Concentrate development from Litchi Juice and quality evaluation during storage

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Abstract. An attempt has been made to concentrate Litchi juice using fresh juice, using class-II preservatives via laboratory scale single stage single effect glass evaporator with vacuum in a batch. Two litchi varieties viz. Dehradun and Seedless late were procured from the Regional Fruit Research Station, Gangian (Distt. Hoshiarpur) and processing was done at Food Science and Technology department (Punjab Agricultural University, Ludhiana, Punjab) pilot-plant. The extraction of juice was attempted via screw-based juice extractor with subsequent muslin cloth filtration. The filtered juice was divided into two lots of which one was concentrated via evaporation while another was preserved using 2000 ppm potassium metabisulphite in glass bottles for later on concentration. The juice was concentrated at 50-55°C temperature with a vacuum of 27-30 inches of Hg. The final concentration of juice was maintained at 80 oBrix in all the cases. Product was packed in pearl pet jars and was stored at ambient room temperature (12-38 oC) (RT) and low temperature (LT) i.e., refrigerated (0-4°C) for 6 months periodic quality evaluation like physico-chemical because of storage. Stored product was analyzed at 0, 2, 4 and 6 months interval for various storage physico-chemical changes like TSS, pH, acidity, ascorbic acid, sugars, browning, pectin, viscosity, tannins and sensory quality. The result outcome proposed that seedless variety yield more juice, pulp and less seed in comparison to Dehradun variety while the sensory characteristics were found more acceptable in Dehradun variety rather than Seedless variety. Physico-chemical properties observed in concentrates from both litchi varieties doesn’t show much difference but a clear difference can be seen room temperature stored concentrate to low temperature stored concentrate. The flow behavior for the concentrates was found to be decreasing slightly with storage period as compared to controls. However, considerable decrease in flow behavior index was observed for the concentrates prepared from Dehradun variety stored at low temperature for 6 months to the seedless variety. The consistency index values has shown positive drift with extending storage time especially for those low temperature concentrates. So, it can be said concentrates from both varieties could be commercially produced with acceptable sensory characteristics.

1. Introduction

The Litchi chinensis sonn. i.e Litchi is a fruit grown in subtropical area and due to its juicy aril and deliciously flavored sweet it is always held in high esteem. It might be cultivated from 1500 BC in China by the Malayan descent people before the Chinese had moved that far south [5]. Citrus ranks top followed by avocado and then Litchi in importance in subtropics [14]. The litchi fruit contains fair amount of protein, fat, minerals and vitamins (A, B and C). It contains protein percent ranges 0.8-0.95, fat percent approx. 0.3 percent, pectin approximately 0.42 percent and specially calcium, phosphorus and iron approximately 0.7 percent as minerals observed in earlier studies [8, 27]. At national level, area under litchi was 56.4 thousand hectares with total production of 433.2 thousand metric tonnes [2]. The average productivity in the country is reported to be 7.6 Tonnes per hectare. It occupies the share of 1.4 percent and 0.9 percent in total area and production, respectively [11]. Shahi, Rose scented, Early
seedless late, Early large red, Calcuttia, Dehradun, Seedless late, Muzaffarpur, Saharanpur are some of the popular varieties of litchi.

As a table fruit litchi is mostly consumed as it is very delicious, juicy and refreshing. Though major part of the litchi produced is marketed as fresh fruit. Along with this, litchi can be utilized for preservation and processed products like squash, canned litchi, syrups, cordial, ready to serve drinks, jelly, jam, juice concentrates and it can also be dehydrated to get a very popular product “litchi nut” as called in China. In addition, litchi juice can also be fermented to produce wine. The litchi fruit rapid postharvest deterioration like browning of pericarp i.e., loss of red colour and fruit decay because it matures in hot season. The postharvest life of litchi fruit at ambient temperature is less than 3 days. Since its postharvest period is short, that limits its transportation and need immediate distribution, marketing and consumption. Therefore, the research outcome proved that for uplifting the litchi production the postharvest losses are the key problem [13].

Storing at low temperature including SO2 fumigation, wax emulsions coating on the litchi fruit etc. are some of the methods that for shelf-life extension in litchi fruit for commercial purpose. However, there is increasing consumer and regulatory resistance to the use of chemicals [9]. So, the concentration of fruit juices to thick viscous liquid or powders for subsequent reconstitution as fruit juice or for use in preparation of beverages, baked products, frozen dairy products and jellies etc. has attracted much attention. The juice concentration permits the economy in storage, packaging, transportation and the probable readiness generates early interest production and sale of fruit juice concentrates.

2. Materials and methods

Two varieties of litchi viz. Dehradun and Seedless late were procured from the Regional Fruit Research Station, Gangian (Distt. Hoshiarpur) and processed in Department of Food Science and Technology established pilot-plant (Punjab Agricultural University, Ludhiana, Punjab). After segregating the injured and bruised fruits the fully mature and healthy fruits were retained for processing. All the sorted fruits were followed by peeling and destoning manually. Extraction of juice attempted by screw type juice-extractor with subsequent filtration through muslin cloth. The filtered juice was divided into two lots. One lot of freshly extracted juice was attempted for concentration and another one was preserved using 2000 ppm KMS (preservative) in glass bottles for later on concentration.

Litchi juice concentrate was prepared from freshly extracted juice, as well as chemically preserved juice with the help of laboratory scale single stage single effect, vacuum glass evaporator batch type. The concentration was done at 50-55 °C temperature and a vacuum of 27-30 inches of mercury. Final concentration of juice was maintained at 80 °Brix in all the cases. Product was packed in pearl pet jars followed by ambient room temperature (12-38 °C) and refrigeration (0-4 °C) for storage studies of 6 months accompanied with periodic quality evaluation like assessing the physico-chemical changes during intervals of storage. Stored product was analyzed at 0, 2, 4 and 6 months interval for various parameters (TSS, pH, acidity, ascorbic acid, sugars, browning, pectin, viscosity, tannins and sensory quality).

2.1 Physical characteristics

For reading the flow characteristics of litchi juice Rheostat 2 viscometer (VEB MLW Prufgerate-werk, Medingen, Germany) with coaxial cylinder attachment was used. The analyzed torque data obtained 0.6 and 145.8 s⁻¹ using H system (bob to cup ratio of 0.81). The concentrates amount taken for sample analysis was 17 ml with a bit slow introduction into the cup. The samples were allowed to rest for 15 minutes to bring down the conditions of the samples for the instrumental experimental temperatures i.e 20 °C, 30 °C, 40 °C and 50 °C for accuracy in results. To maintain the juice concentrates temperature of the samples were controlled using a thermostatic installed water circulating bath. The data obtained from Shear stress cycle (Ascending to descending order followed by a rest of 5 minutes) and subject to further analysis. The flow behaviour index “n” (dimensionless) and consistency index “K” (Pa.sn) were calculated via log plots of log-shear rate vs shear-stress intercept and slope.

The stored samples of juice concentrate were sensory evaluated for colour, flavour, taste, body and overall acceptability characteristics by a panel of semi-trained judges using 9-point Hedonic scale for judging the overall acceptability of the product [1]. The samples of juice concentrate were reconstituted to original strength and chilled before sensory evaluation.
2.2 Chemical characteristics
TSS contents were determined via hand refractometer (Erma, Japan) using solid scale ranged between 0-50 and 40-90 percent. The TSS were expressed as °Brix at 20°C using reference tables. The calculated values for total solids were obtained by formula (100-moisture percent) and expressed as percent total solids. Moisture content, pH, titratable acidity, sugars, reducing sugars, total sugars, ascorbic acid, tannins [3] and browning [17] were determined.

2.3 Statistical analysis
The numerical values for fresh and preserved samples of two varieties evaluated at 0, 2, 4, 6 months interval was analyzed with the help of factorial design in CRD [6] to analyze the genotype varieties effect on the processing treatments, low temperature chosen for storage studies and as the overall acceptability of the stored product.

3. Results and discussion
3.1 Physical characteristics of litchi fruit
The data regarding percentage of different components viz. peel, pulp and seed on prepared fruit basis are given in Table 1. The peel percentage, pulp percentage, seed percentage and juice recovery of Seedless late variety was 18.0, 76.0, 4.0 and 62.5 percent, respectively whereas for Dehradun variety, it was 14.0, 66.5, 16.5 and 47.5 per cent, respectively.

3.1.1 Physico-chemical composition of litchi juice. The physico-chemical composition of juice of two litchi varieties viz. Seedless late and Dehradun are presented in Table 2. Moisture (%), TSS (°Brix), Acidity (%), Ascorbic acid (mg/100gm), pH, Reducing & Total sugars (%) and Tannins (mg/100gm) content of Seedless late variety was 80.2, 18.0, 0.32, 4.40, 28.9, 13.1, 16.5 and 217.0 respectively, whereas for Dehradun variety, it was 80.9, 17.0, 0.48, 5.07, 19.6, 10.2, 13.9 and 179.0 respectively.

3.1.2 Physico-chemical analysis of litchi juice concentrate during storage. The treatments effect on the physico-chemical parameters of litchi juice concentrate for two varieties viz. Seedless late and Dehradun are presented in Table 3.

3.1.3 TSS. The total soluble solids followed an increasing trend during storage. Total soluble solids increased by 0.39 and 0.36 percent in treated concentrate of seedless late and Dehradun variety that were stored at low temperature. The increase in TSS was mainly attributed to loss of moisture from the product during storage. Similar observations were reported in lime, grape and lemon juice concentrates kept at refrigerated temperatures (2-5°C) [22] and in kinnow juice concentrate during storage [7]. The varietal effect, the treatments and temperature chosen during storage was found (P>0.05) non-significant but significant effect has been observed (P<0.05) during storage period on total soluble solids of both varieties stored at low and ambient room temperature.

3.1.4 Total solids. The overall mean value of total solids increased from 81.6 to 84.8 during storage. The total solids values showed a bit hike at low temperature storage to the ambient room temperature storage in case of both varieties. Total solids increased by 4.6 and 4.3 percent in treated concentrates of Seedless late and Dehradun variety stored at low temperature. The total solids increase might be slight but it may be due to loss of moisture from the product during period of storage. A quite similar observations were reported in galgal juice concentrate stored in HDPE bottles that were stored at room temperature (13.3-26.3°C) and low temperature (3-7°C) [23] as compared to the lime, grape and lemon juice concentrates that were kept refrigerated at a temperature of 2-5°C [22]. The varieties, treatments and storage temperature showed a non-significant (P>0.05) effect on per cent total solids in the concentrate during storage, while storage period had significant effect (P<0.05) on total solids of litchi juice concentrate.

3.1.5 Moisture. The moisture content decreased in both treated and untreated concentrates of both varieties stored at low and ambient room temperature during storage. The moisture content decreased by 20.4 and 19.9 per cent in treated concentrates of Seedless late and Dehradun variety, respectively stored at low temperature. The decrease in moisture content was more at low temperature as compared to...
ambient room temperature. Similar type of observations were reported in sugarcane juice concentrate stored at ambient room temperature [24] and in galgal juice concentrate stored in HDPE bottles at room temperature (13.3-26.3°C) and at low temperature (3-7°C) during storage [21].

3.1.6 Acidity. The percent acidity decreased in both the varieties during storage. The mean value overall decreased as percent acidity ranged between 2.1 to 1.73 in both litchi varieties. The decrease in acidity was more in untreated concentrates that were kept for storage at ambient temperature whereas the concentrates with treatment were kept at low temperature during storage exhibited minimum decrease in acidity in both varieties. The decrease in percent acidity was observed more in Seedless late variety as compared to Dehradun variety. The decrease in acidity may be a characteristic of chemical interactions between organic constituents during storage. Similar observations were observed in concentrates made from grape juice [4], as in juice concentrates made from galgal [23] and in kinnow mandarin juice concentrate during storage [21].

3.1.7 The pH. The initial value of pH was recorded as 5.02 and 4.39 in treated concentrates of Dehradun and Seedless late variety while, initial values of pH was 5.04 and 4.47 in untreated concentrates of Dehradun and Seedless late variety. The pH value showed an increasing trend during storage in both varieties at all the storage temperatures. The observations revealed that pH increase was observed more at room temperature (ambient) as compared to low temperature. The increase in pH was recorded as 1.82 and 1.79 percent in treated concentrates of Seedless late and Dehradun variety stored at low temperature. Similar results were reported in concentrates made from grape juice [4], sugarcane [24] and in debittered kinnow during storage, [26] respectively.

3.1.8 Ascorbic acid. The ascorbic acid was significantly lost during storage in both the varieties. The mean value obtained as overall was showing a decrease between 104.5 to 52.9 mg/100gm in both varieties. Ascorbic acid losses observed maximum in non-treated juice concentrates that were stored at ambient temperature in case of both varieties. The ascorbic acid decreased by 26.6 and 37.6 percent in treated concentrates of Dehradun and Seedless late variety stored at low temperature. The ascorbic acid values showed a loss that might be due to effect of light, metal ions, processing and high temperature during storage. The same observations were reported in galgal juice concentrate [23], in coorg mandarin juice concentrate [16] and in Kinnow mandarin orange juice concentrate during storage [21].

3.1.9 Reducing sugars. The reducing sugars followed an increasing trend during storage. The overall mean increases in percent reducing sugars ranged between 24.7 to 24.9 in both varieties. The increase in reducing sugar was higher in untreated concentrates kept at ambient room temperature storage in case of both varieties. The percent increase in reducing sugars was recorded at 0.4 and 0.6 in treated concentrate of Seedless late and Dehradun variety stored at low temperature respectively. The reducing sugars value might be caused to the inversion or hydrolysis of non-reducing sugars into reducing sugars. Similar results were reported in sugarcane juice concentrate [24], in galgal juice concentrate [23] and in kinnow mandarin orange juice concentrate during storage [21].

3.1.10 Total sugars. The total sugars values were decreased for all types of juice concentrates as observed during storage. The overall mean decreased value of percent total sugar ranged between 58.1 to 52.6 for both varieties. The treated concentrates stored at low temperature resulted in minimum decrease in percent total sugars during storage. This decrease in total sugars was recorded as 1.9 and 4.5 percent in treated concentrates of Seedless late and Dehradun variety stored at low temperature respectively. The total sugars values decline may be due to the sugars involvement in browning reactions that results in hydroxymethyl furfural production and sugars converted to monosaccharides because of acid hydrolysis. Similar trend was reported in galgal juice concentrate [23] and in kinnow orange juice concentrate during storage [21].

3.1.11 Tannins. Decrease in tannins was more noticeable in untreated concentrates those stored at ambient room temperature. The decrease in tannins was recorded as 37.1 and 27.5 in treated concentrates of Seedless late and Dehradun variety stored at low temperature. The decrease in tannin content is attributed to losses during processing, concentration and storage period at various temperature ranges. The observed findings correspond to the one reported in grape and malta juice concentrate [10] and in
3.1.12 Browning. The optical density was observed at 440nm. The overall mean increased value for optical density observed in ranges 0.385 to 0.662. The browning was more noticeable at room (ambient) temperature in comparison to storage done at low temperature in both varieties. The browning tinge increase in juice concentrates during storage was due to reaction between sugar and amino acids, degradation of ascorbic acid and reactions of amino acids with other juice constituents i.e. phenols etc. The treated concentrates stored at low temperature exhibited minimum increase in optical density. Significant reduction in browning in treated concentrate may be because of absence of enough amino acids to react with sugars, ascorbic acid and phenols to cause browning. The percent increase for optical density observed was 1.82 and 1.79 for treated concentrates of Seedless late and Dehradun variety stored at low temperature. The minimum browning in Dehradun variety may be due to higher retention of ascorbic acid as compared to Seedless late variety. The similar type of results were quoted in galgal juice concentrate [23], in coorg mandarin juice concentrate [16] and in malta orange juice concentrate during storage [15].

3.2 Rheological measurements

3.2.1 Applicability of power law model. To better understand the rheological behaviour in connection with the composition and flow characteristics, this power law model was fitted to the torque data of the concentrate. Initiating with the lowest speed, the shear stress vs the shear rate data obtained for descending and ascending curves were found to be very close, revealing the time-independent flow characteristics of the juice concentrates.

3.2.2 Flow behaviour index. Overall mean values for index flow behaviour of litchi juice concentrates ranged between 0.65 to 0.97 that confirms the flow behaviour as non-Newtonian in nature [13] as shown in table no 4. The flow behaviour index for the various concentrates prepared from Dehradun variety were similar to those of Seedless late variety. The concentrates stored at ambient room temperature (12-38 °C) for 6 months were found to behave as non-newtonian fluid flow and the index values observed as significantly different to low temperature (0-4 °C) stored samples. The temperature set for experiments ranged from 20-50 °C, the index values for power law flow behaviour were found to be inversly proportional to the temperature rise of the juice concentrate. At 50 °C the flow behaviour index were found in the range of 0.66 to 0.89 as compared to those of 0.66 to 0.97 at 20 °C. The flow behaviour index values for the concentrates were observed to be decreasing slightly with storage period as compared to controls. However, considerable decrease in flow behaviour index was observed for the concentrates prepared from Dehradun variety stored at low temperature for 6 months. A similar type of results were observed in tomato concentrates studies [19], in xanthan gum dispersions [25] and in tomato ketchups [18].

3.2.3 Consistency index. With the temperature rise from 20-50 °C the consistency index value was found considerably influenced. The consistency index values for those samples that were stored at 50 °C were a bit lower than the juice concentrates samples consistency observed at to 20 °C temperature. At 50 °C the consistency index values were observed nearly 15 folds lower than those at 20 °C temperature for the juice concentrates. The consistency index values for various concentrates determined at 30-50 °C for the concentrates stored at room temperature were similar to those of corresponding concentrates stored at room temperature. The juice concentrates kept for storage at low temperature (20 °C) had showed higher consistency index values than the samples stored at room (ambient) temperature. Similarly, the Seedless late fresh juice concentrates kept at room and low temperature were reported with higher values than those of the corresponding Dehradun concentrates as shown in table no 5. These values were also considerably higher than those of the preserved juice concentrates. However, the concentrates prepared from preserved juice of Dehradun variety has shown higher consistency index values to the corresponding concentrates consistency values obtained from Seedless late variety at temperature of 20 °C. The consistency index values has shown a rise with extension in storage time for samples that were stored at low temperature. Whereas, negligible changes were observed in concentrates stored at low temperature except for the Seedless late fresh juice concentrates at 20 °C which increased from 35.2 to 89.0 upon storage for 6 months.
### Table 1. Percentage recovery of the various portions of litchi fruit of two varieties.

| Portion     | Dehradun Weight (Kg) | Percentage | Seedless late Weight (Kg) | Percentage |
|-------------|-----------------------|------------|---------------------------|------------|
| Total fruit | 2.0                   | -          | 2.0                       | -          |
| Peel        | 0.287                 | 14.35      | 0.364                     | 18.2       |
| Pulp        | 1.371                 | 66.55      | 1.539                     | 76.9       |
| Seed        | 0.342                 | 17.10      | 0.097                     | 4.85       |
| Juice       | 0.955                 | 47.75      | 1.250                     | 62.5       |

### Table 2. Chemical composition of juice of different litchi varieties

| Character                                    | Dehradun | Varieties |
|----------------------------------------------|----------|-----------|
| TSS (°Brix)                                 | 17.0     | 18.0      |
| Moisture (%)                                | 80.9     | 80.2      |
| Total solids (%)                            | 19.1     | 19.8      |
| Acidity as citric acid (%)                  | 0.48     | 0.32      |
| Ascorbic acid (mg/100gm)                    | 19.6     | 28.9      |
| pH                                           | 5.07     | 4.4       |
| Reducing sugars, dextrose (%)               | 10.2     | 13.1      |
| Total sugars, dextrose (%)                  | 13.9     | 16.5      |
| Tannins (mg/100gm)                          | 179      | 217       |

### Table 3. Effect of treatment and storage on the physico-chemical parameters of litchi juice concentrate

| Physico-chemical parameter | Storage period (months) | Varieties |  |  |  |  |  |
|----------------------------|-------------------------|-----------|---|---|---|---|---|
|                            | RT | LT | RT | LT | RT | LT | RT | LT |
| TSS (°Brix)                | 0  | 80.00 | 80.00 | 80.00 | 80.00 | 80.00 | 80.00 | 80.00 |
|                            | 2  | 80.11 | 80.12 | 80.09 | 80.21 | 80.13 | 80.21 | 80.17 | 80.22 |
|                            | 4  | 80.14 | 80.16 | 80.12 | 80.27 | 80.17 | 80.23 | 80.19 | 80.29 |
|                            | 6  | 80.20 | 80.21 | 80.17 | 80.29 | 80.22 | 80.27 | 80.21 | 80.31 |
| LSD (0.05)                 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 | 0.24 |
| Total solids (%)           | 0  | 81.8 | 81.8 | 81.5 | 81.5 | 81.6 | 81.6 | 81.4 | 81.4 |
|                            | 2  | 82.4 | 83.6 | 82.6 | 83.8 | 82.2 | 83.1 | 82.1 | 82.7 |
|                            | 4  | 84.7 | 84.2 | 83.2 | 84.1 | 83.1 | 83.6 | 82.9 | 83.4 |
|                            | 6  | 85.4 | 85.8 | 84.3 | 85.1 | 84.2 | 84.8 | 83.2 | 85.2 |
| LSD (0.05)                 | 3.27 | 3.27 | 3.27 | 3.27 | 3.27 | 3.27 | 3.27 | 3.27 |
| Moisture (%)               | 0  | 18.2 | 18.2 | 18.5 | 18.5 | 18.4 | 18.4 | 18.6 | 18.6 |
|                            | 2  | 17.6 | 16.4 | 17.4 | 16.2 | 17.8 | 16.9 | 17.9 | 17.3 |
|                            | 4  | 15.3 | 15.8 | 16.8 | 15.9 | 16.9 | 16.4 | 17.1 | 16.6 |
|                            | 6  | 14.6 | 14.2 | 15.7 | 14.9 | 15.8 | 15.2 | 16.8 | 14.8 |
| LSD (0.05)                 | 3.18 | 3.18 | 3.18 | 3.18 | 3.18 | 3.18 | 3.18 | 3.18 |
| Acidity (%)                | 0  | 2.11 | 2.11 | 2.14 | 2.14 | 2.07 | 2.07 | 2.08 | 2.08 |
|                            | 2  | 1.92 | 2.03 | 1.98 | 2.07 | 1.82 | 1.99 | 1.98 | 2.01 |
|                            | 4  | 1.71 | 1.89 | 1.83 | 2.04 | 1.67 | 1.87 | 1.83 | 1.97 |
|                            | 6  | 1.58 | 1.73 | 1.64 | 1.96 | 1.54 | 1.76 | 1.72 | 1.89 |
| LSD (0.05)                 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| pH                         | 0  | 5.04 | 5.04 | 5.02 | 5.02 | 4.47 | 4.47 | 4.39 | 4.39 |
|                            | 2  | 5.09 | 5.06 | 5.08 | 5.05 | 4.51 | 4.43 | 4.46 | 4.41 |
|                            | 4  | 5.18 | 5.11 | 5.15 | 5.08 | 4.55 | 4.47 | 4.50 | 4.45 |
|                            | 6  | 5.29 | 5.17 | 5.22 | 5.11 | 4.61 | 4.50 | 4.54 | 4.47 |
|                | LSD (0.05) | 0.02  | 0.02  | 0.02  | 0.02  | 0.02  | 0.02  | 0.02  | 0.02  |
|----------------|------------|-------|-------|-------|-------|-------|-------|-------|-------|
| **Ascorbic acid (mg/100gm)** |            |       |       |       |       |       |       |       |       |
| 0              | 87.5       | 87.5  | 93.2  | 93.2  | 114.8 | 114.8 | 122.6 | 122.6 |       |
| 2              | 63.3       | 72.6  | 67.0  | 78.7  | 87.2  | 98.4  | 91.5  | 108.8 |       |
| 4              | 49.1       | 63.5  | 55.1  | 71.2  | 68.3  | 83.4  | 68.5  | 89.1  |       |
| 6              | 33.7       | 51.1  | 39.3  | 68.4  | 39.5  | 72.3  | 43.2  | 76.5  |       |
| **Reducing sugars (%)** |            |       |       |       |       |       |       |       |       |
| 0              | 23.87      | 23.87 | 23.89 | 23.89 | 25.59 | 25.59 | 25.63 | 25.63 |       |
| 2              | 24.03      | 23.96 | 23.98 | 23.94 | 25.73 | 25.69 | 25.72 | 25.68 |       |
| 4              | 24.12      | 24.03 | 24.07 | 23.99 | 25.87 | 25.73 | 25.76 | 25.72 |       |
| 6              | 24.26      | 24.09 | 24.11 | 24.05 | 26.03 | 25.81 | 25.86 | 25.74 |       |
| **Total sugars (%)** |            |       |       |       |       |       |       |       |       |
| 0              | 55.9       | 55.9  | 56.7  | 56.7  | 59.8  | 59.8  | 59.9  | 59.9  |       |
| 2              | 52.4       | 51.5  | 51.2  | 55.7  | 53.1  | 58.7  | 57.8  | 59.4  |       |
| 4              | 49.6       | 51.0  | 50.3  | 54.9  | 51.3  | 57.8  | 56.4  | 58.9  |       |
| 6              | 47.4       | 49.9  | 48.8  | 54.1  | 49.4  | 57.2  | 55.9  | 58.7  |       |
| **Tannins (mg/100gm)** |            |       |       |       |       |       |       |       |       |
| 0              | 789.3      | 789.3 | 816.1 | 816.1 | 852.3 | 852.3 | 917.7 | 917.7 |       |
| 2              | 541.7      | 697.9 | 701.4 | 749.7 | 517.1 | 644.9 | 781.2 | 803.1 |       |
| 4              | 416.1      | 513.8 | 571.5 | 683.4 | 408.7 | 561.1 | 634.3 | 746.4 |       |
| 6              | 397.4      | 446.6 | 498.7 | 591.6 | 362.3 | 481.2 | 487.6 | 576.9 |       |
| **Browning (at 440 nm)** |            |       |       |       |       |       |       |       |       |
| 0              | 0.051      | 0.051 | 0.022 | 0.022 | 0.058 | 0.058 | 0.023 | 0.023 |       |
| 2              | 0.776      | 0.121 | 0.587 | 0.058 | 0.805 | 0.137 | 0.627 | 0.069 |       |
| 4              | 1.121      | 0.179 | 0.763 | 0.099 | 1.142 | 0.196 | 0.891 | 0.141 |       |
| 6              | 1.173      | 0.218 | 0.989 | 0.146 | 1.187 | 0.225 | 1.152 | 0.172 |       |
| **Colour scores** |            |       |       |       |       |       |       |       |       |
| 0              | 7.3        | 7.3   | 8.3   | 8.3   | 7.3   | 7.3   | 8.2   | 8.2   |       |
| 2              | 5.9        | 7.1   | 7.6   | 8.4   | 5.4   | 6.9   | 6.9   | 8.2   |       |
| 4              | 5.8        | 6.9   | 6.4   | 8.2   | 5.3   | 6.8   | 6.3   | 8.1   |       |
| 6              | 4.9        | 6.5   | 5.9   | 7.8   | 4.8   | 6.5   | 6.2   | 7.5   |       |
| **Flavour scores** |            |       |       |       |       |       |       |       |       |
| 0              | 7.7        | 7.7   | 7.5   | 7.5   | 7.6   | 7.6   | 7.4   | 7.4   |       |
| 2              | 7.6        | 7.6   | 6.7   | 7.3   | 6.6   | 6.9   | 6.6   | 7.2   |       |
| 4              | 5.8        | 7.5   | 5.9   | 6.9   | 6.4   | 6.8   | 6.5   | 6.8   |       |
| 6              | 3.7        | 5.5   | 4.0   | 6.8   | 5.5   | 5.9   | 5.7   | 6.6   |       |
| **Taste scores** |            |       |       |       |       |       |       |       |       |
| 0              | 7.7        | 7.7   | 7.8   | 7.8   | 7.5   | 7.5   | 7.6   | 7.6   |       |
| 2              | 6.7        | 7.5   | 6.7   | 7.6   | 6.3   | 6.4   | 7.3   | 7.5   |       |
| 4              | 5.8        | 7.4   | 5.9   | 7.6   | 6.4   | 6.4   | 5.9   | 6.8   |       |
| 6              | 5.6        | 6.6   | 5.6   | 6.9   | 5.6   | 5.9   | 5.6   | 6.7   |       |
| **Body scores** |            |       |       |       |       |       |       |       |       |
| 0              | 7.6        | 7.6   | 8.3   | 8.3   | 7.7   | 7.7   | 8.4   | 8.4   |       |
| 2              | 6.7        | 7.5   | 6.9   | 8.3   | 6.2   | 7.6   | 6.5   | 8.3   |       |
| 4              | 6.7        | 7.5   | 6.7   | 7.8   | 6.1   | 7.4   | 6.4   | 7.6   |       |
| 6              | 6.1        | 7.4   | 6.3   | 7.5   | 5.9   | 7.3   | 6.2   | 7.5   |       |
| **LSD (0.05)** |            | 0.19  | 0.19  | 0.19  | 0.19  | 0.19  | 0.19  | 0.19  | 0.19  |
4. Conclusion

The concentrates of juice obtained from two different litchi varieties viz. Dehradun and Seedless late with treatment of one lot with 2000 ppm potassium metabisulphite and storing in glass bottles observed for its physico-chemical, sensory and rheological characteristics as explained in the tables. The result outcome proposed that seedless variety yield more juice, pulp and less seed in comparison to Dehradun variety while the sensory characteristics were found more acceptable in Dehradun variety rather than Seedless variety. Physico-chemical properties observed in concentrates from both litchi varieties doesn’t show much difference but a clear difference can be seen room temperature stored concentrate to low temperature stored concentrate. The flow behaviour for the concentrates was found to be decreasing slightly with storage period as compared to controls. However, considerable decrease in flow behaviour index was observed for the concentrates prepared from Dehradun variety stored at low temperature for 6 months to the seedless variety. The consistency index values obtained were found to increase with increase in time of storage especially for those juice concentrates that were stored at low temperature. So, it can be said concentrates from both varieties could be commercially produced with acceptable sensory characteristics.

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