REVIEW ARTICLE

The medicinal benefits, phytochemical constituents and antioxidant properties of banana blossom: A mini review

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Abstract:

Banana (*Musaceae* spp.) is a well-known food crop, mainly consumed as a significant yield in most developing countries. However, its blossoms will always end up as agriculture wastes. These by-products are also rich in bioactive compounds and are highly required for our health maintenance. Recent studies have reported that banana blossom contains comparable phytochemical contents. Therefore, this review aims to study the phytochemical constituents, antioxidant properties and medicinal benefits of banana blossoms, making it a potential functional food with diverse nutraceutical values. Several databases such as Web of Science, Scopus, PubMed, Science Direct and Google Scholar were used in this review. Banana blossom also contain bioactive compounds such as phenolics, flavonoids, dietary fibers, tannins, saponins and vitamins. Moreover, banana blossom has potential biological activities such as antioxidant, anti-hyperglycemic, anti-inflammatory, and antimicrobial properties. Thus, it can be concluded that banana blossoms contain appropriate quantities of beneficial secondary metabolites that are significant in maintaining good health. More research into the medicinal potential of banana blossom can be done to provide new approaches to treating and preventing a variety of medical conditions.

Keywords: Antioxidants, banana blossom, medicinal benefits, *Musaceae*, phytochemicals

1. INTRODUCTION

Banana plant is an herbaceous flowering plant of the family *Musaceae* and genus Musa (Sidhu & Zafar, 2018). This plant grows mainly in tropical and subtropical regions. Besides being used for its medicinal purposes, people from all over the world, especially Asian countries commonly consume banana blossom as vegetable as it is rich in antioxidants and nutrients with various health benefits (Pushpaveni et al., 2019). Commonly, banana plant is grown commercially for its fruits while the male flowers will become waste material generated during harvest of crop with low economic value (Nann & Swe, 2012).

The main parts of banana plants consist of its edible fruits, blossoms, leaves, stems, and roots (Figure 1). Banana blossom, flower, heart, or bud is actually the sterile, male flower of the plant. As for the blossoms, they are finger-shaped, subtended by large and fleshy, with purple or reddish colored scales that will fall off as the fruit matures. There will be both male and female flowers, where female flowers will appear first. The flowers will develop into banana "hands" and the ovaries will then develop into seedless fruits without pollination. After all the fruits have been developed from the female flowers, the inflorescence elongates, and cluster of male flowers will be generated within brackets of the bud. However, the male flowers die quickly, and the bud will eventually become smaller. Only one inflorescence will develop per plant (Singh, 2017).

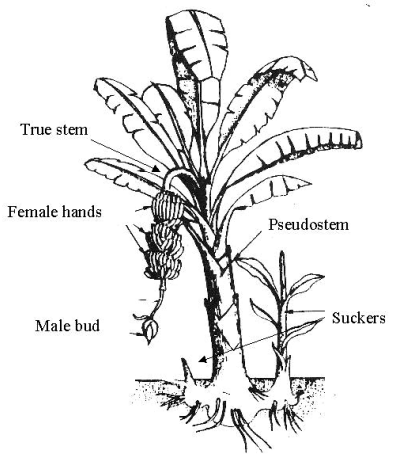

Figure 1. The illustrative representation of banana plant (MacBryde, 2009, p. 20).

The banana blossom also contains various nutritional values that are similar to banana fruits. Due to the presence of many different bioactive elements found in the blossom extract, this part of the banana plant had been traditionally consumed for its tremendous health benefits. These include saponins, flavonoids, glycosides, tannins, steroids, and phenols (Pushpaveni et al., 2019). Besides, this functional food also provides lots of nutrients such as potassium, protein, copper, calcium, iron, phosphorus, vitamin A, C and E, along with various antioxidant properties (Singh, 2017). Some of the blossom properties that have been proven are the antioxidant activity, anti-cancer activity, anti-diabetic activity, and antimicrobial activity. It is also being consumed for its high benefits to women's health. This review aims to provide an overview and gather knowledge on the medicinal benefits, phytochemical constituents, and antioxidant properties of banana (*Musa* sp.) blossom from previous literature studies.

2. METHODOLOGY

The information gathered in this review were collected using various electronic databases such as Web of Science, Scopus, PubMed, Science Direct, and Google Scholar; with the keywords of "Banana blossom", "Banana inflorescence", "Phytochemicals of banana blossom", "Antioxidant activity of banana blossom" and "Medicinal benefits of banana blossom". The literature search was done in English and the publication years of journals used ranged between 2011 and 2020. There were some exclusion criteria used to select articles for this review, where articles with only abstract and cannot be fully accessed were excluded. The total number of selected articles found from the literature search was forty, where thirty-three articles had been used in this review.

3. RESULTS AND DISCUSSION

3.1. Phytochemical Constituents in Banana Blossom

Phenolic

High concentrations of phenolic content of the tepals showed that these biological compounds contribute to the antioxidant property of *Musa paradisiaca* (Rao et al., 2016). These compounds are found to reduce the production of reactive oxygen species and induce scavenging effects of free radicals (Cicerale et al., 2012). Rodrigues et al. (2020) reported that the highest level of phenolics was present in the distilled water extract of male flowers compared to other plant parts, such as bracts, rachis, and the whole inflorescence. These findings also corresponded to a study by Thaweesang (2019) who reported that the total phenolic content of fresh and blanching banana floret ethanolic extract were the highest with 1091.30 µg GAE/g and 1380.58 µg GAE/g respectively, compared to banana bract extract. Although phenolic compounds are present in both bracts and florets, the concentrations were different, where banana florets possessed the highest total phenolic content with 1235.94 µg GAE/g while the total phenolic content of the bract was 741.79 µg GAE/g.

Flavonoid

Flavonoid is also one of the essential secondary metabolites, exhibiting various biological properties, such as antioxidant, anti-inflammatory, anti-thrombotic, anti-fungal, anti-carcinogenic, anti-allergenic, and hepatoprotective property (Sumathy et al., 2011). An analysis by Rodrigues et al. (2020) had found that the highest concentration of flavonoids was observed in the distilled water extract of male flowers compared to extracts of other parts of the banana plant, such as bracts, rachis, and the whole inflorescence. Besides that, a study by Rao et al. (2016) also compared the concentration of phenolics and flavonoids using different extraction solvents, such as methanol, ethanol, and aqueous extracts. It was found that methanolic extract had the highest concentration of both flavonoids and phenolics, with 0.25 mg QE/g and 4.27 mg GAE/g, respectively among all three extracts. Tepal aqueous extract was the least with 0.164 mg QE/g and 1.32 mg GAE/g for both flavonoids and phenolics (Rao et al., 2016). Apparently, it can be assumed that the polarity of solvents used can significantly affect the concentration of phenolic compounds that can be recovered. Methanol and ethanol can be a good solvent system for polar antioxidant extraction as plant materials with increased levels of polar substances are soluble in solvents with increased polarity to obtain the maximum concentration of target compounds in these extracts (Do et al., 2014; Dhawan & Gupta, 2017; Truong et al., 2019).

Dietary Fiber

High dietary fiber elevates the food retention period in the stomach, so it helps in generating early fullness signal; and lowers the risk of developing gastric ulcers. A fiber-rich meal also eases digestion and waste elimination, as well as prevents constipation (Anderson et al., 2009). A study by Ramu et al. (2017) reported that the total dietary fiber in banana blossom (70.07±0.25%) was higher than banana pseudostem with a value of 61.14±0.34%. Insoluble dietary fiber in banana blossom (62.93±1.01%) was also found to be higher than in banana pseudostem (59.10±0.99%) while the soluble dietary fiber in banana blossom (7.14±0.56%) was higher as well compared to banana pseudostem (2.04±0.28%).

When being compared with other fiber-rich fruits, banana blossom also exhibited comparable fiber content. An investigation by Saikia and Mahanta (2016) reported that banana blossom and Burmese grape peel had higher yield of total dietary fiber than the rest (pineapple pomace, Khasi mandarin peel, carambola pomace, and watermelon peel) with values of 77.18±0.20 g/100g and 79.94±0.41 g/100g,

respectively. Moreover, in all samples, the content of insoluble dietary fiber was higher than soluble dietary fiber with the values of 28.57 to 62.21 g/100g and 9.23 to 17.55 g/100g, respectively. These two soluble and insoluble dietary fibers both have their own benefits and can be obtained by consuming foods high in fiber content.

Tannin

Tannin has shown diverse beneficial biological effects in which at low concentrations, it can retard the growth of bacteria; while at a higher concentration, it is known to exhibit antifungal properties (Sumathy et al., 2011). Tannin also demonstrates properties such as anti-inflammatory, antioxidant, anti-carcinogenic, cardioprotective, and radical scavenging properties (Redondo et al., 2014). There are fewer articles studied on the concentration of tannin quantitatively. However, qualitative studies revealed the presence of tannin in banana blossoms (Nann & Swe, 2012; Joseph et al., 2014; Rao et al., 2016). A study by Ramu et al. (2017) reported that tannin content in banana blossom (86.87±02.43 mg/100g) was significantly higher than those in banana pseudostem (7.86±0.21 mg/100g). These findings were also in agreement with a report by Mahmood et al. (2011), where tannin concentration was 88.31±4.53 mg GAE/100g dried sample.

Saponin

Saponin helps in boosting body immunity, lowering bad cholesterol and preventing the growth of cancer cells (Nann & Swe, 2012). It is also frequently utilized medically to treat migraine, chlorosis, epilepsy, and excessive salivation (Sumathy et al., 2011). Similar to tannin, the concentration of saponin content in banana blossom (387.51±1.79 mg/100g) was also higher than in banana pseudostem (305.45±0.60 mg/100g) (Ramu et al., 2017). Mahmood et al. (2011) also revealed the saponin concentration in the banana blossom extract to be 1.43±0.14 g/100g dried sample. These findings indicated that besides its fruits, the banana blossoms can also be a good source of secondary metabolites.

Vitamins

Vitamins are a group of micronutrients that are significant and required in varying quantities for health maintenance and physiological function coordination. Basically, micronutrients are needed in quantities below 100 milligrams daily (Godswill et al., 2020). As vitamins cannot be produced by our bodies, it is vital to take on vitamins from dietary sources, by taking supplements or consuming functional foods high in vitamin content. From a study by Ramu et al. (2017), it was observed that in banana blossoms, ascorbic acid content was the highest in both banana blossom (9.50±0.05 mg/100g) and banana pseudostem (8.81±0.20 mg/100g) compared to other vitamins, such as vitamin E, riboflavin, thiamine, niacin, beta carotene, pyridoxine, and pantothenic acid.

3.2. The Antioxidant Properties of Banana Blossom

The 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) Free Radical Scavenging Activity

The extract made of male blossom had exhibited the lowest IC_{50} value than the other extracts of bracts, rachis, and the whole inflorescence (Rodrigues et al., 2020). A study by Thaweesang (2019) reported that the ethanol extract of fresh and blanching banana blossom showed the highest inhibition of DPPH radical activity by 42.74% and 41.78%, respectively. This showed that DPPH radicals were effectively scavenged by this banana blossom. Furthermore, the DPPH free radical scavenging abilities of either fresh or blanching blossom were not notably different for the blossom extracts. However, for banana bract extracts, both methods of consumption and percent inhibition showed significant differences. The IC_{50} value of fresh blossom extract was 1275.50 µg/mL, which means that fresh banana blossoms only require low concentration of crude extract substance to inhibit 50% DPPH color. These indicated that the antioxidant activity of fresh banana blossom was also stronger than banana bract.

However, these values were relatively higher compared to a study by Schmidt et al. (2015) who reported the IC_{50} value of the banana blossom ethanol extract to be 0.31 mg/mL. These differences in values might be due to the different ethanol concentrations used during extraction. Thaweesang (2019) prepared extraction using 95% ethanol, while Schmidt et al. (2015) reported that the best antioxidant activity of the banana blossom extracts was by using 50% ethanol concentration. Based on these findings, it can be assumed that increasing the concentration of ethanol can also increase the antioxidant capacities of the crude extract with high content of phenolic compounds (Chew et al., 2011).

When comparing the DPPH values of banana blossom with other fruits, the DPPH radical scavenging values of the extracts ranged between 25.58 to 94.30%, with carambola pomace being the highest and watermelon peel the lowest, while banana blossom had a DPPH value of 87.50±0.21% (Saikia and Mahanta, 2016). This showed that banana blossom extract has a good and comparable DPPH value when being analyzed with other fruits extracts with high antioxidant values.

The Ferric Reducing Antioxidant Power (FRAP) Reducing Power

Besides having the lowest IC_{50} value, the distilled water extract made of male blossom also had the highest FRAP value when being compared to other banana plant part

extracts of bracts, rachis, and the whole inflorescence (Rodrigues et al., 2020).

When being compared with other fruits that are also high in antioxidant activity, banana blossom had exhibited an equivalent FRAP value as well. An investigation by Saikia and Mahanta (2016) revealed that the FRAP values of six fruits tested, namely banana blossom, Burmese grape peel, pineapple pomace, Khasi mandarin peel, carambola pomace, and watermelon peel ranged from 685.76±0.42 µmol/100 g to 12,250.00±0.47 µmol/100 g; and the FRAP value for banana blossom was 6791.66±0.39 µmol/100 g.

3.3. The Medicinal Benefits of Banana Blossom

Banana blossom also exhibited various medicinal benefits, making this plant a significant functional food. Thus, this review will focus more on the three most discussed medicinal benefits and biological activities of this banana plant part, which are its anti-hyperglycemic, anti-inflammatory, and antimicrobial properties.

Anti-hyperglycemic

In diabetic patients, inhibiting the enzymes catalyzing polysaccharide degradation, such as α-amylase, α-glucosidase and α-galactosidase may help in reducing blood glucose level (Bouabid et al., 2018). Before the therapeutic use of insulin, the main recommended treatment was diet therapy with the utilization of traditional remedies derived mainly from plants. Vilhena et al. (2020) reported that after 15 days of treatment with aqueous extract of *Musa paradisiaca* (200 mg/kg), all streptozotocin (STZ)-induced diabetic rats treated with extracts and fractions of *M. paradisiaca* had shown a significant reduction in fasting glycemia compared to the rats of the untreated diabetic group.

Besides that, Ramu et al. (2017) also revealed that the ethanol extract of banana blossom (EF) had exhibited dose-dependent inhibition of maltase, sucrase and p-nitrophenyl-beta-D-glucopyranoside (pNPG) hydrolysis of rat intestine with IC_{50} values of 25.54±0.10, 18.76±0.22 and 76.42±1.12 µg/mL, respectively. Oral administration of 100 to 200 mg/kg b. wt. of the blossom ethanol extract in both normal and alloxan-induced diabetic rats also notably enhanced the maltose/glucose-induced postprandial hyperglycemia. Besides that, this study also found that EF, Umbelliferone (C1) and Lupeol (C2) stimulated glucose uptake and secretion of dose-dependent glucose-induced insulin at glucose concentrations of 4.5 and 16.7 mM. Thus, it can be concluded that banana flower extract inhibits α-glucosidases and enhance the uptake of glucose and insulin secretion.

Marikkar et al. (2016) also reported that the ethanolic extract of *Musa sp.* blossoms had anti-amylase and anti-glucosidase activities ranging from 47.31 to 62.58% and 74.98 to 91.62%, respectively. As these enzyme activities are reduced, the blood glucose level would also decrease. From another study by Liyanage et al. (2016), it was found that the serum glucose in CDB (diets containing 0.5% cholesterol with 21% banana blossom powder) Wistar rats fed group was lower compared to the other two groups, CD (diets containing 0.5% cholesterol) and CN (basal diet of casein) fed groups.

These can be further supported by the study from Ramu et al. (2016) that a group of alloxan-induced diabetic rats that were administered with Umbelliferone (C1) and Lupeol (C2) isolated from ethanol extract of banana flower (EF) (100 and 200 mg/kg b. wt.) once daily for 4 weeks indicated a significant reduction of diabetic symptoms, such as polydipsia, polyuria, polyphagia, and urine sugar, with enhanced body weight. The level of HbA1c also decreased while levels of hemoglobin and insulin increased.

Anti-inflammatory

Banana blossoms are also able to exhibit inhibitory effects against various inflammatory mediators, such as NOX, IL-6, IL-1β and TNF-α of cytokine secretion (Sandjo et al., 2019). The inhibition of these mediators is significant in reducing the inflammation effects that can lead to many health problems.

To evaluate this anti-inflammatory property, Sandjo et al. (2019) had conducted a study where four fractions of crude bract and blossom extracts were partitioned in n-butanol and dichloromethane (BDCM, BNBU, FDCM, and FNBU). This study found that FDCM (blossom extract partitioned in dichloromethane) inhibited IL-1, TNF-α, and IL-6 and exhibited promising anti-inflammatory activity; while BDCM (crude bract extract partitioned in dichloromethane) showed significant inhibition of TNF-α secretion. Furthermore, BNBU (crude bract extract partitioned in n-butanol) was also effective in inhibiting IL-6 and NOX. So, it can be postulated that all fractions of banana blossom exhibited anti-inflammatory activity against at least one type of inflammatory mediator except for FNBU (blossom extract partitioned in n-butanol); and can be utilized to control inflammatory-related diseases effectively.

Besides that, Liu et al. (2018) reported that the banana blossom water extract had markedly repressed the production of prostaglandin E2 (PGE2), a formidable inflammatory mediator. The banana blossom extract also inhibited the cyclo-oxygenase-2 (COX2) expression, an enzyme producing PGE2 during inflammation. A report by Divya et al. (2016) also revealed that 10 mg/mL of the aqueous extract of banana blossom was found to stabilize the red blood cell (RBC) membrane up to 92.24%. So, it could be presumed that this banana blossom extract may also stabilize the lysosomal membranes and may likely suppress the inflammatory response.

Antimicrobial

Banana blossoms also express antimicrobial activity, where it is known to inhibit the growth of several Gram-positive and Gram-negative bacterial strains. A study by Sartika et al. (2019) reported that at a concentration of 100% of methanolic extract of Muli banana blossom against *Escherichia coli*, the biggest diameter of inhibition (5.63 mm) was observed, compared to other concentrations of 80% (4.68 mm), 60% (3.82 mm), 40% (3.48 mm) and 20% (1.99 mm). Whereas, for 0% concentration, there was no inhibition zone observed. Thus, based on these findings, the banana blossom extract was characterized to have medium anti-bacterial activity against the tested organism, *E. coli*.

However, the values were considerably lower compared to a study by Sitthiya et al. (2018) that showed significant antimicrobial activity observed when the banana blossom alkaline extract was tested against Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Escherichia coli*) bacteria. At lower extract concentrations (5 and 10 mg/mL), *S. aureus* was more sensitive to the alkaline extract compared to *E. coli*. For *E. coli*, there was no zone of inhibition observed at extract concentrations of 5 and 10 mg/mL. Whereas, at the concentration of 25 mg/mL, the extract was effective against *E. coli* with a diameter of inhibition of 14.30±1.83 mm. As for *S. aureus*, the extract concentration of 5, 10 and 25 mg/mL exhibited a diameter of inhibition of 8.84±0.21 mm, 11.64±1.06 mm and 12.70±0.56 mm, respectively.

These values were also similar to the findings reported by Tin et al. (2015), that the methanolic extract of the blossom exhibited significant inhibition against all Gram-positive bacteria (*Staphylococcus aureus*, *Listeria monocytogenes*, *Bacillus cereus*, and *Brochothrix thermosphacta*) tested with the range of 12.56 to 13.54 mm. This study also reported the extraction parameters that have been found to significantly affect the antibacterial activity of the banana blossom extracts, which were the sample-to-solvent ratio, temperature and extraction period, and methanol-to-solvent ratio. The preparation and extraction methods and parameters that can exhibit optimum antibacterial activity were 50°C of dried sample, methanolic extract, sample-to-solvent ratio of 1:10 v/w, and 3-hour extraction period.

4. CONCLUSION

In conclusion, the presence of phytochemicals, such as phenolics, flavonoids, dietary fibers, tannins, saponins and vitamins in the banana blossom extracts had contributed to the various beneficial properties of the plant, such as antioxidant, anti-hyperglycemic, anti-inflammatory, and antimicrobial; and many other potentials that are yet to be explored. Further studies on the quantitative analysis of bioactive compounds and other significant medicinal benefits of banana blossom can be explored more to expand the knowledge of this functional food, besides providing new approaches that can help to improve and prevent various medical conditions.

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