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Evaluation of physico-chemical and organoleptic properties of breadfruit papad incorporated with green leafy vegetables

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Abstract

Breadfruit, a nutrient dense, large starchy fruit rich in complex carbohydrates, but low in fat and cholesterol, can be used creatively in papad making, a traditional, thin, crispy wafer like food item which enhances meals and snacks, as well as used with nutrient rich green leafy vegetables to provide a wholesome, balanced dietary option. The experiment aimed to develop value-added breadfruit papad incorporated with spinach, coriander, mint, curry (*Bergera koenigii*), fenugreek, drumstick and dill green leaves. The objective was to assess the physico-chemical and organoleptic properties of the breadfruit papad. The experiment was conducted in Completely Randomized Design (CRD), with eight treatments and three replications. Based on the results of experiment, it was observed that treatment T_6 (breadfruit + drumstick leaves) was found best in terms of physico-chemical properties, *viz.,* moisture, ash, fat, protein, carbohydrate and energy. Based on sensory evaluation, treatment T_3 (breadfruit + mint leaves) was found most acceptable in terms of organoleptic properties, *viz.,* colour, taste, flavour, texture and overall acceptability. The present study demonstrated the successful incorporation of green leafy vegetables into breadfruit papad, offering a promising avenue to enhance the utilization and popularity of both breadfruit and green leafy vegetables.

Key words: Breadfruit, green leafy vegetables, organoleptic properties, papad, physico-chemical properties

Introduction

Artocarpus altilis, commonly called breadfruit, is an evergreen tree of the Moraceae family that produces large, starchy, carbohydrate-rich fruits (Sikarwar *et al.,* 2014). The attractive, evergreen trees grow to heights of 15 to 21 m (48 to 70 ft) or more and the trunks may be as large as 2 m (6.6 ft) in diameter at the base. The trees begin bearing in 3-5 years and are productive for many decades. They are easy to propagate, require little attention and input of labour or materials, and can be grown under a wide range of ecological conditions (Ragone, 2006). Breadfruit is a tropical fruit and the tree produces fruit twice in a year, from March to June and from July to September, with certain cultivars fruiting throughout the year (Omobuwajo, 2003).

Fruits of breadfruit are of a very specific structure. In fruit, the central part contains many latex tubes and large vascular bundles. These vascular bundles can rapidly discolour upon cutting because of oxidative enzyme activity. The fruits are variable in size, shape and surface texture. Mostly, they are round, oval and oblong ranging from 9-20 cm, more than 30 cm in long and usually weighing around 0.25-6 kg. The ripe fruits have yellow or yellow-brown skin, and they are soft and sweet at the same time. The colour of breadfruits is usually light green, yellowish-green or yellow when mature. The flesh of the fruit is usually creamy and soft with a pleasant fragrance (Ragone, 1997; Ragone, 2006).

Breadfruit is one of the rare fruits in India, and it is consumed as a vegetable rather than as a fruit. The most commonly eaten plant part is the starchy flesh of the breadfruit fruit, which is prepared mainly by steaming, baking, frying and boiling (Roberts-Nkrumah and Badrie, 2005; Zerega *et al.,* 2005). Breadfruit is rich in nutrients and complex carbohydrates while being low in fat and cholesterol (Roberts-Nkrumah, 2007). It also contains a wide range of amino acids and is particularly high in leucine, isoleucine, phenylalanine and valine, making it a good source of essential amino acids, especially in countries battling malnutrition (Liu *et al.,* 2015).

The traditional savory food papad, also known as appalam, papadam, is a popular tasty food item in Indian dietary science. It is a low-moisture food consumed either after frying or roasting or as an adjunct to vegetable soups and curries. Roasted or grilled papad helps to absorb the fatty material from the mouth and throat. Papad should be eaten in moderate proportion; else it can become the reason for acidity. Papad is very high in sodium; hence not advisable for hypertensive people (Srikari *et al.,* 2023).

Green leafy vegetables constitute a vital part of a balanced diet and are rich in bioactive compounds (polyphenols, carotenoids, flavonoids, flavones, isoflavones and catechins). They are cheap sources of micronutrients that typically provide low-calorie and dietary fibers (Vernekar and Vijayalaxmi, 2018). Green leafy vegetables have been recognized as most abundant source of protein, vitamins and minerals (Aletor *et al.,* 2002; Shukla *et al.,* 2016). Green leafy vegetables have been traditionally recognized as a good source of dietary fiber (Gopalan *et al.,* 2000).

Breadfruit is highly perishable, with fruits ripening quickly and deteriorating within a week, resulting in a short shelf life. The soft, ripe breadfruits are undesirable for consumption, leading to significant production losses. Additionally, green leafy vegetables are underutilized despite their nutritional richness and health benefits. Factors such as limited availability, inadequate

promotion and cultural preferences contribute to the low consumption of many diets. Taking into account these challenges, a value-added breadfruit papad was prepared by incorporating green leafy vegetables such as spinach leaves, coriander leaves, mint leaves, curry leaves, fenugreek leaves, drumstick leaves and dill leaves. This study aims to increase the utilization and popularization of both breadfruit and green leafy vegetables. Furthermore, the present investigation seeks to assess the physico-chemical and organoleptic properties of the breadfruit papad, shedding light on its potential as a nutritious and marketable product.

Materials and methods

The experiment was conducted in the Post Harvest Laboratory, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India, from 2022 to 2024. The experiment was laid out in Completely Randomized Design (CRD), with eight treatments and three replications. The treatments were T_0 (control), T_1 (breadfruit + spinach leaves), T_2 (breadfruit + coriander leaves), T_3 (breadfruit + mint leaves), T_4 (breadfruit + curry leaves), T_5 (breadfruit + fenugreek leaves), T_6 (breadfruit + drumstick leaves), T_7 (breadfruit + dill leaves).

Formulation of breadfruit papad: The seven different types of breadfruit papad, along with the control, were prepared in a quantity of 1 kg each. Each batch of 1 kg breadfruit papad was prepared using 8 kg of breadfruit, 25 g of salt, 20 g of chilli powder, 25 g of papad masala, and 25 g of oil. Additionally, for each formulation, 800 g of assorted green leafy vegetables, including spinach leaves, coriander leaves, mint leaves, curry leaves, fenugreek leaves, drumstick leaves and dill leaves were added for value addition.

Methodology for preparation of breadfruit papad: The breadfruits were washed and cleaned by removing the fruit stalk, outer skin and middle core of the fruit. Then the breadfruits were chopped into small pieces and kept in water to avoid blackening of fruits. The chopped pieces were boiled for 15 minutes in a stainless steel utensil. Boiled pieces were then ground till a coarse paste was obtained. At the time of grinding, other additives (salt, red chilli powder and papad masala) were added for thorough blending with the paste. The plastics sheets were greased with oil and the paste was evenly spread with a uniform thickness of 1 mm. Papads with a plastic sheet still attached to them were kept on a clean cloth material under the sun for drying. After about 4 hours of drying the plastic sheet was removed of partially dried papads. On the second day, with the help of a scissor, the papads were cut to an approximate length of 10 cm and breadth of 7 cm in a rectangular shape. Then, papad was further dried completely under the sun. The dried breadfruit papads were packed in 200 gauge low-density polyethylene (LDPE) plastic pouches and stored at ambient room temperature.

Evaluation of physico-chemical properties of breadfruit papad: The seven different types of breadfruit papad, along with the control, were evaluated for various physico-chemical properties *viz.,* moisture, ash, fat, protein, carbohydrate and energy. The moisture content was analyzed using the oven-dry method (AOAC, 2005). The ash content was analyzed using the muffle furnace method (AOAC, 2005). The fat content was analyzed using the Soxhlet extraction method (Ranganna, 1986). The protein content was analyzed using the Kjeldahl method (Ranganna, 1986). The carbohydrate content was calculated using the difference method (Pearson, 1976). The energy content was calculated using the calorific value determination method (Gopalan *et al.,* 2004). The recorded data of all samples for different parameters were tabulated and statistically analyzed to find out the most suitable treatment combination in terms of physico-chemical properties.

Evaluation of organoleptic properties of breadfruit papad: The seven different types of breadfruit papad, along with the control, were fried and evaluated for various organoleptic properties *viz.,* colour, taste, flavour, texture and overall acceptability. The samples were analyzed using the 9-point hedonic scale rating method by a panel of five judges (Amerine *et al.,* 1965). Each sample was assessed and given a score by the panelists on a scale of 1-9 for each parameter. The mean scores of all samples from all five panelists were tabulated and statistically analyzed to find out which treatment combination is the most acceptable in terms of organoleptic properties.

Results and discussion

Effect of green leafy vegetables on physico-chemical properties of breadfruit papad: The nutritional value of breadfruit papad was evaluated by analyzing its physico-chemical properties *viz.,* moisture, ash, fat, protein, carbohydrate and energy. The data recorded on the effect of green leafy vegetables on the physico-chemical properties of breadfruit papad have been presented in Table 1.

Table 1. Effect of green leafy vegetables on physico-chemical properties of breadfruit papad

Treatment	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (kcal)
T_0 (Control)	10.03	6.49	2.72	2.51	78.24	347.52
T_1 (Spinach leaves)	10.07	6.80	2.20	2.69	78.24	343.48
T_2 (Coriander leaves)	9.73	6.67	2.60	2.97	78.02	347.42
T_3 (Mint leaves)	9.62	6.74	2.56	2.84	78.24	347.33
T_4 (Curry leaves)	9.47	6.73	2.49	3.09	78.21	347.61
T_5 (Fenugreek leaves)	10.17	6.81	2.70	3.03	77.28	345.58
T_6 (Drumstick leaves)	9.32	6.82	2.44	3.17	78.25	347.62
T_7 (Dill leaves)	10.23	6.51	2.68	2.79	77.79	346.43
CD at 5%	0.08	0.05	0.06	0.08	0.13	0.53

The mean values of moisture content in different treatments ranged from 9.32 to 10.23%. The minimum moisture content of 9.32% was recorded in T_6 (breadfruit + drumstick leaves), while the maximum moisture content of 10.23% was recorded in T_7 (breadfruit + dill leaves). The addition of green leafy vegetables to breadfruit papad introduced additional moisture content to the final product due to the high water content naturally present in these vegetables. Maintaining a low moisture content in breadfruit papad helped extend its shelf life and ensured food safety while also preserving its sensory attributes through the control of microbial activity. Similar results were reported by Rahman and Uddin (2008) in papads prepared from mungbean, grasspea and black gram; Nazni and Pradheepa

(2010) in papads prepared from black gram and jowar; Suradkar *et al.* (2014) in papads prepared using soya and urad; Siddiqui *et al.* (2015) in papads prepared using finger millet and soy flour; Butti and More (2017) in papads prepared from sorghum; Vernekar and Vijayalaxmi (2018) in papads prepared using dehydrated betel leaves.

The mean values of ash content ranged from 6.49% to 6.82%. The minimum ash content of 6.49% was recorded in T_0 (Control), while the maximum ash content of 6.82% was recorded in T_6 (breadfruit + drumstick leaves). The addition of green leafy vegetables to breadfruit papad enhanced its ash content due to the minerals in vegetables and served as an indicator of the minerals and their composition in vegetables and enhanced nutritional value of the product. Similar results were reported by Kalpana *et al.* (2013) in papad prepared using small millets like barnyard, foxtail, kodo, little and proso blended with fresh green leafy vegetables; Bukya *et al.* (2018) in papads prepared using urad flour, raw banana and sweet potato; Sharma *et al.* (2020) in papads prepared using semolina and chia seeds; Deb *et al.* (2022) in papad prepared using black gram.

The fat content showed significant differences among different treatments. The mean values of fat content ranged from 2.20% to 2.72%. The minimum fat content of 2.20% was recorded in T_1 (breadfruit + spinach leaves), while the maximum fat content of 2.72% was recorded in T_0 (Control). The fat content was also impacted while incorporating green leafy vegetables, which aligned with healthier dietary preferences by reducing the risk of cardiovascular diseases and also lowering caloric intake. Earlier reports by Nazni and Pradheepa (2010) for papads prepared from black gram and jowar; Kodandaramreddy and Waghray (2013) in papads prepared using black gram and mint leaves; Suradkar *et al.* (2014) in papads prepared from soya and urad; Sonawane *et al.* (2015) in papads prepared using green leafy vegetables; Siddiqui *et al.* (2015) in papads prepared using finger millet and soy; Bukya *et al.* (2018) in prepared papads using urad flour, raw banana and sweet potato showed variation in fat content.

The average protein content varied from 2.51% to 3.17%. The lowest protein content of 2.51% was observed in T_0 (Control), whereas the highest protein content of 3.17% was noted in T_6 (breadfruit + drumstick leaves). Kokani and Pawar (2021) reported analogous results in papads made from rice and tomato, while Kumar *et al*. (2023) observed similar findings in papads prepared with papaya.

The average carbohydrate content varied between 77.28% and 78.25%. The minimum carbohydrate content of 77.28% was observed in T_5 (breadfruit + fenugreek leaves), whereas the maximum carbohydrate content of 78.25% was noted in T_6 (breadfruit + drumstick leaves). Comparable findings were documented by Sonawane *et al*. (2015) in papads made with green leafy vegetables and by Butti and More (2017) in papads made with sorghum.

The average energy content values among the treatments varied between 343.48kcal and 347.62kcal. The minimum energy content of 343.48kcal was observed in T_1 (breadfruit + spinach leaves), whereas the maximum energy content of 347.62kcal was noted in T_6 (breadfruit + drumstick leaves). Similar findings were reported by Renu and Waghray (2016) in papads made with purslane; Vernekar and Vijayalaxmi (2018) in papads made with dehydrated betel leaves; and Venipriyadharshini and Archana (2019) in papads made with pulses.

These vegetables were shown to alter the protein and carbohydrate content, making a nutritionally balanced snack option that can be used to promote overall health. The green leafy vegetables supplied the carbohydrates, proteins and fats that enriched its energy content and thus made the breadfruit papad a nutritious, energy dense snack that supports dietary balance and satiety.

Effect of green leafy vegetables on organoleptic properties of breadfruit papad: The sensory acceptability of breadfruit papad was evaluated by analyzing its organoleptic properties, *viz.,* colour, taste, flavour, texture and overall acceptability. The data recorded on the effect of green leafy vegetables on the organoleptic properties of breadfruit papad have been presented in Table 2.

Statistical analysis showed significant differences in the organoleptic (sensory) scores for colour across all treatments. The average score for colour ranged from 7.7 to 8.8. The lowest score of 7.7 was observed in the control (T_0), while the highest score of 8.8 was recorded in T_3 (breadfruit + mint leaves). These findings align with the results of Vernekar and Vijayalaxmi (2018), who reported similar trends in papads made with dehydrated betel leaves.

For taste, the scores also varied, ranging between 7.8 and 8.9. The control (T_0) received the lowest score of 7.8, while T_3 (breadfruit + mint leaves) achieved the highest score of 8.9. This pattern mirrors findings by Talpade *et al*. (2018) in papads prepared with garden cress seed powder.

Flavour scores showed significant variation as well, with averages ranging from 7.5 to 8.8. The control (T_0) again recorded the lowest score of 7.5, while T_3 (breadfruit + mint leaves) scored the highest at 8.8. These results are consistent with the study by Sharma *et al*. (2020), which examined papads made with semolina and chia seeds.

The texture scores also showed clear differences across treatments, with averages ranging from 7.3 to 8.8. The control (T_0) received the lowest score of 7.3, and T_3 (breadfruit + mint leaves) recorded the highest score of 8.8. Similar results were observed by Landge *et al*. (2022) in papads incorporating legumes.

Table 2. Effect of green leafy vegetables on organoleptic properties of breadfruit papad

Treatment	Colour	Taste	Flavour	Texture	Overall acceptability
T_0 (Control)	7.7	7.8	7.5	7.3	7.9
T_1 (Spinach leaves)	8.3	8.7	8.3	8.0	8.5
T_2 (Coriander leaves)	8.5	8.8	8.7	8.3	8.6
T_3 (Mint leaves)	8.8	8.9	8.8	8.8	8.9
T_4 (Curry leaves)	8.7	8.8	8.7	8.6	8.7
T_5 (Fenugreek leaves)	8.0	8.5	8.2	7.8	8.5
T_6 (Drumstick leaves)	7.8	8.0	7.8	7.6	8.1
T_7 (Dill leaves)	7.9	8.3	8.1	7.5	8.3
CD at 5%	0.2	0.2	0.4	0.2	0.2

When evaluating overall acceptability, the scores ranged from 7.9 to 8.9. The lowest score of 7.9 was given to the control (T_0), while T_3 (breadfruit + mint leaves) achieved the highest score of 8.9. These findings are in line with the study by Srikari *et al*. (2023), which assessed papads made with buckwheat flour.

The sensory properties of green leafy vegetables based natural pigments improved the visual appeal of the bread fruit papad and made the product more attractive to the consumers. These vegetables also provided a new set of flavours and added to the current taste profile of the papad, resulting in distinct taste variations from the control. Incorporation of the aromatic compounds in green leafy vegetables also improved the flavour complexity, while it affected the moisture content and structural integrity, and therefore the texture. Overall, the sensory benefits for consumers were noticeable, in terms of colour, taste, flavour and texture, when green leafy vegetables were included. In summary, T_3 (breadfruit + mint leaves) consistently outperformed the control group (T_0) across all sensory parameters, highlighting its potential for improved sensory appeal.

The physico-chemical properties of breadfruit papad incorporated with drumstick leaves (T_6) were found to be best, with values of moisture (9.32%), ash (6.82%), fat (2.44%), protein (3.17%), carbohydrate (78.25%), and energy (347.62 kcal). In contrast, breadfruit papad with mint leaves (T_3) was found to be the most acceptable based on organoleptic properties that received highest sensory evaluation scores for colour (8.8), taste (8.9), flavour (8.8), texture (8.8) and overall acceptability (8.9).

In conclusion, the study revealed that green leafy vegetables could be added to breadfruit papad to form a nutritious and appetizing snack. The papad combines the breadfruit's unique flavour and texture with the nutritional benefits of green leafy vegetables, providing the essential proteins, carbohydrates and energy to support health and well being. It is an attractive choice as a healthy snack alternative due to its convenient form and ease of preparation. Breadfruit papad enriched with green leafy vegetables thus not only provides a means for promoting breadfruit and green leafy vegetables but also a wholesome and practical snack.

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