

Innovative technologies and products of banana and its by-products

With the changing lifestyle, people are aware that diet and consumption pattern plays a major role in preventing diseases and thus demand convenient food products with higher functional nutrition. Fresh fruit is one of the easiest ways to give our body the essential nutrients required for a healthy life. Studies on fruits have progressed from the discovery of essential nutrients and prevention of dietary deficiency, to the promotion of a state of well-being and health with reduction of the disease risk. Among them, banana is a globally popular fruit, which is a package of nutrients and bio-active compounds. Banana being rich in many essential nutrients and dietary fibre has the capability to cure many diseases. Some of the specific diseases known to be cured by banana are: anaemia, blood pressure, constipation, depression, hangovers, heart burns, morning sickness, PMS, Seasonal affective disorder (SAD), ulcer, stroke, stress and age related disorders. It is good to enhance brain power, and provide instant energy.

INDIA is the largest producer of banana with the production of 30.6 million tonnes from an area of 8.02 lakh ha, contributing 17% of world production. About 90% of banana produced is consumed domestically as fresh fruit. Merely 5% is consumed in processed form providing a good potential for future processing. About 2.5% is only processed purely as banana products and the rest as an ingredient in other foods. The primary product of banana in market is 'fried chips and candy' which constitute around 31% with production capacity of 2.0 lakh tonnes valued at ₹ 500 crores per annum, rest as banana puree 9%, banana pulp 3%, banana beer 3%, banana wafers 3%, banana powder 6% and others. Banana contains considerable amount of resistant starch (non-digestible starch) and non-starch polysaccharides, which have low glycemic index. This property makes it an appropriate ingredient for different functional and convenience foods like cookies, bread, cake, extruded foods and chips, *etc.* Conventional products like chips, jam, jelly, banana fig, ready to drink juice are very familiar products from banana and loads of blogs are available online that detail the protocol for its utilization.

Recently, at ICAR–National Research Centre for Banana, Tiruchirappalli has developed handful of technologies which are not only innovative and low cost but also provide better entrepreneurial opportunities under PMFME and other government schemes which orient towards *Atmanirbhar* initiatives. Product like banana syrup and glucose are unusual but remarkable products. Similarly, unripe banana powder is a customary product, but ripe banana powder is an exceptional item. The future innovation can also include prebiotic and probiotic foods,

function specific targeted micro-encapsulated healthy foods from banana.

Low glycemic resistant starch rich green banana flour based nutri-products

Banana flour prepared from mature unripe banana with high starch content (available and resistant) can be blended with other cereal flours and can be used as a potential ingredient for bakery products. Consumption of unripe banana flour incorporated products can confer beneficial effects for human health, a fact often associated with its high resistant starch content. 5-15% of incorporation of banana flour as a substitution for *Maida* in bakery products like bread, bun, biscuits, muffins, cakes and pizza base and deep fried products like doughnut imparts better nutritional value with low gluten, higher resistant starch, dietary fiber and lower glycemic index.



Banana bread

Modified banana starch for nutraceutical/ pharmaceutical and other industrial applications

The present invention relates to starch modifying (RS- III) process by occupying of C2,C3 and C5 positions of sugar in starch through physical (autoclaving and cooling), enzymatic debranching (using pullulanase), chemical (cross-linked phosphate, oxidized, acetylated, acid thinned and hydroxypropylated) methods. After the modified process, the starches were specifically analyzed for resistant starch content and degree of substitution. The purpose of this modification is to introduce new functional group in native starch and enhance its properties particularly in specific applications such as to improve the increase in water holding capacity, heat resistant behaviour, reinforce its binding, minimized syneresis of starch and improved thickening. We preferred three modifications like autoclaving and cooling, enzymatic debranching, Acetylation and oxidation depending upon its use, easiness and versatility. Enzymatically modified starches could be acted as a pre-biotic for making functional food formulations whereas while oxidized form of starch can be used as edible film in food industry and pharmaceutical companies.



Tailored low Glycemic foods with banana starch: Optimization of extraction procedure and elucidation of functional characteristics

Starch is the second most abundant biopolymer, vital for both human/animal nutrition as well as non-food applications. With an annual starch production is around 70 million tonnes worldwide, it is used in thickening, gelling, imparting consistency, shelf-life stability and varied applications in food processing industries. Starch with relatively slow and incomplete digestion has lower glycemic load and insulin demand. This may lead to increased satiety and higher levels of resistant starch (RS); both are physiologically useful. Resistance starch (RS), with its functional food characteristics, is one such food ingredient, has the potential for not being digested quickly in the digestive system, make them essential food with the changing lifestyle. Banana, with its higher quantity of starch and resistant starch offers a greater extraction of starch other than conventional sources.

Low cost, easy to make, foam mat dried ripe banana powder

The natural matrix of ripe banana usually contains a high amount of carbohydrates and sugar and takes long time to dry in convective drying due to its sense physical structure. Making the pulp porous by whipping, followed by drying can minimize the above mentioned negative effects. The ripe banana powder obtained by this method will be rich in bioactive compounds with potential pre-biotic beneficial effects on human health and can be used as functional ingredient in food preparation. With intense, sweet and indulgent natural flavours the product will be a healthier ingredient. Ripe banana powder can be used in food product formulations like pudding, fudges, pan cakes, bakery fillings along with refined wheat flour. It can also be used as a flavouring ingredient for making low fat yogurt, ice cream, fruit toffee and fruit bar. It can also be suggested for compaction into tablet forms for nutraceutical consumption.



Banana powder

Basil seed suspended banana based ready to serve drinks

Commercially banana RTS with basil seed suspension is not available. Basil seeds are used as diuretic, antipyretic, antispasmodic and stomachic. The complication in suspending basil seeds is that, due to density differences with beverage, it is common tendency for seeds to either settle at the bottom or to float at the top. The proper suspension of soaked basil seeds in the beverage requires addition of suspension agents. The process involves slicing and pulping edible portion of banana followed by enzymatic treatment to get the clarified juice, standardization and pasteurization, to which soaked basil seeds were suspended. Technology was identified to keep them suspended uniformly in banana based ready to serve (RTS) drink. With the technology the seed were in suspended state in banana RTS for more than 6 months without any contamination.

Glucose/Glucose syrup from banana

Glucose is a type of sugar, that we get from foods (especially starchy foods) and our body uses it for energy. Usually corn is major plant source for starch extraction, which can be further converted into glucose (Liquid or powder). On exploration of other starchy biological sources for glucose extraction, unripe banana turned out to be a promising source. Green banana pulp



Glucose syrup

contains up to 70–80% starch on a dry weight basis, a percentage comparable to that in the endosperm of corn grain and the pulp of white potato. Banana starch has a great potential, both from its digestion and functional properties, to have application in processed foods and become a commercially viable starch product. Further, by conversion of the obtained starch from unripe banana into glucose by acid/ enzymatic digestion can supplement the commercially available liquid and powdered glucose in the market. Additionally, the availability of banana glucose in market shelves can give a choice of versatility to the consumers.

Banana fruit concentrated syrup as natural sweetener

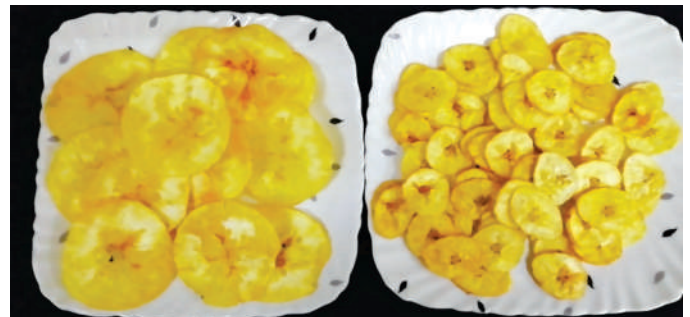
Fruit syrup from dates, lemon, orange, grape etc., is a common product in shelves of Indian market. Being the leading producer of banana, banana syrup can also find its place in super market. By simple concentration of enzyme clarified banana juice, can yield us banana syrup with 65°Brix. Being an energy source and a natural fruit sweetener, banana syrup can be designed for the natural food market, so that the terms 'fruit sweetener', 'sweetened only with fruit' can be used to popularize it. It can be used as a flavouring agent in yoghurt, milkshakes or stopping for pancakes, ice cream, ice slushes, etc. Additionally, it can also give a caramel flavour and tinge of browning of the products in baking, as a result of partial degradation. Since, it has its inherent preservative ability to reduce water activity and to increase osmotic pressure to a level where the growth of even the most spoilage microorganisms is no longer possible, banana syrup, will not require addition of any chemical preservatives to extend its shelf life.



Banana Syrup

Low fat chips

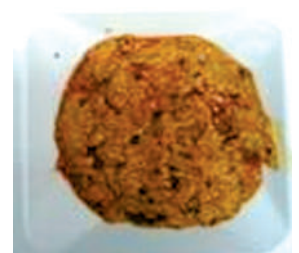
Snack industry is expected to witness stellar growth in accord with the changes in lifestyle and food habits. Endowed with unique savour, banana chips are gaining popularity as a deep fried product. Owing to high incidence of health issues, with consumption of deep fried products, consumers nowadays are more inclined towards healthy products, which are low in fat and calories. Banana chips are produced by deep frying of thin slice of mature, unripe banana from Nendran and Saba variety in India and Philippines, respectively. Owing to high starch content, banana chips from popoulu variety is also preferred by people. Studies have proved that modification of product surface can reduce oil uptake during deep fat frying. Hence, by employing surface modifying agents, the oil absorption during deep fat frying of banana slices can be reduced up to 25%. Pairing low-fat with deep frying technology can yield healthy and appetizing banana chips that will be well suited for calorie conscious people.



Banana chips

Low sodium stem and flower pickles

Large amount of wastes like stem, flower, *etc.* with higher nutritive values are available in banana production system after harvesting bunches. The impact on utilization of low sodium salts on sensory properties of banana stem and flower pickles has proved to be a promising methodology and technology to introduce new, innovative product to the ever growing pickling industry. Without the worry of an enormous amount of salt content being present in the conventional pickle, diet conscious people and people with certain medical conditions, including heart problem, high blood pressure and kidney disorder can dine with this product as banana inherently rich in potassium and the process involves the use of lesser sodium. Low sodium salt had no negative impact on nutritional properties of banana flower and stem pickle but decreased the sodium content. Pickles sodium content less than 23% is considered to be a suitable alternative for preparation of banana stem and flower pickle. The pickle produced can be stored up to 45 days in room



condition, without any changes in comparable differences in physiochemical components and sensory attributes.

Low calorie stem juice

Central core stem from banana which is often considered a farm waste is traditionally known for its rich nutrient content. The inner part of tender pseudostem from banana plant is edible and contains macro and micro nutrients in high concentration. It is also a rich source of potassium and vitamin B6 which helps in the production of insulin and haemoglobin. When consumed, it reduces high blood pressure and can also maintain fluid balance within the body. The extract from tender portion, is an excellent diuretic and helps to detoxify the body, useful for stomach disorder and diabetes. The central stem extracts is an excellent antiurolithiatic agent and is considered to be useful in dissolving the stones in kidney and urinary bladder. Blending of banana central core juice with sweeteners were the most effective with high acceptability, low calorie and high-quality attributes and the storage at 7°C can provide acceptable level of sensory temptation to the juices. No sugar, no preservative alternatives were developed to capture the health conscious population and to bring them into consuming healthy processed food products.



Fibre rich, designer food products using central core stem powder

Process for the production of banana central core stem powder and its incorporation in the preparation of designer foods were evaluated. Banana pseudostem, is regarded as waste, are rich in minerals such as potassium, calcium, sodium, magnesium, phosphorus, copper and iron. The central core stem was washed, sliced, and ground to powder. The dried samples were powdered in a grinder and sieved (sieve no 60 mm). Cookies were prepared by incorporating the prepared banana central



core stem powder with different ratio of substitution. It may have immense potential for commercialization in food industry considering its high nutrient content with antioxidant property and rich in dietary fibre.

Functional enrichment of value added product with banana peel powder

The post-harvest losses in banana have been estimated in the range of 20-25%. Recently, the use of banana as an ingredient for functional foods has gained significant interest. This is particularly due to the banana carbohydrates (starch and non-starch) having low digestibility, which makes it an excellent ingredient



for consumption. The peel has been found to contain high levels of dietary fibre and phenolic compounds. Moreover, the material has been demonstrated to exhibit potent antioxidant capacity, antimicrobial and antibiotic properties. As such, it is a promising material for further applications in the nutraceutical and pharmaceutical industries. The left out in chips industry or the peel from immature banana could be used for making different functional products.

Strategies to promote banana based processing industries

- Unlike developed countries, the food processing sector in India is dominated by the unorganized sector, contributing more than 80% share. Bringing them into the MSME bracket is pre-requisite to boost the processing of horticultural produces especially the crops like banana.
- Creation of cross functional convergence with development agencies, cluster formation in production points by converging Farmer producer organizations (FPOs), market linkages and assessment of the impact through technological incubation and cross cutting initiatives are primary step for the successful establishment of processing industry.
- In the end, bigger players like ITC, Britannia, Parle-G, Horlicks, Boost, Bournvita, Pepsi, Coca Cola, Dabur, etc. should come up with the plan to utilize the banana flour, fruits and juices in their product portfolio to scale up the industrial use and to market it effectively.
- The share of processed industries in agricultural employment has to be enhanced from the present 0.5% to at least 10% with the enhancement of productivity of workers by retaining the youth in agriculture by giving better remuneration and allotting them higher productivity work. With that we can eradicate the dependency of workers in low productivity agricultural activities and shift them to higher remuneration agri-based industrial activities.

- Developing methodologies based on input-output models which provide information about the cluster wise production of banana and could identify the major catchments for supplying the fresh produces. This will allow in calculating the impact of any change in the supply chain. Using AI/ IoT/ App based platforms to provide and generate real time data points.
- In order to sustain the production and growth potential, it is essential to make value added products based on banana, so that farmers get an assured price for their produce all the time. India is the land of more than 30 ethnic varieties in different states with different taste, flavor and nutritional advantages. For example, Nendran is rich in vitamin A and thus could be used for making functional powders to alleviate malnutrition among the rural masses. Likewise, the enormous processing potential could be tapped by developing and commercializing variety dependent technologies.
- Building right infrastructure for converting raw banana into flour, ripe banana into health powder and making banana puree need to be prioritized. All these products have a greater nutritional potential and could be used in functional food markets with its pre-biotic characters. The low glycemic, sugar controlling capability of banana flour has to be rightly marketed to enhance the demand for banana based products.
- Ripe banana could also be used for making dehydrated fruits popularly known as “banana fig” with its fig like taste. This product is highly stable and energy packed thereby could be promoted through giving them to kids in noon meal schemes and to defence personnel other than improving the export market.
- Using banana wastes for the production of innovative products like nutraceuticals, bio colourants, fructans and developing synbiotic foods could pave way for the secondary agriculture. Exploitation of banana wastes and fibre for non-food applications like bio film, edible film, personal hygienic products, handicrafts, and textiles, composite boards will add additional income besides reducing the environmental pollution and carbon foot prints.

Conclusion

Banana being a very popular fruit in the world market has a great diversity of health benefitting nutrients. Not

just the fruit, every part of banana plant is endowed with high value bioactive compounds. Banana is world’s widest-known fruit and it’s harvesting, processing and transportation generates lots of waste. With high crop production projected in the future, there is a vital need to complement this production with proper utilization of the product and its waste, which is rich in nutrient resource, therefore, the volume of processed banana products has developed slowly. Fresh-fruit operations, though continuing year-round, are still affected by seasonality and by supply and demand. With the tremendous growth in food processing and nutraceutical industries as an aftermath of Covid-19 pandemic, banana can play a pivotal role in its further escalation. Being a climatic fruit, with diversified varieties and variety specific preference by consumers the acceptability of its processed products will be much easier, as consumer find potential advantage of products from tropical fruits over fruit flavoured or substituted products and equate such items with better nutritional outcome. However, any pertaining lag to accomplish its acquiescence can be compensated by developing commercial processes with techno-economic feasibility. Smallholder farmers need to improve their position in food value chains in order to improve their margins and as a strategy for coping with agricultural food price volatility through innovations within the chains. Processes endowing high value processed products (starch, antioxidants and pigments) have huge application in food, pharmaceutical and cosmetic industry. Through the combination of farmer’s cooperation, technological upgradation, reduction in postharvest loss, establishment of processing industries and favourable policies, the banana trade from India could make more impact and foot print in the world trade. Ultimately, branding and boosting the entrepreneurship through providing incubation platforms, providing marketing intelligence and handholding for technological backup are prerequisite in the coming days to sustain the banana production and promotion of value addition.

For further interaction, please write to:

P Suresh Kumar (Principal Scientist), Fruit Science, ICAR-NRC for Banana, Thogamalai Road, Trichy, Tamil Nadu 620 102. Corresponding author e-mail: psureshars@gmail.com

**Flowers always make people better, happier, and more helpful;
they are sunshine, food and medicine for the soul.**

– Luther Burbank