

Evaluation of Chemical Attributes of Low Chilling Strawberry (*Fragaria ananassa*) Varieties in Chitwan, Nepal

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Abstract

An experiment to evaluate the qualitative parameters of strawberries to select the promising and high-value varieties was conducted in Bharatpur-5, Chitwan Nepal. The experiment comprises eight varieties 'Florida Beauty, Florida Festival, Sweet Sensation, Ruby Gem, Elyana, Winter Star, Winter Dawn, and Nyho (check variety) as treatments, laid out in a single factorial RCBD with four replications. The fruits of different varieties were harvested at their respective physiological maturity and fresh juice was extracted for qualitative analysis. The qualitative analyses revealed that the maximum TSS (9.88 °Brix) was recorded in the Nyho variety while the minimum TSS (6.58 °Brix) was recorded in Florida Festival. The maximum amount of TA (0.93 %) and the highest Vitamin C (75.57 mg/100 g) was recorded in fruits of Elyana while the minimum TA (0.71 %) in Sweet Sensation and the lowest amount of Vitamin C (59.89 mg/100 g) was recorded in Nyho. In the case of antioxidant properties of evaluated strawberry varieties, Elyana was found to be superior (81.33 %) while the lowest antioxidant properties were observed in fruits of variety Nyho with a value of 63.23 %. The maximum phenols content (0.64 mg GAE/g) was found on harvested fruits of Nyho while the minimum phenols content (0.24 mg GAE/g) was recorded in fruits of the Winter Star variety. Among the tested varieties, sweetness and aroma were the highest in Nyho while Elyana and Sweet Sensation were superior in nutritional attributes.

Keywords : Antioxidant properties, low chilling, qualitative analysis, strawberry varieties

Introduction:

The commercial strawberry (*Fragaria ananassa* Duch.) is a natural hybrid of two dioecious plants, *Fragaria chelonensis* and *Fragaria virginiana*. It is cultivated in cooler regions across the globe due to its delectable fruits that are abundant in vitamins, minerals, and a variety of bioactive compounds (Oszmianski and Wojdyló, 2009). Strawberries belong to the Rosaceae family and cultivated ones are octaploid in nature. Primarily, it is a short-day herbaceous perennial that thrives in temperate climates. However, due to its genetic diversity, highly heterozygous nature, and ability to adapt to a wide range of environments, it is the most widely distributed fruit crop worldwide (Galletta and Bringhurst, 1990). Botanically strawberries are aggregate fruit and seeds

are attached to the outer skin. The plants exhibit different behaviors during their lifecycle, in temperate condition, it behaves like small perennial herb while in subtropical region, they are annuals (Finn and Strike, 2008). Flowers consist of 5 petals and are white. Each flower contains several stamens (male reproductive organs) that surround a central pistil (female reproductive organ). Five sepals, stamens, pistils, and a stem known as the receptacle make up the strawberry flower. The fundamental floral whorl number is five, as is typical for the Rosaceae family, and floral organ initiation progresses centripetally from the outside to the center (Heide et al., 2015).

Strawberry is considered one of the most delectable fruits globally and holds significant value in horticulture due to its ability to yield quick returns within a short period

(Bakshi et al., 2014). It is a crop of great advantage to both small as well as large farmers and growers of temperate or subtropical regions as they give high returns per unit area at a low cost of production. The distribution of strawberry plants is wide and can be cultivated in diverse geographical regions (Biswas et al., 2009). In the context of Nepal, they are cultivated mostly in mild temperate regions, however, studies have been conducted to consider the feasibility of cultivating strawberries in sub-tropical and tropical regions. Meanwhile, successful results have been achieved in the growth of strawberry plants under the subtropical climate of Nepal. It is widely popular among consumers due to its glamorous red color, delicious taste with a blend of acid and sweetness, unique shape, and pleasant flavor due to active volatiles and phenols (Sharma and Yamdagni, 2000). It is a highly nutritious fruit rich in vitamin A (60 IU/100 g fruit), vitamin C (30-120 mg/100 g fruit), niacin, phosphorus, potassium, calcium, and iron. It also has a high pectin content (0.55 %) (Karakara and Dwivedi, 2002).

Currently, world strawberry diversity comprises 500 cultivated varieties and different wild varieties grown worldwide. This wide diversity has been an advantage to researchers and opens new pathways for effective selection procedures. Additionally, the improvement of the crop is mainly based on extensive research and collection of germplasm which will help to select stable strawberry varieties which ensures better production and quality fruits. Considering the above facts, a study of varietal evaluation of strawberries for the assessment of different parameters and characteristics is a must (Asrey and Singh, 2004). Thus, this study aims to identify the various characteristics of different strawberry varieties and their performance in field conditions to ensure higher yield and better-quality fruits.

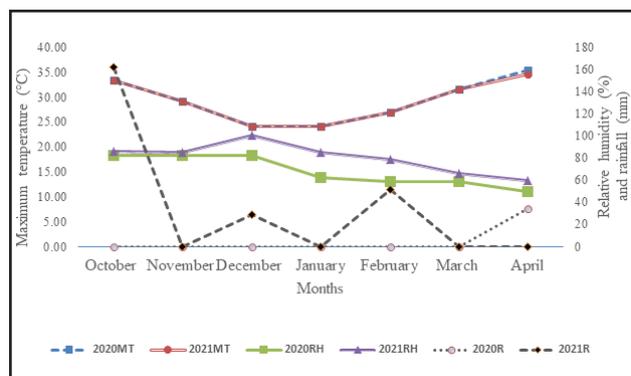
Materials and methods:

Experiment site and duration

This study was conducted at an experimental field located at Bharatpur-5, Chitwan in the years 2020 and 2021 from October to April. Table 1 displays the physicochemical characteristics of the soil in the experimental field, while Figure 1 provides details on the average temperature, rainfall, and humidity of the experimental site.

Table 1 : Physicochemical properties of soil of the experimental site

Properties	Average value	Rating	Method
Physical properties			
Texture	-	Sandy loam	Feel
Chemical properties			
Soil pH	5.13	Acidic	Potentiometric
Organic matter (%)	3.28	Medium	Walkey and Black
Total Nitrogen (%)	0.17	Medium	Kjeldhal digestion distillation
Available Phosphorous (kg ha-1)	71.1	High	Modified Olsen's bicarbonate
Available Potassium (kg ha-1)	460.0	High	Ammonium acetate method



MT = Maximum temperature, RH = Relative humidity and R = Rainfall

Figure 1. Monthly mean ambient maximum temperature (°C), relative humidity (%), and rainfall (mm)

Design of experiment

The experiment was laid out in a single-factor randomized complete block design (RCBD) with eight treatments and four replications.

Treatment details

In this study, 7 low chilling strawberry varieties and 1 most popularly grown variety (check variety) were cultivated to evaluate their relative performance on qualitative parameters (Table 2).

Layout of the field

The area of the experimental field was 362.25 m² with length and breadth of 34.5 m × 10.5 m respectively. Distance between replications was maintained at 1 m and treatments were laid 0.5 m apart.

Planting materials

The planting materials were bare-rooted strawberry transplants developed from runners of the mother plant. The planting materials were exported from Cal-Pacific, Egypt.

Planting of strawberry transplants

Bare-root strawberry transplants were transplanted in raised plastic-mulched beds at a spacing of 30 cm × 30 cm in a double-row system. The planting of transplants was done in the first week of October in both experimental years. The total number of plants per experimental unit was 50.

Table 2 : Detail of treatments

S.N.	Treatments	Treatment details (Variety)	Remarks
1	T1	Florida Festival	Introduced as a low-chilling variety
2	T2	Florida Beauty	Introduced as a low-chilling variety
3	T3	Sweet Sensation	Introduced as a low-chilling variety
4	T4	Ruby Gem	Introduced as a low-chilling variety
5	T5	Elyana	Introduced as a low-chilling variety
6	T6	Winter star	Introduced as a low-chilling variety
7	T7	Winter Dawn	Introduced as a low-chilling variety
8	T8	Nyho (Check)	Commonly cultivated variety in Nepal

Intercultural operations

After transplanting, one week of overhead irrigation was provided to ensure the plant's establishment. Later, the drip irrigation system was installed to meet the water and nutrition requirements of the plant depending upon the growth state and weather. The rate of fertigation was:

Early growth to 3 months of planting = 3:5:4 NPK applied at the rate of 4 Kg/ha/week

3 months of planting to harvest = 2:1:4 NPK applied at the rate of 4 Kg/ha/week

Observations taken

Out of 50 plants planted in each experimental unit, 10 plants were randomly selected and tagged for data collection. Various qualitative parameters were recorded from the fruits of sample plants. The fruits were harvested when they reached physiological maturity (i.e., fruits are 70% ripe red) and fresh samples and juice were extracted and subjected to different analyses. A juice was extracted from the strawberry fruit and total soluble solids (TSS) was measured by using a hand-held refractometer (ERMA Inc., Tokyo, Japan Model number: ERB-32) and expressed as °Brix. The pH level was measured using a pH meter (Hanna HI98128). The juice content was measured using the percentage volume method. Titratable acidity (TA) and ascorbic acid content were measured as described by Rangana (1986). The antioxidant activity was measured using the DPPH (2,2-diphenyl-1-picryl-hydrazyl-hydrate) assay method as described by Brand-Williams et al. (1995), and the total phenolic content was determined using the Folin-Ciocalteu's colorimetric assay method (Singleton and Rossi, 1965).

Data analysis

The data were entered into Microsoft Excel 2016 and analyzed using the R Stat (version 4.2.1). The data were subjected to Analysis of Variance (ANOVA) and mean separation was carried out using Least Significant Difference (LSD) at 0.05 level of significance ($P \leq 0.05$).

Results:

Qualitative properties of strawberries

The result of the pooled analysis of variance revealed

significant differences for every character described (Table 3). The maximum TSS (9.88 °Brix) was recorded in the Nyho variety which was followed by Florida Beauty (8.24 °Brix). The minimum TSS (6.58 °Brix) was recorded in fruits of Florida Festival which was at par with Elyana (6.61 °Brix) and Winter Star (6.84 °Brix).

In the case of Titratable acidity, the maximum TA (0.93 %) was recorded in harvested fruits of Elyana which was followed by Winter Star (0.84 %) while the minimum TA (0.64 %) was recorded in fruits of Nyho. Similar results were observed for TSS/TA with a maximum value of (15.45) in the Nyho variety followed by Sweet Sensation (11.43) and Florida Beauty (11.33), while the minimum value (7.34) was recorded in the Elyana variety. The juice content in fruits of different varieties also differed significantly. The highest juice content (47.46 %) was observed in Nyho while the lowest juice content (33.32%) was recorded in Ruby Gem.

Nutritional properties of strawberries

Among the varieties tested, the nutritional properties of the fruits differed significantly (Table 4). The highest amount of Vitamin C (75.57 mg/100 g) was recorded in fruits of Elyana while the lowest amount of Vitamin C (59.89 mg/100 g) was recorded in Nyho. In the case of antioxidant properties, Elyana was found to be superior (81.33 %) while the lowest antioxidant properties were observed in fruits of the variety Nyho with a value of 63.23%. The maximum phenols content (0.64 mg GAE/g) was found on harvested fruits of the Nyho variety, and the minimum phenols content (0.24 mg GAE/g) was recorded in fruits of the Winter Star variety.

Discussion:

In our study, variations among the cultivars for the chemical properties were observed. The variation in TSS levels could be attributed to the varying expression of genes responsible for TSS, which is influenced by subtropical agro-climatic conditions. The Nyho fruits had higher TSS levels, which could be due to a lower number of fruit sets and accumulated photosynthates. Additionally, early flowering and a longer time to maturity may have contributed to the higher TSS values. Different varieties have different phenological and harvesting features and time, agrometeorological features at the mean time of

Table 3 : Mean values for qualitative properties of strawberry varieties at Bharatpur, Chitwan, Nepal during 2020 and 2021

Treatments	Total soluble solid (oBrix)	Titrateable acidity (%)	TSS/TA	Juice content (%)
Florida Festival	6.58d	0.79bc	8.40cd	39.17d
Florida Beauty	8.24b	0.74cd	11.33b	41.40cd
Sweet Sensation	8.13bc	0.71cd	11.43b	39.01d
Ruby Gem	7.89bc	0.73cd	10.99b	33.22e
Elyana	6.61d	0.93a	7.34d	43.85abc
Winter Star	6.84d	0.84ab	8.17cd	45.93ab
Winter Dawn	7.27cd	0.75bc	9.73bc	42.28bcd
Nyho	9.88a	0.64d	15.45a	47.46a
Grand Mean	7.68	0.77	10.36	41.54
SEM	0.39	0.03	0.87	1.59
LSD	0.86**	0.09**	1.67**	3.91**
CV	7.64	8.03	10.94	6.40

The same-letter separated means in a column do not differ substantially at $p=0.05$, * indicates significance at 5% ($p < 0.05$), ** indicates significance at 1% ($p < 0.01$), SEM stands for standard error of the mean, LSD for least significant difference, and CV for coefficient of variation

Table 4 : Mean values for nutritional properties of strawberry varieties at Bharatpur, Chitwan, Nepal during 2020 and 2021

Treatments	Vitamin C (mg/100 g)	Antioxidant (%)	Total phenols content (mg GAE/g)
Florida Festival	72.47a	72.11b	0.26d
Florida Beauty	63.71b	69.58bc	0.44b
Sweet Sensation	64.50b	73.97b	0.45b
Ruby Gem	64.99b	69.38bc	0.46b
Elyana	75.57a	81.33a	0.28d
Winter Star	73.46a	70.39bc	0.24d
Winter Dawn	64.03b	67.22cd	0.34c
Nyho	59.89b	63.23d	0.64a
Grand Mean	67.32	70.90	0.39
SEM	2.00	1.87	0.05
LSD	4.62**	4.42**	0.07**
CV	4.67	4.24	12.43

The same-letter separated means in a column do not differ substantially at $p=0.05$, * indicates significance at 5% ($p < 0.05$), ** indicates significance at 1% ($p < 0.01$), SEM stands for standard error of the mean, LSD for least significant difference, and CV for coefficient of variation

fruit development and harvesting significantly affect the chemical parameters. These findings align with Menzel and Smith's (2014) research. On the other hand, the Elyana variety had a higher TA, which could be due to its lower TSS content and later fruiting stage, leading to early ripening. This result is consistent with Kurian's (2015) findings, which showed higher TA in late varieties.

Higher acidity and lower TSS (Total Soluble Solids) levels in Elyana may have resulted in a higher Vitamin C content. The early presence of higher ascorbic acid content could be attributed to its early development. Similarly, Singh et al. (2008) suggested that the higher ascorbic acid content in fruits could be linked to

increased vegetative growth, which provided sufficient photosynthate for sugar and acid accumulation. A similar study conducted by Hossain et al. (2016) yielded comparable findings (Hossain et al., 2016). Antioxidant capacity, flavonoids, phenolic acids, and vitamins also contribute to the protective properties against oxidative damage to cells. Assessing the overall antioxidant activity provides a more accurate evaluation of a strawberry's potential protective effects. In a similar study, three strawberry cultivars, namely Dover, Campineiro, and Oso Grande, exhibited similar antioxidant activities (Cordenunsi et al., 2005). Phenolic compounds found in fruits are secondary metabolites, with flavonoids and phenolic acids comprising the majority. Higher phenol

levels are an important characteristic of certain varieties, contributing to the fruit's taste and aroma. The Nyho variety was specifically developed for consumers who prefer sweeter-tasting fruits with a strong aroma. The variation in phenolic content among different varieties may be attributed to genetic factors and environmental conditions during cultivation (de Ancos et al., 2000).

Conclusion:

The findings of this study indicate that there is a notable variation in the chemical properties of the different varieties of strawberries. Among the tested varieties, 'Nyho' stood out as the most superior in terms of its sweetness and aroma, while Elyana and Sweet Sensation excelled in terms of their nutritional characteristics. These results have important implications for the selection of low-chilling strawberry varieties that are suitable for the tropical region of Nepal, taking into account the preferences of both growers and consumers. However, it is crucial to conduct further testing of these selected varieties in farmers' fields at various representative locations to assess their yield, market potential, and consumer preference before making any recommendations.

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Declaration of conflict of interest and ethical approval:

B. Shrestha is involved in designing the experiment, conducting the fieldwork, analyzing the data, and preparing the first draft of the manuscript. K.M. Tripathi, A.K. Shrestha, and R. Gautam are involved in supervising the experimental work, results interpretation, and finalizing the manuscript.

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