Int.J.Curr.Microbiol.App.Sci (2022) *11*(05): 36-45

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 11 Number 05 (2022)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2022.1105.006

Qualitative Analysis of Strawberry Varieties in Sub Tropical Climatic Condition of Assam

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Keywords

Qualitative character, Environmental conditions, Total soluble solids, Total sugar

Article Info

Received:
08 April 2022
Accepted:
30 April 2022
Available Online:
10 May 2022

A B S T R A C T

An experiment was carried out in the Instructional cum Research Farm, Department of Horticulture, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam during 2015-16 to analyse the qualitative characters of strawberry varieties in subtropical climatic condition of Assam. Five varieties namely, Cristal (V_1), Subarina (V_2), Sweet Charlie (V_3), Winter Dawn (V_4) and Eliyana (V_5) were selected and planted in three cultivation situations i.e. open condition (S_1), poly house (S_2) and in net house (S_3). Altogether 15 treatment combinations were laid out in Factorial Randomized Block Design with three replications. Total soluble solids (TSS), titratable acidity, total sugars, reducing sugar, non-reducing sugar, ascorbic acid content and anthocyanin content were selected as qualitative characters of strawberry in the experiment. The data revealed that the qualitative characters of fruits in terms of total soluble solids (8.13°Brix), total sugars (6.60%), reducing sugars (3.29%), non-reducing sugars (3.31%) and anthocyanin content (20.01 mg/100g) were significantly higher in strawberry variety Subarina as compared to other varieties. The variety "Subarina" performed well in all the environmental conditions as compared to the other varieties. Titratable acidity of fruits ranged from 0.53 to 0.68 percent among all the treatment combinations and no significant differences were found among the varieties, cultivation situations or their interaction. The ascorbic acid content was significantly higher in Cristal (32.19 mg/100 g) followed by Subarina (31.18 %). The results of the study revealed that the performance in terms of qualitative characters of fruits were superior in Subarina as compared to other four varieties. The variety "Subarina" performed well in terms of quality in all the cultivation situations as compared to other four varieties selected under the study.

Introduction

Strawberry is one of the most popular soft fruit and has a unique place among cultivated berry fruits. Fruits are attractive, tasty and nutritious with a distinct and pleasant aroma, and delicate flavour.

Adverse weather conditions like occurrence of frost, heavy rains, hails and temperature fluctuations especially during flowering and fruiting are limiting factors in strawberry cultivation. Strawberry plant is shallow rooted and surface feeder therefore moisture and temperature conditions of the upper layer of soil significantly influence the growth and fruiting of the plant. It is cultivated in plains as well as in hills up to an elevation of 3000 metres in humid or dry regions, widely grown under protected and open condition in temperate and subtropical countries with maximum temperature of 22^0-25^0C in the day and 7^0-13^0C at night. Frost free sites make strawberry cultivation comparatively easier and it is also grown under green house and covered plastic. With the development of several day-neutral cultivars, the area and production is increasing at a faster rate.

Strawberry is the highest consumed fresh fruits, rich in proteins, minerals Ca, P and K, fair source of vitamin A, B_1, B_2, B_6 and vitamin C and it is regarded as one of the best natural sources of antioxidant. Besides, strawberry can be processed for making wine, jam, jelly, ice cream and soft drinks etc. Fruits of strawberry contains water 89.9 percent, protein 0.7 g, fat 0.5 g, carbohydrate 8.4 g, vitamin A 60 I.U., vitamin B_1 0.03 mg, vitamin B_2 0.07 mg, vitamin B_6 0.6 mg, vitamin C 59.0 mg, calcium 21.0 mg, phosphorus 21.0 mg, iron 1.0 mg, sodium 1.0 mg and potassium 164.0 mg (Watt and Merrill, 1959). The mature soft fruit contains about 5.0 percent total sugar and 0.90 percent to 1.85 percent acidity. The major acids present in strawberry are citric acid and malic acid with traces of quinic acid, succinic acid, glyceric acid, glycolic acid and oxaloacetic acid. The pigments responsible for the red colour are anthocyanin, pelargonidin-3-monoglucoside and traces of cyanidine.

In India, strawberry is confined only to the Hilly Tracts of Himachal Pradesh, Uttaranchal, parts of Uttar Pradesh and Kashmir valley. However, its cultivation has spread to tropical and subtropical zones, where other states like Meghalaya, Sikkim and Mizoram have taken up the cultivation of this viable fruit. In India, the area and production of strawberry is increasing year after year.

Materials and Methods

Geographical location of the experimental site

The experimental site was situated at 26°15′ N and 27°45′ S latitude and 91°42′ E and 95°30′ W longitude having an altitude of 104 m above mean sea level.

Soil status of the experimental site

Representative soil samples were collected randomly from the experimental area at a depth ranging from 0-30 cm and mixed together then dried, ground and allowed to pass through 2mm sieve and composited for analysis. The samples were analyzed at the soil testing laboratory, Department of Soil Science, Biswanath College of Agriculture, Assam Agricultural University, Biswanath Chariali.

Selection of planting materials

Healthy tissue cultured planting materials with uniform crown and well developed root system were planted in Hill row system in 15-20 cm raised beds with plant to plant distance of 45 cm and row to row distance of 45 cm. The outer leaves were pinched off and soils of the roots of the runners were washed properly.

Layout and Experimental Design

The experiment was designed in Factorial Randomized Block Design having three replications. The runners were planted in three cultivation situation *i.e.* open condition, poly house condition

and net house condition. There were 15 treatment combinations. Each situation comprises 15 numbers of plots, each plot having 18 numbers of plants in poly house and net house condition and 22 numbers of plants in open condition with a spacing of 45 cm x 45 cm.

Cultural Operations

Geographical Location of the Experimental Site

The present investigation was conducted in the Instructional cum Research Farm, Department of Horticulture, Biswanath College Of Agriculture, Assam Agricultural University, Biswanath Chariali during 2015-2016. The experimental site was situated at 26°15′ N and 27°45′ S latitude and 91°42′ E and 95°30′ W longitude having an altitude of 104 m above mean sea level.

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Intercultural operation and aftercare

Being a shallow rooted crop, strawberry requires frequent irrigation in lesser amount of water. During the experiment, irrigation was done with water cane at 1-2 days interval considering the water requirement by the plants. As mulching was done, there were lesser emergence of weeds, thereby weeding was done as and when there were emergence of weeds. The disease infected plants in the early stage of experimentation were uprooted immediately and the gaps were filled up with healthy runners after taking proper sanitation measures. Dried leaves of the plants were cut and removed periodically.

Harvesting

Harvesting was done when half to three fourth of skin develops colour. Depending on the weather conditions, picking was done on every second or third day usually in the morning hours. Strawberries were harvested in small trays or baskets. They were kept in a shady place to avoid damage due to excessive heat in the open field.

Observations

Five uniformly grown plants in each plot were selected to record the observations on qualitative parameters. Observations were recorded at proper time during the crop cycle.

Quality parameters

Qualities of the fruits were analyzed in the laboratory when the fruits were ripened properly. The ripe fruit was cut in to pieces and ground in a mortar. The qualitative parameters selected for analyzing the fruit quality during my experiment were given below-

Total soluble solids (TSS)

TSS of the fruits were determined by Zeiss Hand Juice Brix Refractometer and the results were expressed in percentage. Titratable acidity, reducing sugars, total sugars and non-reducing sugars were estimated by adopting the standard methods of AOAC (1975).

Titratable acidity

For estimation of titratable acidity, 25 g of pulp was ground in mortar, added 250 ml of distilled water

and filtered. Ten (10) ml of filtrate was titrated against 0.1 N NaOH using phenolphthalein as indicator and the light pink colour was considered as the indication of the end point. Titratable acidity was expressed in percentage in terms of anhydrous citric acid as follows.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value x Normality of alkali x Volume made up x Equivalent weight of citric acid x 100}}{\text{Weight of the sample x Aliquot x 1000}}$$

Reducing sugars

Ten (10) ml of standard lead acetate solution and 5 ml of sodium oxalate were added to 25 g of already ground pulp and the volume was made up to 250 ml with distilled water, centrifuged and then filtered. The filtrate was titrated against 10 ml boiling Fehling's solution mixture (5.0 ml of Fehling's solution A + 5.0 ml of Fehling's solution B) using methylene blue as indicator. Deep brick red colour of the solution indicated the end point and percentage of reducing sugar was calculated as follows.

$$\text{Reducing Sugars (\%)} = \frac{\text{Factor x Volume made up}}{\text{Titre value x Weight of sample x 100}}$$

Where the factor was 0.05 (mg of invert sugar)

Total sugars

From the solution of 250 ml made up for estimation of reducing sugars, 50 ml of the solution was taken and 5.0 ml of concentrated HCL was added to it and kept overnight. The solution was then neutralized with 1N NaOH and volume was made up to 150 ml with distilled water and titrated against 10 ml boiling Fehling's solution mixture using methylene blue as indicator as in the case of reducing sugar. From the titre value, percentage of total sugars was calculated as follows:

Total sugars = (% Sucrose + % Reducing sugars)

Sucrose % = (% Total invert sugars - % Reducing sugars) x 0.95

$$\text{\% Total invert Sugars} = \frac{\text{Factor x Volume made up x Volume of stock}}{\text{Titre value x Weight of sample x Aliquot taken}} \text{x } 100$$

Factor = 0.05 (mg of invert sugar)

Non- reducing sugars

Non- reducing sugars were calculated out from the differences of total sugars and non reducing sugars.

Non- reducing sugars (%) = (% total sugars- % reducing sugars)

Ascorbic acid

Ascorbic acid content was determined by using 2, 6-Dichlorophenol-indophenol dye method of Freed (1966). Five gram of the fresh fruit sample was grounded with about 25 ml of 4 % oxalic acid and filter through Whatman no. 4 filter paper. The filtrate was collected in a 50 ml volumetric flask and the volume was made up with 4 % oxalic acid and titrated against the standard dye to a pink point. The amount of ascorbic acid was calculated using the following formula and expressed as mg/100 g.

$$\text{Ascorbic acid (mg/ 100 g)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{volume make up}}{\text{Aliquot} \times \text{weight of the sample}} \times 100$$

Anthocyanin content

Anthocyanin content of each treatment in the three conditions were calculated out with the help of spectrophotometer.

Ten gram of sample was blended with 10 ml of ethanolic HCl (85:15) and transferred to a 100 ml

volumetric flask and the volume was made up with ethanolic HCl. The blended mixture was stored overnight in a refrigerator at 4°C and then filtered in the very next day through Whatman No 1 filter paper. The filtrate was taken and the optical density (O.D) was recorded at 535 nanometer (nm) using ethanolic HCl as blank. The amount of anthocyanin was calculated by the following formula and expressed in mg/100g (Srivastava and Kumar, 2002).

$$\text{Total O. D/100g} = \frac{\text{O. D x Volume made up x 100}}{\text{Weight of sample}}$$

$$\text{Total anthocyanin (mg/100g)} = \frac{\text{Total O. D/ 100g}}{98.2}$$

Results and Discussion

Total Soluble Solids (TSS), titratable acidity, sugar content (total sugar, reducing sugar and non reducing sugar), ascorbic acid content and anthocyanin content were considered as quality parameters.

The data presented in Table 1 and Figure 1 showed considerable variation with respect to TSS content of the fruits ranging between 7.12^{0}Brix to 8.13^{0}Brix. The highest (8.13 ^{0}Brix) TSS content was observed in Subarina (V_2) and the lowest (7.12^{0}Brix) TSS content was observed in Cristal (V_1). The variation in TSS contents among the varieties might be due to genetic makeup of the varieties of strawberry. The result of present experiment was in conformity to the Bakshi *et al.,* (2014).). Rahman (2014) who reported that TSS content of fruits was highly influenced by interaction effect of time of planting and cultivars and found that fruits of early planting contained more TSS than late planting that might be due to the exposure of favourable environment and getting enough time for sugar and acid accumulation in early planting. TSS content of fruits also differed with respect to different cultivation situations. The highest TSS content was analysed in poly house condition and it was lowest in net house condition. The favourable temperature and relative humidity especially in night during fruit growth and ripening period might have led to higher TSS contents in strawberry fruits. Shaw (1990) remarked that TSS was more dependent on environmental condition during growth and development than genetic inheritance in strawberry. Estimation of titratable acidity gives a concept of the amount of acids present in the fruits. Estimation of acids present in the fruits make an important contribution to the post-harvest quality of the fruits, as taste of fruit is mainly a balance between the sugar and acid contents. Hence, post-harvest assessment of acidity is important in the evaluation of the taste of the fruits. In the present research, percentage of titratable acidity content of the fruits could not be influenced by the varieties, cultivation situations and their interaction effects. Titratable acidity was found to be comparatively low in fruits of strawberry which ranged from 0.53 – 0.60 percent (Table 1 and Figure 1). The finding of present experiment is in conformity with the report of Bakshi *et al.,* (2014).

Wysocki (2012) reported that the acidity in strawberry fruits is not a constant feature of the varieties which may change depending on many environmental parameters occurring during the cultivation and to a large extent depends on agricultural factors. Sugar content is one of the main parameters considered in the evaluation of the nutritive value of strawberries. Sugar includes total sugar, reducing sugar and non- reducing sugar which are important components of strawberry fruits to determine the quality of the fruits. In the present investigation, significant variations were observed in the percentages of total sugar, reducing sugar and non reducing sugar among the varieties (Table 2, Figure 2). The highest value of total sugar (6.60%), reducing sugar (3.29%) and non reducing sugars (3.31%) were recorded in Subarina (V_2). The variation in sugar contents might be due to the varied rates of hydrolysis of starch into soluble sugars such as glucose, sucrose and fructose.

Table.1 Total Soluble Solids (^{0}Brix) and Titratable acidity (%) of different varieties of Strawberry in different cultivation situations

Treatments	Total Soluble Solids (TSS)				Titratable acidity			
	S_1 (Open)	S_2 (Poly house)	S_3 (Net house)	Mean	S_1 (Open)	S_2 (Poly house)	S_3 (Net house)	Mean
V_1 (Cristal)	7.35	7.53	6.48	7.12	0.6	0.59	0.6	0.6
V_2 (Subarina)	7.68	9.21	7.49	**8.13**	0.63	0.55	0.6	0.59
V_3 (Sweet Charlie)	7.61	7.3	7.12	7.34	0.58	0.59	0.53	0.57
V_4 (Winter Dawn)	7.15	8.59	6.91	7.55	0.6	0.53	0.58	0.57
V_5 (Eliyana)	7.04	8.82	6.06	7.31	0.54	0.61	0.68	0.61

Table.2 Sugars (total sugar, reducing sugar and non reducing sugar) content of different strawberry varieties in different cultivation situations.

Treatments	Total Sugar (%)				Reducing Sugar (%)				Non reducing sugar (%)			
	S_1 Open	S_2 Poly house	S_3 Net house	Mean	S_1 Open	S_2 Poly house	S_3 Net house	Mean	S_1 Open	S_2 Poly house	S_3 Net house	Mean
V_1 (Cristal)	6.23	6.28	4.54	**5.68**	2.9	3.45	2.11	**2.82**	3.33	2.82	2.43	**2.86**
V_2 (Subarina)	7.39	7.16	5.25	**6.60**	3.29	4.00	2.57	**3.29**	4.10	3.16	2.68	**3.31**
V_3 (Sweet Charlie)	6.46	6.31	4.43	**5.73**	3.02	3.12	2.04	**2.73**	3.45	3.19	2.39	**3.01**
V_4 (Winter Dawn)	6.51	6.38	4.23	**5.71**	3.48	3.67	2.18	**3.11**	3.03	2.72	2.04	**2.60**
V_5 (Eliyana)	6.34	6.11	4.16	**5.53**	3.07	3.25	1.95	**2.76**	3.26	2.86	2.20	**2.77**

Table.3 Ascorbic acid content (mg/100g) and anthocyanin content (mg/100g) of different varieties of strawberry grown in different cultivation situations.

Treatments	Ascorbic acid content (mg/100g)				Anthocyanin content (mg/100g)			
	S1 (Open)	S2 (Poly house)	S3 (Net house)	Mean	S1 (Open)	S2 (Poly house)	S3 (Net house)	Mean
V1 (Cristal)	31.09	41.03	24.45	**32.19**	21.32	24.06	13.76	19.71
V2 (Subarina)	30.75	35.16	27.63	31.18	18.15	24.65	17.23	**20.01**
V3 (Sweet Charlie)	29.09	31.01	19.58	**26.56**	20.35	20.48	17.35	19.39
V4 (Winter Dawn)	26.7	33.34	24.77	28.27	19.35	23.54	16.16	19.68
V5 (Eliyana)	28.92	34.12	21.43	28.16	15.06	22.28	16.31	**17.88**

Fig.1 Total Soluble Solids (^{0}Brix) and Titratable acidity (%) of different varieties of Strawberry in different cultivation situations

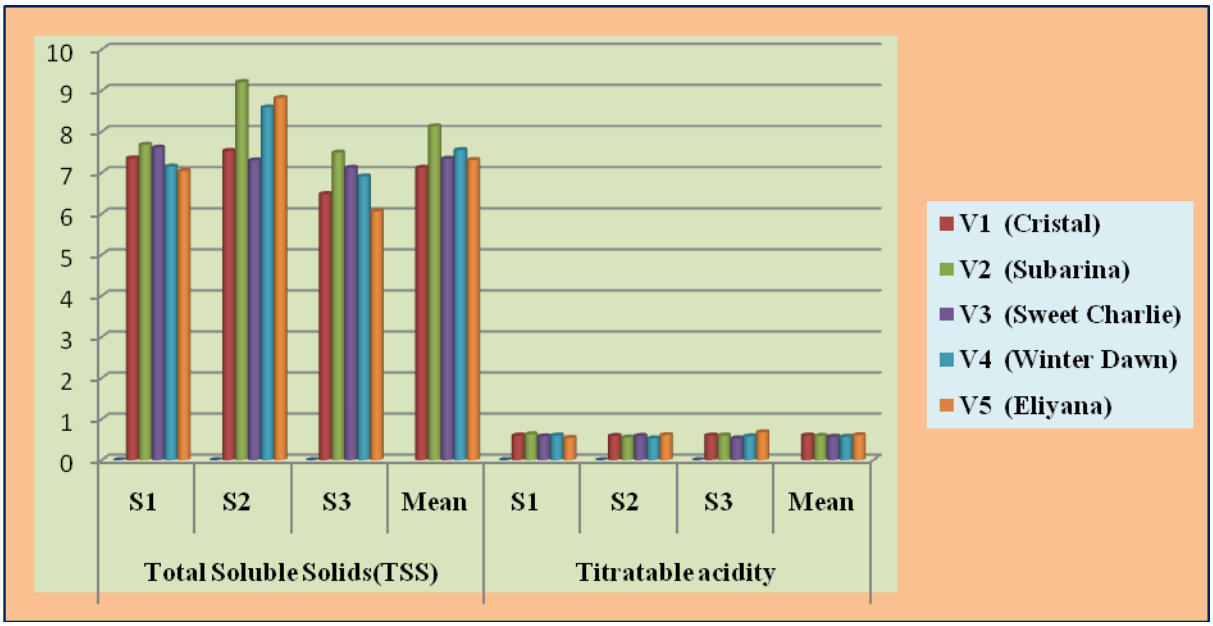


Fig.2 Sugars (total sugar, reducing sugar and non reducing sugar) content of different strawberry varieties in different cultivation situations.

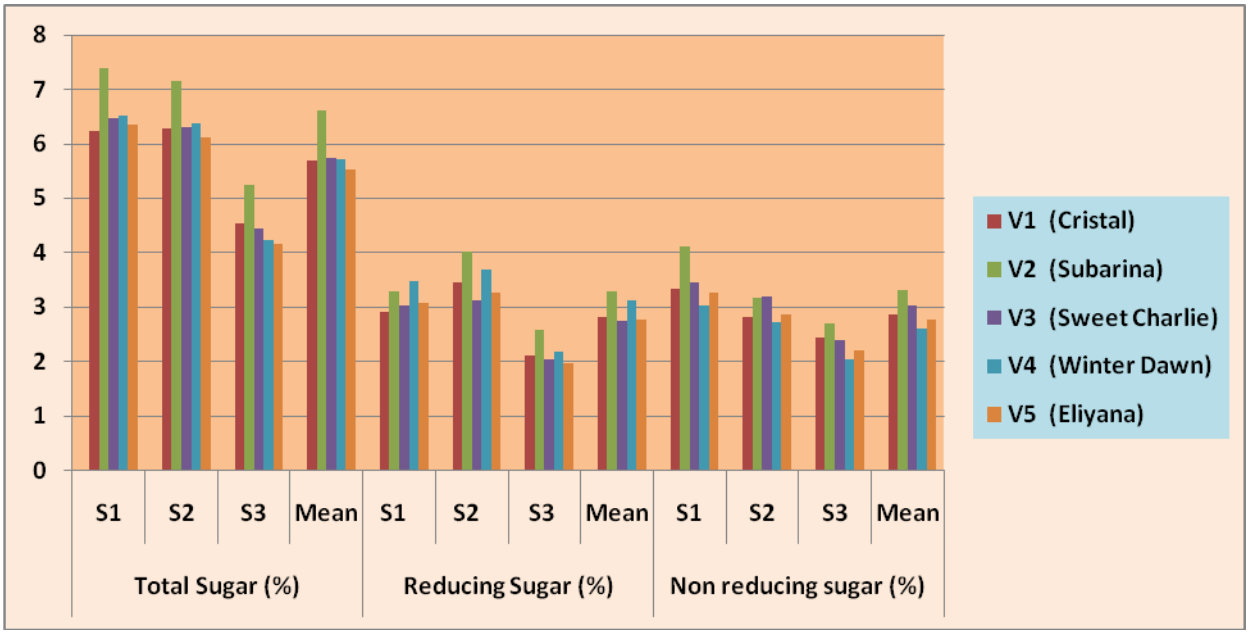
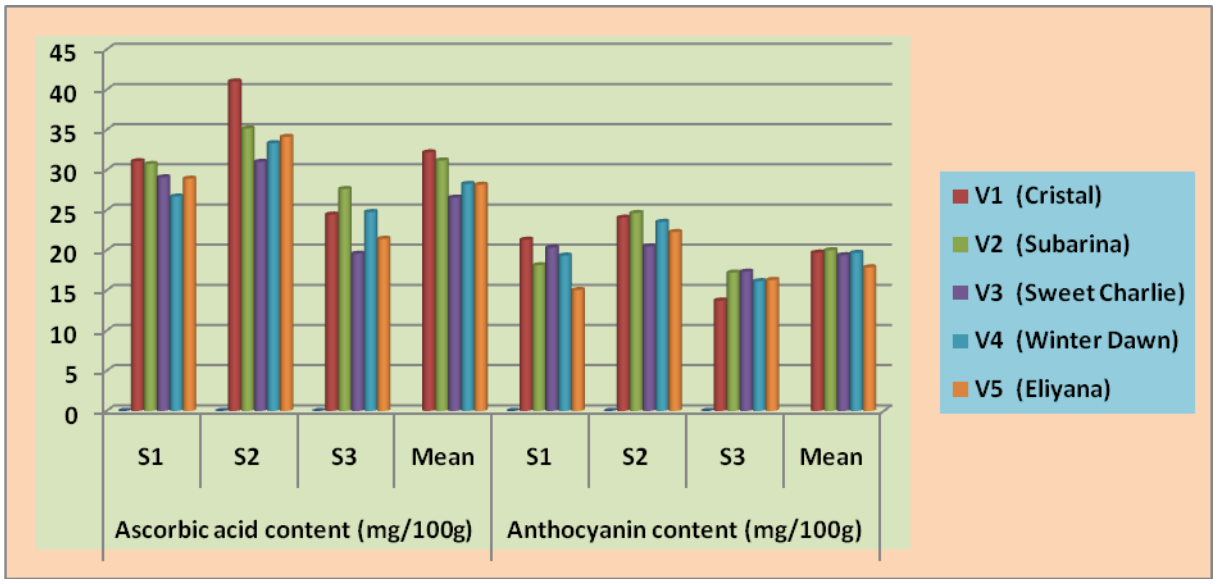


Fig.3 Ascorbic acid content (mg/100g) and anthocyanin content (mg/100g) of different varieties of strawberry grown in different cultivation situations



The results are in conformity with the report of Jami *et al.,* (2015). Data concerning sugar content in strawberries of individual cultivars are divergent which depends not only on the cultivar, but also on many cultivation conditions, such as irrigation (which is particularly important in blossoming phase and fruit setting phase), fertilization (mainly NPK), as well as the health condition of the plantation (Skupien, 2003; Ohtsuka *et al.,* 2004; Koszanski *et al.,* 2005).

The percentages of total sugar, reducing sugar and non-reducing sugar content also varied significantly with respect to cultivation situations. The percentage of total sugar and non-reducing sugar contents were significantly higher in open condition but the percentage of total sugar and non-reducing sugar contents were low in net house condition.

The variation in total sugar content might be due to the exposure of the plants to sunlight in open condition as sunlight is necessary for hydrolysis of starch into sugars. On the other hand, the percentage of reducing sugar was significantly higher (3.50 %) in poly house condition and it was lowest (2.17 %) in net house. The decrease in the contents of sugars in the fruits produced in net house might be due to the shady condition of the net house. The findings are at par with the results of Singh *et al.,* (2008). The ascorbic acid (vitamin C) content is one of the most important components which determine the quality of a strawberry fruit. The data presented in Table 3 and Figure 3 revealed that the varieties were differed significantly in relation to ascorbic acid content. The highest (32.19 mg/100g) and lowest (26.56 mg/100g) ascorbic acid contents were observed in Cristal (V_1) and Sweet Charlie (V_3), respectively. The variation in ascorbic acid content between the varieties might be due to genetic factor. The result of present experiment is more or less in close proximity with the report of Bakshi *et al.,* (2014). Lee and Kader (2000) reported that the ascorbic acid content in fruits and vegetables is affected by many factors, such as genotypic differences, climatic conditions, cultivation and fruit ripening conditions and the time of storage.

Significant variation of ascorbic acid content is also observed in relation to cultivation situations. The value of ascorbic acid content was maximum in plants grown in poly house condition (S_2) whereas minimum ascorbic acid content was observed in net house condition (S_3). It might be due to soil character or environmental conditions.

Anthocyanin is one of the most important compounds that determine the antioxidant activity in strawberry fruit. The anthocyanin content in strawberry depends on many factors, such as the choice of cultivar, agricultural conditions, light availability, nitrogen content in soil, degree of fruit ripeness and storage temperature (Bacchella *et al.*, 2009; Roussos *et al.*, 2009). In the present study (Table 3 & Figure 3), notable variability was found among the varieties and maximum anthocyanin content (20.01 mg/100g) was recorded in Subarina (V_2), on the other hand, minimum anthocyanin content (17.88 mg/100g) was estimated in Eliyana (V_5). The variation of anthocyanin content among the varieties might be due to the genetic factors and edaphic-climatic factors and degree of maturity had a strong influence on the anthocyanin levels. Wang and Hsin-Shan (2000) reported that total anthocyanin content in strawberry increased with maturity.

The cultivation situation also significantly influences the anthocyanin content of strawberry fruit. The maximum anthocyanin content was observed in poly house condition (S_2) and minimum was recorded in net house condition (S_3). It might be due to different environmental factors and soil characters of cultivation situations.

The results of the experiment conceded that the performance in terms of qualitative characters is superior in strawberry variety Subarina as compared to other four varieties. Cultivation of strawberry in different cultivation situations showed that quality of strawberry was better in poly house condition and open condition as compared to net house condition.

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How to cite this article:

Tilak Malakar, D. N. Hazarika, S. Langthasa, R. K. Goswami, M. K. Kalita and Kalita, D. 2022. Qualitative Analysis of Strawberry Varieties in Sub Tropical Climatic Condition of Assam. *Int.J.Curr.Microbiol.App.Sci*. 11(05): 36-45. doi: https://doi.org/10.20546/ijcmas.2022.1105.006