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Antimicrobial and Bioactive Components of Banana their Health Benefits and Applications in Dairy and Food Industry

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ABSTRACT

Bananas are the eldest fruits known for its medicinal value and are highly nutritious. India is the largest producer of bananas and contributes about 20% of world's production, Karnataka occupies in 5th position after Andhra Pradesh, Maharashtra, Gujarat and Tamil Nadu, producing 3,713.79 metric tones. The bacterial resistance to antibiotics has led to the identification of novel and effective antimicrobial compounds. The demand for effective and cost efficient antimicrobial compounds has been increasing. This led to the introduction of banana which is a source of various antimicrobial compounds that are naturally present in it such as malic acid, ferulic acid, dopamine etc. Apart from these banana also contains certain bioactive compounds such as Tannic acid, Dopamine, Ferulic acid, p-Coumaric acid, Trans-α carotene, Serotonin etc. that provide numerous health benefits. It offers a potentially simple eco-friendly alternative to antibacterial and fungicidal agents rather than chemicals.

Keywords: Antimicrobial components, Bioactive components, Dairy Industry.

1. INTRODUCTION

A global staple and most important food after rice, wheat and maize is banana. These are herbaceous plant belonging to genus Musa and family Musaceae. It has been called as a "Poor man's food" . It is derived from the Arabic word 'Banan' which means 'Finger'. The flavour of banana is due to Isoamyl acetate. The fruit and tree has many names such as, Apple of paradise, Adams fig, Antique fruit crop, Plant of virtue, Tree of paradise, Tree of wisdom. India is the largest producer of bananas producing 32,454 million tones on 880 hectare of land. It contributes to about 20% of world's production which was 125 million tonnes in 2021 – 22 and exports about 0.3%, stands in 21st position with a value of 90 million USD. The domestic consumption of bananas are about 24,991 kilo tones and about 6.5% wasted in wholesale level (physical injury, long travel and poor packing) (APEDA, 2022). Banana has its contribution in food, medicine and textile industry. In Food industry banana slivers are used to mimic fish in meen kuzhambu a fish curry and is called as Saiva meen kuzhambu or a vegetarian fish curry. In medicine, banana pulp and peel are used for the development of drugs (Mathew *et al*., 2017), in ayurveda banana flower and stem are used to treat diabetes, tree's sap is used to cure leprosy, epilepsy and insect bites. In textile industry, banana waste and natural banana fibers are used to make eco friendly sarees. These are also used for ornamental purposes (Jiwan *et al*., 2018). There are different varieties of banana which are commercially grown in India s it crop, Plant of virtue, Tree of paradise, Tree of wisdom (Heba, 2021). India is the largest producer of bananas, producing 32,454 metric tones on uch as Grand Nain (G9), Robusta, Dwarf Cavendish, Red Banana, Nendran and Yelakki.

1.1 Plant description

The banana plant has fruits, flowers, and leaves that are 2.7 × 0.6 metres, flexible, and waterproof, with a height of up to 6-7.6 metres tall. Because of their wide waxy surface, the leaves are ideal for food packaging and serving, and they are also rich in fibre, flavonoids, polyphenols, and tannins. These have historically been used to treat a variety of skin conditions including eczema, cuts, irritation, rashes, dandruff, and sunburns because of their cooling properties. Fruits have an elliptical form by nature and come "prepacked," with solid, creamy flesh encased in a thick peal. Because banana fruit is nutritious, containing significant amounts of pro vitamins A, B_1, B_2, C, sterols, minerals (including potassium), sugar derivatives, polyunsaturated fatty acids, and high quantities of bioactive substances (such glycosides and acids like malic and oxalic acid). The pulp may be affected by thermal treatment (at 65◦C for 30 min), as shown by a decrease in polyphenol oxidase activity, protecting total phenolic components from breaking down. The enormous, dark purple blooms, often referred to as the blossom or heart that emerges from each banana bunch, with a flavour that is slightly starchy and bitter. Rich in flavonoids (particularly quercetin), proteins, dietary fibre, vitamins (like C), and some biologically active substances (including tannin and α-tocopherol). Much of the plant biomass, which is typically burned and wasted or left on the plantation land, is made up of the pseudo-stem. Consuming

fresh stem juice has been used to cure diarrhea, dysentery, and epilepsy as well as to cleanse the body and stops formation of kidney stones. The GI tag is attached to the Nanjanagud rasbale and Kamalapur red banana cultivars among those cultivated in India. (Heba, 2021)

Table 1 - State-wise production data of bananas (2021-22)

State	**Production (metric tonnes)**	**% Share**
Andhra Pradesh	5,838.88	17.99
Maharashtra	4,628.04	14.26
Gujarat	3,907.21	12.04
Tamil Nadu	3,895.64	12.00
Karnataka	**3,713.79**	**11.44**
Uttar Pradesh	3,391.01	10.45
Bihar	1,968.21	6.06
West Bengal	1,147.79	3.54
Assam	1,108.00	3.41
Chhattisgarh	585.52	1.80

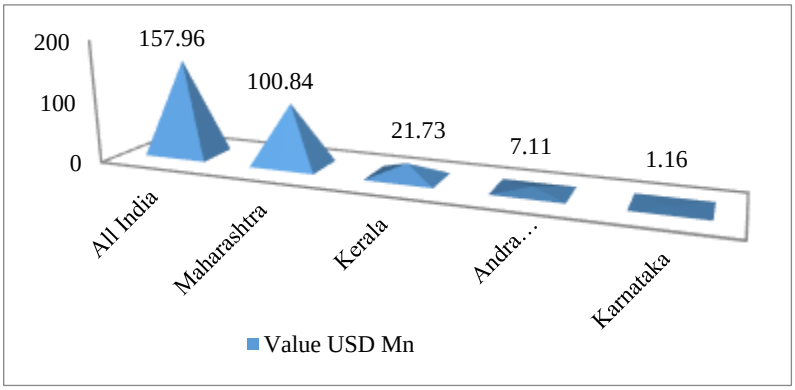
(APEDA, 2022)

Table 2 - Export performance of All India (A I) and Karnataka (KTK)

	2020-21 Value in Mn USD		**2021-22 Value in Mn USD**		**Major Importing Countries**
	A I	**KTK**	**A I**	**KTK**	
Bananas, Fresh	99.86	1.40	157.90	1.16	Iran, UAE, Iraq etc
Curry Plantain	0.15	0.01	0.24	0.00	Nepal, UAE, Maldives etc.,

(APEDA, 2022)

Fig 1 - Banana Exporting states of India (2021 – 22)



(APEDA, 2022)

Table 3 - Composition of Banana

Constituent	**Content (g)**
Energy	371kJ (89 kcal)
Water	74.91
Carbohydrates	22.84
Sugars	12.23
Sucrose	66%
Glucose	20%
Fructose	14%
Dietary fibre	2.6g
Vitamins	**mg (daily value)**
Pantothenic acid (B_5)	0.334 (7%)
Pyridoxine (B_6)	0.4 (31%)
Choline	9.8 (2%)
Vitamin C	8.7 (10%)
Minerals	**mg (daily value)**

Magnesium	27 (8%)
Phosphorous	22 (3%)
Potassium	358 (8%)
Zinc	0.15 (2%)

(Jiwan *et al*., 2018)

Table 4 - Bioactive components in banana (mg/100g)

Tannic acid (122.6-241.4)	Trans-α carotene Trans-β carotene (9.32µg – Red banana, 14.1µg – Nendran)
Gallic acid (56.1)	Violaxanthin
Cinnamic acid (1.93)	Cryptoxanthin (< 10 to 30 µg)
p-Coumaric acid (2.09)	Dopamine (2.5-10)
Gallocatechin gallate (29.6)	Campesterol and stigmasterol
Quercetin (1.51)	Serotonin (8-50µg)

Table1 5 - Antimicrobial compounds in Banana

Antimicrobial compounds	**mg/100g**
Malic acid	200.83
Dopamine	2.5-10
Ferulic acid	16.6
Gallic acid	56.1
Chlorogenic acid	trace
Caffeic acid	
3-carene	
Limonene	

Table 6 - Prebiotic components of banana

Indigestible carbohydrates	60-70% of total fiber
Resistant starch Cellulose Hemicellulose Lignin	

2. Antimicrobial activity of banana

Bananas are among the oldest therapeutic plants. The effectiveness of the naturally occurring active components in bananas, such as antimicrobial agents, has been the subject of numerous studies. It contains a variety of antimicrobial substances, including gallic acid, feluric acid, dopamine, and mallic acid. The discovery of new and potent antimicrobial compounds has become necessary due to the emergence of bacterial resistance to the antibiotics that are already in use. There is a need for antimicrobial substances that are both effective and affordable. Bananas possess antimicrobial, antioxidant, and anticholesterol properties.

2.1 Antibacterial activity

Bacillus subtilis, Bacillus cereus, Streptococcus mutans, Streptococcus faecalis, and *Staphylococcus aureus* are among the gram positive bacteria that bananas are effective against. Gram negative bacteria include *Psedomonas aeruginosa, Escherichia coli, Salmonella enteritidis, Shigella dysenteriae*, and *Vibrio cholera.* The G-positive bacteria (*Bacillus subtilis* and *Staphylococcus aureus*) exhibited maximum inhibitory zones.

2.1.1 Mallic acid

The pathogens *Listeria monocytogenes*, *Escherichia coli*, and *Salmonella enteritidis* are disrupted cytoplasmically by malic acid, leading to an increase in permeability and cytoplasmic leakage. (Raybaudi *et al*., 2009)

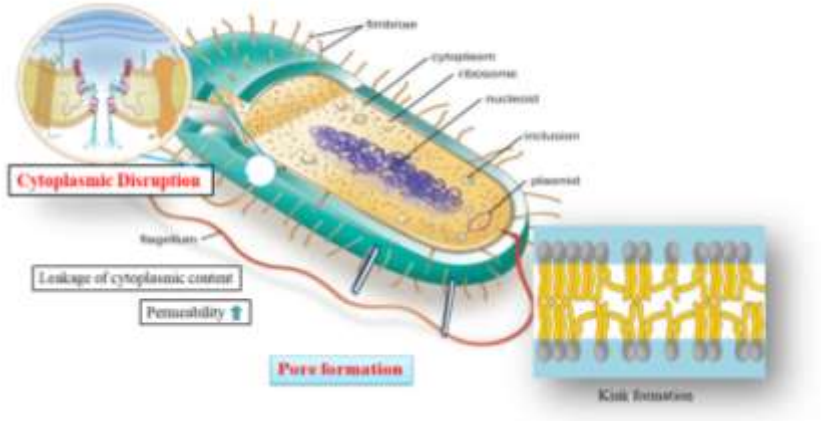


Fig. 1: Action of antimicrobial compounds

2.1.2. Dopamine

Dopamine can induce drastic changes to the cell structure i.e. changes in fluidity of *E. coli* by formation of kinks in the cell membrane.

2.1.3. Ferulic acid

Ferulic acid treatment alteres the hydrophobicity, reduces the negative surface charges and causes pore formation that enables essential cellular components to leak out, the properties of the cell membrane (intra and extracellular permeability, charge, and physicochemical attributes) were permanently altered. It works well against *S. aureus, E. coli* and *P. aeruginosa*. (Borges *et al.*, 2013)

2.1.4. Gallic acid

Gallic acid caused the bacterial intima to significantly shrink and changes in shape in a dose-dependent manner (Lu et al., 2016). By interacting with the lipid bilayers of G-positive and G-negative bacteria, it increases permeability within the cell and disrupts adhesion, motility, spreading, and sporulation. (Rasooly *et al.*, 2019)

2.2. Antifungal activity

When feluric acid and gallic acid were tested against the pathogenic bacteria, it was discovered that there were irreversible changes in the membrane's physicochemical properties, extra/intracellular permeability, decrease in negative surface charge, and localised occurrences of rupture or pore formation. Potential antifungal action against four investigated yeasts of *Candida spp*. was identified for gallic acid. It has been discovered that bananas work well against Penicillium, Candida, and Alternaria spp. (Heba, 2021)

3. Antioxidant Property of Banana

Oxidation is the process of loss of electrons i.e, during oxidation an electron can be knocked out of the chemical bond resulting in a highly reactive free radical where an unshared electron occurs. This free radical can capture electrons from normal healthy molecules and create free radicals that damage the healthy molecules. The damaged cell can release free radicals and continue the effects of oxidative stress to surrounding cells. To prevent these destructive processes, the body constantly needs a reservoir of antioxidant molecules. Antioxidant is essentially the exact opposite of oxidation, in that antioxidant molecules have electrons to spare. Once an antioxidant and a free radical come in to contact, the antioxidant will supply the free radical with an electron.These antioxidants travel through the blood vessels to reach the damaged cells, repairs and stabilizes the chemical bond. In supplying electrons the antioxidant molecules do not themselves become free radicals. The frequent intake of these antioxidants will minimize the oxidative stress and repairs damaged cells. (Kyle, 2012)

4. Anti – cholesterol Property

Cholesterol, a waxy fat like substance. These are of two kinds HDL (High density lipoprotein) and LDL (Low density lipoprotein). HDL is regarded as the good cholesterol whereas LDL as a bad one. Many cardiovascular diseases are caused due to higher LDL levels. The deposition of LDL on the walls of blood vessels causes shrinkage of veins and blocks the flow of blood to other parts of the body leading to death. As banana contains soluble fibers (0.7g/100g), these mixes with the water and forms a gel like structure. This gel binds to the cholesterol and helps in removing it from the body through stools. Thereby reducing the bad cholesterol and preventing cardiovascular diseases.

5. Health benefits of Bioactive compounds in Banana

Bioactive compounds	Health benefits	Reference
Catechin	Resistance to oxidation, brachial artery dilation increased plasma antioxidant activity, and fat oxidation	Williamson and Manach, 2005
Gallic acid	Antioxidant and potential hepato protective effects	Rasool *et al*., 2010
Cinnamic acid	Is a precursor to the sweetener aspartame by the means of enzyme catalysed amination to phenylalanine	Garbe, 2000
p-Coumaric acid	Antioxidant properties and potentially reduce the risk of stomach cancer	Ferguson *et al*., 2005
Gallocatechin gallate	Cholesterol reduction	Ikeda *et al*., 2003
Quercetin	Promotes overall cardiovascular health by encouraging blood flow	Perez-Vizcaino *et al.*, 2010
Ferulic acid	Antioxidant, antimicrobial, anti-inflammatory, antiallergic, anticarcinogenic, modulation of enzyme activity, antiviral and vasodilatory action	Kumar *et al*., 2014
Serotonin	Might contribute to feelings of well-being and happiness	Young, 2007
Trans-α carotene	Precursor to vitamin A	Li *et al.*, 2011
Trans-β carotene	Reduce the risk of CVD and cancer	
Violaxanthin	Used as a food colourant	DeLorenze *et al.*, 2010
Cryptoxanthin	Food colourant might reduce the risk of lung cancer	
Dopamine	Reduce the plasma oxidative stress and enhance the resistance to oxidative modification of LDL	Yin *et al*., 2008
Campesterol and stigmasterol	Reduces the absorption of cholesterol in the human intestines	Choudhary *et al*., 2011

6. Applications of banana in the Dairy Industry

6.1. Fermented probiotic yoghurt

Cultures of *Lactobacillus acidophilus, Bifidobacterium bifidum, Streptococcus thermophilus*, and *Lactobacillus delbrueckii* were utilised to produce fermented yoghurt using green banana pulp (GBP) as a prebiotic. The concentrations of GBP used were 3, 5, and 10%. A maximum probiotic count of 21 × 108 CFU/ml was maintained, and a 3% level of GBP with an acidity of 0.93% was accepted. (Costa *et al*., 2017)

6.2. Probiotic blend

Apple juice and banana pulp puree (7 and 15%) were combined with *L. casei* to create a probiotic blend, and the blend's viability was examined. For a 20-day storage period, a banana puree content of 7% worked well. (Mahdavi *et al.*,2018)

6.3. Coconut curd

A product containing probiotic bananas, which was created by blending coconut milk, banana fruit pulp (6%–9%), and skim milk powder (9%–12%), demonstrated acceptable firmness, appearance, texture, flavour, and colour. For every 100 g of coconut milk, the ideal formula (90 percent desirability) contained 6.98 g of pulp and 12 g of skim milk powder. The formula showed suitability as a vehicle for *L. acidophilus* and *L. fermentum* (10^7 Colony forming unit/g) probiotics after 20 days. (Kumar *et al.*, 2018)

7. Applications of banana in the Food Industry

Application	Banana	Food	Maximum accepted %	Reference
Wheat substitute	Whole green banana flour	Bread	20	Rajeswari *et al*., 2018 Gomes *et al.*, 2016
		Cake	25	
Natural antioxidant	Banana flour	Indonesian meat ball	5	Suniati *et al*., 2019
Fat substitute	Green banana pulp	Pound cake	25	Desouza *et al*., 2018
Sucrose substitute	Banana flour	Sponge and layer cake	20	Segundo *et al.*, 2017

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