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Development of carambola pomace based cookies and its consumer acceptability

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Abstract
Agro industrial waste material is a rich source of various bio active components and fibre rich. Carambola pomace is a by-product of carambola juice processing unit. Fruit juice industries generate considerable amount of Carambola pomace as waste from fresh Carambola (*Averrhoa carambola* L.). However, the nutritional assets of Carambola pomace that include antioxidants, mainly polyphenols, should not be neglected, and be further processed in developing food supplements. In this study, Carambola pomace was found to be indeed nutrient-rich. This pomace was subsequently employed in development of Carambola pomace cookies, as a functional snack. Carambola pomace with 5%, 10%, 15%, 20% and 25% were used to incorporate in cookies. The characterisation of the Carambola pomace cookies delineated their healthfulness in terms of antioxidant potential, and 5% Carambola pomace got maximum consumer acceptance. The present study highlights the importance of utilising a wasted bioresource in adding functional value to a common food that otherwise is only a fat-rich snack.

Keywords: Carambola, pomace, cookies, antioxidants, consumer acceptance, polyphenols

Introduction
Fruits are high in bioactive compounds such as carotenoids, anthocyanins, and other antioxidant polyphenols, as well as vitamins and minerals. Fruit and vegetable wastes are cheap, plentiful and have high dietary fibre content, resulting in a high-water binding capacity and relatively low enzyme digestible organic matter (Serena & Knudsen, 2007) [13]. Industrial by-products derived from agriculture are a good source of antioxidants and dietary fibre. Dietary fibre aids in the control of cholesterol and glucose levels in the blood. It functions as a bulking agent, regulates calorie intake, promotes satiety, limits weight gain, and maintains digestive system health by fermenting in the colon by the bacteria there, which produces a variety of secondary bioactive metabolites with health-promoting qualities (Elia and Cummings, 2007). Dietary fibre is employed for a variety of purposes, including nutritional, functional, and technical. Dietary fibre should be consumed at a rate of 25-30 g/day. Dietary fibre should thus be added into frequently consumed foods to augment daily diets. The co-products could be employed to alter the physicochemical properties of diets due to their high dietary fibre content and contrasting dietary fibre qualities.
Carambola (*Averrhoa carambola* L.) belongs to the family Oxalidaceae, is an important fruit of warm tropical and subtropical areas of the world (*Studies on Preparation of Carambola (Averrhoa*, n.d.). The fruit is said to have originated in Southeast Asia, maybe in Indonesia or Malaysia, although it is now grown all over the world in the tropics and subtropics. China Taiwan, Malaysia, Thailand, Pakistan, Indonesia, Australia, West Indies and United States are the main producers of carambola (Bose *et al*., 2002) [3]. Uttar Pradesh, Karnataka, Assam, West Bengal, Madhya Pradesh, Bihar, and Tamil Nadu are among the Indian states where it is cultivated. Fruit usually has five ribs which give rise to the common name of 'five-corners' or 'starfruit'. The Star-fruit plant belongs to the genus, Averrhoa, which contains 5 species, namely *A. bilimbi*, *A. dolichocarpa*, *A. leucopetala*, *A. microphylla* and *A. carambola*. However, A. carambola is widely cultivated on a commercial scale (Khoo *et al*., 2016; Muthu *et al*., 2016) [6, 8]. Carambolas are divided into two groups. One is a smaller, more sour, strongly flavoured variety with higher oxalic acid content. The other is a larger, sweet kind that is mildly flavoured, bland and has less oxalic acid.
Averrhoa carambola is a small, ornamental, multi-stemmed, slow-growing evergreen tree or shrub with a short trunk. Leaves are 15-25 cm long, alternate, spirally oriented, elliptical to oval-oblong in shape, imparipinnate and have 5-11 green pedant leaflets that are 2 – 9 cm long and 1 - 4.5 cm broad.

The axils of the leaves yield purple to vivid purple-coloured flowers. When the fruits are little and immature, they are green but when they are large and ripe, they turn yellow or orange. The fruits are fleshy, oval, 5-6 angled longitudinally, 5- 15 cm long and up to 9 cm wide. The fruits are crunchy with a crisp texture and are star-shaped when cut in cross-section, hence the name. The fruits have an odour that is similar to oxalic acid (Chakraborty & Nath Bala, 2013) [4]. Carambola is a low-calorie fruit containing only 34 cal/100 g. Carambola is composed of protein 0.38 g, lipids 0.08 g, carbohydrates 9.38 g, fiber 0.80-0.90 g, water 80%, vitamins A, E, group B, and C then Ca, Fe, Mn, Mg, P, Na, Zn, and a high concentration of K. It is also rich in flavonoids such as quercetin, lutein, and zeaxanthin, and α and β carotene. Oxalic acid has a larger concentration than the other organic acids, reaching up to 7 mg/g in sour types and 0.4-0.8 mg/g in sweet kinds. The fruit also contains citric, malic, fumaric, tartaric, succinic, and α-ketoglutaric acids. The fruit also contains large levels of insoluble fibers, mucilage terpenes, enzymes, and tannins in the fruit.

A. carambola includes two toxic compounds, Caramboxin and oxalic acid, according to phytochemical investigations and it may cause nephrotoxicity and neurotoxicity when significant amounts of star fruit are consumed on an empty stomach or in people who have chronic renal disease. Caramboxin is a chemical with a structure similar to phenylalanine that is thought to be responsible for the fruit's toxicity to the central nervous system (Ferrara, 2018) [14]. There are several processing techniques like water boiling methods, Deep freezing, fermentation, pickling, dilution methods and even sun drying can reduce the level of antinutrients and can pave the way for new food product development. Ripe fruits or their juice are used as an antipyretic, laxative, appetite stimulant, sialagogue, astringent, and antiscorbutic in India. The mature fruit is considered digestive, tonic and induces biliousness in Ayurveda. In addition, the fruits are used to cure throat inflammation, mouth ulcers, toothaches, cough, asthma, hiccups, indigestion, food poisoning, colitis, diarrhoea, jaundice, malarial splenomegaly, haemorrhoids, skin rashes, pruritis, sunstroke and several eye disorders. Both men and women utilise them as an aphrodisiac. The fruits can be used to enhance lactation in women and can also function as an emmenagogue in big quantities (Chakraborty & Nath Bala, 2013) [4]. The ripe fruit can be made into fermented or unfermented beverages, jams, or jellies, or eaten raw or as a dessert. Unripe fruit can also be consumed as a vegetable. Carambola fruits are stored in thin packaging and shipped from South China to other countries. Carambolas are eaten raw, cut and served in salads, or garnished with avocado or shellfish. They are used in desserts, tarts, stews and curries. The juice of the carambola is given as a refreshing drink. In India, the juice is bottled either with additional citric acid (1 percent by weight) and 0.05 percent potassium metabisulphite, or by simply sterilising the filled bottles in boiling water for 1/2 hour. The flowers are acidic and used in salads in Java and they are also used to make preserves in India (Manda *et al*., 2012) [15].

The food sector generates a large number of by-products, which pose disposal issues. These goods are typically used in animal feed. Despite the fact that it is biodegradable, its disposal results in massive industrial waste and cause major environmental issues (Bordiga *et al*., 2015) [2]. Fruit processing waste includes pomace, discarded fruit, and fruit stones. Small stalks, skin, seed, and some pulp from the fruit make up the pomace. Pomace contains significant levels of bioactive components, including dietary fibre, which is very desirable for nutritional purposes. The Bagasse or pomace after Carambola juice extraction contains more antioxidant activity than the juice itself. Residue extracts are high in phenolic content and have significant antioxidant activity when utilised in functional food products. Residue powder may provide health advantages, and residue extracts should be considered as potential nutraceutical resources. Residues have rich fibres consisting of pectin, hemicelluloses, substances with water retention capacity, swelling properties and cation exchange capacity superior to those of cellulose (Shui & Leong, 2004) [11].

Pomace contains a high concentration of insoluble fibre-rich fractions (FRFs), including as insoluble dietary fibres, alcohol insoluble solid, and water-insoluble solid (46.0–58.2 g/100 g of pomace). Different dietary insoluble fractions isolated from carambola pomace have been shown to effectively adsorb glucose, retard glucose diffusion, postpone glucose release from starch, and inhibit α-amylase activity to varying degrees, resulting in a concerted function in lowering the rate of glucose absorption and, as a result, lowering the postprandial serum glucose concentration. Carambola pomace can be used as a High Dietary fibre powder for modifying and improving the technological and nutritional features of low-calorie food compositions. Carambola pomace is made up 52.4% of the fresh fruit by weight with a moisture content of 89.4 ± 0.3 percent wb. Carambola pomace has a significant Dietary Fibre content (36.7% db), with the insoluble fraction accounting for 76% and the soluble fraction accounting for the rest. Pomace also had a 49% greater Extractable Poly Phenol content than fresh fruit, as well as stronger antioxidant capabilities (measured by the FRAP and ABTS techniques, respectively, 51 percent and 46 percent).

Cookies made from bakery products are a quick and easy snack. Cookies come in a variety of flavours and tastes. Because of people's modern and fast lifestyles, cookies, which are high in energy, are consumed in big quantities. In India and other areas of the world, biscuits and cookies are the most popular bakery foods. They are popular because they are ready to eat, have a high nutritional value, can be stored for a long time, and can be flavoured with various flavours (Ajila *et al*., 2013) [1]. Nutrient availability, palatability, compactness, and convenience are all advantages of cookies. They vary from other baked goods such as bread and cakes in a way that it has low moisture content, relatively free from microbial deterioration, and have a long shelf life (Wade, 1988). Because of the rising prevalence of metabolic disorders, obesity, and gluten sensitivity, there is a desire to develop fortified goods that are high in dietary fibre and antioxidants, low in gluten, and have a nice flavour. Cookies are a popular snack because they are ready-to-eat, durable, and have a long shelf life. In addition, they represent a matrix suitable for fortification, thus providing an opportunity for the intake of important nutrients (Zlatanovic *et al*., 2019) [16].

In the proposed study the carambola pomace flour rich in dietary fiber will be dried and pulverised to get a new food ingredient with the goal of boosting the nutritional profile and functional qualities of the cookies.

Materials and Methods

Fresh, ripe Carambolas (*Averrhoa carambola* L.) were procured from Kerala that were grown in neighbours and relative's house.

Preparation of Carambola pomace powder

Carambolas need to be cleaned and pressed to release the juice, and the pomace (leftover skin and seeds) should be separated from the pulp. Then the pomace has to be dried in a hot air oven at 60 °C for 12 h. Thereafter, the dried pomace should be milled by pulverisation to obtain the powder. This pomace powder is then passed through a sieve of 0.5 mm and stored in air-tight polyethylene bags at 23 ±1 °C in desiccator until further use.

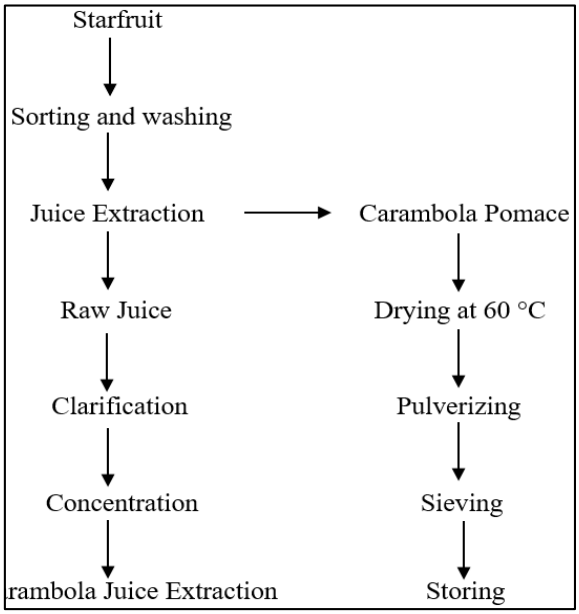

Fig 1: Flowchart of carambola juice and pomace extraction

Cookies preparation

Different concentrations of Carambola pomace i.e., 5, 10, 15, 20 and 25% are incorporated in the recipe of cookies. The control cookies flour weight formula was: 100 g wheat flour, 50 g sugar, 45 g butter, 20 g milk powder, 1 g baking powder, 1 g baking soda and 5ml water. Two drops of vanilla essence are also included in the recipe of cookies. Shortening need to be done in 10 mins by adding butter and sugar. Wheat flour with different concentration of Carambola pomace and leavening agent are added with baking soda and baking powder. The dough is rolled and cut into round in shape and baked in an electric oven at 130 °C for 20–25 min.

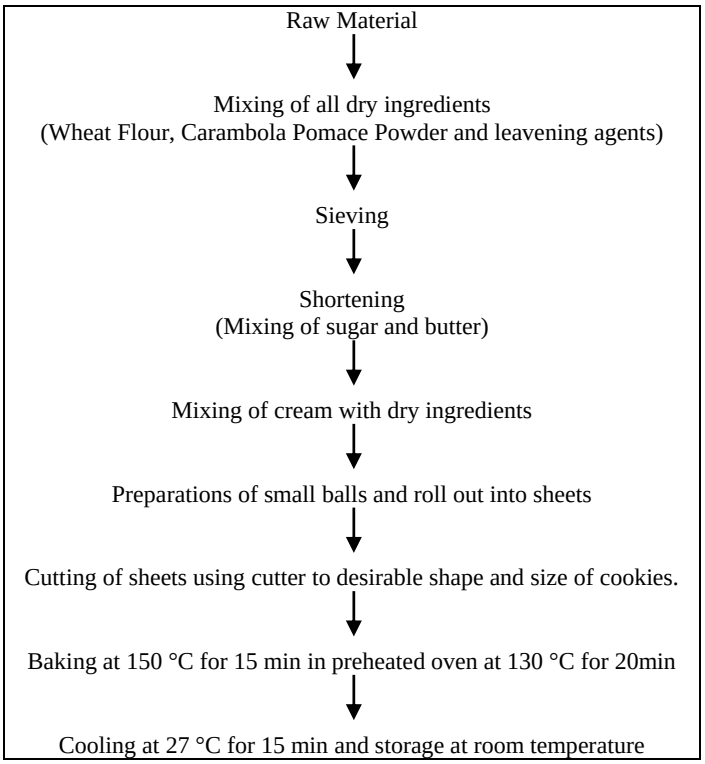

Fig 2: Flowchart for cookies preparation

Sensory Evaluation of Cookies

The sensory characteristics of cookies are evaluated for its different sensory attributes using ten semi trained panellists. Panellists were given control sample and the treatments along with cookies with 25% refined wheat flour at the time of evaluation. Sensory attributes like colour and appearance, texture, taste, flavour and overall acceptability are evaluated using 9-point hedonic rating (Ranganna, 2011) [17].

Statistical Analysis

All of the Experiments will be done in triplicate and the results will be expressed as the mean ±standard deviation of three separate experiments. Using SPSS software, a one-way ANOVA will be performed on the means to see whether there is a significant difference in the data at $p \leq 0.05$.

Result and Discussion

Fibre rich cookies prepared using Carambola Pomace Powder from 0% to 25% were analysed for their sensory quality. 9 Point hedonic scale was used for evaluating the sensory properties of the cookies. Cookies were evaluated with respect to different sensory parameters namely colour and appearance, texture, taste, flavour and overall acceptability. Sensory evaluation of Carambola pomace incorporated cookies is presented in the following table.

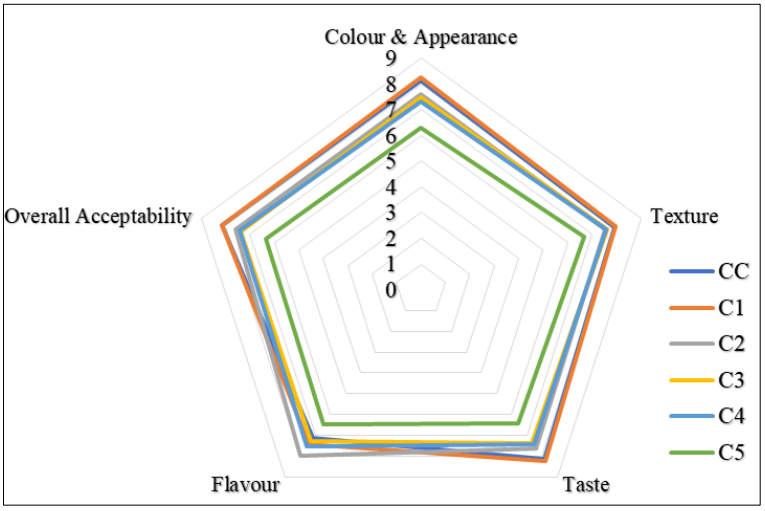

Fig 3: Sensory evaluation of cookies

Table 1: Sensory evaluation of cookies incorporated with Carambola pomace powder

Sample	Colour & Appearance	Texture	Taste	Flavour	Overall Acceptability
C_C	8.15 ± 1.089^{c}	7.92 ± 0.990^{b}	8.14 ± 0.774^{bc}	7.14 ± 0.878^{b}	8.14 ± 0.923^{bc}
C_1	8.27 ± 0.617^{c}	7.95 ± 0.597^{b}	8.21 ± 0.580^{c}	7.45 ± 0.916^{b}	8.17 ± 0.543^{c}
C_2	7.6 ± 0.619^{bc}	7.54 ± 0.447^{b}	7.64 ± 0.792^{bc}	7.97 ± 0.686^{b}	7.61 ± 0.700^{bc}
C_3	7.47 ± 0.935^{bc}	7.60 ± 1.018^{b}	7.36 ± 1.005^{b}	7.28 ± 0.967^{ab}	7.37 ± 0.846^{b}
C_4	7.3 ± 1.254^{b}	7.59 ± 1.116^{b}	7.45 ± 1.152^{bc}	7.55 ± 1.168^{b}	7.42 ± 1.042^{bc}
C_5	6.32 ± 0.805^{a}	6.67 ± 1.150^{a}	6.41 ± 0.971^{a}	6.45 ± 1.007^{a}	6.37 ± 0.915^{a}

*Each value is average of 20 determinations

C_C – 0% Carambola Pomace C_1 – 5% Carambola Pomace

C_2 – 10% Carambola Pomace C_3 – 15% Carambola Pomace

C_4 – 20% Carambola Pomace C_5 – 25% Carambola Pomace

Colour and appearance are the important parameter for the likeability of the consumer and helps the consumer in judging baking quality of the cookies. The sensory score for the colour and appearance decreased with the increase in the level of CPP in flour blend. The score for colour and appearance decreased from 8.15 ± 1.089^{c} (C_C) to 6.32 ± 0.805^{a} (C_5). Addition of CPP resulted in the darkening of the cookies. Mir *et al.* (2015) [20] observed the same trend in the colour of the crackers incorporated with the Carambola pomace. Colour variation was due to the Carambola pomace which is rich in polyphenols and act as a substrate for enzymatic browning (Sudha *et al.*, 2007) [18]. Sensory scores for colour and appearance summarized that CPP incorporation had marked negative effect on colour of the cookie.

It is evident from the table that textural properties gradually decreased with the increase in the levels of CPP and found to be acceptable 20%. The score for the texture decreased from 7.92 ± 0.990^{b} (C_C) to 6.67 ± 1.150^{a} (C_5). However, the further increase in CPP up to 25% affected the acceptability. Increase in the level of CPP resulted in hardness and decrease in the crispiness. Mir *et al.* (2015) [20] reported that the decrease in the crispiness value of the crackers with the increase in Carambola pomace level.

Sensory Score for the taste decreased from 8.14 ± 0.774^{bc} to 6.41 ± 0.971^{a}. The increase in taste score was due to sweet and peculiar taste of Carambola pomace. The descrease in taste score was due to astringency and tart flavour of further addition of CPP. Ajila *et al.* (2008) [1] reported that similar taste was detected in mango peel powder biscuits.

Sensory score for the flavour increased from 7.14 ± 0.878^{b} (C_C) to 7.97 ± 0.686^{b} (C_2) followed by decrease from 7.28 ± 0.967^{ab} (C_3) to 6.45 ± 1.007^{a} (C_5). The improvement in flavour could be attributed to significant decrease in the grainy flavour and increase in fruity flavour of the cookies. Sudha *et al.* (2007) [18] reported that increasing levels of apple pomace, resulted in cakes with pleasant fruit flavour.

Overall acceptability scores of the cookies varied from 8.14 ±0.923^{bc} (C_C) to 6.37 ±0.915^{a} (C_5). Cookies with 5% CPP (C_1) scored maximum (8.17±0.543^{c}) whereas cookies with 25% scored minimum (6.37 ±0.915^{a}). Marked increase in the overall acceptability of the cookies with 5% CPP (C_1) could be attributed to better taste and flavour of the cookies.

However, if comparison is on fibre basis, Carambola pomace may be an alternative dietary fibre source for cookie due to high fibre content of Carambola pomace. Carambola pomace have rich fibres consisting of pectin, hemicelluloses, substances with water retention capacity, swelling properties and cation exchange capacity superior to those of cellulose (Shui & Leong, 2004) [11]. Pomace contains a high concentration of insoluble fibre-rich fractions (FRFs), including as insoluble dietary fibres, alcohol insoluble solid, and water-insoluble solid (46.0–58.2 g/100 g of pomace) (Chen *et al*., 2004) [19].

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