

Research Article

Impact of Water Chestnut Addition on Development and Characterization of Supplemented Date Bar

Muhammad Nadeem^{1*}, Aneeta Rehman¹, Masooma Munir^{1*}, Hira Fatima², Faiqa Malik¹, Aqsa Iqbal¹ and Alaiha Asif³

¹Institute of Food Science and Nutrition, University of Sargodha, Sargodha, Pakistan; ²Department of Botany, University of Lahore, Sargodha Campus, Sargodha, Pakistan; ³Institute of Food Science and Technology, BZU, Multan, Pakistan.

Abstract | Water chestnut (*Trapa natans* L.) is one of Pakistan's most overlooked fruits; despite its high nutritional value, it fails to capture the attention of food processors in Pakistan due to its seasonal availability. Many types of products can be made because of its starchy taste, firm and crispy texture. In the present study, three treatments (T₀, T₁ and T₂) of date bar of approximately 36±2g weight with high nutritional value were prepared on the basis of water chestnut supplementation. For this purpose, water chestnut powder and date paste were used in different proportion. These bars were analyzed for physico-chemical, microbial and sensory analysis characteristics. The proximate analysis of date bars supplemented with water chestnut indicated that the moisture, crude protein, fat, fiber, ash and NFE contents for treatments ranges from 5.45-7.27%, 4.02-5.25%, 1.77-2.81%, 1.48-2.97%, 1.28-1.93% and 82.69-83.09%, respectively. The microbial analysis of fruit bars showed that mean values of TPC changed gradually from 1.64 to 2.31 log₁₀ CFU / g during 90 days of storage. The mean values for sensory assessment indicated that T₁ was preferred over the other treatments in terms of overall acceptability, color, taste, flavor, and texture. The bars received a favorable sensory score and remained stable over a 90-day storage period. Additionally, the study discovered that water chestnut powder can be used to boost the nutritional value and health benefits of date fruit bars.

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***Correspondence** | Muhammad Nadeem and Masooma Munir, Institute of Food Science and Nutrition, University of Sargodha, Sargodha, Pakistan; **Email:** nadeem.abdul@uos.edu.pk and masoomamunir@parc.gov.pk

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Keywords | Fruit bar, Water chestnut, Dates, Nutritional aspects, Value addition



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Introduction

Fruits are eaten and liked by many people of all age groups belonging to different regions of the world but some fruits are available during the specific season. To enjoy the taste and health benefits of fruits we can preserve them. Development of fruit bars is

one of the methods used to preserve fruits. Mostly fruit bars are prepared for value addition from the fruits that are perishable in nature and have low shelf life. Varieties of fruit bars are prepared from combinations of different fruits or from a single one (Akhtar *et al.*, 2014). Global market study on nutritional bars has revealed that in North America

nutritional bars are providing more than 40% global market share and this is increasing day by day (Van Toan and Vinh, 2018).

A fruit bar is a dense concentrated processed food product that provides the consumer with vitamins, minerals, and calories. The addition of a new ingredient to an existing product must improve the product's desirable characteristics such as shelf life, nutritional value, taste, smell, and texture (Parekh *et al.*, 2014). Fruit bars are prepared mechanically, which makes them hygienic and easily consumable. Fruit bars are referred to as adaptable food products because they can be consumed either with ice cream, milk, or yoghurt or on their own (Maurer *et al.*, 2005). Food bars were introduced to meet the demand of the snack market by providing a nutritious food (Ryland *et al.*, 2010).

Date palm is a native plant of Middle East countries (Jain *et al.*, 2011). In 2015, date production exceeded 537204 tons in Pakistan. To reduce post-harvest losses of date fruit and for better health benefits of products it is recommended by many national and international forums to process date into to innovative food products (Rehman *et al.*, 2020). Many innovative food products are processed with date paste in Aryan market that includes jams, jellies, syrup and pickle (Alhamdan, 2002).

Water chestnut is a fruit with the scientific name of *Trapa natans* but known as Singhara in different parts of Pakistan. It is an annual fruit which is mainly present in the aquatic environment with the floating leaves. Its main habitats are sub-tropical and tropical regions (Takano and Kadono, 2005). Water chestnut fruit is full of nutrients but it failed to get importance and the desired attention of food processors due to its short time availability in Pakistan. Water chestnut is a versatile fruit of Pakistan as it can be used raw, grilled, fried, boiled, pickled or can be added in omelet, chop suey, stir fish or curries. Its extracted oil can be used in salads and other products (Habib *et al.*, 2014). Water chestnut possesses great Ayurveda importance as it has good cooling, diuretic, anti-diarrheal, astringent, anti-cancer, tonic and aphrodisiac properties (Parekh and Chanda, 2007) or as an analgesic (Panda *et al.*, 2010) or as anti-inflammatory (Patel *et al.*, 2010).

Products from natural sources are being used for centuries (Ranjha *et al.*, 2020). In the current scenario

development of date bars supplemented with high nutritional food such as water chestnut is an acceptable and nutritious alternative to other snack products. Date bars have superiority among other snack products as it is not only a source of natural sugars, sucrose and fructose (Al-Farsi *et al.*, 2005), but also contain a significant number of dietary fibers. Use of water chestnut flour in date bars may be attractive for the people as it could be a conventional alternative of existing date bars. From last few years progress is observed in formation of date bars, Snack bars with dates and cereals is being studied (Munir *et al.*, 2016; Nadeem *et al.*, 2018; Bemfeito *et al.*, 2021) but addition of chestnut in date bars has not been studied yet. The purpose of this project was to determine the suitability of date paste and water chestnut powder for use in nutrient dense fruit bars and to evaluate the quality of fruit bars during storage through physicochemical, microbial, and sensory analysis.

Materials and Methods

Selection of raw materials

Commercially available dried water chestnut, roasted corn, dates, and salt were brought from market of Sargodha, Pakistan. Analytical chemicals were also purchased locally.

Preparation of ingredients

Dried water chestnut kernels and roasted corn were ground to make water chestnut and corn flour. Repeated sieving and grinding were done to obtain a fine powder. Dates were washed, dried, and then pitted. Pitted dates were steamed for 10 minutes until softened then sundried for two hours. Steamed dates were minced by using a mincing machine to form date paste.

Procedure for development of water chestnut supplemented date bars

Water chestnut supplemented date fruit bar was formulated following the method of Rehman *et al.* (2020) with minor changes. Water chestnut powder, roasted corn flour, and salt were added in date paste and properly mixed to form firm dough. To achieve a more defined bar shape, the dough was transferred to a sheeting and cutting table. After sheeting with a roller, the sheet was cut into bars 2.5 cm wide, 1 cm thick, and 7.5 cm long with a cutter (Munir *et al.*, 2016). The bars were immediately transferred to the oven and baked for 15 minutes at 180°C after cutting.

After cooling at room temperature, the baked bars were wrapped in airtight aluminium foil packs. The proportion of each ingredient is listed in Table 1 and 2 (Figure 1).

Table 1: Formulation of water chestnut supplemented date bars.

Ingredients	Quantity (g)
Date paste	100
Corn flour	10
Water chestnut powder	7.5-15
Salt	0.1

Proximate analysis

Water chestnut supplemented date bar was analyzed for its proximate composition on dry matter basis that mainly include moisture, crude fat, crude protein, crude fiber and ash according to the procedures given in AACC (2000).

Microbial analysis

Total plate count: Method No. 42-11, as described in (AACC, 1999), was used for the total plate count determination. 1 g crushed bar sample was placed on sterile weighing paper and transferred to a sterile blender jar with 9 ml buffered phosphate diluents using a sterile spoon. It was blended at a slow speed for 1–2 minutes until the sample was comminuted. 1 ml of the previous sample was transferred to 9 ml phosphate diluents to create decimal dilutions. All dilutions were agitated to resuspend the material, and 1 ml of each dilution was transferred to a duplicate petri dish with the appropriate labelling. Within 15 minutes of the original dilution, 12 to 15 mL of cooled (45°C) plate count agar was poured into plates and allowed to solidify. Dilutions were poured into control plates which were then rotated to ensure mixing of sample with medium. Inverted Petri dishes were incubated for 48 hours at 35°C. On plates, colonies were counted and multiplied by the dilution factor. The arithmetic mean was denoted by a plate per gram.

Sensory analysis

Sensorial properties such as texture, flavour, overall acceptability and color of water chestnut supplemented date bars was evaluated at room temperature in a sensory evaluation lab by a panel of judges using the 9 points Hedonic Scale (Land and Shepherd, 1988).

Statistical analysis

Using the analysis of variance technique, the obtained results were statistically analyzed. To determine the differences among means, the least significant design was used (Steel et al., 1997).

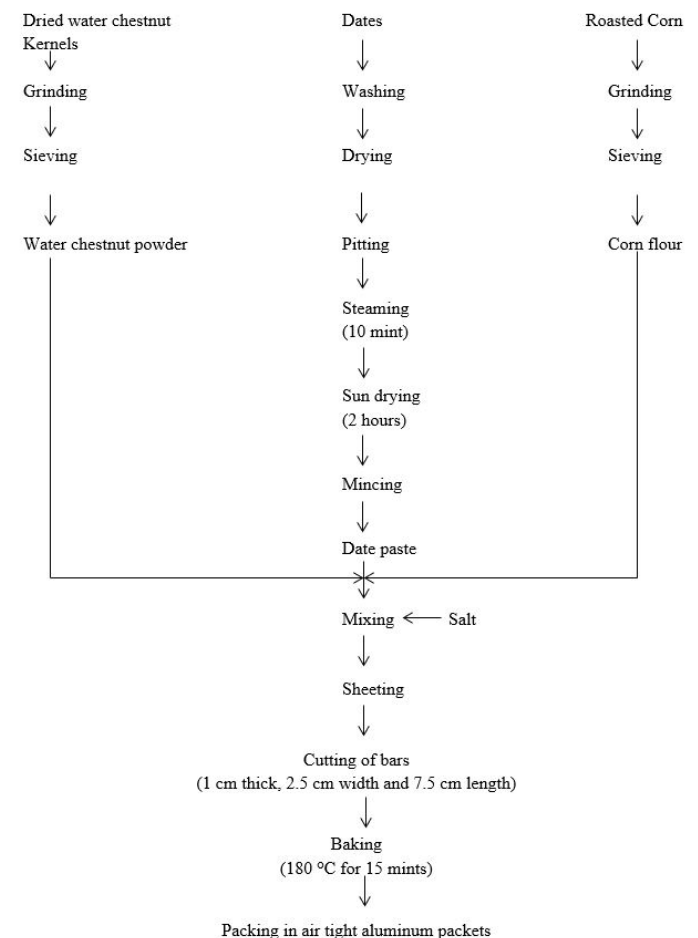


Figure 1: Flow Chart of water chestnut supplemented date bars.

Results and Discussion

Proximate composition of water chestnut supplemented date bars

Moisture (%): Figure 2 depicts the mean values for the influence of treatments upon the moisture content of water chestnut supplemented date bars. Results demonstrate that with each treatment the moisture content decreases in significant manner. The mean values exhibited by T₀, T₁, and T₂ were 7.27, 6.85, and 5.45 %, respectively. The highest mean value was noticed in the case of T₀, whereas the least was observed in the case of T₂, owing to the fact that T₂ contains more water chestnut powder with a low moisture content. Van Toan and Vinh (2018) reported similar findings, noting that the moisture content of five treatments decreased gradually from 20.50 to 18.90% of nutritional bars prepared with varying proportions of oat flour and brown rice flour.

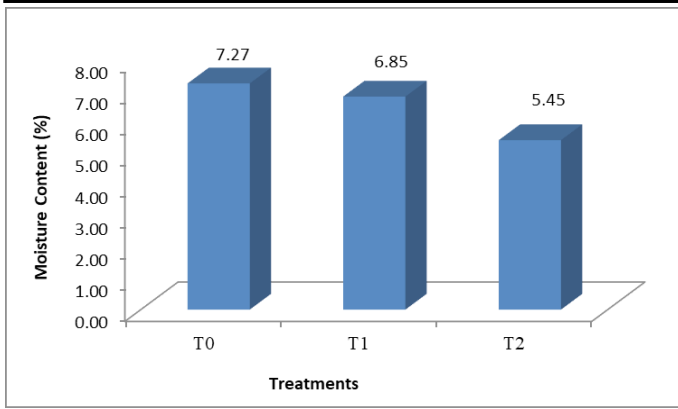


Figure 2: Moisture profile of different treatments of water chestnut supplemented date bars. T₀ = Date bars without addition of Water chestnut powder; T₁ = Date bars supplemented with 25% of Water chestnut powder; T₂ = Date bars supplemented with 50% of Water chestnut powder.

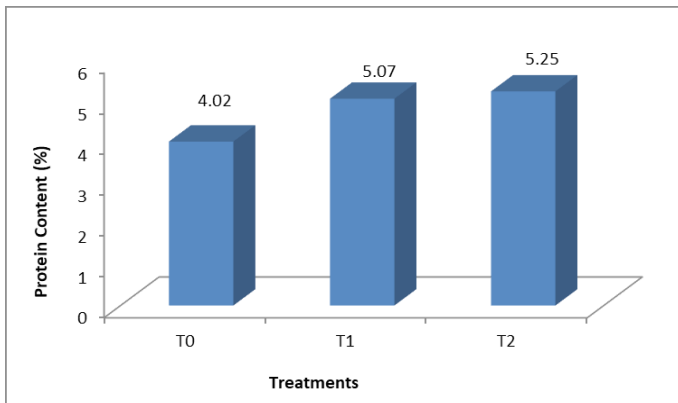


Figure 3: Protein profile of different treatments of water chestnut supplemented date bars. T₀ = Date bars without addition of Water chestnut powder; T₁ = Date bars supplemented with 25% of Water chestnut powder; T₂ = Date bars supplemented with 50% of Water chestnut powder.

Protein (%): In Figure 3, the mean values for the effect of treatments on protein content are plotted. Protein content increased significantly across treatments. The treatment T₀, T₁, and T₂ exhibited mean values of 4.02, 5.07, and 5.25 %, respectively. T₂ had the highest protein content, while T₀ had the lowest. Munir *et al.* (2018) reported similar findings, stating that the protein content of oat supplemented date fruit snack bars increased significantly from 9.7 to 14.3% from treatment T₀ to T₃, as the white oat proportion increased.

Fat (%): Additionally, from T₀ to T₂, the fat content increased. Figure 4 illustrates the mean values for the effect of treatments on fat content. T₀, T₁, and T₂ had mean values of 1.77, 2.53, and 2.81 %. As a result, the maximum mean value was discovered in T₂, while the minimum mean value was noticed in T₀. The changes in fat content are consistent with findings of Munir *et al.* (2018).

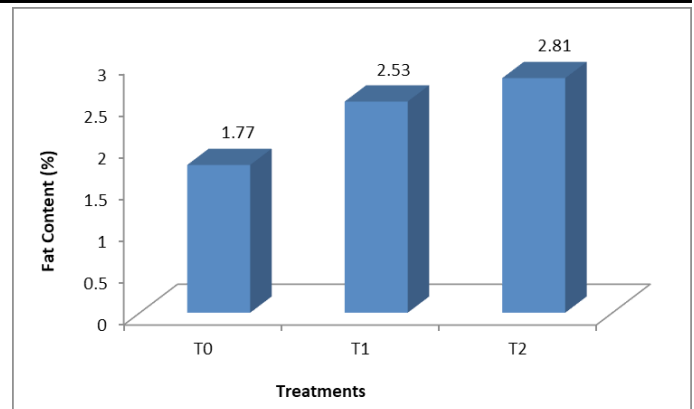


Figure 4: Fat profile of different treatments of water chestnut supplemented date bars. T₀ = Date bars without addition of Water chestnut powder; T₁ = Date bars supplemented with 25% of Water chestnut powder; T₂ = Date bars supplemented with 50% of Water chestnut powder.

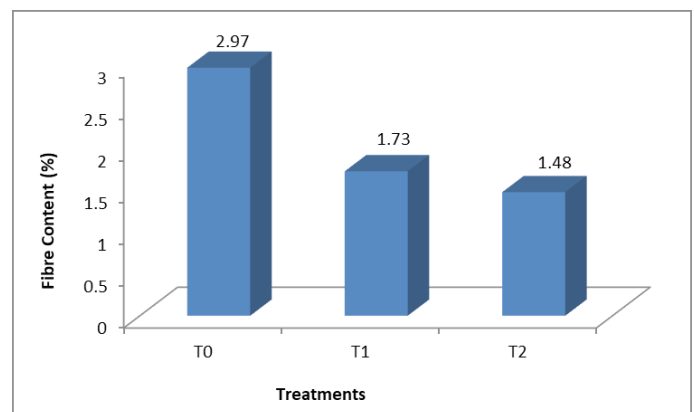


Figure 5: Fiber profile of different treatments of Water chestnut supplemented date bars. T₀ = Date bars without addition of Water chestnut powder; T₁ = Date bars supplemented with 25% of Water chestnut powder; T₂ = Date bars supplemented with 50% of Water chestnut powder.

Fiber (%): The results indicate that the crude fibre content decreases significantly with each treatment. In Figure 5, the mean values regarding the influence of treatments upon the fiber contents of date bar supplemented with water chestnut are plotted. The mean values for T₀, T₁, and T₂ were 2.97, 1.73, and 1.48 %, respectively. The maximum mean value was discovered for T₀, while the minimum mean value was discovered for T₂. The change in crude fiber content is consistent with the findings of Van Toan and Vinh, (2018), who noted that the crude fiber content of five treatments decreased progressively from 1.15 to 0.56 % of nutritional bars prepared with varying proportions of oat flour and brown rice flour.

Ash (%): Figure 6 plots the mean values for the effect of treatments on the ash content. The results indicate that the ash content increased from T₀ to T₂. The mean values for T₀, T₁, and T₂ were 1.28, 1.73, and

1.93 %, respectively. As a result, the highest mean value was discovered in T_2 and the lowest mean value was discovered in T_0 . The results regarding the change in ash content are highly consistent with findings of Munir *et al.* (2018).

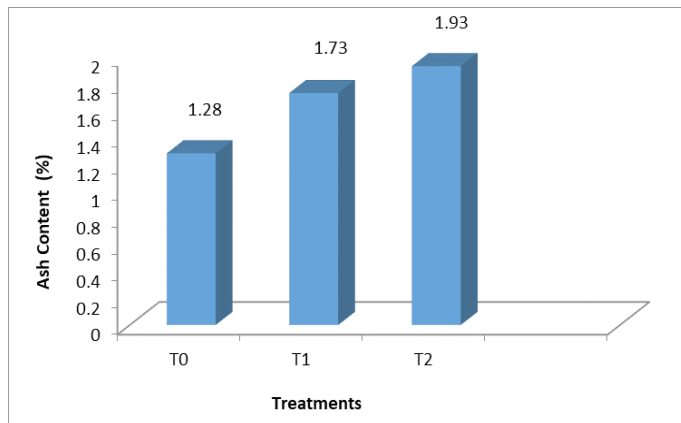


Figure 6: Ash profile of different treatments of Water chestnut supplemented date bars. T_0 = Date bars without addition of Water chestnut powder; T_1 = Date bars supplemented with 25% of Water chestnut powder; T_2 = Date bars supplemented with 50% of Water chestnut powder.

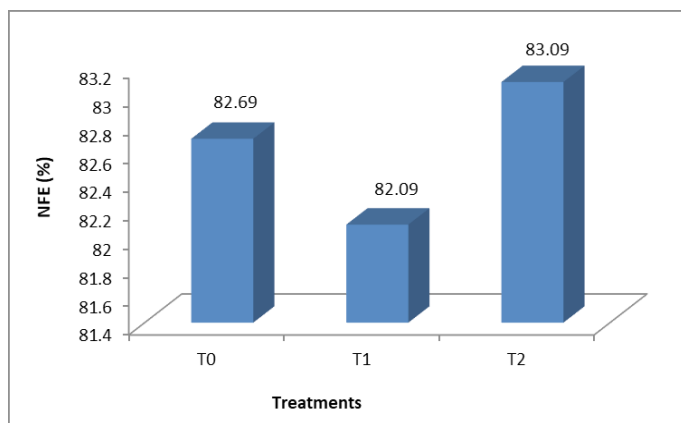


Figure 7: NFE profile of different treatments of Water chestnut supplemented date bars. T_0 = Date bars without addition of water chestnut powder; T_1 = Date bars supplemented with 25% of Water chestnut powder; T_2 = Date bars supplemented with 50% of Water chestnut powder.

Nitrogen free extract (NFE %)

The concentration of NFE varied significantly between treatments. In Figure 7, the mean values regarding the influence of treatments upon the nitrogen free extract content have been plotted. The mean values of 82.69, 82.09, and 83.09%, was recorded in case of treatments T_0 , T_1 , and T_2 , respectively. Thus, the highest mean value was discovered in T_2 , while the lowest mean value was discovered in T_1 . The results regarding the change in NFE content are consistent with those of Rehman *et al.* (2020), who found that contents of NFE varied in significant manner between apricot-date bar treatments.

Table 2: Variable formulation of water chestnut supplemented date bars (Treatment plan).

Treatment	Date paste (g)	Water chestnut powder (g)	Corn flour (g)	Salt (g)
T_0	100	0	10	0.1
T_1	100	7.5	10	0.1
T_2	100	15	10	0.1

Microbial analysis

Total plate count: TPC levels varied significantly between treatments. Similarly, a significant effect of storage periods on TPC was observed. The TPC values for water chestnut supplemented date bar samples are shown in Table 3. The mean total plate count for treatments T_0 , T_1 , and T_2 is 2.01, 1.92, and 1.93 log₁₀ CFU/ g, respectively. At 0 and 90 days, the mean values for storage increased gradually from 1.64 to 2.31 log₁₀ CFU/g. The change in TPC concentrations during storage for various treatments is consistent with the findings of Rehman *et al.* (2020), who reported that TPC concentrations increased significantly during storage for all five treatments, ranging from 1.00 to 2.18 log₁₀ CFU/g of fiber-enriched date bars derived from natural resources.

Sensory evaluation of water chestnut supplemented date bars

Quality of water chestnut supplemented date bars can also be assessed through sensory evaluation. For consumer acceptance the bars should have good color, flavor, taste and overall acceptability (Table 4).

Color: The data pertaining to the color of water chestnut supplemented date bars as influenced by storage intervals of 90 days was collected and evaluated. The findings indicate that significant differences exist between the various treatments. The mean color values indicate that T_1 was more liked than the other treatments. The effect of storage was determined to be statistically significant as well. The mean color score ranged from 7.63 to 6.02 over a 90-days storage period. Thus, a maximum score was observed when date bars were fresh, and a minor decreasing trend was observed as time passed. The effects of treatment and storage on the color of date bars were not significant. Similarly, Akhtar *et al.* (2014) discovered that storage periods have a marginally significant effect on the color of apple date fruit bars made with varying amounts of pectin and starch. Color change was observed after three months of storage at ambient temperature.

Table 3: Mean values for total plate count ($\text{Log}_{10} \text{CFU/g}$) of Water chestnut supplemented date bars.

Treatments	Storage (days)				Means
	0	30	60	90	
T ₀	1.68±0.02fg	1.87±0.04d	2.17±0.07b	2.32±0.14a	2.01 ^a
T ₁	1.61±0.10g	1.79±0.11de	2.01±0.08c	2.30±0.06a	1.92 ^b
T ₂	1.65±0.10fg	1.72±0.12ef	2.06±0.12bc	2.31±0.05a	1.93 ^b
Means	1.64d	1.79c	2.08b	2.31a	

Different alphabets with means represent significant trend.

Table 4: Mean values for sensory evaluation score of water chestnut supplemented date bars.

Physical analysis	Treatments	Storage (days)				Means
		0	30	60	90	
Color	T ₀	7.60±0.57ab	7.35±0.63abc	6.65±0.67cde	6.15±0.47ef	6.94 ^{ab}
	T ₁	7.90±0.39a	7.45±0.55ab	7.10±0.70bcd	6.17±0.58ef	7.15 ^a
	T ₂	7.40±0.46abc	7.25±0.49abcd	6.55±0.64de	5.75±0.59f	6.74 ^b
	Means	7.63a	7.35a	6.77b	6.02c	
Taste	T ₀	7.70±0.48ab	7.40±0.46abc	6.45±0.64de	5.85±0.47ef	6.85 ^{ab}
	T ₁	8.05±0.64a	7.68±0.59ab	6.65±0.75cde	6.01±0.54ef	7.09 ^a
	T ₂	7.40±0.46abc	7.20±0.63bcd	6.50±0.85de	5.51±0.76f	6.65 ^b
	Means	7.72a	7.43a	6.53b	5.79c	
Texture	T ₀	7.50±0.58ab	7.25±0.49abc	6.75±0.86bcde	6.00±0.71e	6.87 ^{ab}
	T ₁	7.75±0.72a	7.40±0.57ab	6.90±0.74abcd	6.11±0.52de	7.04 ^a
	T ₂	7.35±0.75ab	7.15±0.63abc	6.40±0.57cde	5.90±0.66e	6.70 ^b
	Means	7.53a	7.26a	6.68b	6.00c	
Overall acceptability	T ₀	7.60±0.57ab	7.20±0.42abcd	6.70±0.67cde	6.10±0.61ef	6.90 ^{ab}
	T ₁	7.85±0.67a	7.50±0.47abc	6.80±0.67bcde	6.22±0.58ef	7.09 ^a
	T ₂	7.40±0.84abc	7.10±0.61abcd	6.50±0.47de	5.60±0.66f	6.65 ^b
	Means	7.62a	7.26a	6.67b	5.97c	

Different alphabets with means represent significant trend.

Taste: The findings indicated that the taste of bars varied significantly between treatment groups. The mean taste values indicate that T₁ was preferred over the other treatments. Storage had a significant effect on the flavor of bars. The mean value of taste varied between 7.72 and 5.79 over a 90-days storage period. Thus, the highest score was observed for fresh bars and a decreasing trend was observed with time; however, all treatments remained acceptable following the storage study period. The effects of treatment and storage on the taste of date bars were insignificant. Besbes *et al.* (2009) observed similar results in fruit bars made from three different date varieties: Deglet Nour, Allig, and Kentchi.

Texture: The mean texture values indicate that T₁ was preferred over the other treatments. The effect of storage was noted to be statistically significant as well. The mean texture score varied between 7.53 and 6.00

over a 90-days storage period. Thus, the maximum score was observed in the case of fresh date bars, while a minor decreasing trend was observed over time. The effects of treatment and storage on the texture of date bars were insignificant. Similarly, Rehman *et al.* (2020) reported that date bars enriched with fibre derived from natural resources had an acceptable texture.

Overall acceptability

The findings indicate that there are significant differences between the various treatments. The mean overall acceptability score indicate that T₁ was preferred over the other treatments. The effect of storage was noted to be statistically significant as well. Besides, mean values of overall acceptability varied between 7.62 and 5.97 over a 90-days storage period. Thus, the maximum score was observed in the case of fresh date bars, while a minor decreasing trend

was observed over time. The effects of treatment and storage on the overall acceptability of date bar were insignificant. Ahmed *et al.* (2005) also concluded that storage causes a significant impact on the overall acceptance of papaya fruit bar. They noticed that during storage at room temperature a decrease in overall acceptance was from 7.45 to 6.82. This result corroborates the current study's findings.

Conclusions and Recommendations

As a result of the foregoing discussion, it is concluded that while all treatments containing water chestnut in varying proportions were found to be acceptable over a 90-days storage period, T₁ was found to be the best. While the total number of plates increased significantly during storage, it remained within acceptable limits. The development of date bars on a laboratory scale demonstrated the feasibility of converting surplus dates, particularly during periods of high production, into fruit bars. The bars were analysed and found to be of high quality, outperforming the comparable imported product. The storage study determined that date bars prepared in the laboratory had a long shelf stability and could be stored at ambient temperature without compromising their quality characteristics. Because of their elevated nutritional value, appealing color, and delectable taste, water chestnut supplemented date bars could be manufactured on an industrial scale. The use of water chestnut is appealing to consumers as a beneficial addition to the production of conventional fruit bars. It will not only alter water chestnut and date fruit consumption patterns, but will also help reduce post-harvest losses of these fruits. The raw material used to make water chestnut-infused date bars is inexpensive and could be used to boost the local market and cottage industry. Thus, the development and characterization of date bars using various parameters demonstrates that they are extremely nourishing and can be consumed at any time, meeting the nutritional requirements of all age groups.

Novelty Statement

The use of water chestnut is attractive to the consumers into the date fruit bar production by changing its consumption pattern and it will also reduce the post-harvest losses of these fruits.

Author's Contribution

Muhammad Nadeem: Conceptualization, supervision and statistical data analysis.

Aneeta Rehman: Did chemical analysis and collected data and wrote manuscript.

Masooma Munir: Wrote manuscript.

Hira Fatima: Wrote manuscript and proof read.

Faiqa Malik and Aqsa Iqbal: Wrote, Reviewed and modify the manuscript.

Alaiha Asif: Wrote and worked on tables and graphs.

Conflict of interest

The authors have declared no conflict of interest.

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