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Physical and Antioxidant properties of Dehydrated Banana Blossom Powder with *Moringa oleifera* Powder Incorporation on Biscuits

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ABSTRACT

This study aimed to investigate the physical and antioxidant properties of dehydrated banana blossom powder (DBBP) with Moringa oleifera powder (MLP) incorporated into biscuits, to improve its overall characteristics and nutritional parameter. Biscuits were formulated with ratios of 3:3,2:2,1:1 .DBPP and MLP combination. The physical properties of the biscuits such as the texture, colour, moisture content, spread ratio, and bulk density were evaluated. The antioxidant properties of the biscuits were evaluated using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity method. The results showed that the incorporation of DBBP and MLP did not affect the colour of the biscuits. The spread ratio of the biscuits increased with an increased level of the BPP and MLP combination. The hardness of the biscuits decreased with an increased level of the DBBP and MLP combination. The biscuits' DPPH radical scavenging activity and fiber content values also increased with an increased level of the DBBP and MLP combination. The study concluded that the incorporation of dehydrated banana blossom powder and Moringa oleifera powder into biscuit dough could be used to reduce post-harvest losses and improve the nutritional and antioxidant properties of the biscuits economically.

Key Words : *Moringa oleifera*, MLP *Musa AAB*, DBBP,Nendran, Biscuits, Physicochemical properties, Post-harvest losses, Fiber, Antioxidant properties

INTRODUCTION

Bananas (Musa sp.) are widely grown in India, particularly in the states of Kerala, Tamil Nadu, Karnataka, and Maharashtra. India is the leading producer of bananas worldwide, yielding 13.90 million tons annually, followed by Uganda with 10.14 million tons (Pari and Uma Mageshwari, 2000). In India, bananas rank first in production and third in area cultivated, behind mangoes and citrus fruits. The highest area under cultivation is in Tamil Nadu and the second highest is in Maharashtra. Maharashtra also has the highest productivity of bananas at 60 metric tons per hectare, followed by Tamil Nadu with 52.70 metric tons per hectare. The all-India average is 34.30 metric tons per hectare (Hi Tech banana production practices by Jain irrigation systems Ltd., 2003 and Bindu, 2019).

Bananas are a popular fruit due to their year-round availability, affordability, and nutritive value. The banana heart, also known as the banana blossom, is a highly

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nutritious edible flower found at the end of the banana plant (Suzanne, 1996). It is rich in dietary fiber and antioxidants and has been used as a remedy for digestive issues. However, it is perishable and so is often dehydrated as a method of preservation.

A biscuit is a small, baked, and typically sweet treat that is often enjoyed with a cup of tea or coffee. Biscuits can be made from a variety of ingredients, including flour, sugar, butter, eggs, and various flavorings. The dough is usually rolled out and cut into shapes before being baked until crispy and golden. Some common properties of biscuits include their flaky or crumbly texture, their sweet flavour, and their versatility in terms of flavour and shape. Biscuits are popular as a snack or dessert and can be enjoyed on their own or topped with butter, jam, or other spreads.

Moringa oleifera is another plant native to India that is known for its nutritional and medicinal properties. The leaves are rich in vitamins and minerals and contain high levels of polyphenolics and antioxidants. The plant has been used to address malnutrition, and different parts of the tree can be used for medicinal applications, functional food preparation, and water purification. Moringa is drought-resistant, and its tuberous roots make it a useful food during times of famine. However, its potential as a food source has not been fully realized due to a lack of knowledge and research.

METHODOLOGY

Sample preparation:

Banana blossom powder (DBBP):

This experiment was conducted in the food analysis lab of Parul University, Gujarat. *Musa AAB* is more popular in the state of Kerala.

The bracts of the sandal white blossoms were removed, and the blossoms spread on filter paper for 2 minutes to remove any moisture present on the surface. The blossoms were then cut into 3 mm pieces according to a previous study and immersed in either citric acid solution (0.2%) or rinsed rice water solution for 1 hour. Citric acid and rinsed rice water are natural antioxidants that help prevent the formation of brown pigments caused by the reaction between PPO (polyphenol oxidase enzyme) and phenolic compounds. To reduce the development of the brown pigment, a rapid inactivation of the PPO is necessary before it can create o-quinones. For this reason, rinsed rice water is used in vegetables because it contains Vitamin B3 (nicotinic acid), which acts as an antioxidant and minimizes the enzymatic browning reaction (Elaveniya and Jayamuthunagai, 2014).

After the pre-treatment, the sliced blossoms were drained and loaded into an electric tray dryer and dried at 50°C for 5-6 hours. The best results were found at 50°C, while temperatures of 60°C and 70°C resulted in a charred product and 40°C extended the time (Elaveniya and Jayamuthunagai, 2014).

Moringa oleifera powder (MLP):

Leaf Harvesting:

Young and old Moringa leaves both can be used to make dried leaf powder. The leaves are characterized by their morphology; they are 20-70 cm long, grayish-downy when young, with a long petiole, 8-10 pairs of pinnae, two pairs of opposite elliptic or obovate leaflets, with one at the apex, all 1-2 cm long (Peter, 1978). In addition, there are glands at the bases of the petioles and pinnae. To ensure the best quality of the leaf powder, the leaves should be harvested early in the morning and the initial processing should be completed on the same day, if possible (Ajibola *et al.,* 2015).

Washing and Draining:

Collected leaves are washed thoroughly with running tap water to remove dirt. Afterward, they have soaked in a 1% sodium chloride (NaCl) solution for 5 minutes to eliminate microbes. The leaves are then washed with 70% ethanol and twice with distilled water. This step is critical in removing dust, pathogens, and any other microbes present on the leaves. The excess water can be removed by exposing the leaves to sunlight for a short period of time until the water on the surface of the leaves is gone (Ajibola *et al.,* 2015).

Drying and Grinding :

Leaf drying in shade is recommended, with the leaflets spread on a sterile, clean green net in an insect, rodent and dust-proof, well-ventilated room. Air circulation should be improved with ceiling and floor level vents protected with clean filters, and leaves should be turned over with sterile gloves once for uniform drying. Leaves should be completely dry in 4 days, with a loading density of 1 kg/m^2 (Ajibola *et al.,* 2015). PPE (head caps, nose masks, disposable gloves, etc.) must be always used. In small-scale operations, leafs can be ground using a mortar and pestle or a pulmonizer machine. A common pore size screen with a range of 0.5 mm - 1.0 mm is typically used

to separate the fine grinded leaf powder.

Chemicals and reagents:

Methanol, Gallic acid, Folin's – Ciocalteu reagent, DPPH (2, 2-diphenyl-1-picrylhydrazyl), Copper sulphate, Sodium hydroxide, Sulphuric acid, Sodium carbonate, Ammonium sulphate, Methyl indicator, Petroleum ether (Ajibola *et al.,* 2015).

Macronutrient Profile Analysis:

The nutritional composition of banana blossoms and *Moringa oleifera* was analysed using the AOAC method. A sample was weighed and dried in an oven at 105°C to a constant weight, then the protein content was determined using Nano Drop spectrophotometer. Crude fat was extracted using a Soxhlet apparatus with petroleum ether and total ash content was determined by igniting the sample in a muffle furnace at 600°C for 3-4 hours. Crude fibre was estimated by acid-alkali digestion method and mineral analysis was done using an atomic absorption spectrophotometer (AAS) (Ajibola *et al.,* 2015).

Functional properties :

A sample of 1 gram of banana flower powder and *Moringa oleifera* was weighed in a pre-weighed 50 mL centrifuge tube, and then mixed with 10 mL of distilled water. The centrifuge tube was then heated in a bath of 80°C for 30 minutes, while being shaken continuously. After that, the tube was cooled to room temperature, and then centrifuged for 15 minutes at a speed of 2200 RPM. The supernatant was evaporated, and the dried residue was weighed to determine the solubility. The solubility has been calculated using the following formula:

Solubility % = (weight of dried sample in supernatant/weight of original sample) x 100

The swollen sample, obtained by decanting the supernatant, was also weighed to determine the swelling power. The answer can be found using this equation.

Swelling Capacity = (weight of wet mass sediment/ weight of dry matter in the solution) (Ajibola *et al.,* 2015).

Foaming capacity and stability:

2 grams of blossom powder and *Moringa oleifera* powder was combined with 50ml of distilled water in a 100ml measuring cylinder. The suspension was vigorously shaken to create foam. The volume of foam produced (ml) after mixing was recorded as the foam capacity, and the volume of foam at 60 minutes after shaking was used as an indication of foam stability (Elaveniya and Jayamuthunagai, 2014).

Least gelation concentration :

A suspension of banana blossom and *Moringa oleifera* powder was prepared by mixing 5 ml of distilled water with 2 to 20% (w/v) concentration in test tubes. The test tubes were then heated in a boiling water bath for one hour, cooled rapidly under running tap water and placed in a refrigerator at 4°C for two hours. The least gelation concentration was determined by inverting the test tubes and observing whether the sample fell or remained in place (Elaveniya and Jayamuthunagai, 2014).

Water and oil absorption capacities:

A sample of 1g of blossom powder and *Moringa oleifera* powder was mixed with 10ml of distilled water or oil in a pre-weighed 50ml centrifuge tube. The suspension was agitated for one hour on a shaker, after which it was centrifuged for 15 minutes at a speed of 2200 rpm. The oil was extracted using a pipette and its weight was measured again (Elaveniya and Jayamuthunagai, 2014). The capacity of the sample to absorb water or oil was calculated by subtracting the weight of the sample after oil removal from the initial weight. This value was expressed as grams of water or oil absorbed per gram of the sample.

Bulk density:

A sample of banana blossom powder and *Moringa oleifera* powder was placed in a 25 ml measuring cylinder, filled to a depth of 5 ml (Elaveniya and Jayamuthunagai, 2014). The cylinder was then tapped on a tabletop until a constant volume was achieved. The bulk density (g/m^3) was then calculated using the following formula:

Bulk density = (Weight of the sample / Volume of the sample after tapping) (g/ml or g/cm^3).

Emulsification capacity:

2g of blossom powder, *Moringa oleifera* powder and 23 ml of distilled water were mixed together in a beaker for 30 seconds using a magnetic stirrer at 10 Ruhrer speed. The mixture was stirred until the powder had completely dispersed. Refined vegetable oil was then added continuously from a burette and blended

continuously at room temperature until the emulsion broke, which is marked by the separation of the mixture into two layers (Elaveniya and Jayamuthunagai, 2014). The emulsification capacity of the powder was also determined across a range of pH values (1-12) and the results were expressed in millimeters of oil emulsified by 1g of flour.

Physical-chemical properties

pH values:

Ten grams of the blossom powder and *Moringa oleifera* powder was shaken with 100ml water, allowed to stand for 30 minutes. The filtrate was tested for pH using a pH meter, and the results were recorded.

Colour Analysis:

In order to measure the colour of banana blossom powder and biscuits, an instrumental colour analyzer was used (Abbas *et al.,* 2010). The HUNTER LAB device was employed, which utilizes a 6.4 mm diameter diaphragm with an optical glass to collect the sample. The collected sample was placed directly on the glass to measure its colour.

The results of the measurement were then expressed in the CIE L*a*b* colour space, which is a three-dimensional space that describes colour according to lightness (L*), red-green (a*) and yellow-blue (b*) coordinates.

Antioxidant properties:

Total phenol content:

The total phenolic content of banana blossom powder and *Moringa oleifera* powder was determined using the Folin- Ciocalteau colorimetric method. An aliquot of 1 ml of the extract or standard solution of Gallic acid was added to a 25 ml volumetric flask, containing 9 ml of distilled water. A reagent blank was prepared using distilled water. 1ml of Folin- Ciocalteau's phenol reagent was then added to the mixture and shaken. After 5 minutes, 10ml of 7% Na_2CO_3 solution was added to the mixture and it was diluted to the volume (25ml) with distilled water and mixed. After incubation for 90 minutes at room temperature, the absorbance against the prepared reagent blank was determined at 750 nm with a spectrophotometer. The total phenolic content of the banana blossom powder was expressed as milligrams of gallic acid equivalents (GAE) per 100g (Elaveniya and Jayamuthunagai, 2014).

Free radical scavenging activity:

DPPH radical scavenging activity was evaluated by mixing various concentrations of flower extracts and *Moringa oleifera* powder with a solution of DPPH radicals in methanol (AOAC, 1995). The absorbance of the resulting solution was measured and compared to a control solution containing no antioxidant. The radical scavenging activity was then calculated as a percentage of DPPH discoloration using the equation: % RSA= [(Acontrol-As)]/Acontrol] x 100. The extract concentration providing 50% of the free radical scavenging activity was calculated from the graph of radical scavenging activity percentage against extract concentration (AOAC, 1980).

Biscuit preparation:

This biscuit preparation idea is based on research and literature reviews. However, the novelty of this biscuit lies in the unique combination of ingredients and its composition. We tried different concentrations for making the biscuit from (1% to 6%) for 100g. 6% shows the darkest color. 4% show a good appearance.

T (1)	
Ingredients	Weight (grams)
Sugar	24.24
Butter	18.8
Baking powder	1.81
Maida	33.36
Wheat	15.79
MLP	3
DBBP	3

T (2)	
Ingredients	Weight (grams)
Sugar	25
Butter	14
Baking powder	2.5
Maida	36.26
Wheat	18.24
MLP	2
DBBP	2

T (3)	
Ingredients	Weight (grams)
Sugar	27
Butter	14
Baking powder	2.5
Maida	36.36
Wheat	18.14
MLP	1
DBBP	1

Statistical analysis:

Three separate analyses were performed for each sample. The experimental data were reported as the mean ± standard deviation of the three determinations (Fig. 1 to 4).

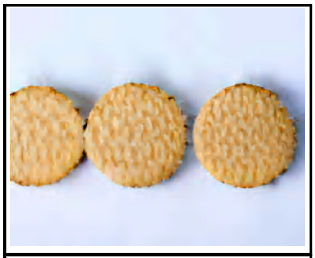

Fig. 1 : Biscuit standard

Fig. 2 : Ratio 3 : 3 T1

Fig. 3 : Ratio 2 : 2 T2

Fig. 4 : Ratio 1 : 1 T3

RESULTS AND DISCUSSION

Proximate analysis of Banana blossom and *Moringa oleifera* powder:

The proximate composition of banana blossom powder samples was analysed to determine moisture, protein, fat, ash and crude fiber content. The moisture content of the powdered samples was 10%, compared to the 89% moisture of the fresh sample.

The ash content of the dried powder was 3.5%, higher than the fresh sample's 2%. The fat content of the powdered sample was 0.6%, which was similar to the fresh sample's fat value. The oil absorption of the powdered sample was slightly reduced compared to the other two samples. Five fatty acids, including palmitic, stearic, oleic acid, linoleic, and α-linolenic acids, were identified in the banana blossom.

The protein content of the powdered sample was higher than the control samples increased nutrients (fibre, protein, fat, minerals and β-carotene) The crude fibre content of the powdered samples was 16%, while the blossom powder-incorporated biscuits contained 20% fiber, more than the standard biscuits.

Organoleptic evaluation:

Sensory evaluation has been done by the method using a 9-point Hedonic scale (Fig. 5).

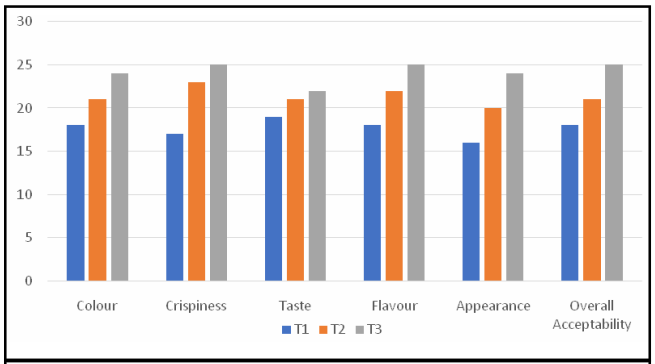

Fig. 5 : Organoleptic evaluation

Functional Properties:

Least gelation concentration:

Gelation is an aggregation of denatured molecules that can form gels and provide a structural matrix for holding water, flavours, sugars, and food ingredients. The least gelation concentration of DBBP and MLP was 0.7 (W/V). The results indicate that PCAS powder could be used as a good gel-forming or firming agent and could be beneficial in food systems such as biscuits and snacks that require thickening and gelling.

Water absorption capacity:

Water absorption capacity of flour is a useful indicator of the protein it contains and can be incorporated into aqueous food formulations, especially those involving dough handling. The interactions of protein with water are important in determining properties such as hydration, swelling power, solubility, and gelation. The high-water absorption capacity of the powder suggests that it may be useful in cookie formulation. The results showed that the water holding capacity of the MLP sample was 580% (5.80g/g) and the DBBP sample had 542% (5.42g/g) (Elaveniya and Jayamuthunagai, 2014).

Oil absorption capacity:

When compared with water absorption capacity, banana blossom powder sample had a higher oil absorption capacity. DBBP-714% (7.14g/g) was significantly ($p<0.05$) higher than *M. olifeira* seed flour (1.01 mL/g or 0.91 g/g) and leaf powder (1.6 mL/g or 1.46 g/g). Lipid binding is dependent on the surface availability of hydrophobic amino acids, making oil absorption capacity important for retaining flavor and providing a soft texture to foods such as cakes, soups, and sausages.

Emulsification capacity:

The emulsification capacity of the blossom powder control was 1.35 mL. In MLP, the highest emulsion capacity was seen at acidic (pH 3) and basic (pH 10) pH levels. On the other hand, the greatest emulsion stability (65.81%) was found at pH 4, followed by pH 10 (62.26%).

Physico-Chemical Properties:

pH-The pH of blossom powder is 6.91 and the microbial limit value is 8.0. This is key when considering food preservation and storage, as acid can inhibit the

Table 1 : Effect of MLP and CP on the physical characteristic of biscuit

Sample	Diameter (cm)	Weight (g)	Thickness (cm)	Spread Ratio
T1	5.53±0.06	12.22±1.30	0.57±0.06	9.83±1.01
T2	5.10±0.17	11.63±1.98	0.67±0.12	7.81±1.37
T3	4.87±0.07	11.03±1.94	0.66±0.02	7.35±0.27

Values in the same column with different superscripts are significantly different ($P \leq 0.05$).
Means ± standard deviations of triplicate samples (Ajibola *et al.,* 2015)

Table 2 : Effect of MLP and DBBP on nutritional characteristics of biscuits

Parameters/Samples	T1	T2	T3
Moisture %	1.60±0.05	1.65±0.02	1.70±0.06
Protein %	12.70±0.44	13.37±0.23	13.99±0.09
Fat %	14.46±0.09	13.83±0.43	13.19±0.33
Ash %	2.31±0.25	2.45±0.08	2.31±0.07
Fibre %	3.05±0.25	2.45±0.2	2.5±0.5
Carbohydrate	16.98±0.45	17.15±0.67	16.15±0.44
Iron (mg)	2.80±0.08	4.83±0.09	2.80±0.08
Calcium (mg)	41.17±0.53	36.63±0.42	29.17±0.25

growth of microorganisms and enzymes. Vegetables are typically processed at higher temperatures and for longer times than more acidic fruits. The pH of a food can also affects its physical properties, such as texture and gel strength.

DPPH radical scavenging activities of aqueous extracts of biscuits incorporated with MLP and DBBP:

The DPPH radical is an oil-soluble free radical that becomes a stable molecule after accepting an electron or hydrogen from an antioxidant. It is stable in methanol and shows maximum absorbance at 517 nm. When it encounters a proton-donating substance such as an antioxidant, the radical is scavenged, and absorbance is reduced. This can be used to measure the antioxidant activity of a substance, as its ability to scavenge the DPPH radical. The DPPH radical scavenging activities of aqueous extracts of biscuits have been studied, with the highest activity observed in sample T(1) control sample. This is consistent with the total phenolic content results for both non-supplemented and supplemented samples. For example, sample T1 with the highest polyphenol content exhibited the highest DPPH radical scavenging activity, while the lowest DPPH radical scavenging activity was recorded for sample T3 with the lowest polyphenol content. This shows that there is a positive correlation between the polyphenolic content and the DPPH radical scavenging activity of the biscuit extracts (Fig. 6).

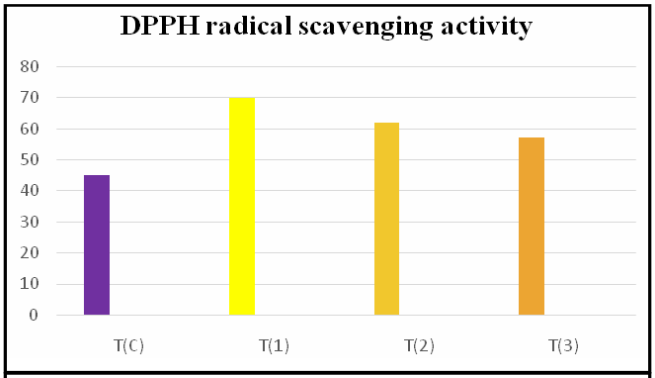

Fig. 6 : The DPPH radical scavenging ability of biscuits incorporated in aqueous extracts was assessed. With *Moringa oleifera* leave and Banana Blossom Powder

Conclusion:

The use of Moringa leaf powder (MLP) and banana blossom powder (DBBP) has been found to be effective in improving the spread ratio, nutritional properties, and antioxidant activity of biscuits. This study sought to determine the effects of adding these two powders on biscuits. It was found that when MLP and DBBP were added, the spread ratio, protein, crude fiber, iron, calcium, and antioxidant activity of the biscuits all increased. Furthermore, the biscuits had a more desirable colour and taste. This study's results highlight the potential of using MLP and DBBP to make biscuits more nutritious and provide health benefits. With their high fiber content and antioxidant properties, these two powders can be

used to improve the nutritional factors of biscuits. DBBP will get very cheap as compared to any other fiber-rich food products. Fibre is essential for a healthy diet and helps reduce the risk of certain diseases in the gastrointestinal pathway and reduce constipation. Additionally, antioxidants have been found to have numerous health benefits, such as improving heart health and reducing inflammation in the body and neutralizing free radicals by donating electrons, and reducing the chance of cancer cells in the body. As such, it is beneficial to incorporate MLP and DBBP into biscuits. Moreover, it helps to reduce post-harvest loss of food and food waste by using the DBBP as the major ingredient because it is not widely used as a food product all over the world.

The study provides evidence that MLP and DBBP can be used to make biscuits more nutritious and beneficial for health. However, further research is needed to expand on these findings and to determine the optimal levels of MLP and DBBP to be used in biscuits. Additionally, it is important to consider the safety and efficacy of using these two powders in food products. With further research, MLP and DBBP have the potential to become staple ingredients in the food industry.

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