and 94º12´E longitude having an elevation of 94 meters above mean sea level. The field experiment was carried out during the year 2015-2016 in the Horticultural orchard/Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat located in the state of Assam in India. The experimental location was considered to be well drained with uniform topography. The soil of the experiment site belonged to the order inceptisol and derived from the alluvial deposits of the river Brahmaputra. The soil of the experimental field is acidic, well drained and sandy loam in texture**.** The results of physicochemical characterization and available nutrients of the soil of experimental site are presented in Table 1 and Table 2.

There are five agroclimatic zones of Assam and the district Jorhat falls under Upper Brahmaputra Valley Zone. The climatic condition of this zone is characterized by a subtropical humid climate having hot humid summer and relatively dry and cool winter. Hot summer is experienced during

May to August and the cold winter from December to January, whereas a mild winter is experienced during September to November and February to April. The average rainfall is about 2200 mm but unevenly distributed throughout the year. Normal monsoon rain starts from June and continuous up to September with the premonsoon shower commencing from mid-March. The intensity of the rainfall is the highest in monsoon season which normally begins from the first week of June and the intensity of rainfall decreases from October onwards. In general, the maximum temperature is around 34ºC during summer and the minimum of around 9.1ºC during winter [8].

2.2 Treatment and Design

The present experiment was undertaken under polyhouse as off-season crop and as normal crop in open condition as main season crop during the period December-2015 to March-2016 and February-2016-June-2016 respectively. Six F_1 hybrids *i.e.* Don, Malini, Sedona, NS 404, Alisha and Noori, collected from local seed market of Jorhat. The name of the seed company and their varietal characteristics has been illustrated in Table 3. The spacing maintained under polyhouse was at 60cm × 30 cm while in the open condition the seedlings were planted at a spacing at 100cm × 60cm. More spacing has been followed in open condition because wines are allowed to grow on the ground without any support. For both, the conditions five replications were adopted for each variety in a randomized block design. The crop duration was of three months in each season. Individual plot size was 2.8 m^2 and 12.6 m^2 and the total area of the experimental site was 200 m^2 and 536 m^2 for polyhouse and an open condition, respectively.

Table 1. Physical properties of soil

Particulars	Values	Textual class
Course sand (%)	11.75	
Fine sand (%)	53.15	Sandy
Silt (%)	16.13	loam
Clay (%)	17.30	

Table 2. Chemical properties of soil

Particulars	Values
pH	4.55
Organic carbon (%)	0.91
Available Nitrogen (kg/ha)	168.52
Available Phosphorous (kg/ha)	40.77
Available Potassium (kg/ha)	110.09

2.3 Data Collection

Uniform cultural practices were followed for all the treatments. A fertilizer of NPK @ 100:75:50 kg/ha were applied 7 days before sowing under polyhouse and in open condition. Half of N with full doses of P_2O_5 and K_2O was applied was basal and remaining half of N was top dressed at 30 days emergence of seedlings as per the recommendation of package of practices of Assam. Black polythene mulch (30 micron thick and 1.5 m wide) was used and planting holes

Table 3. Details of seed source and description of different cucumber hybrids

S.No	Hybrid	Notation	Source	Characteristics
1.	Don	V1	Nunhems India Private Limited, Bengaluru	F_1, healthy crop with longevity. Better quality fruit, attractive green colour long and straight fruits. Capability of better storage. Very good fruit setting
2.	Malini	V2	Seminis, Mumbai	F_1, strong plant with dense foliage, light green smooth textured fruit.
3.	Mahy Sedona	V3	Mahyco Limited, Mumbai	F_1, light green segmented fruit.
4.	NS-404	V4	Namdhari seed private limited, Bengaluru	F_1, early fruits, light green with scattered specks. High yield with good keeping quality.
5.	Alisha	V5	Crystal Crop Science Limited, Bengaluru	F_1, attractive long green fruit. Excellent keeping quality. High ascorbic acid content.
6.	Improved Noori	V6	Nunhems India Private Limited, Bengaluru	F_1, crispy uniform and straight fruits. Excellent shelf life suitable for long distance shipping.

were made on the polythene film at a spacing of 60 cm × 30cm to sow the seeds for poly-house and 100cm × 60cm cm for open condition, respectively. For sowing under poly-house healthy seeds with uniform size were sown during last week of November on tray containing a mixture of three parts of cocopeat, two part of vermiculite and one part of perlite. Seedlings were transplanted 10 days after sowing on raised beds and by maintaining a spacing of 60 cmx30cm between the rows and plants respectively. Similarly, in open condition, healthy seeds with uniform size were sown during the first week of February on tray containing a mixture of three parts of cocopeat, two part of vermiculite and one part of perlite. Seedlings were transplanted 10 days after sowing on raised beds and by maintaining a spacing of 100 cm x 60cm between the rows and plants, respectively. The harvesting was done at the tender stage before they attained full maturity. The proximate analysis was carried out by using standard laboratory technique as described by Association of Analytical Communities.

2.4 Quality Analysis

Moisture Content, %:

Fruit samples were collected and were cut into small pieces. Their fresh, as well as dry weight, was calculated. The percent moisture content in the plant was calculated as follows.

Moisture content, % = {(Fresh weight (g) – Dry weight (g))/ Dry weight (g)} X 100

Total Soluble Solids (°B):

The total soluble solids of the fresh fruits were determined with the help of Zeiss hand refractometer and were expressed in °Brix [9].

Ascorbic acid (mg 100 g^{-1}) :

Ascorbic acid content was determined by using 2, 6- Dichorolophenol indophenols dye visual titration method given by Ranganna [10] and expressed in mg 100 g^{-1} fresh weight.

5 g of fruit sample was grinned in a mortar and 50 ml of 4% oxalic acid was added to the grinded sample and filtered. 5 ml of filtered solution was taken and titrated against the dye solution. Amount of ascorbic acid was calculated using the dye factor and expressed as mg 100 gm^{-1} by following formula:

Ascorbic acid = {(Titre value X Dye factor X Volume made up)/ (Aliquot of extract taken for estimation X Weight for volume of sample taken for estimation)} X 100

Reducing sugar content (mg 100 g^{-1}):

It was estimated by using the standard method of A.O.A.C. [11]. 10 ml of saturated lead acetate and 5g of sodium oxalate were added to 25 g of pulp and made-up to 250 ml with distilled water. The made up solution was filtered and filtrate was titrated against 10 ml boiling Fehling's solution (A and B) mixture using methylene blue as indicator and reducing sugar was determined with the following formula and expressed as percentage.

Reducing sugar = {(mg of invert sugar X Dilution)/ (Titre value X Wt. of sample)} x 100

Total sugar (mg 100 g^{-1}):

It was estimated by using the standard method of A.O.A.C. From the solution of 250 ml made up for reducing sugar estimation, 50 ml of solution was taken and 5ml concentrated HCl was added and kept for overnight. The solution was then neutralized with 1 N NaOH, made up to 150 ml with distilled ater and titrated against boiling Fehling's solution. From the titre value, percentage of total sugar was calculated as follows:

Sucrose (%) = (% total invert sugar - % reducing sugar originally present) X 0.95

Total sugar = (% sucrose + % reducing sugar)

Total invert sugar = {(mg of invert sugar X Volume made up X 2^{nd} volume made up)/ (Titre value x Wt. of the sample X Sample for overnight)} X 100

Superoxide dismutase (µ mg^{-1} protein):

The superoxide dismutase (SOD; EC1.15.1.1) activity was determined spectrophotometrically by measuring the inhibition of blue diformazone in the presence of riboflavin/nitro blue tetrazolium (NBT) and light as described by Beauchamp and Fridovich [12] .

Reagents:

i. Methionine solution (200 mM)
ii. Riboflavin Solution (75 µM)
iii. Nitro-blue tetrzolium (NBT) solution (1.25 mM)
iv. Ethylene diamine tetra acetic acid (EDTA) disodium solution (1.5 mM)
v. Phosphate buffer (50 mM; pH 7.0)
vi. Phosphate buffer (50 mM; pH 7.8)

Enzyme extraction:

Leaf sample weighing 500 mg was homogenised in ice-cold 50 mM phosphate buffer (pH 7.0) containing 0.5 mM EDTA in a pre-chilled pestle and mortar. The homogenate was centrifuged at 4°C for 30 minutes at 30,000 g. The supernatant was transformed to another tube and used as enzyme extract.

Assay:

The assay solution consi43sted of 0.2 ml methionine (200 mM), 0.2 ml NBT (1.125 mM), 0.2 ml EDTA (1.5 mM), 40 µL enzyme extract, 2.19 ml phosphate buffer at pH 7.8 and 0.2 ml Riboflavin (75 µM). Riboflavin was added as the last component. Tubes were shaken and placed 30 cm below a light source, consisting of two 15 W fluorescent tubes. The reaction was started by switching off after 10 minutes to stop the reaction. The tubes were covered with black cloth immediately after switching off the light. A non-irradiated reaction mixture containing enzyme reaction mixture containing enzymes extract, which did not develop colour, was used as a control. Blanks were lacking an enzyme in reaction i reaction mixture and develop minimum colour. The absorbance of the reaction mixture was read at 550 nm. The volume of the enzyme extract producing 50 percent inhibition of the reaction was read from the resultant graph. Activity was expressed in the unit of mg^{-1} protein. One unit of SOD activity is defined as the enzyme which causes 50 percent inhibition of the initial rate of the reaction in the absence of enzyme.

2.5 Data Analysis

The experimental data obtained from various observations were analyzed statistically by using Fischer's method of analysis of variance in Randomized Block design as described by Panse and Sukhatme [13]. The Significance of the variance of variety effect was determined by calculating respective 'F' values.

The standard error of the difference was calculated by using the formula:

$$S.Ed = \sqrt{\frac{2EMS}{r}}$$

The critical difference (C.D) at 5% probability level was calculated to find out the mean difference between the treatments. CD was calculated by using the following expression.

$C.D. = S.Ed \times t_{5\%}$ for error degree of freedom

Where,

T = tabulated value of 't' at 5% probability level for appropriate degree of freedom.

3. RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

3.1 Moisture Percent

From the Table 4, it is evident that the hybrids grown under polyhouse were found to have the mean moisture percent in the range of 95.72 (Don) to 96.75 (Malini) and the values were found to be non significant. The mean moisture percent for cucumbers grown in the open condition was recorded in the range of 95.54 (Don) to 96.16 (Noori) and the values were found to be non significant.

3.2 Total Soluble Solids (TSS)

Significant variation was observed among hybrids of cucumber with respect to TSS (Table 4) under both polyhouse and open condition. The values of TSS for varieties ranged from 2.94 °Brix (Alisha) to 4.06 °Brix (Malini) under the polyhouse. The highest TSS was recorded in Malini (4.06 °B) which was found to be statistically significant over Sedona (3.88 °B) and Noori (3.50 °B). The lowest TSS content was recorded in Alisha (2.94 °B). These results are also confirmed by Pragathi [14] who showed that there were significant differences in TSS of fruits between the varieties. The TSS of the hybrids grown in the open condition ranged from 3.01°Brix (Alisha) to 4.22 °Brix (Sedona). The highest TSS content was recorded in Sedona (4.22 °B) which was significant over Malini (3.98 °B). The least TSS content was recorded in

Table 4. Quality parameters of cucumber grown under polyhouse and in open condition varieties

	Moisture (%)		TSS (°B)		Ascorbic acid (mg100 g^{-1})		Reducing sugar (%)		Total sugar (%)		Superoxide dismutase (µ mg^{-1} protein)	
	Polyhouse	**Open**	**Polyhouse**	**Open**	**Polyhouse**	**Open**	**Polyhouse**	**Open**	**Polyhouse**	**Open**	**Polyhouse**	**Open**
V1: Don	95.72	95.54	3.43	3.38	4.24	4.10	0.53	0.52	3.35	3.30	25.17	22.46
V2: Malini	96.75	96.05	4.06	3.98	3.53	3.58	0.59	0.58	3.48	3.46	27.20	25.30
V3: Sedona	96.65	95.65	3.88	4.22	3.86	3.02	0.61	0.55	3.51	3.42	26.68	24.01
V4: NS 404	96.23	95.79	3.32	3.62	4.34	3.87	0.55	0.50	3.42	3.23	27.59	25.05
V5: Alisha	95.94	95.60	2.94	3.01	6.38	6.25	0.46	0.43	3.25	3.19	28.47	26.94
V6: Noori	96.68	96.16	3.50	3.50	4.17	3.92	0.54	0.53	3.37	3.39	24.46	20.47
S.Ed	0.63	0.65	0.07	0.10	0.36	0.34	0.01	0.01	0.03	0.02	0.45	0.93
$C.D_{(0.05)}$	NS	NS	0.14	0.20	0.76	0.72	0.02	0.03	0.07	0.04	0.94	1.94

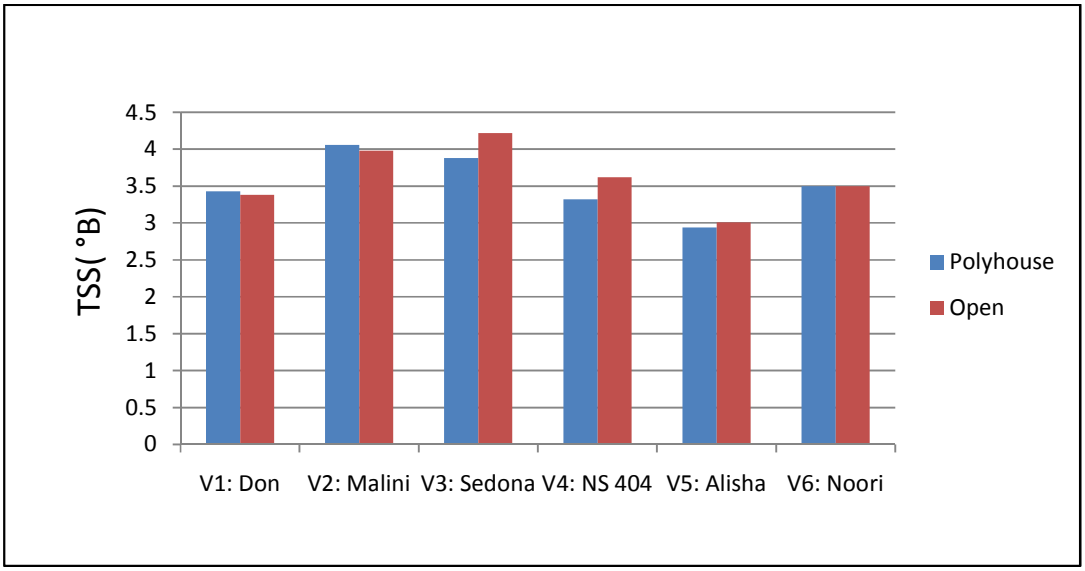

Fig. 1. TSS content of fruits

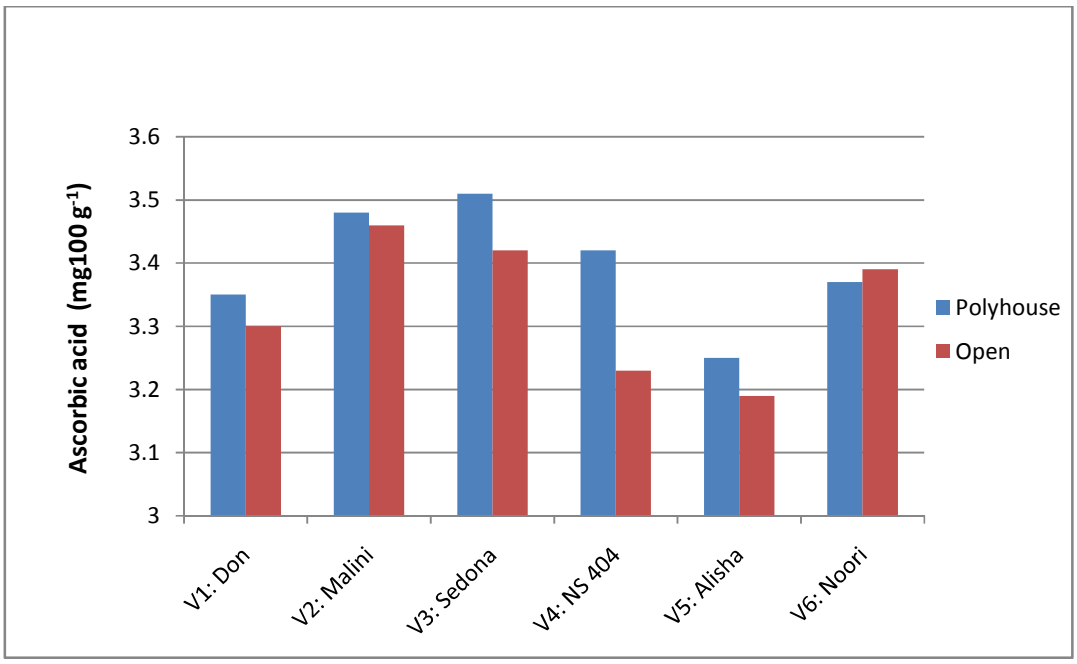

Fig. 2. Ascorbic acid content

Alisha (3.01 °B). High temperature cause considerable increased in TSS content in cucumber[15].

3.3 Ascorbic Acid

Highly significant difference was observed with respect to ascorbic acid content of cucumbers for both the conditions of cultivation (Table 4). Under the polyhouse the mean ascorbic acid content ranged from 3.53 (Malini) to 6.38 (Alisha) as illustrated in Table 2. The highest ascorbic acid content was recorded in Alisha (6.38 mg). The experimental results obtained by Phookan et al., [16], also showed highest ascorbic recorded by Alisha. However, Malini (3.53 mg) recorded the lowest. The mean ascorbic acid content in open condition ranged from 3.02 (Sedona) to 6.25 mg

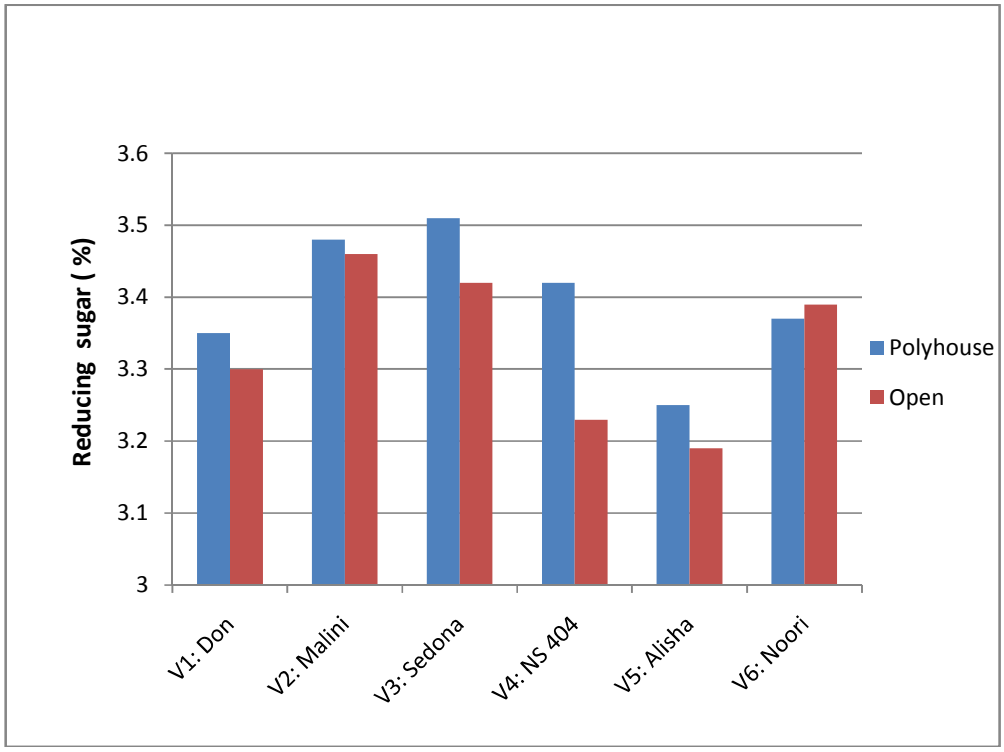

Fig. 3. Reducing sugar content

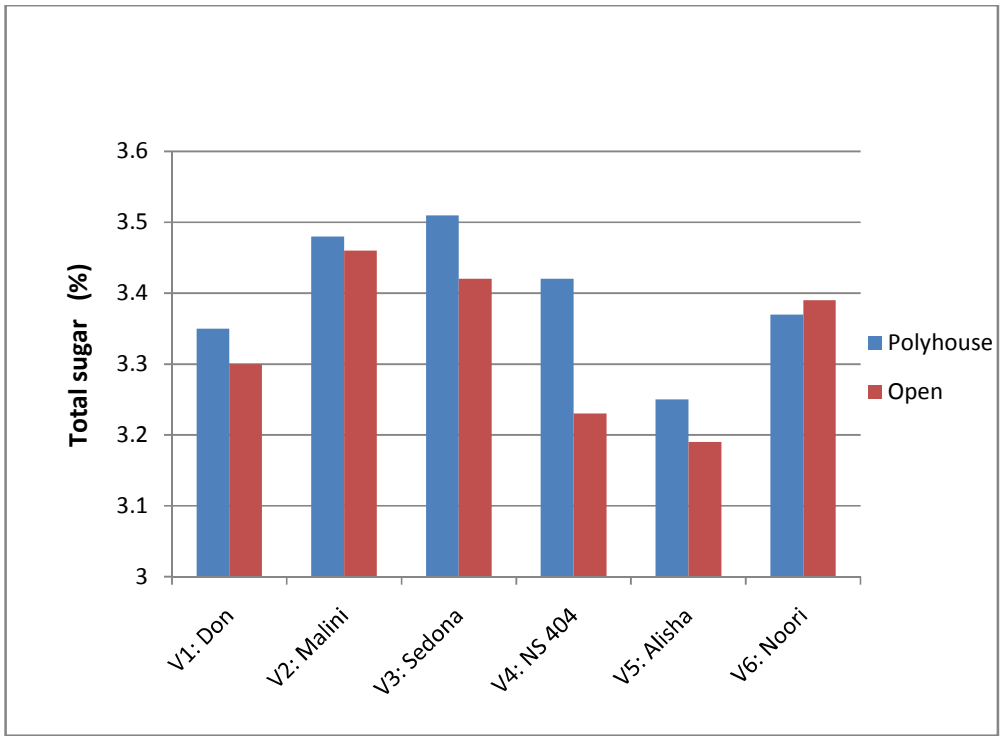

Fig. 4. Total sugar content

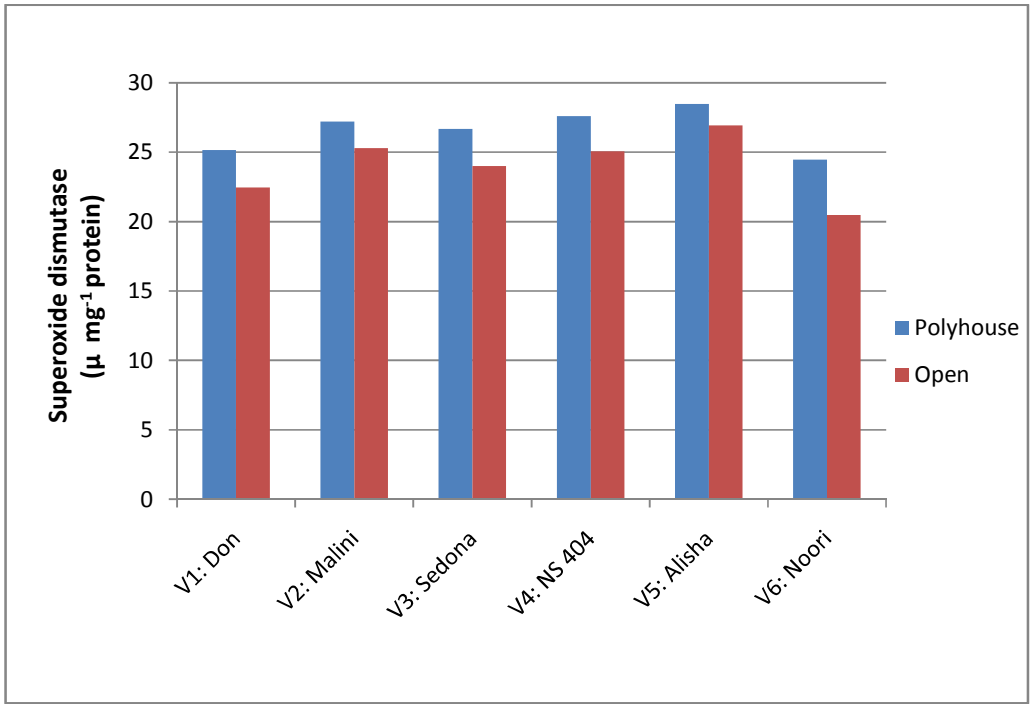

Fig. 5. Activity of superoxide dismutase

(Alisha) of fresh fruit. The hybrid, Alisha (6.25 mg) recorded the maximum ascorbic acid content and the least was observed in Sedona (3.02 mg). Generally, high ascorbic acid content would increase the nutritive value of cucumbers, which would help better retention of colour and flavor. Similar findings reported by Rahman et al. [17] in cucurbits. Therefore, cucumber hybrids possessing high ascorbic acid are highly preferred. Polyhouse grown cucumber hybrids were found to have higher ascorbic content than the ones grown in open condition and thus were superior in quality.

3.4 Reducing Sugar

The hybrids grown under polyhouse were found to have the mean reducing sugar in the range of 0.46% (Alisha) to 0.61% (Sedona) as presented in Table 4. The highest quantity of reducing sugar was in Malini (0.61%). The hybrid Alisha was found to have the lowest reducing sugar content among all the hybrids. In the open condition the mean reducing sugar content was recorded in the range of 0.43% (Alisha) to 0.58 % (Malini). The hybrid Malini (0.58) recorded the highest amount of reducing sugar and similarly, hybrid Alisha (0.43) was found to have the lowest reducing sugar content among all the hybrids. The results are in accordance with Pardossi et al, [18] who showed that melons grown in summer exhibited poor quality due to reduced sucrose content.

3.5 Total Sugar

The mean total sugar content under polyhouse ranged between 3.25% (Alisha) to 3.51% (Sedona) as presented in Table 4. The highest sugar content was recorded in Sedona **(**3.46) and Alisha (3.25) was found with the lowest total sugar. In the open condition the mean total sugar content ranged from 3.19% (Alisha) to 3.46% (Malini). Among all the hybrids Malini recorded the highest total sugar content in open condition. It can be observed that the total sugar content was highest under the polyhouse which can be attributed to the increased metabolic activity of the plants to support the reproductive growth and quality of the fruits [19].

3.6 Superoxide Dismutase

Significant difference was observed with respect to superoxide dismutase activity as mg $100g^{-1}$ protein of cucumbers for both the conditions of cultivation. Under the polyhouse the mean of SOD activity was found in the range of 24.46 μ mg^{-1}(Noori) to 28.47 μ mg^{-1} (Alisha) as presented

in Table 4. The highest SOD activity was found in Alisha (28.47 μ mg^{-1}). In the open condition the mean of SOD was recorded in the range 20.47 (Noori) - 26.94 (Alisha) presented in Table 4. The highest activity was observed in Alisha (26.94). The hybrid Noori (20.47) recorded the lowest SOD activity. Reduced activity of SOD in open condition might be due to high temperature [20].

4. CONCLUSION

It is evident from the above result that cucumber grown under polyhouse showed superior quality than grown under open condition. The demand of quality produce is increasing day by day. Also, off-season production of crop can be possible under polyhouse. Therefore, cultivation of cucumber can be advocated under polyhouse so that it can catch early market that would ultimately fetch better price in the market and thus improve the socio economic status of the farmer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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