NUTRITIONAL COMPOSITION AND QUALITY EVALUATION OF CHERRY JUICE CONCENTRATE

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Abstract
The present investigation was carried to develop cherry juice concentrate and evaluation of its quality and nutritional composition. Product was developed by using rotary vacuum evaporator at a temperature of 60°C and 100rpm. The juice samples were concentrated for 0, 20, 40, 60, 65, 70, 75 and 80 minutes designated as T_0, T_1, T_2, T_3, T_4, T_5, T_6 and T_7. Moisture content, ascorbic acid, L & b* values were found highest in T_0 and lowest in T_7. Highest total soluble solid (TSS), sugar content and a* values were found in T_7 and lowest in T_0. The final TSS (T_7) were stored at 60, 70 and 80°C in an oven and samples drawn after 0, 2, 4, 6, 8 and 10 hours and were designated as T_{7a}, T_{7b}, T_{7c}, T_{7d}, T_{7e} and T_{7f}. Highest degradation of quality parameters was found in T_{7f} at 80°C and lowest in T_{7a} at 60°C. A ready to serve (RTS) beverage was prepared from concentrated cherry juice by adding water and citric acid. The RTS beverage possess pH of 3.2, reducing sugar of 11 %, total sugar 12.6 % and was adjusted at 14 ^{0} Brix and 0.28 % acidity. The color shows more degradation with increase in storage temperature as anthocyanin content decreases and color gets faded. However among the various storage temperatures the highest degradation was found at 80°C. Also at 80°C the highest degradation was found at T_7f while the lowest was found at T_7a.*

Keywords: Rotary Vacuum Evaporator, Cherry Juice, Quality Parameters, Degradation Kinetics

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Introduction

Cherry is the common name for several species of *Rosaceae* family, *Prunoideae* subfamily, and *Prunus* genus that have their origin in the Asian continent, and produce fruits and hardwood. Around 40% of world cherry production originates in Europe and around 13% in the United State. In India, Cherry is mainly grown in the North-Western Himalayan region of Jammu and Kashmir (J&K), Himachal Pradesh (H.P) and Uttarakhand hills.
Sweet cherries are known to have various antioxidants. The major phenolic antioxidants in sweet cherries are anthocyanins but sweet cherries also have significant amounts of phenolic acid and flavonols. The major phenolic acids in sweet cherries are hydroxycinnamic acids (Jakobek et al., 2007, Usenik et al., 2008). Phenolic antioxidants have been reported to have positive effects on human health like anti-inflammatory and anticarcinogenic effects and are important in human nutrition (Usenik *et al.*, 2008). Furthermore, phenolic antioxidants from sweet cherries have shown protective effects on neuronal cells (Kim *et al*., 2005). Sweet cherry fruits contain different phenolic compounds, including phenolic acids (hydroxycinnamic derivatives) and flavonoids (anthocyanins, flavan-3-ols and flavonols), that have been related with their antioxidant potential. Due to its high content in antioxidants, such as phenolic compounds and vitamins, *P. avium* beneficial effects have been recognized, namely in the prevention of cardiovascular diseases, cancer and other diseases related with oxidative stress. They have a low glycemic index (Brand-Miller & Foster-Powell, 1999), which is an advantage over other fruits and vegetables. Sweet cherry fruits are also considered a source of vitamins, especially vitamin C (Schmitz-Eiberger & Blanke, 2012) and minerals, such as potassium, phosphorus, calcium and magnesium (Yıgıt *et al*., 2009).
Shelf life of cherry fruit is very less and large quantities get wasted. Also there is lack of efficient post-harvest management of cherries, which leads to the rapid quality deterioration

and sudden glut in the market. Various products prepared from cherries are juice, frozen cherries, dehydrated cherries, canned products, cherry jam, cherry juice concentrate, cherry juice powder, cherry bars and cherry candies (Imtiyaz *et al*., 2015).

The concentration of juices may be employed as flavouring materials in some food products besides consumption after reconstitution in time of rarity (Abd El-Fadeel, 1981). Evaporation of excess water in fruit juices is considered to be the most economical and most widely used method of concentration. The objectives of the present investigation were (a) to study the effect of concentration time on quality parameters of cherry juice concentrate prepared by vacuum evaporation. (b) To study the degradation kinetics of cherry juice concentrate at different storage temperatures. (c) To prepare ready-to-serve beverage from cherry juice concentrate.

MATERIAL AND METHODS

Procurement of raw material

Fresh, ripe and sound fruits of cherry cultivar Makhmali devoid of any microbial infection or mechanical fissures were procured from local market of Pulwama and then bought to the Food processing and Training centre of Islamic university of Science and Technology, Awantipora for further processing.

Grading of fruit

The fruit was graded on the bases of colour into three grades i.e. dark red, medium red and slight red which is done visually. The fruit length, width and weight were measured and then TSS, pH, acidity and colour of each grade was measured.

Physical observations

Fruit weight

A representative sample of 30 fruits from each grade in triplicate was weighed on an electric balance and average fruit weight calculated.

Fruit dimensions

Fruit length and diameter were recorded on representative samples of five fruits from each grade in triplicate using Vernier caliper.

Preparation of fresh cherry juice

Fresh fruits were washed in the cold tap water and drained. The fruit juice was extracted by hot break method followed by hydraulic press. The juice yield was measured and recorded as weight/weight of pulp. The juice was heated to 85˚C for 10 minutes to inactivate the enzymes and cooled.

Centrifugation of cherry juice

Cherry juice was centrifuged (Remi centrifuge) at 3000 rpm for 10 minutes. This was done to get clear juice which was free from sediments.

Preparation of concentrate

Juice was concentrated by rotary vacuum evaporator (IKA HB10) at temperature of 60 °C for 20, 40, 60, 65, 70, 75 and 80 minutes at 100 rpm.

Degradation kinetics of cherry concentrate

Thermal degradation of cherry concentrate was studied in 66.8˚Brix concentrate at 60, 70 and 80°C. Aliquots of 10 ml samples were put into screw-cap test tubes to prevent evaporation and these tubes were designated as T_7a, T_7b, T_7c, T_7d, T_7e and T_7f and were placed into preheated oven to a given temperature. At regular time intervals (0, 2, 4, 6, 8 and 10 hour), samples were removed from the oven and rapidly cooled by plunging into an ice tray to stop further degradation. All the quality parameters were measured immediately.

Preparation of ready-to-serve (RTS) beverages

The concentrated cherry juice was used to prepare ready to serve beverage by adding water and citric acid. The beverage was adjusted to 14˚Brix and 0.28% acidity. The blended juice was heated to 90˚c for 2 minutes and filled in sterilized bottles and sealed by crown corking. The sealed bottles were allowed to cool overnight at room temperature.

Methods

Moisture (%)

Moisture was determined by AOAC (2000)

Sugars, reducing sugars and total sugars (%)

These were estimated by Lane and Eynon's (1932) volumetric method.

Acidity (g/100)

Titratable acidity was determined by titration and values are expressed as maleic acid (Ranganna, 1986).

pH

This was carried out using Pearson's method.

Determination of Total Soluble Solids (˚Brix)

It was determined in accordance with AOAC (2000).

Colour (L^* a^* b^*)

Color analysis of hot air dried tomato slices was done by using Hunter Lab Colorimeter (Model SM-3001476 Micro Sensors, N. York).

Total solids (%)

Total Solids were calculated using the formula:

Per cent total solids = 100- per cent moisture content.

Determination of total phenolic content

Total phenolic content (TPC) of sample was determined according to the Folin-Ciocalteau method.

Determination of Ascorbic Acid (mg/100)

Ascorbic acid was determined according to the method of Klein and Perry (1982).

Determination of Anthocyanin content (mg/100)

Reagents:

Ethanolic HCl solution prepare by mixing 95% ethanol with and 1.5N HCl in the ratio 85: 15.

Determination of Antioxidant Activity by different methods:

1) DPPH (1, 1-Diphenyl- 2 -picrylhydrazyl radical)

The DPPH free radical scavenging activity measurements were carried out according to the procedure of Lee et al. (2004).

2) FRAP (Ferris-reducing antioxidant power assay)

The FRAP assay was done according to Benzie and Strain (1996)with some modifications.

Non-enzymatic browning (NEB)

For estimation of browning reaction, 5g of the sample was mixed with 100ml of 60 ml/100 ml absolute alcohol in a glass stoppered flask. The mixture was shaken thoroughly, kept for 12 hours and then filtered through Whatman No. 4 filter paper. The absorbance (OD) of the filtrate was measured at 420 nm against 60 ml/100 ml alcohol in a spectrophotometer. Browning index was expressed as absorbance value at 420 nm.

Statistical analysis

The data obtained for each parameter was statistically analysed. Statistical analysis was done using OPSTAT software.

RESULTS AND DISCUSSION

The products were prepared by concentrating cherry juice at temperature of 60˚C, 100 rpm in different time intervals and were designated as T_0, T_1, T_2, T_3, T_4, T_5, T_6 and T_7.

Pomological parameters and Color parameters

The data regarding the pomological parameters of different cherry grades is present in Table 1. It was found that the average fruit dimensions were 19.2 mm, 26.4 mm for width and length while average weight was 5.2 g. There was an overall increase over time in fruit width, length, weight, TSS. The TSS increases 8.6 to 11.4 from light red to dark red stage. The pH increases 2.7 to 3.0 from light red to dark stage while acidity decreases 3.0 to 2.0 from light red to dark stage. The result shows similarity with the results depicted by Gunduz *et al*., (2013).

The colour parameters of different grades of cherry are present in Table 1.

Among the colour variables, L^* exhibited a continuous decrease as fruit colour increases, b^* demonstrated the similar patterns, while a^* shows increase in pattern.

Table 1: Mean and mean separation for several pomological parameters of sweet cherry fruits sampled from three grades.

Grades	Width (mm)	Length (mm)	Weight (g)	TSS (%)	Titrable Acidity (%)	pH	L*	a*	b*
Light red	20.4±0.18^c	25.6±0.20^c	5.2±0.05^c	8.6±0.06^c	0.299±0.02^a	2.7±0.06^b	24.63±0.09^a	18.82±0.06^c	10.97±0.05^c
Medium red	24.2±0.20^b	28.2±0.26^b	5.8±0.06^b	10.4±0.05^b	0.280±0.04^a	2.9±0.10^{ab}	22.69±0.05^b	20.23±0.04^b	14.39±0.03^b
Dark red	26.1±0.22^a	30.2±0.30^a	6.4±0.10^a	11.6±0.04^a	0.270±0.05^a	3.0±0.09^a	20.16±0.02^c	22.42±0.01^a	17.59±0.01^a

Values are expressed as mean ± standard deviation. Means having different letters within the column differ significantly at $p<0.05$

The highest values for the colour parameters were obtained from light red to dark red grades. For a^*, the lowest values was measured at light red stage while highest at dark red stage. Changes in b^* values indicate a colour change from light red to medium red, change in a^* value indicate a turn in colour from green to red. The result shows similarity with results reported by Ozgen *et al*., (2009).

Proximate analysis and Antioxidant activity

The data regarding the proximate composition of fresh cherry juice is presented in Table 2. It was found that fresh cherry juice contained 83.5% moisture, 0.27% titrable acidity, 4.27% pH, 16.10 mg/100g ascorbic acid, 9.9% total sugars, 11.8˚ Brix and 0.07 Non-enzymatic browning. The result shows similarity with the results depicted by Medeni Maskan (2006), Imtiyaz *et al*., (2013) and Thakur *et al*., (2000).

The data regarding the antioxidant activity of fresh juice is presented in Table 2. It was found that fresh cherry juice contained 340.71 mg of DPPH and 180.02 of FRAP, 440.01mg of total phenols (TPC) and 67.80 mg of total anthocyanin content (TAC). The similar result was shown by Jinping *et al*., (2015).

Effect of vacuum concentration on physicochemical properties of cherry juice

Data in Table 3 shows the changes occurred in physiochemical properties of cherry juice after concentrating at different time intervals under vacuum. The moisture content of cherry juice decreased significantly from 83.50 to 35.99%. Highest mean moisture content was found at T_0 (83.50%), while the lowest mean moisture content was found T_7 (35.99%). The total soluble solids increased significantly from 11.8 to 66.8°Brix. Highest mean TSS content was found at T_7 (66.8°Brix) and lowest was found at T_0 (11.8°Brix).The pH values of cherry juice significantly decreases from 4.27 to 3.16. Highest mean pH was found at T_0 (4.27) while the lowest was found at T_7 (3.16).The total acidity gets usually increased, but there occurs some destruction which might be due to volatilization of some acid. Highest mean acidity was found at T_7 (1.15%) and the lowest mean acidity was found at T_0 (0.27%). These results show similarity with the results reported by Ibrahim (1985), Mostafa (2002) and Dyab *et al*., (2003).

Total sugars increased from 9.9 to 65.22% and reducing sugars from 8.10 to 60.15%. This increase in sugar content may be due to evaporation of water during the concentration. Highest mean total sugar was found at T_7 (65.22%), while the lowest mean total sugar was found at T_0 (9.9%) and the highest mean reducing sugar was found at T_7 (60.15%) and lowest was found at T_0 (8.10%). The ascorbic acid content decreases from 16.10 to 11.04mg/100. This decrease may be due to destruction caused by heat. Highest mean ascorbic acid was found at T_0 (16.10mg/100) and lowest mean ascorbic acid was found at T_7 (11.04mg/100). These results agree with those reported by Mostafa (2002).

Table 2: Proximate composition and antioxidant activity of cherry juice

Parameter	Values
Moisture (%)	83.5±0.45
TSS (˚Brix)	11.8±0.05
pH	4.27±0.09
Acidity (%)	0.27±0.01
Ascorbic acid (mg/100g)	16.10±0.22
Total sugars (%)	9.9±0.05
Total solids (%)	16.5±0.55
Non-enzymatic browning	0.07±0.01
DPPH (%)	45.71 ± 0.05
FRAP (µM TE/g)	180.02 ± 0.09
Total phenols (mg/g GAE/g)	445.00 ± 0.57
Anthocyanins (mg/100g F.W)	13.00 ± 0.05

Table 3: Proximate parameters of cherry concentrate

	Moisture (%)	TSS (°Brix)	pH	Acidity (%)	Ascorbic acid (mg/100g)	Reducing sugars (%)	Total sugars (%)	Total solids (%)	NEB
T_0	83.50±0.4[a]	11.8±0.06[h]	4.27±0.05[a]	0.27±0.05[h]	16.10±0.10[a]	8.10±0.09[h]	9.9±0.05[h]	16.50±0.30[h]	0.07±0.05[e]
T_1	72.30±0.4[b]	20±0.05[g]	4.20±0.01[b]	0.28±0.05[g]	15.82±0.09[b]	18.34±0.06[g]	24.09±0.04[g]	23.70±0.32[g]	0.08±0.05[e]
T_2	68.40±0.4[c]	26.4±0.04[f]	4.06±0.01[c]	0.39±0.04[f]	14.37±0.08[c]	24.56±0.06[f]	28.67±0.06[f]	29.60±0.31[f]	0.10±0.04[d]
T_3	63.20±0.4[d]	35.2±0.04[e]	3.98±0.05[d]	0.45±0.03[e]	13.50±0.08[d]	30.74±0.05[e]	34.56±0.06[e]	36.80±0.32[e]	0.11±0.02[d]
T_4	55.32±0.5[e]	37.4±0.02[d]	3.59±0.01[e]	0.52±0.04[d]	12.90±0.06[e]	38.65±0.05[d]	40.21±0.04[d]	44.68±0.30[d]	0.13±0.02[c]
T_5	47.56±0.52[f]	50±0.01[c]	3.37±0.01[f]	0.60±0.02[c]	12.27±0.04[f]	46.32±0.04[c]	48.34±0.01[c]	52.4±0.35[c]	0.14±0.02[b]
T_6	40.57±0.5[g]	55.2±0.02[b]	3.25±0.01[g]	0.80±0.02[b]	11.77±0.02[g]	52.21±0.02[b]	57.11±0.01[b]	59.43±0.38[b]	0.16±0.01[a]
T_7	35.99±0.5[h]	66.8±0.01[a]	3.16±0.01[h]	1.15±0.02[a]	11.04±0.01[h]	60.15±0.02[a]	65.22±0.02[a]	64.01±0.41[a]	0.17±0.01[a]

Values are expressed as mean ± standard deviation. Means having different letters within the column differ significantly at $p<0.05$.

Effect of vacuum concentration on total phenols, anthocyanin, antioxidant properties and colour parameters of cherry juice

Data in Table 4 shows the result of total phenols, anthocyanin and antioxidant properties are in agreement with those observed by Mir and Nath (1993) and Dyab *et al.*, (2003).The total phenol content gets increased from 445.00 to 451.01mg/g GAE/g. Highest mean total phenol was found at T_7 (451.01mg/g GAE/g) while the lowest mean total phenol was found at T_0 (445.00mg/g GAE/g). Similar trend was shown by anthocyanin content and antioxidant content which gets increased from T_0 to T_7.However the anthocyanin content gets degraded to some extent due to heating and gets polymerized with other phenolic compounds. Highest mean FRAP content was found at T_7 (183.07µM TE/g) and lowest mean FRAP content was found at T_0 (180.02µM TE/g). Highest mean DPPH content was found atT_7 (49.23%) while lowest mean DPPH was found at T_0 (45.71%). Highest mean anthocyanin was found at T_7 (16.22mg/g 100g F.W) and lowest mean was found at T_0 (13.00mg/g 100g F.W). This increase was due to concentration of juice by which water content gets decreased and these constituents get increased.

The data in Table 4 shows the results of colour change during concentration of cherry juice at different colour intervals. The L^* values get decreased from 16.23 to 1.85 shows that the colour of the cherry juice concentrate was changing from light red and becoming darker as non-enzymatic browning progressed. Burdurlu and Karadeniz, (2003) and Koca *et al.*, (2003) also reported a decrease in L* for apple and citrus juice concentrates respectively. The increase in a* (redness) value with increase in time is due to appearance of melanoidins which increase the reddish tone. An increase in a* value with time has also been reported by Tosun (2004) for zile pemezi (concentrated grape juice with a Brix content of 83.2°Brix). The decrease in b* values in cherry concentrate is associated with a decrease in yellowness of cherry juice concentrate. Similar results were also depicted by Bharty and Singh (2015) while working on processing effect on sweet cherry into sweet juice concentrate with special reference to its quality characteristics and Medeni Maskan (2006) during vacuum evaporation process of pomegranate juice.

Table 4: Mean and mean separation of total phenols, anthocyanin and antioxidant activity of cherry concentrate

Concentrated cherry juice	Total phenols (mg/g GAE/g)	Anthocyanin (mg/g 100g F.W)	DPPH (%)	FRAP (µM TE/g)	L^*	a^*	b^*
T_0	445.00 ±0.05[f]	13.00±0.05[e]	45.71±0.02[e]	180.02±0.05[f]	16.23±20[a]	9.81±0.50[f]	7.09±0.18[a]
T_1	445.77±0.09[e]	14.34±0.05[d]	46.99±0.02[d]	180.32±0.05[e]	13.17±22[b]	10.22±0.45[e]	6.72±0.16[b]
T_2	446.69±0.09[d]	14.69±0.09[cd]	47.45±0.02[c]	180.70±0.05[e]	9.22±20[c]	10.62±0.45[e]	6.29±0.10[b]
T_3	447.58±0.06[c]	14.99±0.09[c]	47.78±0.02[bc]	181.09±0.01[d]	7.95±18[d]	10.99±0.30[d]	6.07±0.9[c]
T_4	448.62±0.06[b]	15.29±0.06[bc]	48.28±0.03[bc]	181.58±0.01[c]	5.12±10[e]	11.86±0.10[c]	5.88±0.9[d]
T_5	449.27±0.05[ab]	15.62±0.06[ab]	49.45±0.03[ab]	182.25±0.05[b]	4.22±0.9[f]	12.40±0.10[b]	5.57±0.6[d]
T_6	450.18±0.05[a]	15.85±0.04[ab]	49.90±0.04[ab]	182.79±0.05[ab]	2.35±0.9[g]	13.37±0.9[a]	5.22±0.5[e]
T_7	451.01±0.05[a]	16.22±0.05[a]	50.23±0.04[a]	183.07±0.01[a]	1.85±0.5[h]	13.79±0.6[a]	5.01±0.5[f]

Values are expressed as mean ± standard deviation Means having different letters within the column differ significantly at $p<0.05$.

Degradation kinetics of cherry concentrate at various temperatures (60 °C, 70 °C and 80 °C).

Thermal degradation of cherry concentrate was studied in 66.8˚Brix concentrate at 60, 70 and 80°C.

Degradation kinetics of proximate parameters of cherry concentrate at 60˚C

The data regarding the degradation kinetics of proximate components of cherry concentrate at 60°C is shown in Table 5.The moisture content (%) shows gradual degradation with increase in storage time. Highest mean moisture content was found at T_7a (35.99%) while the lowest mean moisture content was found at T_7f (26.50 %). The TSS (˚Brix) gets increased with storage time as the moisture content get decreased. Highest mean TSS was found at T_7f (71.8) while lowest mean TSS was found at T_7a (66.8). The acidity shows decrease in pattern and get degraded from T_7a (1.15%) to T_7f (0.47%). The pH shows increase in pattern with increase in time. Lowest mean pH was found at T_7a (3.16), while the highest mean pH was found at T_7f (3.88). The ascorbic acid shows decrease in trend with increase in storage time. Highest mean ascorbic acid was found at T_7a (11.04 mg/100) and lowest mean was found at T_7f (9.68 mg/100). The reducing (%) and total sugars (%) also shows increase in trend with increase in time. Highest mean reducing sugar was found at T_7f (62.46%) while the lowest mean was found at T_7a (60.15%) and highest mean total sugar was found at T_7f (67.39%) and lowest mean was found at T_7a (65.22%). The total solids (%) shows similar increase in trend with time and the highest mean total solid was found at T_7f (73.5%) while the lowest mean was found at (64.01%).The degradation was more rapid in first two hours and rather gets decreased with the course of time treatment. This shows rate of degradation is directly proportion to the concentration.

Degradation kinetics of total phenols, anthocyanin, antioxidant content and colour in cherry concentrate at 60°C

The data regarding the degradation kinetics of total phenols, anthocyanin and antioxidant content of cherry concentrate at 60°C is shown in Table 6. The total phenol (mg/g GAE) content shows gradual degradation with increase in storage time. Highest mean total phenol content was found at T_7a (451.01 mg/g GAE**)** while the lowest mean total phenol content was found at T_7f (441.09 mg/g GAE).The antioxidant content also shows similar trend. Highest mean DPPH (%) was found at T_7a (49.23%) and the lowest mean DPPH was found at T_7f (41.50%).Also highest mean FRAP (µM TE/g) content was found at T_7a (183.07µM TE/g) while the lowest mean FRAP content was found at T_7f (172.14µMTE/g). Anthocyanin content in fruit juices is highly unstable in fruit juices and gets degraded more severely with increase in temperature and time. At 60°C about 50-63% of anthocyanin gets degraded. Highest mean anthocyanin was found at T_7a (16.22mg/g 100g F.W) and lowest mean anthocyanin was found at T_7f (8.90mg/g 100g F.W). Similar result was depicted by Yalcinoz et al (2015).

Colour of cherry concentrate during thermal treatment was characterized in terms of L^*, a^* and b^* values. It was observed that L^*, a^* and b^* decrease during heating process.

Table 5: Degradation kinetics of proximate parameters of cherry concentrate at 60°C

Concentrated cherry juice	Moisture (%)	TSS (˚Brix)	Acidity (%)	pH	Ascorbic acid (mg/100)	Reducing sugars (%)	Total sugars (%)	Total solids (%)
T_7a	$35.99{\pm}0.10^a$	$66.8{\pm}0.01^d$	$1.15{\pm}0.01^a$	$3.16{\pm}0.1^f$	$11.04{\pm}01^a$	$60.15{\pm}0.09^c$	$65.22{\pm}0.10^d$	$64.01{\pm}0.09^f$
T_7b	$31.78{\pm}0.14^b$	$68.8{\pm}0.02^c$	$0.77{\pm}0.01^b$	$3.35{\pm}0.02^e$	$9.97{\pm}0.01^b$	$61.76{\pm}0.06^b$	$66.65{\pm}0.09^c$	$68.22{\pm}0.06^e$
T_7c	$29.40{\pm}0.16^c$	$70.2{\pm}0.02^b$	$0.67{\pm}0.01^c$	$3.51{\pm}0.01^d$	$9.20{\pm}0.01^c$	$62.32{\pm}0.05^{bc}$	$67.20{\pm}0.09^b$	$70.6{\pm}0.02^d$
T_7d	$28.88{\pm}0.18^d$	$70.8{\pm}0.01^{ab}$	$0.60{\pm}0.01^d$	$3.64{\pm}0.01^c$	$8.84{\pm}0.01^d$	$63.20{\pm}0.04^{ab}$	$67.71{\pm}0.08^{ab}$	$71.12{\pm}0.05^c$
T_7e	$27.64{\pm}0.20^e$	$71.4{\pm}0.02^a$	$0.55{\pm}0.01^e$	$3.76{\pm}0.01^b$	$8.47{\pm}0.01^e$	$63.42{\pm}0.02^a$	$68.64{\pm}0.06^{ab}$	$72.36{\pm}0.05^b$
T_7f	$26.50{\pm}0.22^f$	$71.8{\pm}0.01^a$	$0.49{\pm}0.01^f$	$3.88{\pm}0.01^a$	$8.18{\pm}0.01^f$	$63.86{\pm}0.02^a$	$68.95{\pm}0.05^a$	$73.5{\pm}0.02^a$

Values are expressed as mean ± standard deviation. Means having different letters within the column differ significantly at $p<0.05$

Table 6: Degradation kinetics of total phenols, anthocyanin and antioxidant activity of cherry concentrate at 60°C

Concentrated cherry juice	Total phenols (mg/g GAE/g)	Anthocyanin (mg/g 100g F.W)	DPPH (%)	FRAP (µM TE/g)	L^*	a^*	b^*
T_7a	451.01±0.05[a]	16.22±0.05[a]	50.23±0.04[a]	183.07±0.05[a]	1.85±0.5[a]	13.79±0.6[a]	5.01±0.5[a]
T_7b	447.79±0.04[b]	10.80±0.05[b]	47.01±0.04[b]	179.85±0.06[b]	1.70±0.5[ab]	8.60±0.9[b]	4.27±0.6[b]
T_7c	445.56±0.04[c]	9.43±0.06[c]	45.89±0.02[c]	176.60±0.06[c]	1.63±0.6[b]	6.55±0.9[c]	3.87±0.9[bc]
T_7d	443.36±0.04[d]	9.10±0.04[d]	44.74±0.02[d]	175.46±0.06[d]	1.55±0.6[c]	5.89±0.10[d]	3.22±0.9[c]
T_7e	442.21±0.02[e]	8.91±0.04[e]	43.61±0.05[e]	173.30±0.04[e]	1.40±0.9[d]	5.00±0.16[e]	2.89±0.10[e]
T_7f	441.09±0.02[f]	8.60±0.02[f]	42.50±0.05[f]	172.14±0.04[f]	1.33±0.10[e]	4.46±0.10[f]	2.50±0.10[f]

Values are expressed as mean ± standard deviation. Means having different letters within the column differ significantly at $p<0.05$

At 60°C, decrease in a^* value was nearly 57.5%, while decrease in b^* value was 29.4% and decrease in L^* value was 26.5%. The L^* value decrease significantly with time and treatment temperature. Reduction in b^* and L^* were not severe as compared to a^* value. Decrease of Hunter L^* and a^* values was expressed due to fading of the red colour as heat destroyed anthocyanin pigments which are unstable in fruit juices. Similar results was depicted by Chutintrasri *et al.*, (2007) and Barreiro *et al.*, (1997).

Degradation kinetics of proximate composition of cherry concentrate at 70°C

The data regarding the degradation kinetics of proximate components of cherry concentrate at 70°C is shown in Table 7.The moisture content (%) shows gradual degradation with increase in storage time. Highest mean moisture content was found at T_7f (35.99%) while the lowest mean moisture content was found at T_7a (25.50 %). The TSS (˚Brix) gets increased with storage time. Highest mean TSS was found at T_7f (72.8) while lowest mean TSS was found at T_7a (66.8). The acidity shows decrease in pattern and get degraded from T_7a (1.15) to T_7f (0.27). The pH shows increase in pattern with increase in time. Lowest mean pH was found at T_7a (3.16), while the highest mean pH was found at T_7f (3.99). The ascorbic acid shows decrease in trend with increase in storage time. Highest mean ascorbic acid was found at T_7a (11.04) and lowest mean was found at T_7f (7.02). The reducing (%) and total sugars (%) also shows increase in trend. Highest mean reducing sugar was found at T_7f (63.36) while the lowest mean was found at T_7a (60.15). Highest mean total sugar was found at T_7f (68.93) and lowest mean was found at T_7a (65.22). The total solids (%) also shows similar increase in trend with time and the highest mean total solid was found at T_7f (74.5) while the lowest mean was found at (64.01).The degradation was more than that was found at 60°C.

Degradation kinetics of total phenols, anthocyanin, antioxidant activity and colour of cherry concentrate at 70°C

The data regarding the degradation kinetics of total phenols, anthocyanin and antioxidant content of cherry concentrate at 70°C is shown in Table 8. The total phenol (mg/g GAE) content shows gradual degradation with increase in storage time. Highest mean total phenol content was found at T_7a (451.01) while the lowest mean total phenol content was found at T_7f (448.23).

Table 7: Degradation kinetics of proximate parameters of cherry concentrate at 70°C

Concentrated cherry juice	Moisture (%)	TSS (˚Brix)	Acidity (%)	pH	Ascorbic acid (mg/100)	Reducing sugars (%)	Total sugars (%)	Total solids (%)
T_7a	35.99±0.10[a]	66.8±0.01[d]	1.15±0.04[a]	3.16±0.01[f]	11.04±0.1[a]	60.15±0.09[d]	65.22±0.10[e]	66.01±0.10[e]
T_7b	29.78±0.08[b]	70.0±0.02[c]	0.79±0.02[b]	3.41±0.02[e]	9.27±0.02[b]	61.36±0.09[c]	66.65±0.09[d]	70.22±0.09[d]
T_7c	29.20±0.08[b]	70.8±0.02[c]	0.58±0.02[c]	3.66±0.01[d]	8.80±0.02[c]	61.82±0.06[c]	67.20±0.08[c]	70.8±0.06[d]
T_7d	28.88±0.06[c]	71.6±0.01[b]	0.46±0.04[d]	3.78±0.01[c]	8.64±0.04[d]	62.20±0.05[b]	67.86±0.06[b]	71.12±0.04[c]
T_7e	27.64±0.05[d]	72.0±0.02[ab]	0.35±0.06[e]	3.91±0.01[b]	7.47±0.04[e]	62.82±0.04[a]	68.16±0.06[a]	72.36±0.05[b]
T_7f	25.50±0.04[e]	72.8±0.01[a]	0.27±0.05[f]	3.99±0.01[a]	7.28±0.05[f]	63.36±0.02[a]	68.93±0.05[a]	74.5±0.04[a]

Values are expressed as mean ± standard deviation. Means having different letters within the column differ significantly at $p<0.05$.

Table 8: Degradation kinetics of total phenols, anthocyanin and antioxidant activity of cherry concentrate at 70°C

Concentrated cherry juice	Total phenols (mg/g GAE/g)	Anthocyanin (mg/g 100g F.W)	DPPH (%)	FRAP (µM TE/g)	L^*	a^*	b^*
T_7a	451.01±0.05^a	16.22±0.05^a	49.23±0.06^a	183.07±0.09^a	1.85±0.5^a	13.79±0.6^a	5.01±0.5^a
T_7b	449.51±0.04^b	9.75±0.06^b	47.95±0.03^b	181.70±0.06^b	1.60±0.5^b	8.98±0.6^b	4.45±0.6^b
T_7c	448.17±0.04^c	8.42±0.06^c	46.74±0.04^c	180.38±0.05^c	1.40±0.6^c	7.22±0.4^c	4.01±0.9^c
T_7d	447.92±0.04^d	8.16±0.04^d	45.49±0.06^d	180.05±0.04^d	1.32±0.9^d	6.0±0.5^d	3.80±0.10^d
T_7e	446.59±0.02^e	7.81±0.04^e	44.13±0.05^e	179.85±0.02^e	1.20±0.10^e	5.48±0.5^e	3.52±0.9^e
T_7f	445.23±0.02^f	7.49±0.02^f	43.88±0.08^f	179.47±0.02^f	1.02±0.10^f	5.02±0.5^f	2.12±0.5^f

Values are expressed as mean ± standard deviation Means having different letters within the column differ significantly at p<0.05

The antioxidant content also shows similar trend. Highest mean DPPH (%) was found at T_7a (49.23) and the lowest mean DPPH was found at T_7f (46.88).Also highest mean FRAP (µM TE/g) content was found at T_7a (183.07) while the lowest mean FRAP content was found at T_7f (179.47). Anthocyanin content in fruit juices is highly unstable in fruit juices and gets degraded more severely with increase in temperature and time. Highest mean anthocyanin was found at T7a (16.22) and lowest mean anthocyanin was found at T7f (7.89) Cemeroglu *et al.*, (1994) shows similar results.

Colour of cherry concentrate during thermal treatment was characterized in terms of L^*, a^* and b^* values. It was observed that L^*, a^* and b^* decrease during heating process. At 70°C, decrease in a^* value was nearly 61.6%, while decrease in b^* value was 39.4% and decrease in L^* value was 30.5%. The L^* value decrease significantly with time and treatment temperature. Reduction in b^* and L^* were not severe as compared to a^* value. Decrease of Hunter L^* and a^* values was expressed due to fading of the red colour as heat destroyed anthocyanin pigments which are unstable in fruit juices. Similar results were depicted by Chutintrasri *et al.*, (2007) and Barreiro *et al.*, (1997).

Degradation kinetics of proximate composition of cherry concentrate at 80°C

The data regarding the degradation kinetics of proximate components of cherry concentrate at 80°C is shown in Table 9.The moisture (%) content shows gradual degradation with increase in storage time. Highest mean moisture content was found at T_7a (35.99%) while the lowest mean moisture content was found at T_7f (24.21 %). The TSS (˚Brix) shows increase in trend with storage time. Highest mean TSS was found at T_7f (73.8) while lowest mean TSS was found at T_7a (66.8). The acidity shows decrease in trend and get degraded from T_7a (1.15) to T_7f (0.15). The pH shows increase in pattern with increase in time. Lowest mean pH was found at T_7a (3.16), while the highest mean pH was found at T_7f (4.21). The ascorbic acid shows decrease in trend with increase in storage time. Highest mean ascorbic acid was found at T_7a (11.04) and lowest mean was found at T_7f (9.28). The reducing (%) and total sugars (%) also shows increase in trend. Highest mean reducing sugar was found at T_7f (64.42) while the lowest mean was found at T_7a (60.15) and highest mean total sugar was found at T_7f (69.32) and lowest mean was found at T_7a (65.22).

Table 9: Degradation kinetics of proximate parameters of cherry concentrate at 80°C

Concentrated cherry juice	Moisture (%)	TSS (˚Brix)	Acidity (%)	pH	Ascorbic acid (mg/100)	Reducing sugars (%)	Total sugars (%)	Total solids (%)
T_7a	35.99±0.10^a	66.8±0.02^e	1.15±0.04^a	3.16±0.06^f	11.22±0.0^a	60.15±0.09^e	65.22±0.10^e	64.01±0.10^f
T_7b	28.85±0.12^b	70.4±0.02^d	0.68±0.04^b	3.76±0.05^e	8.18±0.04^b	61.87±0.09^d	66.9±0.06^d	71.15±0.06^e
T_7c	27.43±0.14^c	71.2±0.01^c	0.56±0.03^c	3.84±0.05^d	7.74±0.05^c	62.23±0.08^c	67.54±0.06^c	72.15±0.05^d
T_7d	26.11±0.18^d	72.8±0.01^b	0.40±0.02^d	3.97±0.04^c	6.89±0.03^d	62.90±0.06^{bc}	68.12±0.04^b	73.89±0.04^c
T_7e	25.61±0.20^e	73.2±0.01^{ab}	0.28±0.05^e	4.05±0.03^b	7.40±0.04^e	63.7±0.03^b	68.89±0.03^{ab}	74.39±0.04^b
T_7f	24.21±0.22^f	73.8±0.01^a	0.15±0.06^f	4.21±0.04^a	7.02±0.02^f	64.42±0.04^a	69.23±0.02^a	75.79±0.02^a

Values are expressed as mean ± standard deviation. Means having different letters within the column differ significantly at p<0.05

Table 10: Degradation kinetics of total phenols, anthocyanin and antioxidant activity of cherry concentrate at 80°C

Concentrated cherry juice	Total phenols (mg/g GAE/g)	Anthocyanin (mg/g 100gF.W)	DPPH (%)	FRAP (μM TE/g)	L^*	a^*	b^*
T_7a	451.01 ± 0.05^a	15.01 ± 0.05^a	49.23 ± 0.06^a	183.07 ± 0.09^a	1.85 ± 0.5^a	12.79 ± 0.6^a	5.01 ± 0.5^a
T_7b	448.65 ± 0.05^b	7.50 ± 0.05^b	46.76 ± 0.06^b	178.71 ± 0.06^b	1.55 ± 0.6^b	7.80 ± 0.5^b	3.99 ± 0.6^b
T_7c	445.78 ± 0.04^c	7.02 ± 0.04^c	44.25 ± 0.05^c	176.21 ± 0.05^b	1.37 ± 0.6^c	5.21 ± 0.4^c	3.76 ± 0.6^{bc}
T_7d	443.18 ± 0.04^d	6.72 ± 0.04^d	42.80 ± 0.04^d	175.69 ± 0.04^d	1.20 ± 0.9^d	3.78 ± 0.4^d	2.11 ± 0.9^c
T_7e	442.69 ± 0.02^e	6.24 ± 0.02^e	41.18 ± 0.02^e	174.28 ± 0.02^e	1.03 ± 0.9^e	2.22 ± 0.5^e	1.77 ± 0.9^d
T_7f	440.08 ± 0.02^f	6.02 ± 0.02^f	40.68 ± 0.02^f	173.81 ± 0.02^f	0.89 ± 0.10^f	1.91 ± 0.5^f	1.20 ± 0.9^e

Values are expressed as mean ± standard deviation. Means having different letters within the column differ significantly at $p<0.05$

The total solids (%) shows similar trend with time and the highest mean total solid was found at T_7f (75.79) while the lowest mean was found at (64.01).The degradation was more rapid in first two hours and rather gets decreased with the course of time treatment. This shows rate of degradation is directly proportion to the concentration. At this temperature, degradation is more than that was found at 60 and 70°C.

Degradation kinetics of total phenols, anthocyanin, antioxidant activity and colour of cherry concentrate at 80°C

The data regarding the degradation kinetics of total phenols, anthocyanin and antioxidant content of cherry concentrate at 80°C is shown in Table 10. The total phenol (mg/g GAE) content shows gradual degradation with increase in storage time. Highest mean total phenol content was found at T_7a (451.01) while the lowest mean total phenol content was found at T_7f (446.08).The antioxidant content also shows similar trend. Highest mean DPPH (%) was found at T_7a (49.23) and the lowest mean DPPH was found at T_7f (44.68).Also highest mean FRAP (μM TE/g) content was found at T_7a (183.07) while the lowest mean FRAP content was found at T_7f (178.01). Anthocyanin content in fruit juices is highly unstable in fruit juices and gets degraded more severely with increase in temperature and time. At 80°C about 80.70% of anthocyanin gets degraded. Highest mean anthocyanin was found at T_7a (16.22) and lowest mean anthocyanin was found at T_7f (6.02). These results show similarity with the results of Cemeroglu *et al.*, (1994).

Colour of cherry concentrate during thermal treatment was characterized in terms of L^*, a^* and b^* values. It was observed that L^*, a^* and b^* decrease during heating process. At 80°C, decrease in a^* value was nearly 71%, while decrease in b^* value was 45.4% and decrease in L^* value was 35.3%. The L^* value decrease significantly with time and treatment temperature. Reduction in b^* and L^* were not severe as compared to a^* value. Decrease of Hunter L^* and a^* values was expressed due to fading of the red colour as heat destroyed anthocyanin pigments which are unstable in fruit juices. Similar results was depicted by Chutintrasri *et al.*, (2007) and Barreiro *et al.*, (1997).

CONCLUSION

Cherry juice is an important source of phenolic compounds such as anthocyanins and, also good source of natural antioxidants. Consumption of cherries decreased markers for oxidative stress, inflammation, exercise-induced muscle soreness and loss of nutrients strength, and blood pressure acutely after ingesting cherries. It also has beneficial effects on arthritis, diabetes, blood lipids, sleep, cognitive functions, and possibly mood. Cherry juice has a strong flavor and can have high acidity, so when produced commercially as a beverage product

CONFLICT OF INTEREST

The authors don't have any conflict of interest.

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