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# Nutrient profile, antioxidant activity and property analysis of selected edible flowers

# Análisis de propiedades, perfil nutricional y actividad antioxidante de flores comestibles seleccionadas

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ABSTRACT

Edible flowers have gained more attention in this era due to their bioactive compounds and are mostly available in all seasons. They are less consumed and underutilized when compared to the green leafy vegetables due to lack of nutritional and medical knowledge that is yet to be scientifically documented. The study is an imprint to investigate proximate, microbial load, antioxidant activity, functional and optical properties of the selected edible flower namely agathi, hibiscus, moringa and rose on dry basis. Fully blossomed flowers were collected from the same location in the spring season, and they were shade dried. Hibiscus and rose were dried for lesser duration than other flowers and agathi flower yield more quantity after drying. Ash content of the flowers was between eight to nine per cent. Agathi flower were rich in carbohydrate, protein, and Vitamin C, whereas moringa flower were rich in calcium and iron. DPPH radical scavenging activity of the aqueous extracts of flower powder 95 per cent of inhibition at different concentrations. FT-IR analysis of flower powder showed the presence of triglycerides and polysaccharides. Hibiscus flower showed more darkness with reddish shade and moringa flower exposed the least dullness. This study proves that all the selected four edible flowers contain quantifiable amount of nutrients and antioxidant activity. Due to the richness of colour and antioxidant activity, these edible flowers can be incorporated as natural colorants and preservatives as well. It can be added to increase the sensory attributes, and nutritive value of any product from bakery to conventional dishes either in liquid or powder form as such or in combination to enhance the product and can be included in special diet plans without much affecting the nature of the product.

Keywords: edible flowers, antioxidant, agathi, hibiscus, moringa, rose

RESUMEN

En esta época las flores comestibles han acaparado más atención debido a sus compuestos bioactivos y, además, están disponibles gran parte de las estaciones del año. Son menos consumidas e infrautilizadas en comparación con las verduras de hoja verde debido a la falta de conocimientos nutricionales y médicos que aún

no se han demostrado científicamente. Este estudio tiene por objeto investigar la carga microbiana, la actividad antioxidante y las propiedades funcionales y ópticas de las flores comestibles seleccionadas, a las que pertenecen el agathi, el hibisco, la moringa y la rosa, sobre una base seca. Las flores, completamente florecidas, se recolectaron en el mismo lugar en primavera y se secaron a la sombra. El porcentaje de cenizas de las flores oscilaba entre el ocho y el nueve por ciento. La flor de agathi era rica en carbohidratos, proteínas y vitamina C, mientras que la flor de moringa era rica en calcio y hierro. La actividad de barrido de radicales DPPH de los extractos acuosos de polvo de flores alcanzó el 95% de inhibición a diferentes concentraciones. El análisis FT-IR del polen de la flor mostró la presencia de triglicéridos y polisacáridos. La flor de hibisco mostró más oscuridad con tonalidad rojiza y la flor de moringa expuso la menor opacidad. Este estudio demuestra que las cuatro flores comestibles seleccionadas poseen una cantidad cuantificable de nutrientes y actividad antioxidante. Debido a la riqueza de color y a la actividad antioxidante, estas flores comestibles pueden incorporarse también como colorantes y conservantes naturales; también pueden utilizarse para aumentar los atributos sensoriales y el valor nutritivo de cualquier producto, desde productos de panadería hasta platos convencionales, para mejorar el producto, además de poder incluirlas en regímenes dietéticos sin afectar en gran medida a la naturaleza del producto.

Palabras clave: flores comestibles, antioxidante, agathi, hibisco, moringa, rosa

## INTRODUCTION

Edible flowers play a significant role in the food culture in many countries and considered as foods from the plant with valuable sources of nutrients. The flowering portion of many plants are less consumed and concerned but packed with many medicinal and nutritional properties (Oyeyemi *et al*., 2017). Pires *et al*., (2019) explored that the presence of many phenolic compounds particularly caffeoylquinic acids and cyanidin-3-*O*-glucoside has the fortune to utilize as natural additives or preservatives or colorants which attract the interest of food industries and consumers that can be applied as a substitute to their artificial counterparts. Zheng *et al.,* (2021); Fernandes *et al*., (2017) explored that there was no or low adverse effect of bioactive compounds extracted from edible flowers when consumed up to 1500 mg as whole or particular portion contains more nutrients and poses many functional properties and suggested edible flowers should be included in the diet slowly as their allergens are not commonly known and choose flowers without pesticides.

*Hibiscus rosasinensis* (L) belongs to the family Malvaceae, an evergreen herbaceous plant that is mostly cultivated as an ornamental plant. Flowers are pentamerous, actinimorphic, pendicillate and complete. Its corolla consists of five to many petals, red to different shades about 8 cm in diameter. The flowers and the leaves are highly nutritious and used for culinary purposes (Oyeyemi *et al*., 2017). Rengarajan *et al*., (2020) investigated the presence of antioxidant potential in hibiscus flowers and found Hibiscetin-3-glucoside acts as anti-carcinogenic agent. Bahuguna *et al*., (2018) Shelke *et al*., (2021) revealed that the components of hibiscus has been used as hypotensive, anti-pyritic, anti-cancer, anti-inflammatory, anti-diabetic, antioxidant and as would healing agent and has been utilised in many dishes and drinks.

*Moringa oleifera* (Lam.) is a fast growing, evergreen or deciduous tree that belongs to the family Moringaceae. The tree grows widely in the tropics and sub-tropics of Asia and Africa. It typically ranges in height from 5 to 10 meters. Its flowers have been reported to contain nine amino acids, sucrose, traces of alkaloids and ash which is rich in potassium and calcium (Oyeyemi *et al*., 2017). Moringa flowers are the storehouse of many bioactive phytochemicals and the mechanism of this therapeutic rich flower has to be identified and it poses antibacterial, antifungal, antiviral, antioxidant, anti-inflammatory and anticancer properties. (Kalappurayil and Joseph, 2017)

*Sesbania grandiflora L.* grows in different parts of Asian counties a legume plant spreads more in Leguminosae family and is also referred as agati or sevvagatti or agast. The plant is rich in many phytochemicals like tannins, flavonoids, coumarins, steroids and triterpenes. The active ingredient present in flower is oleanolic acid and its methyl ester and Kaempferol-3-rutinoside. All parts of the plant are utilized in conventional folk medicine to treat catarrh, diarrhea, fever, migraine, smallpox, sore throat, and stomatitis. (Bhoopathy R and Muralidharan Palayyan 2021; PP. V 2020).

Mahboubi, M. (2016) reviewed that the active compounds in *Rosa damascena* mill L are citronella and geraniol responsible for pharmacological activities, an economically viable flower that paves way for therapeutic medicine in modern science. Oyeyemi *et al*., (2017) investigated that flowers of *Rosa damascena* mill L was rich in saponins and hibiscus was rich in alkaloids, tannins, saponins and phenols. All the flowers showed a high level of minerals including calcium, copper, manganese, iron, magnesium, mercury, and nickel were below the permissible level that indicates safe for human consumption. The objective of this research is to highlight the proximate, microbial load, antioxidant activity, functional and optical properties of the selected four edible flower namely agathi, hibiscus, moringa and rose on dry basis that plays an important role in contributing ample of nutrients in daily life.

## MATERIALS AND METHODS

Edible Flower Processing: Agathi (*Sesbania grandiflora* L. Fabaceae), hibiscus (*Hibiscus rosa sinensis* Linn), moringa (*Moringa oleifera* Lam) and rose (*Rosa damascena* mill L) were collected around the district of Karur, Tamil Nadu, India in spring as it was the flowering season of all the selected flowers. Among many varieties of flowers fully bloomed, white flowers of Agathi, red shade five petal variety of hibiscus, PKM 2 of moringa and pink colored paneer rose were harvested on the first day for further analysis (Figure 1). The collected flowers were washed and only the petals were segregated for further processing. Isolated petals were shade dried, ground into fine powders, and stored below nine per cent moisture in an air-tight container for further analysis.

Proximate Analysis: Proximate analysis like moisture (AOAC 930.15), ash (AOAC 942.05), carbohydrate (Anthrone method), protein (AOAC 2001.11), fat (AOAC 2003.05), crude fiber (AOAC 97.10), Vitamin C (ascorbic acid assay), Iron (Folin Ciocalteau method), Calcium (titration against $KMnO_4$) were analysed for the selected dried edible flower powder.

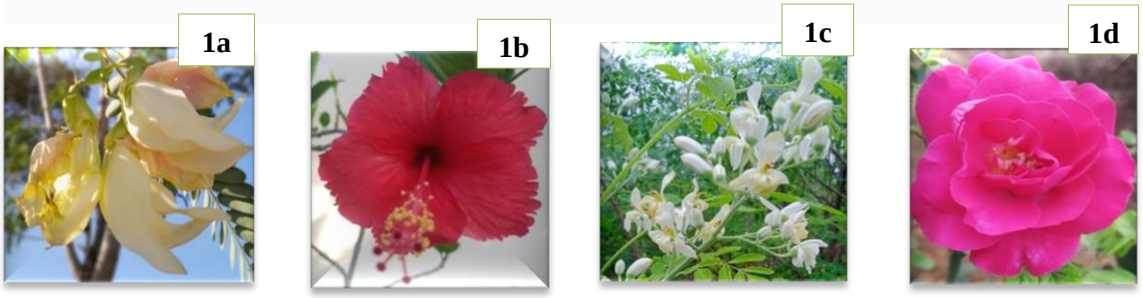


Figure – 1 Selected edible flowers, 1a. Agathi flowers, 1b. Hibiscus flowers, 1c. Moringa flowers, 1d. Rose flowers

Microbial Analysis: Total plate count, Escherichia coli, yeast and mould count were carried out for analysing microbial load in selected edible flowers powder by standard serial dilution technique, colony counter technique for 30 days at atmospheric temperature.

Antioxidant Activity

Antioxidant activity of the dried flower powder was analysed by using the scavenging activity of 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay and ascorbic acid as standard in an aqueous medium. IC50 values were determined to represent the antioxidant capability through linear regression analysis. IC50 value ranging between 10 to 50 mg / mL is considered to possess strong antioxidant activity whereas 50 to 100 mg / mL exhibits intermediate and the range above 100 exhibits weak antioxidant activity (Jadid *et al*., 2017).

Functional Property: Functional properties like presence of alkenes, alkanes, sugar molecules of edible flower powders in the range from $4000^{-1}$to 450 $cm^{-1}$ were analysed by Shimadzu Fourier-Transform Infrared (FTIR) Spectrophotometer. .

Optical Property: Optical property of the dried flower powder was analysed through laboratory scale food color reader. It was measured by L*, a* and b*. L indicates the lightness, a* and b* shifts from positive to negative where – a* stands for greenness and +a* for redness whereas –b* for blueness and + b* indicates the intensity of yellowness by calibrating black and white lightness.

## RESULTS AND DISCUSSION

Drying and total yield of Edible Flowers: Petals of agathi, hibiscus and rose were isolated and thoroughly washed and stalks, calyx, stamen and pistil of the flower were removed, and shade dried. Moringa was shade dried as such after removing dirt and stalks. Agathi, hibiscus, moringa and rose flowers took 72, 36, 42 and 32 hours to dry completely with an average total yield of 24, 21, 20 and 11 percentage. Agathi flower powder, hibiscus flower powder, moringa flower powder and rose flower powder was coded as AFP, HFP, MFP and RFP (Figure 2). Processing time and quantity yield is mentioned in table -1.

Table 1. Processing of Edible Flowers

| S.No | Flowers | Raw flowers (g) | Processing time (Hrs) | Total yield after drying (g) | Percentage of yield (%) |
|---|---|---|---|---|---|
| 1 | Agathi | 500 | 72 | 120 | 24 |
| 2 | Hibiscus | 500 | 36 | 103 | 21 |
| 3 | Moringa | 500 | 42 | 100 | 20 |
| 4 | Rose | 500 | 36 | 56 | 11 |


Figure 2 Fine powders of selected edible flowers 2a.AFP, 2b. HFP, 2c. MFP, and 2d. RFP

Proximate Analysis of Edible Flowers Powder: Different proximate content of the selected edible flowers powder was analysed by standard procedure and shown in table 2 as mean (n=3) ± standard deviation. Moisture content of MFP, HFP, AFP and RFP were below nine per cent that paves way for longer shelf life. Ash content of AFP, RFP, MFP and HFP was 9.7 ± 0.19, 9.2 ± 0.21, 9.1 ± 0.32 and 8.9 ± 0.18 g respectively that indicates the presence of enormous amount of macronutrients. 29.3 ± 1.72, 15.08 ± 0.09, 12.5 ± 0.89 and 7.4±2.04 g of carbohydrate was present in AFP, RFP, HFP and MFP respectively. Protein content of AFP was higher with 7.2 ± 1.18 g followed by MFP, RFP and HFP with 5.8±2.06, 3.25 ± 0.75 and 1.23 ± 0.23 g. Fat content was higher in AFP and all the selected flowers have very low lipid profile. Crude fiber was very low in HFP followed by MFP, AFP and RFP with 1.48 ± 0.11, 7.7 ± 3.16, 7.9 ± 1.52 and 8.92 ± 0.46. Vitamin C is higher in flowers as like green leafy vegetables and it exhibits the presence of antioxidant and anti-inflammatory properties. AFP contains more Vitamin C followed by MFP, RFP and HFP with 121 ± 14.17, 108 ± 8.24, 94 ± 1.95 and 7.9± 1.52. All the selected flower was rich in nutrient that adds nutritive value to daily diet.

Table 2. Proximate Analysis of Edible Flowers Powder

| Nutrient | AFP | HFP | MFP | RFP |
|---|---|---|---|---|
| Moisture (%) | 7.7 ± 0.59 | 8.1 ± 0.42 | 8.9 ± 0.81 | 7.4 ± 0.36 |
| Ash (g) | 9.7 ± 0.19 | 8.9 ± 0.18 | 9.1 ± 0.32 | 9.2 ± 0.21 |
| Carbohydrate (g) | 29.3 ± 1.72 | 12.5 ± 0.89 | 7.4±2.04 | 15.08 ± 0.09 |

| | | | | |
|---|---|---|---|---|
| Protein (g) | 7.2 ± 1.18 | 1.23 ± 0.23 | 5.8±2.06 | 3.25 ± 0.75 |
| Fat (g) | 2.38 ± 0.16 | 4.21 ± 0.09 | 3.91 ± 0.11 | 2.49 ± 0.19 |
| Crude Fibre (g) | 7.9 ± 1.52 | 1.48 ± 0.11 | 7.7 ± 3.16 | 8.92 ± 0.46 |
| Vitamin C (mg) | 121 ± 14.17 | 7.9 ± 1.52 | 108 ± 8.24 | 94 ± 1.95 |
| Iron (mg) | 2.6 ± 0.55 | 0.98 ± 0.2 | 3.8 ± 0.28 | 1.32 ± 0.09 |
| Calcium (mg) | 72.1 ± 7.01 | 3.76 ± 0.09 | 82.7 ± 6.32 | 8.19 ± 1.04 |

*AFP- Agathi Flowers Powder, HFP-Hibiscus Flowers Powder, MFP-Moringa Flowers Powder, RFP- Rose Flower Powder

Microbial Analysis of Edible Flowers Powder: Total plate count of the four selected flowers were mentioned in $10^{-4}$, $10^{-5}$, $10^{-6}$ dilution on 30$^{th}$ day that were below 50 CFU/g. Escherichia coli were not grown and yeast and mould growth were below one CFU/g for AFP and below two CFU/g for HFP, MFP and RFP. The results indicated that the processed flowers can be stored in air-tight container for 3-4 months at room temperature. Wilczyńska *et al*., (2021) investigated the native flowers of Poland for the presence of *Escherichia coli, Salmonella* sp. and *Staphylococcus aureus, moulds* and yeasts and declared that E.Coli was presented in certain flowers, s*taphylococcus aureus* at > 3 log CFU $g^{-1}$ and the total yeast and mould loads were less than 6 log CFU $g^{-1}$ Microbial Analysis of Edible Flowers Powder were tabulated in table 3.

Table - 3 Microbial Analysis of Edible Flowers Powder

| Flowers Powder | Total Plate count (CFU/g) | | | E.coli (CFU/g) | Yeast and Mould (CFU/g) |
|---|---|---|---|---|---|
| | $10^{-4}$ | $10^{-5}$ | $10^{-6}$ | | |
| AFP | 48 | 42 | 38 | Nil | <1 |
| HFP | 27 | 20 | 16 | Nil | <2 |
| MFP | 33 | 29 | 31 | Nil | <2 |
| RFP | 42 | 39 | 34 | Nil | <1 |

*AFP- Agathi Flowers Powder, HFP-Hibiscus Flowers Powder, MFP-Moringa Flowers Powder, RFP- Rose Flower Powder

Antioxidant Activity of Edible Flowers Powder: The antioxidant activity of the edible flowers powder was analysed from 120 ml aqueous extracts by radical scavenging activity of DPPH. The IC50 value for standard ascorbic acid is 10.49 µl/ml. Antioxidant activity of AFP, HFP, MFP and RFP was analysed in different concentrations at 10, 50, 150, 250, 350, 500 and 750 µl and the percentage of inhibition is tabulated along with $R^2$, Y slope and IC50 values. The per cent of inhibition for AFP was higher at 750 µl concentration with 94.26 per cent, HFP at 500 µl concentration with 93.44 per cent, MFP at 50 µl concentration with 95.08 per cent and RFP

was higher at the concentration of 150 µl with 96.72 per cent of inhibition that will increase the free radical scavenging potential with enhanced antioxidant activities. IC50 measures the concentration of edible flowers required to inhibit 50 per cent of radical scavenging activity. Lower the IC50 value, higher the antioxidant activity. RFP showed strong antioxidant activity, AFP and HFP showed intermediate antioxidant activity and MFP showed weaker antioxidant activity as per the standards indicated by Jadid *et al*., (2017). Table 4 and Figure 3 denote the antioxidant activity of selected edible flowers.

Table – 4 Antioxidant Activity of Edible Flowers Powder

| Concentration (µl) | Percentage of Inhibition (%) | | | |
|---|---|---|---|---|
| | AFP | HFP | MFP | RFP |
| 10 | 65.57 | 62.3 | 93.44 | 63.11 |
| 50 | 71.31 | 63.93 | 95.08 | 83.61 |
| 150 | 75.41 | 77.05 | 95.08 | 96.72 |
| 250 | 83.61 | 85.25 | 95.08 | 95.08 |
| 350 | 91.8 | 90.98 | 95.08 | 95.08 |
| 500 | 92.62 | 93.44 | 94.26 | 93.44 |
| 750 | 94.26 | 93.44 | 94.26 | 91.8 |
| $R^2$ | 0.8263 | 0.7709 | 0.0056 | 0.27 |
| Y slope | 0.0396x + 70.435 | 0.0448x + 67.73 | -0.0002x + 94.665 | 0.0236x + 81.464 |
| IC50 (µl/ml) | 78.09 | 54.92 | 139.88 | 15.76 |

*AFP- Agathi Flowers Powder, HFP-Hibiscus Flowers Powder, MFP-Moringa Flowers Powder, RFP- Rose Flower Powder.

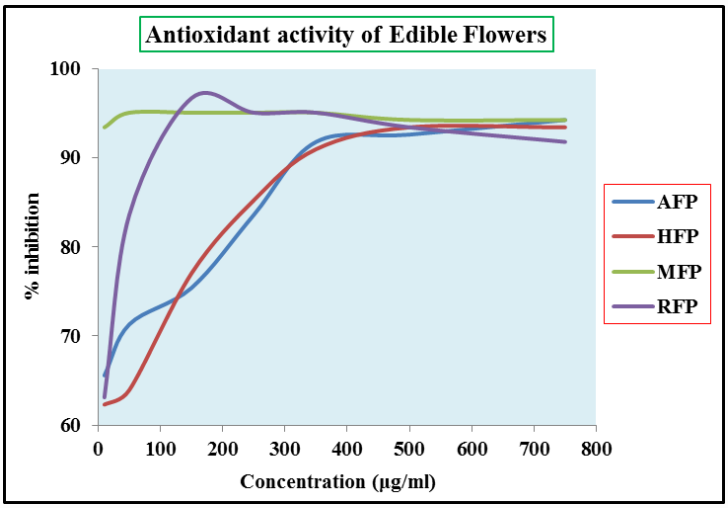


Figure 3 Antioxidant Activity of Edible Flowers Powder

Functional Property of Edible Flowers Powder: Functional property of edible flowers powder was analysed to identify the presence of alkene, alkane, volatile compounds, polysaccharides, and many other active compounds through Fourier-Transform Infrared Spectrophotometer in the range from $4000^{-1}$to 450 $cm^{-1}$ and the results and graph of AFP, HFP, MFP and RFP shown in table 5 and figure 4. Peaks at 3278.99, 3263.56, 3255.85 and 3309.85 for AFP, HFP, MFP and RFP indicate the presence of hydroxyl groups. HFP and RFP shows the presence of volatile compounds at 2285.37 and 2916.37 due to vibrational stretching of C-H bonds. All four-flower powder shows the presence of C=O different absorbing rate indicates the presence of lipids and triglycerides along with suberin at the wavelength of 1635.64, 1527.62, 1404.18 for AFP, 1743.65, 1627.92, 1527.62, 1404.18 for HFP, 1627.92, 1527.62, 1411.89 for MFP and 1728.22, 1604.77, 1442.75 for RFP. Peaks at 1234.44, 1234.44 and 1334.74 for AFP, MFP and RFP represent the presence of polysaccharide due to the vibration of OH group. C-O vibrations at 1018.41 for AFP, HFP, MFP and 1026.13 for RFP showed strong peaks indicate the presence of polysaccharide. Few strong and weak peaks at the region between 918 to 671 shows the vibration band arises due to C–H stretching. The medium peaks between 594.08 to 408.91 of AFP, HFP, MFP and RFP shows the vibration stretch due to the presence of hydroxyl groups especially glycogen. PP. V (2020) in AFP leaves, Mak, Y. W *et al.,* (2013) in hibiscus flowers showed the similar results.

Table 5. FT-IR spectrum Edible Flowers Powder

| Wavelength ($cm^{-1}$) | | | | Intensity of Peak | Absorbing feature |
|---|---|---|---|---|---|
| AFP | HFP | MFP | RFP | | |
| 3278.99 | 3263.56 | 3255.85 | 3309.85 | weak | O-H stretch |
| | 2285.37 | | 2916.37 | medium | C–H stretch |
| 1635.64, 1527.62, 1404.18 | 1743.65, 1627.92, 1527.62, 1404.18 | 1627.92, 1527.62, 1411.89 | 1728.22, 1604.77, 1442.75 | weak | C=O bend |
| 1234.44 | | 1234.44 | 1334.74 | weak | O-H bend |
| 1018.41 | 1018.41 | 1018.41 | 1026.13 | weak | C-O bend |
| | 817.82 | 918.12 | 871.82, 817.82 | weak | =C–H stretch |
| 686.66 | 671.33 | 671.33 | 671.33 | strong | CHO stretch |
| 509.21, 478.35, 408.91 | 470.63, 432.05 | 563.21, 470.63 | 493.78, 447.49 | medium | |
| 594.08, 563.21 | 594.08, 555.50, 408.91 | 594.08, 423.05 | 594.08, 555.50, 408.91 | Weak | |

*AFP- Agathi Flowers Powder, HFP-Hibiscus Flowers Powder, MFP-Moringa Flowers Powder, RFP- Rose Flower Powder

Table 6 Optical Property of Edible Flowers Powder

| S.No | Flowers Powder | L* | a* | b* |
|---|---|---|---|---|
| 1 | AFP | 48.56 ± 1.12 | 9.60 ± 0.61 | 7.72 ± 0.42 |
| 2 | HFP | 14.30 ± 0.20 | 20.16 ± 1.01 | 3.80 ± 0.36 |
| 3 | MFP | 37.38 ± 0.32 | 6.43 ± 0.08 | 15.28 ±0.14 |
| 4 | RFP | 35.66 ± 1.11 | 19.37 ± 0.41 | 2.35 ± 0.15 |

*AFP- Agathi Flowers Powder, HFP-Hibiscus Flowers Powder, MFP-Moringa Flowers Powder, RFP- Rose Flower Powder.

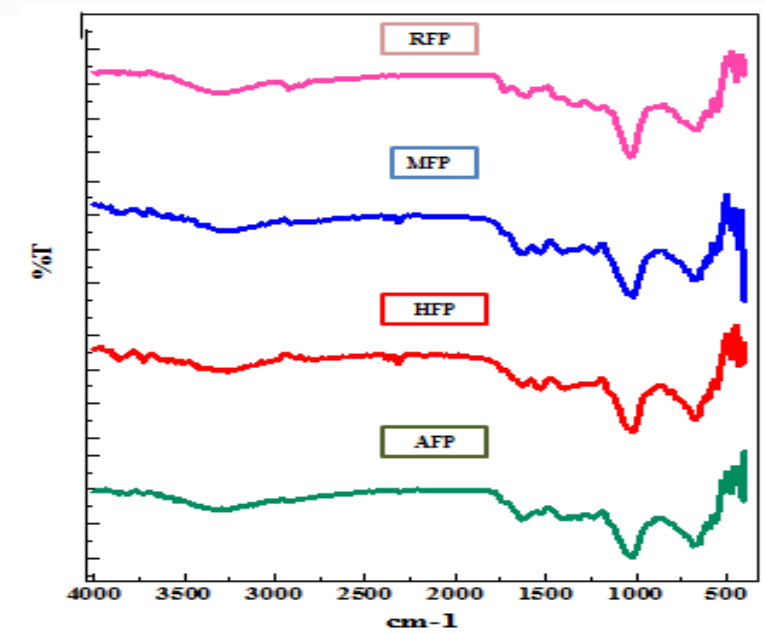


Figure 4. FT-IR graph of Edible Flowers Powder

Optical Property of Edible Flower Powder: The lightness (*L) of HFP was lowest, showed more darkness followed by RFP, MFP and AFP. The values of (*a) of HFP, RFP, AFP and MFP was +20.16, +19.37, +9.60 and +6.43 which indicates HFP was reddish flower powder as the intensity of value was higher. (*b) values of MFP, AFP, HFP and RFP was +15.28, +7.72, +3.80 and +2.35 that indicated yellowness of the flower powders. Among the selected four edible flowers, HFP showed more darkness and reddish shade whereas MFP showed the least dullness and reddish shade in L* and a* and all flowers showed yellowness with different intensity. Colour of the flowers represents the presence of factors like chemical nature of pigments, acylation and methylation content, pH, cyaniding derivatives, genetic inheritance and phytonutrients like flavonoids, anthocyanins,

chlorophyll, xanthones, and betalains. The intensity of blue and red colour might have been due to the presence of the anthocyanins. (Mak, Y. W *et al.,* 2013; Kumar *et al*., 2017). Data for the optical property of selected flowers were represented in table 6 as mean (n=3) ± standard deviation.

## CONCLUSION

Around the world, many edible flowers are employed in food preparations, and this research provides a modest scientific impression of the nutritional value, antioxidant activity, and functional qualities of four chosen edible flowers in dry form. Flowers of most green leafy vegetables can be consumed along with them in all recipe preparations, especially in special diet plans they are packed with high nutrients. Edible flowers can be infused with any food products that are concerned with antioxidants and the chemical composition doesn't affect the products to which the flowers are incorporated, infused, or added. Due to its richness in optical properties and flavor, it can be blended with any other ingredients in bakery, confectionary, and beverage industries in suitable form as fine powders or extracts. Incorporation of underutilized edible flowers in food and pharmaceutical products adds value and enhances the nutritive value, antioxidant activity, sensory quality, and consumer acceptance as they were available plenty in most of the seasons, cost-effective, and reduces the risk of many pathological states.

Conflict of Interest: The authors confirm that they have no conflicts of interest with respect to the work described in this manuscript.

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