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A Comprehensive Investigation Of Novel Ber (Ziziphus mauritiana) Products From South Punjab, Pakistan

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A Comprehensive Investigation Of Novel Ber (Ziziphus mauritiana) Products From South Punjab, Pakistan

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A COMPREHENSIVE INVESTIGATION OF NOVEL BER (*ZIZIPHUS MAURITIANA*) PRODUCTS FROM SOUTH PUNJAB, PAKISTAN

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ABSTARCT

Ber also known as jujube (*Ziziphus mauritiana*) is an evergreen shrub and known as poor man's apple belongs to the *Rhamnacae* family. It is a minor fruit of Pakistan with short post-harvest shelf life. The present study was planned to develop jujube products such as jam, syrup, jelly, dehydrated jujubes, pickle, and candied jujube from Dil Bahar cultivar followed by a shelf-life study based on TSS, Ascorbic acid, total sugars, moisture and crude fiber content at prescribed intervals. Results showed higher total phenolic content in Dil Bahar (144.38 mgGAE/100g) cultivar as compared to other cultivars. Shelf life study showed that total soluble solids of jujube products increased when storage time increased. Moisture content in products was reduced as storage time was increased. Ascorbic acid content showed significant values when storage time was increased. Sugars content in products showed significantly high values with increased storage time. Crude fiber content showed a minute difference and remained stable when storage time was increased.

Keywords: Jujube, products, TSS, ascorbic acid, storage.

INTRODUCTION

Pakistan is considered to be in the list of few countries in the world where variation in climatic conditions allows the production of different types of fruits and vegetables. Ber (*Ziziphus mauritiana*) is one of the minor fruits that can be grown easily in the Pakistani climate. It can grow even on marginal lands or inferior soils where most of the other fruit trees either fail to grow or give very poor performance. It is regarded as the king of arid zone fruits and also as a poor man's apple (Nandwani and Duquesne, 2014). Dried jujube fruits are highly preferable by consumers, as they have rich aroma and flavor followed by nutrients such as vitamins, minerals, and polyphenols (Gao et al., 2012; Gao et al., 2013; Hernández et al., 2016; Wojdyło et al., 2016). This fruit contains antioxidant compounds mainly Poly-phenols that possess various health benefits including anti-obesity, anti-tumor, anti-proliferative, anti-oxidant and proapoptotic properties and help in preventing cardiovascular diseases and type-II diabetes (Gao et al., 2013).

Food processing is done to reduce food spoilage chances during storage by reducing the chances of microbe's entry. It results in the availability of seasonal products for a longer period. Minimum processing helps in maintaining sensory and nutritional attributes of foods that have health-promoting effects (Krishna and Parashar, 2013). Moreover, previous researches studied the processing and storage stability of jujubes and their possible value-added products including pickles, dehydrated jujubes and candied jujubes (Uddin and Hussain, 2012).

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Jujube fruit can be used as squeezed pulp or food products development like jams, jellies, and beverages. Dried jujube pulp is commonly used in the preparation of cakes, bread and teas. It can also be added as an active food ingredient in product development industries such as snacks, bread and cakes. Additionally, it is used in the food product to enhance the nutritional status and product quality such as yogurts. Eventually, it is considered an active ingredient to develop functional products to gain overall acceptability, possible health benefits and profits (Feng et al., 2019).

Up till now, no research-based study has been carried out to check the nutritional status of food items and storage stability. Hence the present study is focused to develop value-added jujube products and check storage stability on prescribed intervals by considering the following parameters; total soluble solids, moisture, ascorbic acid, sugars and crude fiber content.

METHODOLOGY

Procurement of Raw Material

Four jujube cultivars, named as Dil Bahar, Akash, Pak white and Karela were procured from Regional Agricultural Research Institute, Bahawalpur. The soil condition was maintained sandy loam. The selected varieties were subjected to nutritional profiling. All chemicals were procured from Sigma Aldrich, Germany.

Moisture Content (%)

The powder was analyzed for moisture by using method No. 44-15A. The moisture contents were evaluated by drying oven (SLN-53-STD, POL-Eko-Apparatus). A sample of 2g was placed in a china dish for drying at 105°C for 24 hours. The moisture content was calculated by following the formula:

$$\text{Moisture (\%)} = \frac{W_2 - W_1}{W_0} \times 100$$

W_1= Weight of blank china dish (g)
W_2= Weight of china dish + Sample after drying (g)
W_0= Weight of sample (g)

Ash Contents (%)

The ash content of jujube powder was evaluated according to method No. 08-01. The ash contents were determined by using a muffle furnace (SNOL 39/1100, Utena, Lithuania). Sample of about 3g was taken in a crucible and ashing of the sample was done on a low flame of spirit lamp until smoking of sample was ceased. After ashing, the sample was placed in the muffle furnace at 550°C for 3-4 hours. After the completion of recommended time, this sample was removed from the muffle furnace until the temperature was reduced to at least 250°C. The door of the muffle furnace was removed carefully to avoid loss of ash. Then crucible was transferred to the desiccator and covered with a lid and crucibles were allowed to cool before weighing. The following formula was used for the calculation of ash contents:

$$\text{Ash (\%)} = \frac{W_2 - W_1}{W_0} \times 100$$

W_1= Weight of blank crucible before ashing (g)
W_2= Weight of crucible + Sample after ashing (g)
W_0= Weight of Sample (g)

Crude Fat (%)

The jujube powder was subjected to determine the crude fat contents by following method No. 30-25. All glassware was washed with petroleum spirit, trenched, dried in an oven at 102°C for thirty minutes and then cooled in a desiccator. A piece of cotton wool was placed in the bottom of a 100 mL beaker. A lump of cotton wool was placed in the

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lowermost of an extraction thimble. 15g sample was taken into the thimble. Glass rod was cleaned with a piece of cotton wool. The sample was dried in an oven at 102°C for 5 hours. The sample was cooled in a desiccator. The piece of cotton was taken from the lowermost and placed at the top of the thimble. The thimble was placed in the Soxhlet Extractor (Merck, Sigma Aldrich). Petroleum spirit of about 90mL was placed in the flask. The extraction unit was assembled over a heating mental. The solvent was heated in the flask till boiling. Continue extraction till three washing are completed. After extraction thimble was removed from the extractor and placed in the muffle furnace for 4 hours. The extraction mixture was detached from the condenser and extractor. Then thimble was removed from the muffle furnace and this sample was weighed. This thimble was placed in the desiccator. The crude fat contents were calculated by following formula:

$$\text{Crude fat (\%)} = \frac{W_2 - W_1}{W_0} \times 100$$

W_1= Weight of blank petri dish (g)
W_2= Weight of petri dish + Oil after completion of the process (g)
W_0= Weight of sample (g)

Crude Fiber (%)

By technique No. 32-10, the resulting fat-free jujube powder was utilized to determine the crude fiber content. For digestion, 200 mL of boiling 1.25 percent H_2SO_4 was used, followed by three ethanol rinses. The sample was digested one more time in 200 mL of boiling NaOH for 30 minutes and then filtered three times in ethanol. After that, they were dried for 2 hours at 130°C before being weighed (W_1). Muffle furnace at 600°C was used to burn the dry residue, cooled it, and weighed it again (W2). The following formula was used to calculate crude fiber:

$$\text{Crude fiber (\%)} = \frac{W_2 - W_1}{W_0} \times 100$$

W_1 = Weight of blank crucible (g)
W_2 = Weight of crucible + sample after ashing (g)
W_0 = Weight of sample (g)

Crude Protein (%)

The crude protein content was determined using the Kjeldahl equipment and technique No 46-10. The three phases of the Kjeldahl apparatus are digestion, distillation, and titration. Jujube powder (2g) was mixed with 20 mL of 98% concentrated sulphuric acid (H_2SO_4) and two digestion combination tablets in a digestion tube (as a catalyst). The digestion was carried out in a digestion unit for 3-4 hours until transparent residual contents were formed, after which the digested material was diluted with distilled water to a final concentration of 50ml and allowed to cool. To liberate gaseous ammonia, the mixture was neutralized with 70mL of a 40 % NaOH solution. Kjeldahl's distillation apparatus was used to distill the neutralized solution. The ammonia was captured in a 4 % boric acid solution with indicators (methyl red and ethylene blue).

The recovered ammonia was then titrated against 0.1N sulphuric acid until a purple endpoint was reached. A blank determination was performed using the same process but without the test sample.

$$\text{N (\%)} = \frac{\text{Volume of } H_2SO_4 \text{ used} \times \text{Volume of sample diluted} \times 0.0014}{\text{Weight of sample (gm)} \times \text{Volume of diluted sample used for disilation}} \times 100$$

$$\text{Crude Protein \%} = \text{N \%} \times 6.25$$

Nitrogen-Free Extract (NFE)

The nitrogen-free extract of the moisture-free sample was measured with the help of consequent analysis

NFE % = 100 - (Moisture + Crude fat + Crude protein + Ash + Crude Fiber) %

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Mineral Analysis of Jujube Powder

The minerals contents of jujube powder were determined by Unit Atomic Absorption Spectrophotometer (AA240 Varian K, Australia) on an acetylene air flame and flame photometer by following the protocols discovered by the Association of Official Analytical Chemists (AOAC, 2010) method No. 3.014-016. The sample was taken in a clean and moisture-free conical flask. HNO_3:$HCLO_4$acids were added in the flask with a ratio of (3:1). Placed the flask on a hot plate for minerals digestion. After the digestion sample solution was diluted for further steps of analysis. The diluted sample was used to determined Fe, Mg, Na, Zn and Ca by unit atomic absorption spectrophotometer. K, Na also was evaluated from a diluted sample by flame photometer.

Total soluble solids (°Brix)

Total soluble solids contents of ber varieties were measured by using a handheld PAL-1 digital refractometer (ATAGO, JAPAN). The prism of meter was cleaned and calibrated with distilled water. After blending ber pulp in 200mL deionized water, two to three droplets of juice were placed on prism and reading was noted (AOAC, 2010).

Vitamin C/Ascorbic Acid Content (M g/100 g)

The concentration of vitamin C in samples was determined by 2, 6 dichloroindophenols titrimetric method (AOAC Method 967.21). For analysis, 10 mL of jujube juice was taken in a 100mL volumetric flask with the addition of 0.4% oxalic acid up to the mark. After the juice was filtered by using filter paper, 5 mL filtrate was taken and titrated against dye (2, 6-dichlorophenolindophenol) until light pink color appeared. Further, it was calculated by using the following formula:

$$\text{Ascorbic acid (mg/100mL)} = 1\times R_1\times V/R\times W\times V_1\times 100$$

R= mL of dye used to titrate against 2.5 Ml
R1= dye used to titrate against aliquot of V1
V= 0.4% oxalic acid volume used
V1= juice used for titration
W= juice used in mL

Titratable acidity

Titratable acidity was calculated by the following method of Larriguadière et al. (2002). 10mL juice was taken in 100mL graduated beaker with the addition of 2-3 drops of phenolphthalein indicator. After this, titrate the prepared sample against 0.1N NaOH till light pink color appeared. The following formula was used for TA determination:

$$\text{Titratable acidity \%} = \frac{0.0064\times\text{Volume of NaOH used}\times 10\times 100}{}$$

Assessment of Total Phenolic Content and Antioxidant Capacity

TPC and Total Anti-oxidant capacity were measured from the pulp of jujube fruit as stated by Kassim et al. (2013).

Extraction

In this method, 3g of the pulp of ber fruit was taken from samples that were stored in an ultra-low freezer (-80℃). Further, 15mL of extraction mixture was added in samples and homogenized by using pestle and mottle. This extraction mixture was vortexed well by using a vortex machine and then centrifuged for 3-5 minutes at 4℃ with 9000rpm y using 320-R Centrifuge (Hettich Gmbh, Tuttlingen, Germany) to take supernatant, which was used in the estimation of above attributes.

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Total Phenolic Content (TPC)

Folin – Ciocalteu's method was used to check the total phenolic content. For analysis, 1mL of standard gallic acid and aliquots (10, 20, 40, 60, 80, 100µg/mL was located into the test tubes and 0.5mL of Folin Ciocalteu,s reagent and 5 mL of distilled water was mixed and shaken. About 1.5 mL of 20% sodium carbonate was added after 5 minutes and volume was completed to 10 ml with distilled water. It was incubated for 2 hours at room temperature and blue color was developed. After the completion of incubation, absorbance was calculated at 750nm by using a spectrophotometer. The extracts were performed three times. By using a reagent blank with solvent, the blank was done. In this method, Gallic acid was used as standard. By using standard gallic acid, the calibration curve was plotted (Kassim et al., 2013).
The data for the total phenolic contents were expressed as:

mg of Gallic acid equivalent weight (GAE)/100 g of dry mass.

The amount of phenolic content present in the sample was calculated as:

Phenol (mg/g) = Sample O.D × Dilution factor × Graph factor

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

The free radical scavenging activity was performed by spectrophotometer by following the process of Kassim et al. (2013). About 4.3mg of DPPH (1, 2-Diphenyl-2- picrylhydrazyl) was dissolved in 3.3µL methanol for the preparation of DPPH solution. Aluminum foil was used to cover the test tubes for the protection of DPPH from light. About 150µl DPPH solution was mixed with 3mL methanol and for control, reading absorbance was taken at 517nm instantly. About 50µL of numerous concentrations like 40 µg/mL, 80 µg/mL, 120 µg/mL, 160 µg/mL, 200 µg/mL, 240 µg/mL, 280 µg/mL, 320µg/mL and 360µg/mL of the sample in addition to ascorbic acid was and volume was made till 150 µL by addition of methanol and then individually samples were diluted up to 3µL and individual 150µL DPPH was further added. After 15 min absorbance was taken at 517nm using methanol as blank on UV–visible spectrometer, IC50 and standard preparations were calculated. The following formula was used for the measurement of DPPH radical scavenging activity.

DPPH Scavenging effect (%inhibition) = $\{(A_{02}-A_1)/A_0) \times 100\}$

Selection of Best Cultivar

Dil Bahar cultivar was selected for product development based on maximum total phenolic content.

Product Development

i. Jujube Jam

Jujube jam was prepared by the following protocol of Dawney et al. (2002). Freshly ripened ber were washed and de-stoned followed by cutting into small pieces. After cutting, about 2 kg ber were boiled in 1L water for 10 minutes until softened. After boiling, it was filtered through stainless steel sieve or mesh to remove skin and stones for clear juice extraction. After filtration, add 1L water and 1450g sugar were mixed. Gentle heating was done for few minutes followed by an increase in heat and boiled mixture until Brix reaches 65º. At 82-85ºC, hot-fill in clean sterilized jars and cool it for few minutes.

ii. Jujube Jelly

Jujube jelly was prepared by following protocol of Panchal et al., (2018). The fruit was cut into slices after de-stoning. Slices were heated for about 10 minutes until get softened. After heating, fruit extract was

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filtered by using a muslin cloth and further proceeded for jelly preparation. Clear fruit extract (1000 mL) of ber was moved towards heating until boiled enough. After that, sugar (450g) was added according to the requirement. The mixture was boiled until its TSS become 55º. Then sugar mixed pectin was added with continued boiling until TSS reaches 58º. After this, citric acid was added and boiling was continued until desired consistency was achieved and TSS becomes 67º. Then, potassium metabisulphite was added for preservation purposes. When the mixture became sufficiently thick, heating was stopped. The finished end product was cooled down to 94ºC and filled in clean jars.

iii. Jujube Pickle

Jujube pickle was prepared by following the protocol of Lal et al., (1986). Fruit (1kg) was weighed and washed followed by cutting into small pieces after destoning. Fruit pieces were subjected to blanching for 2 minutes and dried for 2 minutes. After drying, 60g salt, 15g turmeric powder, 15g red chili powder, 10g cumin seeds, 10g aniseeds, 10g clove powder, 5g cardamom, 20mL acetic acid were mixed with fruit. The mixture was filled in a jar and boiled mustard oil, cooled to about 60ºC was added. Later, it was cooled in a dry place**.**

iv. Jujube Preserve and Candied Jujube

Jujube preserves and candy was prepared by following the protocol of Pareek, 2013. After washing of fruits, the fruit was pricked with help of a fork followed by blanching for 2 minutes. Softened fruit was submerged into sugar syrup having a Brix of 40º. After this, sugar concentration was increased until Brix reached up to 70º. The citric acid (0.5 %) was added at the end of the procedure. For candied ber preparation, jujubes were submerged into sugar syrup having 40º brix followed by increasing its strength by addition of sugar until its Brix reaches 75º.

v. Dehydrated Jujubes

Dehydrated jujubes were prepared by following the procedure followed by Lal et al. (1986). The fruit was pinked with help of a fork followed by blanching for 2 minutes. After this, fruits were submerged into potassium metabisulphite solution (0.3 %) for 30 minutes. After this procedure, fruits were again washed and dipped into sugar syrup having Brix of 40º with the addition of 0.5% citric acid overnight. Next days, fruits were drained by using mesh and allowed to dry in a dehydrator at 55-60º C for 12 hours.

Jujube products

vi. Jujube syrup

Jujube syrup was prepared by following the protocol of California Rare fruit Growers (2001). Dried ber of about 1.5kg were drained and picked by using fork followed by boiling with 5 cups of water, 5cups of sugar and 1 tablespoon corn starch (for viscosity) with continuous stirring for 30 minutes. After boiling, cool, cover and chill overnight. Next day, again boiled for 30 minutes until syrup reduced to 2 cups.

vii. Shelf Life Study

Developed jujube products were subjected to shelf life study at prescribed intervals by considering following parameters *i.e.* moisture content, crude fiber, total sugars content, ascorbic acid content and TSS. Reason for selecting above mentioned paramters is that these parameters play an important role in effecting shelf life of any food commodity.

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Table 1: Physico-chemical composition of jujube cultivars.

Physico-chemical parameters	Karela	Aakash	Pak White	Dil bahar
Proximal composition				
Moisture (%)	76.77±0.02	77.37±0.02	84.41±0.03	73.46±0.02
Ash (%)	2.11±0.02	1.79±0.02	1.63±0.94	1.83±0.02
Crude fat (%)	0.19±0.02	0.13±0.02	0.20±0.03	0.22±0.02
Crude fiber (%)	6.39±0.02	4.21±0.02	5.85±0.01	3.98±0.02
Crude protein (%)	1.05±0.02	0.05±0.03	1.12±0.02	1.18±0.05
NFE (%)	13.14±0.62	17.61±2.11	9.77±0.65	18.96±0.70
Biochemical composition				
TPC (mgGAE/100g)	86.23±0.02	66.38±0.02	104.25±0.04	143.31±0.03
TSS (%)	16.65±0.01	5.21±0.06	5.93±0.06	5.33±0.06
Ascorbic acid (mg/100g)	30.22± 0.02	11.36 ±0.04	15.59 ±0.08	50.69 ±0.05
Anti-oxidant activity (%)	27.13±3.00	17.99±2.00	14.12±2.00	39.15±3.00
Total sugars (%)	41.21±0.03	6.33±0.02	7.86±0.03	43.29±0.02
Reducing sugars (%)	40.29±0.02	14.55±0.01	2.87±0.02	32.67±0.02
Non-reducing sugars (%)	32.45±0.04	6.72±0.03	10.62±0.03	18.39±0.03
Minerals				
K (mg/100g)	255.00±2.00	243.00±2.00	221.00±2.00	251.00±2.00
Na (mg/100g)	5.00±2.00	5.00±2.00	1.33±0.58	6.333.06
Zn (mg/100g)	0.08±0.01	1.10±0.10	0.05±0.02	0.05±0.04
Ca (mg/100g)	20.00±1.00	18.00±1.00	21.00±1.00	18.00±1.00
Mg (mg/100g)	7.67±0.58	8.00±1.00	6.00±0.00	4.33±0.58
P (mg/100g)	23.00±2.00	25.00±2.00	29.00±2.00	27.00±1.00
Fe (mg/100g)	0.53±0.02	0.85±0.02	0±.51±0.02	0.340.04

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Table 2: Biochemical parameters of various jujube based value added products during storage.

Days	TSS	Moisture (%)	Ascorbic acid(mg/100g)	Total sugars (%)	Crude Fiber (%)
			Jujube Syrup		
0 day	67.39±0.04^{a}	28.14±0.03^{a}	51.67±0.02^{a}	67.86±0.03^{a}	3.85±0.02^{a}
30th day	68.23±0.04^{b}	27.99±0.02^{b}	51.52±0.03^{b}	67.94±0.01^{b}	3.84±0.02^{ab}
60th day	69.52±0.04^{c}	27.94±0.03^{c}	51.18±0.03^{c}	68.12±0.03^{c}	3.82±0.02^{b}
90th day	70.71±0.06^{d}	27.77±0.04^{d}	51.01±0.02^{d}	68.47±0.02^{d}	3.80±0.01^{b}
			Jujube Jam		
0 day	68.28±0.03^{a}	26.31±0.02^{a}	50.39±0.04^{a}	66.24±0.02^{a}	3.89±0.01^{a}
30th day	69.11±0.05^{b}	26.24±0.02^{b}	49.97±0.02^{b}	66.51±0.03^{b}	3.92±0.01^{a}
60th day	69.98±0.07^{c}	26.18±0.03^{c}	49.94±0.04^{c}	67.22±0.03^{c}	3.93±0.01^{a}
90th day	70.24±0.05^{d}	26.10±0.02^{d}	49.90±0.03^{d}	68.41±0.02^{d}	3.95±0.01^{ab}
			Jujube Jelly		
0 day	67.14±0.03^{a}	19.44±0.02^{a}	49.69±0.04^{a}	57.55±0.03^{a}	3.88±0.01^{a}
30th day	67.23±0.02^{b}	18.43±0.01^{b}	49.53±0.03^{b}	57.73±0.01^{b}	3.90±0.01$_{a}$
60th day	67.37±0.02^{c}	15.41±0.02^{c}	49.48±0.01^{c}	57.94±0.03^{c}	3.92±0.01^{ab}
90th day	67.54±0.02^{cd}	11.39±0.02^{d}	49.40±0.01^{cd}	58.11±0.03^{d}	3.94±0.01^{c}
			Candied Jujube		
`0 day	69.21±0.04^{a}	15.24±0.02^{a}	50.33±0.02^{a}	61.85±0.01^{a}	3.87±0.02^{a}
60th day	69.32±0.03^{b}	15.13±0.02^{b}	50.29±0.04^{b}	61.82±0.02^{b}	3.85±0.02^{a}
120th day	69.37±0.02^{c}	14.93±0.02^{c}	49.93±0.02^{c}	61.77±0.03^{c}	3.84±0.02^{a}
180th day	69.46±0.03^{d}	14.77±0.02^{d}	49.84±0.03^{d}	61.73±0.02^{d}	3.81±0.02^{ab}

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Dehydrated Jujube					
`0 day	41.11±0.04[a]	8.73±0.02 [a]	50.30±0.02[a]	61.85±0.01[a]	3.91±0.02[a]
60th day	41.30±0.03[b]	8.81±0.02 [b]	50.27±0.04[b]	61.97±0.02[b]	3.92±0.01[a]
120th day	41.39±0.02[c]	8.85±0.02[c]	49.98±0.02[c]	62.12±0.03[c]	3.94±0.02[a]
180th day	41.51±0.03[d]	8.90±0.02 [d]	49.92±0.03[d]	62.55±0.02[d]	3.95±0.01[ab]
Jujube preserve					
0 day	67.14±0.03[a]	19.44±0.02[a]	49.69±0.04[a]	57.55±0.03[a]	3.88±0.01[a]
30th day	68.23±0.02[b]	18.43±0.01[b]	49.23±0.03[b]	58.73±0.01[b]	3.90±0.01[ab]
60th day	69.37±0.02[c]	16.41±0.02[c]	48.78±0.01[c]	60.94±0.03[c]	3.92±0.01[b]
90th day	71.54±0.02[d]	15.39±0.02[d]	46.40±0.01[d]	65.11±0.03[d]	3.94±0.01[bc]

Jujube pickle					
`0 day	54.39±0.02[a]	15.24±0.01[a]	51.37±0.02[a]	41.37±0.02[a]	3.88±0.02[a]
60th day	53.92±0.03[b]	15.13±0.02[b]	51.31±0.03[b]	41.39±0.01[b]	3.85±0.01[a]
120th day	53.74±0.04[c]	14.93±0.02[c]	50.27±0.03[c]	41.41±0.02[c]	3.82±0.02[a]
180th day	53.67±0.02[d]	14.77±0.01[d]	48.22±0.04[d]	41.45±0.02[d]	3.78±0.02[b]
Jujube tea					
0 day	36.54±0.02	5.64±0.07	32.65±0.07	57.26±0.02	3.71±0.01
60th day	38.12±0.01	6.89±0.04	30.71±0.02	58.35±0.04	3.64±0.01
120th day	39.06±0.05	7.14±0.04	29.42±0.01	59.66±0.02	3.58±0.08
180th day	40.35±0.07	7.65±0.06	26.78±0.03	61.94±0.09	3.46±0.07

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After development of products, the dried products were placed at room temperature (25 ºC), whereas, the other were placed at refrigerator (0-7 ºC). Shelf life study at prescribed intervals was considered by considering following parameters *i.e.* moisture content, crude fiber, total sugars content, ascorbic acid content and TSS. Reason for selecting above mentioned paramters is that these parameters play an important role in effecting shelf life of any food commodity. After development of products, the dried products were placed at room temperature (25 ºC), whereas, the other were placed at refrigerator (0-7 ºC).

DISCUSSION

Physico-chemical composition

The compositional analysis of the fresh jujube powder is exhibited in Table 1. Moisture content in Karela, Aakash, Pak White and Dil Bahar cultivar was analyzed as 76.77±0.02%, 77.37±0.02%, 84.41±0.03% and 73.46±0.02% respectively. Higher moisture content (84.41±0.03%) was observed in Pak white whereas lower moisture content (73.46 ±0.02%) was observed in Dil Bahar. The current findings of the moisture content of ber were in corroboration with Gao et al., (2013) that showed moisture content in ber as 77.86%.

Crude fat content in Karela, Aakash, Pak white and Dil Bahar cultivar was calculated as 0.19±0.02%, 0.13±0.02%, 0.20±0.03% and 0.22±0.02% respectively. Present results of crude fat content of ber were matched with Gao et al. (2013) that showed 0.20% crude fat content in ber.

Crude protein content was measured as 1.05±0.02% in Karela, 0.05±0.03% in Aakash, 1.12±0.02% in Pak white and 1.18±0.05% in Dil Bahar. Higher crude potein content (1.18±0.05%) was observed in Dil Bahar whereas lower crude protein content (0.05±0.03%) was observed in Aakash. The current result of crude protein content of ber was linked with the conclusion of Li et al. (2007). According to their findings, crude protein content in ber was 1.13%.

Crude fiber content was recorded as 6.39±0.02%, 4.21±0.02%, 5.85±0.01% and 3.98±0.02% in Karela, Aakash, Pak white and Dil bahar respectively. The current result of crude fiber content of ber was linked with the conclusion of Li et al. (2007). According to their findings, crude fiber content in ber was 5.24-7.18%.

Ash content in Karela, Aakash, Pak white and Dil bahar was calculated as 2.11±0.02%, 1.79±0.02%, 1.63±0.94% and 1.83±0.02% respectively. Higher ash content (2.11±0.02%) was observed in Dil Bahar whereas lower ash content (1.63±0.94)% was observed in Karela. The current result of crude ash content of Ber was linked with the conclusion of Li et al. (2007). According to their findings, ash content in ber was 2.26 %.

Nitrogen free extract in Karela, Aakash, Pak white and Dil bahar was calculated as 13.14±0.62%, 17.61±2.11%, 9.77±0.65% and 18.96±0.70% respectively. Higher NFE (18.96±0.70%) was observed in Dil Bahar whereas lower NFE (9.77±0.65%) was observed in Pak white.

The minerals composition of fresh jujube powder was performed by using Atomic Absorption Spectrophotometer and flame photometer according to the respective protocol as illustrated by (AOAC, 2010) as shown in table 1.

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Potassium content in Karela was measured higher i.e. 255.00±2.00mg/100g followed by 251.00±2.00mg/100g, 243.00±2.00mg/100 and 221.00±2.00mg/100g in Aakash, Pak White and Dil Bahar respectively. Sodium content in selected cultivars was calculated as 5.00±2.00mg/100g, 5.00±2.00mg/100g, 1.33±0.58mg/100g and 6.333.06mg/100g respectively. Result showed maximum zinc content (1.10±0.10mg/100g) in Aakash cultivar while lowest (0.05±0.02mg/100g) in Pak white and Dil Bahar. Calcium content in Karela cultivar was analyzed as 20.00±1.00mg/100g while in Aakash, Pak White and Dil Bahar cultivar, results obtained were calculated as 18.00±1.00mg/100g, 21.00±1.00 mg/100g and 18.00±1.00mg/100g. Results regarding magnesium content showed higher value in Aakash and Pak White cultivar i.e. 8.00±1.00 mg/100g followed by 7.67±0.58 mg/100g and 4.33±0.58 mg/100g in Karela and and Dil Bahar. Phosphorus content was measured as 23.00±2.00 mg/100g, 25.00±2.00 mg/100g, 29.00±2.00 mg/100g and 27.00±1.00 mg/100g in Karela, Aakash, Pak White and Dil Bahar cultivar respectively.

Titratable acidity in selected cultivars were calculated as shown in Table 1. Higher titratable acidity (3.45 ±0.02 %) was observed in Dil Bahar whereas lower (2.96 ±0.02%) was observed in Aakash.

Total Soluble Solids in Karela, Aakash, Pak white and Dil bahar cultivars were calculated as 13.15±0.01%, 5.27±0.06%, 5.93±0.06% and 4.73±0.06% respectively. Higher TSS (13.15±0.01%,) was observed in Karela whereas lower TSS (4.73±0.06%) was observed in Dil Bahar.

Higher ascorbic acid content (51.69 ±0.05 mg/100g) was recorded in Dil Bahar followed by 31.26± 0.02 mg/100g in Karela, 19.59 ±0.08 mg/100g in Pak white and 13.34 ±0.04 mg/100g in Aakash cultivar. The current findings recorded for ascorbic acid content of selected ber cultivars was different from the conclusion of Pareek et al. (2010) due to difference in cultivar and environmental conditions. According to their findings, ascorbic acid content in ber varieties was 65.8-76.0mg/100g.

Total phenolic content showed maximum value (144.38mgGAE/100g) in Dil Bahar whereas lower TPC value (69.35±0.03mgGAE/100g) in Karela. The current result of total phenolic content of ber were in confirmity with the conclusion of Koley et al. (2016). According to their findings, TPC content in ber varieties was ranged between 258.06±37.99 and 187.48±34.16 mgGAE/100g

Antioxidant activity recorded for respective cultivars was 28.00±0.02%, 18.00±0.02%, 13.00±0.02% and 39.00±0.02%. Higher antioxidant activity (39.00±3.00%) was observed in Dil Bahar whereas lower antioxidant activity (13.00±2.00%) was noted in Pak White.

Storage Stability

i. Jujube syrup

The TSS of jujube syrup at was analyzed as 67.39±0.04% (day 0) and increased slightly at 30th, 60th and 90th day of storage. The reason may be due to the hydrolysis of carbohydrates into simple sugars and disaccharides. Current findings of this study were matched with Mandal and Sahoo (2014) that showed an increase in TSS content of syrup during increase in storage time.

Total sugar content at 0, 30th, 60th and 90th day of storage was significantly increased as shown in table 2. The reason of increased sugar content may be due to hydrolysis of starch (50.3 %) into sugars

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or polysaccharides may convert into monosaccharide.

Ascorbic acid content of syrup was decreased during storage (0, 30th, 60th, 90th) from 51.67±0.02 mg/100g to 51.01±0.02 mg/100g. A decrease in ascorbic acid content may be due to the conversion of ascorbic acid into dehydroascorbic acid (Chauhan et al., 2018).

Moisture content in jujube syrup reduced as storage time increased *i.e.* 28.14±0.03%, 27.99±0.02%, 27.94±0.03% and 27.77±0.04% at 0, 30th, 60th and 90th day respectively. Reduction in moisture content may be due the fact that sugars bind moisture during storage (Hajmeer et al., 2000).

The crude fiber content of jujube syrup was slightly decreased during storage as shown in table 2. Decrease in fiber content may be due to the degradation of fiber into monosaccharides.

ii. Jujube Jam

TSS of jujube jam at day 1 was analyzed as 68.28±0.03% and increased further from 69.11±0.05% to 70.24±0.05%. Reason may be due to the hydrolysis of polysaccharides and solubilization of fruit pulp. Current findings of this study conformed with Sawant et al. (2009) that showed increased TSS content of syrup during storage.

Ascorbic acid content of jujube jam was decreased during storage *i.e.* 50.39±0.04mg/100g, 49.97±0.02mg/100g, 49.94±0.04mg/100g, 49.90±0.03mg/100g at 0, 30th, 60th and 90th day respectively. Decrease in ascorbic acid content may be due to degradation of ascorbic acid at higher temperatures during the summer season as ascorbic acid is thermolabile. Moreover, it may be due to degradation of ascorbic acid into dehydroascorbic acid by presence of ascorbinase enzyme (Shakir et al., 2008).

Total sugar content of jujube jam was increased at 0, 30th, 60th and 90th day respectively. Reason may be due to the dissolution of pulp content, hydrolysis of starch and pectin into sugars or polysaccharides may convert into monosaccharides. These results were in justification with Ahmed et al. (2016) that showed similar increase trend in sugar content.

Moisture content in jujube jam was reduced as storage time increased *i.e.* 26.31±0.02%, 26.24±0.02%, 26.18±0.03% and 26.10±0.02% at 0, 30th, 60th and 90th days respectively. Reduction in moisture content may be due the fact that sugars bind moisture and make it unavailable for microbial growth during storage (Afoakwa et al., 2006).

Crude fiber content of jujube jam was remained stable during 0, 30th, 60th and 90th day of storage. Reason of stability is that it is macromolecule and can be stable at low water activity and room temperature.

iii. Jujube Jelly

Moisture content in jujube jelly was analyzed at 0, 30th, 60th and 90th day and results showed significant decrease in moisture content *i.e.* 19.44±0.02%, 18.43±0.02%, 15.41±0.04% and 11.39±0.02% respectively. Reduction in moisture content may be due to binding of moisture by sugars or due to reopening of the jelly jar for analysis purposes (Muhammad et al., 2008). Current findings were in corroboration with Panchal *et al.* (2018) that showed similar reduction in moisture content.

TSS of jujube jelly at day 1 was analyzed as 67.14±0.03% and increased slightly from 67.23±0.02%, 67.37±0.02% to 67.54±0.02% at 30th, 60th and 90th day respectively. Reason may be due to conversion of polysaccharides into monosaccharide (Kumar and Deen, 2017). Current findings of this study were identical to Singh and Chandra (2012) that showed increased TSS content of apple jelly during storage.

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Total sugar content of jujube jelly was increased during storage and reason may be due to loss of moisture content during storage, hydrolysis of starch into sugars. These results were in collaboration with Relekar et al., (2011) that showed similar trend in sugar content.

Ascorbic acid content of jujube jelly was decreased during storage *i.e.* 49.69±0.04 mg/100g (0 day), 49.53±0.03 mg/100g (30^{th} day), 49.48±0.01 mg/100g (60^{th} day) and 49.40±0.01 mg/100g (90^{th} day). Decrease in ascorbic acid content may be due to degradation of ascorbic acid at higher temperature or oxidation of ascorbic acid or catalytic activity of fructose in ascorbic acid metabolism. Moreover, it may be due to degradation of ascorbic acid into dehydroascorbic acid (Kumar and Deen, 2017).

Crude fiber content of jujube preserve was remained stable during storage. Reason of stability is that it is macromolecule and can be stable at low water activity and room temperature.

iv. Jujube Preserve

The TSS contents of jujube preserve was measured over a period of 90 days with 30 days interval. The initial value (0 day) was noticed 67.14±0.03% that increased significantly with a final value 67.54±0.02% (90^{th} day). Reason may be due to conversion of polysaccharides into monosaccharide.

Moisture content in jujube preserve showed significant decrease in moisture content at 0 day (19.44±0.02 g/100g), 30^{th} day (18.43±0.01 g/100g), 60^{th} day (16.41±0.02 g/100g) and 90^{th} day (15.39±0.02 g/100g). Reduction in moisture content may be due binding of moisture by sugars.

Ascorbic acid content of jujube preserve was significantly decreased *i.e.* 49.69±0.04 mg/100g, 49.23±0.03 mg/100g, 48.78±0.01 mg/100g and 46.40±0.01 mg/100g at 0, 30^{th}, 60^{th} and 90^{th} day respectively. Decrease in ascorbic acid content may be due to degradation of ascorbic acid at higher temperature or oxidation of ascorbic acid or due to breakdown of ascorbic acid into dehydroascorbic acid.

Total sugar content of jujube preserve showed significantly increased value with 30 days duration. At 0 day, total sugar content was recorded as. 57.55±0.03% followed by 58.73±0.01%, 60.94±0.03% and 65.11±0.03% at 30^{th}, 60^{th} and 90^{th} day respectively. Reason may be due to the breakdown of starch into sugars.

Fiber content of jujube preserve showed non-significant results and remained stable during storage Reason of stability is that it is macromolecule and can be stable at low water activity.

v. Jujube pickle

TSS of jujube pickle was analyzed as 54.39±0.02% at day 0 and increased non-significantly at 60^{th}, 120^{th} and 180^{th} day of storage. Current findings of this study were identical to Thakur et al., (2017) that showed increased trend of TSS content in pickle during storage.

Ascorbic acid content of jujube pickle was significantly reduced for a period of 60 days interval. Results showed that ascorbic acid value at 0 day was measured as 51.37±0.02mg/100g while lowest value was noticed at 180^{th} day of storage i.e. 48.22±0.04mg/100g. Decrease in ascorbic acid content may be due to degradation of ascorbic acid at higher temperature or due to breakdown of ascorbic acid into dehydroascorbic acid.

Fiber content of jujube pickle was decreased slightly during storage from 3.88±0.02 g/100g , 3.85±0.01 g/100g , 3.82±0.02 g/100g and 3.78±0.02 g/100g at 0, 60^{th}, 120^{th} and 180^{th} day respectively. Decrease in fiber content may be due to its degradation into simple sugars.

Moisture content of jujube pickle was decreased slightly and showed non-significant results during storage as shown

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in table 2. Decrease in moisture level may be because of binding of moisture by sugars.

Total sugars content of jujube pickle was increased non-significantly during storage i.e. 41.37±0.02% (highest) and 41.45±0.02% (lowest) at 0, 60th, 120th and 180th day respectively. Increase in sugar content may be due to conversion of starch into sugars.

vi. Candied Jujube

Total sugars content of candied jujube was decreased during storage from 61.85±0.01%, 61.82±0.02%, 61.77±0.03% and 61.73±0.02% at 0, 60th, 120th and 180th day respectively. Decrease in sugar content may be due to its oxidation at room temperature.

Ascorbic acid content of candied jujube was decreased during storage from 50.33±0.02mg/100g, 50.29±0.04mg/100g, 49.93±0.02mg/100g and 49.84±0.03mg/100g at 0, 60th, 120th and 180th day respectively. Decrease in ascorbic acid content may be due to degradation of ascorbic acid at higher temperature.

Moisture content of candied jujube was decreased slightly during storage from 15.24±0.01%, 15.13±0.02%, 14.93±0.02% and 14.77±0.01% at 0, 60th, 120th and 180th day respectively. Decrease in moisture level may be because of binding of moisture by sugars.

TSS of candied jujube was analyzed as 69.21±0.04 at day 1 and increased slightly from 69.32±0.03 69.37±0.02 and 69.46±0.03 at 60th, 120th and 180th day respectively. Reason may be due to conversion of starch into simple sugars.

Fiber content of candied jujube remained stable during storage and showed no significant difference *i.e* 3.87±0.02%, 3.85±0.01%, 3.84±0.02% and 3.81±0.02% at 0, 60th, 120th and 180th day respectively. Reason of stability is that it is macromolecule and can be stable at low water activity.

vii. Dehydrated jujube

Ascorbic acid content of dehydrated jujube was decreased during storage from 50.30±0.02mg/100g, 50.27±0.04mg/100g, 49.98±0.02mg/100g and 49.92±0.03mg/100g at 0, 60th, 120th and 180th day respectively. Decrease in ascorbic acid content may be due to increase in temperature during storage that increased water mobility inside jujubes. As a result, degradation of ascorbic acid into dehydroascorbic acid occurs (Rodríguez et al,. 2009).

Moisture content of dehydrated jujube was increased during storage from 8.73±0.02%, 8.81±0.02%, 8.85±0.02% and 3.95±0.01% at 0, 60th, 120th and 180th day respectively. An increase in moisture level may be because of absorption of moisture by fiber content in jujube powder.

Fiber content of dehydrated jujube was remained stable during storage *i.e.* 3.91±0.02%, 3.92±0.01%, 3.94±0.02% and 3.95±0.01% at 0, 60th, 120th and 180th day respectively. Reason for stability is that it is macromolecule and can be stable at low water activity (Sudha et al. 2007)
Total sugars content of dehydrated jujube was increased during storage from 61.85±0.01%, 61.97±0.02%, 62.12±0.03% and 62.55±0.02% at 0, 60th, 120th and 180th day respectively. An increase in sugar content may be due to hydrolysis of polysaccharides in dehydrated jujube powder.

TSS of dehydrated jujube was analyzed as 41.11±0.04 at day 1 and increased slightly from 41.30±0.03, 41.39±0.02 and 41.51±0.03 at 60th, 120th and 180th day respectively. Reason may be due to increased concentration of sugars due to the conversion of starch into monosaccharide. Current findings of this study were identical to Rahel et al. (2016) that showed increased trend of TSS content during storage.

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CONCLUSION

Study showed that jujube products are an excellent source of nutrition with higher shelf life. Development of value-added products from jujube will be a great approach to minimize post-harvest losses and maximum utilization of minor fruit in Pakistan. As jujubes appear for shorter time span, development of products will assist to enjoy jujube taste throughout the year. Moreover, study showed that sugar content, TSS, and moisture content increased significantly during storage while crude fiber content remained stable.

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CONFLICT OF INTEREST

The researchers/scientist do not owe any conflict of interest.

AUTHOR'S CONTRIBUTION:

All authors contributed equally in performing research activities and compilation of results.

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