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# Nutritional evaluation of banana inflorescence and development of food products

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**Abstract** Bananas, being versatile herbaceous plants, are valuable for their fruit, fruit peel, inflorescence, pseudostem and fibre, which are nutritionally, medicinally and industrially valuable. This study ventures to report nutritional, functional and food products (pickles and cookies) using the inflorescence of a native variety of bananas in southwest India. Uncooked and cooked inflorescence flours did not show notable changes in moisture or total lipid contents. Protein, crude fibre and ash contents were significantly higher in uncooked as compared to cooked flours, whereas the opposite was true for carbohydrates and calorific value. Cooked flours had significantly higher bulk density, swelling power, percent solubility, and water-absorption capacity, whereas uncooked flours had significantly lower gelation concentration, emulsion activity and foam properties. Oil-absorption capacity and emulsion stability did not show any difference between uncooked and cooked flours. Pickles (uncooked and cooked chops) and cookies (uncooked and cooked flours) offered good sensory scores, indicating their acceptability as food products. The study suggested that the inflorescence of bananas could be a valuable source of dietary supplements and food products owing to its superior nutritional properties, functional attributes and sensory values.

**Keywords:** Cookies, Functional profile, Pickles, Proximal qualities, Sensory evaluation

## Introduction

Edible flowers have been considered an important ingredient in developing several foods and food products for human consumption and nourishment (e.g., jellies, syrups, teas and vinegars) (Rop *et al*., 2012; Petrova *et al.,* 2016). Edible flowers have grown in popularity in recent years, and they are now used to garnish meals and produce a variety of delectable delicacies.

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Banana (*Musa* sp.) is a multipurpose herbaceous plant, useful as fruit, fruit peel, inflorescence (or blossom), pseudostem and fiber. It is one of the most important tropical fruits consumed all over the world owing to its aroma, texture and bioactive components (Mohapatra *et al.,* 2010; Vu *et al.,* 2019). Banana inflorescence is a byproduct of banana cultivation with high nutrient contents, calorific value and health benefits (Florenta *et al.,* 2015; Krishnan and Sinija, 2016). It is also considered a vegetable and consumed ethnically in many Asian countries (e.g., Indonesia, Malaysia and Philippines) (Liyanage *et al.,* 2016). It is used in the preparation of a variety of dishes either raw (uncooked) and following different processing methods (e.g., blanched, boiled, cooked and fried) to harness its nutritional, functional and medicinal benefits. Banana inflorescence consists of several bioactive compounds (e.g., coumarins, cardiac glucosides, flavonoids, phenolics, saponins, tannins and terpenoids) and antioxidant potential was not affected by pressure-cooking (Soans *et al.,* 2023). Banana inflorescence must be used or processed immediately because it is easily perishable and cannot be stored for an extended period of time. In addition, preparation of dishes and development of products is tough as well as elaborative (Elaveniya and Jayamuthunagai, 2014). Hence, banana inflorescence is a modest edible raw material consumed only in some parts of the world.

Although a plethora of value-added edible indigenous agricultural byproducts are accessible worldwide, only a few of them have been considered for human consumption. In spite of the significance of banana inflorescence in human nutrition and health, its proximal properties and functional qualities are rarely reported. Furthermore, systematic accounts of the dishes and products of this inflorescence are lacking. Thus, the study focused on the nutritional and functional profiles of the banana inflorescence of a regional variety of southwest India along with the production of commercially useful food products (pickles and cookies) and to assess the nutritional features, functional properties and development of food products, uncooked and cooked inflorescence were investigated.

## Materials and methods

### *Inflorescence sampling and processing*

The inflorescence of an indigenous local variety of banana (called Kadali) was collected during the winter season (January 2018) from Kudupu village, Mangalore, India (12º54'N, 73º53'E; 73 m asl) (Figure 1). The inflorescence from mature banana bunches was harvested in three locations at a distance of 300 m to consider them as replicates. The harvested samples were wrapped in paper towels, brought to the laboratory and processed within 1–2 hr. Each replicate was divided into two sets by removing the outer 2 or 3 mature bracts and flowers. Tender bracts and flowers were chopped and soaked in freshwater to avoid enzymatic browning. The first set was drained and dried in a hot air oven (55–60°C) to attain moisture <10%. The second set was pressure-cooked with the addition of limited water in a pressure-cooker (Deluxe, TTK Prestige$^{TM}$, Prestige Ltd., Bangalore, India), followed by drying in an oven as above. The dried samples were powdered using a household mixer (Panasonic, MX-AC555, Super Mixer Grinder Appliances India Co. Ltd., Chennai, India). The powdered samples were labelled and stored in airtight zip lock sachets at room temperature for a couple of days for analysis. Powdered samples were used to evaluate both nutritional and functional properties. Pickles were made using chopped uncooked and cooked inflorescence. A schematic presentation of nutritional evaluation and development of products using banana inflorescence is given in Figure 2.


**Figure 1.** Harvested banana inflorescence (a), chopped uncooked inflorescence (b), uncooked inflorescence flour (c) and cooked inflorescence flour (d)

***Proximal properties of flours***

The proximal qualities of uncooked and cooked flours from banana inflorescence were determined following standard protocols (AOAC, 2012).

**Moisture**

The moisture content of flours was determined gravimetrically (%).

$$\text{Moisture content (\%)} = \frac{\text{Wb} - \text{Wa}}{\text{W}} \times 100$$

(Where Wb, weight of the sample prior to drying in g; Wa, weight of the sample after drying in g; W, weight of flour in g).

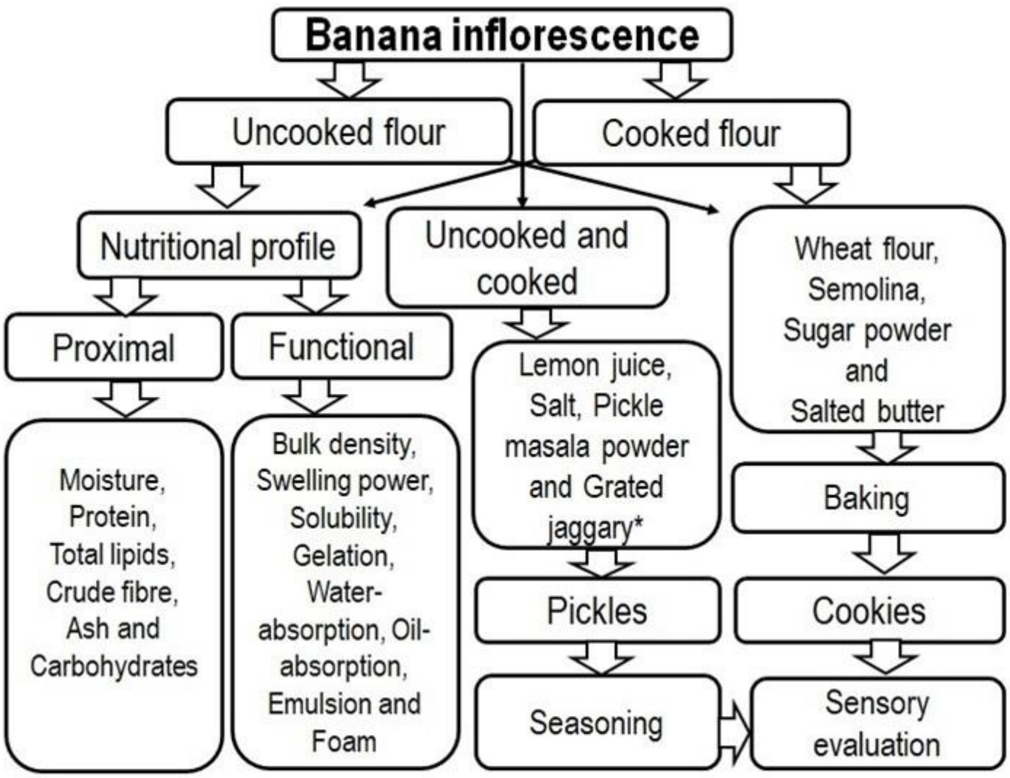


**Figure 2.** Schematic presentation of nutritional evaluation and development of products (pickle and cookies) (*, Grated jaggary was used for cooked banana inflorescence to prepare pickle)

**Protein**

The protein content (g/100 g) of the flours was estimated based on the method by Lowry *et al.* (1951). Powdered samples were extracted by following TCA Acetone for protein extraction (Méchin *et al.,* 2007; Xu *et al.,* 2008; Vilhena *et al.,* 2015). Flour samples (2 g) were mixed with precipitation solution [10% TCA (w/v), 0.07% 2-Mercaptoethanol (v/v) in cold acetone)] (10 ml) and stored at –20ºC (1 hr) followed by centrifugation at at 4ºC (10,000 g, 10 min).

After discarding the supernatants, pellets were suspended in cold rinsing solution [(0.07% 2-Mercaptoethanol (v/v) in cold acetone] (10 ml) and stored at –20ºC (1 hr) followed by centrifugation (10,000 g, 10 min, at 4ºC). The supernatants were again discarded and pellets were resuspended in rinsing solution. The above steps were repeated twice to recover a white pellet. The pellets were allowed to dry to eliminate the acetone. The dry pellets were suspended in 10% cold TCA (10 ml, 30 min) and centrifuged to collect the pellets. The pellets obtained were dissolved in NaOH (0.2 N). The test samples dissolved in NaOH (0.2 ml) were made up to 1 ml by distilled water. The alkaline copper sulphate reagent was added (5 ml) and allowed to stand (10 min) followed by the addition of Folin-Ciocaltaeu's reagent (0.5 ml) and incubated at laboratory temperature in the dark (30 min). The absorbance was assessed at 660 nm. The protein content of the samples was expressed as percent using bovine serum albumin as a standard.

**Total lipids**

The total lipids of flours were extracted using cold extraction by a mixture of chloroform and methanol (2:1 v/v) (Bligh and Dyer, 1959) with a slight modification. The known quantity of flours (1 g) was homogenized using distilled water (10 ml) using a mortar and pestle, then transferred to conical flasks, which were re-homogenized with a mixture of chloroform and methanol (2:1 v/v) (30 ml). The samples were extracted at laboratory temperature overnight, followed by the addition of chloroform (20 ml) and distilled water (20 ml). The contents of the conical flasks were centrifuged (5000 rpm; 10 min), transferred to a separatory flask and kept for separation. The clear lower chloroform layer containing lipids was shifted to a pre-weighed beaker. The solvent was allowed to evaporate completely at room temperature. The final weight of the beakers was determined gravimetrically to calculate the total lipids.

$$\text{Total lipids (\%)} = \frac{B2-B1}{W} \times 100$$

(Where B2, weight of the beaker with lipid in g; B1, weight of empty beaker in g; W, weight of flour in g)

**Crude fibre**

The crude fibre of flours was determined gravimetrically according to AOAC (2012) with a slight modification. Defatted flours (2 g) were treated with sulphuric acid (0.255 N; 200 ml) and boiled (30 min) along with bumping chips. The contents were filtered through muslin cloth and the residual acid traces were eliminated by repeated washings using boiling distilled water. The residue obtained was boiled in a sodium hydroxide solution (0.31 N; 200 ml; 30 min). The contents were again filtered through muslin cloth and residues of alkali were removed by repeated washings with boiling distilled water. The final residue was transferred to a pre-weighed Petri dish, dried in an oven (100±2°C, 2 hr) followed by ignition in a muffle furnace for 30 min (600±15°C), cooled and re-weighed.

$$\text{Crude fibre (\%)} = \frac{(\text{P2} - \text{P1})}{\text{W}} \times 100$$

(Where P2, weight of Petri dish with fibre in g; P1, weight of empty Petri dish in g; W, weight of flour in g)

**Ash**

The ash content of flours was determined gravimetrically (g/100 g) based on the AOAC (2012) method. The flours (1 g) were transferred to a pre-weighed crucible and dehydrated in an oven at 100±2°C for 6 hr. The crucible with dried flour was transferred to a hot muffle furnace (550±10ºC, 3 hr) and the final weight was determined after cooling to laboratory temperature to determine the ash content.

$$\text{Ash (\%)} = \frac{(\text{C2} - \text{C1})}{\text{W}} \times 100$$

(Where C2, weight of crucible along with ash in g; C1, weight of empty crucible in g; W, weight of flour in g)

**Total carbohydrates**

To evaluate the total carbohydrates in flours (g/100g), phenol sulphuric acid method was employed (Dubois *et al.,* 1956). Powdered samples (100 mg) were transferred to boiling tubes and hydrolyzed with 2.5 N HCl (5 ml) in a boiling water bath (3 hr), neutralized with solid $Na_2CO_3$ until effervescence clears. The final volume was made up to 100 ml using distilled water, centrifuged and supernatants were taken for analysis. Test samples (0.2 ml) were made up to 1 ml by distilled water, then adding phenol solution (5%, 1 ml) and sulphuric acid (96%, 5 ml). The mixture in the test tubes was shaken well and incubated in a water bath (30°C, 20 min), read at 490 nm along with glucose as the standard to express total carbohydrates in percent.

**Calorific value**

The gross energy as calorific value (kJ/100 g) was determined by multiplying the percentages of protein, total lipids and carbohydrates by the factors 16.7, 37.7 and 16.7, respectively (Ekanayake *et al.,* 1999).

$$\text{Gross energy (kJ/100 g)} = (\text{Protein} \times 16.7) + (\text{Total lipids} \times 37.7) + (\text{Carbohydrates} \times 16.7)$$

### *Functional properties of flours*

Functional properties such as bulk density, swelling power, solubility, least gelation capacity, water-absorption, oil-absorption, emulsion properties and foam properties were determined using standard protocols.

The bulk density of flours (g/ml) was evaluated by following the protocol outlined by Elaveniya and Jayamuthunagai (2014). Swelling power (g/g) and percent solubility (%) of flours were determined according to Butool and Butool (2013) and Elaveniya and Jayamuthunagai (2014), respectively. The least gelation concentration (LGC) of flours in percentage was determined based on the procedure by Coffman and Garcia (1977). The method outlined by Beuchat (1977) was used to evaluate the water-absorption capacity (WAC) (ml/g) and the oil-absorption capacity (OAC) (ml/g) of flours. The emulsion properties, like emulsion activity (EA) and emulsion stability (ES) were assessed (Neto *et al.,* 2001). The foam properties, such as foam capacity (FC) and foam stability (FS) were measured (Kabirullah and Willis, 1982).

### *Development of food products*

Fresh banana inflorescence was finely chopped and immersed in water for up to 1 hr to avoid browning. After draining the water, the chopped inflorescence was mixed with salt, lemon juice was added, and everything was set aside for up to 20 min. To prepare the masala powder, split black gram, Bengal gram, mustard, cumin, fenugreek, turmeric powder, red chillies and curry leaf were dry roasted until the contents turned a light-brownish red (Table 1). The roasted ingredients were cooled for a while and finely powdered. The prepared masala powder was mixed with salted inflorescence and seasoned with mustard seeds, cumin seeds and curry leaves using sesame oil. The uncooked banana inflorescence pickle was stored in an airtight sterile glass jar at laboratory temperature.

Fresh banana inflorescence was finely chopped and cooked by adding water on a low flame in a pressure-cooker for 10 min. The cooked chops were placed in a clean vessel and submerged in water for 1 hr. After draining the water, it was mixed with lemon juice, salt and grated jaggery and kept aside for 20 min. The masala mixture was prepared as above and mixed with sweet and salted chops. The pickle was seasoned with mustard seeds, cumin seeds and curry leaves using sesame oil. The cooked inflorescence pickle was stored in airtight sterile glass jars at laboratory temperature.

To prepare cookies, powdered sugar and salted butter were whipped to obtain a creamy texture (Table 2). Wheat flour, uncooked flour, semolina and water were added to the cream, followed by mixing. The cookie dough was left alone for 10 min to set. After giving cookie shapes to the dough, they were transferred to a baking tray and baked in an oven at 180°C (15 min). Later, the cookies were removed from the oven, cooled to laboratory temperature and stored in airtight containers. The cooked flour was also processed as above to prepare cookies.

**Table 1.** Ingredients used for the preparation of pickles using banana inflorescence

| | Quantity | |
|---|---|---|
| | Uncooked | Cooked |
| **Banana inflorescence (g)** | 250 | 250 |
| **Split black gram (g)** | 12 | 12 |
| **Split Bengal gram (g)** | 12 | 12 |
| **Mustard seeds (g)** | 13 | 13 |
| **Cumin seeds (g)** | 10 | 10 |
| **Fenugreek seeds (g)** | 4 | 4 |
| **Turmeric powder (g)** | 2 | 2 |
| **Red chilli (g)** | 13 | 13 |
| **Curry leaf (g)** | 1 | 1 |
| **Salt (g)** | 100 | 100 |
| **Jaggery (g)** | 0 | 50 |
| **Sesame oil (ml)** | 50 | 50 |
| **Lemon juice (ml)** | 10 | 10 |

**Table 2.** Ingredients used for the preparation of cookies using banana inflorescence

| | Quantity | |
|---|---|---|
| | Uncooked | Cooked |
| **Inflorescence flour (g)** | 25 | 25 |
| **Wheat flour (g)** | 75 | 75 |
| **Semolina (g)** | 30 | 30 |
| **Sugar powder (g)** | 30 | 30 |
| **Salted butter (g)** | 50 | 50 |
| **Water (ml)** | 5 | 5 |

***Sensory evaluation of food products***

The sensory acceptability of food products such as pickles and cookies made from chops and flours, respectively, was evaluated by 20 panellists aged 21–25 years using a 9-point Hedonic scale (Okilya *et al.,* 2010). A sensory score card was prepared to obtain individual opinions about the food products from panel members, according to Ackbarali and Maharaj (2014).

### *Data analysis*

Based on Statistica version 8.0 (StatSoft, 2008), a student's *t*-test determined the difference in proximal qualities and sensory evaluation between uncooked and cooked samples (StatSoft, 2008).

## Results

### *Proximal qualities*

The moisture content of the uncooked and cooked flours was below 5% and did not differ significantly ($p>0.05$) (Table 3). The protein content of flours ranged from 0.9 to 1.2%, with uncooked flour having a significantly higher protein content ($p<0.001$). The total lipid content was low (0.72−0.74%) and did not vary among the flours. The crude fibre of flours was considerably high (19.1−20.3%) and it was significantly high in uncooked flours ($p<0.01$). Similar to fibre, the ash content was also high (15.7−18.8%) and it was significantly higher in uncooked flours ($p<0.001$). The total carbohydrates content was also high in flours (68.3−72.7%) and it was significantly increased in cooked flours ($p<0.05$), so also the calorific value of flours.

**Table 3.** Proximal characteristics of banana inflorescence on dry mass basis (n=3; mean±SD). Asterisks across the cooked and uncooked inflorescence are significantly different (*t*-test: *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$)

| | **Uncooked** | **Cooked** |
|---|---|---|
| **Moisture (%)** | 4.43±0.75 | 4.33±0.56 |
| **Protein (%)** | 1.24±0.01*** | 0.86±0.01 |
| **Total lipids (%)** | 0.74±0.05 | 0.72±0.02 |
| **Crude fibre (%)** | 20.33±0.30** | 19.08±0.24 |
| **Ash (%)** | 18.76±1.08*** | 15.73±1.11 |
| **Total carbohydrates (%)** | 68.33±1.53 | 72.67±0.58* |
| **Calorific value (kJ/100g)** | 1189.73±24.92 | 1255.08±10.13* |

### *Functional qualities*

The bulk density (0.77−0.79 g/ml) significantly increased in cooked flours ($p<0.05$), as did the swelling power (4.9−8.9 g/g) ($p<0.001$) as well as the solubility (3.9−8.0%) ($p<0.001$) (Figure 3a, b, c). However, cooked flour had a lower gelation concentration (14%) than uncooked flour (20%) (Figure 3d).

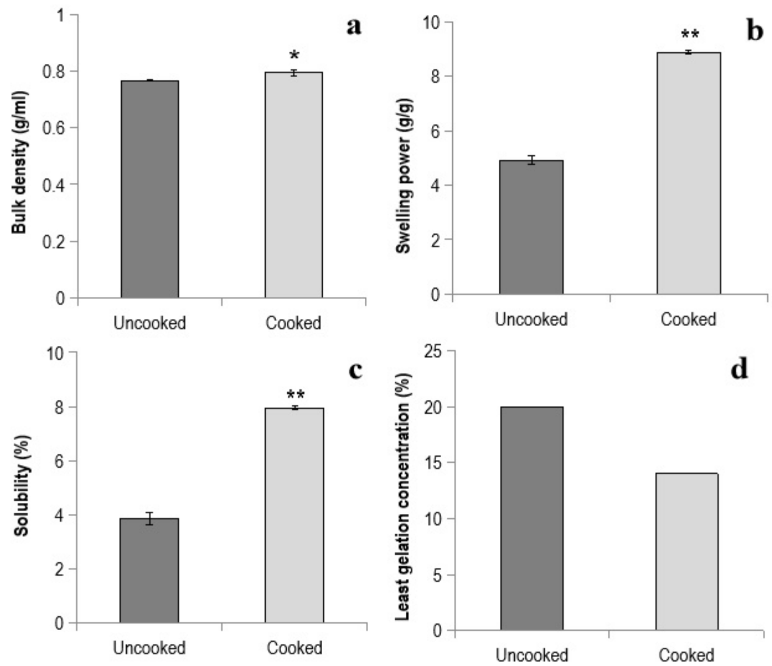


**Figure 3.** Bulk density (a), swelling power (b), solubility (c) and least gelation concentration (d) of uncooked and cooked inflorescence of banana (*t*-test: *, $p<0.05$; **, $p<0.001$)

Cooking significantly increased the water-absorption capacity of flour (2.7 vs. 4.3 ml/g) ($p<0.05$) (Figure 4a). However, the oil-absorption capacity did not show much difference between uncooked and cooked flours (1.7 vs. 1.8 ml/g) ($p>0.05$) (Figure 4b). Although the emulsifying activity was low in flours (1.5−1.6%), it was significantly high in uncooked flour ($p<0.05$) (Figure 4c). Emulsifying stability was the highest in both flours (100%) (Figure 4d). The foam capacity (6.7−9.3%) in uncooked flour was significantly higher ($p<0.05$) (Figure 4e), as was the foam stability at 10 min ($p<0.01$) (Figure 4f).

***Sensory qualities***

Pickles prepared with uncooked and cooked chops were subjected to sensory evaluation (Figure 5). Significant differences were not seen in appearance, aroma, taste, texture and overall acceptability of pickles produced by uncooked and cooked chops ($p>0.05$), while colour was significantly better in cooked pickles ($p<0.05$) and mouthfeel was significantly better in uncooked pickle ($p<0.05$) (Table 4). The 9-point Hedonic scale resulted in 8 points/scores for all sensory characteristics of both types of pickles, which indicates their superior quality as they were liked by the panellists.

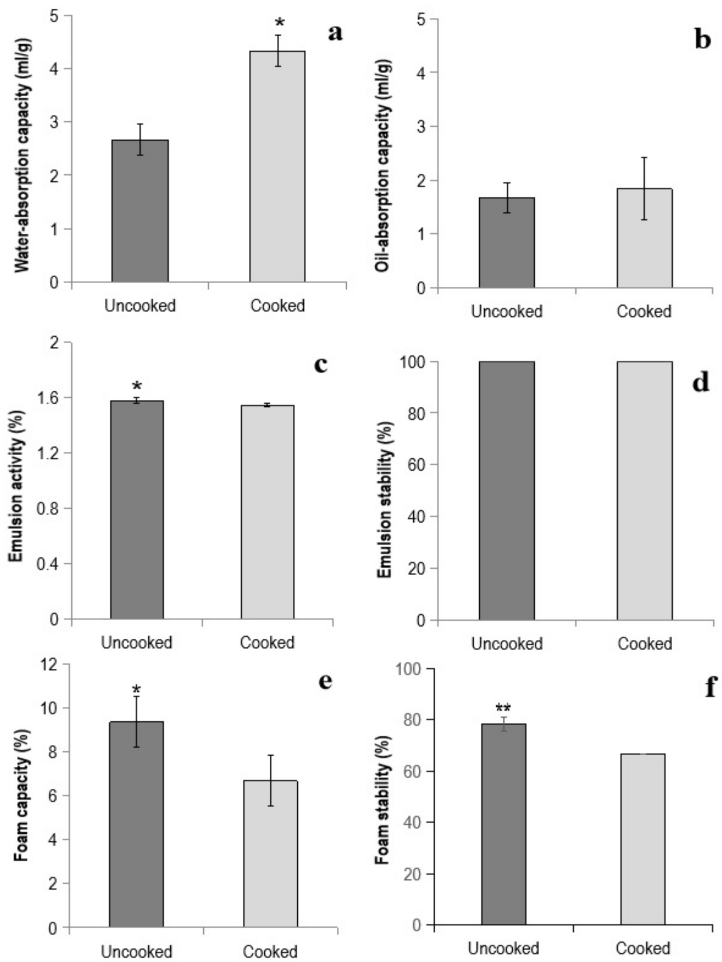


**Figure 4.** Water-absorption capacity (a), oil-absorption capacity (b), emulsion activity (c), emulsion stability (d), foam capacity (e) and foam stability (f) of uncooked and cooked inflorescence of banana (*t*-test: *, $p<0.05$; **, $p<0.01$)

The cookies produced with uncooked and cooked flours were assessed for sensory evaluation (Figure 6). Appearance, colour, texture, taste and overall acceptability of cookies prepared with uncooked and cooked flour were not significantly different (p>0.05) (Table 4). Aroma and mouthfeel were significantly higher in cookies made with cooked flours (p<0.05). Similar to the pickles, the 9-point Hedonic scale resulted in 8 points/scores for all sensory characteristics for both types of cookies, showing the superior quality as indicated by the panellists.


**Figure 5.** Ingredients used for the preparation of banana inflorescence pickles (a), pickle masala powder (b), uncooked inflorescence pickle (c), cooked inflorescence pickle (d) and bottled cooked inflorescence pickle (e)

**Table 4.** Sensory evaluation scores (9-point Hedonic scale) by panellists for banana inflorescence pickles and cookies (n=20, mean±SD) (*t*-test: *, $p<0.05$)

| | **Pickle** | | **Cookie** | |
|---|---|---|---|---|
| | Uncooked | Cooked | Uncooked | Cooked |
| **Appearance** | 7.75±1.12 | 8.10±1.12 | 7.80±0.95 | 7.80±1.11 |
| **Aroma** | 7.85±1.46 | 7.80±1.28 | 7.70±1.17 | 7.95±1.10* |
| **Colour** | 7.55±1.32 | 8.00±0.86* | 7.70±1.17 | 7.75±1.02 |
| **Texture** | 7.80±1.24 | 7.85±1.18 | 8.10±0.72 | 8.00±1.17 |
| **Taste** | 8.15±0.81 | 8.35±0.67 | 8.15±0.75 | 8.30±0.86 |
| **Mouthfeel** | 8.40±0.68* | 7.90±1.12 | 8.00±0.97 | 8.25±1.02* |
| **Overall Acceptability** | 8.05±0.94 | 8.35±0.75 | 8.10±0.72 | 8.25±0.79 |

## Discussion

Banana inflorescence is a major byproduct of agricultural cultivation, and it will be wasted owing to its perishability. Although this byproduct is consumed in different parts of the world, its nutritional value and health benefits are less well understood.


**Figure 6.** Ingredients used for the preparation of banana inflorescence cookies: uncooked flour (a), cooked flour (b), wheat flour and sugar mixture (c), semolina (d), butter (e), uncooked cookie dough (f), uncooked inflorescence cookies (g) and cooked inflorescence cookies (h)

### *Proximal qualities*

Our study revealed the low protein content of the Kadali variety was significantly decreased upon cooking (1.2 vs. 0.9%). Its quantity in uncooked flours is comparable to that of the Monthan variety of southern India (1.3%) (Krishnan and Sinija, 2016), which is higher than that of the Ouro variety (*Musa acuminata*) in Brazil (0.1%) (Fingolo *et al.,* 2012). However, the protein content of uncooked and cooked samples was found to be low compared to the fresh and dehydrated banana blossoms of the Embul variety of Sri Lanka (0.9–1.2 vs. 20.5%) (Wickramarachchi and Ranamukhaarachichi, 2005). Thus, the inflorescence of the Kadali variety is not a good source of proteins.

Similar to protein content, total lipid content was low in the Kadali variety (0.7%) in our study, which is higher than two varieties from southern India (Poovan and Monthan) (0.4 and 0.5%) (Krishnan and Sinija, 2016) and the Ouro variety from Brazil (0.02%) (Fingolo *et al.,* 2012), but lower than the Embul variety from Sri Lanka (5.8%) (Wickramarachchi and Ranamukhaarachichi,

2005) and three genotypes of Cameroon (AAA, AAB and ABB) (5–15.7%) (Florenta *et al.,* 2015). Therefore, the inflorescence of the Kadali variety has low total lipids and is useful for producing low-lipid food products.

The crude fibre of the Kadali variety (19.1−20.3%) is comparable with the Embul variety of Sri Lanka (17.4%) (Wickramarachchi and Ranamukhaarachichi, 2005), while its content is higher than two varieties of southern India (15.3 and 15.5%) (Krishnan and Sinija, 2016). High dietary fibre is helpful in lowering plasma cholesterol and maintaining blood glucose and insulin levels (Sridhar and Seena, 2006). Other benefits of high fibre content include a hypocholesterolemic impact and the prevention of degenerative ailments.

The ash content of the Kadali variety (15.7−18.8%) is higher than that of three Cameroonian genotypes (9.9−12.3%) (Florenta *et al.,* 2015) and the Embul variety in Sri Lanka (8.5%) (Wickramarachchi and Ranamukhaarachichi, 2005), Ouro variety of Brazil (0.1%) and two varieties of southern India (3.1–4.2%) (Krishnan and Sinija, 2016). The presence of a high ash content in inflorescence indicates the presence of several minerals, which are significantly reduced in cooked flours (18.8 vs. 15.7). However, cooked flours appear to meet the requirements of several major and minor minerals to fulfil mineral nutrition.

Total carbohydrates (68.3–72.7%) were lower in comparison to two varieties from southern India (93.4 and 95.2%) (Krishnan and Sinija, 2016), but higher in comparison to three genotypes from Cameroon (22.4–62.2%) (Florenta *et al.,* 2015). The high carbohydrate content of the Kadali variety's inflorescence appears to meet human nutritional and energy requirements, as it was not significantly reduced during cooking. Interestingly, many bioactive compounds of banana inflorescence and some antioxidant activities were not influenced by pressure-cooking (Soans *et al.,* 2023). However, detailed studies on the various sugar compositions of banana inflorescence are warranted (e.g., non-reducing sugars, oligosaccharides and starch) to fine-tune the value-added food products.

The calorific value of any raw food material depends on its protein, total lipids and carbohydrates. Although the inflorescence of the Kadali variety has low protein as well as low total lipids, it significantly increases during cooking, indicating the benefits of retaining the energy in food stuffs through thermal treatments.

### *Functional qualities*

Functional properties are mainly dependent on several intrinsic factors like the structure of proteins, their size and their confirmation, as well as many environmental factors like temperature, pH and ionic strength (Niveditha and

Sridhar, 2017). Functional properties have an important role in the physical behaviour of foodstuffs during preparation, processing, storage and organoleptic qualities (Seena and Sridhar, 2005).

The bulk density of Kadali inflorescence flours is comparable to the banana blossom (*Musa paradisiaca*) of southern India (0.8 vs. 0.7 g/ml) (Elaveniya and Jayamuthunagai, 2014). Low bulk density in inflorescence will be beneficial in the formulation of complementary foods (Chandra and Samsher, 2013). The swelling power of Kadali flours is higher (4.9–8.9 vs. 1.1 g/g), while the solubility is lower (3.9−7.9 vs. 14.2%) compared to the banana variety of southern India (Elaveniya and Jayamuthunagai, 2014). The gelation concentration of Kadali flours has decreased with cooking, which depends on the amount of protein, lipids and carbohydrates (Shad *et al.,* 2011). High swelling power, low solubility and the lowest gelation concentration of Kadali inflorescence facilitate the production of several functional foodstuffs, including bakery products (Söderberg, 2013; Kusumayanti *et al.,* 2015). Solubility also controls gelation, emulsion and foam properties, which facilitate the production of semi-solid food products.

The water- and oil-absorption capacities of flours of Kadali variety were considerably lower compared to the banana variety of southern India (1.7−4.3 vs. 5.8−7.1 g/g) (Elaveniya and Jayamuthunagai, 2014). Water- and oil-absorption capacities depend on intrinsic factors like hydrophobicity, composition of amino acids and protein confirmation (Chandra and Samsher, 2013). The good water-absorption capacity of banana inflorescence is beneficial in the preparation of soups and gravies, which need good viscosity (Chandra *et al.,* 2015). On the other hand, oil-absorption capacity helps with flavour retention, improves palatability and extends the shelf life of bakery as well as meat products (Sridhar and Seena, 2006; Baljeet *et al.,* 2010).

The emulsion activity was lower in the Kadali variety compared to another variety of banana in southern India (1.6 vs. 13.5%) (Elaveniya and Jayamuthunagai, 2014). The formation and stabilization of the food emulsions are important functional attributes useful in the preparation of products like cake, coffee whitener and others (Adebowale *et al.,* 2005). Foam capacity as well as stability are useful in the food industry to improve the consistency, flavour and appearance of the food materials (Elaveniya and Jayamuthunagai, 2014).

### *Sensory qualities*

The sensory evaluation is an important criterion for determining consumer acceptability of food products. There are some studies where banana inflorescence flour has been incorporated in the production of biscuits as well as dark chocolate (Sharmila and Puraikalan, 2013; Elaveniya and Jayamuthunagai, 2014). The food stuffs like pickles and cookies prepared from the inflorescence of the Kadali variety showed pleasing organoleptic characteristics, with 8 points/scores for all characteristics under the category *like very much*. Thus, raw and cooked banana inflorescence is an ideal feedstock to produce pickles and cookies.

## Conclusions

The current study projected the nutritional, functional and product development (pickles and cookies) of an understudied indigenous banana inflorescence as raw material. The nutritional quality of the inflorescence showed good nutritional and functional qualities. The nutritional as well as functional qualities of inflorescence facilitate the development of a variety of quality food products. The production of pickles and cookies from uncooked and cooked inflorescence demonstrated its industrial quality. Because banana inflorescence is readily available in bulk, uncooked and cooked chops will be used to make pickles that can be stored for an extended period of time. The bioactive compounds of banana inflorescence and antioxidant potential were not impaired by pressure-cooking. The preservation of chopped fresh inflorescence by appropriate methods (e.g., freezing and drying) without loss of quality needs to be studied. Similarly, uncooked and cooked banana inflorescence flours could be preserved for the production of value-added products like cookies and biscuits. However, the storage quality of such flours must be evaluated before they can be used to make desired foods. Besides, such flours will serve as an additive (low fat, high fibre, high carbohydrate and high calorie) useful in the production of beverages and functional foods.


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