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Biochemical characteristics of strawberry can be varied with changing growing medias and cultivars in soilless systems of temperate Himalayas of J&K

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Abstract
An experiment was carried out in controlled conditions at the Division of Fruit Science during the year 2018. The investigation involved 20 treatment combinations laid out in randomized complete block design (RCBD), having three replications. All soil less substrates significantly increased TSS, Total sugars, reducing sugars, non-reducing sugars and ascorbic acid content except M_1 (Sand). The mean maximum TSS (8.77 ^{0}Brix), total sugars (6.60%), reducing sugars (4.43%), non-reducing sugar (2.16%), ascorbic acid (25.27 mg/100 gm.) and organoleptic rating (4.02) were recorded from the plants grown on substrate M_2(coco-peat),whereas, mean minimum TSS (7.22^{0}B), Total sugars (4.09%), reducing sugars (3.16%), non-reducing sugars (0.93%) and ascorbic acid (21.35 mg/100 gm.) were recorded in M_1(Sand). Among different varieties studied, Kimberly recorded mean maximum TSS (8.16 ^{0}B), total sugars (5.68%), reducing sugars (4.05%) and ascorbic acid (38.90 mg/100 g) content. Substrate coco-peat and variety Kimberly is the best for the soil less production, system of the strawberry in the passively ventilated green-house condition.

Keywords: Strawberry, substrate, variety, soilless media, growth, yield

Introduction
Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most important widely consumed small fruit in the world. Soilless growing is becoming an attractive option because of the contamination of agricultural land due to the use of excessive fertilizers and insecticides to get higher productivity per unit area and the yield advantage with soilless culture getting more yields per unit area than the conventional growing. The future of soilless culture will depend on the development of new production systems, cultivars and substrates that are competitive in costs and returns in comparison to conventional agriculture. Strawberry is a monoecious octoploid (2n=56) hybrid of two species of dioecious octoploid, *Fragaria chiloensis* Duch. And Fragaria virginiana Duch. With a basic chromosome number (x) of 7 from the Rosaceae family. Though commercially grown in temperate regions, it can still be grown under tropical and subtropical climatic conditions. Strawberry is a short-day plant, grown at optimum daytime temperatures of 22 °C to 25 °C and 7 °C to 13 °C at night [3]. It is grown on 2 lake hectares in 73 countries worldwide and grows strawberry of 31-Lac metric tons.
Botanically, strawberry is an aggregate fruit (Eterio of achenes) and the edible berry comprises the mature receptacle and achenes [5]. The fruits are extremely perishable in traditional fruit growing systems and therefore have limitations in long distance transport. It is the most important fruit of the berry and it is produced twice as much globally. Strawberries not only have a high nutritional content, vitamin C and folate, but are also rich in phenolic compounds, including anthocyanins, tannins and phenolic acids (such as ellagic acid) and have several health benefits including lowering cholesterol, increasing endothelial vascular function and anti-inflammatory biomarkers and decreasing oxidative stress mediated diseases such as cancer (Hannum, 2004; Zhang *et al*., 2008; Giampieri *et al*., 2012) [9, 15, 3]. As the strawberry flavor and fragrance are among the most popular hedonic characteristics for consumers, strawberry fruit is widely used in a variety of manufacturing, including foods, beverages, confectionery, perfumes and cosmetics.
In field conditions, the strawberry crop is often threatened by several internal and external conditions that have adverse effects on plant growth and development, resulting in significant reduction in crop productivity and post-harvest quality.

Soilless growing is becoming an attractive choice due to the pollution of the agricultural land due to the use of excessive fertilizers and insecticides and also to obtain higher productivity per unit area and yield gain. Soilless culture methods, used mostly for products such as tomatoes and peppers, have been used for strawberry plants as well. The number of plants per unit area has increased, especially via soilless culture applications; thus, the yield per unit area has also increased (Paroussi *et al.*, 1995; Ozeker *et al.*, 1999; Paranjpe *et al.*, 2008) [14, 12, 13]. The quality of fruit has also increased, as this method of cultivation enables managed cultivation. Substrate selection is essential for the planning of soilless cultivation system along with the growing system (Favaro *et al.*, 2003) [7]. Therefore soilless cultivation of strawberry can be an alternative to the conventional soil cropping method.

Considering the importance of soilless culture, the current study aimed at finding out in Kashmir the possibility of soilless strawberry culture. As such, the experiment was designed to study the effect of different substrates and varieties on yield and the quality characteristics of strawberries that could help improve fruit, yield and quality in the future. Under Kashmir conditions, no such work has been performed so far. Taking into account the above-mentioned facts, the present investigation was designed to explore the role of various growing media such as sand, coco peat, perlite, sawdust and soil and to find the most suitable soilless strawberry substrate.

Materials and methods

The Experiment was carried out under controlled conditions in a Polyhouse in the experimental field of Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus, Srinagar during the year 2018. The aim of this experiment was to determine the effect of different substrates and varieties on quality and yield of strawberries in different soilless cultures. Five substrates viz., Sand (M_1), Coco-peat (M_2), Perlite (M_3), Sawdust (M_4) Soil (control) (M_5) and four varieties viz., Honeoye (V_1), Camarosa (V_2), Everly (V_3), and Kimberley (V_4) were used in the experiment. Hence, the experiment was two factors having 03 replications (7 plants/replication) and the total number of treatment combinations as 20. The design used for the experiment was RCBD (Randomized Complete Block Design) for statistical analysis. The transplanting was done in the first week of March 2018. Before transplanting root zone of runners were dipped in Ridomil (0.1%). Vermicompost in the ratio of 1:3 was added uniformly to all the media. The respective media were then filled into Perforated PVC pipes of dimensions 10 feet long and 6 inches diameter placed on iron stands of height 3 feet provided with drainage holes for aeration and drainage of excess water. In addition, plants were planted in soil beds of 10 x 10 feet dimension at a distance of 18cm×30cm under Polyhouse conditions which served as control. Uniform cultural practices were followed throughout the growing period. The pH during the entire experiment were maintained from 6.0-6.5 to facilitate the maximum uptake of nutrients. The Electrical Conductivity (EC) for soilless growing strawberry was maintained below 1.5 mS cm-1 for better growth, and better-quality fruits. Fertigation was provided manually at weekly intervals by dissolving 8 grams of each urea, DAP and Potash (K_2SO_4) in 100 ml of waters applied to the root zone until fruit set on the first truss of each established plant and afterwards fruiting formulation were introduced. Furthermore, weeding-cum-hoeing and plant protection measures were carried out as and when required.

With respect to the methodology of the observations recorded and the biochemical characters of the fruit that were analyzed were fruit TSS (^{0}Brix), Total sugars (%), Reducing sugars (%), Non-reducing sugars (%) and vitamin C (mg/100g). Fruit TSS of ripe fruit juice was determined with the help of a digital refractometer (0-32^0 B). Total sugars (%), Reducing sugars (%), Non-reducing sugars (%) and vitamin C (mg/100g) were analyzed by respective methods as reported by (A.O.A.C. 1990)

Table 1: Effect of different growing media and varieties on total soluble solids (^{0}Brix) of strawberry

Media /Variety	Total soluble solids (^{0}Brix)				
Sand	**Honeoye**	**Camarosa**	**Everly**	**Kimberly**	**Mean**
Coco-peat	8.81	8.63	8.46	9.20	8.77
Perlite	7.36	8.30	8.94	9.00	8.40
Sawdust	7.55	7.91	7.82	8.20	7.87
Soil (control)	7.28	7.10	7.29	7.33	7.24
Mean	7.64	7.86	7.94	8.16	
C.D ($p \leq 0.05$)					
Media	0.524				
Variety	0.342				
Interaction	1.215				

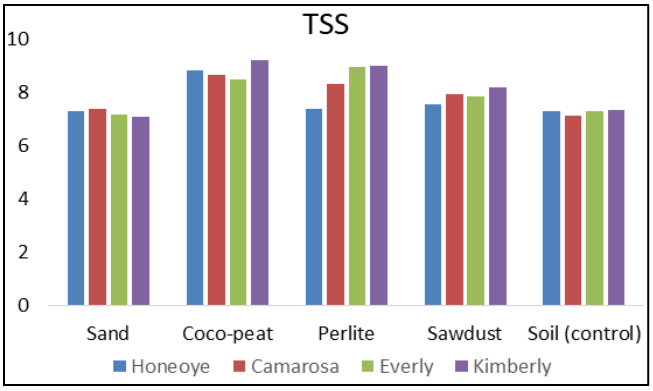

Fig 1: Effect of different growing media and varieties on total soluble solids (^{0}Brix) of strawberry

Table 2: Effect of different growing media and varieties on Total sugar (%) of strawberry

Media/Variety	Total sugar (%)				
	Honeoye	**Camarosa**	**Everly**	**Kimberly**	**Mean**
Sand	3.96	4.02	4.29	4.10	4.09
Coco-peat	6.82	6.78	6.29	6.50	6.60
Perlite	5.60	5.06	5.39	6.06	5.66
Sawdust	5.32	5.31	6.22	5.86	5.67
Soil (control)	4.05	3.97	3.8	5.89	4.45
Mean	5.15	5.03	5.22	5.68	
C.D ($p \leq 0.05$)					
Media	0.20				
Variety	0.18				
Interaction	0.40				

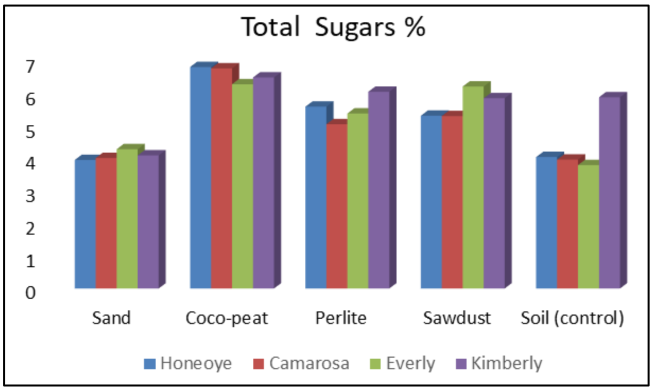

Fig 2: Effect of different growing media and varieties on Total sugar (%) of strawberry

Table 3: Effect of different growing media and varieties on reducing sugars (%) of strawberry

Media/Variety	Reducing sugars (%)				
	Honeoye	Camarosa	Everly	Kimberly	Mean
Sand	3.08	3.10	3.13	3.34	3.16
Coco-peat	4.53	4.52	4.36	4.3	4.43
Perlite	4.08	4.37	4.57	4.72	4.42
Sawdust	3.80	3.91	4.06	4.13	3.97
Soil (control)	3.40	3.69	3.86	3.74	3.67
Mean	3.78	3.92	3.99	4.05	
C.D ($p \leq 0.05$)					
Media	0.35				
Variety	0.53				
Interaction	1.33				

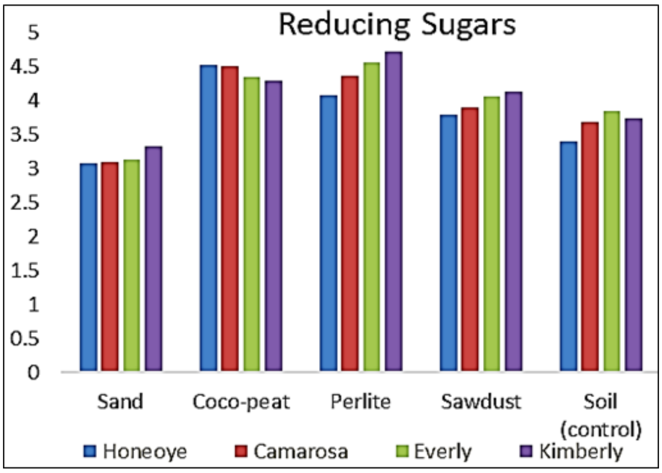

Fig 3: Effect of different growing media and varieties on reducing sugars (%) of strawberry

Table 4: Effect of different growing media and varieties on non-reducing sugars (%) of strawberry

Media/Variety	Non-reducing sugars (%)				
	Honeoye	Camarosa	Everly	Kimberly	Mean
Sand	0.88	0.92	1.16	0.76	0.93
Coco-peat	2.28	2.26	1.92	2.18	2.16
Perlite	1.52	0.69	0.82	1.34	1.09
Sawdust	1.51	1.40	2.16	1.73	1.70
Soil (control)	0.66	0.28	0.03	2.15	0.79
Mean	1.37	1.11	1.21	1.63	
C.D ($p \leq 0.05$)					
Media	0.19				
Variety	0.10				
Interaction	0.39				

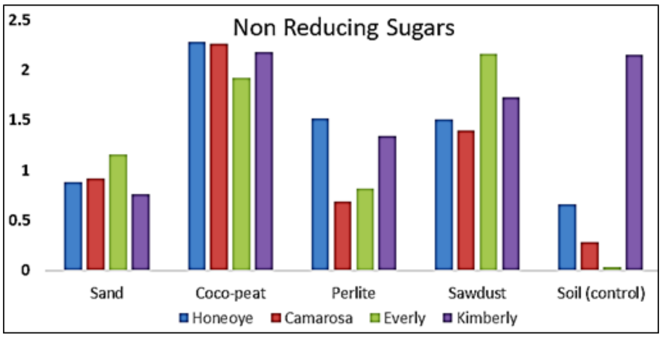

Fig 4: Effect of different growing media and varieties on non-reducing sugars (%) of strawberry

Table 5: Effect of different growing media and varieties on Vitamin C (mg/100g) of strawberry

Media/Variety	Vitamin C (mg/100g)				
	Honeoye	Camarosa	Everly	Kimberly	Mean
Sand	29.07	41.93	28.44	27.21	21.35
Coco-peat	40.24	39.05	41.33	59.67	25.27
Perlite	37.93	36.08	37.15	36.55	24.46
Sawdust	25.02	26.53	35.6	38.03	22.60
Soil (control)	31.22	30.00	32.42	33.26	23.27
Mean	32.69	34.71	35.00	38.90	
C.D ($p \leq 0.05$)					
Media	0.21				
Variety	0.18				
Interaction	0.42				

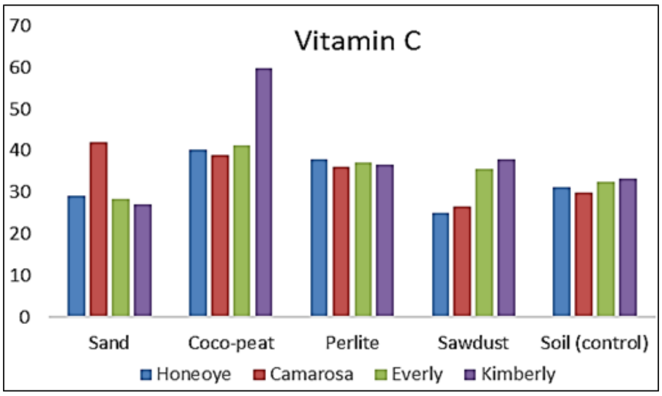

Fig 5: Effect of different growing media and varieties on Vitamin C (mg/100g) of strawberry

Results and Discussion

The investigation revealed that TSS, total sugars, reducing sugars, non-reducing sugars and ascorbic acid content increased significantly under different combinations of soilless substrates when compared to soil. The highest TSS (8.77^0brix), total sugar (6.60%) and reducing sugars (4.43%), non-reducing sugar (2.16%) and ascorbic acid (25.27 mg/ 100 g) content were recorded in M_2 (coco peat). The increased TSS and sugars in fruits could be attributed to the increased leaf area, which in turn might have favored photosynthetic rate, translocation and accumulation of sugars and metabolites in fruits under soilless culture. Similar results were obtained by (Ozdemir *et al.*, 1997; Ayesha *et al.*, 1997) [11, 5] in strawberry where maximum TSS and better taste was observed in soilless culture in comparison to soil. (Gruda *et al.*, 2004) [8] also reported increase in the dry matter, sugars, soluble solids, vitamins and carotenoid content under soilless culture in tomato. In the present study, significant difference in various combinations of soilless media also observed with respect to TSS, TSS/acid ratio and sugars. This might be due to the different proportion of coco peat, perlite and Vermicompost affecting the physical and chemical properties of the substrates, which significantly influenced the quality characteristics in strawberry. Further, hydroponic plants are generally less stressed than soil-grown plants since the plants are in their optimum growing conditions all the time. This might be one of the important factors contributing to better quality of hydroponically grown strawberries besides other factors like better vegetative growth. The results are also in line with the findings of (Jafarnia *et al.*, 2010; Ameri *et al.*, 2012) [10, 4] were a significant influence of various substrate combinations was observed on TSS and sugar content. However, contrasting results were obtained by (Cantliffe *et al*., 2008) [6] according to them the main characteristics related to nutritional quality, i.e. TSS, organic acids, soluble sugars and minerals differed non-significantly under soil and soilless culture system.

Substantial variation also existed among the different cultivars for TSS, total sugars, reducing sugars, non-reducing sugars and ascorbic acid. The maximum TSS (8.16^{0}brix), total sugar (5.68%), reducing sugars (4.05%) and ascorbic acid (38.90 mg/100 g), non-reducing sugar (1.63%) content were recorded in V_4 (Kimberly), however minimum TSS (7.64^{0}brix), reducing sugar (3.78%), and ascorbic acid content (32.69 mg/100 g) were recorded in V_1 (Honeoye), respectively. The variation in quality characterization in different cultivars of strawberry can be attributed to genetic makeup and the climatic conditions.

From the experiment it can be concluded that Different combinations of substrates and varieties significantly influenced the biochemical aspects of strawberries.

1. The highest percentage of total soluble solids TSS (8.7^{0}brix), total sugar (6.60%) and reducing sugars (4.43%) and non-reducing sugar (2.16%) were recorded in the fruits obtained from M_2(coco-peat), while minimum was found in M 1 (sand) during the year of Investigation.
2. The highest vitamin C content was observed in the fruits harvested from M_2 (25.27 mg/100 g), whereas minimum ascorbic acid content (21.35 mg/100 g) was recorded in M 1 (sand).
3. The quality parameters of that of TSS(8.16%),total sugars (4.05%) and ascorbic acid (38.90 mg/100 g) and non-reducing sugars (1.996%) content was recorded maximum in V 4(Kimberly), whereas minimum TSS (7.64 ^{0}Brix), reducing sugars (3.78) and ascorbic acid (32.69 mg/100 g) was recorded in V_1 (Honeoye), respectively.

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