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# A Study on the Antioxidant and Anti-Microbial Properties of Juices of Four Varieties of Passion Fruit (Passiflora Edulis, Passiflora Foetida, Passiflora Edulis F. Flavicarpa and Passiflora Quadrangularis)

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***Abstract*** **– This study is based on understanding the antioxidant and the anti-microbial activities of juices extracted from four different varieties of Passion fruit (*Passiflora edulis, Passiflora foetida, Passiflora edulis f. flavicarpa* and *Passiflora quadrangularis*) available in South India and showed few positive results. The citric acid in the juices confer the juices a significantly large antioxidant potential. All the four varieties of Passion fruit can be considered as one of the richest sources of citric acid and ascorbic acid, making them effective antioxidants. All the four Passion fruit juices showed a remarkable activity against the Gram-positive bacteria, *B. subtilis* and *S. aureus* rather than the Gram-negative bacteria, *E. coli* and *P. putida.***

***Keywords*** **– Antioxidant Activity, Antimicrobial Activity, Gram Negative, Gram Positive, *Passiflora*.**

## I. INTRODUCTION

There are more than 500 species of *Passiflora* in the family *Passifloraceae*, but only one *Passiflora edulis* Sims, is known as passion fruit. There are two distinct forms of *Passiflora edulis* Sims, the standard yellow (*Passiflora edulis f.flavicarpa* Deg.) and the purple (*Passiflora edulis f.edulis*), differing in acidity and starch content. The yellow are more acidic and less starchy while the purple are less acidic and more starchy. Both the varieties, *viz.,* purple Passion Fruit *(P. edulis)* and yellow Passion Fruit *(P. edulis* var. *flavicarpa)* are of commercial importance. The hybrids of these two have also been developed for cultivation.

i. *Passiflora Edulis (Purple Passion Fruit) :*

Passion fruit (*Passiflora edulis*) is a native of Brazil, belonging to family Passifloraceae. It is grown mostly in tropical and sub- tropical parts of the world from South America to Australia and Asia to Africa. In India, it was introduced in the early twentieth century in Nilgiris, Coorg and Malabar regions of Southern India. Passion fruit (*Passiflora edulis*) is a perennial, woody, climbing vine that produces round or ovoid fruits. Fruits have a rough, waxy, dark purple colored rind with white specks all over it. The fruit contains orange pulpy juice with hard, dark brown to black-colored seeds. The fruits are not generally used for table purpose, but they are used to prepare juices, squashes, concentrates, etc. owing to its delicious, refreshing and aromatic juice. It is known for its blending quality. The fruit contains large quantities of reducing and non-reducing sugars.

ii. *Passiflora Foetida (Red Passion Fruit) :*

*Passiflora foetida* is a species of Passion flower that is native to the south-western United States (southern Texas and Arizona), Mexico, the Caribbean, Central America, and much of South America. It has been introduced to tropical regions around the world, such as Southeast Asia, South Asia, and Hawaii. It is a creeping vine like other members of the genus, and yields an edible fruit. The specific epithet, foetida, means "stinking" in Latin and refers to the strong aroma emitted by damaged foliage. The stems are thin and wiry, covered with minute sticky yellow hairs. Older stems become woody. The leaves are three-to-five-lobed and viscid hairy. When crushed, these leaves give off a pungent odor that some people consider unpleasant. The flowers are white to pale cream colored, about 5-6 diameter. The fruit is globose, 2-3cm diameter, yellowish-orange to red when ripe, and has numerous black seeds embedded in the pulp; the fruit are eaten and the seeds dispersed by birds.

iii. *Passiflora Edulis F.Flavicarpa (Yellow Passion Fruit) :*

The yellow Passion fruit has a round to egg like shape and thick yellow skin, often times tinged with spots of lime green. The interior of its rind has soft creamy white walls and encases an exceptionally juicy yellow-orange pulp and many petite brown seeds. Its flavor is sweet, acidic and tropical with mild floral notes. Growing on a climbing vine the yellow passion fruit has green tendrils and leaves and will bloom prior to fruiting. The ornate and colorful flowers of the yellow passion fruit are larger more aromatic than the purple variety. Yellow passion fruit is available in the late winter and throughout the summer months.

iv. *Passilflora Quadrangularis (Giant Granadilla):*

The Giant Granadilla produces the largest fruit of any species within the genus *Passiflora*. It is a perennial native to the neotropics, having smooth, cordate, ovate or acuminate leaves; petioles bearing from 4 to 6 glands; an emetic and narcotic root; scented flowers; and a large oblong fruit, containing numerous seeds, embedded in a sub-acid edible pulp. The fruit juice is used as a beverage. In some parts of Sri Lanka the fruit is cooked as a vegetable curry, and the seeds are consumed as a snack or used to extract juice. Tea is made from the leaves used to control high blood pressure and diabetes.

v. *Antioxidant Activity:*

Fruits and vegetables containing vitamin C, vitamin E (tocopherols), and carotenoids (a-carotene, b-carotene, b-cryptoxanthin, lutein, zeaxanthin, and lycopene) are believed to provide a natural source of antioxidants. Antioxidant activity is associated with decreases in DNA

damage, a reduction in lipid peroxidation, maintenance of the immune function, and prevention of the development of some diseases (Gropper, Smith, & Groff, 2005). In the present study, the juices of *Passiflora edulis, Passiflora foetida, Passiflora edulis f.flavicarpa* and *Passiflora quadrangularis* are tested for their antioxidant activity conferred by citric acid and ascorbic acid, the best sources of antioxidants and calculating their free radical-scavenging activity.

vi. *Anti-Microbial Activity:*

Anti-microbial activity can be defined as any biological activity that acts against bacteria, fungi, or virus. There are many plant-based extracts available that have been proven to have antimicrobial properties. In the present study, the juices of *Passiflora edulis, Passiflora foetida, Passiflora edulis f.flavicarpa* and *Passiflora quadrangularis* are tested for their anti-microbial activity, if any, against two Gram-positive bacteria-*Bacillus subtilis* and *Staphylococc- -us aureus* and two Gram-negative bacteria- *Escherichia coli* and *Pseudomonas putida*.

## II. Materials and Methods

a. *Extraction of Juices* of *P. edulis, P. foetida, P. edulis f.flavicarpa* and *P. quadrangularis*:

All the four species of Passion fruits were botanically identified at the Biosciences department of Presentation College of Applied Sciences, Puthenvelikkara, Ernakulam, Kerala. The healthy, ripe, purple, unshrivelled fruits were selected, washed, halved with stainless steel knives and the pulp was scooped out with the help of stainless steel scooping or pitting knives or with ordinary spoons. The pulps (composed of juice and seeds) were then squeezed through muslin cloth and the juices thus obtained were immediately employed for analysis. The juices were thus freshly extracted whenever necessary as per requirement.

b. *The Study of Antioxidant Activity of Juices of P. edulis, P. foetida, P. edulis f.flavicarpa and P. quadrangularis :*

The juices extracted from the four species of Passion fruits were used to study its antioxidant activity by:

i. *Estimation of Citric Acid Content in the Juices :*

Citric acid is the best source of antioxidant. It is adequately present in citrus fruits like Lemon and Orange. The presence of citric acid in the four species of Passion fruits juices will reveal their antioxidant activity.

The estimation of citric acid in the Passion fruit juices was done by titration method as follows:

1) Standard solution of sodium hydroxide of normality 1N was prepared and filled into a burette.
2) The sample juice (10mL of each Passion fruit variety) was taken in conical flask.
3) One drop of phenolphthalein indicator was added to it and titrated against the made sodium hydroxide taken in burette till the pink color disappears.
4) The titration was repeated until concordant values were obtained.

The volume of sodium hydroxide was noted and was substituted in the following formula to calculate the amount of citric acid present in each fruit juice sample.

citric acid content = 6.404 g* Volume of NaOH/L

ii. *Estimation of Ascorbic Acid Content in the Juices:*

Ascorbic acid is another antioxidant of great significance. It is very widely recommended by dieticians world-wide in the form of fruits and vegetables. In the present study, the ascorbic acid in *P. edulis, P. foetida, P. edulis f.flavicarpa* and *P. quadrangularis* is done by colorimetric analysis. The dehydroascorbic acid alone reacts quantitatively and not the other reducing substances present in the sample extract. Thus this method gives an accurate analysis of ascorbic acid content.

*Principle:*

Ascorbic acid is first dehydrogenated by bromination. The dehydroascorbic acid is then reacted with 2, 4 dinitrophenyl hydrazine to form osazone and dissolved in sulphuric acid to given an orange-red color solution which is measured at 540nm.

*Procedure:*

1) 10-100µg standard dehydroascorbic solution was pipetted out into a series of tubes.
2) Similarly different aliquots (0.1mL - 2mL) of brominated sample extract were pipetted out.
3) The volume in each tube was made up to 3mL by adding distilled water.
4) 1 mL of DNPH reagent followed by 1-2 drops of thiourea was added to each tube.
5) A blank as above but with water in place of ascorbic acid solution was set.
6) The contents of the tubes were mixed thoroughly and incubated at $37^0$C for 3 hours.
7) After incubation, the orange-red osazone crystals formed was dissolved by adding 7mL of 80% sulphuric acid.
8) The absorbance was measured at 540 nm.
9) A graph of ascorbic acid concentration versus absorbance was plotted and the ascorbic acid content in the 100mL of sample was calculated using the following formula:

Concentration of ascorbic acid = (Absorbance of Test/ Absorbance of standard*Concentration of standard/ Volume of Test) *100

iii. *Determination of Radical-Scavenging Activity of the Passion Fruit Juices using Ascorbic Acid as Standard :*

The radical-scavenging activity of the Passion fruit juices were calculated using the values obtained from ascorbic acid taken as standard using the following formula:

Scavenging activity (%) = $[(A_0A_1) /(A_0)]*100$

c. *The Study of Anti-Microbial Activity of Juices of P. edulis, P. foetida, P. edulis f.flavicarpa and P. quadrangularis :*

Testing of anti-microbial activity of juices of *P. edulis, P. foetida, P. edulis f.flavicarpa* and *P. quadrangularis* was done by testing it against two Gram positive bacteria-*Bacillus subtilis* and *Staphylococcus aureus* and two Gram

negative bacteria-*Escherichia coli* and *Pseudomonas putida* by agar well-diffusion assay. These pathogens were procured from the Biosciences Laboratory of Presentation College of Applied Sciences, Puthenvelikkara. The assay was performed as follows:

i. *Enrichment of Bacteria:*

The test organisms were procured and enriched with media. The media used for enriching *B. subtilis*, *S. aureus*, *E. coli* and *P. putida* was nutrient agar broth. The inoculated broths were kept for overnight incubation at 32ºC in a rotary shaker. Bacterial cultures were subjected to bacterial subculture, after which on the third day nutrient agar plates where prepared and the bacteria were inoculated on to the nutrient agar plates using sterile cotton swabs to study the effects of juices of *P. edulis, P. foetida, P. edulis f.flavicarpa* and *P. quadrangularis* on the bacteria.

ii. *Preparation of Plates for Agar Well Diffusion Method:*

Forty-four sterile plates of nutrient agar were prepared. Four plates each were used to study the effect of the methanol solvent-based extracts of *P. edulis, P. foetida, P. edulis f. flavicarpa* and *P. quadrangularis* in concentrati--ons ranging from 10% to 100% on each of the four pathogens used. The plates were kept for overnight incubation. Duplicate for each plate was maintained. The plates were subjected to 36 hour incubation at room temperature and observed for zones of inhibition. The area of zones of inhibition in all plates was calculated using the following formula:

$$\text{Net area of zone of inhibition } (mm^2) = \pi (A/2)^2 - \pi(B/2)^2$$

Where, A = diameter of zone of inhibition (mm)
B = diameter of the well (1 mm)

## III. Results and Discussion

I. *The Study of Antioxidant Activities of Juices of P. edulis, P. foetida, P. edulis f.flavicarpa and P. quadrangularis :*

The juices extracted from juices of *P. edulis, P. foetida, P. edulis f.flavicarpa* and *P. quadrangula- -ris* were used to study their antioxidant activities by:

a. *Estimation of Citric Acid Content in the Juices :*

The citric acid content in *P. edulis* was found to be **300.988 g/L.**

The citric acid content in *P. foetida* was found to be **268.968 g/L.**

The citric acid content in *P. edulis f.flavicarpa* was found to be **409.856 g/L.**

The citric acid content in *P. quadrangularis* was found to be **198.524 g/L.**

b. *Estimation of Ascorbic Acid Content in the Juices :*

The ascorbic acid content in all four species of Passion fruit was estimated using the following observations noted.

Table 2: Estimation of ascorbic acid content in the juices of Passion fruits

| Sl. No | Tube | Volume of standard (ml) | Concentration of standard (100µg/ml) | Volume of distilled water (ml) | Volume of DNPH (ml) | Volume of Thiourea | Incubation at 37°C for 3 hrs. | Volume of 80% sulphuric acid (ml) | OD at 540 nm |
|---|---|---|---|---|---|---|---|---|---|
| 1. | B | 0 | 0 | 3 | 1ml | 1-2 drops | Incubation at 37°C for 3 hrs. | 7ml | 0.00 |
| 2. | S1 | 0.1 | 10 | 2.9 | | | | | 0.02 |
| 3. | S2 | 0.2 | 20 | 2.8 | | | | | 0.01 |
| 4. | S3 | 0.3 | 30 | 2.7 | | | | | 0.09 |
| 5. | S4 | 0.4 | 40 | 2.6 | | | | | 0.09 |
| 6. | S5 | 0.5 | 50 | 2.5 | | | | | 0.11 |
| 7. | S6 | 0.6 | 60 | 2.4 | | | | | 0.10 |
| 8. | S7 | 0.7 | 70 | 2.3 | | | | | 0.08 |
| 9. | S8 | 0.8 | 80 | 2.2 | | | | | 0.09 |
| 10. | S9 | 0.9 | 90 | 2.1 | | | | | 0.02 |
| 11. | S10 | 1.0 | 100 | 2.0 | | | | | 0.04 |
| 12. | T1 | 0.5 | | 2.5 | | | | | 0.03 |
| 13. | T2 | 0.5 | | 2.5 | | | | | 0.02 |
| 14. | T3 | 0.5 | | 2.5 | | | | | 0.07 |
| 15. | T4 | 0.5 | | 2.5 | | | | | 0.02 |

Concentration of ascorbic acid in *P. edulis* juice is found to be **12.0mg/100ml.**

Concentration of ascorbic acid in *P. foetida* juice is found to be **8.0mg/100ml.**

Concentration of ascorbic acid in *P. edulis f. flavicarpa* juice is found to be **28.0mg/100ml.**

Concentration of ascorbic acid in *P. quadrangularis* juice is found to be **16.0mg/100ml.**

c. *Determination of Radical-scavenging Activity of the Passion Fruit Juices :*

Radical-scavenging activity of *P. edulis* juice is found to be **55.55%.**

Radical-scavenging activity of *P. foetida* juice is found to be **22.22%.**

Radical-scavenging activity of *P. edulis f.flavicarpa* juice is found to be **77.77%.**

Radical-scavenging activity of *P. quadrangularis* juice is found to be **66.66%.**

II. *The study of Anti-microbial Activity of Juices of P. edulis, P. foetida, P. edulis f.flavicarpa and P. quadrangularis:*

Testing of anti-microbial activity of juices of *P. edulis, P. foetida, P. edulis f.flavicarpa* and *P. quadrangularis* was done by testing it against two Gram-positive bacteria viz., *Bacillus subtilis* and *Staphylococcus aureus* and two Gram-negative bacteria viz., *Escherichia coli* and *Pseudomonas putida* by agar well-diffusion assay.

The observations were tabulated as follows:

a. *Anti-microbial Effects of Juice Extracted from P. edulis :*

Table 3. Anti-microbial effects of juice extracted from *P. edulis*.

| Plate No. | Bacterium inoculated on agar plate | Concentration of samples inoculated in wells (µl) | Diameter of zone of inhibition (mm) | Area of zone of inhibition $(mm)^2$ |
|---|---|---|---|---|
| 1. | *B. subtilis* | 10 | 1 | 40.035 |
| 2. | *B. subtilis* | 20 | 1 | 40.035 |
| 3. | *B. subtilis* | 30 | 1.4 | 115.395 |
| 4. | *B. subtilis* | 40 | 1.4 | 115.395 |
| 5. | *B. subtilis* | 50 | 1.4 | 115.395 |
| 6. | *B. subtilis* | 60 | 1.3 | 94.2 |
| 7. | *B. subtilis* | 70 | 1.6 | 162.495 |
| 8. | *B. subtilis* | 80 | 1.5 | 138.16 |
| 9. | *B. subtilis* | 90 | 1.5 | 138.16 |
| 10. | *B. subtilis* | 100 | 1.8 | 215.875 |
| 11. | *S. aureus* | 10 | Nil | Nil |
| 12. | *S. aureus* | 20 | Nil | Nil |
| 13. | *S. aureus* | 30 | Nil | Nil |
| 14. | *S. aureus* | 40 | Nil | Nil |
| 15. | *S. aureus* | 50 | Nil | Nil |
| 16. | *S. aureus* | 60 | Nil | Nil |
| 17. | *S. aureus* | 70 | Nil | Nil |
| 18. | *S. aureus* | 80 | Nil | Nil |
| 19. | *S. aureus* | 90 | 1.5 | 138.16 |
| 20. | *S. aureus* | 100 | 1.4 | 115.395 |
| 21. | *E. coli* | 10 | Nil | Nil |
| 22. | *E. coli* | 20 | 0.9 | 25.12 |
| 23. | *E. coli* | 30 | 1.1 | 56.52 |
| 24. | *E. coli* | 40 | 1 | 40.035 |
| 25. | *E. coli* | 50 | 1.1 | 56.52 |
| 26. | *E. coli* | 60 | 1.3 | 94.20 |
| 27. | *E. coli* | 70 | 1.2 | 74.575 |
| 28. | *E. coli* | 80 | 1.3 | 94.20 |
| 29. | *E. coli* | 90 | 1.4 | 115.395 |
| 30. | *E. coli* | 100 | 1.1 | 56.52 |
| 31. | *P. putida* | 10 | Nil | Nil |
| 32. | *P. putida* | 20 | 0.9 | 25.12 |
| 33. | *P. putida* | 30 | 1.2 | 74.575 |
| 34. | *P. putida* | 40 | 1.2 | 74.575 |
| 35. | *P. putida* | 50 | 1.1 | 56.52 |
| 36. | *P. putida* | 60 | 1 | 40.035 |
| 37. | *P. putida* | 70 | 1.1 | 56.52 |
| 38. | *P. putida* | 80 | 1.2 | 74.575 |
| 39. | *P. putida* | 90 | 1.2 | 74.575 |
| 40. | *P. putida* | 100 | 1.4 | 115.395 |

(b) *Anti-microbial Effects of Juice Extracted from P. foetida :*

Table 4. Anti-microbial effects of juice extracted from *P. foetida*.

| Plate No. | Bacterium inoculated on agar plate | Concentration of samples inoculated in wells (µl) | Diameter of zone of inhibition (mm) | Area of zone of inhibition $(mm)^2$ |
|---|---|---|---|---|
| 1. | *B. subtilis* | 10 | Nil | Nil |
| 2. | *B. subtilis* | 20 | Nil | Nil |
| 3. | *B. subtilis* | 30 | 8.5 | 18.25 |
| 4. | *B. subtilis* | 40 | 9 | 25.12 |
| 5. | *B. subtilis* | 50 | 12.5 | 84.19 |
| 6. | *B. subtilis* | 60 | 12.5 | 84.19 |
| 7. | *B. subtilis* | 70 | 13.5 | 104.60 |
| 8. | *B. subtilis* | 80 | 14 | 115.39 |
| 9. | *B. subtilis* | 90 | 10 | 40.03 |
| 10. | *B. subtilis* | 100 | 12.5 | 84.19 |
| 11. | *S. aureus* | 10 | Nil | Nil |
| 12. | *S. aureus* | 20 | Nil | Nil |
| 13. | *S. aureus* | 30 | 9.5 | 32.38 |
| 14. | *S. aureus* | 40 | 9.5 | 32.38 |
| 15. | *S. aureus* | 50 | 8 | 11.78 |
| 16. | *S. aureus* | 60 | 9.5 | 32.38 |
| 17. | *S. aureus* | 70 | 10 | 40.03 |
| 18. | *S. aureus* | 80 | 8.5 | 18.25 |
| 19. | *S. aureus* | 90 | 13 | 94.2 |
| 20. | *S. aureus* | 100 | 12.5 | 84.19 |
| 21. | *E. coli* | 10 | Nil | Nil |
| 22. | *E. coli* | 20 | Nil | Nil |
| 23. | *E. coli* | 30 | Nil | Nil |
| 24. | *E. coli* | 40 | Nil | Nil |
| 25. | *E. coli* | 50 | 11 | 56.52 |
| 26. | *E. coli* | 60 | 10.5 | 48.08 |
| 27. | *E. coli* | 70 | Nil | Nil |
| 28. | *E. coli* | 80 | 13 | 94.2 |
| 29. | *E. coli* | 90 | 8.5 | 18.25 |
| 30. | *E. coli* | 100 | 10 | 40.03 |
| 31. | *P. putida* | 10 | Nil | Nil |
| 32. | *P. putida* | 20 | Nil | Nil |
| 33. | *P. putida* | 30 | Nil | Nil |
| 34. | *P. putida* | 40 | Nil | Nil |
| 35. | *P. putida* | 50 | 10.5 | 48.08 |
| 36. | *P. putida* | 60 | 10 | 40.03 |
| 37. | *P. putida* | 70 | 8 | 11.78 |
| 38. | *P. putida* | 80 | 11.5 | 65.35 |
| 39. | *P. putida* | 90 | 12.5 | 84.19 |
| 40. | *P. putida* | 100 | 13 | 94.2 |

(c) *Anti-microbial Effects of Juice Extracted from P. edulis f.flavicarpa :*

Table 5. Anti-microbial effects of juice extracted from *P. edulis f.flavicarpa*.

| Plate No. | Bacterium inoculated on agar plate | Concentration of samples inoculated in wells (µl) | Diameter of zone of inhibition (mm) | Area of zone of inhibition $(mm)^2$ |
|---|---|---|---|---|
| 1. | *B. subtilis* | 10 | 9 | 25.12 |
| 2. | *B. subtilis* | 20 | 11 | 56.052 |
| 3. | *B. subtilis* | 30 | 9 | 25.12 |
| 4. | *B. subtilis* | 40 | 10.5 | 48.08 |
| 5. | *B. subtilis* | 50 | 11 | 56.52 |
| 6. | *B. subtilis* | 60 | 10 | 40.03 |
| 7. | *B. subtilis* | 70 | 10 | 40.03 |
| 8. | *B. subtilis* | 80 | 13 | 94.2 |
| 9. | *B. subtilis* | 90 | 10 | 40.03 |
| 10. | *B. subtilis* | 100 | 11 | 56.52 |
| 11. | *S. aureus* | 10 | 9.5 | 32.38 |
| 12. | *S. aureus* | 20 | 10 | 40.03 |
| 13. | *S. aureus* | 30 | Nil | Nil |
| 14. | *S. aureus* | 40 | Nil | Nil |
| 15. | *S. aureus* | 50 | Nil | Nil |
| 16. | *S. aureus* | 60 | 12.5 | 84.19 |
| 17. | *S. aureus* | 70 | 10 | 40.03 |
| 18. | *S. aureus* | 80 | 11 | 56.52 |
| 19. | *S. aureus* | 90 | 13.5 | 104.60 |
| 20. | *S. aureus* | 100 | 15 | 138.16 |
| 21. | *E. coli* | 10 | Nil | Nil |
| 22. | *E. coli* | 20 | Nil | Nil |
| 23. | *E. coli* | 30 | Nil | Nil |
| 24. | *E. coli* | 40 | Nil | Nil |
| 25. | *E. coli* | 50 | 8 | 11.78 |
| 26. | *E. coli* | 60 | 8.5 | 18.25 |
| 27. | *E. coli* | 70 | 9 | 25.12 |
| 28. | *E. coli* | 80 | 9.5 | 32.38 |
| 29. | *E. coli* | 90 | Nil | Nil |
| 30. | *E. coli* | 100 | Nil | Nil |
| 31. | *P. putida* | 10 | Nil | Nil |
| 32. | *P. putida* | 20 | Nil | Nil |
| 33. | *P. putida* | 30 | Nil | Nil |
| 34. | *P. putida* | 40 | Nil | Nil |
| 35. | *P. putida* | 50 | 12 | 74.58 |
| 36. | *P. putida* | 60 | 12.5 | 84.19 |
| 37. | *P. putida* | 70 | 13 | 94.2 |
| 38. | *P. putida* | 80 | 13.5 | 104.60 |
| 39. | *P. putida* | 90 | 11 | 56.52 |
| 40. | *P. putida* | 100 | 11.5 | 65.35 |

(d) *Anti-microbial Effects of Juice Extracted from P. quadrangularis :*

Table 6. Anti-microbial effects of juice extracted from *P. quadrangularis*

| Plate No. | Bacterium inoculated on agar plate | Concentration of samples inoculated in wells (µl) | Diameter of zone of inhibition (mm) | Area of zone of inhibition $(mm)^2$ |
|---|---|---|---|---|
| 1. | *B. subtilis* | 10 | Nil | Nil |
| 2. | *B. subtilis* | 20 | Nil | Nil |
| 3. | *B. subtilis* | 30 | Nil | Nil |
| 4. | *B. subtilis* | 40 | 0.8 | 11.775 |
| 5. | *B. subtilis* | 50 | 1.2 | 74.575 |
| 6. | *B. subtilis* | 60 | 1.2 | 74.575 |
| 7. | *B. subtilis* | 70 | 1.2 | 74.575 |
| 8. | *B. subtilis* | 80 | 1.5 | 138.16 |
| 9. | *B. subtilis* | 90 | 1.3 | 94.20 |
| 10. | *B. subtilis* | 100 | 1.5 | 138.16 |
| 11. | *S. aureus* | 10 | 0.9 | 25.12 |
| 12. | *S. aureus* | 20 | 0.8 | 11.775 |
| 13. | *S. aureus* | 30 | 0.9 | 25.12 |
| 14. | *S. aureus* | 40 | 1.1 | 56.52 |
| 15. | *S. aureus* | 50 | 0.9 | 25.12 |
| 16. | *S. aureus* | 60 | 0.8 | 11.775 |
| 17. | *S. aureus* | 70 | 1.2 | 74.575 |
| 18. | *S. aureus* | 80 | 1.1 | 56.52 |
| 19. | *S. aureus* | 90 | 1.5 | 138.16 |
| 20. | *S. aureus* | 100 | 1.6 | 162.495 |
| 21. | *E. coli* | 10 | 0.8 | 11.775 |
| 22. | *E. coli* | 20 | 0.8 | 11.775 |
| 23. | *E. coli* | 30 | Nil | Nil |
| 24. | *E. coli* | 40 | Nil | Nil |
| 25. | *E. coli* | 50 | Nil | Nil |
| 26. | *E. coli* | 60 | 1.1 | 56.52 |
| 27. | *E. coli* | 70 | 1 | 40.035 |
| 28. | *E. coli* | 80 | Nil | Nil |
| 29. | *E. coli* | 90 | 0.9 | 25.12 |
| 30. | *E. coli* | 100 | 1 | 40.035 |
| 31. | *P. putida* | 10 | Nil | Nil |
| 32. | *P. putida* | 20 | 1 | 40.035 |
| 33. | *P. putida* | 30 | 1 | 40.035 |
| 34. | *P. putida* | 40 | 1.1 | 56.52 |
| 35. | *P. putida* | 50 | 1 | 40.035 |
| 36. | *P. putida* | 60 | 1.2 | 74.575 |
| 37. | *P. putida* | 70 | 1.1 | 56.52 |
| 38. | *P. putida* | 80 | 1.2 | 74.575 |
| 39. | *P. putida* | 90 | 1.3 | 94.2 |
| 40. | *P. putida* | 100 | 1.3 | 94.2 |

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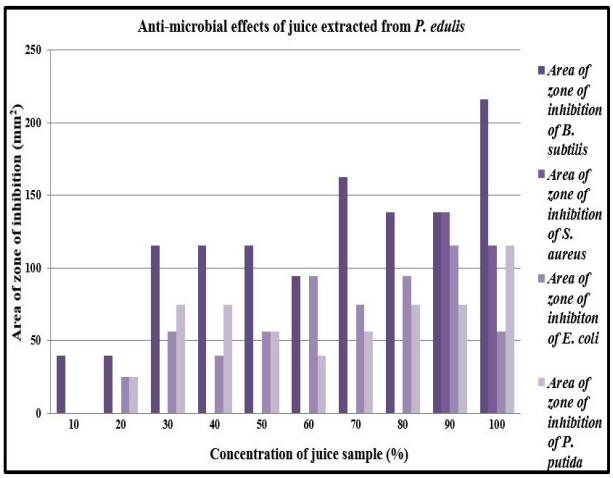
The comparison of anti-microbial activities of juices of the four varieties of Passion fruit can be graphically represented as follows:




Graph 1. Anti-microbial effects of juice extracted from *P. edulis*

The juice of *P. edulis* was seen to show the best anti-microbial activity against *B. subtilis,* followed by *S. aureus*. It showed the least activity against *P. putida* and *E. coli*. The result was verified by taking Ampicillin antibiotic and methanol as controls.

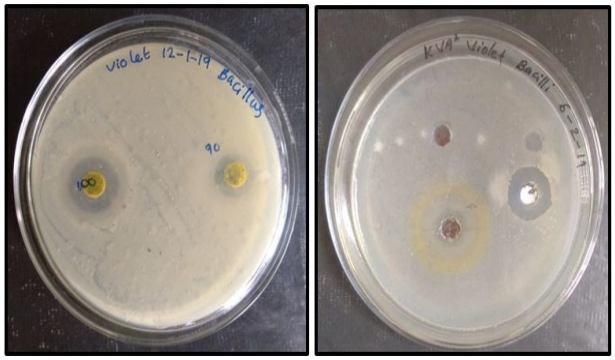
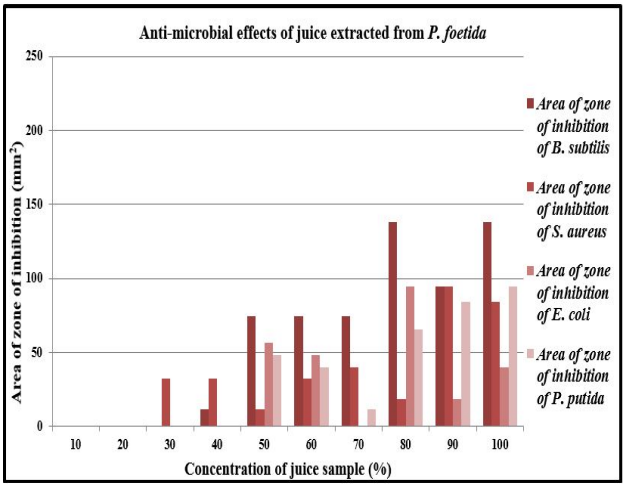


Fig. 5. Anti-microbial activity of *P. edulis* against *B. subtilis*.




Graph 2. Anti-microbial effects of juice extracted from *P. foetida*.

The juice of *P. foetida* was seen to show the best anti-microbial activity against *B. subtilis.* It showed the least activity against *P. putida* and *E. coli*. The result was verified by taking Ampicillin antibiotic and methanol as controls.

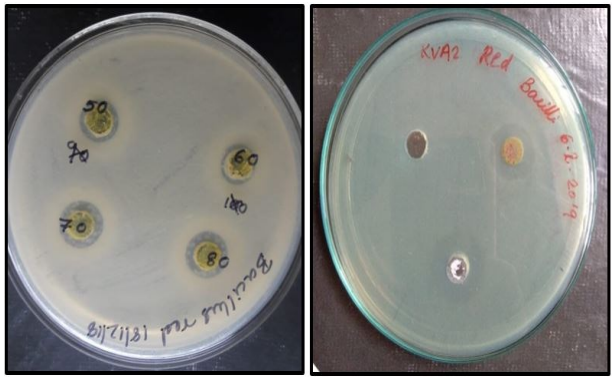
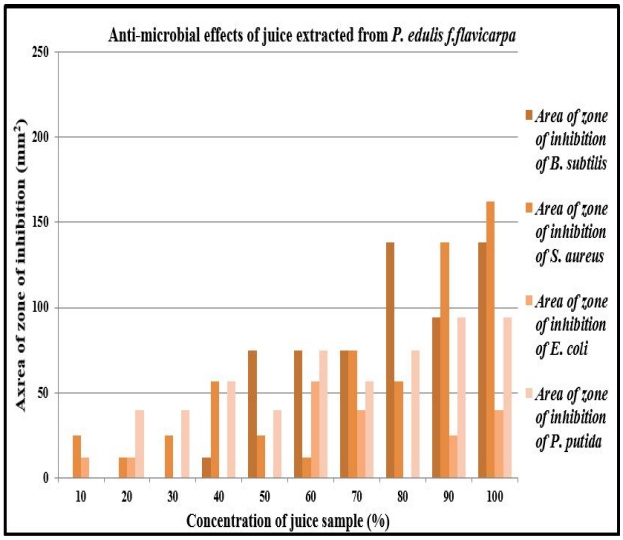


Fig. 6. Anti-microbial activity of *P. foetida* against *B. subtilis*




Graph 3. Anti-microbial effects of juice extracted from *P. edulis f.flavicarpa*.

The juice of *P. edulis f.flavicarpa* was seen to show the best anti-microbial activity against *S. aureus,* followed by *B. subtilis* and. It showed the least activity against *E. coli,* followed by *P. putida*. The result was verified by taking Ampicillin antibiotic and methanol as controls.

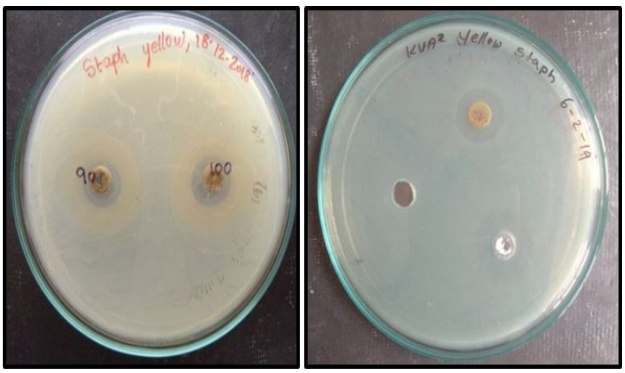


Fig. 7. Anti-microbial activity of *P. edulis f. flavicarpa* against *S. aureus*.

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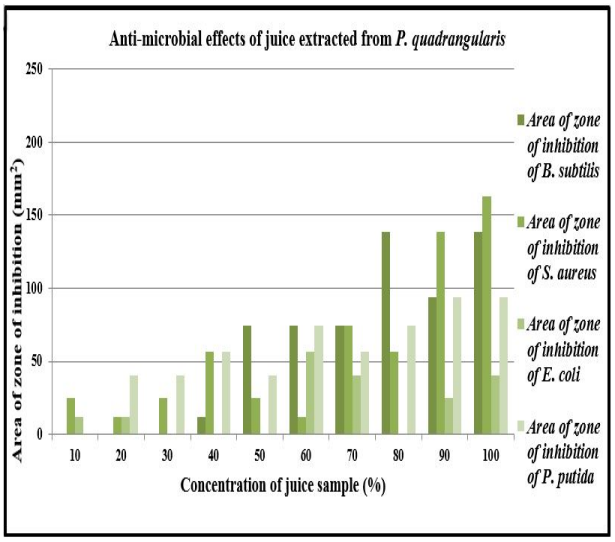


Graph 4. Anti-microbial effects of juice extracted from *P. quadrangularis*.

The juice of *P. quadrangularis* was seen to show the best anti-microbial activity against *S. aureus,* followed by *B. subtilis*. It showed the least activity against *P. putida,* followed by *E. coli*. The result was verified by taking Ampicillin antibiotic and methanol as controls.

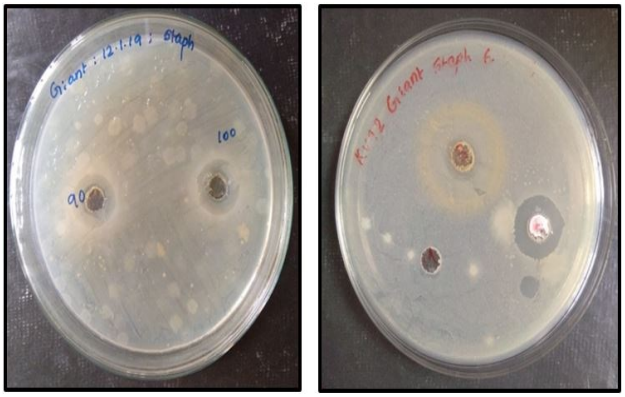

Fig. 8. Anti-microbial activity of *P. quadrangularis* against *S. aureus*.

In the present study, juices of four varieties of Passion fruits locally available-*Passiflora edulis, Passiflora foetida, Passiflora edulis f.flavicarpa* and *Passiflora quadrangula--ris* were studied for their antioxidant and anti-microbial activities. The study of antioxidant activities of the juices of Passion fruits was done by estimation of citric acid (antioxidant) content in the juices, estimation of ascorbic acid (antioxidant) content in the juices and the determination of their radical-scavenging activities. The anti-microbial activities of the juices was studied by testing them against two Gram-positive bacteria viz., *Bacillus subtilis* and *Staphylococcus aureus* and two Gram-negative bacteria viz., *Escherichia coli* and *Pseudomonas putida*.

The results showed that, the citric acid content in *P. edulis* was the greatest among the four juices, followed by that in *P. edulis f.flavicarpa*. The least amount of citric acid was seen in *P. quadrangularis*. The citric acid in the juices confer the juices a significantly large antioxidant potential. However, the ascorbic acid content was seen to be the greatest in *P. edulis f.flavicarpa* amongst the four juices, followed by that in *P. quadrangularis*. The least amount of ascorbic acid was seen in *P. foetida*. The radical-scavenging activity was seen the greatest in *P. edulis f.flavicarpa* amongst the four juices, followed by that in *P. quadrangularis*. However, radical-scavenging activity shown by *P. edulis* and *P. foetida* were moderately high.

The results of anti-microbial assays of the juices showed that *P. edulis* showed highest activity against *B. subtilis,* followed by *S. aureus*. It showed the least activity against *P. putida* and *E. coli*. The juice of *P. foetida* was seen to show the best anti-microbial activity against *B. subtilis.* It showed the least activity against *P. putida* and *E. coli*. *P. edulis f. flavicarpa* was seen to show the best anti-microbial activity against *S. aureus,* followed by *B. subtilis*. It showed the least activity against *E. coli,* followed by *P. putida*. It was seen that *P. quadrangularis* show the best anti-microbial activity against *S. aureus,* followed by *B. subtilis*. It showed the least activity against *P. putida,* followed by *E. coli*. It can be stated that, all the four Passion fruit juices showed a remarkable activity against the Gram-positive bacteria, *B. subtilis* and *S. aureus* rather than the Gram-negative bacteria*, E. coli* and *P. putida.*

## IV. Conclusion

In the present study, juices of four varieties of Passion fruits locally available - *Passiflora edulis, Passiflora foetida, Passiflora edulis f.flavicarpa* and *Passiflora quadrangularis* were studied for their antioxidant and anti-microbial activities. The study of antioxidant activities of the juices of Passion fruits was done by estimation of citric acid (antioxidant) content in the juices, estimation of ascorbic acid (antioxidant) content in the juices and the determination of their radical-scavenging activities. The anti-microbial activities of the juices was studied by testing them against two Gram - positive bacteria viz., *Bacillus subtilis* and *Staphylococcus aureus* and two Gram-negative bacteria viz., *Escherichia coli* and *Pseudomonas putida*.

The results showed that, the citric acid content in *P. edulis* was the greatest among the four juices, followed by that in *P. edulis f. flavicarpa*. The least amount of citric acid was seen in *P. quadrangularis*. The citric acid in the juices confer the juices a significantly large antioxidant potential. However, the ascorbic acid content was seen to be the greatest in *P. edulis f.flavicarpa* amongst the four juices, followed by that in *P. quadrangularis*. The least amount of ascorbic acid was seen in *P. foetida*. The radical-scavenging activity was seen the greatest in *P. edulis f. flavicarpa* amongst the four juices, followed by that in *P. quadrangularis*. However, radical-scavenging activity shown by *P. edulis* and *P. foetida* were moderately high. Thus, all the four varieties of Passion fruit can be considered as one of the richest sources of citric acid and ascorbic acid, making them effective antioxidants. They can substitute for the citrus fruits in the diet. The juice extracts can be used to produce cosmetics such as anti-oxidant-rich, age-control skin creams. The commercial production of such cosmetics may lead to a great demand of these Passion

fruit varieties in the global commercial markets. This demand can in turn, boost up the cultivation of the Passion fruit varieties, increasing the economic status of the cultivators.

The results of anti-microbial assays of the juices showed that *P. edulis* showed highest activity against *B. subtilis,* followed by *S. aureus*. It showed the least activity against *P. putida* and *E. coli*. The juice of *P. foetida* was seen to show the best anti-microbial activity against *B. subtilis.* It showed the least activity against *P. putida* and *E. coli*. *P. edulis f.flavicarpa* was seen to show the best anti-microbial activity against *S. aureus,* followed by *B. subtilis*. It showed the least activity against *E. coli,* followed by *P. putida*. It was seen that *P. quadrangularis* show the best anti-microbial activity against *S. aureus,* followed by *B. subtilis*. It showed the least activity against *P. putida,* followed by *E. coli*. It can be stated that, all the four Passion fruit juices showed a remarkable activity against the Gram-positive bacteria, *B. subtilis* and *S. aureus* rather than the Gram-negative bacteria*, E. coli* and *P. putida.* The Passion fruit juices can be used in the manufacture of medicinal preparations against the diseases caused by *B. subtilis* and *S. aureus*. They can be used synergistically with the medicines prevalently available, reducing the side-effects and the cost of manufacture. This can help in raising the turnover of the industries manufacturing the pharmaceuti--cals.

In India, only the Passion fruit varieties- *P. edulis* and *P. edulis f. flavicarpa* are cultivated on a large-scale commercial basis. The cultivation of the other two Passion fruit varieties- *P. foetida* and *P. quadrangularis* is also equally beneficial as they are equally significant antioxidants and healthy nutritional supplements. Thus, the cultivation and promotion of all these varieties of Passion fruits in a developing country like India, can enhance the economic and financial status of the small-scale cultivators, thus enhancing their living standards.

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