Journal of Applied Horticulture, 24(3): 326-329, 2022

DOI: https://doi.org/10.37855/jah.2022.v24i03.58

Journal of Applied Horticulture
ISSN: 0972-1045

Bael (*Aegle marmelos*) and wood apple (*Limonia acidissima* L.): Postharvest processing and properties evaluation of fruit powders for their food applicability

M. Kirthy Reddy[1], Rita Narayanan[2]*, V. Appa Rao[3], C. Valli[4] and G. Sujatha[5]

*[1]CFDT, TANUVAS, Chennai, Tamil Nadu, India– 600 052. [2]Department of Food Processing Technology, CFDT, TANUVAS, Chennai, Tamil Nadu, India–600 052. [3]Faculty of Food Sciences, CFDT, TANUVAS, Chennai, Tamil Nadu, India – 600 052. [4]Faculty of Basic Sciences, MVC, TANUVAS, Chennai, Tamil Nadu, India – 600 007. [5]Department of Food Process Engineering, CFDT, TANUVAS, Chennai, Tamil Nadu, India– 600 052. *E-mail: ritanarayanan@yahoo.com*

Abstract

Bael (*Aegle marmelos*) and wood apple (*Limonia acidissima* L.) are indigenous and underutilized fruits with high potential to use in various food applications, and these are seasonal fruits and perishable making them go to waste. Hence this study aimed to process their pulp into powders and analyze physical and functional properties to find their applicability in different foods. Bael and wood apple pulps were dried in a hot air oven at 65 and 60^o C for 670 and 720 mins, respectively. The bael fruit powder (BFP) and wood apple powder (WAP) yield after drying was 33.89 and 29.62 g%, respectively. The final moisture content and water activity of the powders were 7.96±0.78, 7.34±0.72 and 0.327±0.12 and 0.314±0.17, respectively. Bulk and tapped density values for both powders were high, resulting in higher Carr's Index and Hausner's Ratio indicating inferior flowability. The Water Absorption Capacity of BFP (1.31±3.27g/g) was higher than WAP (1.15±3.28g). The oil absorption capacity of WAP was 101.19±1.46% and BFP was 101.86±1.85% which is higher than the Water Absorption Capacities of both powders. The swelling capacities and solubility of BFP and WAP were 4.39±0.01, 4.15±0.02 mL/g and 97.67±0.06, 98.45±0.02%, respectively. Foaming capacities for BFP and WAP were 23.45±0.09 mL and 25.62±0.06 mL, respectively. Both fruit powders did not form strong gels even at 20%. The results showed that these fruit powders can potentially be used in fiber-enriched and other new food formulations.

Key words: Bael fruit powder, wood apple powder, functional properties, swelling capacity, water solubility, water absorption, oil absorption, water activity, least gelation

Introduction

Bael (*Aegle marmelos*) and wood apple (*Limonia acidissima* L.) are native and indigenous fruits of India generally grown in Subtropical Southeast Asia (Singh and Chaurasiya, 2014). They have gained importance due to their excellent medicinal and nutritional properties. Bael fruit and wood apple contain innumerable amounts of phytochemicals and bioactive compounds like phenolics, alkaloids, carotenoids, flavonoids, coumarins, pectins, phytosterols, tannins and terpenoids (Dar *et al.,* 2013). Bael fruit contains marmelosin which is known to be the panacea for stomach ailments (Singh and Nath, 2004). Wood apple cures diseases like dysentery, diarrhea, asthma, wounds and tumours (Illango and Chitra, 2009). These fruits are the powerhouse of anti-oxidants and have the potential to scavenge free radicals in the human body (Nithya and Saraswath, 2010).

Bael and wood apple are seasonal fruits that spoil quickly due to their short shelf life. Various preservation techniques can be used to reduce post-harvest losses and retain nutrition. Drying is one of the most common methods for preserving bael and wood apple fruit pulps as powders for a longer time. The dried products have a very long shelf-life at ambient temperature. For any horticulture produce, it is very important to determine its physical properties to design and develop harvesting and post-harvesting technologies. Functional properties are the essential characteristics of powders that relate to the constitutions, compounds integrations of ingredients between the configuration, and the behaviour during processing and preparation (Joshi, 2015). These properties help us to understand the powders' applicability in various food products. Therefore, an attempt was made in the present study to process the bael and wood apple fruit pulps into flours and analyze their physical and functional properties to understand their application in food products.

Materials and methods

Procurement of fruits: Freshly harvested matured bael and wood apple fruits (free from defects and damages) were procured from the local market in Chennai. The ripening stage of the wood apple was checked by a drop test (Ali Khan *et al.,* 2019). Unripe wood apple fruits were kept under indirect sunlight for 2 weeks and then used for further processing (Jayakumar and Geetha, 2010).

Processing methods: Bael fruits were processed as per Anurag Singh *et al.* (2015) with slight modifications. Rinds of ripened bael fruits were opened with a domestic knife. Fruit pulp, seeds, and fibres were scooped out and ground in a mixer grinder. The ground pulp was spread on a tray at a thickness of 2 mm in height and dried at 65^{o}C in a hot air oven until constant weight is achieved. The dried pulp was cooled at normal room temperature (30±2°C) and ground to a mesh size of 250 μm.

Matured and ripe wood apples were processed following the procedure given by Khan *et al.* (2019). Selected fruit shells were cracked open with the help of a wooden hammer. Shells were separated and pulp was collected using a sharp domestic knife. After cooling, the pulp and seeds were ground in a mixer grinder and dried into a powder in a hot air oven at 60 °C (Poongodi *et al.,* 2013). Both Fruit Pulp Powders (FPPs) were stored in labeled airtight containers at room temperature for further analysis.

Moisture content and water activity: The initial pulp and final powder moisture contents were analyzed by the Hot air oven method at 105^0C ± 2^0C until constant weights are achieved. The water activity of the fruit powders was analyzed by Lab Swift portable-water activity meter.

Flow properties

Bulk and tapped density: The bulk densities of the flours were calculated by following the formula and method described by Okaka and Potter, (1979). Tapped density was determined by weighing after tapping the contents.

$$\frac{Bulk}{tapped} density = \frac{Weight\ (g)}{Volume\ (cm^3} \quad (1)$$

Carr compressibility index and Hausner ratio: The flow characteristics of the flour samples were measured by calculating Carr Index (Carr, 1965) and Hausner's ratio (Hausner, 1969) from bulk density and tapped density values.

$$Carr\ Index\ CI = \frac{Tapped\ density - Bulk\ density}{Tapped\ density} * 100 \quad (2)$$

$$Hausner\ Ratio = \frac{Tapped\ density}{Bulk\ density} \quad (3)$$

Functional Properties

Water/Oil-Absorption Capacity (WAC/OAC): Water/Oil absorption capacity is defined as the amount of water or oil retained by powder without any application of external force. It was calculated from the difference between the weight of the mixture resulting from adding 10 mL of water or 10 mL of soyabean oil to 1 g of powder and the weight of the same mixture. WAC was and OAC was determined by Femenia *et al.* (1997) with slight changes. In a centrifuge tube, 1 g of dried fruit powders sample was mixed with 10 mL of distilled water or 10 mL of oil, then vortexed and allowed to stand still for 30 mins. The contents were then centrifuged at 3000 rpm for 15 min, and the excess water was decanted. The dried sample with absorbed water was reweighed, and WAC/OAC was expressed as g water/g DW.

Swelling capacity and water solubility capacity: The flour sample (W_1) of 500 mg and 20 mL of distilled water (W_2) were taken in centrifuge tube. The glass tube containing sample was heated at 70 °C for 30 minutes in the water bath. Centrifugation was done for 10 minutes at 2292 x g. The supernatant of 10mL (V_s) was decanted and was placed in a crucible (W_3) to determine the solubility. The sample in the crucible was placed in an oven at 105 °C for 12 h for drying (Islam *et al.,* 2009). Once constant weight (W_4) is achieved, the following properties was calculated. After separating the supernatant, the tube with contents is weighed (W_5).

$$Swelling\ Capacity\ (g/g) = \frac{W_5 - W_2}{W_1} \quad (4)$$

$$Solubility(\%) = \frac{W_4 - W_3}{V_S} * \frac{100}{W_1} \quad (5)$$

Foaming capacity: 10g of sample was dispersed in 100 mL distilled water and the suspension was mixed vigorously for 2 min using a blender. The initial solution volume (V_1) and final volume after mixing (V_2) were noted down. FC was calculated as FC = $((V_2-V_1)/V_1) \times 100$ (Acuna *et al.,* 2012)

Least gelation capacity: The least gelation concentration (LGC) is evaluated using the method of Coffman and Garcia (1977). The flour dispersions of 2, 4, 6, 8, 10, and 20 % (w/v) prepared in 5 mL distilled water was heated at 90°C for 1 h in water bath. The contents were cooled under tap water and kept for 2 h at 10 ± 2 °C. The lowest gelation concentration was determined using the method given as that concentration when the sample from the inverted tube does not slip.

Statistical analysis: Data were subjected to one-way analysis of variance and the significance means were compared by Duncan's multiple comparison test at a P=5%.

Results and discussion

Product (powder) yield: The results are tabulated in Table 1. The pulp from 1 kg of bael fruits and wood apple weighed around 720 g and 675 g, respectively. The powder yield after drying in these fruits was 33.89 and 29.62 g%, respectively. This was correlated with the study of Poongodi *et al.* (2013) where the powder yield from wood apple was 25.9 g% from 630 g of pulp. Similar findings were obtained by Chaudhary *et al.* (2020) for bael fruit pulp powder. The time taken for pulp to attain constant weights was 670 min for Bael fruit and 720 min for Wood apple.

Moisture content and water activity: The initial moisture contents of the bael fruit and wood apple pulps were 76.21±0.03 % and 69.73±0.16 %, respectively (Table 1). Singh *et al.* (2015) found that the initial moisture content of bael fruit pulp was 551.6% (db). Poongodi *et al.* (2013) reported a slightly higher value of initial moisture content (72%) and Sneha *et al.* (2018) observed a lower initial moisture content (65%) in wood apple pulp. Chaudhary *et al.* (2020) and Singhania and Ray (2019) testified that the final moisture contents were 8.1 % and 7.54±1.05 % for bael and wood apple pulp powders dried in a hot air oven, respectively. These results were correlating to the investigated value in the present study *i.e.*, 7.96±0.78% and 7.34±0.72% for Bael and Wood apple pulp powder. Reduced moisture content in flour achieves better shelf life and stability. Saha *et al.* (2021) observed a similar range of moisture content values in camachile aril fruit powder.

Water activity values for bael (BFP) and wood apple pulp powders (WAP) were 0.327±0.12 and 0.314±0.17, respectively (Table 1). Generally, food with water activity around 0.3 was stable both microbiologically and chemically (Porrarud and Pranee, 2007). Sornsomboonsuk *et al.* (2019) reported that water activity values increased from 0.27 to 0.33 in bael fruit powder during storage. Our findings are correlated to the aw values (0.3 to 0.345) of pitaya fruit powder obtained by spray drying (Tze *et al.,* 2012). The study by Mishra *et al.* (2017) showed water activity values range from 0.20 to 0.32 in hog plum fruit powder.

Bulk density and tapped density: The bulk densities of the BFP and WAP were noted to have higher bulk density *i.e.*, 0.59 g/cm³ ± 0.02 and 0.63 g/cm³ ±0.01 while the tapped densities values were 0.88 g/cm³±0.02 and 1.39 g/cm³ ± 0.01 for BFP and WAP, respectively (Table 1). Generally, a higher bulk density of the flour is desirable for greater ease of dispersibility and can be used

Table 1. Physicochemical and flow properties of BFP and WAP

	Bael Fruit	Wood Apple
Product yield (%)	49.57±0.05[a]	44.88±0.08[b]
Initial Moisture content (%)	76.21±0.03[a]	69.73±0.16[b]
Final Moisture content (%)	7.96±0.78[a]	7.34±0.72[b]
Water activity (aw)	0.327±0.12[a]	0.314±0.17[b]
Bulk Density (g/cm³)	0.59 ± 0.02[b]	0.63 ±0.01[a]
Tapped Density (g/cm³)	0.88 ±0.02[b]	1.39 ± 0.01[a]
Carr's Index	32.95± 0.78[b]	54.67± 0.82[a]
Hausner's ratio	1.49±0.02[b]	2.20±0.08[a]

Values are expressed as mean ± standard Error (SE). The mean values with different superscript letters in the same column are significantly different ($P < 0.05$) as per Duncan multiple comparison test.

to reduce paste thickness (Jadhav *et al.,* 2017). Sornsomboonsuk *et al.* (2019) reported similar bulk (0.56±0.02) and tap density (0.72±0.03) values for bael Fruit Powder. Pongoodi *et al.* (2013) reported slightly higher values of bulk density (0.68±0.01) and lower values for tap density (1.33±0.00) for wood apple powder.

Carr's index (CI) and Hausner's ratio (HR): Having a low CI below 25 indicates superior flowability and HR lower than 1.25 indicates good flowability (Prasad *et al.,* 2020). CI values in this study were 32.95± 0.78 and 54.67± 0.82 for BFP and WAP indicating poor flowability. These results are in accordance with the study by Sornsomboonsuk *et al.* (2019) and Poongodi *et al.* (2013). HR values of BFP and WAP were 1.49±0.02 and 2.20±0.08, respectively (Table 1).

Functional properties

Water and oil absorption capacity (WAC/OAC): WAC of BFP (1.31±3.27g/g) was higher when compared to WAC of WAP (1.15±3.28g/g) (Table 2). These results were in accordance with the study by Chaudhary *et al.* (2020) where WAC values ranged from 105 to 130 for hot air-dried BFPs developed from different cultivars. Prasad *et al.* (2020) reported a higher value of WAC (133.3%) for WAP and Poongoodi *et al.* (2013) reported a similar WAC value for hot air oven dried WAP (1.14±0.01). Lower values of WAC for both fruit powders can be associated with the presence of sugars which reduces WAC. WAC depends on the fiber source and its chemical, physical and structural characteristics (Raghavendra *et al.,* 2004).

The Oil Absorption Capacity (OAC) serves as a pivotal technical parameter intricately linked to the chemical composition of plant polysaccharides. Its determination hinges on a complex interplay of factors such as surface properties, overall charge density, thickness, and the hydrophobic characteristics inherent in the fiber particles (Fernandez-Lopez *et al.,* 2009). OAC of WAP was 101.19±1.46% and BFP was 101.86±1.85% (Table 2) which were similar to the OAC of Wood apple seed meal (111g/100g) as observed by Rao *et al.* (2011). These values are comparable to that of air-dried camachile fruit aril powder reported by Saha *et al.* (2020) and in dried breadfruit flour (Taruna *et al.,* 2018). The lower water absorption and higher oil absorption in WSPC might also be due to the presence of polar amino acids. The high oil absorption capacity makes the powders suitable for facilitating enhancement in flavour and mouth feel when used in food preparations. These fruit powders may be more suitable for sausage, soup and cake recipes in which the oil ability of flours is an important factor (Aremu *et al.,* 2006).

Swelling capacity: The swelling capacity of powder is an important aspect as it improves the mouth feel of the product and retains the flavor (Abulude *et al.,* 2005). The swelling capacities of BFP and WAP were 4.39±0.01mL/g and 4.15±0.02 mL/g, respectively (Table 2). Poongodi *et al.* (2013) reported a lower value of swelling capacity in wood apple powder (0.40±0.01). The values of swelling capacities of both the fruit pulp powders were less when compared to pequi fruit powder (8.82±0.36), *G. erubescens* fruit (11.26±0.03) and bael powder (56ml) as reported by Leao *et al. (*2017); Korese and Achaglinkame (2022) and Chaudhary *et al.* (2020), respectively.

These pulp powders can be introduced as fiber-rich food ingredients and contribute to formulated foods' textural properties and stability. Additionally, the swelling capacity of fiber-rich food ingredients is relevant for their hypoglycemic activity and hypolipidemic effects (Jiang *et al.,* 2021).

Table 2. Functional properties of BFP and WAP

	Bael fruit powder	Wood apple powder
Water absorption capacity (g/g)	1.31±3.27[a]	1.15±3.28[b]
Oil absorption capacity (%)	101.19±1.46[a]	101.86±1.85[a]
Swelling capacity (mL/g)	4.39±0.01[a]	4.15±0.02[b]
Water solubility index (%)	97.67±0.06[b]	98.45±0.02[a]
Foaming capacity (ml)	23.45±0.09[b]	25.62±0.06[a]

Values are expressed as mean± Standard Error (S) The mean values with different superscript letters in the same column are significantly different ($P < 0.05$) as per Duncan's multiple comparison test.

Water solubility index (WSI): The solubility values for BFP and WAP were determined to be 97.67±0.06 and 98.45±0.02%, respectively (Table 2). These findings align with the observations made by Sornsomboonsuk *et al.* (2019) in their investigation of bael fruit powder. Regarding wood apple spray-dried powder, the water solubility index (WSI) exhibited a range of 75.50 to 99.25%, as reported in the study conducted by Saini (2018). This behavior suggests that the release of polysaccharides or polysaccharide content from the granules was restrained when excessive water was introduced.

Foaming capacity (FC): Foam is a colloidal of many gas bubbles trapped in a liquid or solid. Small air bubbles are surrounded by thin liquid films. Foaming capacities for BFP and WAP were 23.45±0.09 and 25.62±0.06 mL, respectively. The foam capacity of samples ranged between 13.2 and 25.2mL for bael fruit powders obtained by different drying techniques (Chaudhary *et al.,* 2020). Wood apple seed powder has shown 58 mL of foam as studied by Narsing *et al.* (2011).

Least gelation capacity: Dried bael and wood apple pulp powders exhibited their lowest gelation concentration at 10%, the firm gel was not observed even up to 20% concentration. Poongodi *et al.* (2013) also had such findings in wood apple powder.

The study revealed that bael and wood apple fruits can be efficiently dried using the hot air oven method at 65 and 60°C, respectively. Despite low flowability, they have high oil absorption and low water capacity. These pulp powders can enhance food texture due to swelling, with low solubility indicating intact polysaccharides. They don't form strong gels even at 20% concentration. This offers potential for innovative food products, minimizing waste and ensuring year-round availability through powder conversion.

Acknowledgement

This research work was supported by the College of Food and Dairy Technology, Tamil Nadu Veterinary and Animal Sciences University, Koduveli, Chennai – 52, India.

References

Abulude, F.O., L.O. Lawal and A.O. Kayode, 2005. Effect of processing on some functional properties of millet (*Eleusine coracana*) flour. *J. Food Technol.,* 3(30): 460-463.

Acuna, C., S. Patricia, G. González, J. Humberto, I. Torres and I. Darío, 2012. Physicochemical characteristics and functional properties of vitabosa (*Mucuna deeringiana*) and soybean (*Glycine max*). *Food Sci. Technol.,* 32(2): 98-105.

Ali Khan, M., K. Singh, K.K. Patel and M. Siddiqui, 2019. Some physical properties of wood apple (*Feronia Limonia* L*.). Rec. Adv. in Food Sci. Nutri*., 2(1): 79-86.

Aremu, M.O., O. Olaofe and E.T. Akintayo, 2006. Functional properties of some Nigeria varieties of legume seed flours and flour concentration effect on foaming and gelation properties, *J. Food Technol.,* 5: 10-115.

Carr, R. 1965. Evaluating flow properties of solids. *Chemistry Engineering*, 18: 163-168.

Chaudhary, V., K. Vivek, B.R.Singh, S. Jaivir, C. Neelash and P. Kumar, 2020. Drying characteristics of Bael pulp using different drying methods and different varieties*. Int. J. Agril. Engg.,* 13(1): 19-30.

Coffman, W. and V.V. Garcia, 1977. Functional properties and amino acid content of protein isolate from mungbean flour. *J. Food Technol.,* 12: 473-484.

Dar, A.I., G. Masar, V. Jadhaw, S.K. Bansal and R.C. Saxena, 2013. Isolation and structural elucidation of the novel flavone glycoside from *Feronia limonia* L. *J. Pharma Res.,* 7: 697-704.

Prasad, Durga, R.A. Yeshwanth and T.V.N. Padmavathi, T.V.N, 2020. Value addition of *Limonia acidissmia* L. *CG. Int. J. Chem. Stu.,* 8(5): 779-785.

Femenia, A., A.C. Lefebvre, J.Y. Thebaudin, J. Robertson and C.M. Bourgeois, 1997. Physical and sensory properties of model foods supplemented with cauliflower fiber. *J. Food Sci.,* 9: 62:635.

Fernandez-Lopez, J., E. Sendra-Nadal, E, C. Navarro, V. Martos, and J.A.Perez-Alvarez, 2009. Storage stability of a high dietary fibre powder from orange by-products. *Int. J. Food Sci. Technol.,* 44: 748-756.

Hausner, H. H., 1969. *Friction Conditions in a Mass of Metal Powder*. Polytechnic Inst. of Brooklyn. Univ. of California, Los Angeles.

Ilango, K and V. Chitra, 2009. Anti-diabetic and antioxidant activity of *Limonia acidissima Linn*, In alloxan induced rats. *Der Pharmacia Lettre*, 1(1): 117-125.

Islam, M., R. Begum, M. Khatun and K.C. Dey, 2009. A study on nutritional and functional properties analysis of jackfruit seed flour and value addition to biscuits. *Int. J. Engg. Res. and Technol.,* 4: 139-147.

Jadhav, H.T.O., C. Ozoh, S.T. Marripudi, X. Cao and K.A. Rosentrater, 2017. Studies on Ground Corn Flowability as Affected by Particle Size and Moisture Content, ASABE Annual International Meeting. American Society of Agricultural and Biological Engineers.

Jayakumar, A. and K. Geetha, 2010. Wood apple: uses and benefits. Market Survey. 2010, (www.ffymag.com/admin/issuepdf/Wood%20 Apple_Aug%2012.pdf).

Jiang, H., W. Zhang, X. Li, Y. Xu, J. Cao and W. Jiang, 2021. The anti-obesogenic effects of dietary berry fruits: A review. *Food Res. Int.,* 147: 110539.

Joshi, U.A., L. Changqi and K.S. Shridhar, 2015. Functional properties of select seed flours. *LWT-Food Sci. Technol.,* 60(1): 325 -331.

Korese, J.K. and A.M. Achaglinkame, 2022. Exploring effects of slice thickness, pretreatment and drying air temperature on nutritional, functional and pasting properties of *Gardenia erubescens* Stapf. & Hutch. fruit powder. *J. Agril. Food Res.,* 8: 100283.

LeãoAdriana, D., S. FrancaLeandro, S. Oliveira, I. BastosManuel and A. Coimbra, 2017. Physicochemical characterization, antioxidant capacity, total phenolic and proanthocyanidin content of flours prepared from pequi (*Caryocar brasilense* Camb.) fruit by-products. *Food Chem.,* 225: 146-153.

Mishra, P., A. Brahma and D. Seth. D, 2017. Physicochemical, functionality and storage stability of hog plum (*Spondia pinnata*) juice powder produced by spray drying. *J. Food Sci. and Technol.,* 54(5): 1052-1061.

Narsing Rao, G., P.G. Prabhakara Rao and D. Govardhana Rao, 2011. Preparation of wood apple (*Feronia limonia* L.) seed protein concentrate and evaluation of its nutritional and functional characteristics. *Int. Food Res. J.,* 18(3): 949-955.

Nithya, N and U. Saraswathi, 2010. *In vitro* antioxidant and antibacterial efficacy of Feronia elephantum Correa fruit. *Indian J. Nat. Prod. and Reso.,* 1(3): 301-305.

Okaka, J.C and N.C. Potter, 1979. Physicochemical and functional properties of cowpea powders processed to reduce beany flavour. *J. Food Sci.,* 4: 1235-1240.

Porrarud, S and A. Pranee, 2007. Microencapsulation of Zn-chlorophyll pigment from pandan leaf by spray drying and its characteristics. *Int. Food Res. J.,* 17: 1031-1042.

Poongodi, V.K.T., K. Punitha and L. Banupriya, 2013. Drying characteristics and quality evaluation of wood apple (*Limonia acidissima L.)* fruit pulp powder. *Int. J. Curr. Tr. Res.,* 2(1): 147-150.

Raghavendra, S.N., N.K. Rastogi, K.S.M.S. Raghavarao and R.N. Tharanathan, 2004. Dietary fiber from coconut residue: Effects of different treatments and particle size on the hydration properties. *Eur. Food Res. Technol.,* 218: 563-567.

Saha, Pushpita, M. Kirthy Reddy, CH. Ramya, Y. Pavithra, V. Manasa and G. Vamsi, 2021. Evaluation of *Pithecellobium dulce* (Camachile) fruit and its aril powder. *Int. J. Chem. Stu.,* 9(2): 671-676.

Saha, Pushpita, Kirthy Reddy, M., Ramya, C.H., Pavithra, Y., Manasa, V and Vamsi, G. 2020. Development and incorporation of Pithecellobium dulce (Camachile) fruit powder in multi-grain pasta. *Pharma Innovation J.,* 10(6): 635-641.

Saini, C.S. 2018. Effect of different process conditions of spray drying on properties of wood apple juice powder. *Int. J. Adv. Sci. Engg. Technol.,* 6(4): 2321-2329.

Singh, Anurag, H.K. Sharma, N. Kumar, A. Upadhyay and K.P. Mishra, 2015. Thin layer hot air drying of bael (*Aegle marmelos*) fruit pulp. *Int. Food Res. J.,* 22(1): 398-406.

Singh, K. and A.K. Chaurasiya, 2014. Post Harvest Management and value addition in Bael (*Aegle marmelos* Corr.). *Int. J. Interdisciplinary Multidisciplinary Stu.,* 1(9): 65-77.

Singh, A.K and N. Nath, 2004. Development and evaluation of whey protein enriched bael (*Aegle marmelos)* fruit beverage. *J. Food Sci. Technol.,* 14(1): 432-436.

Singhania, N. and B.A. Ray, 2019. Effect of drying techniques on physicochemical properties of wood apple (*Limonia acidissima*)*. J. Agril Engg Food Technol.,* 6(1): 9-12.

Sneha, and Prahlad Deb, 2018. Effect of drying methods and pre-drying treatments on chemical quality of wood apple pulp powder. *J. Pharmacognosy Phytochem.,* 7(3): 01-04.

Sornsomboonsuk, S., T. Junyusen, N. Chatchavanthatri, P. Moolkaew and N. Pamkhuntod, 2019. Evaluation of physicochemical properties of spray dried bael fruit powder during storage. *Int. J. Food Engg.,* 5(3): 1431-1439.

Taruna, I., A.L. Hakim, and Sutarsi, 2018. Physical quality characteristics of the microwave-dried breadfruit powders due to different processing conditions. International Conference on Green Agro-industry and Bioeconomy IOP Publishing IOP Conf. Series: Earth and Environmental Science.

Tze, L.N., P.C. Han, Y.A. Yusof, C.N. Ling, A.R. Talib, F.S. Taip and M.G. Aziz, 2012. Physicochemical and nutritional properties of spray-dried pitaya fruit powder as a natural colorant. *Food Sci. Biotechnol.,* 21(3): 675-682.

Received: August, 2022; Revised: August, 2022; Accepted: August, 2022