Research Article

Physicochemical, nutritional, bioactive compounds and fatty acid profiling of Pumpkin flower (*Cucurbita maxima*), as a potential functional food

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Abstract
The edible flowers and its several products gaining its importance as functional food. Pumpkin flower mainly consumed in India and Mexico but due to lack of scientific research there is a neophobia among people. The objective of the paper is to analyse the physicochemical, biochemical properties, proximate analysis, antioxidant activities, anthocyanin content and fatty acid profiling. The fresh pumpkin flower was having an average moisture content of 85% (wb) with a dimension of 90 × 51 x 22 mm (l x w x t). The (L, a*, b*) value signifies the bright yellow color having gumminess (26 g) and chewiness (4.70 mJ). In this study the nutritional properties of the pumpkin flower were also determined and significant amount of Sodium (11.5 mg/100 g), Potassium (18.2 mg/100 g), Calcium (17.6 mg/100 g), phenol (17.39 µg/ml), flavonoid (17.13 µg/ml), antioxidant (51.65%DPPH) and anthocyanin (10.3 mg/100 g) was present. Among several fatty acids' oleic acid (21%), myristic acid (15.99%) and stearic acid (15.19%) was maximum. The presence of several phytonutrients and fatty acids makes pumpkin flower a potential source of functional food in near future.

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Graphical abstract

Keywords Pumkin flower · Edible flower · Fatty acid · Phytonutrients · Antioxidant properties

1 Introduction

There is a change in the food habit of the consumer for the last decade. Now a days, the consumers are more attracted towards the micronutrient's rich food [1]. Due to this change in food habit, edible flowers are getting importance in the global market [2]. There are several flowers which are considered as edible flower such as Calendula, Borage, Snapdragon etc. [3]. Pumpkin flower also considered as one of the traditional edible flowers in Mexico, India and different parts of USA.

Pumpkin belongs to the *cucurbita* genus and *Cucurbitaceae* family. There are several varieties of *cucurbita* present through the worldwide. In the plant kingdom, the family is one of the largest edible plant species. The origin of the plant was in Mexico and then spread all over the world. According to the FAOSTAT production of pumpkin in India was estimated over 5.1 million tons for the year 2017–2018. India and China had a share of 47% of the total pumpkin production. The plant is creeping plant and can grow throughout the year from sea level to high altitude [4]. The plant is mainly famous for its fruit and seed but the flower also used as a consumable part [5]. Almost every part of the plant is popularly consumed in the rural communities. It is a high yield vegetable, inexpensive and easy to grow. The popularity of pumpkin flower increases as it is a cost effective and nutrient rich source.

The difference between male and female flowers are clearly significant, with a presence of 3–5 cm long ovoid ovary. Male flowers are generally long and pedicellate [4]. Male flowers generally emerged after 11–14 weeks of plantation whereas female flower took more 4 weeks to grow. Male flowers borne straight off the vine whereas, females grew near the stem. The flowers are bright in color and having a sweet scent and nectar inside. Itokawa et al., had reported that the flower of *cucurbita pepo* had 2 new glycosides i.e. rhamnazin 3 – rutinoside and isorhamnetin–3 retinoside–4–rhamnoside [6].

Some of the most popular products from cucurbita genus are Zucchini and Squash [7]. The pumpkin flower is consumed as several dishes such as Flores De Calabaza in Mexico, Classic stuffed peppers in West America, Pakoda or Vajji in India. The flowers can be consumed as raw in salads, otherwise cooked with other vegetables, and steamed in soups. Canned blossoms are also available in the local Mexican markets but always the fresh blossoms are preferred for the consumption. Traditionally the flower is used as a remedy of mainly for cold, male infertility, eye problems, bone formation. The flower can improve antioxidation, immune function and biological activities of the human body. Overall, the

flower is used to increase the immunity of the human system. The fruit and the seed of pumpkin have antidiabetic [8] and anticarcinogenic properties [9]. The fruit is also rich in antioxidant and fibre content [10]. Presence of high amount of carotenoids, saponins, minerals and several phytochemicals makes it as a modern tool for antibacterial, antihypertensive, antitumor, anti-inflammatory, anti-hypercholesterolemia [11]. But there is no research regarding the pumpkin blossoms.

There is a huge number of research available on different pumpkin fruit varieties and seeds however no data are available related to the studies on pumpkin flowers. Neophobia (to try new novel food) regarding direct consumption of pumpkin flower is observed mainly in children and the youth. Proper scientific knowledge of physical, mechanical, thermal and textural properties will help to design and develop new equipments for sorting, sizing, grading, cutting etc. The physicochemical and biochemical properties will be helpful for future research. So, the objectives of this study are to determine the physicochemical, nutritional properties as well as the fatty acid profiling of different solution for pumpkin flower.

2 Materials and methods

Pumpkin blossoms (*Cucurbita maxima*) (Ambili variety) were harvested from the agriculture fields of Guntur District, Andhra Pradesh, India in the month of January. The nodes of the flowers were sampled in a random manner after one day of blossom. The blossoms were picked in the early morning, perforated plastic bags were used to store it and transported to the laboratory within 3–4 h. For the experimental purpose, the sorting was done to identify good quality male blossoms with uniform size, colour and without defects. Physical parameters of the flower were determined with fresh flowers. Flower petals only used for experimental purpose. Pollens had been removed separately. Remaining pumpkin blossoms were dried in hot air oven for further chemical analysis (Fig.1).

2.1 Physical parameters:

Various physical properties like length (l); width (w); thickness (t); mass (m); surface area (SA); geometric mean diameter (g_d); arithmetic mean diameter (a_d); volume (v); bulk density (BD) and yield has been calculated.

The length (l), breadth (w), and thickness (t) of the blossom has been measured in terms of millimetre (mm) by using Digital Vernier Callipers (Zhart Electronics, India, least count = 0.1 mm) [12]. Individual flower weight was measured using digital weighing balance (Indosaw Private Limited, Ambala, India) and expressed in g. 100 flowers were used to measure the mass of the product. Projected surface area of the blossom has been measured by using graphical method and expressed in cm^2 [13]. Volume of the blossom has been measured by fluid displacement method and expressed in cm^3. Arithmetic mean Diameter (a_d), Geometric mean diameter (g_d), Bulk density (BD) were determined by the following Eqs. (1–3).

$$a_d = \frac{l + w + t}{3} \tag{1}$$

$$g_d = (l * w * t)^{1/3} \tag{2}$$

$$BD = \frac{m}{v'} \tag{3}$$

where m represents mass of the blossom and v′ represents volume of blossom.

Randomly 50 flowers were selected to measure the consumable part and the wastage from the flower. In case of pumpkin flower, the sepal and the stem attached with the flower were considered as wastage. The edible portion of the flower was calculated as ratio of the weight of the consumable part to the flower by the weight of the whole flower.

2.2 Thermal properties

To account the thermal properties of the pumpkin blossoms the properties such as specific heat (Cp); thermal diffusivity ($\propto$) and thermal conductivity (K) were calculated with the help of moisture content considering the blossom moisture content should be greater than 60% [14]. Equations 4–6 were used to measure thermal properties of the flower. Thermal conductivity (K), Specific heat (Cp), and Thermal diffusivity ($\propto$) were determined by the following equations.

$$Cp = 1.675 + 0.025\ M \tag{4}$$

$$K = 0.148 + 0.0049\ M \tag{5}$$

$$\propto = \frac{K}{\rho Cp} \tag{6}$$

where Cp represents the specific heat (KJ/kg °C); K represents thermal conductivity (J/ms °C); M represents moisture content (%); $\propto$ represents the thermal diffusivity ($\times 10^{-7}$ m^2/ s); ρ represents true density Cp represents the specific heat capacity (KJ/kg °C).

(a)

(b)

Fig.1 **a** Female and male Pumpkin flower **b** Male pumpkin flower used for experimental purpose

2.3 Color characteristics

Hunter Lab Colorimeter (Color Flex EZ, Hunter Lab, Virginia, USA) was used to determine the color values of the blossom. Lightness to darkness (100–0) was determined by L value, a represents red (+ ve) and green (–ve) color and b denotes yellow (positive) and blue (negative). The chroma (C) value and hue angle (h) was determined by the Eqs. 7 and 8 respectively [13]. Chroma value was used for determining the purity of the color whereas hue value used for appearance of the color.

$$C = \sqrt{a^2 + b^2} \tag{7}$$

$$h = tan^{-1}\left(\frac{b}{a}\right) \tag{8}$$

2.4 Textural properties

The textural properties of pumpkin flower were determined with the help of texture analyser (CT3, Brookfield, Middleboro, USA) with stainless steel probe (cylindrical, 6 mm) with a product distance of 3 mm. The sample resistance was represented and measured in Newton. The software Texture pro CT installed with the system was used to determine the adhesiveness, resilience, stringiness, springiness, gumminess and chewiness of the flower [15].

2.5 Chemical properties

Different proximate analysis (moisture, ash, fat, protein, fibre, carbohydrate) of the fresh flower was determined as per the standard procedure given below. The moisture content of the flower was determined by gravimetric method using hot air oven at 60 °C for 7 h until it reaches constant weight [16]. The ash content of the blossom was determined using muffle furnace at 550 °C for 5 h time [16]. The fat content of the flower was measured by using the completely dried samples and extracted by using petroleum ether as solvent in Soxhlet apparatus. Protein content was determined by Kjeldhal method (Kel plus, Pelican Equipment, India) and converting it to nitrogen factor by multiplying with 6.25 as given by [16]. Crude fibre present in the blossom was estimated by Fibra Plus (FES 2 R TS, Pelican Equipment, India), Fibre extraction system [15]. Carbohydrate content was measured by finding the difference of the main constituents (fat, protein, fibre, ash) from 100%. Total sugar content of the flower was estimated by Lane and Yane method using Fehling A and Fehling B solution [15]. pH and total solid was determined by pH meter and digital refractometer.

2.6 Mineral analysis

Sodium, Potassium and Calcium present in the pumpkin flower were determined by Atomic Emission Spectrometer (Agilent 4100 MP-AES system, USA) against respective standards and the results were expressed as mg/100 g [15, 16]. Minerals present (Cu, Mg, S, Fe, P) in the pumpkin flower has been estimated by ICP-OES (Inductively coupled plasma—optical emission spectrometry) (Shimadzu, Japan). The amount of Cu, Mg, S, Fe, P in the flower material sample has been calculated taking into account the dilution factor [17].

2.7 Phytochemical screening analysis

As there was no scientific data available till now for the pumpkin flower phyto-chemicals, pumpkin flowers have been investigated initially by screening methods using 4 different solvents mainly hexane, ethyl acetate, methanol and water (aqueous) [18, 19].

2.7.1 Tests for alkaloids

Pumpkin flower extracts were separately treated with drops of hydrochloric acid (diluted) and filter. Hagner's test, Mayer's test, Dragendorff's test and Wagner's test were performed to check the presence of alkaloids.

2.7.2 Anthraquinones (Borntgers Test)

A dry test tube containing chloroform was used with 0.5 g of flower extract, shaken for 5 min and filtered. Equal volume (10%) ammonia solution was added. Positive results were indicated by pink violet or red colour in the ammoniacal layer.

2.7.3 Test for Flavonoids

Ferric chloride test: To alcoholic extract, few drops of neutral ferric chloride solution has been added, blackish red colour. Lead acetate test, Shinda's test, Zinc-hydrochloric acid test, and NaOH test were performed for the confirmation of flavonoids.

2.7.4 Test for Glycosides

The extracts were separately hydrolysed with hydrochloric acid (dilute) for few hours in a water bath and then Libermann-Burchard's test, Legal test and Bomtrager's test were performed for the presence of glycosides in the flower.

2.7.5 Test for Phenolic Compounds

Gelatin test and Ferric chloride test were performed for the confirmation of the phenolic compounds in the flower extract.

2.7.6 Test for Phytosterols

Alcoholic potassium hydroxide was used to reflux the extract until saponification. Then it was diluted with distilled water. The mixture was extracted with ether and evaporated. The residue was used to perform Libermann-Burchard's test and Salkowski test.

2.7.7 Test for Saponins

Foam test and Haemolysis test were performed to check the content of saponin.

2.7.8 Terpenoids

5 ml of the flower extract was mixed with 2 ml of chloroform and H_2S0_4 (concentrated) to make a layer. The presence of terpenoids was indicated by the formation of reddish-brown color interface.

2.7.9 Phlobatanins

0.5 g flower extract was dissolved in distilled water. The mixture was filtrate and boiled with HCl (2%). Presence of phlobatanins was confirmed by the formation of red precipitate.

2.7.10 Cardiac glycoside (Keller-Killani Test) test

2 ml of chloroform and sulphuric acid mix was added to the flower extract. Presence of cardiac glycoside was confirmed by the formation of brown ring at interphase.

2.8 Phenolic compound

Folin-Ciocalteu method was used to determine the total phenolic content of the flower where Gallic acid was used as standard [13]. For phenolic extract quantification, aqueous and methanolic extract was used. UV/Visible Spectrophotometer (Shimadzu, Japan) was used to measure the absorbance at 650 nm and the results were expressed as mg of gallic acid equivalent per gram of dry weight.

2.9 Flavonoid compound

Aluminium chloride colorimetric method was used to determine the total flavonoid content of aqueous extract of the flower as Quercetin as standard [20]. The spectrophotometric method (Shimadzu, Japan) was used at an absorbance of 510 nm and the result was expressed as mg Quercetin equivalent per gram of dry weight.

2.10 Alkaloid content

The total alkaloid content in pumpkin flower was determined by Spectrophotometric (Shimadzu, Japan) method. The aqueous and methanolic extract was used to determine the alkaloid content [21]. 2 N HCl was added to 1 ml of flower extract and filtered. The absorbance was determined at 470 nm for test and standard solutions using spectrophotometer. The result of alkaloid content has been expressed as mg of AE/g of extract**.**

2.11 Antioxidant activity

2.11.1 DPPH method

Antioxidant activity was determined spectrophotometrically with a slight modification of the method given by Al-Duais et al. [22]. Dried pumpkin flower (0.3 g) was added with 80% methanol (10 ml) and sonicated for 5 min. Whatman filter paper number 41 was used to filter the extract. The experiments were performed in dark area having a blank of 120 µm DPPH (160 µl) and 80% methanol (200 µl). After 30 min of reaction time the absorbance (515 nm) was measured. The percentage of inhabitation was determined by the given equation

$$\%\ inhibition = \frac{(Absorbance\ of\ the\ control - Absorbance\ of\ the\ sample)}{Absorbance\ of\ the\ control} * 100 \quad (9)$$

2.11.2 FRAP method-

Pumpkin flowers (1 g) were extracted with the help of 10 ml of 80% methanol and 1% HCl keeping at 4 °C for 12 h. The Ferric ion reducing antioxidant power was measured with slight modification (the incubation time and temperature for the sample was 20 min for 40 °C) by the method given by Pellegrini et al. [23]. The results were expressed as mmol $FeSO_4$/100 g FW. $FeSO_4$ was for calibration curve.

2.12 Anthocyanin content

Methanolic extract of pumpkin flowers was used to determine the total anthocyanin of pumpkin flower. Spectrophometric method was used to determine the anthocyanin content. The absorbance of the flower extract was measured at 535 nm. Cyanidin–3–glucoside was used as the standard reference and the result were expressed as mg cyn–3–glu eq./100 g FW [24].

2.13 Total carotenoid content

Total carotenoid contents were determined from 10 g fresh pumpkin flowers with a mixture of methanol/ethyl acetate/petroleum ether (1:1:1, v/v/v) containing BHT (antioxidant) and calcium carbonate. The total carotenoid content was estimated spectrophotometrically at 450 nm [20].

2.14 Fatty acid profiling

Fatty acid profiling has been done by gas chromatographic method. The GC equipment consisted of an FID (Flame Ionized Detector) HEWLETT PACKARD (HP) 5890 SERIES II Gas Chromatograph. It was used for fatty acid separation [25]. Hamilton manual syringe was used for sample injection and separation was performed on Agilent HP 50 + Capillary column (30 m length, 0.32ID mm, 0.25 µm Film). The isolation and transmethylation process was carried out with slight modification of the process given by Contarini et al. [25]. 50 g of dried flower was weighed and heated with a mixture of methanol, tetrahydrofuran, heptane, 2,2–dimethoxypropane and sulphuric acid (37:20:36:5:2). Simultaneous digestion and lipid transmethylation took place in a single phase at 80 °C.

Hydrogen was used as a mobile phase where the flow rate of it was 2 ml/min. The stationary phase or column used for the separation was Agilent HP 50 + Capillary column (30 m length, 0.32ID mm, 0.25 µm Film). The column temperature with gradient mode of separation was employed where the total run time of 25 min was employed with an initial temperature of 4 °C for 4 min which was made to raise to a temperature from 150 °C at a rate of 25 °C/min with a holding time of 1 min and then to a temperature of 220 °C at a rate of 4 °C/min with a holding time of 5 min and finally to a temperature of 240 °C at a rate of 4 °C/min with a holding time of 15 min. The retention times of the fatty acids were compared with the standard chromatogram and fatty acids were identified for the flower sample.

2.15 Statistical analysis

All the experiments were conducted in triplicate and the data for several parameters have been reported as mean ± standard deviation. The statistical analysis was performed using Microsoft office Excel, 2016.

3 Results and discussions

3.1 Physical parameters

The physical parameters are the basic and fundamental requirements for scientific reporting a new horticultural product. These parameters are also useful for the designing and development of different machines like graders, stem cutters, pricking purpose and so on. Several physical properties of pumpkin flower were analysed and tabulated in Table 1.

The average mean weight of pumpkin flower was found to be 4.88 g. The mean length, breadth and thickness of the blossom were 90.43 mm, 51.56 mm and 22.63 mm respectively. The standard deviation of the length varied due to the variation of the flowers. The average arithmetic mean diameter and average geometric mean diameter have been found to be 54.84 mm and 13,054.97 mm respectively. These parameters can be used for making small gadgets i.e. cutters, and graders for the specific flower. The average surface area of the blossom has been found to be 23.5 cm^2 and the average volume of the blossom has been found to be 51.96 cm^3. The details can

Table 1 Physical Properties of Pumpkin Flower

Sl. No	Parameters	Mean	Max	Min	Standard Deviation
1	Mass (g)	4.88	7.2	3.4	1.23
2	Length (mm)	90.43	114	81	10.80
3	Width (mm)	51.56	65	42	6.35
4	Thickness (mm)	22.63	26.7	21.7	1.46
5	Arithmetic Mean Diameter (mm)	54.87	67.56	52.9	6.20
6	Geometric Mean Diameter (mm)	13,054.97	20,895.14	11,015.51	77.85
7	Surface Area (cm^2)	23.5	26.8	18.2	6.08
8	Volume (cm^3)	51.96	65.2	41.2	8.82
9	Bulk density (g/ml)	0.11	0.16	0.089	0.023
10	% Consumable part	55	65	45	14.14
11	% Wastage	45	55	35	14.14

further be used for respiration rate, and gas permeability for storage study of the flowers. For any heat and mass transfer study also, these details are needed [12]. Bulk density of the blossoms has been found to be 0.11 g/ml. The % Consumable part of the blossom has been found to be 55% and %wastage part has been found to be 45%. The petals are of light weight than stem and sepal so the weight percentage of the wastage is more.

3.2 Thermal properties, color and textural properties

3.2.1 Thermal properties

Thermal properties are important to design any storage and refrigeration unit for the food products. Considering the pumpkin flower as a food material, thermal property of the flowers was determined. These data can be used for determining the different process parameters like refrigeration, drying, heating and freezing properties. The values of thermal properties were tabulated in Table 2. Thermal properties also depend on the moisture content of the flower. The specific heat of the pumpkin flower was 4.07 kJ/kg °C at a moisture content of 85% (w.b). The specific heat increases with the increase in moisture content [13]. The more the value of specific heat, the more time the flower retains the temperature [14]. It was observed that specific heat of the pumpkin flower is more than few fruits like cashew apple, guava, banana, and Sohiong [12, 13]. The thermal conductivity of the pumpkin flower was reported as 0.62 J/ms °C. There was no data reported regarding the thermal properties of the flower, so it was compared with several small fruits. It can be concluded that conductivity was more in case of pumpkin flower than small fruits. The thermal property is used to calculate the heat flux of the product in various unit operation to keep its freshness. Thermal diffusivity of the pumpkin flower was recorded as 0.127 $\mu m^2/s$. The lower value signifies that the less time it can withstand the temperature. The flower has lower value than the smaller fruits due to the porous nature of the flower.

Table 2 Thermal, Color, Textural Properties, Proximate analysis and minerals of Pumpkin Flower

S. No	Thermal Properties	Results
1	Specific heat capacity (kJ/kg °C)	4.071 ± 0.02
2	Thermal conductivity (J/ms °C)	0.620 ± 0.001
3	Thermal diffusivity ($\mu m^2/s$)	0.127 ± 0.0001
	Color Properties	
4	L*	72.38 ± 1.33
5	a*	14.60 ± 1.09
6	b*	53.49 ± 2.55
7	Chroma	55.56 ± 1.73
8	Hue	74.70 ± 3.04
	Textural Properties	
9	Deformation (%)	49.90 ± 1.21
10	Adhesiveness (mJ)	0.20 ± 0.0003
11	Resilience	0.37 ± 0.0002
12	Stringiness (mJ)	0.10 ± 0.0001
13	Cohesiveness	0.58 ± 0.0002
14	Springiness Index	0.49 ± 0.0001
15	Gumminess (g)	26.00 ± 1.33
16	Chewiness (mJ)	4.70 ± 0.26
	Proximate Analysis (%)	
17	Moisture content (w.b)	85.03 ± 1.87
18	Ash content	3.1 ± 0.23
19	Fat content	0.15 ± 0.004
20	Protein content	2.23 ± 0.1
21	Fibre content	4.35 ± 0.3
22	Carbohydrate content	5.28 ± 0.55
23	Total Sugar	2.03 ± 0.01
24	pH	6.64 ± 0.1
25	Total solid (^{0}B)	10.2 ± 0.001
	Mineral content (mg/100 g)	
26	Sodium	11.5 ± 0.002
27	Potassium	18.2 ± 0.001
28	Calcium	17.6 ± 0.002
29	Magnesium	2.75 ± 0.002
30	Sulphur	1.23 ± 0.001
31	Iron	4.23 ± 0.001
32	Potassium	4.23 ± 0.002
33	Copper	0.75 ± 0.003

3.2.2 Color properties

The pumpkin flower possesses a very bright color. It was mainly varied between yellow and orange color. The L value of the flower was 72.38 which signifies a bright nature of the flower. The positive value of the a* (14.60) gives a justification of red color tendency (orange). The similar value was observed in case of pumpkin fruit [26]. The positive and high range of b* (53.49) value indicates the yellow color of the flower. Chroma value indicates the saturation of the color. High value (55.56) of chroma was noticed for pumpkin flowers. Hue value represents the quantitative representation of the color. 74° hue value denotes color between orange and yellow [16]. The color values were mentioned in Table 2.

3.2.3 Textural properties

The textural properties of the flower consist of deformation, adhesiveness, resilience, stringiness, cohesiveness, gumminess, and chewiness which were tabulated in Table 2. Moisture content plays a major role in case of textural properties. All the characteristics were measured at 85% moisture content for the fresh flower. Textural Profile analysis (TPA) was conducted for the flower. It was observed that deformation was 50%, with adhesiveness (0.20 mJ), resilience (0.37), stringiness (0.10 mJ), cohesiveness (0.58), gumminess (26 g) and chewiness (4.7 mJ) for the pumpkin flower. The above parameters were useful to determine the freshness and budding stage of the flower [1].

3.3 Proximate composition and mineral analysis

The initial moisture content of the fresh pumpkin flower and dried flower had a moisture content of 85.03% (w.b) and 3.63% (w.b) respectively. Similar type of data was observed for dahlia, aloe vera, pansy and snapdragon flower having a moisture content ranging from 72 to 93% (w.b) for fresh flower [27, 28]. Presence of considerable amount of moisture content helps for hydration and intestinal functioning which improves the digestion system after consuming. Table 2 consists the nutritional parameter and the mineral content present in the pumpkin flower. The ash, fat, protein, and fibre content of the flower was 3.1%, 0.15%, 2.23%, and 4.35% respectively. Pumpkin flower has lower protein value compared to the other flowers as Aloe vera content (11.75%) [29], Mexican agave salmiana (16.9%), *E. Caribaea* (27.9%), and broccoli florets (22.4%) [30]. The presence of carbohydrate, protein fat, ash and sugar were 77.1, 10.9, 7, 5.03, 20 g/100 g dw for *Bauhinia variegata L. var. candida alba* bunch flower respectively in Brazil [31]. The presence of fat content was lower than the other edible flowers in case of pumpkin flower [32]. A variety of pumpkin flower from Mexico had a moisture content of 93.2%, crude protein, fibre and ash content of 219, 105, 159 g/kg sample. Presence of several essential amino acids were also observed in the dried flower [5]. Fernandes et al. [27] summarises different chemical composition of several edible flowers. The higher the presence of fatty acid and lipid from the plant source was useful as a good remedy for cardio vascular diseases. Pumpkin flower was considered as good source of fibre content as compared to the other flowers having more than 3 g of fibre/100 g. The presence of fibre in the food component increased the water retention capacity for improving the shelf life of the food. The carbohydrate content of the flower was observed as 5.28%. Total sugar of 2.03% with a total solid content of 10.2 B was present in case of pumpkin flower. There is a presence of minerals in all the edible flowers. Pumpkin flowers are also a rich source of Potassium (18.2 mg/100 g), Calcium (17.6 mg/100 g) and Sodium (11.5 mg/100 g). Pansy and snapdragon flowers are also possessed similar trend of data for mineral content [27]. Comparing with all the other edible flowers pumpkin flower was quite rich in mineral. Presence of minerals can be also calculated from the ash content. There is no more scientific data available for pumpkin flower. But the butternut pumpkin fruit had a fat, protein, ash and carbohydrate content as 0.17, 1.45, 1.31, and 8.18% respectively. Presence of potassium is also maximum in case of the fruit [7].

3.4 Phytochemical screening analysis

As there is no previous data available for the pumpkin flower, screening test was done to determine the qualitative compounds present in the flower. Several researches have shown that different solvent or process was useful for the quantification and extraction of the particular compound. So, four different polar and non-polar solvent were used to extract the sample and to analyse the presence of the particular compound. Table. 3 describes the solvent used and the compounds present in the extract. Hexane, Ethyl acetate, methanol and water (aqueous) were used as solvent to extract the compounds. Alkaloids and phenolic compounds were present both in methanol and aqueous solution extract (Fig. 2). Flavonoids and glycosides were present only in the aqueous extract. Phytosterols and terpenoids were present in the polar solvent extract. The detailed quantification of the compound was described in the next section. Suffo et al. [18] has observed similar type of data for Amaranthus.

3.5 Phenolic, flavonoid and alkaloid content

The amount of phenols, flavanols and alkaloids from different solvent extraction were given in Table 4. There was a significant change in the phenolic content when compared with aqueous and methanolic extract pumpkin flower samples. The amount of phenolic content in aqueous extract was 8.09 µg/ml in terms of gallic acid equivalent (GAE), whereas in case of methanolic extract the value increased upto 17.39 µg/ml in terms of gallic acid equivalent (GAE). There were several researches regarding the phenolic content of the edible flower [33]. Secondary metabolites of phenol help to defend insects, animals and pathogens [34]. Dahlia, Roses, Calendula flowers possesses different types of phenolic compound in hydro–methanolic extracts [33]. Pansy flower (44.88 mg GAE/g) showed a higher level of Total Phenolic Content (TPC) than snapdragon flowers (28.35 mg GAE/g) [27]. For different 51 varieties of edible flower, Li et al. [34]

conducted a study and it was observed that the value was in between 34.17 and 1.11 mg GAE/g. Chen et al. [35] had characterised different 23 edible flowers and concluded that *Peonia lactiflora* consists maximum phenolic compound. Total phenolic content in pumpkin fruit was 199 mg GAE/100 g [7]. Several studies demonstrated that the higher the phenol content the more the antioxidant activity [36].

Flavanols were detected only in aqueous extract of the flower. The amount was measured in terms of Quercetin Equivalent. 17.134 µg/ml flavanols were present in the pumpkin flower extract. Similar result was obtained for pansy and snapdragon flower having total flavonoid content 3.3 mg CE/g and 1.18 mg CE/g respectively [27]. *Osmanthus fragrans* was reported having highest amount of flavanol content of 27.90 mg RE/g.

Alkaloid content of the pumpkin flower was also determined in both aqueous and methanolic extract. Significant differences were also found with change in the extraction method. The result was interpreted in terms of Atropine

Table 3 Screening results for Phyto constituents present in different four solvent extract for Pumpkin Flower

S No	Phyto constituent	Test results observed for extract			
		Hexane	Ethyl acetate	Methanol	Aqueous
1	Alkaloids	Negative	Negative	Positive	Positive
2	Anthraquinones	Negative	Negative	Negative	Negative
3	Flavonoids	Negative	Negative	Negative	Positive
4	Glycosides	Negative	Negative	Negative	Positive
5	Phenolic Compounds	Negative	Negative	Positive	Positive
6	Phytosterols	Positive	Positive	Positive	Negative
7	Saponins	Negative	Negative	Negative	Negative
8	Terpenoids	Positive	Positive	Positive	Negative
9	Phlobatanins	Negative	Negative	Negative	Negative
10	Cardiac Glycoside	Negative	Negative	Negative	Negative

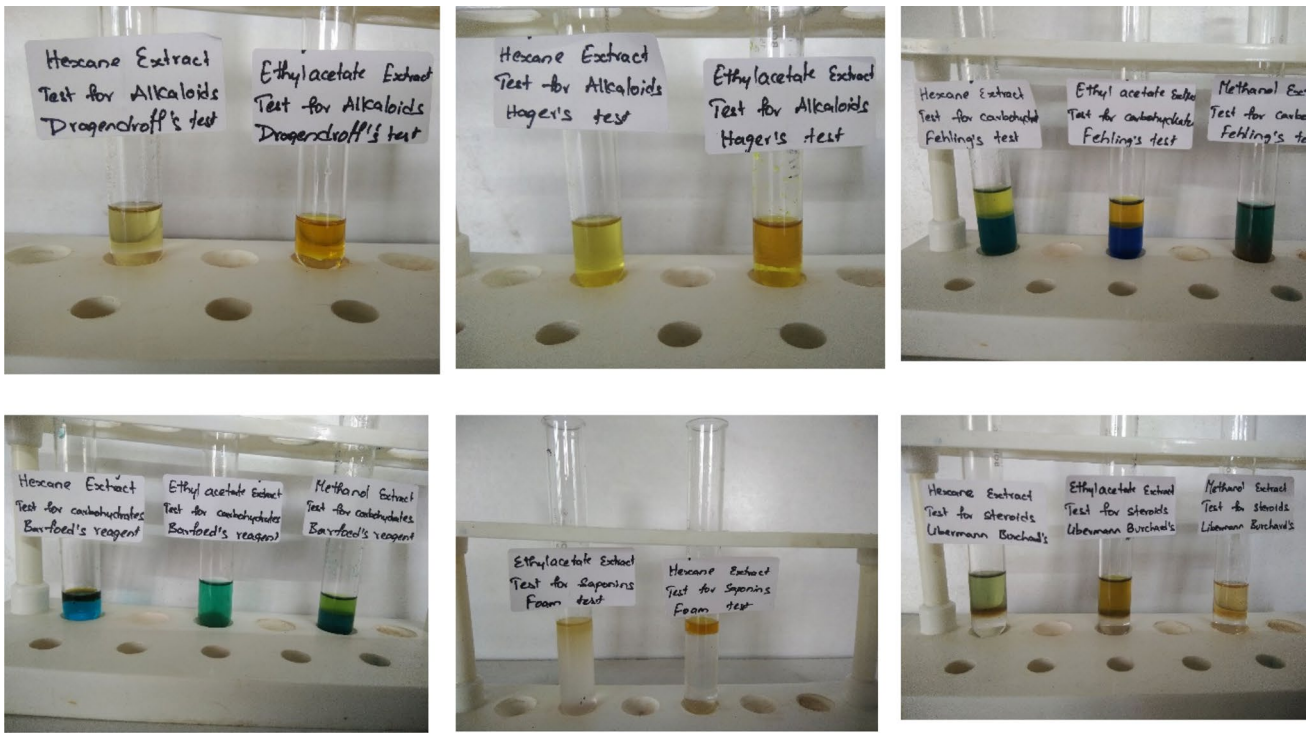

Fig. 2 Different Phyto constituents screening analysis for pumpkin flower

Table 4 Quantification of micronutrients in different solvent extract

Compound	Type of Extract	Amount Estimated in (µg/ml)
Phenolic content (gallic acid)	Aqueous	8.09 ± 0.02^{a}
	Methanolic	17.39 ± 0.01^{b}
Flavonoid content (Quercetin)	Aqueous	17.134 ± 0.01^{a}
Alkaloid content (Atropine)	Aqueous	2.29 ± 0.001^{a}
	Methanolic	1.76 ± 0.001^{b}
Antioxidant activity (DPPH)	Methanolic	51.65%
Antioxidant activity (FRAP)	Methanolic	9.64 mmol $FeSO_4$/100 g FW
		10.3^{a} mg cyn-3-glu eq./100 g FW
Anthocyanin content	Methanolic Aqueous	11.2^{b} mg cyn-3-glu eq./100 g FW
Carotenoid content	Methanolic	373 mg/100 g fresh flowers

Means in the same column with different letters were significantly different at $p \leq 0.05$ (a, b for Different Types of Extract)

equivalent. The aqueous extract of pumpkin flower had 2.29 µg/ml whereas methanolic extract had 1.76 µg/ml.

3.6 Antioxidant activity by DPPH and FRAP method

Generally bright color fruits and vegetables are rich source of antioxidant. Presence of more antioxidant compound also indicates the presence of phyto-chemicals. Comparing with other vegetables pumpkin fruit had a highest antioxidant capacity of 281 µg Trolox/g [7]. Pumpkin flower also has a bright yellow orange color. The % scavenging activity of the flower in terms of DPPH value was 51.65%. In a study conducted by Pires et al. [33] has observed antioxidant for different flower was in the range of 0.18 to 1.37 mg/ml in methanolic extract. Antioxidant values were reported by Chen et al. [35] for different 23 edible flowers. Some of the common flower as Buch ham, pansy and snapdragon had DPPH value of 87, 41.75, and 32.12 respectively for the maceration process [27, 31].

The scavenging activity of pumpkin flower by FRAP method was evaluated as 9.64 mmol $FeSO_4$/100 g FW in methanolic extract. Similar values were found for a different variety of pumpkin flower in Mexico having FRAP value of 8.66 mmol $FeSO_4$/100 g FW [5]. Similar scavenging activity for different flowers were given by different researchers [3, 27].

3.7 Anthocyanin and carotene content

Anthocyanin content of pumpkin flower was quite high than the other flowers. It was observed by Benvenuti et al. [3] that red color flowers had more anthocyanin content compared to yellow and orange color flowers. The anthocyanin content of methanolic extract and aqueous extract of pumpkin flower was 10.3 mg cyn–3–glu eq./100 g FW and 11.2 mg cyn–3–glu eq./100 g respectively. Similar result was observed by Benvenuti et al. [3] for different 12 edible flowers. The maximum and minimum value of the anthocyanin content was varied from 0.35–14.44 mg cyn–3–glu eq./100 g FW. It was noticed that the anthocyanin content mainly depends on the color of the flower. The same flower with different color had different % of anthocyanin content. The more the dark in color, the value of anthocyanin content increases. Petunia flower (red color) showed maximum whereas the viola (white color) had the minimum amount of anthocyanin content. It was observed that mostly white color flowers are having less anthocyanin content than red color.

The total carotene content in the fresh pumpkin flower was 373 mg/100 g fresh flowers. The bright orange yellow color of the flower is due to the high amount of carotene content and the presence of anthocyanin content. The similar kind of result was observed for bright orange –yellow flowers with a total carotene content ranges from 57 to 2760 µg/g fresh weight [27].

3.8 Fatty acid profiling

There is a new trend to find the fatty acids from the plant source. Several medicinal and aromatic flowers were considered as valuable sources for different fatty acids. The presence of the fatty acid present in the flower signifies the lipid quality and its uses as functional food. Eleven different fatty acids were identified in the pumpkin flower (Fig. 3). The concentration percentage of different fatty acids were given in Table 5. The saturated fatty acids (SFA) were mainly Capric acid, Lauric acid, Myristic acid, Palmitic acid, Stearic acid, Arachidic acid, Heneicosanoic acid, and Behenic acid. Two different monounsaturated fatty acid were (MUFA) Palmitoleic acid and Oleic acid. Polyunsaturated fatty acid as Linoleic acid was the only fatty acid identified in the pumpkin extract. Oleic acid (21%) was present in the highest amount, Myristic acid (15%), Stearic acid (15%) and

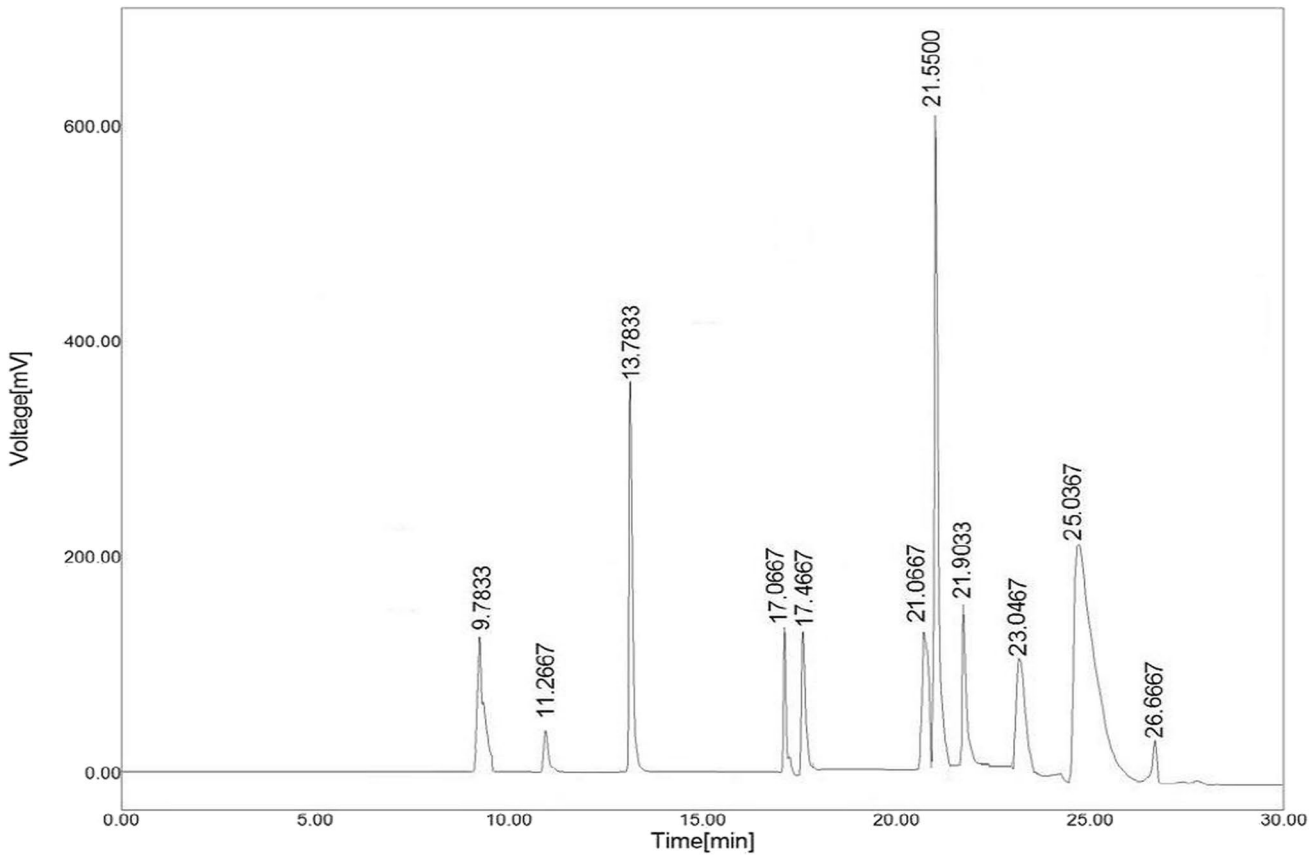

Fig. 3 Fatty acid Profiling for pumpkin flower

Heneicosanoic acid (12%) were present in the moderate level. In case of aloe-vera flower, presence of myristic acid and palmitic acid were noticeable [29]. In Buch ham flower presence of several fatty acids were observed with a concentration range (5.61–28.89) g/100 g dw. The maximum fatty acid concentration was for C18:2n6 [31]. In case of pumpkin seed oil different four fatty acid as palmitic, stearic, oleic, and linoleic was observed by Kulaitiene et al. [37].

Table 5 Fatty acid composition in Pumpkin flower

Sl No	Fatty Acid	Retention Time (min)	Amount Estimated in relative (%)	Type of fatty acid
1	Capric acid—(C10:0)	9.7833	2.99 ± 0.14	SFA
2	Lauric acid—C12:0)	11.2667	2.75 ± 0.11	SFA
3	Myristic acid—(C14:0)	13.7833	15.99 ± 0.23	SFA
4	Palmitic acid—(C16:0)	17.0667	4.57 ± 0.13	SFA
5	Palmitoleic acid—(C16:1 n-7 *cis*)	17.4667	4.45 ± 0.17	MUFA
6	Stearic acid-–(C18:0)	21.0667	15.19 ± 0.32	SFA
7	Oleic acid-–(C18:1 n-9 *cis*)	21.5500	21.72 ± 0.26	MUFA
8	Linoleic acid—(C18:2 n-6 *cis*)	21.9033	9.54 ± 0.14	PUFA
9	Arachidic acid—(C20:0)	23.0467	6.55 ± 0.12	SFA
10	Heneicosanoic acid—(C21:0)	25.0367	12.62 ± 0.19	SFA
11	Behenic acid—(C22:0)	26.6667	3.63 ± 0.10	SFA

*SFA Saturated Fatty Acid; *MUFA* Mono Unsaturated Fatty Acid; *PUFA* Poly Unsaturated Fatty Acid

4 Conclusion

Researches are its peak for high pigmented fruits, vegetables, herbs and flowers due to the presence of high amount of anthocyanin and antioxidant properties which are helpful for chronic diseases Due to proper research and marketing, the idea of eating flowers is still viewed with suspension. The neophobia still makes the product to reach out globally. Pumpkin is one of the most common vegetable which is consumed worldwide. But the flower of pumpkin was consumed as vegetable in Mexico and India locally from ancient days. The flowers are bright orange yellowish in color. No specific research was found on this topic. So, the objective of the paper is to investigate the physicochemical, nutritional, antioxidant properties and fatty acid composition of the flower. It was found that the dimension of the flower mainly varies 90 × 51 x 22 mm (l x w x t) when it was fresh having a moisture content of 85% (w.b). the average weight of the flower was 4.8 g where 55% was considered as consumable part. The fresh flower had a stinginess of 0.1 mJ, gumminess of 26 g, chewiness of 4.70 mJ, and cohesiveness of 0.58. The bright yellow orange color scientifically was proved by a*(14) and b*(53) value. The flowers are rich source of mineral content. Among all the minerals, presence of Sodium, Potassium and Calcium was maximum. The fibre and carbohydrate content of the flower was 4.3 and 5.2% respectively. Several phytonutrients as phenol (17.39 µg/ml), flavonoid (17.13 µg/ml), antioxidant (51.65% DPPH) and anthocyanin (10.3 mg/100 g) content were present mostly in methanolic extract. The flower also acts as a potential source of plant based fatty acid substitute having several saturated, monounsaturated and polyunsaturated fatty acids. Significant amount of oleic acid (21%), myristic acid (15.99%) and stearic acid (15.19%) was found in the Pumpkin flower. The flower can be considered as a potential source of functional food. Several future prospects are present for pumpkin flower in the food industry.

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Author contributions Payel Ghosh–Conceptualization, Experimental work, Writing. Sandeep Singh Rana–Experimental work, Writing, Editing and correction.

Compliance with ethical standards

Conflicts of interest No potential conflict of interest was reported by the authors.

Consent to participate Both the people participated actively in the project.

Consent for publication Payal Ghosh and Sandeep Singh Rana have mutual consent for publication.

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