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Processing and Nutritional Evaluation of Amla (*Phyllanthus emblica*) Pomace

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ABSTRACT

Background: Amla (*Phyllanthus emblica*), popularly known as the Indian gooseberry, belongs to Euphorbiaceae family is known for its cool, refreshing, pleasant taste and utilised for various products and beverages. During processing, massive amounts of amla pomace that is an abundant source of polyphenols, ascorbic acid, dietary fibre and tannins is discarded as waste.

Methods: The research was undertaken to standardize the process of dehydration and nutritional evaluation of amla pomace. The physico-functional properties, sensory evaluation, particle size distribution and its effect on hydration properties, microbial load was carried out from initial to 45 days of storage at both ambient and refrigerated temperature conditions for amla pomace powder.

Result: The physico-functional properties indicated pH 3.44±0.01, colour *L** 86.47±0.25, *a** -0.74±0.08 and *b** 11.13±0.71, particle density 1.23±0.08 g/cm^3, water holding capacity 12.30±0.45 g/g, water binding capacity 12.37±0.37 g/g and swelling capacity 13.0± 0.50 mL/g. The nutrient composition was found to have good amount of total dietary fibre (41.7±0.04 g) with abundant minerals like calcium (128±1.10 mg), phosphorus (116±0.70 mg) and magnesium (48±1.32 mg) along with low fat (0.18±0.004 g), low carbohydrate (7±0.44g) and low calorific value (36±0.76 Kcal) per 100 g. The phytonutrients, *viz.*, ascorbic acid, tannins and polyphenols were 432±6.0, 524±7.0 and 677±4.0 mg per 100 g, respectively. The sensory scores of Amla pomace were good and the microbial counts were within the permissible limits during 45 days of storage period. Hence, amla pomace powder, a nutritious by-product can be utilized effectively as a functional ingredient in value added products.

Key words: Amla pomace, Microbial load, Minerals, Phytonutrient, Processing.

INTRODUCTION

Mother nature has gifted mankind with wonderful medicinal herbs to lead a disease-free and healthy life. Abundant medicinal plants are featured in the Indian traditional systems of medicine (like Ayurveda, Unani, siddha), mostly used one amongst them is Indian gooseberry or Amla (*Phyllanthus emblica*.) belongs to the family Euphorbiaceae and said to be native to India, which is an important medicinal herb in Ayurveda and Unani systems of medicine. It is enormously used as a tonic to restore the lost body's energy and vigor (Dasaroju and Gottumukkala, 2014). Amla fruits are fleshy, spherical, attractive, deeply ribbed, yellowish-green in colour and have six vague perpendicular furrows enclosing seeds. The amla fruit is well known across the world for its nutritional, commercial and medicinal benefits. Amla is a rich source of ascorbic acid, amino acids, minerals and phytochemicals such as polyphenols, tannins, emblicol, linoleic acid, corilagin, phyllemblin and rutin. It has 89 to 94 per cent pulp, 0.8 to 2 per cent fibre, 10 to 14 per cent total soluble solids, 1.4 to 2.4 acidity, 700 to 900 mg vitamin C per 100 g, 2.4 to 3.1 per cent pectin and 2 to 3 per cent phenols make up the amla fruit (Parveen and Khatkar, 2015).

Amla, particularly contains a greater volume of vitamin C and critical nutrients, protects a wide range of medical conditions owing to its potent biological and antioxidant capabilities. It can be utilised in the biopharmaceutical and nutraceutical sectors as well as a putative food additive. It is an ingredient of many Ayurvedic medicines and tonics, as it removes excessive salivation, nausea, vomiting, giddiness, spermatorrhoea, internal body heat and menstrual disorders (Kumar *et al.,* 2012). It is also observed that fruits like amla, mango, banana, watermelon and citrus fruits all leave behind a large amount of residue in the form of peels, pulp, seeds and stones. This fruit residue or pomace has lot of potential in the culinary, pharmaceutical and cosmetic sectors because of the presence of phenolic compounds, which imparts nutraceutical properties. The extraction of bioactive compounds from less expensive or

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residual sources has become researcher's curiosity in the recent years (Gupta *et al.,* 2012). Fruit pomace is a novel, effortlessly available, efficient, low-priced, natural and economic source of antioxidants and antimicrobial agents (Prakash *et al.,* 2013).

Pomace, which makes up 20% to 50% of the weight of the fruit, is produced in great quantities when processed fruits, such as juices, jellies, chutney and pulping, are used. Pomace is made up of husks, seeds, stalks and leftover pulp. Pectin, soluble and insoluble fibre, which is extracted from fruit peel and is generally recognised for its potential nutritional and health advantages, is utilised to make the nutrient-rich chips that are currently available on the market. So, using fruit pomace in the food business is an option. These pomaces can preserve nutrients and bioactive substances with various biological functions, such as phenolic acids, flavonoids, anthocyanins and carotenoids (Santos *et al.,* 2022).

A significant quantity of wastage is produced as a by-product of amla processing, both at the household and industrial level. A huge portion of this waste is edible and has numerous nutritional and health perks. It is crucial to understand the composition and nutritional characteristics of such substances in order to gauge their potential for use. Hence, the present research work was carried out to study the physico-functional properties, nutrient composition, sensory evaluation, microbial and storage quality of the amla pomace.

MATERIALS AND METHODS

The present investigation was carried out at Department of Food Science and Nutrition, University of Agricultural Sciences, Bangalore during 2020-2021.

Selection and collection of sample

The fresh and matured amla fruits were procured from the local market of Bengaluru, Karnataka, India.

Processing and dehydration

The processing of amla fruits into dehydrated amla pomace powder is illustrated in Fig 1 and 2. The amla fruits were washed under running tap water and they were wiped using a clean dry cloth. Amla fruits were cut into pieces by using a stainless-steel knife and the seeds were separated by slicing the pulp into small pieces. Then, the amla pieces were ground into pulp in the laboratory mixer, the juice was extracted from the pulp and the residue (pomace) was separated. Dehydration was carried out by weighing fresh pomace sample and subjected to dehydration in a laboratory model ezidri ULTRAFD1000 tray dryer at 45°C for 4 hours. The dried pomace was ground to fine powder and sieved through a scientific sieve and stored in the air tight zip lock pouches in refrigerated conditions for further use.

Physico-functional properties

The pH of the amla pomace powder was determined by taking 1 g of sample and diluting in 20 ml of distilled water. The pH of the sample was recorded using digital pH meter of analog model. The colour of the amla pomace powder was measured by using spectrophotometer (CM-5) Konica Minolta. The colour was expressed in *L** (Lightness/ darkness), *a** (greenness/redness) and *b** (blueness/ yellowness) values (Nazaruddin *et al.,* 2011). Particle density was determined as described by Sangnark and Noomhorm (2003), through displacement in petroleum ether (40-60°C). Water holding capacity, water binding capacity, swelling capacity and particle size distribution of the sample was determined using the method described by Sowbhagya *et al.* (2007).

Nutritional composition

Moisture, ash, protein, fat, energy, carbohydrate, dietary fibre, crude fibre and tannin content were estimated by the method given in standard AOAC, (1980). Ascorbic acid and polyphenols were determined by the method of Ranganna,

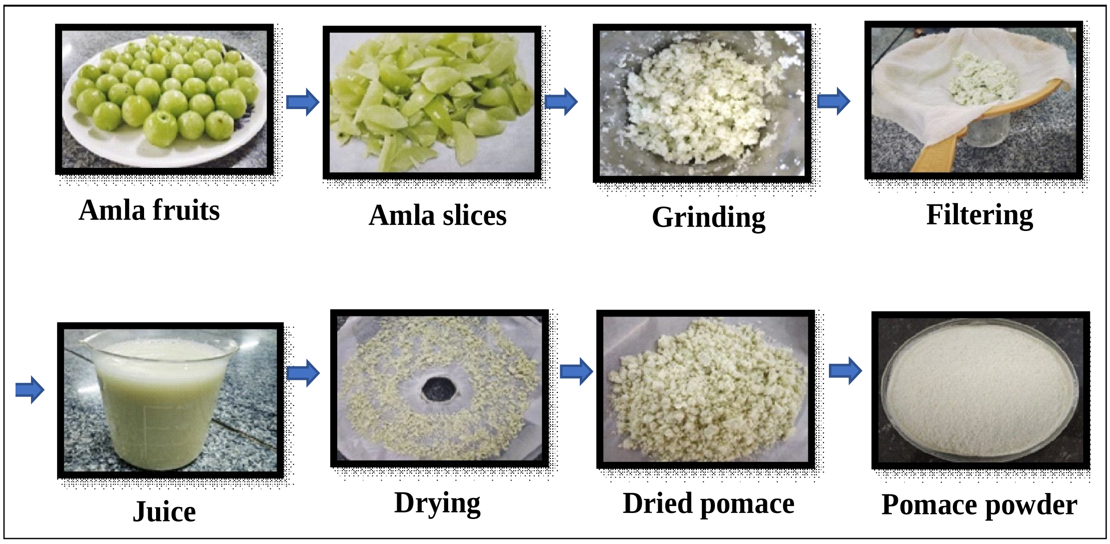

Fig 1: Images from experiment of amla pomace powder making process.

(2005). Minerals like calcium, magnesium, phosphorus, sodium, iron, zinc, copper and manganese were analysed by using the methods of standard AOAC. (1980).

Sensory evaluation

The product was subjected to sensory evaluation. Sensory quality attributes were evaluated by a panel of 21 semi-trained members using a nine-point hedonic scale (Amerine *et al.,* 1965). The product was evaluated for their appearance, color, texture, flavor, taste and overall acceptability.

Microbiological enumeration

The microbial analysis was carried out by standard plate count method using nutrient agar (NA) for bacteria, Martin's Rose Bengal Agar (MRBA) for mold and YEPDA for yeast (Tate, 1995).

Statistical analysis

The data were subjected to Complete Randomised Design (CRD) analysis of variance for testing the significance of variation in microbial load and sensory evaluation of amla pomace powder by using the statistics *i.e.* software Statistical Package for Social Sciences (SPSS) version 12.0 (Sabine and Brian, 2004). The results were expressed as mean ± standard deviation. Statistical significance was P≤0.05.

RESULTS AND DISCUSSION

Physico-functional properties

The physico-functional characteristics of the dehydrated amla pomace powder such as colour, pH, particle density, water holding capacity, water binding capacity and swelling capacity were assessed and indicated in Table 1 and particle size distribution in Table 2. The pH was found to be 3.44±0.01, colour lightness (*L*)* value 86.47±0.25, greenness (*a*)* value -0.74±0.08 and yellowness (*b*)* value 11.13±0.71, particle density 1.23±0.08 g/cm^{3,} water holding capacity was found to be 12.30±0.45 g/g, water binding

Table 1: Physico-functional properties of amla pomace powder.

Particulars		Value
Ph		3.44±0.01
Colour	*L** (whiteness)	86.47±0.25
	*a** (Greenness)	- 0.74±0.08
	*b** (Yellowness)	11.13±0.71
Water holding capacity (g/g)		12.30±0.45
Water binding capacity (g/g)		12.37±0.37
Swelling capacity (ml/g)		13.00±0.50
Particle density (g/cm^3)		1.23±0.08

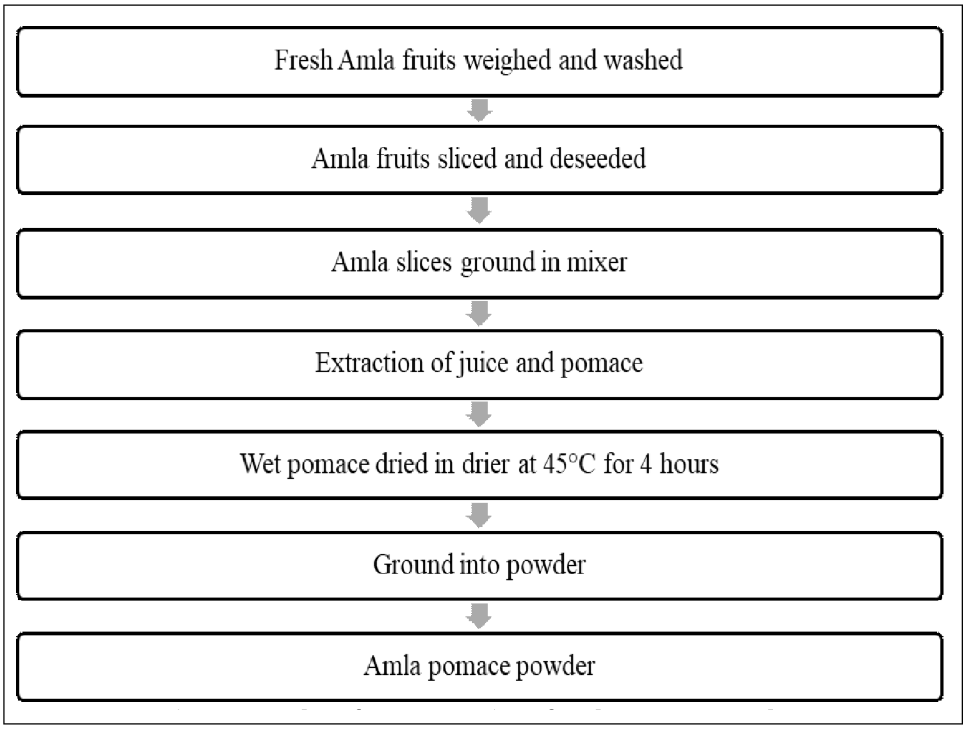

Fig 2: Procedure for preparation of amla pomace powder.

Table 2: Distribution and Effect of particle size on hydration properties of amla pomace powder.

Mesh size (mm)	Micron	Particle size distribution (%)	WHC (g/g)	SC (ml/g)	WBC (g/g)
0.053	53	21.44±1.08	8.91±0.09	8.5±0.50	7.48±0.15
0.125	125	16.93±0.43	13.08±0.43	10±1.11	10.55±0.40
0.250	250	61.22±1.25	15.70±0.54	12.5±0.32	12.11±0.35

capacity was 12.37±0.37 g/g and swelling capacity was 13.0±0.50 ml/g. Similar values are reported by Gupta and Premavalli (2010) for ash gourd and radish fibre with values for particle density to be 1.21 and 1.17 g/cm^3, water holding capacity (12.26 and 13.81 g/g) and higher values (≤0.05) for water binding capacity (14.13 and 15.61 g/g) and swelling capacity (19.49 and 12.95 ml/g) compared to the present findings. The functional properties of dragon fruit peel powder reported by Chia and Chong (2015) for water holding capacity and swelling capacity was found to be 2.52 g/g and 6.23 ml/g, respectively that is lower than the present study. Also, the physico-functional properties of pear pomace reported by Yan *et al.* (2019) indicated values of pH to be 3.88 that is higher than the pH value obtained in the present investigation, water holding capacity was found to be 3.44 g/g and swelling capacity 5.09 g/ml that are lower than the values obtained in the present study.

The distribution of particle size of amla pomace powder was 21.44±1.08, 16.93±0.43 and 61.62±1.25 per cent through the mesh sieves 53, 125 and 250 microns, respectively. The highest yield was recorded 61.62±1.25 per cent for 250 microns. The water holding capacity, swelling capacity and water binding capacity of amla pomace powder increased with increase in particle size. It exhibited 8.91±0.09 g/g, 8.5±0.50 ml/g and 7.48±0.15 g/g for 53 micron, 15.70±0.54 g/g, 12.5±0.32 ml/g and 12.11±0.35 g/g for 125 micron, 13.08±0.43 g/g, 10±1.11 ml/g and 10.55±0.40 g/g for 250 microns, respectively. As the particle size of amla pomace powder increased, the water holding capacity, swelling capacity and water binding capacity of amla pomace powder also increased. The reason can be attributed to the ability of a pomace powder to absorb and hold more water due to its texture, porosity, density and finer particle size. Similar results were observed by Gupta and Premavalli (2010) who reported distribution of particle size of ashgourd and radish fibre yields ranged from 26-30 per cent and 14-17 per cent on 30 and 100 mesh sieves, whereas in 60 mesh sieve highest yield was recorded 40.33 and 43.83 per cent, respectively.

Nutritional composition

The nutritional composition of amla pomace powder is indicated in Table 3. Among all nutrients ascorbic acid was found to be in higher amount of 432±6.0 mg/100 g indicating that amla pomace would be good ingredient to supplement ascorbic acid. The total dietary fibre (TDF), insoluble dietary fibre (IDF), soluble dietary fibre (SDF) and crude fibre content of amla pomace was found to be 41.7±0.04, 27.4±0.19, 14.5±0.04 and 13.4±0.05 g, respectively indicating that the by-product of amla, *i.e.* amla pomace would be a good source of fibre which would otherwise go as a waste. Amla pomace has low calorific value of 36±0.76 Kcal, low carbohydrate of 7±0.44 g and low fat of 0.18±0.004 g per 100g and hence can be used to formulate low calorie, low fat, low carbohydrate, high fibre and high ascorbic acid containing functional foods. The other nutrients like moisture, protein and ash was found to be 4.99±0.01, 1.55±0.01 and 2.60±0.04 g, respectively. Increase in nutritional composition of amla pomace may be due to removal of moisture content.

The findings were slightly higher in the present investigation than reported by Nagamaniammai (2013) who analysed dietary fibre content of amla pomace powder *i.e.* total dietary fibre (39.79 g), insoluble dietary fibre (26.18 g) and soluble dietary fibre (13.57 g). And other nutritional parameters of amla pomace powder in the present study is almost similar to that reported by Nagamaniammai (2013). Also, the values obtained in the present study were lower compared to the study conducted by Fathima (2018) reported nutrient composition of banana peel powder to be moisture (6.39 g), protein (7.04 g), ash (11 g), fat (4.84 g), crude fibre (28.30 g), carbohydrate (71 g) and energy (355 kcal). This difference in nutrient composition in the present study and reported studies may be due to varietal difference and agro climatic conditions.

The results of phytonutrients such as polyphenols and tannins of amla pomace powder are presented in Table 4 and the values being 677±4.0 and 524±7.0 mg, respectively that are slightly lower than the study conducted by Nagamaniammai (2013) for 743 mg and 590 mg for polyphenols and tannins. The reason can be attributed to the variation in varieties, climatic condition and geographic location grown. It was noticed that amla pomace is the store

Table 3: Nutrient composition of amla pomace powder (Per 100 g).

Nutrients	Content
Moisture (g)	4.99 ±0.01
Protein (g)	1.55±0.01
Ash (g)	2.60±0.04
Fat (g)	0.18±0.004
Carbohydrate (g)	7.0±0.44
Energy (Kcal)	36±0.76
Ascorbic acid (mg)	432±6.
Total dietary fibre (g)	41.7±0.04
Insoluble dietary fibre (g)	27.4±0.19
Soluble dietary fibre (g)	14.5±0.04
Crude fibre (g)	13.4±0.05

Table 4: Phytonutrient and mineral composition of amla pomace powder (Per 100 g).

Parameters	Content (mg)
Phytonutrients	
Polyphenols	677±4.0
Tannins	524±7.0
Minerals	
Calcium	128±1.10
Phosphorus	116±0.70
Sodium	92.2±1.0
Magnesium	48±1.32
Manganese	2.0±0.20
Copper	1.34±0.14
Iron	1.12±0.10
Zinc	0.92±0.02

house of minerals. The total ash content of amla pomace in the present study was 2.60±0.04 g in which the calcium content was 128±1.10 mg, phosphorus 116±0.70 mg, sodium 92.2±1.0 mg, magnesium 48±1.32 mg, manganese 2.0±0.20 mg, copper 1.34±0.14 mg, iron 1.12±0.10 mg and zinc 0.92±0.02 mg. It is observed that the mineral composition in the present study is lower than the results obtained by Silva *et al.* (2017) who studied the mineral content of citrus residue and found 680 mg of calcium, 11.64 mg of iron, 91.55 mg of magnesium and 7.4 of mg zinc, respectively per 100 g which is higher than the present study.

Sensory evaluation of the amla pomace powder

Sensory evaluation of the amla pomace was carried out by 21 semi-trained sensory panellists on a nine-point hedonic scale. Attributes like appearance, texture, colour, flavour, taste and overall acceptability were scored based on its intensity scale. The result of the sensory analysis is presented in Fig 3. The amla pomace powder had good acceptable sensory score for appearance 7.50±0.59, for colour 7.68±0.47, for texture 7.09±0.68, for flavour 6.68±0.77, for taste 6.77±0.61 and for overall acceptability 7.18±0.58. The sensory scores show that the amla pomace powder to be acceptable by panelists.

Microbial load of amla pomace powder on storage

Microbial study for total bacterial count, yeast and mold was carried out for amla pomace powder for 45 days at both ambient temperature (25±2°C) and refrigerated temperature (4°C) and results are presented in Table 5. The results indicated that bacterial counts of amla pomace powder on the initial day was nil, however it was observed that there was increase on 15th day, 30th and 45th day it was found to be 0.33×10^5 cfu/g, 1.33×10^5 cfu/g and 2×10^5 cfu/g respectively. The yeast and mold counts were found to be nil on initial and on 15th day. However, it was increased to 1.33×10^2 cfu/g of yeast and 2×10^3 cfu/g of mold on 45th day in ambient temperature conditions. In refrigerated conditions the bacterial, yeast and mold count recorded was 1.33×10^5 cfu/g, 1.33×10^2 cfu/g and 1.33×10^3 cfu/g respectively on 45th day of storage period. However, it was observed that the microbial counts were within the permissible limits. Statistically significant difference ($P\leq0.05$) was found during storage period at different time

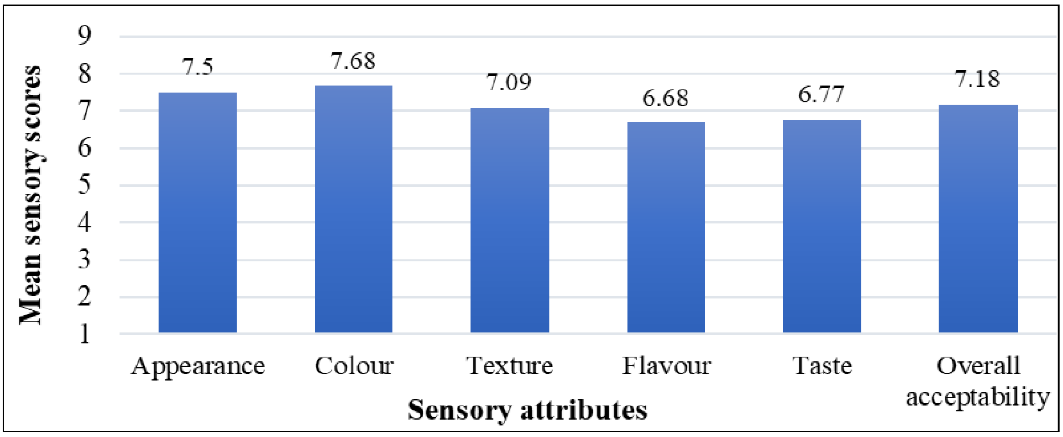

Fig 3: Sensory scores of amla pomace powder.

Table 5: Microbial load of amla pomace powder on storage.

Storage condition	Duration	TBC ($\times10^5$ cfu/g)	Yeast ($\times10^2$ cfu/g)	Mold ($\times10^3$ cfu/g)
Ambient temperature	Initial	Nil	Nil	Nil
	15th day	0.33	Nil	Nil
	30th day	1.33	1	1.33
	45th day	2	1.33	2
	F value	*	*	*
	SEm±	0.23	0.16	0.33
	CD@5%	0.78	0.55	1.10
Refrigerated temperature	Initial	Nil	Nil	Nil
	15th day	Nil	Nil	Nil
	30th day	0.66	1	0.66
	45th day	1.33	1.33	1.33
	F value	*	*	*
	SEm±	0.23	0.33	0.23
	CD@5%	0.78	1.10	0.78

NS= Non-significant, *= Significant ($P\leq0.05$) and TBC= Total bacterial count.

intervals. The microbial counts in the present study were found to be lower than that reported by Akshata (2017) who conducted study on muskmelon powder where in the bacterial counts on the initial day was nil and on 15th day, 30th day and 45th day it was found to be 1.02, 2.90 and 4.20×10^4 cfu/g respectively. Whereas mold count was found to be nil and population increased to 1.6, 2.58 and 4.65×10^4 cfu/g on 45th day of storage.

CONCLUSION

During processing of Amla, extraction of amla juice results in lot of wet amla residue or amla pomace as a by-product that is comprised of lots of nutrients. These bioactive compounds are known to have many health benefits and therapeutic value in human when consumed. It can be concluded that amla pomace powder is a rich source of ascorbic acid, good source of dietary fibre and also phytonutrients like polyphenols and tannins. It is also a good source of minerals like calcium, phosphorus, sodium and magnesium. Amla pomace offers a tremendous potential for its applications in food and pharmaceutical industries as nutraceutical especially the dietary fibre. Amla pomace powder was acceptable with respect to all sensory parameters. These bioactive compounds in the amla pomace makes this by-product as a potentially viable and valuable raw material for the development of novel and functional food products. Hence, this research promotes the reducing food waste since whole fruit tissues have been used leading to the maximum exploitation of food raw materials without any carbon foot prints.

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Conflict of interest

The author(s) declares no conflict of interest.

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