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Effect of hot water blanching on enzyme inactivation and physicochemical properties of ber fruit (*Ziziphus mauritiana* Lamk)

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Abstract
Blanching was performed to inactivate the enzyme using hot water blanching and effects on the enzymatic activity, physical properties (mass, length, width, thickness, bulk density, true density, and porosity) and chemical properties (moisture content, total sugar, ascorbic acid and TSS) of raw ber fruit were studied. The blanching effects of ber fruit was performed with hot water blanching (2, 4, 6, 8 and 10 min) with 100°C temperature. More than 95% of peroxidase (POD) activity was lost within the 100°C at 6 min in hot water blanching. The mass, length, width, thickness, bulk density, true density, and porosity of blanched ber fruit changed from 15.10 to 15.78 g, 30.72 to 32.27 mm, 20.94 to 23.07 mm, 20.28 to 22.25 mm, 660.12 to 642.92 kg/m^3, 1263.85 to 1295.56 kg/m^3 and 47.77 to 50.38% in hot water blanching for 6 minutes. The moisture content, total sugar, ascorbic acid and TSS of blanched ber fruit change from 76.51 to 77.80%wb, 27.62 to 21.34%, 228.3 to 159.3 mg/100g and 16.27 to 14.83 °Brix in hot water blanching for 6 minutes.

Keywords: Blanching, hot water blanching, enzymatic inactivation

Introduction

Fruits are generally protective foods as they provide essential vitamins, minerals, and fibers for human. They provide good health effects and reduce the cause of cardio-vascular diseases, cancer, and various degenerative diseases. Phytochemicals in fruits acts as strong antioxidant potential in scavenging free radicals which has great attention to the scientists (Kaur and Miani, 2001; Engwa, 2018; Chaudhary *et al.*, 2023; Swallah *et al.*, 2020) [16, 8, 7, 35].
Ber (*Ziziphus mauritiana* Lamk.) is one of the tropical fruits generally belongs to the family Rhamnaceae and grown in northern hemispherical region (Hussain *et al.*, 2021; Guo *et al.*, 2024) [14, 13]. In India, generally two domesticated varieties of ber are *Ziziphus mauritiana* Lamk. (Indian ber or jujube) and *Ziziphus jujube* Mill. (Chinese or common jujube). Both varieties are grown in northwest of India and in the arid parts of South India (Ali *et al.*, 2001; Meghwal *et al.*, 2007) [4, 22].
Generally, Ber (Ziziphus Mauritiana Lamk.) is cultivated as it is highly rich in Vitamin C and B complex and is regarded as poor man's apple due to its high nutritional value (Gajbhiya *et al.*, 2003; Vilas, 2019; Akter & Rahman, 2019) [9, 37, 3], low production cost (Singh *et al.*, 2007) [33], easy availability, delicious and nutritious as compared to an apple. It provides fortification to the diet (Prasad, 2005; Adilah *et al.*, 2023) [28, 2]. As it is grown in warm climate and therefore it had different names and languages in different countries. Some of them are Chinese date, Berra, Putrea, Kul, Baher, Beri, Nakhi, Dara, Kunar, Gob, madadebara, Iradi, Kulvali, Widara, Nabig, Than, Epal, Siam, Bidaru, Zi, Zee-pen, Berwarter, Ilanda, Masaka, Bogori, Indian Plum, Indian Cherry. In India, it is generally adapted as ber in Gujrati, Hindi, Marathi, Punjabi, Sindhi and Urdu languages.
These fruits are perishable and have short shelf-life at ambient temperature (25-35°C). Generally, they are kept for 4 to 12 days without loss of organoleptic quality depending on their cultivar and storage conditions (Pareek *et al.,* 2009) [26]. It is difficult to transport ripen fruits and results in large post-harvest losses (Kudachikar *et al.*, 2000) [18]. Perishable foods are classified as fresh fruits having moisture content more than 80 percent (Orsat *et al.*, 2006) [6].

Ber has more protein, phosphorous, calcium, carotene and vitamin C as compared to apple and also predominates oranges in phosphorous, iron and vitamin C (Pareek, 2001; Gill and Bal, 2006) [25, 12]. Ber too have medicinal properties as its seeds, roots and stem are used for medicinal purposes. Leaves of ber possess antimicrobial activity and wound healing properties. It also has antifungal properties (Adamu *et al.*, 2006) [1] and anti-cancer properties (Mishra *et al.*, 2011) [23].
For any fruit, the pre-treatment and preservation method are mostly important to increase its shelf life so in this study we have uses blanching as a pre-treatment and drying as a preservation method. Blanching is a traditional and well-practiced method used in food industry. Increasing product quality was focused on early technological developments. Later, the product throughput, energy efficiency, and waste effluent reduction are taken for consideration. Blanching is the first step in preservation of fruits by canning, freezing and dehydration which consist of a partial cooking usually in steam or hot water.

Materials and Methods
Selection of ber fruit
Fruit variety of ber namely 'Umran', was procured at ripe stage from the horticulture farm, CHESS, Vejalpur, Godhra. Umran is late maturing variety. The fruits obtained were thoroughly cleaned and screened to remove decayed, rotten, and damaged fruits and other foreign material. The fruits were washed under running water to remove dirt and dust. The fruits were washed with distilled water before blanching process.

Experimental procedure
The representation of blanching experiment process shown in Fig.1. The blanching study was pointed in researching time to inactivate the enzymatic action and impact of hot water blanching on physico-synthetic properties of ber fruits. The independent variables were selected based on previous work reported by Khurdiya, (1980) [17] on ber variety and preliminary trials were conducted. 100 g of matured ber fruit sample were soaked in water at 100°C temperature with sample to water ratio of 1:10 w/w and blanched for 2, 4, 6, 8 and 10 min followed by draining of water and placing the sample on a blotting paper to absorb free surface moisture. Hot water blanching experiments were done in triplicates. Determination of Physico-chemical properties was done after blanching to check the blanching effect on physico-chemical properties.

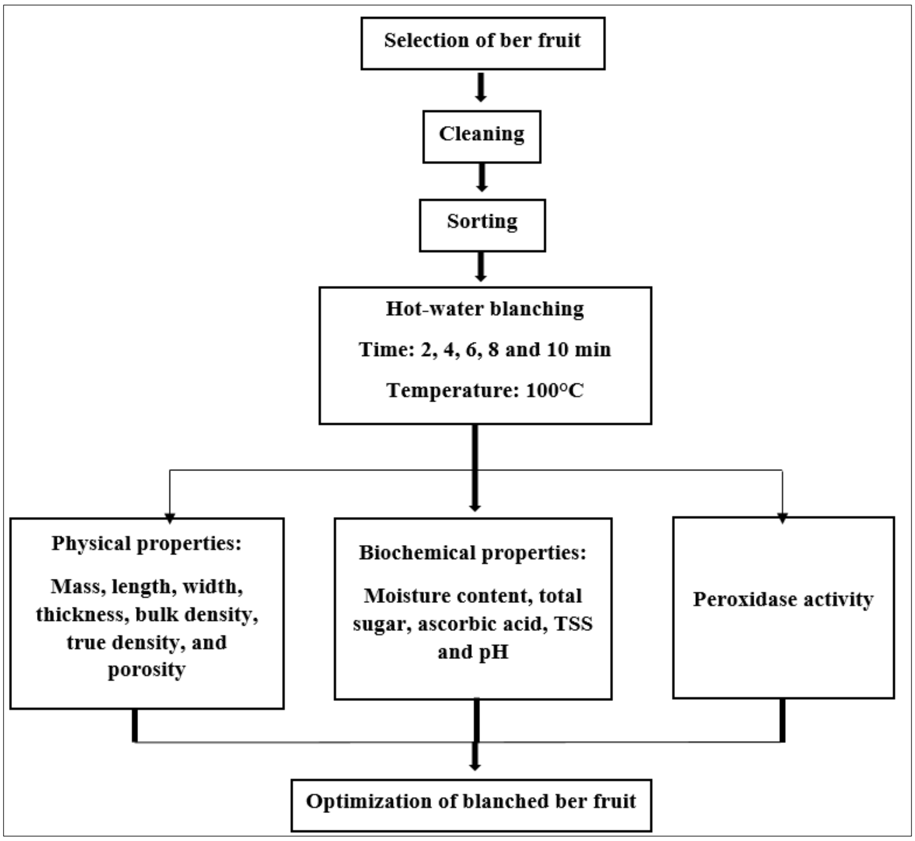

Fig 1: Process flowchart for blanching experiment of ber fruit

Measurement of Physical properties
Mass (g), Length (mm), Width (mm) and Thickness (mm)
A digital balance (M/S Shimadhu Corporation, Japan) with measurement precision of ± 0.001 g was used for weighing the sample. The three major perpendicular dimensions of the 100 randomly selected ber fruits were measured using a digital vernier caliper (M/S Mitutoyo Measuring Instrument (Suzhou) Co. Ltd., China) having precision of ± 0.002mm.

Bulk density (kg/m^3), True density (kg/m^3) and Porosity (%): The bulk density of ber fruit was determined using standard procedure reported by Kumar (2006) [19] ber fruits were taken and put them in to wooden box and noted the weight of ber fruits and volume of wooden box. The calculation of bulk density is shown in Eq.1. The volume of toluene dislodged was found by submerging a mass of ber fruits in the toluene (Singh & Goswami, 1996) [32]. The true density was calculated by using Eq.2. The porosity was calculated using the relationship was given by (Mohsenin, 1970) [24] as per Eq.3.

$$\text{Bulk density } (kg/m^3) = \frac{\text{mass of sample}}{\text{volume of sample}} \quad (1)$$

$$\text{True density}(\text{kg}/m^3) = \frac{\text{mass of sample}}{\text{volume of sample}} \quad (2)$$

$$\text{Porosity}(\varepsilon) = \left(1 - \frac{\text{Bulk density}}{\text{True density}}\right) \times 100 \quad (3)$$

Determination of biochemical characteristics

Moisture content

The samples were oven dried at 105°C for 24 h in uncovered pre-weighed petri dishes (Ranganna, 2000) [30]. The ber fruit samples were taken in the petri dishes and kept into the hot air oven. The drying air temperature in the chamber was estimated straightforwardly utilizing thermocouple-based temperature pointer gave in the unit. Subsequent to drying, petri dishes were covered with a top and cooled in desiccators containing silica gel prior to gauging (Ranganna, 2000) [30].

Ascorbic acid, Total sugar, TSS, pH

The ascorbic acid and total sugar of the sample was determined by 2, 6- dichlorophenolindophenol visual titration method and Lane and Eynon method respectively, followed by TSS and pH also measured by using refractometer and digital pH meter as described by Ranganna (1986) [29].

Determination of Peroxidase Enzymatic Activity

A little part was taken in a test cylinder to a profundity of around 1 inch. 10 ml of guaiacol (0.5%) and 10 ml of hydrogen peroxide (0.08%) was added. The test tube was shaken and saved for 3 mins and variety readings were noted following 3 minutes. Shade of the combination changing from variety less to brick red demonstrated inadequate enzyme inactivation. The substrate arrangement was moved into a cuvette and actually takes a look at absorbance 720 nm in spectrophotometer. (M/S Microprocessor UV-VIS Spectrophotometer- 2371, Electronicsindia, India) (Sheu and Chen, 1991; Gandhi *et al.*, 2023; Gandhi *et al.*, 2025) [31, 10, 11]. The residual activity was estimated using the Eq.4.

$$\text{Residual activity (\%)} = \frac{\text{absorbance of fresh sample} - \text{absorbance after blanching}}{\text{absorbance of fresh sample}} \times 100 \quad (4)$$

Results and Discussion

Physico-Chemical Properties of Fresh Ber Fruit

The various physical properties of ber fruit like mass, length, width and thickness varied from 14.20 to 21.46 g, 25.31 to 31.27 mm, 18.21 to 22.72 mm and 14.21 to 16.34 mm with an average value of 15.10±0.27 g, 30.72±0.67 mm, 20.94±0.20 mm and 20.28±0.04 mm respectively. The various chemical composition of ber fruits like ascorbic acid, total sugar and TSS varied from 160 to 230 mg/100 g, 22.57 to 28.31% and 14.9 to 16.3 g with an average value were 228.3±1.53 mg/100 g, 27.62±0.61% and 16.27±0.06 °Brix respectively.

Variation in physical characteristics of blanched ber fruit

Mass: The initial ber fruit mass about 15.10 g in fresh fruit. The ber mass significantly increased from 15.10 to 15.81 g in hot water blanching (P<0.01). It can be observed from Fig. 2 that the mass of blanched samples increased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 9.67 at P values of 0.00068 against $F_{Critical}$ value of 3.10 indicating the change in mass was also significant (P<0.01). The increment is mass is clear because of the assimilation of water by the ber fruits in hot water blanching. Comparative expansion in mass was reported in sweet corn by Kachhadiya *et al.,* (2018) [15] and in sweet potato slices by Pathan *et al.,* (2025) [27].

Length

The initial length was about 30.71 mm in fresh ber fruit. The ber fruit significantly increased from 30.71 to 32.53 mm in hot-water blanching (P<0.01). It can be observed from Fig. 2 that the length of blanched samples increased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 11.74 at P value of 0.00027 against $F_{Critical}$ value of 3.10 indicating the change in length was also significant (P<0.01). The increment is length is obvious because of the assimilation of water by the ber fruits in hot water blanching in much the same way. Comparative expansion in mass was reported in sweet corn by Kachhadiya *et al.,* (2018) [15] and in sweet potato slices by Pathan *et al.,* (2025) [27].

Width

The initial width was about 20.94 mm in fresh ber fruit. The ber fruit significantly increased from 20.94 to 23.10 mm in hot-water blanching (P<0.01). It can be observed from Fig. 2 that the width of blanched samples increased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 23.48 at p values of 8.23×10^{-06} against $F_{Critical}$ value of 3.10 indicating the change in width was also significant (P<0.001). The increment is width is obvious because of the ingestion of water by the ber fruits. Comparative expansion in mass was reported in sweet corn by Kachhadiya *et al.,* (2018) [15] and in sweet potato slices by Pathan *et al.,* (2025) [27].

Thickness

The initial thickness was about 20.28 mm in fresh ber fruit. The ber fruit significantly increased from 20.28 to 22.27 mm in hot-water blanching (P<0.01). It can be observed from Fig. 2 that the width of blanched samples increased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 552.78 at p value of 9.52×10^{-14} against $F_{Critical}$ value of 3.10 indicating the change in thickness was also significant (P<0.01). The increment is thickness is additionally apparent because of the assimilation of water by the ber fruits. Comparable expansion in thickness was likewise detailed by (Kachhadiya *et al.*, 2018) [15].

Bulk Density

The initial bulk density was about 660.12 kg/m^3 in fresh ber fruit. The bulk density significantly decreased from 660.12 to 635.52 kg/m^3 in hot water blanching (P<0.01). It can be observed from Fig. 2 that the bulk density of blanched samples decreased with increase in blanching time at constant temperature on 100°C.

It can be observed from Table 1 that F value for time of hot water blanching was 1178.05 at P values of 1.03×10^{-15} against $F_{Critical}$ value of 3.10 indicating the change in bulk density was also significant (P<0.01). The lessening bulk density is likewise obvious because of the expansion in volume because of retention of moisture by the ber fruits. Comparable outcome in bulk density was likewise detailed by (Kachhadiya *et al*., 2018) [15].

True density

The initial true density was about 1263.85 kg/m^3 in fresh ber fruit. The true density significantly increased from 1263.85 to 1298.11 kg/m^3 in hot water blanching (P<0.01). It can be observed from Fig. 2 that the true density of blanched samples increased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 1178.05 at P value of 1.03×10^{-15} against $F_{Critical}$ value of 3.10 indicating the change in true density was also significant (P<0.01). The expanded true density is obvious because of the retention of moisture by the ber fruits. Comparative outcome in evident thickness was likewise revealed by (Kachhadiya *et al*., 2018) [15].

Porosity

The initial porosity was about 47.77 in fresh ber fruit. The porosity significantly increased from 47.77 to 51.04 in hot water blanching (P<0.01). It can be observed from Fig. 2 that the porosity of blanched samples increased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 914.53 at P value of 4.7×10^{-15} against $F_{Critical}$ value of 3.10 indicating the change in porosity was also significant (P<0.01). The increase in porosity is evident due to decrease in bulk density in hot water blanched samples, which indicates increase in void space due to increase in size of ber fruit.

Effect of Blanching on Biochemical Characteristics

Moisture content

The initial moisture content was about 76.51%wb in fresh ber fruit. The ber fruit moisture content significantly increased from 76.51 to 77.84% wb in hot-water blanching (P<0.01). It can be observed from Fig. 2 that the moisture content of hot water blanched samples increased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 1616.99 at P value of 1.55×10^{-16} against $F_{Critical}$ value of 3.10 indicating the change in moisture content was also significant (P<0.01). The increment is moisture content is clear because of the retention of water by the ber fruits. Comparable aftereffect of expansion in moisture content in hot water blanching was likewise announced by (Mcdaniel *et al.,* 1988 and Kachhadiya *et al*., 2018) [21, 15].

Ascorbic acid

Ascorbic acid content decreased in all the samples during blanching as compared to fresh sample. The initial ascorbic acid was about 228.33 mg/100g in fresh ber fruit. The ascorbic acid significantly decreased from 228.33 to 114.33 mg/100g in hot water blanching (P<0.01). It can be observed from Fig. 2 that the ascorbic acid of blanched samples decreased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 1423.35 at P value of 3.33×10^{-16} against $F_{Critical}$ value of 3.10 indicating the change in ascorbic acid was also significant (P<0.01). The reduction is ascorbic acid is obvious because of the retention of dampness (water movement) by the ber fruits. Comparative lessening in ascorbic acid was additionally revealed by (Kachhadiya *et al*., 2018) [15].

Total sugar

The initial content of total sugar was 27.62% in fresh ber fruit. Total sugar significantly decreased from 27.62 to 20.39% in hot water blanching (P<0.01). It can be observed from Fig. 2 that the total sugar of blanched samples decreased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 309.29 at P values of 3.03×10^{-12} against $F_{Critical}$ value of 3.10 indicating the change in total sugar was also significant (P<0.01). The deficiency of water-solvent sugars may be connected with the filtering of sugar during blanching (Song *et al*., 2013) [34].

Total soluble solid

The initial TSS was about 16.27 °Brix in fresh ber fruit. The TSS significantly decreased from 16.27 to 11.91 °Brix in hot water blanching (P<0.01). It can be observed from Fig. 2 that the TSS of blanched samples decreased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching was 12258.22 at P value of 8.25×10^{-22} against $F_{Critical}$ value of 3.10 indicating the change in TSS was also significant (P<0.01). The decrease in TSS may be due to passing of sample through heat treatment during blanching so that leaching of total soluble solid occurred. (Trongpanich *et al*., 2000) [36].

pH

The initial pH was about 7.3 in fresh ber fruit. The pH varied from 6.9 to 7.4 in hot water blanching was not significantly changed in blanching period. It can be observed from Figure 2 that the change in pH was not significant. It can be observed from Table 1 that F value for time of hot water blanching was 2060.2 at P values of 3.63×10^{-17} against $F_{Critical}$ value of 3.10 indicates the change in pH was not significant.

Peroxidase activity

The impacts of hot water blanching treatment on enzymatic exercises are introduced in Fig.2. Remaining action of peroxidase protein in ber fruits decreased with expansion on schedule of high temp water blanching therapy. More than 95% of peroxidase (POD) movement was lost inside the first 100°C at 6 min in steaming hot water whitening. It is prescribed to decrease the marker compound action by 90% for choosing the suitability of blanching technique and advancement of nature of non-purified item (Bahceci *et al.*, 2005) [5]. It tends to be additionally seen from Fig. 2 that ideal degree of time for heated water blanching were 100°C at 6 min (P<0.01). It can be observed from Fig. 2 that the peroxidase activity of blanched samples decreased with increase in blanching time at constant temperature on 100°C. It can be observed from Table 1 that F value for time of hot water blanching were 6297.1 at P value of 4.48×10^{-20}

against $F_{Critical}$ value of 3.105875 indicating the change in peroxidase activity was also significant (*P*<0.01).

Optimization of blanching samples

Blanched samples were optimized based on maximum ascorbic acid content, total sugar, TSS and inactivated enzymes and 10% level of peroxidase activity. In hot water blanching time 6 minute at temperature 100°C sample was related due to maximum ascorbic acid content, total sugar and less than 10% of peroxidase activity. The optimized sample from blanching experiment was considered for the further drying process.

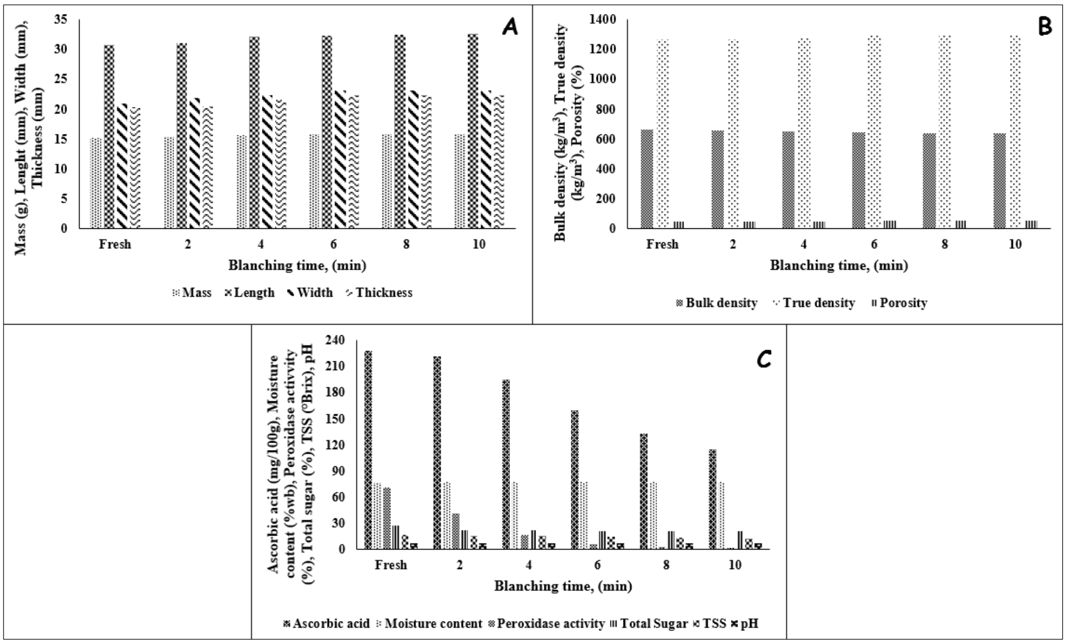

Fig 2: Variation of Physico-chemical properties of ber fruit during blanching

Table 1: ANOVA for different responses of hot water blanching of ber fruit

Source of variation	SS	df	MS	F	P-Value	Fcritical	Source of variation	SS	df	MS	F	P-Value	Fcritical
	Mass							Ascorbic acid					
Time	1.27	5	0.25	9.68	0.000682	3.106	Time	33211.61	5	6642.32	1423.36	3.33×10-16	3.106
Within groups	0.32	12	0.03				Within groups	56	12	4.67			
Total	1.59	17					Total	33267.61	17				
	Length							Moisture content					
Time	9.37	5	1.87	11.74	0.000276	3.106	Time	4.132317	5	0.83	1616.99	1.55×10-16	3.106
Within groups	1.92	12	0.16				Within groups	0.006133	12	0.00			
Total	11.29	17					Total	4.13845	17				
	Width							Peroxidase activity					
Time	11.78	5	2.36	23.48	8.23×10-06	3.106	Time	11496.93	5	2299.39	6297.10	4.48×10-20	3.106
Within groups	1.20	12	0.10				Within groups	4.3818	12	0.37			
Total	12.98	17					Total	11501.31	17				
	Thickness							Total sugar					
Time	13.02	5	2.60	552.78	9.52×10-14	3.106	Time	108.312	5	21.66	309.29	3.03×10-12	3.106
Within groups	0.06	12	0.00				Within groups	0.840467	12	0.07			
Total	13.08	17					Total	109.1524	17				
	Bulk density							TSS					
Time	1649.40	5	329.88	1178.06	1.03×10-15	3.106	Time	38.47718	5	7.70	12258.22	8.25×10-22	3.106
Within groups	3.36	12	0.28				Within groups	0.007533	12	0.00			
Total	1652.77	17					Total	38.48471	17				
	True density							pH					
Time	1649.40	5	329.88	1178.06	1.03×10-15	3.106	Time	0.51505	5	0.10	2060.20	3.63×10-17	3.106
Within groups	3.36	12	0.28				Within groups	0.0006	12	0.00			
Total	1652.77	17					Total	0.51565	17				
	Porosity												
Time	31.71	5	6.34	914.53	4.7×10-15	3.106							
Within groups	0.08	12	0.01										
Total	31.80	17											

Conclusion

The different physico-chemical properties of ber fruit were determined in this study. The blanching effects of ber fruit was performed with hot water blanching (2, 4, 6, 8 and 10 min) with 100°C temperature. More than 95% of peroxidase (POD) activity was lost within the first 100°C at 6 min in hot water blanching. The mass, length, width, thickness, bulk density, true density, and porosity of blanched ber fruit changed from 15.10 to 15.78 g, 30.72 to 32.27 mm, 20.94 to 23.07 mm, 20.28 to 22.25 mm, 660.12 to 642.92 kg/m^3, 1263.85 to 1295.56 kg/m^3 and 47.77 to 50.38% in hot water blanching for 6 minutes. The moisture content, total sugar, ascorbic acid and TSS of blanched ber fruit change from 76.51 to 77.80%wb, 27.62 to 21.34%, 228.3 to 159.3 mg/100g and 16.27 to 14.83 °Brix in hot water blanching for 6 minutes.

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