

ABSTRACT

The increasing demand for ready-to-eat (RTE) and ready-to-cook (RTC) foods reflects a shift toward convenience-driven consumption. Parallel to this, consumers are increasingly inclined to choose healthier food products over conventional options, a trend driven in part by the growing incidence of non-communicable diseases associated with lifestyle changes. Incorporating functional ingredients such as dietary fiber, prebiotics, and antioxidants enhances their nutritional value, fuelling their market growth. Bananas are nutrient-dense fruits, and unripe banana flour has gained recognition as a valuable functional ingredient due to its high resistant starch and dietary fiber content. These properties make unripe banana flour a promising ingredient for health-oriented ready-to-eat (RTE) and ready-to-cook (RTC) products. Therefore, this study aimed to evaluate the potential of unripe banana flours (UBFs) from *Musa paradisiaca* cultivars Peyan (ABB) and Monthan (ABB) as functional adjuncts in RTE and RTC products by examining their nutritional, physicochemical, prebiotic, and antioxidant properties, as well as assessing the nutrient composition, acceptability, prebiotic potential, and predicted glycemic index of the developed RTE and RTC products.

In phase 1 of the study, a baseline online survey assessed the knowledge, attitude, and practice (KAP) of 500 respondents regarding RTE and RTC foods using a structured questionnaire. Phase 2 of the study involved selection, procurement, and authentication of *Musa paradisiaca* cultivars, Peyan (ABB) and Monthan (ABB). The physical characteristics of the fruits and the ripening stage were determined, and unripe banana flours (UBFs) were prepared. Starch morphology, compositional analysis, and evaluation of functional properties were carried out with standard protocols in phase 3. In phase 4, nutrient and phytonutrient composition were analyzed, alongside antimicrobial activity against *E. coli* and *S. aureus* and antioxidant potential by DPPH, ABTS, and FRAP assays. Prebiotic potential was assessed using the growth promotion of selected probiotics- *Lactobacillus acidophilus*, *Bifidobacterium longum*, and *Lactobacillus paracasei*. The predicted GI of the unripe banana flours was determined. Phase 5 included the development, standardization, and comparison of RTE and RTC products of 15%, 30%, and 50% PUBF and MUBF incorporation with 100% wheat flour controls for sensory acceptability. Based on favorable sensory results, products containing 30% PUBF and 30% MUBF were further analyzed for nutrient composition, physicochemical properties, and shelf-life stability. In phase 6, the prebiotic potential and the predicted glycemic index (eGI) of PUBF-based cookies and noodles were estimated. The purchase intent for PUBF-incorporated cookies and noodles was also evaluated using a 5-point scale.

The study provided insights into consumers' knowledge, attitudes, and consumption patterns of functional foods. The study population was predominantly young, with 62.75% in the 20–30 years age group, followed by 27% in the 31–40 years group and 10.25% in the 41–50 years group. Females constituted 75% of the sample, indicating stronger participation from younger women, particularly those aged 20–30 years. Overall, 76% of participants were aware of functional foods and nutraceuticals, with 29 % recognizing raw banana and sweet potato as functional foods. Notably, 52% of respondents preferred the inclusion of functional ingredients in ready-to-eat (RTE) and ready-to-cook (RTC) foods, highlighting a growing interest in convenient yet health-conscious dietary choices.

Unripe bananas (*Musa paradisiaca*) were selected for their rich resistant starch, dietary fiber, availability, and versatility as a functional ingredient. Given the diverse banana cultivars, selective exploration was essential, and *Musa paradisiaca* Peyan (ABB) and Monthan (ABB) were chosen for their indigenous presence in Southern India, abundant availability, underutilization, and limited research. Unripe Banana flours (UBFs) were prepared by the method outlined by Kumar et al. (2019) where in the ripening stage-1 bananas were peeled, sliced, treated with citric acid, tray-dried at 50 °C for 48 h, milled, sieved (60-mesh), and stored in airtight bags. UBF had a creamy, pale-yellow hue, and the flour recovery was 30.45 % for Peyan flour (PUBF) and 23.25 % for Monthan flour (MUBF).

SEM images showed intact starch granules, and XRD analysis revealed relative crystallinity of 8.91% for PUBF and 13.06% for MUBF. Total starch content ranged from 83 % to 86 %, with both varieties containing 23% amylose. Both cultivars contained 44% resistant starch and 13% dietary fiber. The gelatinization temperature of banana flours ranged from 85.6 to 88.3°C, with UBFs showing good hydration and gelling properties. The *Musa paradisiaca* cultivars had an appreciable amount of polyphenolics and flavonoids, exhibited antibacterial activity against *E. coli*, and demonstrated significant antioxidant potential. The unripe banana flours (PUBF and MUBF) demonstrated prebiotic potential, and the unripe banana flour from Peyan (PUBF) had a low estimated glycemic index (eGI) of 54.39, while MUBF had an eGI of 57.60, categorizing it as medium-GI.

RTE and RTC products with 30% PUBF and MUBF were well-accepted for their sensory attributes. The incorporation of unripe banana flours significantly enhanced the dietary fiber and resistant starch (RS) content of the developed products compared to the wheat flour controls. Control cookies contained 8.54 g/100 g dietary fiber and 1.41g/100g RS, whereas PUBF and MUBF cookies exhibited higher values of 10-11 g/100g fiber, with RS contents of

12.53 and 10.03 g/100g, respectively. Muffins prepared with UBFs contained approximately 4 g/100 g dietary fiber and resistant starch, in contrast to lower values in the control. Similarly, cereals with PUBF and MUBF recorded appreciable RS levels of 6.27 g/100 g and 5.17 g/100 g, respectively. In noodles, RS decreased substantially on cooking, from 12.28 g/100 g to 2.1 g/100 g in the control; however, UBF noodles retained markedly higher RS (36 g/100 g in dry form, 11–12 g/100 g when cooked). A similar trend was observed in pasta, where UBF incorporation yielded 36–37g/100g RS in the dry state and 11–12g/100g after cooking, compared with 15.12 g/100g and 3 g/100g in the control, respectively. The RTE and RTC products had acceptable shelf life with good microbial standards, peroxide value, and free fatty acid value. Fermentation of 30% PUBF-based cookies and noodles with selected probiotics resulted in a decrease in pH and an increase in optical density and colony count, with prebiotic index values exceeding one, indicating positive effects on probiotic growth. PUBF-based cookies and noodles exhibited medium eGI values of 62.85 and 63.28, respectively, compared to higher eGI values for their control counterparts. The purchase intent of PUBF cookies and noodles was favorable, confirming the potential of PUBF as a functional ingredient for low-glycemic, health-enhancing foods.

This study recommends incorporating unripe banana flours from *Musa paradisiaca* cultivars Peyan and Monthan into food formulations to enhance health benefits, addressing the growing demand for nutritious and convenient food options.