Sonication and Microwave Processing of Phalsa Drink: A Synergistic Approach

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ABSTRACT
Non-thermal processing techniques not only prevent the nutritional losses but also improve the food quality and security. In recent years, consumers demand healthy, safe, and nutritious food. Ultrasound is one of the emerging techniques, which is being studied extensively on various food products. On the other hand, in microwave treatment heat transfer is rapid, so sensory characteristics, nutrients, vitamin content, flavor and color of food are well preserved. A study was conducted on combined effect of sonication and microwave processing on phalsa drink and stored for 120 days. The juice was filled in plastic bottles, sealed and after microwave treatment immediately chilled in ice cold water at 4 ± 1°C. It was observed that synergistic approach of sonication and microwave had shown positive impact on nutritional quality of phalsa drink as it increased (p ≤ 0.05) the total phenolic, flavonoids, reducing power and antioxidant properties of phalsa drink and reduced the microbial load with increase in sonication time from 2 to 8 min. It was concluded that combination of sonication and microwave can be employed without chemical preservatives for treatment of phalsa drink with better retention of nutritional attributes.

KEYWORDS
Phalsa drink; sonication; microwave; bioactive compounds; antioxidant properties

Introduction

Products from natural sources are being used from centuries (Mahmood, 2019; Ranjha et al., 2020a, 2020b). Fruits and vegetables play an important role in nourishing and healthy life due to the presence of phytochemicals such as antioxidants, phenolic compounds, carotenoids, tannins and ascorbic acid (Gardner et al., 2000; Irfan et al., 2019; Ranjha et al., 2021). Fruits and vegetables exhibit health-promoting properties by delaying the aging process and by reducing the risk of various diseases including cardiovascular disease, cancer rheumatoid arthritis, cataract, Parkinsons or Alzheimers diseases (Sabtain et al., 2021; Shehzadi et al., 2008; Szajdek and Borowska, 2008). Phalsa (Grewia asiatica L.) is an exotic bush of Tiliaceae family and is very liked for its refreshing and relishing taste, eye appealing color, excellent fragrance and fantastic nutritional and medicinal worth. It is considered as a small fruit crop from horticultural point of view but significant in folk medicine. Ripe fruits are eaten fresh, used in desserts and processed into energizing and refreshing drinks, squash, juice and jam etc. According to ancient treatise, phalsa fruits are cooling tonic and allay thirst. They are a rich source of minerals, vitamins and fiber while low in fat and calories (Yadav, 1999). The storage of phalsa fruit in raw form is difficult due to its highly perishable characteristics (Tiwari et al., 2014). During the last few years, consumers have been demanding for healthy, safe and nutritious food. Consequently,
processors are attempting novel non-thermal techniques compared to traditional and thermal processing methods (Cheok et al., 2013; Munir et al., 2020). Thermal treatments ensure food safety and extend storage life, but they can cause losses of heat sensitive nutrients of the product (Gomez-Mejia et al., 2011). Non-thermal techniques such as ultrasound and high hydrostatic pressure (HHP) have been researched in recent few years (Mehmood et al., 2019; Munir et al., 2020). Microbial contamination can be reduced through these non-thermal techniques with improving other qualitative parameters of drinks (Jabbar, Abid, Hu, Wu, Hashim, Lei, Zhu, Zeng, 2014b; Nadeem, Ubaid, Qureshi, Munir, Mehmood, 2018a), however enzymes cannot be inactivated by these non-thermal technologies alone (Seyderhelm et al., 1996; Villamiel and de Jong, 2000a). The combination of non-thermal processing techniques is one of the innovative way of food processing to enhance the quality, safety and storage stability of fruits and vegetables juices (Rupasinghe and Yu, 2012). Ultrasound technique is an innovative food processing technology through which health related compounds and other quality parameters of fruit juices have efficaciously been improved (Bhat et al., 2011; Rawson et al., 2011). Additionally, due to its less energy consumption, eco-friendly and short processing time this technique is considered as more useful (Mason et al., 2005; Tiwari et al., 2008). Sonication treatment significantly extends vitamin C, DPPH free radical scavenging function, phenolic compounds and total antioxidant capacity along with significant reduction in microbial population of fruit juices (Nadeem, Ubaid, Qureshi, Munir, Mehmood, 2018a; Qureshi et al., 2016, 2020). Microwave can be defined as a part of electromagnetic waves which have frequency range in between 300 MHz and 300 GHz accompanying to wavelength from 1 mm to 1 m. Microwave frequencies of 915 MHz and 2.45 GHz can be utilized for scientific, medicinal and industrial applications (Puligundla et al., 2013). In 1930s, the exploitation of dielectric heating application in food industry started in radio frequency range (Puschner, 1966). The require energy transfer rate enhancement lead to an increased frequency; the microwaves. In 1952 the first patent, describing an industrial conveyor belt microwave system was bring out but its first use was started ten years later. This was led to the desire for high power microwave sources to be developed.

So, keeping in view the importance of phalsa drink and increasing trend toward nutritious foods, this study was designed to prepare phalsa drink of higher nutritional values with minimal processing and without chemical preservatives. The objective of study was to investigate the combined effects of sonication and microwaves treatments on the physiochemical attributes, anti-oxidant activity, and shelf stability of phalsa drink during refrigerated storage.

Materials and methods

Fully ripe and good quality phalsa fruit were procured from the local market of Sargodha, and other raw materials like CMC, preservatives, citric acid and plastic bottles were also purchased from local market of Sargodha, Pakistan. The fruits were sorted and washed to remove dirt, dust and damaged fruits. The phalsa fruit was washed and crushed in a juice extractor and juice was obtained separately. The juice was filtered through double layer muslin cloth for removing solid particles.

Preparation of Phalsa Drink

Fruit, sugar, citric acid, and KMS were separately weighed. Water was also measured as per formula (Table 1). Phalsa fruit and all other ingredients were mixed in a blender (Moulinex LM209041 Super Blender) to make phalsa drink.

Ultrasonic treatment

After preparation of phalsa drink, it was treated by ultrasonic processor (UP400S, Hielscher Ultronics GmbH Hielscher USA, Inc.) of 525 W with a probe of 0.5 inch at temperature of 15°C. The juice (200 mL) in a 500 mL beaker was placed in a sonicator and sonication was performed at 70% amplitude
for 2–10 min (Table 2) with pulse duration of 5 s on and 5 s off and 20 kHz frequency. Sample treatment was carried out in triplicate. The depth of probe was 25 mm dip in phalsa ready to drink.

Sonication (20 kHz frequency, 70% amplitude level (525 W power) and pulse duration 5 s on and 5 s off, time range 2–10 min at 15°C) of all the samples (200 mL) was performed by using an ultrasonic processor.

**Microwave Processing**

After sonication of phalsa drink, microwave treatment was applied in a microwave oven (Model: DW-128 G, microwave frequency: 2450 MHz, output: 900 W) for 120 s to achieve 95°C temperature of phalsa drink. Time (120 s) was selected for treatment by preliminary trials. In preliminary trials, juice sample (200 mL) was given microwave treatment ranging from 30 to 150 s and 95°C temperature was recorded at 120 s. The juice (200 mL) after microwave treatment was filled in plastic bottles, sealed and immediately chilled in ice cold water at 4 ± 1°Cs.

**Chemical preservation**

Potassium-meta bisulfite (KMS) was used as chemical preservatives in treatment T0+ to compare the drink with control and other treatments. The treatment plan is shown in Table 2.

**Physicochemical analysis**

**Total Soluble Solids**

Total soluble solids were determined by hand refractometer. pH of the samples was measured by pH meter (AD 1040 Benchtop meter, Adwa, Hungary). Acidity was measured by the standard titration method as described in AOAC (2016). Vitamin C was determined by dye reduction method as reported in AOAC (2016).

**Total Phenolic Content**

Total phenolic content was measured spectrophotometrically by the method described by Singleton et al. (1999) with little modification. After dilution 0.5 mL of sample was taken for performing the experiment.

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**Table 1. Formulation of phalsa drink.**

| Ingredients       | Quantity |
|-------------------|----------|
| Phalsa fruit      | 100 g    |
| Water             | 500 mL   |
| Sugar             | 80 g     |
| CMC               | 2 g      |
| Citric acid       | 1 g      |
| KMS               | 0.1%     |

**Table 2. Treatment plan of phalsa drink.**

| Treatment | Quantity                          |
|-----------|-----------------------------------|
| T0-       | No preservative                   |
| T0+       | 0.05% KMS                         |
| T1        | 2 min sonication + 2 min microwave |
| T2        | 4 min sonication + 2 min microwave |
| T3        | 6 min sonication + 2 min microwave |
| T4        | 8 min sonication + 2 min microwave |
| T5        | 10 min sonication + 2 min microwave |
Gallic acid was used to make a standard solution for calibration curve. The results of total phenolic were expressed as mg of gallic acid equivalent (GAE)/100 mL of drink. Flavonoids contents were measured by the described method of Jabbar, Abid, Hu, Wu, Hashim, Lei, Zhu, Zeng, (2014b). Catechin (in ethanol) was used as a standard and the results were expressed as mg of (±) catechin equivalent (CE) per 100 mL of sample.

**Total Anthocyanin Contents**

Total anthocyanin contents were measured by the described method of Jabbar, Abid, Hu, Wu, Hashim, Lei, Zhu, Zeng, (2014b). For anthocyanin determination 5 mL Phalsa drink was centrifuge at 5000 rpm for 10 min. 1 mL centrifuged sample was taken in test tube and 9 mL potassium chloride buffer (0.025 M, pH 1.0) solution was added in this test tube. Absorbance was taken at 520 nm then at 700 nm. Again 1 mL centrifuged sample was taken in test tube and 9 mL sodium acetate buffer (0.4 M, pH 4.5) solution was added and absorbance was recorded at 520 nm then at 700 nm. Total anthocyanins were calculated by applying following formula

Total anthocyanins (mg/L) = \( A \times Mw \times DF \times 1000/ (\varepsilon \times 1) \)

Where \( A = (A_{520}–A_{700}) \) pH = 1.0 – (A520–A700) pH = 4.5, MW = 493.2 g/mol, DF = 10,1 = path length (1 cm), Extinction coefficient \( \varepsilon = 28,000 \) L/mol/cm

**Total Anti-Oxidant Activity**

For determination of total antioxidant activity samples of all treatments were tested by using the method stated by Prieto et al. (1999). Ascorbic acid was used for making standard calibration curves and the results were expressed as µg ascorbic acid equivalent (AAE/mL drink).

**Reducing power**

The reducing power of all samples was determined using the method as described by Hegazy and Ibrahim (2012) with some modification. Reducing power ability was calculated using ascorbic acid standard calibrations curves and the results were expressed as mg ascorbic acid equivalent (AAE)/100 mL of sample. The increased absorbance of the sample mixture depicted increased reducing power.

**DPPH Free Radical Scavenging Activity**

Phalsa drink was assessed for DPPH free radical scavenging activity by the method of Yi et al. (2008) with minor changes. Briefly, after diluting 1 mL sample was taken and 1 mL of DPPH (60 µmol in ethanol) solution was added into it. This solution was placed in dark for 30 min and then at 517 nm the absorbance was taken by using spectrophotometer. Similar procedure was done for preparation of control (ethanol) sample. Decrease in absorbance was calculated in the prepared samples and radical scavenging activity was calculated.

**Total Plate Count**

Total plate count was done according to the FDA’s standard method mentioned in bacteriological analytical manual (Maturin and peeler, 2001). One mL sample of phalsa drink was taken into sterile test tubes with micropipette. It was mixed with 9 mL buffered phosphate diluents, shaken for 2 minon low speed until sample was comminuted. Ten mL dilution was prepared by shifting 1 mL of previous dilution to 9 mL. All the dilutions were shaken well. Each dilution test tube was stirred up to mix suspend material that might have settled down and transferred 1 mL from each test tube into appropriately marked duplicate petri dishes. Then, 12–15 mL of plate count media (cooled to 45°C) was poured in plates within 15 min of time of original dilution and allowed to set. Dilutions were then
poured in control plates for each series of samples then mixed samples dilutions and ager medium by rotating petri dishes on the surface. Petri dishes were inverted and incubated for 48 h at 35°C. After incubation colonies on those plates were counted containing between 30 and 300 colonies and multiplied by dilution factor. Arithmetic average was counted plate per gram.

**Statistical Analysis**

The data obtained was statistically analyzed using Statistix 8.1 software (Analytical Software, Tallahassee, FL, USA). Significant differences between mean values were determined by LSD pairwise comparison test at a significance level of $P < .05$.

**Results and discussion**

*Impact of Sonication and Microwave on pH and TSS*

It was observed that during sonication and microwave processing there was not any prominent change in pH of phalsa drink. Similarly, the effect of storage period on the pH of phalsa drink revealed non-significant difference on pH of phalsa juice irrespective of the amplitude level and storage conditions but increasing trend in pH was observed after 120 days storage. The Mean pH value at start of storage study was (3.58 ± 0.09) and after 120 days it was found (3.64 ± 0.16) (Table 3). $T_0$, (3.68 ± 0.03) indicated the maximum pH and the minimum was observed in $T_4$ (3.37 ± 0.08). It was observed that sonication did not show any significant effect on TSS of phalsa drink but slightly decrease was noted after 120 days of storage study. The highest *Brix was found in $T_0+$ (17.93 ± 0.42) while the lowest value was observed in $T_1$ (17.18 ± 1.36). $T_0$ was discarded after 30 days of storage, due to fermentation it was spoiled (Table 4). The results concerning increase in pH and decrease in TSS are similar with the earlier findings of ultrasound carrot-blends (Gao and Rupasinghe, 2012). Nguyen and Nguyen (2018) analyzed the ultrasonic impact on the qualitative parameters of mulberry juice. They noticed that there was non-significant change in the pH of juice. The similar results had also been observed by Cruz-Cansino, Reyes-Hernández, Delgado-Olivares, Jaramillo-Bustos, Ariza-Ortega, Ramirez-Moreno, (2016). Abid et al. (2014) analyzed the sonicated apple juice at different amplitude levels of probe type sonicator. They observed that sonication was not significantly affected the total soluble solids of apple juice during storage as compared to non-sonicated samples. According to Nayak et al. (2018) the treatment methods like pasteurization and thermo-sonication were not significantly affected the total soluble solids of star fruit juice.

*Titratable acidity*

The titratable acidity of all treated samples was not affected significantly but at the end of storage period it was slightly decreased. The maximum acidity was observed in $T_3$ (0.08 ± 0.037%) while the

| Table 3. The mean pH values ± SD of phalsa drink during storage. |
|-------------------|---------|---------|---------|---------|---------|---------|---------|
| **Treatment**     | **0**  | **30** | **60** | **90** | **120** | **Mean** |
| T0-               | 3.70 ± 0.015b | 3.67 ± 0.005b | -       | -       | -       | 3.68 ± 0.03a |
| T0+               | 3.70 ± 0.015b | 3.68 ± 0.005b | 3.50 ± 0.02g | 3.43 ± 0.005j | 3.81 ± 0.01a | 3.63 ± 0.14a |
| T1                | 3.62 ± 0.02 c | 3.68 ± 0.005b | 3.52 ± 0.02f | 3.50 ± 0.005f | 3.79 ± 0.015a | 3.62 ± 0.11a |
| T2                | 3.51 ± 0.015fg | 3.51 ± 0.01fg | 3.41 ± 0.015jk | 3.30 ± 0.005mn | 3.52 ± 0.005fg | 3.45 ± 0.08 c |
| T3                | 3.52 ± 0.015fg | 3.50 ± 0.005fg | 3.35 ± 0.01 l | 3.32 ± 0.005l-n | 3.51 ± 0.005fg | 3.44 ± 0.09 c |
| T4                | 3.46 ± 0.005hi | 3.43 ± 0.01 j | 3.29 ± 0.015 n | 3.25 ± 0.00 o | 3.42 ± 0.005 j | 3.37 ± 0.08d |
| T5                | 3.56 ± 0.015de | 3.52 ± 0.005fg | 3.42 ± 0.015 j | 3.33 ± 0.005 lm | 3.57 ± 0.005d | 3.49 ± 0.15b |
| **Mean**          | 3.58 ± 0.09b | 3.57 ± 0.10 c | 3.41 ± 0.07d | 3.39 ± 0.10e | 3.64 ± 0.16a |

*Means that do not share a letter are significantly different*
Table 4. TSS (values ± SD) of phalsa drink during storage.

| Treatment | Storage (days) |          |          |          |          |          |          |
|-----------|---------------|----------|----------|----------|----------|----------|----------|
|           | 0             | 30       | 60       | 90       | 120      | Mean     |
| T0-       | 17.94 ± 0.1bc | 17.34 ± 0.25 j | -        | -        | -        | 16.96 ± 0.74 g |
| T0+       | 17.95 ± 0.01bc| 17.95 ± 0.05ab | 17.95 ± 0.02bc | 17.95 ± 0.05ab | 17.84 ± 0.01d | 17.93 ± 0.42a |
| T1        | 18.00 ± 0.02a | 17.45 ± 0.05i | 17.17 ± 0.02k | 16.91 ± 0.05n | 16.35 ± 0.01p | 17.18 ± 1.36 f |
| T2        | 18.00 ± 0.01a | 17.70 ± 0.01 f | 17.29 ± 0.01 j | 17.00 ± 0.05 m | 16.65 ± 0.05o | 17.33 ± 0.71e |
| T3        | 17.97 ± 0.1ab | 17.85 ± 0.05d | 17.50 ± 0.15 h | 17.32 ± 0.05j | 17.11 ± 0.0l | 17.55 ± 0.77d |
| T4        | 17.97 ± 0.05ab| 17.84 ± 0.01d | 17.65 ± 0.01 g | 17.54 ± 0.0 h | 17.40 ± 0.05i | 17.68 ± 0.68 c |
| T5        | 17.97 ± 0.1ab | 17.90 ± 0.1c | 17.78 ± 0.2e | 17.70 ± 0.1f | 17.63 ± 0.05 g | 17.80 ± 0.47b |
| Mean      | 17.97 ± 1.02a | 17.72 ± 1.07b | 17.48 ± 0.99 c | 17.30 ± 0.59d | 16.99 ± 1.04e |

*Means that do not share a letter are significantly different.

Table 5. The means values ± SD for Titratable acidity (%) of phalsa drink.

| Treatment | Storage (days) |          |          |          |          |          |          |
|-----------|---------------|----------|----------|----------|----------|----------|----------|
|           | 0             | 30       | 60       | 90       | 120      | Mean     |
| T0-       | 0.08 ± 0.01 c-g | 0.13 ± 0.02a | -        | -        | -        | 0.08 ± 0.037a |
| T0+       | 0.07 ± 0.003 c-g | 0.08 ± 0.002 c-g | 0.08 ± 0.006 c-f | 0.04 ± 0.006k-n | 0.04 ± 0.003mn | 0.06 ± 0.021bc |
| T1        | 0.10 ± 0.006bc | 0.07 ± 0.003e-k | 0.05 ± 0.003 h-n | 0.05 ± 0.003 h-n | 0.04 ± 0.006 l-n | 0.06 ± 0.020bc |
| T2        | 0.08 ± 0.006 c-h | 0.08 ± 0.01 c-e | 0.07 ± 0.003e-k | 0.04 ± 0.003mn | 0.04 ± 0.003mn | 0.06 ± 0.022 c |
| T3        | 0.10 ± 0.006 e-e | 0.12 ± 0.01ab | 0.07 ± 0.010e-k | 0.06 ± 0.003 f-l | 0.05 ± 0.003 j-n | 0.08 ± 0.026a |
| T4        | 0.07 ± 0.006d-e | 0.06 ± 0.003 e-g | 0.07 ± 0.003e-k | 0.06 ± 0.006 g-m | 0.05 ± 0.003 j-n | 0.07 ± 0.012bc |
| T5        | 0.08 ± 0.003 c-g | 0.09 ± 0.01 c-e | 0.07 ± 0.003 c-i | 0.06 ± 0.006 g-m | 0.05 ± 0.006i-n | 0.07 ± 0.015ab |
| Mean      | 0.08 ± 0.01b | 0.09 ± 0.02a | 0.07 ± 0.012 c | 0.052 ± 0.01d | 0.04 ± 0.01e |

*Means that do not share a letter are significantly different.

The lowest acidity was found in T2 (0.06 ± 0.022%). The maximum titratable acidity (0.09 ± 0.02%) was observed at 30th day of storage while the minimum (0.04 ± 0.01%) was noticed at 120 days of study (Table 5). The effect of storage period on the acidity of phalsa drink revealed that, in the start increased in acidity was observed and then it decreased with the passage of time. T0 was discarded after 30 days of storage, due to fermentation it was spoiled. Abid et al. (2014) observed the titratable acidity of sonicated apple juice at 30, 60 and 90% amplitude levels in probe type sonicator. They claimed that during storage sonication did not show any significant changes in titratable acidity of apple juice in all treatments, however, after 21 days, it was slightly reduced. Previously, decrease in titratable acidity of ultra-sonicated apple-carrot juice blend was reported by Gao and Rupasinghe (2012).

**Ascorbic acid**

The results represent significant change in ascorbic acid of sonicated phalsa drink when compared with non-sonicated samples. The highest vitamin C was observed in T4 (374.0 ± 51.55 mg/100 mL) while the lowest ascorbic acid was found in T1 (345.5 ± 35.83 mg/100 mL). During storage ascorbic acid of drink gradually reduced from 0 to 120 days (Table 6). The minimum value of vitamin C was observed at 120 days of storage with mean value of (294.71 ± 5.72 mg/100 ml) and the maximum vitamin C was found at 0 days of storage with mean value of (392.14 ± 4.60 mg/100 ml). Ascorbic acid is an important potential antioxidant which prevents from many heart diseases and cancer (Marin et al., 2012). Nguyen and Nguyen (2018) studied the ultrasonic effect on the mulberry juice. Juice samples were subjected to sonication treatment for 30, 60, 90, and 120 min in bath type sonicator. Results revealed that after 60 min sonication, contents of ascorbic acid (37.4 mg/100 mL) were reached on its peak but reduced when increased the time. This decrease in the vitamin C might be due to from cell fluid during cavitation that was produced by the treatment of ultrasound together with the elimination of dissolved oxygen, leading to an increase in L-ascorbic acid in the juice. Valdramidis, Cullen, Tiwari, O’donnell, (2010) and Petrier et al. (2007) analyzed that, during sonication process oxidative processing can cause
the loss of vitamin C in aerobic and anaerobic environments and the production and use of hydroxyl radicals are associated with it.

**Total Phenolic and Flavonoids Contents**

Highly significant effect of sonication and microwave processing was observed on phenolic contents of phalsa drink (Table 7). The maximum total phenolic contents were found in T4 (132.20 ± 10.67 mg/100 mL) and the minimum in T0 (101.0 ± 7.05 mg/100 mL GAE). The phenolic contents of phalsa drink reduced during storage from 0 to 120 days. The changes in total flavonoids of phalsa drink indicated highly significant effect of ultra-sonication and microwave processing on flavonoids contents. The highest flavonoids were noticed in T4 (478.87 ± 33.42 mg/100 mL CE) while the lowest T0 (408.49 ± 13.30 mg/100 mL CE). The effect of storage period on the flavonoids and phenolic contents of phalsa drink were demonstrated that the concentration of flavonoids and phenolic contents were reduced with the length of storage period (Table 8).

Pérez-Grijalva et al. (2018) reported that microwave treated blackberry mash appeared higher concentration of total phenolic contents as compared to blank samples. Some researchers observed that microwave blanching shows good impact on the concentration of total phenolic contents when performed prior extraction of apple mash, and it was treated by microwave treatment (Gerard and Roberts, 2004).

Saeeduddin et al. (2016) determined the impact of sonication on pear juice for 15, 30, 45, and 60 min of durations. Results revealed significant increased ($p < .05$) in flavonoids during the sonication of 30, 45, and 60 min. From 30 to 60 min of sonication increased range from 189.33 to 222.7 mg/100 mL and these results were compared with 15 min of sonicated treatment and without sonicated treatment which were 180.83 and 179.93 mg/100 mL, respectively. Similar results were earlier observed

### Table 6. The means values ± SD for ascorbic acid (mg/100 mL) of phalsa drink.

| Treatment | 0         | 30        | 60        | 90        | 120       | Mean          |
|-----------|-----------|-----------|-----------|-----------|-----------|---------------|
| T0-       | 395.50 ± 20.1a-b | 352 ± 31.85 c-g | -         | -         | -         | 373.5 ± 32.97a |
| T0+       | 404.50 ± 15.46a-b | 374 ± 26.67a-e | 341.50 ± 25.13d-g | 341.50 ± 14.93d-g | 281.50 ± 27.51k | 348.6 ± 25.94bc |
| T1        | 345.50 ± 30.30 c-g | 384.50 ± 17.15a-c | 334.50 ± 37.64e-h | 334.50 ± 27.02e-h | 328.50 ± 44.04f-h | 345.5 ± 35.83 c |
| T2        | 399.50 ± 24.71a-b | 372 ± 22.21a-e | 367 ± 13.21b-f | 367 ± 26.03b-f | 285.50 ± 37.64i-k | 358.2 ± 34.76bc |
| T3        | 393.50 ± 41.17a-b | 372 ± 14.71a-e | 369 ± 27.51b-f | 369 ± 15.03b-f | 296 ± 27.94 h-j | 360.0 ± 15.87b |
| T4        | 411 ± 25.36a | 379 ± 35.20a-d | 378.50 ± 26.00a-d | 378.50 ± 25.51a-d | 322.50 ± 15.69 g-i | 374.0 ± 51.55a |
| T5        | 395.50 ± 25.36a-b | 376.50 ± 12.21a-d | 351 ± 16.03 c-g | 351.50 ± 24.16c-g | 295 ± 14.73 h-j | 354.0 ± 24.50bc |
| Mean      | 392.14 ± 14.60a | 372.86 ± 22.84b | 350.86 ± 25.80 c | 350.86 ± 34.88 c | 294.71 ± 25.72d |

*Means that do not share a letter are significantly different

### Table 7. The means values ± SD for total phenolic contents (mg/100 mL) of phalsa drink.

| Treatment | 0         | 30        | 60        | 90        | 120       | Mean          |
|-----------|-----------|-----------|-----------|-----------|-----------|---------------|
| T0-       | 108.33 ± 13.05 f-i | 93.50 ± 8.05 g-k | -         | -         | -         | 101.0 ± 7.05 c |
| T0+       | 205.00 ± 12.0a | 162.67 ± 9.51a-c | 121.13 ± 8.01e-g | 111.47 ± 2.50 f-h | 89.47 ± 5.50 g-k | 137.95 ± 12.30a |
| T1        | 129.00 ± 10.0d-f | 106.13 ± 7.01 f-i | 102.33 ± 7.51f-j | 65.33 ± 4.40k | 49.13 ± 2.10 l | 90.39 ± 9.20 c |
| T2        | 179.13 ± 12.01a-c | 153.33 ± 11.60 c-e | 112.33 ± 11.65 f-h | 71.67 ± 8.13 j-l | 69.67 ± 3.81 j-l | 117.23 ± 6.04b |
| T3        | 180.67 ± 14.40a-c | 180.33 ± 21.70a-c | 121.33 ± 9.60e-g | 86.00 ± 3.35 h-k | 71.0 ± 5.72 j-l | 127.87 ± 11.55ab |
| T4        | 174.33 ± 13.51a-c | 190.67 ± 10.10a-b | 89.33 ± 5.04 g-k | 89.33 ± 8.51g-k | 76.00 ± 6.23i-l | 132.20 ± 10.67a |
| T5        | 189.0 ± 23.0ab | 150.33 ± 13.05 c-e | 120.33 ± 12.35e-g | 72.00 ± 6.23 j-l | 70.67 ± 2.33 j-l | 120.4 ± 8.12b |
| Mean      | 166.50 ± 22.56a | 148.14 ± 12.43b | 113.88 ± 9.19 c | 81.92 ± 11.99d | 69.85 ± 4.52e |
by Zafra-Rojas et al. (2013); Abid et al. (2014); Jabbar, Abid, Hu, Wu, Hashim, Lei, Zhu, Zeng, (2014b). Abid et al. (2013) observed the sonication impact on flavonoids contents of apple juice. During sonication shear force of extraction is one of the phenomena involved in significantly enhancing in the concentration of polyphenolic contents (i.e., phenolic and flavonoids) and as a result rapid changes occur in the pressure of liquid medium and destroyed the trigger cell wall ultimately which cause free movement of polyphenols in the liquid that were chemically bounded. Abid et al. (2013) also quoted the reason for the improvement of these compounds due to production of hydroxyl radicals through the implosion of bubbles. Ashokkumar et al. (2008) explained one of the most important factor that improve the polyphenolic compounds like flavonoids and phenolic contents is the addition of second hydroxyl group in para or ortho positions of these compounds.

Nguyen and Nguyen (2018) determined the impact of sonication on the quality attributes of phenolic contents of mulberry juice. Study demonstrated that mulberry juice sonicated for 60 min shows two times more improvement in phenolic contents (183.3 mg/100 mL) when it is compared with pressed juice (73.7 mg/100 mL). As ultrasonic time period increased from 30 to 60 min, significantly increased the concentration of antioxidants (p < .05). As discussed above the highest concentration was observed at 60 min of sonication but further increased the duration of ultrasound reduction caused in the concentrations of total phenolic contents.

### Anthocyanin

Analysis of variance for Anthocyanin content indicated highly significant difference among treatments under storage condition (Table 9). The anthocyanin contents of all treated samples slightly decreased during storage of 120 days. The highest anthocyanin was observed in T4 (79.8 ± 2.78 mg/100 mL) followed by T5 (78.4 ± 2.9 mg/100 mL) and the lowest anthocyanin contents was found in T0. (72.7 ± 2.6 mg/100 mL) and T0a (72.5 ± 2.9 mg/100 mL). The effect of storage period on anthocyanin of phalsa drink described that anthocyanins gradually decreased with the passage of storage time. The minimum amount of anthocyanin was observed at 120 days of storage (71.01 ± 2.9 mg/100 mL) and

| Table 8. The mean values ± SD for flavonoids contents (mg/100 mL) of phalsa drink. |
|---------------------------------|------------------|----------------|----------------|----------------|----------------|----------------|------------------|
| Treatment | 0 | 30 | 60 | 90 | 120 | Mean |
| T0- | 553.63 ± 12.10i | 546.20 ± 22.51 j | - | - | - | 408.47 ± 13.30 g |
| T0+ | 667.37 ± 21.5b | 567.07 ± 32.5 h | 554.77 ± 23.5i | 416.03 ± 12.5j | 229.27 ± 15.5q | 486.90 ± 23.30a |
| T1 | 635.20 ± 33.0d | 556.90 ± 23.0i | 553.23 ± 17.51i | 231.50 ± 15.0q | 209.77 ± 12.51 r | 437.32 ± 18.80e |
| T2 | 655.40 ± 31.0c | 567.10 ± 14.0h | 556.90 ± 23.0i | 262.53 ± 31.05 n | 213.73 ± 23.51 r | 451.13 ± 21.90d |
| T3 | 659.53 ± 22.51 c | 575.20 ± 27.51 fg | 571.93 ± 33.51 gh | 269.63 ± 19.51 m | 256.67 ± 21.31op | 466.59 ± 31.51 c |
| T4 | 696.30 ± 42.51a | 582.73 ± 32.51e | 579.27 ± 24.51ef | 273.97 ± 12.08 m | 262.07 ± 17.51no | 478.87 ± 33.42b |
| T5 | 578.40 ± 27.0ef | 575.23 ± 11.51 fg | 543.30 ± 32.0jk | 256.60 ± 21.0p | 186.93 ± 11.51 s | 427.97 ± 42.20 f |
| Mean | 635.12 ± 42.37a | 567.20 ± 32.64b | 557.03 ± 19.50 c | 277.20 ± 31.52d | 218.64 ± 13.09e |

*Means that do not share a letter are significantly different

| Table 9. The mean values±SD for the effect of treatments on anthocyanin (mg/100 mL) contents of phalsa drink during storage. |
|------------------|------------------|----------------|----------------|----------------|----------------|------------------|
| Treatment | 0 | 30 | 60 | 90 | 120 | Mean |
| T0- | 74.3 ± 2.1b-h | 71.055 ± 3.05d-h | - | - | - | 72.7 ± 2.6d |
| T0+ | 75.6 ± 3.4b-h | 72.9 ± 3.1d-h | 73.6 ± 2.8 c-h | 71.9 ± 2.7d-h | 69.6 ± 2.7gh | 72.5 ± 2.9d |
| T1 | 75.9 ± 2.1a-h | 75.5 ± 3.1b-h | 74.0 ± 3.0b-h | 72.2 ± 3.1d-h | 71.2 ± 3.3f-h | 73.4 ± 2.9 cd |
| T2 | 78.6 ± 3.2a-g | 75.5 ± 2.5b-h | 75.6 ± 3.6b-h | 73.6 ± 3.4c-h | 72.0 ± 3.1d-h | 74.9 ± 3.16 cd |
| T3 | 79.9 ± 3.0a-f | 76.2 ± 3.0a-h | 76.4 ± 2.7a-h | 74.6 ± 3.4b-h | 7bg2.0 ± 2.8d-h | 75.8 ± 2.98bc |
| T4 | 85.08 ± 2.7a | 82.9 ± 2.3a-c | 80.9 ± 3.1a-e | 76.0 ± 3.0a-h | 74.4 ± 2.8b-h | 79.8 ± 2.78a |
| T5 | 83.2 ± 3.1ab | 81.3 ± 2.6a-d | 79.2 ± 2.5a-f | 75.12 ± 3.2b-h | 73.2 ± 3.1d-h | 78.4 ± 2.9ab |
| Mean | 79.0 ± 2.8a | 77.05 ± 2.8ab | 76.6 ± 2.9b | 73.6 ± 3.1 c | 71.01 ± 2.9d |

*Means that do not share a letter are significantly different
the maximum anthocyanin was found at start of storage (79.0 ± 2.8 mg/100 mL). Similar results also reported by Waskar and Khurdiya (1987) in phalsa beverages, Shafiee (2007) in strawberry crush and Sharma (2012) in value-added products of jamun. Moreover, it was also discovered that monomeric anthocyanin of juice was significantly enhanced in the results of blackberry mash treated with microwave for 60 s Pérez-Grijalva et al., 2018). Few previous studies also supported efficient and rapid extraction of anthocyanins from raspberry juice permitted by microwaves processing (Sun, Liao, Wang, Hu and cheng, 2007). These observations shows that expansion with subsequent rupture of the cell walls caused by microwaves which may leads toward better results in the extraction of antioxidants (Pérez-Grijalva et al., 2018).

**Total Antioxidant Capacity**

Statistical analysis revealed highly significant effect of sonication and microwave on total antioxidant capacity of phalsa drink during storage (Table 10). The total antioxidant capacity ranged from (461.18 to 626.13 µg/g AAE). The highest antioxidant capacity was detected in T4 (626.13 ± 2.41 µg/g AAE). Meanwhile the lowest antioxidant capacity was observed in T0, (482.54 ± 2.29 µg/g AAE). The total antioxidant activity of phalsa drink gradually increased from 2 to 8 min of sonication with 2 min of microwave treatment as compared to control but at 10 min of sonication 2 min of microwave treatment it was started decreasing. The increased in TAC might be attributed to ultrasonic treatment because this technology enhanced the activity of bound antioxidants such as total phenols, flavonoids and ascorbic acid leading to increased total antioxidant capacity. Moreover enzymes deactivated by ultrasonic treatment for instance polyphenols oxidases which are responsible for enzymatic browning through which TAC improved. Total antioxidant capacity of all samples treated by sonication and microwave, gradually decreased during storage of 120 days. The highest antioxidant capacity was detected in T4 (626.13 ± 22.41 µg/g AAE), while the lowest antioxidant capacity was observed in T0, (482.54 ± 32.29 µg/g AAE). T0 was discarded after 30 days of storage, due to fermentation it was spoiled.

Pérez-Grijalva et al. (2018) reported that antioxidant capacity of microwaved blackberry mash significantly increased as longer the time of microwave processing. The increasing concentration of antioxidants of blackberry juice could be attributed to better extraction of antioxidant compounds such as anthocyanins of blackberry mash treated by microwave processing. Microwaves cause rapid energy transfer and sharp heating, so compounds found in food products just like anthocyanins having excellent medicinal properties can be preserved in better way. The antioxidant capacity is dependent on the antioxidants compounds like ascorbic acid and phenolic compounds present in the samples (Abid et al., 2013).

Nayak et al. (2018) observed that thermo-sonication treatments increased significantly bioavailability of bioactive compounds in star juice as compared to control. It was concluded that with increasing sonication time and temperature the antioxidant activities are also enhanced positively. Lafarga et al. (2019) also demonstrated the impact of thermosonication on potential antioxidants,

**Table 10.** The mean values ± SD for total antioxidant activity (µg/g AAE) of phalsa drink.

| Treatment | 0       | 30      | 60      | 90      | 120     | Mean       |
|-----------|---------|---------|---------|---------|---------|------------|
| T0-       | 498.33 ± 22.081 m-p | 466.75 ± 12.51 n-p | -       | -       | -       | 482.54 ± 32.29 f |
| T0+       | 642.67 ± 12.51 d-e | 638.00 ± 23.01 d-f | 578.00 ± 18.0 h-j | 509.33 ± 42.51 l-m | 494.33 ± 24.51 m-o | 572.47 ± 28.70 c |
| T1        | 557.33 ± 27.56 j-k | 535.33 ± 32.51 k-l | 506.33 ± 15.51 l-m | 471.33 ± 21.51 n-p | 460.67 ± 23.51 o-p | 506.20 ± 21.51 e |
| T2        | 617.67 ± 32.51 e-g | 580 ± 13.2 h-j | 604.00 ± 13.05 f-h | 510.33 ± 35.51 l-m | 506.67 ± 13.51 l-m | 563.73 ± 34.15 c-d |
| T3        | 698.33 ± 34.01 b | 698.33 ± 35.51 b-l | 607.33 ± 24.0 f-h | 540.00 ± 34.51 k-l | 510.33 ± 9.6 l-m | 603.33 ± 43.72 b |
| T4        | 741.0 ± 33.09 a | 685.33 ± 24.51 b-c | 624.33 ± 22.51 e-g | 565.67 ± 11.53 j-k | 514.33 ± 26.51 l-m | 626.13 ± 22.41 a |
| T5        | 597.33 ± 13.05 g-i | 591.67 ± 11.51 g-j | 560.67 ± 32.05 j-k | 520.00 ± 13.05 l-m | 497.33 ± 17.51 m-n | 553.40 ± 29.83 f |
Mean       | 621.84 ± 42.80 a | 593.96 ± 29.82 b | 561.74 ± 33.0 c | 509.24 ± 25.85 d-m | 489.29 ± 32.86 e |

*Means that do not share a letter are significantly different
microbiological, physicochemical and nutritional quality of an anthocyanin enriched tomato juice. They concluded that availability of bioactive compounds was higher in thermal treated samples. The increasing trend was observed by thermo-sonicated samples at 60°C for 5 min duration, as compared with thermal processed samples at 80°C for 1 minute.

Combined impact of blanching and sonication at 70% amplitude increased in antioxidants potential of carrot juice (Jabbar et al., 2014b). During sonication the mechanical effect of cavitation bubbles implosions take placed in samples of fruit juices and as a result of ultra-sonication might be attributed to explore the extraction of antioxidant compounds like ascorbic acid and total phenolic contents in the product that enhanced the total antioxidant capacity of fruit juices (Bhat et al., 2011; Nadeem et al., 2018a; Qureshi et al., 2016, 2020).

Reducing power

Statistical analysis revealed highly significant effect of sonication and microwave on reducing power of phalsa juice treatments. The total concentration of reducing power ranged from 976.0 to 1264.3 µg/g AAE. The highest reducing power contents were observed in T₄ (1264.3 µg/g AAE) followed by T₃ (1221.1 µg/g AAE) while the lowest value was present in T₀ (976.0 µg/g AAE). The reducing power concentration was enhanced along with treatments but during storage it was decreased as storage period increased. T₀ was discarded after 30 days of storage, due to fermentation it was spoiled (Table 11).

Nadeem et al. (2018a) determined the impact of sonication on quality attributes of carrot-grape blend. They noticed significant improvement in the reducing power of sonicated carrot-grape juice as compared to non-sonicated sample. They also observed that chemically preserved treatment of carrot-grape blend did not show any positive effect on the nutrients. These results also supported by Santhirasegaram (2015) on chokanan mango by Qureshi et al. (2016); Qureshi et al. (2020)).

DPPH Radical Scavenging Activity

Statistical analysis revealed that there was significant effect of sonication and microwave processing on DPPH radical scavenging activity of phalsa drink treatments. DPPH radical scavenging activity increased as increased the sonication time from 2 to 8 min but on further increasing it was reduced. The DPPH radical scavenging activity of phalsa juice ranged from 1003 to 1148 µg/g AAE. The highest DPPH radical scavenging activity founded in T₄ (1148 µg/g AAE) followed by T₀ (1003 µg/g AAE) whereas the lowest values was noticed from T₁ (1003 µg/g AAE) followed by T₀ (1055.5 µg/g AAE). The total amount of DPPH radical scavenging activity was significantly decreased during storage from day 0 to day 120. T₀ was discarded after 30 days of storage, due to fermentation it was spoiled (Table 12).

From health point of view the role of radical scavenging activity is very important. It accelerated the lipid oxidation and tissue and restorative tissue damaging. DPPH radical scavenging activity effectively

| Table 11. The mean values ± SD for reducing power (µg/g AAE) of phalsa drink. |
|----------------|----------------|----------------|----------------|----------------|----------------|
| Treatment      | 0              | 30             | 60             | 90             | 120            | Mean           |
| T₀             | 1091.0 ± 33.0ab| 861.0 ± 23.0b  | -              | -              | -              | 976.0 ± 23.0c  |
| T₀+            | 1292.3 ± 43.51a| 1284.7 ± 44.04a| 1244.7 ± 32.05a| 1259.0 ± 41.0a| 1252.3 ± 19.53a| 1272.6 ± 31.42a|
| T₁             | 1180.3 ± 52.64a| 1180.3 ± 23.05a| 1118.7 ± 37.51ab| 1095.0 ± 32.0ab| 1085.3 ± 37.51ab| 1146.0 ± 44.14b|
| T₂             | 1245.7 ± 31.51a| 1235.3 ± 33.21a| 1206.7 ± 43.05a| 1198.3 ± 39.51a| 1175.7 ± 33.51ab| 1214.3 ± 49.35b|
| T₃             | 1258.0 ± 41.0a  | 1240.3 ± 36.51a| 1214.0 ± 41.0a  | 1202.3 ± 43.51a| 1181.0 ± 23.60a | 1221.1 ± 38.72b|
| T₄             | 1284.0 ± 34.0a  | 1281.3 ± 40.04a| 1261.7 ± 47.51a| 1254.3 ± 26.05a| 1240.0 ± 24.0a  | 1264.3 ± 53.72a|
| T₅             | 1221.3 ± 44.04a| 1184.3 ± 21.51a| 1161.3 ± 49.51a| 1163.7 ± 29.51ab| 1144.0 ± 36.0ab | 1183.1 ± 41.11ab|
| Mean           | 1233.3 ± 33.52a| 1183.6 ± 43.29a| 1201.2 ± 45.43a| 1174.7 ± 51.02a| 1154.8 ± 38.19a |                |

*Means that do not share a letter are significantly different.
determined through simple process for evaluating the antioxidant potential (Peksel et al., 2010). Fruit juices contain numerous compounds that contribute to their antioxidant activity. Therefore, more than one method was used to measure antioxidant properties according to their ability to scavenge specific radicals, to chelate metal ions and to inhibit lipid peroxidation (Martinez et al., 2012). Due to the direct relation of radical scavenging activity with food and consumers health it is very important. Free radicals leading to lipid oxidation and stimulate cell and tissue destruction which is highly bad for human health (Nadeem et al., 2018a). Increase in DPPH may be attributed to increase in phenolic compounds as a result of sonication activity treatments. As the sonication time was increased, more the antioxidants entered the solution and thus more free radicals were scavenged (Zou and Hou, 2017). Previously, increase in DPPH activity after sonication was reported by Abid et al. (2013) in apple juice and Zou and Hou (2017) in blueberry juice and Nadeem et al. (2018a) in carrot-grape juice blend.

**Total Plate Count**

Results of total plate count statistically revealed significant influence of temperature and processing time of the treatments on phalsa drink under storage condition (Table 13). The highest plate count was identified in T0+ (2.06 ± 0.03 log$_{10}$ cfu/mL) while the lowest plate counts were observed in T0- (1.67 ± 0.02 log$_{10}$ cfu/mL). The impact of storage period described that total plate counts gradually increased with the passage of storage time. The minimum total plate counts were observed at 0 and 30 days of storage with mean value of (1.68 ± 0.04 log$_{10}$ cfu/mL) and (1.82 ± 0.04 log$_{10}$ cfu/mL) respectively and the maximum value of total plate counts were found at 120 days of storage with mean value of (2.13 ± 0.02 log$_{10}$ cfu/mL). T0- was discarded after 30 days of storage, due to fermentation it was spoiled.

**Table 12.** The mean values ± SD for DPPH radical scavenging activity of phalsa drink.

| Treatment | 0          | 30         | 60          | 90          | 120         | Mean         |
|-----------|------------|------------|-------------|-------------|-------------|--------------|
| T0-       | 1103.0 ± 30.05 g | 1008.5 ± 43.05 no | -            | -            | -           | 1055.5 ± 37.05e |
| T0+       | 1322.5 ± 22.07a | 1285.5 ± 46.51d | 1030.5 ± 33.0 l-n | 1038.5 ± 13.0kl | 951.5 ± 22.51s | 1125.7 ± 12.15b |
| T1        | 1253.5 ± 32.51e | 1022.0 ± 18.64no | 938.5 ± 39.51 t | 909.0 ± 24.04 u | 892.0 ± 34.51 v | 1003.0 ± 31.24 g |
| T2        | 1288.0 ± 19.05d | 1146.5 ± 25.51g | 1035.5 ± 24.04k- m | 1006.5 ± 15.60pq | 965.5 ± 14.04 r | 1088.4 ± 23.13e |
| T3        | 1304.5 ± 27.51bc | 1175.5 ± 61.51 f | 1058.5 ± 43.60 j | 1023.5 ± 33.60 m-o | 999.5 ± 33.51q | 1123.2 ± 36.34 c |
| T4        | 1309.0 ± 19.73b | 1281.0 ± 46.51d | 1104.0 ± 51.51i | 1043.0 ± 14.04k | 1006.5 ± 11.0pq | 1148.7 ± 29.95a |
| T5        | 1310.0 ± 44.08b | 1164.0 ± 33.0 f | 1040.5 ± 17.60kl | 1029.5 ± 41.04 l-n | 940.5 ± 16.07st | 1096.9 ± 43.14d |
| Mean      | 1297.2 ± 52.26a | 1170.0 ± 47.81b | 1031.6 ± 43.54 c | 1007.8 ± 35.72d | 950.1 ± 29.26e |              |

*Means that do not share a letter are significantly different

**Table 13.** The mean values ± SD for effect of treatment on total plate count (log$_{10}$ cfu/mL) of phalsa drink.

| Treatment | 0          | 30         | 60          | 90          | 120         | Mean         |
|-----------|------------|------------|-------------|-------------|-------------|--------------|
| T0-       | 1.96 ± 0.04 g-i | 2.16 ± 0.03de | -            | -            | -           | 2.06 ± 0.03 c |
| T0+       | 1.51 ± 0.02s | 1.59 ± 0.03q-s | 1.64 ± 0.02 p-r | 1.77 ± 0.05 m-o | 1.82 ± 0.02 j-m | 1.67 ± 0.02 g |
| T1        | 1.81 ± 0.03 j-n | 1.87 ± 0.04i-l | 1.99 ± 0.02 f-h | 2.08 ± 0.02ef | 2.25 ± 0.04 cd | 2.00 ± 0.02b |
| T2        | 1.71 ± 0.03 n-p | 1.89 ± 0.02 h-k | 1.95 ± 0.03 g-i | 2.04 ± 0.04fg | 2.18 ± 0.03rd | 1.96 ± 0.01 c |
| T3        | 1.64 ± 0.04p-r | 1.78 ± 0.02 l-n | 1.88 ± 0.03i-k | 2.01 ± 0.04 fg | 2.17 ± 0.01de | 1.90 ± 0.05d |
| T4        | 1.60 ± 0.03q-s | 1.80 ± 0.05k-n | 1.90 ± 0.02 h-k | 1.95 ± 0.04 gi | 2.04 ± 0.03 fg | 1.86 ± 0.04e |
| T5        | 1.55 ± 0.02rs | 1.61 ± 0.04qr | 1.67 ± 0.02bo-q | 1.76 ± 0.02 m-o | 1.90 ± 0.02 h-j | 1.70 ± 0.03 f |
| Mean      | 1.68 ± 0.04e | 1.82 ± 0.04d | 1.90 ± 0.02 c | 2.01 ± 0.02b | 2.13 ± 0.02a |              |

*Means that do not share a letter are significantly different
Zou and Jiang (2016) sonicated carrot juice for 20, 40 and 60 min and examined the microbial load as compared with non-sonicated juice sample. They observed significant decreased in total plate count of sonicated carrot juice as compared to blank with sonication time but increase with storage period. The maximum reduction in total plate count of carrot juice was noticed in 60 min sonicated juice as compared to control. Similar results also reported by Abid et al. (2013) that noted maximum decreased in total plate count of apple juice sonicated for 60 and 90 min as compared with non-sonicated juice sample. So they further explained previous studies shows that target of 5-log reduction in microbial contamination juices were successfully achieved by the sonication. The reduction in microbiological contents was due to the enhancement in biocides production as a result of cavitation induced by ultrasound waves. Pressure increases due to cavitation bubbles which produced free radicals that are responsible for deactivations of microorganisms. According to the national sanitary standards (NSS) the maximum accepted limits recommended for foods are < 10 cfu per cm³ for aerobic mesophilic bacteria and < 1 cfu cm³ for yeast and mold. Statistical analysis shows significant (p < .05) influence of temperature and processing time of treatments and as well as the interactions of these two factors on microbial counts for juice samples.

Conclusion

The study was conducted for evaluating the influence of sonication and microwave treatments on physicochemical properties of phalsa drink during storage of four months. It may attributed from the present study that combinations of sonication and microwaves treatments produced high quality phalsa drink with valuable stability of physicochemical and phytochemical parameters during storage. In combined treatments of sonication and microwave pH, acidity, TSS, ascorbic acid, antioxidant activity, total, phenols, flavonoids, and reducing power of phalsa drink gradually enhanced. In addition, at 8 min of sonication with 2 min of microwaves showed the maximum retention in phytochemicals and reduced microbial load but on giving further time in sonication, it showed decline in phenolic compounds and ascorbic acid. On the basis of present study we suggested that the combined use of sonication and microwave processing of phalsa drink without chemical preservation may be implemented on commercial scale with improved quality and shelf stability during storage.

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