

ORIGINAL ARTICLE

A Study on the Development and Characterization of Products Incorporated with *Terminalia Arjuna*: an Exploration on Traditional Herb

Hiteshi Malika and Divya Puri

Department of Nutrition & Dietetics, Faculty of Allied Health Sciences, Manav Rachna International
Institute of Research & Studies, Faridabad, Haryana-121004
Email- ¹hiteshimalik@gmail.com, ^{2*}divyapuri.fas@mriu.edu.in

ABSTRACT

Non-communicable diseases are the major cause of death worldwide and its incidence is increasing every past day due to lifestyle as well as environmental changes. Medicinal plants have been used since ages to cure and prevent various diseases, one such blessing of nature is *Terminalia arjuna*, an ancient ayurveda herb that is known for its cardioprotective effect due to presence of various polyphenolic compounds such as flavonoids, phenolics, tannins and glycosides. The present study focused on the development and phytochemical analysis of different products (nutritional bars & wafers) using *T. arjuna* bark. The process for making products were standardized using suitable concentrations of *T. arjuna*. The findings of this study may help in developing commercial products for effective utilization of unexplored attribute of *T. arjuna*. Results confirmed the presence of bioactive compounds such as crude fibre, flavonoids and tannins responsible for various promising health benefits. The levels of these bioactive compounds increased with increasing concentrations of *T. arjuna* in the variants prepared of each product. The prepared products and its variants using *T. arjuna* bark were found to be a potent source of various bioactive compounds validating the results of various studies on phytochemicals found in *T. arjuna* responsible for vast health benefitting properties. This study will provide future directions in the field of development of food products using *Terminalia arjuna*.

Keywords: Antioxidant, arjuna products, cardioprotective, hypertension, *Terminalia arjuna*

Received 24.05.2023

Revised 01.06.2023

Accepted 19.06.2023

How to cite this article:

Hiteshi Malika and Divya Puri. A Study on the Development and Characterization of Products Incorporated with *Terminalia Arjuna*: an Exploration on Traditional Herb. Adv. Biores., Vol 14 (4) July 2023: 95-100.

INTRODUCTION

Medicinal plants have always been considered as a nature's blessing due to its natural therapeutic properties without any side-effects. Last decade saw a revival of interest in herbal medicines due to various advantages such as easy availability, affordable cost and cultural acceptability, making these medicinal plants more important in pharmacotherapy to be used as pharmaceuticals with the aim of preventing diseases or restoring the organic functioning of body systems. India is particularly a country which depends majorly on its traditional medicinal system namely Ayurveda and Siddha, which are primarily plant based systems. Humans from a long time consume wide range of food, drugs and dietary supplements derived from plant which confer various health benefits. Primarily the secondary metabolites such as tannins, terpenoids, alkaloids and flavonoids present in medicinal plants are responsible for various health benefitting properties. Since the present day consumers are becoming increasingly health conscious and are very picky in their food choices aiming to satisfy both the requirements of food being tasty and healthy. With due regards to this increase in demand for healthy snacking ideas, snack foods incorporated with some herbs with potential health benefits serve as an important vehicle for meeting the aforementioned objective. One such plant in this regard is *Terminalia arjuna*, (commonly called *arjuna*) belonging to the family of Combretaceae. The plant, especially the bark of the tree is used since ages in Ayurveda system of medicine for cardiac disorders, hypertension and dyslipidemia. The bark is also known to possess diuretic, anti-inflammatory and anti-thrombotic

properties making *arjuna* an ideal herb for preventing and treatment of various chronic diseases related to heart, liver and cancer.

However, like other herbal plants *Terminalia arjuna* also have a characteristic bitter flavor and dark woody color. This limits its intake and hence the benefits remain unexploited. Hence through this study we aim to develop tasty and handy snack foods incorporated with *T.arjuna* to effectively mask the pungent flavor and utilize the potential benefits offered by this natural herb without any side-effects.

Arjuna, a potential cardioprotective ayurvedic plant belonging to the combretaceae family is known to possess strong medicinal properties. It has been mentioned in many Indian medicinal text including Charaka Samhita, Sushruta Samhita and Astang hridayam and was advocated by Vagabhatta for the first time for the prevention against heart ailments. While it also has mentions in Ayurveda for relieving chronic fever and hemorrhages. Ayurvedic physicians recommend the use of this herb in the treatment of three types of tumors Vata, Pitta, and Kapha [1,2,3].

Terminalia arjuna is also commonly known by the local names such as white Marudah in English, Thalla in Telugu and Neer Marathu in Malyalam. The bark powder having widespread potential is popular in indigenous system of medicine and is being used widely in Asian -subcontinent for various treatments like anginal pain, hypertension, cholesterol, leukorrhea, diabetes, cirrhosis etc. and now it is available in other parts of the world as well in the form of herbal powder, tablets, tea etc. Other parts of the plant are also used for various purposes like bark ashes for snake bite and scorpion sting, bark powder boiled in water for headache and to kill worms in teeth, fruit paste typically for wounds, leaf juice for earache [4,5]. Polyphenolic compounds such as flavonoids, phenolics, tannins and glycosides are major bioactive compounds present in *T.arjuna* which are responsible for vast potential health benefiting properties such as prevention of chronic diseases, antioxidant activity and promotion of overall health. So far no serious side effects or toxicity levels has been reported making it a promising drug for treating or preventing various non-communicable diseases.

Various health benefitting phytoconstituents have been isolated from *T.arjuna*. Majorly tannins and flavonoids are found to be responsible for its antioxidant properties and triterpenoids are responsible for cardioprotective properties.

Phytochemical analysis revealed presence of triterpenes like arjunic acid, arjunolic acid, arjunolitin and arjungenin, tannins like arjunin, catechin, gallic acid, epigallocatechin, epigallocatechin, glycosides like arjunglucoside-1, arjunetoside, terminolitin and very high amounts of flavonoids, ellagic acids and phytosterols as well as minerals such as calcium, magnesium, zinc, copper [6].

Apart from polyphenols, flavonoids, tannins, saponins, sterols, minerals., amino acids such as tryptophan, tyrosine, histidine and cysteine are major constituents of *T. arjuna* which are important from medical point of view [7].

Flavonoids like arjunolone, flavones, luteolin, baicalein, quercetin, kempferol and pelargonidin are present in high levels providing cardiovascular benefits. The luteolin isolated from *T.arjuna* is found to possess antimutagenic and anti-bacterial activity [7].

A variety of tannins nearly around fifteen types of tannins and their related compounds were isolated from the bark of *T.arjuna*, known to provide wound healing, astringent, hypotensive, antioxidant and antimicrobial effects.

The herb is also a potent source of various health benefitting polyphenols such as flavon-3-ols (catechin, gallic acid, ellagic acid and its derivatives contributing to as high as 70% polyphenolic content.

Studies suggest that the bark of *T.arjuna* contains a variety of minerals in large amounts such as magnesium (4000µg/g), calcium (3133µg/g), zinc (119µg/g) and copper (19 µg/g) [7].

Table 1- Major constituents of *Arjuna* bark [8]

Part of Plant	Major chemical constituents	Major chemical constituents
Stem bark	Triterpenoids	Arjunin, arjunic acid, Arjunolic acid, arjungenin, terminic acid, arjunglucosides IV
	Glycosides	Arjunetin, arjunoside I and II, terminosideA
	Flavonoids	Arjunolone, arjunone, luteolin, gallic acid, ethyl gallate, quercetin, kempferol, pelargonidin
	Tannins	Castalagin, casuariin, casuarinin, terflavin C, pyrocatechols.
	Minerals	Calcium, aluminum, magnesium, silica, zinc, copper

Terminalia arjuna, is known to possess widespread potential in terms of clinical benefits. The bark of *T.arjuna* is the most beneficial and hence the widely used for various purposes. Phytochemical analysis

conducted on the plant extracts revealed the presence of constituents which are known to exhibit medicinal as well as physiological activities. Many animal and clinical studies have validated anti-ischemic, antihypertrophic, anti-hypertensive, hypolipidemic, antiplatelet and antioxidant effects. Initially *arjuna* was mentioned as 'Hridya', the drug which strengthens the heart but various studies and experiments show that these chemical constituents (secondary metabolites) present in plant also have anti-fungal, anti-bacterial, anti-cancer and hepatoprotective effects [3-22].

According to ayurveda, *Arjuna* is a kapha eliminating herb and can be used in cough, cold, sneezing and sinus. It is cooling in nature and thus is also helpful in reducing pitta and ailments related to that like skin diseases, urinary tract infections, migraine etc., [1,2,3,23].

Ayurvedic physicians also suggest use of *arjuna* bark for reducing body fat, purifying blood and treating respiratory disorders [24].

The concept of three meals a day is an increasingly antiquated notion. Modern day consumers are grazers and snackers. This perpetually increased the populace of ready to eat and handy food stuff that is nutritionally adequate as present day consumers are health conscious and hence prefer buying healthy ready to eat snacking food. Eating several smaller portion meals daily is the trend of the moment and is nutritionally advisable also, that most food industry experts agree is not going away. With this idea and owing to increasing interest of consumers towards functional foods including herbs, two snack foods namely nutritional bars and wafers were developed in this study, using *Terminalia arjuna* totap the benefits of the plant through consumption of handy snack food items.

MATERIAL AND METHODS

Following two snack foods were prepared from *Terminalia arjuna* to extract the benefits of herb.

Nutritional bars

Barjun (bar developed from *arjuna* herb) was developed with the aim of promoting health in a tasty and easy way. It was incorporated with powdered *Terminalia arjuna* bark (6% & 7% of total weighed product) procured from a local park and other ingredients such as date fruit (30g), oats(25g), walnuts (10g), almonds (10g), flaxseeds (3g), melon seeds (3g), pumpkin seeds (3g), raisins (5g) per 110g all of which are studied for their hypolipidemic affect and hence will be beneficial for cardiac as well as for people with high cholesterol.

Wafers

Wafers are another nutritious handy snack formulated using *arjuna* bark powder with the objective of providing a healthy snack packed with nutrients. In the era of junk eating this baked snack will help replace caloric dense snack to a more nutrient dense snack, which may serve as good option for handy snacking. And as it is baked and incorporated with nutritious ingredients such as gram flour (50g) and traditional condiments such as carom seeds (0.5g), cumin (1g), turmeric (0.20g), black pepper (0.5g), asafoetida (0.2), pink salt (2g), etc., will be beneficial for cholesterol and hypertensive consumers as well.

Terminalia arjuna bark was procured from a nearby park in Faridabad, Haryana, India. *Arjuna* powder was produced by shade drying the procured bark for about one week and grinding it in a mixer grinder to powdered consistency. *Arjuna* bark powder and other raw material such as oats, almonds, walnuts, flaxseeds, melon seeds, raisins, pumpkin seeds, dates (for barjun) and gram flour, carom seeds, cumin seeds, turmeric powder, black pepper, pink salt and oil (for wafers) were collected and weighed according to the requirements. The products (i.e. nutritional bars and wafers) were finally prepared and standardized using the mentioned ingredients. Different variants using varying concentrations of *arjuna* powder were also prepared.

Physicochemical analysis

The products prepared using *T.arjuna* was subjected to following three tests to assess their phytochemical properties. The tests were performed in the month of January and February 2020 in the lab of Manav Rachna International Institute of Research & Studies (Department of Nutrition & Dietetics, Faculty of Allied Health Sciences, Faridabad, Haryana, India.)

Crude fibre test

Crude fibre test was performed on all samples using standardized method from FSSAI Manual-2016 to assess the fibre content of the prepared food products.

Flavonoid test

Flavonoids including kaempferol, quercetin and lutein (2,3 and 2,6) present in *T.arjuna* were analyzed through HPLC (High Performance Liquid Chromatography in accordance with the study conducted by Bae [25].

Tannins test

The composition of tannins present in the prepared food samples were analyzed through TLC (Thin Layer

Chromatography) method in accordance with the study by Elgailani and Ishak [26].

RESULTS AND DISCUSSION

The entire analytical tests conducted to assess the biochemical parameters of the developed products confirmed the presence of appreciable values of phytochemicals which is responsible for pharmacological benefits. The analysis was based on triplicate readings obtained from standardized methods for each of the test conducted.

Crude fibre content

Crude fibre, the indigestible cellulose, pentosans, lignin, and other components present in plant sources are known to exert various gastrointestinal as well as other health benefits like protective role against certain colonic disorders and metabolic diseases[27]. Patil et al., 2011 through quantitative evaluation of various phytochemicals reported considerable crude fibre content in the bark of *T.arjuna*. The results of crude fibre analysis of both the developed products were in conjunction to Patil's study as test indicated increased fibre content with increasing *arjuna* powder content.

Table 2: depicting the crude fibre values of developed food products

Sample	Crude fibre (g/100g)	Sample	Crude fibre (g/100g)
C _B	0.74±0.12	C _W	1.05±0.11
E _{B1}	0.96±0.01	E _{W1}	1.06±0.10
E _{B2}	1.06±0.23	E _{W2}	1.09±0.10

* The values are represented as Mean±SD (derived from triplicate readings). C_B& C_W: Control samples of Barjun & wafers respectively (containing no *arjuna* bark powder); E_{B1}& E_{W1}: First experimental sample of barjun & wafers (containing 6% of *arjuna* bark); E_{B2}& E_{W2}: Second experimental sample of barjun & wafers (containing 7% of *arjuna* bark).

Crude fibre test conducted to analyze the indigestible matter in the developed products through successive acid alkali digestion method indicated that crude fibre increased on addition of *T.arjuna* to the control sample of both nutritional bars and wafers. Fibre content of products gradually increased by increasing the concentration of *arjuna*. The least fibre content was reported in control sample i.e. C_B and C_W while highest in second experimental sample (E_{B2}& E_{W2}) that is the samples containing 7% *arjuna* powder.

Tannin content

Tannins are astringent, bitter tasting, water soluble polyphenols found in many plants. Tannins are considered as non-nutritive components present in plant derived food but over the years many studies found tannins to be responsible for evincing anticarcinogenic and antimutagenic properties. Antimicrobial properties of tannins are also well documented thus serving as a natural defense against pathogens.

Patil et al.,2011 reported presence of tannins in *arjuna* bark through qualitative evaluation of phytochemicals, which is responsible for exhibiting anticancer, antibacterial and hepatoprotective properties [3,15]. The results obtained through testing collate with the aforementioned studies and hence confirms retainment of tannin content in the developed product.

Table 3: depicting the tannin values of developed food products

Sample	Tannin Content (mg/100g)	Sample	Tannin Content (mg/100g)
C _B	0.045±0.11	C _W	0.06±0.22
E _{B1}	0.029±0.10	E _{W1}	0.063±0.10
E _{B2}	0.081±0.09	E _{W2}	0.065±0.01

* The values are represented as Mean±SD (derived from triplicate readings). C_B& C_W: Control samples of Barjun & wafers respectively (containing no *arjuna* bark powder); E_{B1}& E_{W1}: First experimental sample of barjun & wafers (containing 6% of *arjuna* bark); E_{B2}& E_{W2}: Second experimental sample of barjun & wafers (containing 7% of *arjuna* bark).

Tannins content was also found to be increasing on addition of *T.arjuna* to the control sample of both nutritional bars and wafers. Highest tannin content was found in second experimental sample of both Barjun and wafers (E_{B2}&E_{W2}) i.e. samples with 7% *arjuna* concentration. But higher value was observed in case of E_{B2}, which is 7% of barjun due to preparation method as no heat was applied in case of barjun.

Flavonoid content

Flavonoids are group phenolic substances found naturally in fruits, vegetables, grains, bark of many plants. Flavonoids are known for their potent therapeutic properties such as antioxidant, antimutagenic,

anti-inflammatory, antiviral, antibacterial, antiallergic and vasodilating activities. Flavonoids have been widely used in Chinese traditional medicinal system for hypertension, inflammatory disorders and cancer treatment.

Three isolated flavonoids that is quercetin, lutedin 2,3 and lutedin 2,6 were tested in the food products and the results are depicted in the following table.

Table 4: depicting the flavonoid values of developed food products

Sample	Quercetin (mg/100g)	Lutedin 2,3 (mg/100g)	Lutedin 2,6 (mg/100g)	Sample	Quercetin (mg/100g)	Lutedin 2,3 (mg/100g)	Lutedin 2,6 (mg/100g)
C _B	0.06	0.0012	0.0019	C _w	0.054	0.0016	0.0025
E _{B1}	0.064	0.0015	0.0026	E _{w1}	0.062	0.0017	0.0029
E _{B2}	0.069	0.0026	0.022	E _{w2}	0.071	0.016	0.024

* The values are represented as Mean±SD (derived from triplicate readings). C_B& C_w: Control samples of Barjun & wafers respectively (containing no *arjuna* bark powder); EB1& Ew1: First experimental sample of barjun & wafers (containing 6% of *arjuna* bark); EB2& Ew2: Second experimental sample of barjun & wafers (containing 7% of *arjuna* bark).

The three different types of flavonoids i.e. quercetin, lutedin 2,3 and lutedin 2,6 analyzed in the study increased with increasing the percentage of *arjuna* powder. The tabular representation clearly demonstrated that the highest proportion was that of quercetin in experimental sample 2 with 7% *T.arjuna* concentration. The results were in accordance to various studies [3,4,6,8,15] depicting clinical benefits such as antioxidant cardiovascular, antibacterial and anti-inflammatory properties due to presence of flavonoids in *T.arjuna* bark. Hence, increasing the *arjuna* powder amount improved the flavonoid content leading to utilization of clinical benefits of the herb.

CONCLUSION

In conclusion, the study proved the presence of phytochemicals like fibre, tannins and flavonoids, which increased by increasing the bark powder content in the developed products in concurrence with many studies indicating *Terminalia arjuna* to be a potent source of these phytoconstituents all of which are well studied for exhibiting various medicinal characteristics.

Herbs incorporated in everyday food are gaining wide popularity these days due to increasing health consciousness and awareness about the medicinal benefits offered by these medicinal plants. *T.arjuna*, one of the versatile indigenous medicinal plant, a rich source of bioactive compounds was used since ages to ameliorate and even prevent diseases and growing interest in it has led various pharmacological and experimental studies. The studies relating to development, standardization and effect of cooking on phytochemicals present in *T.arjuna* were however not yet explored. This study targeted the mentioned parameters and therefore will be useful for giving directions to future studies in this field. Also an attempt was made through this study to make people partake the *arjuna* in their daily diet in form of two easy snackable items with the aim to deliver both taste and medicinal properties.

Funding:

None (This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors)

Competing Interest:

The authors have declared that no competing interest exists.

REFERENCES

1. Tripathi VK, Singh B. (1996). *Terminalia arjuna*- it's present status (a review). Orient J chem ; 12:1-16.
2. Dwivedi S, Udupa N. (1989). *Terminalia arjuna*: pharmacognosy, phytochemistry, pharmacology and clinical use: a review. Fitoterapia. 60:413-420.
3. Jain S, Yadav PP, Gill V, Vasudeva N, Singla N.(2009). *Terminalia arjuna* a sacred medicinal plant: phytochemical and pharmacological profile. Phytochemical Rev; 8:491-502.
4. Patil UH, Gaikwad DK. (2011). Pharmacognostical evaluation of stem bark of *Terminalia arjuna*. Int J Pharm Pharm Sci; 3(4):98-102.
5. Dwivedi S, Chopra D. (2014). Revisiting *Terminalia arjuna*- an ancient cardiovascular drug. J Trad Complement Med; 4(4):224-231.
6. Seth S, Dua P, Maulik S.K. (2013). Potential benefits of *Terminalia arjuna* in cardiovascular disease. J. Prev. Cardiol ; 3:428-432.

7. Amalraj A, Gopi S. (2017). Medicinal properties of *Terminalia arjuna* (Roxb.) Wight & Arn.: a review. J Tradit Complement Med; 7:27-50.
8. Sharma M, Kumawat M, Kachchhwhaha J, Rathore BS, Singh C, Adlakha M. (2018). Role of *Terminalia arjuna* in cardiovascular disorders – a review article. J of Pharma Research. 7(5):363-372.
9. Gupta R, Singhal S, Goyle A, Sharma VN. (2000). Antioxidant and hypocholesterolaeamic effects of *Terminalia arjuna* tree bark powder: a randomized placebo controlled trial. J Assoc Physicians India; 49: 231-235.
10. Ali A, Kaur G, Hamid H, Abdulla T, Ali M, Niwa M, Alam M.S. (2003). Terminoside A, a new triterpene glycoside from the bark of *Terminalia arjuna* inhibits nitric oxide production in murine macrophages. Journal of Asian Natural Product Research; 5:137-142.
11. Paarakh P.M.(2010). *Terminalia arjuna* (Roxb.) Wt. and Arn.: a review. Int J Pharmacol. 6: 515-534.
12. Patil UH, Gaikwad DK. (2011). Pharmacognostical evaluation of stem bark of *Terminalia arjuna*. Int J Pharm Pharm Sci; 3(4):98-102.
13. Gupta A, Chaphalkar SR.(2015). Immunopharmacological activity of saponin from *Terminalia arjuna* and *Prosopis spicigera*. Journal of Pharmacological Reports; 1: 1-4. 22.
14. Chaudhari, M., Mengi, S. (2006). Evaluation of phytoconstituents of *Terminalia arjuna* for wound healing activity in rats. Phytotherapy Research ; 20: 799–805.
15. Gupta S, Bishnoi J.P, Kumar N, Kumar H, Nidheesh T. (2018). *Terminalia arjuna* (Roxb.) Wight & Arn.: competent source of bioactive components in functional food and drugs. The Pharma Innovation Journal ; 7(3): 223-231.
16. Nammi S, Gudavalli R, Babu B.S, Lodagala D.S, Boini K.M. (2003). Possible mechanism of hypotension produced by 70% alcoholic extract of *terminalia arjuna* (L.) in anaesthetized dogs. BMC Complementary and Alternative Medicine; 16:3-5.
17. Sandhu JS, Shah B, Shenoy S, Chauhan S, Lavekar GS, Padhi MM. (2010). Effects of *Whithania somnifera* and *Terminalia arjuna* on physical performance and cardiorespiratory endurance in healthy young adults. Int J Ayurveda Res; 1: 144-9.
18. Takahashi, S., Tanaka, H., Hano, Y., Ito, K, Nomura, T., Shigenobu, K. (1997). Hypotensive effects in rats of hydrophyllic extract from *Terminalia arjuna* containing tannin-related compounds. Phytotherapy Research; 1: 424–427.
19. Chander R, Singh K, Khanna A.K, kaul S.M, Puri A, Saxena R, Bhatia G, Rizvi F, Rastogi A.K. (2004). Antidyslipidemic and antioxidant activities of different fractions of *Terminalia arjuna* stem bark. Indian J. of Clinical Biochem; 19(2): 141-148.
20. Kumar G, Srivastava A, Sharma SK, Gupta YK. (2012). Safety and efficacy evaluation of Ayurvedic treatment (*Arjuna* powder and *Arogyavardhini Vati*) in dyslipidemia patients: A pilot prospective cohort clinical study : A pilot prospective cohort clinical study. Ayu ; 33:197-201.
21. Manna P, Sinha M, Sil P.C. (2006). Aqueous extract of *Terminalia arjuna* prevents carbon tetrachloride induced hepatic and renal disorders. BMC Complementary and Alternative Medicine; 6:33-44.
22. Manna P, Sinha M, Sil P.C. (2007). Arjunolic acid, a triterpenoid saponin ameliorates arsenic induced cyto-toxicity in hepatocytes. Chemico Biological Interaction; 170: 187-200.
23. Cooper EL. (2005). CAM, bioprospecting: the 21st century pyramid. Evid Based Compliment Alternat Med; 2:125–127.
24. Sharma S, Sharma D, Agarwal N. (2012). Diminishing effect of arjuna tree (*T.arjuna*) bark on the lipid and oxidative stress status of high fat high cholesterol fed rats and development of dietary recipes containing the tree bark for human consumption. Research in Pharmacy; 2(4): 22-30.
25. Bae, H., Jayaprakasha, G. K., Jifon, J., & Patil, B. S. (2012). Extraction efficiency and validation of an HPLC method for flavonoid analysis in peppers. Food Chemistry; 130: 751–758.
26. Elgailani, I. E. H, Ishak, C. Y., (2016). Pak. J. Anal. Environ. Chem. 2016, 17,10.21743.
27. Trowell H. (1976). Definition of dietary fiber and hypotheses that it is a protective factor in certain diseases. Am J Clin Nutr; 29:417-27.

Copyright: © 2023 Author. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.