ABSTRACT
Banana blossom or banana male bud are other names for banana flower. It is a substantial dark maroon blossom that grows from the end of a bunch of bananas. Since the flower is a rich source of a class of bioactive compounds, including alkaloids, flavonoids, tannins, vitamins, minerals and phenolic compounds. These pretty flower can be eaten incorporate of different type of food products like –chocolate, cookies, because this type food products shelf life long lasting. In this study, the antioxidant and anti-hyperglycemic properties of banana flower from six different Malaysian cultivars –namely, pisang Abu (Musa balbisiana cv p. Abu), pisang Berangan (Musa acuminata cv p. Berangan), pisang Nipah (Musa balbisiana cv p. Nipah), pisang susu (Musa acuminata cv p. Mas). The flower’s functional characteristics, such as bulk density, oil and water holding capacity, swelling power, and solubility, were also examined. The flower’s low bulk density revealed that banana flower power could be added to a variety of foods to boost their antioxidant and fibre content. Banana flower many or health benefits prevent diabetes, lower menstrual bleeding, increase the milk production for lactating women, good for gastrointestinal health, helpful in weight loss, prevent ulcer, constipation.

KEYWORDS: Banana flower, Diabetes mellitus, chocolate, antioxidants, nutritional properties, Fiber rich, whole milk.

INTRODUCTION
The increase in population worldwide has given rise to the demand for conventional food products majorly byproducts of fruits and vegetables which are usually discarded as waste but are good source of nutrients including various bioactive compounds which work as antioxidants to fight the oxidative stress produced in the body. Bananas are popularly
consumed fruit which are grown in almost every country in the world especially in the tropical and subtropical countries. Global production of banana grew at a compound annual rate of 3.2%, reaching a record of 114 million tones in 2017. The biggest producer is India, which produced 29 million tones year on an average between 2010 and 2017, followed by China at 11 million tones on an average per year (FAOSTAT, 2017).[1] Lots of banana flowers are produced. The flowers are large, pointed and crimson colored with some yellow and others being pink (Ambrose, 2018).[2] Taste of the flower is crunchy, nutty and starchy. The color ranges from orange to purple and the florets inside are either white or pale yellow in color (Catherine, 2019).[3] Flowers are waste material produced during crop production but has good nutritional profile. According to a study (Preethi and Balakrishnamurthy, 2011).[4] 300 kgs of banana bracts are produced as residues during per hectare harvesting of banana fruits of banana flowers are produced. The flowers are large, pointed and crimson colored with some yellow and others being pink (Ambrose, 2018).[5] Medicinal properties beneficial to mankind. Because of the protective action against food spoilage, green banana leaves are commonly used in Malaysia and Indonesia for wrapping up of a popular breakfast food known as nasi lemak. The fiber extracted from the banana pseudostem has been used in different applications. The plant sap can be applied externally to soothe the pain of stings and bites. Roots are also known for medicinal applications. Kumar et al. (2012).[6] The flower of banana tree is also a popular vegetable among the people living in countries such as Malaysia, Philippines, Indonesia, and Si Lanka. It is usually red or purple red in color and attached to the end of the banana fruit bunch. In the red or purple red bracts, lots of small whitish flowers, which would turn into the mature edible banana fruit could be found. In Malaysia, banana flower is cooked to serve in preparing different types of cuisines. Apart from its food uses, banana flowers are also believed to possess some medicinal properties.[7]

FLOWER PROFILE
SCIENTIFIC CLASSIFICATION

Kingdom: plantae
Class: Liliopsida
Clade: Tracheophytes, Angiosperms, Monocots, commelinids
Order: zingiberales
Family: Musaceae
Genus: Musa
Species: M. ornata

CHEMICAL CONSTITUENTS

The chemical composition of banana fiber is cellulose, hemicelluloses, and lignin. It is highly strong fiber. It has smaller elongation. It has somewhat shiny appearance depending upon the extraction and spinning process. The crude fat, crude fibre, crude protein, ash, carbohydrates, and dry matter content of banana blossoms were 6.54, 23.71, 12.58, 18.30, 34.36, and 65.49% respectively. Antioxidant activity of banana blossom was 21.02+0.31 and the value was expressed as IC50 values (ppm) against the corresponding standard ascorbic acid.

USES

i. NUTRITIONAL IMPORTANCE

Banana flower is considered as an agricultural by-product which is often consumed by many countries. It is a highly nutritious edible flower which has been estimated for various nutritional components worldwide. The flowers are dipped into the concentration of citric acid and salt solution for varied period of time to prevent browning and thereafter are used for further estimations (Singh, 2017).

The nutritional components of the flower has been repeatedly estimated such as moisture, ash, protein, fiber and carbohydrates (Krishnan, 2016), (Elaveniya et al., 2014) (Olusegun and Eniade, 2014) using different standard methods which states that the flower is a rich source of fiber (70%), carbohydrates (53.78%) and Protein (19.60%) (Ramu et al., 2017).

ii. GIT

Being a rich source of fiber, Banana flower and its parts helps in reducing ulcers, improving bowel movements and thus maintaining the gut health (Anderson, 2009). Blossoms are found to be rich in various minerals including potassium, sodium, phosphorous, calcium,
magnesium, iron and zinc (Sheng et al., 2017)\textsuperscript{[14]} and Elaveniya et al., 2014).\textsuperscript{[15]} Mineral analysis by a study revealed that the flower is rich in macro and micro minerals in the order of K>Ca>Mg>P>Na (Ramu et al., 2017).\textsuperscript{[16]}

**ANTIMICROBIAL ACTIVITY**

According to a study conducted by Ramu et al., (2015)\textsuperscript{[17]} the extract of banana flower is a rich source of saponins, terpenoids, flavanoids, coumarins, cardiac glycosides and steroids. The extract also posses antimicrobial activity thus is a new source of nutraceutical.\textsuperscript{[18]}

**DIABETES**

Diabetes mellitus is a chronic metabolic disorder caused due to insulin deficiency or insulin resistance. In Type 1 diabetes autoimmune destruction of the beta cells of pancreas leads to insulin deficiency. Type 2 diabetes involves insulin resistance or decreased insulin secretion. Insulin is essential for maintaining blood glucose and regulating carbohydrate metabolism. Insulin receptor (IR) is a tetrameric protein consisting of two extracellular alpha subunits and two transmembrane beta subunits.\textsuperscript{[19]} The binding of insulin to alpha subunit of IR causes conformational changes in the receptor leading to the activation of tyrosine kinase beta subunit. The activated IR has the ability to autophosphorylate and phosphophorylate intracellular substrates that are essential for initiating other cellular responses of insulin.\textsuperscript{[20-22]} These events lead to the activation of downstream signaling molecules that participate in the insulin signaling pathway.\textsuperscript{[23]} Insulin signaling, including activation of IR tyrosine kinase activity, is impaired in most patients with diabetes mellitus. This resistance to insulin then leads to hyperglycemia and other metabolic abnormalities of the disease.\textsuperscript{[24,25]} Hence, compounds that augment insulin tyrosine kinase activity would be useful in the treatment of diabetes mellitus.

Bio-flavonoids are well-known for their multi-directional biological activities including anti-diabetic efficacy. The flavonoids, ubiquitous in plants, are the largest class of polyphenols, with a common structure of diphenylpropanes (C6-C3-C6), consisting of two aromatic rings linked through three carbons. The six major subclasses of flavonoids include the flavones (e.g. apigenin, luteolin), flavonols (e.g. quercetin, myricetin), flavanones (e.g. naringenin and hesperitin), flavanols (or catechins) (e.g. epicatechin and gallocatechin), anthocyanidins (e.g. cyanidin and pelargonidin) and isoflavones (e.g. genistein and daidezin).\textsuperscript{[26]} It has been demonstrated that flavonoids can act per se as insulin secretagogues or insulin mimetics, by influencing the pleiotropic mechanisms.\textsuperscript{[27]}
Musa sapientum commonly known as ‘banana’ is widely used in Indian folk medicine for the treatment of diabetes mellitus.\textsuperscript{[28]} The available literature confirms that flavonoids are present in banana flowers\textsuperscript{[29]} The chloroform, water and ethanol extract of Musa sapientum flowers were found to exhibit hypoglycaemic activity in alloxan diabetic rat.\textsuperscript{[30]} Intraperitoneal administration of prunin (naringenin 7-O-β-D-glucoside) produces a significant hypoglycemic effect in diabetic rats.\textsuperscript{[31]} Chronic treatment with hesperitin and naringenin was found to lower the blood glucose level of db/db mice.\textsuperscript{[32]} Banana flower extracts are able to promote glucose uptake into the cells, which could be beneficial in diabetes mellitus. It can be hypothesized that consumption of nutraceutical-rich extract of banana flower could replace some amount of insulin being taken for diabetes mellitus.\textsuperscript{[33]} Although insulin has become one of the most important therapeutic agents known to medicine, there is a continuing effort to find insulin substitutes, secretagogues, or sensitizers from synthetic or plant sources for the treatment of diabetes mellitus.\textsuperscript{[34]} In the present study we have attempted to dock the banana flower flavonoids with insulin receptor tyrosine kinase to understand the interactions. This insilico approach can be further investigated to generate more effective and potential insulin receptor tyrosine kinase activators through ligand based drug designing approaches.

MATERIALS AND METHODS

Crop culture
The M. acuminata “Williams” cultivar was selected for this study. Banana crops were planted in the field in an area of approximately 2.3 hm\textsuperscript{2} located in Tianbao Town, Zhangzhou City (23˚34’53" N, 117˚32’14" E). Banana plants were grown in a deep-furrow border-check system (4.0–4.5 m in border-check width, 0.5–0.7 m in furrow width, 0.4–0.6 m in depth). The spacing of individual plants was 2.0–2.5 m, and the height of plants varied from 2.0–2.5 m.

Classification lopmental stages
The developmental stages of banana in Tianbao Town were classified as seedling stage (fifty days from planting in the field), vigorous growth stage (sixty days), flower bud burst stage (sixty days), formation of fruits stage (forty days), fruit development stage (sixty days) and harvest stage (thirty days) (Fig 1).
**Sampling method**
Twenty 40-day-old seedling plants were selected for tissue culture, randomly sampled in a "Z" pattern and labeled for observation at 10-day intervals. The damage rate of plants was recorded in all the plant tissues (stems, leaves, flower buds, and fruits) during the whole growth period.

**Population dynamics of thrips**
The twenty selected banana plants mentioned above were investigated, and the population dynamics of banana flower thrips were analyzed as described by.[19] Bamboo poles (1.7 m high) used to hang yellow sticky traps (29.7 cm × 21 cm) were stuck into the earth, 50 cm away from the sampled plants. The sticky traps were 1.5 m above the ground. The number of thrips on each sticky trap was recorded every 10 days using a 40× magnifier. The sticky traps were replaced every 10 days. This experiment was repeated 3 times.

**Preference of thrips for different tissues**
Ten thirty-day-old thrips-free inflorescences (3 layers of young fruit) were covered with insect net (50 mesh) bags, and one hundred banana flower thrips were then transferred into each bag for twenty days. One fruit and flower bud from each layer of inflorescence on the selected banana trees were marked and collected in black transparent bags. All samples were transported to the lab immediately to assess the damage rate. All the dark spots (S1 Fig) on the surface of each sample (young fruit and flower bud) were recorded under a 20X binocular microscope (SZ760, Chongqing Optec Instrument Co., Ltd., Chongqing, China). The severity of damage to fruits and flowers was divided into four levels: L0, undamaged; L1, < 10 spots; L2, < 30 spots; and L3, > 30 spots. Thrips-free inflorescences were used as a control, and this experiment was repeated five times.

**Nutritional quality of flower buds and young fruit**
The protein, reducing sugar, crude fat, ash, vitamin C, and water contents in each sample were measured in the same layers for samples with different damage rates. The L0 samples were.
Regarded as the control (CK) and the experiment was repeat for 5 times. The protein content was determined with the method described by Kjeldah.\textsuperscript{[35]} reducing sugar content was determined using direct titration.\textsuperscript{[36]} Crude fat content was extracted using Soxhlet extraction.\textsuperscript{[37]} ash content was determined with the method described by Dinuzzo et al.\textsuperscript{[38]} vitamin C content was determined using 2,6-dichloroindophenol titration\textsuperscript{[39]} and water content was determined using direct drying.\textsuperscript{[40]}

**Procurement of banana flower**

Banana flower was procured from the local Bengali market located at C-scheme area of Jaipur city in Rajasthan. After procurement of banana flower, it was weighed using digital weighing balance. The outer bracts of the flower was weighed and discarded as it was the inedible part of the flower. The inner bracts were weighed as they were edible.

**Processing of the flower**

To prevent darkening, the flowers were immersed in various concentrations of citric acid and salt solution for varied period of time. The pre-treated flowers were dried in hot air oven for 4 hours at 50 degrees and later ground to fine powder.\textsuperscript{[41]}

**Physicochemical analysis of the flower**

The Moisture, ash, protein, fiber, fat, carbohydrate, iron, phosphorous, vitamin C, calcium, antioxidant activity and phytochemical content of the flower were analyzed. The estimations were done in triplicates.
• **Moisture content**
Oven drying method was used for the estimation of moisture content.\(^{[42]}\) 5gm of flower sample was kept in petri-plate at 60°C for 4-5 hours for drying.

• **Ash content**
Dry ashing method was used for the estimation of ash content.\(^{[42]}\) Three gram of sample was taken for ashing. Two concordant readings were taken.

• **Protein content**
Nitrogen content was estimated using Micro-Kjeldahl method (KELPLUS) which includes digestion, distillation and titration.\(^{[42]}\) The nitrogen content was then multiplied by the conversion factor 6.25 to get the protein content.

• **Crude Fiber content**
Acid-alkali wash method was used for the estimation of Crude fiber content.\(^{[42]}\) Five grams of moisture and fat free sample was taken for the estimation of fiber.

• **Fat content**
Soxhlet method was used for the estimation of fat content.\(^{[42]}\) Where di-ethyl ether was used as solvent.

• **Carbohydrate**
Carbohydrate content was assessed using difference method where moisture, protein, fat, ash and crude fiber were subtracted from 100.

• **Iron and phosphorous content**
Estimation of Iron content present in banana flower was done using Wong’s method. Colorimeter set to 570 nm was used for taking the optical density of the samples.\(^{[43]}\) Titrimetric method was used for the estimation of phosphorous where Ammonium molybdate solution was taken for the estimation.\(^{[44]}\)

• **Calcium content**
Calcium estimation was performed using titration method against potassium permanganate.\(^{[45]}\)
• **Vitamin**
Vitamin C was estimated using metaphosphoric acid by titration method where readings were taken in triplicates.\(^{[45]}\)

• **Anti-oxidant activity**
Antioxidant activity of the banana flower was estimated using DPPH where Trolox was used for the preparation of standard solution.\(^{[46]}\)

• **Phytochemicals**
Total Phenols and total flavonoids were estimated in banana flower where quercetin and Gallic acid were taken as standards respectively.\(^{[47]}\) Banana blossom was analyzed for its functional properties which included assessment of Bulk density,\(^{[48]}\) water and oil holding capacity,\(^{[49]}\) solubility index and swelling power.\(^{[50]}\)

• **Bulk density**
10gm of dried sample was taken in 100ml measuring cylinder and was tapped to a constant volume and bulk density (g/cm\(^3\)) was calculated.

• **Water holding capacity**
One gram sample was mixed with 10ml of distilled water and allowed to stand at room temperature for 30 min. Centrifugation was done at 3000rpm for 25min. Water was discarded and weight of the vial was taken using which water holding capacity is calculated.

• **Oil holding capacity**
One gram of sample was mixed with 10ml of vegetable oil in pre weighed centrifuge tube. Tube was stirred for 1 min and is allowed to stand at room temperature for 30 min. Centrifugation was done at 3000rpm for 25 min. Separated oil was removed using pipette after which the weight of the tube was taken and oil holding capacity was calculated.

• **Solubility**
One gram of sample was weighed in pre weighed centrifuge tube and was mixed with 10 ml distilled water. The tube was heated at 80° for 30 min and then was removed from bath. Later it was kept for drying at room temperature and centrifuged at 2200rpm for 15 min. The supernatant was discarded and dried residue was weighed to determine the solubility.
• **Swelling power**

Weight of the swollen sample was taken which was obtained from decanting the supernatant and weighing it.

**BANANA FLOWER UTILIZATION**

The production of banana all over the world is on quite a large scale resulting into more production of banana flowers. The flowers are available at minimal price as they are underutilized. Due to good nutritional profile of the flower it is now been used in development of different types of food products. Being rich in Iron and Fiber, banana flower together with gooseberries was used to develop a product called ‘humus’ (Anand et al., 2019),[51] biscuits were developed by dehydrating banana flower (Elaveniya et al., 2014),[52] banana flower ‘sisig’ was developed incorporating banana flower with coconut powder, onion, ginger and salt (Salvador, 2012),[53] (Sharmila et al.,)[54] 2013 developed and evaluated dark chocolate incorporating banana flower. Dried slices, flour and RTC products are developed using three varieties of banana flower viz. Nendran, Rasakadali and Palayankodan (Mahendran, 2014). Zehla in 2018[55] developed laddu incorporating banana flower and Komal (2019)[56] developed a value added product incorporating nut chocolate with banana flower. Due to the low cost and good nutritional profile the flower can be used to develop various new food products and dehydrated powders which will be helpful in ameliorating various disorders.

**HEALTH BENEFITS OF FLOWER**

Banana blossoms are rich source of various minerals and antioxidants including various bioactive compounds which helps in improving various diseases and disorders. The flower extract helps in exhibiting cytotoxic effect on BPH-1 cells hence suppressing benign prostatic hyperplasia by regulating the inflammatory response (Lin et al., 2018).[57] Due to rich in fiber and iron the blossoms helps in reducing blood sugar level and raising blood hemoglobin levels. It also help in lowering the menstrual bleeding and muscle cramps together with helping in production of milk in lactating mothers (Singh, 2015)[58] (Sumathy et al., 2011)[59] (Mehmood et al., 2012).[60] According to a study the presence of dietary fiber, unsaturated fatty acids, total saponins, vitamin E and flavanoids in banana flower it has hepatoprotective, hypocholesterolaeamic and hypoglycemic effect (Liyanage et al., 2016).[61] The flower has been used in traditional medicine to treat bronchitis, constipation and ulcer problems (Divya et al., 2016). It is also helpful in controlling obesity and diabetes (Awedem et al., 2015).[62]
Flavanoids present in banana flower act as activators of IR tyrosine kinase (Gangupati et al., 2017).\textsuperscript{[63]} A very good cytotoxic and anti-proliferative effect of banana flower extract has been reported together with its anticancer activity on cervical cancer cell line (Timsina et al., 2014).\textsuperscript{[64]} Anthocyanins present in banana flower bracts act as potential anti-cancerous compounds which helps inhibit growth of HT-29 human colon cells and HeLa cervical cancer cells (Suman et al., 2018).\textsuperscript{[65]}

**Consumption of banana flower**

The flowers of banana are been consumed in many countries including Indonesia, Thailand, Myanmar. It is considered as vegetable and is cooked in variety of dishes in India, Sri Lanka and South East Asian countries.\textsuperscript{[66]} It is exclusively included in south Indian cuisines and Bengali recipes, the Assamese community use it in a rustic and a simple way with fewer spices to make koldil bhaji and koldil mangxho\textsuperscript{[67]} The extract of banana blossom has also been used to prepare banana tea in United States\textsuperscript{[68]} Blossom is also consumed in Bangladesh as vegetable and as salad with rice and wheat bread in different countries of Asia.\textsuperscript{[69]}

**RESULTS AND DISCUSSION**

Banana flower is a nutritionally rich edible byproduct of banana which can be consumed as vegetable. The flower is rich in fiber and various bioactive compounds. Present study was done to assess nutritional composition and functional properties of banana flower, so that it can be incorporated in the diet in various forms for better health.

**Physicochemical properties of banana flower**

The physicochemical composition of Banana flower was assessed. Moisture content was reported to be 71.516 g/100g. Sheng\textsuperscript{[70]} also reported slightly high moisture content of 89.42 g/100g in banana flower. The ash content of the flower was estimated to be 3.58 g/100g which was close to the value of 3.5% as reported by Elaveniya.\textsuperscript{[71]} Fiber content was found to be 12.38 g/100g which indicated flowers can be consumed as dietary fiber supplements. The fat content of the flower was estimated to be 4.501 g/100 which was close to 6.54% as assessed by Liyanage.\textsuperscript{[72]} Protein content of banana flower was found to be 5.639 g/100g. According to a study by Florent et al.\textsuperscript{[73]} flower has a good protein quality and high levels of unsaturated fatty acids especially linoleic and gamma-linolenic acids. Carbohydrate content of the flower was calculated to be 2.64 g/100g. Iron and phosphorous content of the banana flower were found to be negligible. Calcium content of banana flower was estimated to be 60.2 mg/100g. As per the study conducted by Sheng et al.\textsuperscript{[74]} banana flower was found to
have 56 mg/100g of calcium. Antioxidant activity of the flower was estimated using DPPH methods and was found to be 11.44 mg/TAE/100g which shows that the flower is a good source of antioxidants. Vitamin C content of banana flower was found to be 38 mg/100mg. The total phenol content was estimated and was expressed as gallic acid equivalents which was 96.155mg GAE/100g and total flavonoids was 137.585mg QUE/100g, which was expressed as quercetin equivalent.

Table 1: Nutritional composition of banana flower.

<table>
<thead>
<tr>
<th>Proximate parameter</th>
<th>Amount (g/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>71.516 ± 1.007</td>
</tr>
<tr>
<td>Ash</td>
<td>3.58 ± 0.531</td>
</tr>
<tr>
<td>Fiber</td>
<td>12.379 ± 0.951</td>
</tr>
<tr>
<td>Fat</td>
<td>4.502 ± 0.555</td>
</tr>
<tr>
<td>Protein</td>
<td>5.639 ± 0.292</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>2.64 ± 0.726</td>
</tr>
<tr>
<td>Mineral (mg/100g)</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>-</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>-</td>
</tr>
<tr>
<td>Calcium</td>
<td>60.2mg</td>
</tr>
</tbody>
</table>

Antioxidant activity

| DPPH                | 11.44 mg/TAE/100g |
| Vitamin C           | 38mg              |

Phytochemicals

| Total phenols       | 96.155mg GAE/100g |
| Total flavonoids    | 137.585mg QUE/100g |

Functional properties of banana flower

Functional properties of the banana flower are represented in (Table 2). Bulk density of banana flower was found to be 0.606g/cm3. Bulk density is the measure of heaviness of powder which determines the ease of packaging and transportation, also low bulk density of a powder states its good quality for development of different products. The sample was also estimated for oil and water holding capacity According to some researches solubility is an indicator of its quality.\cite{75} High solubility suggested that it is digestible and can be considered for the development of food products.

Table 2: Functional properties of banana flower.

<table>
<thead>
<tr>
<th>Functional parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk density (g/cm3)</td>
<td>0.60</td>
</tr>
<tr>
<td>Oil holding capacity (g/g)</td>
<td>0.17</td>
</tr>
<tr>
<td>Water holding capacity (g/g)</td>
<td>0.89</td>
</tr>
</tbody>
</table>
CONCLUSION

Banana is produced and consumed worldwide which leads to the production of its byproduct i.e. banana blossom to a large scale. This banana blossom possesses a very high nutritional profile and is known for its therapeutic properties; hence by introducing proper utilization and consumption methods, may be in the form of new product development, and then it would be helpful in combating the risk of various diseases and disorders. The banana flower is an underutilized byproduct of Banana plant but possess a good proximate profile as reported in the present study. The flower is found to be good in dietary fiber which is an important nutrient as it relieves constipation, lowers the cholesterol level, helps in weight reduction, helps in controlling blood sugar levels and maintains good bowel health by acting as prebiotics. Besides, the high dietary fiber content, it possesses good antioxidant profile also, so, from the present study it is concluded that banana flower can be incorporated in the diet 2022 Res. Jr. of Agril. Sci. (Nov-Dec) 12(6): 2020–2023 CARAS for better health. The low bulk density of the banana flower indicates that it can be used for the development of various food products and beverages.

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