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Physio-chemical characterization of juice and dried pulp from three indigenous strawberry (*Fragaria* × *ananassa*) Varieties

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Abstract
The main aim of this study was to investigate the physical and physio-chemical characteristics of different strawberry cultivars. Camarosa, Chandler and Sweet Charlie were selected to evaluate physio-chemical composition of juice and dried pulp. For most of the physical characters, Camarosa has the highest fruit weight (69.1 g), maximum berry length (115.1 mm), highest berry breadth (86.5 mm) and highest juice content (52.2%) followed by chandler. For physio-chemical characters, Camarosa recorded the maximum total sugars (19.7%), reducing sugar (10.3%), and non-reducing sugar (10.4%). The maximum ascorbic acid content in juice, Sun dried pulp and oven dried pulp was recorded in camarosa (220.9 mg/100g), (222.7 mg/100 g) and (217.2 mg/100 g) respectively, while minimum was recorded in Chandler. Carotenoid content in juice, sun dried pulp and oven dried pulp was recorded maximum in Camarosa (6.2 µg/100 g), (5.4 µg/100 g), (5.8 µg/100 g) respectively. The maximum phenolic content and anthocyanin juice, Sun dried pulp and oven dried pulp was recorded maximum in Camarosa cultivar and the flavonoid content juice, Sun dried pulp and oven dried pulp was recorded maximum in Sweet Charlie (97.1 mg/100 g), (94.7 mg/100 g) and (100.5 mg/100 g) respectively. It is concluded that the Camarosa was superior to Chandler and Sweet Charlie in most of characteristics. The Camarosa has more antioxidant potential, which influences the nutritional value of fruits.

Keywords: Strawberry, physio-chemical characters, pulp, antioxidants.

Introduction
The cultivated strawberry (*Fragaria* x *ananassa* Duch) is belongs to the family Rosaceae and is grown in temperate, subtropical and at high altitudes of tropical regions of the world. It is cultivated on an area of 1000 ha area with the annual production of 5000 MT in the country (NHB 2017) and mainly grown in Himachal Pradesh, Meghalaya, Maharashtra, Uttarakhand, Jammu & Kashmir, Punjab, Haryana, West Bengal and Rajasthan. It is an aggregate fruit which is rich in vitamins and minerals and edible portion is fleshy thalamus. Other polyphenols present include flavonoids, such as anthocyanins, flavanols, and phenolic acids, such as hydroxybenzoic acid and hydroxycinnamic acid. Strawberries contain fisetin and possess higher levels of this flavonoid than other fruits. Although achenes comprise only about 1% of total fresh weight of a strawberry, they contribute 11% of the fruit's total polyphenols, which, in achenes, include ellagic acid, ellagic acid glycosides, and ellagitannins.
Strawberries are known for their characteristic aroma, which is attributed to the presence of volatile esters. The most important aroma compounds are ethyl hexanoate, methyl hexanoate, ethyl heptanoate, ethyl propionate, ethyl butanoate, methyl butanoate, furanone and linalool. Essential oil can also be extracted from strawberry leaves. Strawberry fruits are delicious but highly perishable needing immediate utilization as dessert fruit or processed product. Different cultivars of strawberry are used for preparation of purees, juice concentrate, juice, jams, preserves and preparation of alcoholic beverages including strawberry wine. The cultivars 'Chandler', 'Doughlas' and 'Camarosa' are used for making wine, however, 'Camarosa' was rated superior to 'Chandler' and 'Doughlas'. Other cultivars, *viz.* 'Elsanta', 'Polka', Jewel', 'Honeoye' and 'Tenira' are suitable for processing purpose. Strawberry flavor is used extensively in the food industry for the production of beverages, confectioneries, bakery fillings, yoghurts, ice creams, cake mixes, etc.

Material and Methods
The present study "Physio-chemical Characterization of Juice and Dried Pulp from Three Indigenous Strawberry Varieties" was conducted to evaluate the physio-chemical properties of pulp and juice of three strawberry cultivars under Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib.

The healthy disease free, fully matured uniform sized fruits with firm texture were selected and washed with water in order to remove dust, dirt and any other foreign material. The fruits were oven (60° C for 6 to 8 hours) and solar dried (for 2-3 days at 50-60%) and fruit juice for further analysis. CRD experimental design is used for statistical analysis of data.

Results and Discussion

Physical parameters

The results have been depicted in tabular from and illustrated with tables and figures in order to obtain comprehensive idea of investigation. The data have been analyzed statistically. The results obtained are presented under appropriate heading, which are as follows:

Average fruit weight (g)

The data concerned with fruit weight of different cultivars are given in Table 4.1.1 and illustrated pictorially in Fig 4.1.1. There was significant variation in average fruit weight was noted among three cultivars of strawberry. The highest fruit weight was recorded by camarosa (69.1 g) while the minimum fruit weight (67.3 g) was recorded in chandler.

Berry length (mm)

The data concerned with fruit weight of different cultivars are given in Table 4.1.1 and illustrated pictorially in Fig 4.1.1. There was significant variation in berry length was noted among three cultivars of strawberry. The maximum berry length was recorded by camarosa (115.1 mm) while the minimum berry length (107.3 g) was recorded in chandler.

Berry breadth (mm)

The data concerned with fruit weight of different cultivars are given in Table 4.1.1 and illustrated pictorially in Fig 4.1.1. There was significant variation in berry breadth was noted among three cultivars of strawberry. The highest berry breadth was recorded by camarosa (86.5 mm) while the minimum berry breadth (85.0 mm) was recorded in sweet charlie.

Juice percentage (%)

The data concerned with fruit weight of different cultivars are given in Table 4.1.2 and illustrated pictorially in Fig 4.1.2. There was significant variation in juice percentage was noted among three cultivars of strawberry. The highest juice percentage was recorded in camarosa (52.2%) while the minimum juice percentage (50.2%) was recorded in chandler.

Table 1: Studies on the fruit weight, berry length and berry breadth characters of strawberry varieties

Cultivars	Fruit Weight (g)	Berry length (mm)	Berry breadth (mm)	Juice percentage (%)
Camarosa	69.1	115.1	86.5	52.2
Chandler	67.3	107.3	85.7	50.2
Sweet Charlie	68.5	111.0	85.0	52.2
S.E.	0.568	1.269	1.332	0.109
CD (5%)	1.688	3.770	3.956	0.323
CV%	4.325	5.933	8.074	1.107

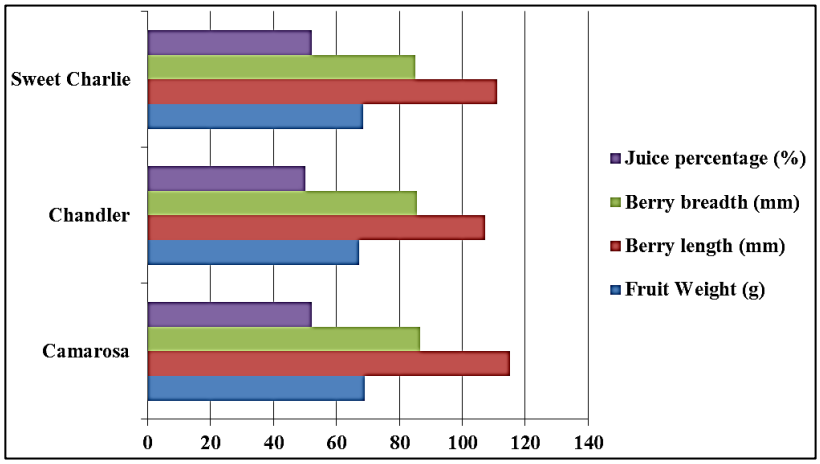

Fig 1: Studies on the fruit weight, berry length and berry breadth characters of strawberry varieties

Physio-chemical Parameters

Total sugars (%)

The data concerned with fruit weight of different cultivars are given in Table 4.2.1 and illustrated pictorially in Fig 4.2.1. There was significant variation in total sugars was noted among three cultivars of strawberry. The highest tostal sugar was recorded in Camarosa (19.7%) while the minimum total sugar (17.1%) was recorded in Sweet Charlie.

Reducing sugars (%)

The data concerned with fruit weight of different cultivars are given in Table 4.2.1 and illustrated pictorially in Fig 4.2.1. There was significant variation in reducing sugars was noted among three cultivars of strawberry. The highest reducing sugar was recorded in Camarosa (10.3%) while the minimum total sugar (9.3%) was recorded in Chandler.

Non-reducing sugars (%)

The data concerned with fruit weight of different cultivars are given in Table 4.2.1 and illustrated pictorially in Fig 4.2.1. There was significant variation in non-reducing sugar was noted among three cultivars of strawberry. The maximum non-reducing sugar was recorded in Camarosa (10.4%) while the minimum non-reducing sugar (7.6%) was recorded in Sweet Charlie.

Total soluble solids (º Brix)

The data concerned with fruit weight of different cultivars are given in Table 4.2.2 and illustrated pictorially in Fig 4.2.2.

There was significant variation in TSS was noted among three cultivars of strawberry. The highest TSS was recorded in sweet charlie (30.0º Brix) while the minimum total sugar (26.6 º Brix) was recorded in camarosa.

Table 2: Studies the total sugar, reducing sugar and non- reducing sugar characters of strawberry varieties

Cultivars	Total Sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	TSS (ºBrix)
Camarosa	19.7	10.3	10.4	26.6
Chandler	18.9	9.3	8.7	28.0
Sweet Charlie	17.1	9.4	7.6	30.0
S.E.	0.116	1.269	1.332	0.151
CD (5%)	0.346	3.770	3.956	0.450
CV%	0.362	5.933	8.074	2.790

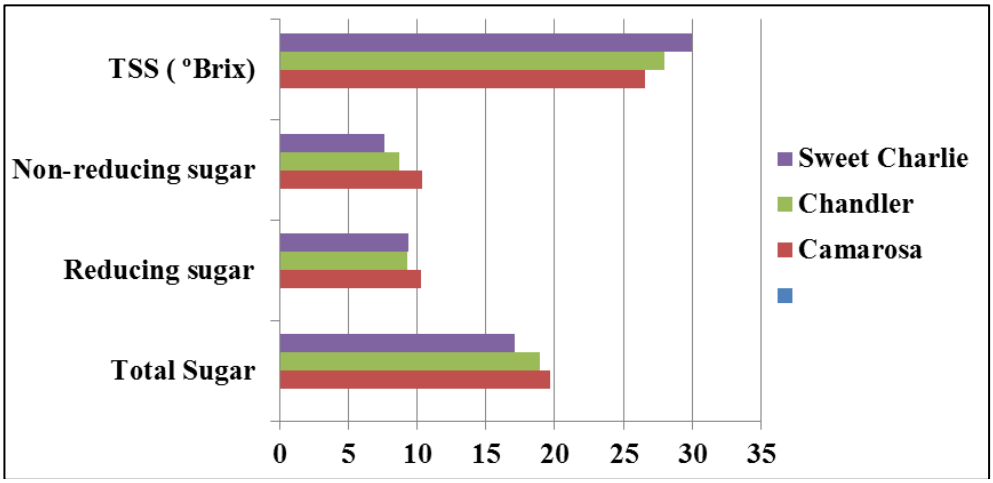

Fig 2: Studies on the total sugar, reducing sugar and non- reducing sugar characters of strawberry varieties

Carotenoid content (mg/ g) in juice and pulp

The data concerning to carotenoid contents for different strawberry cultivars are given in Table 4.2.3 and depicted pictorially in Fig 4.2.3. The observed data clearly indicated that the cultivars had significant variation in carotenoid content amongst them. The carotenoid content was recorded highest in camarosa juice 6.2 mg/ 100 g, sun drying pulp 5.4 mg/ 100 g and oven drying pulp 5.8 mg/ 100 g. The minimum carotenoid content was found in chandler juice 2.4 mg/ 100 g, sun drying pulp 2.8 mg/ 100 g and oven drying pulp 2.4 mg/ 100 g.

Anthocyanin content (mg/ 100 g) in juice and pulp

The data concerning to anthocynin contents for different strawberry cultivars are given in Table 4.2.4 and depicted pictorially in Fig 4.2.4 The observed data clearly indicated that the cultivars had significant variation in anthocynin content amongst them. The anthocynin content was recorded highest in camarosa juice 0.7 mg/ 100 g, sun drying pulp 0.7 mg/ 100 g and oven drying pulp 0.6 mg/ 100 g. The minimum anthocynin content was found in sweet charlie juice 0.5 mg/ 100 g, sun drying pulp 0.5 mg/ 100 g and oven drying pulp 0.4 mg/ 100 g.

Flavonoid Content (mg/ 100 g) in juice and pulp

The data concerning to flavonoid contents for different strawberry cultivars are given in Table 4.2.5 and depicted pictorially in Fig 4.2.5. The observed data clearly indicated that the cultivars had significant variation in flavonoid content amongst them. The flavonoid content was recorded highest in sweet charlie juice 97.1 mg/ 100 g, sun drying pulp 94.7 mg/ 100 g and oven drying pulp 100.5 mg/ 100 g. The minimum flavonoid content was found in chandler juice 93.8 mg/ 100 g, sun drying pulp 96.7 mg/ 100 g and oven drying pulp 93.1 mg/ 100 g.

Table 3: Studies on Carotenoid, anthocyanin and flavonoid content in strawberry varieties

Cultivars	Carotenoid content			Anthocyanin content			Flavonoid content		
	Juice	Sun drying pulp	Oven drying pulp	Juice	Sun drying pulp	Oven drying pulp	Juice	Sun drying pulp	Oven drying pulp
Camarosa	6.2	5.4	5.8	0.7	0.7	0.6	96.4	93.7	92.2
Chandler	2.4	2.8	2.4	0.6	0.6	0.5	93.8	96.7	93.1
Sweet Charlie	3.2	2.2	3.1	0.5	0.5	0.4	97.1	94.7	100.5
Mean	4.0	3.5	3.8	0.6	0.6	0.5	95.8	95.0	95.3
S.E.	0.161	0.093	0.090	0.026	0.015	0.011	0.147	0.085	0.87
CD (5%)	0.386	0.264	0.262	0.062	0.045	0.042	0.352	0.250	0.252
CV%	1.452	0.752	0.749	0.124	0.114	0.107	0.799	0.547	0.561

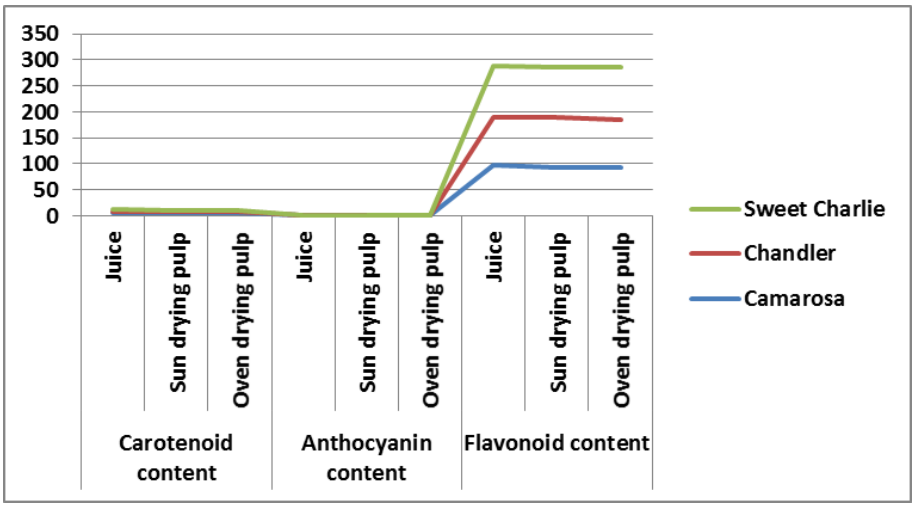

Fig 3: Studies on Carotenoid, anthocyanin and flavonoid content in strawberry varieties

Ascorbic acid (mg/ 100 g) of juice and pulp

The data concerning to ascorbic acid contents for different strawberry cultivars are given in Table 4.2.6 and depicted pictorially in Fig 4.2.6 The observed data clearly indicated that the cultivars had significant variation in ascorbic acid content amongst them. The ascorbic acid content was recorded highest in camarosa juice 220.9 mg/ 100 g, sun drying pulp 222.7 mg/ 100 g and oven drying pulp 217.2 mg/ 100 g. The minimum ascorbic acid content was found in chandler juice 211.0 mg/ 100 g, sun drying pulp 210.9 mg/ 100 g and oven drying pulp 204.6 mg/ 100 g.

Phenol content (mg/ 100 g) of juice and pulp

The data concerning to phenol contents for different strawberry cultivars are given in Table 4.2.7 and depicted pictorially in Fig 4.2.7 The observed data clearly indicated that the cultivars had significant variation in phenol content amongst them. The phenol content was recorded highest in camarosa juice 189.8 mg/ 100 g, sun drying pulp 184.3 mg/ 100 g and oven drying pulp 187.5 mg/ 100 g. The minimum phenol content was found in chandler juice 180.4 mg/ 100 g, sun drying pulp 181.6 mg/ 100 g and oven drying pulp 184.4 mg/ 100 g.

Titrable acidity (%) of juice and pulp

The data concerning to titrable acidity for different strawberry cultivars are given in Table 4.2.8 and depicted pictorially in Fig 4.2.8. The observed data clearly indicated that the cultivars had significant variation in titrable acidity amongst them. The titrable acidity was recorded highest in camarosa juice 2.2%, sun drying pulp 2.1% and oven drying pulp 2.3%. The minimum titrable acidity was found in chandler juice 2.1%, sun drying pulp 2.0% and oven drying pulp 2.1%.

Table 4: Studies on Ascorbic acid, phenol and titrable acidity content in strawberry varieties

Cultivars	Ascorbic acid			Phenol content			Titrable acidity		
	Juice	Sun drying pulp	Oven drying pulp	Juice	Sun drying pulp	Oven drying pulp	Juice	Sun drying pulp	Oven drying pulp
Camarosa	220.9	222.7	217.2	189.8	184.3	187.5	2.2	2.1	2.3
Chandler	211.0	210.9	204.6	180.4	181.6	184.4	2.1	2.0	2.1
Sweet Charlie	211.6	213.8	206.5	182.9	183.4	186.4	2.2	2.1	2.2
Mean	214.5	215.8	209.4	184.4	183.1	186.1	2.2	2.1	2.2
S.E.	0.159	0.094	0.086	0.161	0.093	0.093	0.034	0.019	0.016
CD (5%)	0.381	0.272	0.215	0.386	0.276	0.276	0.100	0.081	0.058
CV%	0.387	0.207	0.197	0.453	0.475	0.430	1.245	0.547	0.427

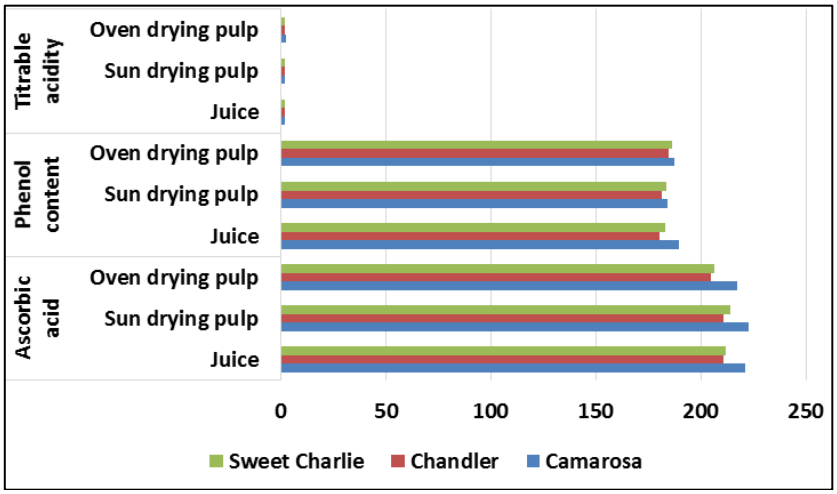

Fig 4: Studies on Ascorbic acid, phenol and titrable acidity content in strawberry varieties

Conclusion

There were distinct variations between three strawberry varieties for nutritional and physio-chemical characters of fruit under study. In the present study, it can be concluded that variety Camarosa was superior to Chandler and Sweet Charlie in most of characteristics. Camarosa has more antioxidant potential, which influences the nutritional value of fruits. Strawberry juice and pulp strongly support total polyphenols as a good source of antioxidants higher nutritional value which can be successfully incorporated in food products as it enhances the nutritional quality.

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