RESEARCH | Egyptian Journal of Agricultural Research | Horticulture

Applied study of seed husk extracts from some Terminalia trees

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Received: 31-07-2023**; Accepted:** 22-11-2023**; Published: 3**0-11-2023 **DOI:** 10.21608/EJAR.2023.224966.1418

ABSTRACT

This investigation highlights the chemical seed husk extracts of *Terminalia bellirica* and *Terminalia arjuna.* On the other side, the consumer highly favored orange juice, but its shelf life is less than 7 days at 4°C. So, juice requires a preservation press to increase self-life. This chemical preservation may be harmful to health in the long run. This study showed the effect of aqueous and ethanol extracts seed husks (at 0.5 and 1% concentrations) on orange juice. Compared to sodium benzoate (Artificial chemical preservation) it stored all treatments at 4°C for 14 days. This study showed a higher quality of natural preservation during the juice storage period compared to artificial. Seed husk extracts are a natural product that showed control of pathogenic growth as artificial preservation. Orange juice still seems to be fresh for more than a week without detectable, unfavorite physical or chemical changes compared to the control at 4°C.

Keywords: *Terminalia bellirica*, *Terminalia arjuna*, Seed husk extracts, Orange juice, Self-life.

INTRODUCTION

Terminalia bellirica and *Terminalia arjuna* are species belonging to the Combretaceae family. Egypt is an ideal location for their cultivation. Their wood commands a high price and is used in manufacturing doors, windows, and furniture. These trees contribute to soil and water conservation and are beneficial for protecting livestock. As major components of a city's green infrastructure, trees help mitigate erosion by absorbing rainwater. *T. bellirica* seeds are rich in protein (5%) and fat (34%). The kernels of *T. bellirica* contain the following vitamins per 100g: Thiamine (B1) at 0.145 mg, Riboflavin (B2) at 0.351 mg, Retinol (A) at 1.450 mg, and Ascorbic Acid (C) at 0.792 mg. Meanwhile, *T. arjuna* rice contains protein and fat (20% and 22% respectively). On this side, rice contains 0.110, 0.293, 0.952 and 1.030 mg/100g Thiamine (B1), Riboflavin (B2), Retinol (A) and Ascorbic Acid (C) vitamins, respectively (Abozyd and Gharib, 2021).

T. bellirica husks can be preservative kernels viable for one year, Mohideen *et al.* (2011) and Kokate *et al.* (2007). The *T. arjuna* husks had viable kernels for at least one year when stored in sealed tins (Paarakh, 2010). Preservatives are substances added to food to prolong freshness. In the past, food was preserved by potting it down in clay jars, allowing it to remain edible for longer periods. Since the earliest Pharaonic civilizations, extending shelf-life has been a focus. A traditional method of increasing storage periods and reducing harmful pathogens was drying food. Other methods for enhancing shelf-life periods were mixed with salt and sugar in ancient times to create food environments that increased osmotic stress, served as a warning sign to prevent bacteria from growing, and reduced the amount of water that bacteria needed to survive and multiply (Seetaramaiah *et al.*, 2011). Public food natural organizations have several ways to manufacture fitness juice Lima by preventing outbreaks of juice-borne diseases (Tribst *et al.*, 2009). Thermal is a successful technique for inhibiting contamination in the methods of protecting juice from pathogens. However, it may well have various undesirable effects such as mineral sufferers and a reduction in fresh flavor approximation (Kuldiloke and Eshtiaghi 2008; Corbo *et al.*, 2010). The modern methodology had been developed to retain the relationship between diet and the sensory superiority of juice using ultrasound and irradiation (Mosqueda-Melgar *et al.*, 2008; Rupasinghe and Yu (2012). Beverages have traditionally employed preservation agents like sodium benzoate to increase their storage periods. It presents serious health risks (Walker and Phillips, 2008).

While consumers prefer safe products without synthetic additives, the use of synthetic preservatives has increased the need for preservatives in the case of natural juices (Raybaudi-Massilia *et al.*, 2009). Some juice

products have been treated with common preservatives such as phenolic compounds (Rico *et al.* 2007; Raybaudi-Massilia et al., 2009). *T. arjuna* 100 mg/kg of powdered leaves from El Zohria garden in Giza, Egypt normalized liver enzymes without toxic effects (Pullaiah and Ramaiah, 2021).

Terminalia is the next major species that greatly improves people's stamina against various diseases with the help of traditional by (Abozyd and Gharib, 2021; Gupta *et al.*, 2021). *T. arjuna* trees had a much higher ability to produce phytochemicals and showed strong antioxidant effects. These phytochemicals are a natural source of antioxidants. *T. arjuna* in dairy products and juices is applied for beverage production and (Said *et al.,* 2014; Abozyd and Gharib, 2021). Alkaloids and flavonoids ensure safety and health by creating ant pathogens for *Tecomella* and *T. arjuna* (Said *et al.*, 2014).

T. arjuna improved the stability of food processing by increasing the resistance of lipids to oxidation and increasing the shelf life of processed foods by up to 42 days (Cao *et al.,* 2021). It reproduces formaldehyde preservation in addition to benzoates, nitrates, sorbates, and sulphates, as well as parabens and other artificial ingredients. The reproduction of pathogens is reduced by chemical artificial preservation but not destroyed. They act on specific metabolic targets in bacteria, including membranes, genes, and enzymes (Pisoschi *et al.,* 2018).

This exponential focus emphasizes the husk content of the Terminalia tree and reuses the fruits waste to increase juice storage time compared to control and artificial canning. Use of various seed husk extracts of the species *T. bellirica* and *T. arjuna* as preservatives.

MATERIALS AND METHODS

The dried, separated mature seed husks were collected from Al-Zohria Garden, Giza, Egypt. After that, it was shaded at room temperature until all debris and soil particles appeared on the surface. The air-dried seed husks were pulverized with an electric mill and separated and extracted as shown in **Fig. 1.**

Fig. 1. *T. bellirica* and *T. arjuna* fruits and seed husks

Preparer husk samples:

Husks were separately air-dried and cut with disinfected, very sharp stem-cutting scissors into small pieces before being ground by the grinder.

Aqueous extraction:

The samples had been soaked in 1 L of distilled water for 2 days.

Treatments were done with a shaker apparatus. The filter papers had filtered extracts (Ryan *et al.*, 2001).

Ethanol extraction:

Using ethanol (70%) for extracting husks by Soxhlet apparatus Extracts were individually filtered by (Suresh *et al.,* 2018)**.** To determine phytochemistry, extracts were evaporated at 40–50 °C in a rotary evaporator.

The orange was peeled, then sliced with a stainless-steel knife and mashed by El-Rafie *et al.* (2016)**,** which was then immediately juiced and mixed with ethanol and aqueous extracts of Terminalia seed husks.

Treatments:

Fresh orange juice was mixed with Terminalia husk extract, filtered by filter papers, and stored for various durations (0, 7, and 14) days at 4ºC for all treatments as follows:

- Juice without additives.
- The juice was mixed with 0.1% sodium benzoate.
- The juice was mixed with a 1% aqueous extract of *T. arjuna* husks.

- The juice was mixed with 0.5% aqueous extract of *T. arjuna* husks.
- The juice was mixed with a 1% aqueous extract of *T. bellirica* husks.
- The juice was mixed with a 0.5% aqueous extract of *T. bellirica* husks.
- The juice was mixed with a 1% ethanol extract of *T. arjuna* husks.
- The juice was mixed with a 0.5% ethanol extract of *T. arjuna* husks.
- The juice was mixed with a 1% ethanol extract of *T. bellirica* husks.
- The juice was mixed with a 0.5% ethanol extract of *T. bellirica* husks.

Evaluation Terminalia husks extract physical characters:

The investigation of Terminalia husks by their size, form, odor, taste, color, and characteristics containing texture and fracture serve as the basis for their microscopic characteristics (Kokate, 1994; Khandelwal 2008; El-Kady *et al.,* 2015). In this research, husks underwent standard procedures-based preliminary phytochemical screening (Barba *et al.,* 2019). Preliminary color reactions were carried out in this work on the husks using conventional techniques by Mulay and Karle (2020).

Phytochemical analysis:

Conferring to the procedure defined in the Macagnan *et al.* (2016) contents, rough fibers, and moisture were evaluated by Weinmann (1947). Ash values and extractive values are determined according to World Health Organization (WHO) guidelines for total carbohydrates according to Pellet (1970).

Determination of total phenolic content (TPC):

The Folin-Ciocalteu practice by Elmastaş *et al.* (2006). measures the total phenol of husk extract. After adding 1 ml of Folin-Ciocalte mixture, the inside flask was carefully mixed. The contents of the flask were thoroughly mixed. 3 ml of Na_2CO_3 (2%) was added after 3 minutes, and the mixture was allowed to rest for 2 hours while being periodically shaken. Plotting the calibration curve of a gallic acid standard allowed researchers to determine the concentration of total phenolic content.

Determination of total flavonoid content (TFC):

The extracts contain flavonoids, compounds with varying concentrations depending on the solvent. Nanofiltration, a low-temperature process, can concentrate these extracts. Spectrophotometric analysis showed that the cell membrane effectively held 99% of flavonoids in water solutions and 90% in ethanolic solutions. This nanofiltration method demonstrated high efficiency in concentrating extracts (Mello *et al.,* 2010).

Determination of DPPH:

The described method of radical scavenging activity described in Molyneux (2004) was used to evaluate the antioxidant activity of extracts based on the free stable radical scavenging activity of DPPH. A pH meter was used to measure the pH of 2 ml of orange juice at room temperature with constant. Then the negative logarithm of hydrogen was expressed. Total Soluble Solids TSS (Brix) and the refractive index were measured at a temperature room using a refractometer (Bellingham and Stanley, England). The number of microbial assays aerobic plates (AP) was quantified using the plate fill method followed by subsequent dilution on plate count agar (PCA). Replica platters were brooded for 48 hours at 30 °C hours. Total yeast and mold (YM) counts were performed at 25 °C for 5 days using the Potato Dextrose Agar (PDA) plating method. Escherichia coli (EC) group counts were performed on Macconsey agar (MA) at 37 °C for 24 hours using the same dilution. Data were expressed as colony-forming units (CFU)/mL according to Salfinger and Tortorello (2015).

Statistical analysis:

All data were statistically examined by using the difference (ANOVA) with a significance level of 0.05 using SPSS the statistical program and the data were processed with a complete randomization plan according to Leech *et al.* (2005). An LSD test was applied to establish the significance between the means of different samples.

Sensory evaluation:

Evaluation sensory parameters, color, taste, smell, texture, and overall palatability were evaluated on a 9-point scale where one is very similar, and one is not very like. Trained panelists were selected by Food Tech. The Resolution Institute (FTRI) included both males and females (Nayab *et al.*, 2019).

RESULTS

Morphology characteristics:

The husks are brown and gray with a faint earthy odor, while *T. arjuna* and *T. bellirica* each have a faint pungent odor.

Table 1. Morphology characters seed husks of some extract Terminalia spp.

Characters	*T. arjuna*	*T. bellirica*
Color	brown	Grey
Odour	mild earthy	mild earthy
Taste	Light acrid	light acrid
Size	medium	medium
Miscellaneous	fibers	fibers
Length	2-3 cm	2-3 cm

Phytochemical analysis seed husks of some *Terminalia* spp:

The moisture percentage of *T. bellirica* and *T. arjuna* husks was 3.5 and 3.9% respectively. This apprehension, *T. arjuna* husks had recorded 9.40% the highest cured fiber percentage associated with *T. bellirica* 8.50%. Total ash percentage was documented at 11.31 and 10.02% in *T. bellirica* and *T. arjuna* husks, respectively. Temporarily, *T. bellirica* had the lowest water-soluble ash 2.98%. *T. arjuna* husks recorded an 11.31 sulfated ash percentage. *T. bellirica* husks 11.2% heighten the total sugar percentage associated with others **(Table 2).**

Table 2. Phytochemical analysis seed husks of some *Terminalia* spp.

Parameters	Moisture %	Crude fiber %	Total ash %	Acid Insoluble ash %	Water soluble Ash %	Sulfated Ash %	Total sugars %
***T.arjuna* husk**	3.90	9.40	10.02	3.12	3.00	11.31	10.3
***T.bellirica* husk**	3.50	8.50	11.31	3.02	2.98	11.23	11.2

Yield solvent percentage

Percentage values of ethanol and water extracts from husks of Terminalia spp. ranged (from 15.60 to 24.30%). Extractability by aqueous ethanol was possible for all treatments. Table (3).

Table 3. The Percentage yield of different fractions of seed husk extracts of *T. bellirica* and *T. arjuna*.

Solvents	Ethanol	Aqueous
***T. arjuna* husk**	20.8	15.6
***T. bellirica* husk**	24.3	17.4

Phytochemical analysis of *Terminalia* sp.:

Table (4) showed that both *T. bellirica* extracts identified higher significantly increased phenolic values than *T. arjuna* (450, 220, and 270, 150 mg/k) respectively. There were no significant differences in flavonoid content in the husk of Terminalia. The aqueous extract of *T. arjuna* husk had the lowest significantly decreased DPPH value associated with the ethanol extract (20.33, 36.45 mg/k) respectively.

Table 4. Phytochemical analysis of seed husks of *Terminalia* spp.

Treatments	*T. arjuna* seed husks	*T. bellirica* seed husks
Total phenolic content (mg/k)		
Ethanol extract	270.00	450.00
Aqueous extract	150.63	220.00
LSD 0.5%	**12.65**	
Total flavonoid content (mg/k)		
Ethanol extract	7.21	7.45
Aqueous extract	6.54	7.43
LSD 0.5%	**0.72**	
DPPH (mg/k)		
Ethanol extract	36.45	38.55
Aqueous extract	20.33	22.56
LSD 0.5%	**0.98**	

Effect of *Terminalia* extracts on antioxidant, total phenolic and flavonoids on orange juice:

This is the table's data. (5) *T. bellirica* and *T. arjuna* husks in 1% ethanol extract showed the highest increase in antioxidant content compared to the other treatments, (335.40 and 314.97) respectively. Control was greatly improved while ethanol and aqueous extracts were more effective. On the other hand, benzoate treatment showed a slightly significant decrease compared to 0.5% aqueous extract of *T. arjuna* (41.01-64.75), respectively.

The total phenol having the 0.5% aqueous of *T. bellirica* enhanced higher than that of *T. arjuna*. Meanwhile, there was no significant variance among benzoate and 0.5% *T. arjuna* extract (0.32-1.55), respectively, and the control group showed the lowest significant decrease after 14 days of storage. The total flavonoid content did not show a significant average value during the storage period (0-7-14) days (0.95-0.88-0.82), respectively, and the lowest value was recorded in the control group and significantly decreased. Regarding this issue, *T. bellirica* showed the greatest increase at various concentrations.

Table 5. Effect of *Terminalia* spp. aqueous and alcohol seed husk extracts on the on antioxidant, total phenolic and flavonoids of orange juice during the storage periods.

Storage days / **Treatments**		**0**	**7**	**14**
		Antioxidant (DPPH)%		
Control		35.59	19.08	15.59
Benzoate		84.01	21.09	17.93
Aqueous extract	*T. bellirica* seed husk 0.5%	99.80	69.80	55.82
	T. bellirica seed husk 1%	205.33	185.33	175.33
	T. arjuna seed husk 0.5%	89.75	59.75	44.75
	T. arjuna seed husk 1%	184.72	163.72	154.72
Ethanol extract	*T. bellirica* seed husk 0.5%	175.30	147.30	131.30
	T. bellirica seed husk 1%	350.74	332.74	322.74
	T. arjuna seed husk 0.5%	161.20	129.20	121.20
	T. arjuna seed husk 1%	331.64	311.64	301.64
LSD 0.05%		**10.21**	**9.70**	**7.69**
Total phenolic compounds(mg/g)				
Control		0.60	0.47	0.30
Benzoate		0.72	0.53	0.32
Aqueous extract	*T. bellirica* seed husk 0.5%	4.35	3.75	2.30
	T. bellirica seed husk 1%	10.12	10.00	7.93
	T. arjuna seed husk 0.5%	2.95	2.60	1.55
	T. arjuna seed husk 1%	7.62	6.10	3.51
Ethanol extract	*T. bellirica* seed husk 0.5%	6.55	6.02	5.00
	T. bellirica seed husk 1%	17.90	16.81	14.92
	T. arjuna seed husk 0.5%	3.98	3.32	2.15
	T. arjuna seed husk 1%	10.70	8.72	6.21
LSD 0.05%		**0.11**	**0.04**	**0.019**
Total flavonoid compounds(mg/g)				
Control		0.15	0.13	0.11
Benzoate		0.15i	0.14	0.13
Aqueous extract	*T. bellirica* seed husk 0.5%	0.75	0.70	0.65
	T. bellirica seed husk 1%	1.63	1.51	1.42
	T. arjuna seed husk 0.5%	0.65	0.62	0.55
	T. arjuna seed husk 1%	1.42	1.31	1.23
Ethanol extract	*T. bellirica* seed husk 0.5%	0.85	0.83	0.75
	T. bellirica seed husk 1%	1.63	1.53	1.42
	T. arjuna seed husk 0.5%	0.73	0.65	0.60
	T. arjuna seed husk 1%	1.52	1.41	1.32
LSD 0.05%		**0.04**	**0.01**	**0.01**

Effect extracts of Terminalia on orange juice pH, acidity and TSS:

Table 6 shows that the pH of juice mixed with ethanol and water extracts from the husks of *T. bellirica* at a 1% concentration did not show significant differences in separately prepared orange juices at different storage times (0, 7, and 14 days), with pH values of 3.37 for each time point respectively. Significance of Acidity with Terminalia Husks in Various Extracts: It was established that the average acidity value for all variants slightly decreased over a storage period of 7 days. Treatments with 0.5% and 1% concentrations of different Terminalia seed husks using water and alcoholic extracts were unaffected by the juice's total soluble solids.

Table 6. Effect of Terminalia spp aqueous and alcohol seed husk extracts on the chemical properties of orange juice during the storage periods

Storage days / Treatments		0	7	14
		pH value		
Control		3.41	3.41	3.44
Benzoate		3.49	3.49	3.50
Aqueous extract	*T. bellirica* seed husk 0.5%	3.30	3.30	3.31
	T. bellirica seed husk 1%	3.35	3.35	3.35
	T. arjuna seed husk 0.5%	3.30	3.30	3.31
	T. arjuna seed husk 1%	3.33	3.33	3.33
Ethanol extract	*T. bellirica* seed husk 0.5%	3.35	3.35	3.35
	T. bellirica seed husk 1%	3.37	3.37	3.37
	T. arjuna seed husk 0.5%	3.35	3.35	3.35
	T. arjuna seed husk 1%	3.36	3.36	3.36
LSD 0.05%		**0.011**	**0.015**	**0.008**
Acidity%				
Control		1.00	0.99	0.97
Benzoate		1.01	1.01	1.00
Aqueous extract	*T. bellirica* seed husk 0.5%	1.07	1.07	1.06
	T. bellirica seed husk 1%	1.08	1.08	1.07
	T. arjuna seed husk 0.5%	1.05	1.05	1.04
	T. arjuna seed husk 1%	1.06	1.06	1.05
Ethanol extract	*T. bellirica* seed husk 0.5%	1.09	1.09	1.09
	T. bellirica seed husk 1%	1.15	1.15	1.15
	T. arjuna seed husk 0.5%	1.08	1.08	1.08
	T. arjuna seed husk 1%	1.10	1.10	1.10
LSD 0.05%		**0.03**	**0.03**	**0.04**
TSS%				
Control		11.12	11.12	11.13
Benzoate		11.5	11.50	11.60
Aqueous extract	*T. bellirica* seed husk 0.5%	12.00	12.00	12.00
	T. bellirica seed husk 1%	12.00	12.00	12.00
	T. arjuna seed husk 0.5%	12.00	12.00	12.00
	T. arjuna seed husk 1%	12.00	12.00	12.00
Ethanol extract	*T. bellirica* seed husk 0.5%	12.00	12.00	12.00
	T. bellirica seed husk 1%	12.00	12.00	12.00
	T. arjuna seed husk 0.5%	12.00	12.00	12.00
	T. arjuna seed husk 1%	12.00	12.00	12.00
LSD 0.05%		**0.20**	**0.21**	**0.30**

Effect of storage period on orange juice microbiological counts:

For this concern, it showed the recommended total bacterial and yeast count for fruit juice is in Tab. 7. It did tests 3 times (0, 7, and 14) days. All treatments extracted evaluated total bacterial, and yeast counts during storage refrigerator temperatures. The results showed that control treatments had the highest bacteria and yeast accounts ($3x10^3$, $7x10^3$, and $10 x10^3$) and ($5x10^2$, $1x10^3$, and $5x10^3$) respectively. As shown in Table (8).

Meanwhile, treated with *T. bellirica* and *T. arjuna* seed husks aqueous extracts at 0.5% concentration were more capable than benzoate ($8x10^2$, $8x10^2$, $8x10^2$, $9x10^2$, $9x10^2$, and $9x10^2$) and ($1x10^3$, $1x10^3$ and $1x10^3$) respectively. Meanwhile, the bacterial count by using *T. bellirica* was more enhanced than *T. arjuna.* While the yeast count had the same behavior during different storage periods at 0.5% concentration. On the other side, ethanol extract treatments of *T. bellirica* seed husks in more increments than *T. arjuna* at different concentrations during storage periods on the microbial count.

Table 7. The previous studies suggested a maximum pathogen count for juice obsessive:

Constraint	Total calculate	Pathogen
Max. calculate	5.0×10^3	100
Max. calculate acceptable	1.0×10^4	1.0×10^3

Table 8. Effect of different extractor preservation on the total pathogen calculate of orange juice (CFU/g) during stored period

Blends		**Total bacterial calculate**				**Yeast and mold**			
		Storage period (days)			**Max.** calculate **accepted**	**Storage period (days)**			**Max.** calculate **accepted**
		0	**7**	**14**		**0**	**7**	**14**	
Control		$3x10^3$	7×10^3	10×10^3		5×10^2	1×10^3	5×10^3	
Benzoate		$1x10^3$	$1x10^3$	$1x10^3$		2×10^2	2×10^2	2×10^2	
Aqueous extract	*T. bellirica* seed husk 0.5%	$8x10^2$	$8x10^2$	$8x10^2$		1.5×10^2	1.5×10^2	1.5×10^2	
	T. bellirica seed husk 1%	$6x10^2$	$6x10^2$	$6x10^2$		1×10^2	1×10^2	1×10^2	
	T. arjuna seed husk 0.5%	$9x10^2$	$9x10^2$	$9x10^2$		2×10^2	2×10^2	2×10^2	
	T. arjuna seed husk 1%	$8x10^2$	$8x10^2$	$8x10^2$		1.5×10^2	1.5×10^2	1.5×10^2	
Ethanol extract	T. bellirica seed husk 0.5%	$5x10^2$	$5x10^2$	$5x10^2$		1×10^2	1×10^2	1×10^2	
	T. bellirica seed husk 1%	$3x10^2$	$3x10^2$	$3x10^2$		0.5×10^2	0.5×10^2	0.5×10^2	
	T. arjuna seed husk 0.5%	$7x10^2$	$7x10^2$	$7x10^2$		1.5×10^2	1.5×10^2	1.5×10^2	
	T. arjuna seed husk 1%	$5x10^2$	$5x10^2$	$5x10^2$	$1x\ 10^4$	1×10^2	1×10^2	1×10^2	1×10^3

Sensory evaluation of orange juice content:

The recorded data showed that *T. bellirica* and *T. arjuna* seed husks in both extracts at concentrations of 0.5 and 1 percent (8.35, 8.55, 8.10, 8.25, 7.90, 7.31, 7.32, and 7.55) respectively. Meanwhile, juice mixed with the extract had an insignificant effect on taste compared to the control (8.05) at 0 days.

On the other hand, juice mixed with husk extracts at both concentrations after 14 days of storage at 4°C showed no significant difference in taste compared to benzoate. After 7 days of storage, juice treated with different concentrations of Terminalia husk extract showed no significant difference in odor between the aqueous extract (8.10, 7.90, 8.00, and 7.85 respectively) and the control (8.15). Using 1% Terminalia seed husk extract is more effective than 0.5% in preserving juice color during different storage periods.

Table 9. The sensory evaluation of orange juice mixed with or without different extracts from seed husks of *T. bellirica* and *T. arjuna.*

Treatments \ Storage days		0	7	14
		Taste		
Control		8.05	7.45	6.05
Benzoate		8.40	7.09	7.00
Aqueous extract	*T. bellirica* seed husk 0.5%	8.35	7.85	7.35
	T. bellirica seed husk 1%	8.55	8.05	7.55
	T. arjuna seed husk 0.5%	8.10	7.60	7.50
	T. arjuna seed husk 1%	8.25	7.75	7.25
Ethanol extract	*T. bellirica* seed husk 0.5%	7.90	7.40	6.90
	T. bellirica seed husk 1%	7.31	6.81	6.32
	T. arjuna seed husk 0.5%	7.32	6.82	6.30
	T. arjuna seed husk 1%	7.55	7.05	6.55
LSD 0.05%		**0.74**	**0.72**	**0.70**
		Odor		
Control		8.50	8.15	7.65
Benzoate		7.10	6.70	6.20
Aqueous extract	*T. bellirica* seed husk 0.5%	8.50	8.10	7.65
	T. bellirica seed husk 1%	8.30	7.90	7.42
	T. arjuna seed husk 0.5%	8.40	8.00	7.50
	T. arjuna seed husk 1%	8.20	7.85	7.32
Ethanol extract	*T. bellirica* seed husk 0.5%	7.80	7.43	7.30
	T. bellirica seed husk 1%	7.40	7.00	6.65
	T. arjuna seed husk 0.5%	7.56	7.15	6.60
	T. arjuna seed husk 1%	7.44	7.05	6.51
LSD 0.05%		**0.72**	**0.70**	**0.63**
		Color		
Control		8.50	8.35	7.80
Benzoate		7.52	7.05	6.55
Aqueous extract	*T. bellirica* seed husk 0.5%	8.00	7.50	6.15
	T. bellirica seed husk 1%	8.32	7.82	7.90
	T. arjuna seed husk 0.5%	8.05	7.54	7.15
	T. arjuna seed husk 1%	8.20	7.70	7.30
Ethanol extract	*T. bellirica* seed husk 0.5%	7.60	7.10	6.65
	T. bellirica seed husk 1%	7.80	7.30	6.80
	T. arjuna seed husk 0.5%	7.50	7.00	6.55
	T. arjuna seed husk 1%	7.64	7.15	6.83
LSD 0.05%		**0.82**	**0.75**	**0.73**

DISCUSSION

Previous research has shown that the *Terminalia* genus contains hydroquinone (27.70 mg/g), trans-cinnamic acid (20.3 mg/g), and gallic acid (153.8 mg/g). Additionally, it has vanillic acid (34.4 mg/g) and syringic acid (11.70 mg/g). It also showed that 1 g of the genus contains ferulic acid (67.20 mg/g) (Manikandan and Rejula, 2008). Hydroquinone, a natural preservative, does not alter the taste (O'Brien, 2008). Cinnamon and vanillin impart aroma and flavor (Kido *et al.,* 2005; Jelen, 2011).

Terminalia stem bark exhibits cork, parenchymatous ground tissue, and secondary phloem with patches of sclerenchyma fibers, mucilage-secreting ducts, and tanniniferous cells. Kido *et al.* (2005) reported that *T. arjuna* contains less than 2% impurities by mass, a total ash content of less than 27% by mass, acid-insoluble ash less than 2% by mass, and an alcohol-soluble extractability of 16% by mass. Additionally, the aqueous extract constitutes more than 17% wt./mass. Jaiswal *et al.* (2021) tentatively described Terminalia as a tool to limit the use of indicator sugars and glycosides in chemical analysis.

Most of the tree components found in herbal medicines can be extracted using ethanol and water-soluble solvents, with the highest extractability and solubility (Horvath 2006; Sinha *et al.*, 2022). This result of Sun *et al.* (2015) showed that the extraction yield was highest in dilute ethanol solvent when combined with aqueous extract. The results are corroborated by Kumar and Prabhakar (1987), who demonstrated the presence of polyphenols in Terminalia trees (60–70%), including flavones, flavonols, and phenylpropanoids.

Kandil and Nassar (1998) investigated the phenolic components of Terminalia, discovering a new arjunin and four other tannins. Bajpai *et al.* (2005) reported that the phenolic content of the Arjuna tree is 72.0–167.2 mg/kg. Conversely, Jaiswal *et al.* (2021) isolated pyrocatechin-containing phytosterols from the same tree. Kuo et al. (2005) found that the Arjuna tree produces casuarinin. Previous studies have noted that flavonoids, which demonstrate antioxidant effects, are more commonly present in the Terminalia tree (Hosamath, 2011). Additionally, luteolin, a type of flavonoid, has been shown to have antibacterial activity (Harborne and Turner, 1984). Myricetin, a flavonoid, may occur according to Harborne and Turner (1984). Sharma et al. (1982) found that the highest number of flavonoids possessed antibacterial properties, preventing the spread of Gram-negative pathogens.

The bark of *T. arjuna* was found to contain 56 mg/g of flavonoids, which is a significant amount according to Cock (2015), Sarkar *et al.* (2014), Beales (2004), and Jain *et al.* (2011). Arjuna peel contains the isolated compound Arjunaphthanoloside, which has antioxidant properties. A previous study found that the concentration of total polyphenols and the antioxidant capacity were reduced in orange juice during storage, with some minor changes in the total content of flavanones as noted by Klimczak *et al.* (2007). Ascorbic acid, as an antioxidant, inhibits the oxidation of phenol and prevents browning by converting to dehydroascorbic acid (Polydera *et al.,* 2005; Tiwari *et al.,* 2008).

There was a strong association between *T. bellirica* and phenol and flavonoid concentrations. Ascorbic acid and other chemical components that make up the sugars in the extract may also cause certain interferences (Elizabeth *et al.,* 2017). Regarding this issue, the results indicate that *T. bellirica* is a very rich source of vitamin C, indicating high nutritional value (Badoni *et al.,* 2016). Arjunic acid has been found to be a much stronger antioxidant and free radical scavenger (Sun *et al.,* 2008). The previous study identified turbidity and hydrolysis of juice pectin by yeast enzyme, with Krop (1974) discussing the pectin degradation rate. Phytochemical extracts of T. arjuna and T. bellirica have shown limited microbial activity (Gupta *et al.,* 2020; Vijayalakshmi *et al.,* 2023). Standard (2000) described some important standard microbiological guidelines for all fruit juices. Previous studies showed that the degradation of ascorbic acid during storage is described by a first-order kinetic model and is dependent on storage time, temperature, and dissolved oxygen content. These concerns, Beales (2004) established that the growth mechanism of the pathogen is related to the acidic environment of the juice. Jain *et al.* (2011) reported the addition of two gram-positive and two gram-negative bacteria to an aqueous extract of Terminalia tested for antifungal and anti-yeast activity (Manikandan and Rejula, 2008; Patil and Gaikwad, 2011). On the other hand, *T. arjuna* powder showed significant activity against all microorganisms tested: *Escherichia coli, Pseudomonas aeruginosa* and *Staphylococcus aureus*.

Terminalia contains hydroquinone, trans-cinnamic acid, genetic acid, vanillic acid, syringic acid, and trans-ferulic acid (Manikandan and Rejula, 2008). In this regard, hydroquinone, a natural preservative, did not alter the taste or odor of food additives (O'brien, 2008). In this regard, hydroquinone does not alter the taste and odor of food additives like natural preservatives (Jelen, 2011). At this time, *T. arjuna* and *T. bellirica* should have contained gallic acid, methyl gallate, ellagic acid, and vanillic acid (Fyhrquist, 2007; El-Ameen *et al.*, 2013). Phytochemical studies of Terminalia trees have demonstrated the presence of several types of active constituents such as tannins, flavonoids and phenolic compounds (Fahmy *et al.,* 2015).

CONCLUSION

The study results revealed that extracts from *Terminalia* species seed husks at various concentrations significantly extended the shelf life of orange juice compared to the control. Data indicated that the aqueous extract of Terminalia was significantly preferred in sensory evaluations over the ethanol extracts. Consequently, Terminalia seed husks are considered a promising natural source of antimicrobial and antioxidant-rich extracts, which substantially increase the shelf life of juice compared to the control.

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دراسة تطبيقية لمستخلصات قشر البذور من بعض أشجارTerminalia

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يسلط هذا البحث الضوء على مستخلصات قشور البذور لأشجار *Terminalia bellirica* و*Terminalia arjuna*. كما يفضل المستهلك عصير البرتقال طازج بشكل عام ، إلا أن مدة صلاحيته تقل عن 7 أيام عند درجة حرارة 4 درجة مئوية لذلك يتطلب العصير ماده حفظ لزيادة فترة صلاحيته للاستهلاك. قد تكون المادة الحافظة ضاره بالصحة على المدى الطويل. أظهرت هذه الدراسة تأثير المستخلص المائي والإيثانولي لقشور البذور (بتركيزين 0.5 و 1%) على عصير البرتقال. بالمقارنة مع بنزوات الصوديوم ، فقد تم تخزين جميع المعاملات عند درجة حرارة 4 درجة مئوية لمدة 14 يومًا. أظهرت هذه الدراسة قدرة المستخلصات الحد من نمو البكتريا والخمائر المسببة لفساد العصير وعلي هذا استمر عصير البرتقال طازجًا لأكثر من أسبوع دون حدوث تغيرات فيزيائية أو كيميائية غير مرغوبة مقارنةً بالكنترول عند 4 درجة مئوية..

الكلمات الرئيسية: ترمينالیا بیلیریکا, ترمينالیا أرجونا, مستخلصات قشر البذور, عصير البرتقال, الحياة الذاتية.