*International Journal of Research and Review*
*Volume 11; Issue: 9; September 2024*
*Website: www.ijrrjournal.com*
*Review Paper* *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

# *Passiflora edulis* seeds: Phytochemical Analysis and Therapeutic Properties

**Dhanya Bhat[1], Yashmitha S Raj[2], Aishwarya Patil [3], Sharad S Achar[4]**

[1,2,3,4] Department of Biotechnology,
Padmashree Institute of Management and Sciences, Bangalore University, Bengaluru, India.

Corresponding Author: Dr. Sharad S Achar

**DOI: https://doi.org/10.52403/ijrr.20240930**

## ABSTRACT

*Passiflora edulis* is a tropical vine that is extensively farmed for its delicious, beautiful fruits, and its medicinal properties. The seeds of this fruit that is generally thrown away has been found to contain high levels of phytochemicals, dietary fiber, protein, and essential minerals. The objective of this present study is to carry out a literature review on the phytochemical composition and therapeutic effects of *Passiflora edulis* seeds. It is suggested that the seeds themselves are medicinal, with antioxidant, anti-inflammatory, anti-diabetic and antibacterial properties. The seeds have been researched for their use in curing diseases, and in cosmetics and drugs, skin care and also as an organic sunscreen. These studies provide a good basis for the medical use of *Passiflora edulis* seeds. However, more research is needed to pinpoint a specific candidate molecule that can be useful in future drug formulations. This study suggests that further research should be done on the pharmaceutical properties of *Passiflora edulis* seeds being used for the purpose of designing a new medicinal compound that can be useful in treatment of diseases or utilized in cosmeceuticals.

***Keywords:*** *Passiflora edulis* seeds; Bioactive compounds; Passifloraceae, Cosmeceuticals; Phytochemicals.

## INTRODUCTION

Passion fruit (*Passiflora edulis*) is a major cash crop and a medicinal fruit from the family *Passifloraceae* i.e. grown for its unique taste and aromatic juice. This is a tropical vine found in hot and humid conditions and is cultivated extensively worldwide in the tropics to subtropics regions. [1] The cultivation of Passiflora species is mostly concentrated for their edible and attractive fruits as well as their pharmaceutical applications. The fruit contains a juicy to firm moist interior that is filled with seeds. While the fruit juice is the primary revenue generator, the rest of the fruit parts (rind and seeds) are a source of several phytochemical compounds and medicinal value.

Traditionally these seeds have been discarded by crushing after the juice is extracted from the pulp of the fruit. However, studies have indicated that seeds of *Passiflora edulis* Sims and *P. edulis f. flavicarpa* are edible and rich in oil content. While the seeds of passion fruit are often ignored, they actually contain dietary fiber (which is good for digestion), protein and essential minerals like iron and magnesium. The seeds also contain bioactive compounds including piceatannol, polyphenolic and anti-inflammatory substances that can protect against oxidative damage and are known to be beneficial in type 2 diabetes and cardiovascular diseases. Passion fruit seeds are generally added to a number of dishes for an extra nutty flavour in the

preparation of salads, sweets and even milk shakes or consumed along with fruit pulp. Moreover, their high oil content paves way for its potential use in food and cosmetic applications as a moisturizer. [2] Hence further studies are needed to explore the various other properties and uses of these seeds. This article is a comprehensive review on the properties of the *Passiflora edulis* seeds mentioned in different articles and its possibilities in the pharmaceutical sector.

A complete review on *Passiflora edulis* encompassing its botanical information, origin, and distribution, description of the plant, its parts and its habitat. The authors have reported the historical data on the usage of this fruit, its uses, constituents of the fruit and nutritional facts. [3] Similar results are also mentioned about the seeds of *Passiflora edulis* to contain bio active compounds. [4]

**Extraction techniques:**

Different techniques viz. supercritical fluid extraction (SFE), cold maceration and ultrasound assisted extraction to obtain the extracts from seed cake. Among the different extraction techniques used, SFE method and cold maceration technique were best methods as high product yield was obtained from seed and seed cake respectively. [5] The extraction method of using 70% ethanol at 80 °C for 30 minutes to be more efficient to extract high concentrations of polyphenolic compounds. [6] n-hexane, ethyl acetate and aqueous extracts from seeds of *Passiflora edulis* using methanolic water under liquid-liquid extraction was performed. [7] High yield in using soxhlet extraction method and containing high contents of unsaturated fatty acids was observed. [8] The supercritical CO2 extraction of passion fruit seed oil was done and evaluated the effect of temperature, pressure and ultrasound in the extraction process. [9] They have utilized field emission scanning electron microscopy, and proved UAE leads to mechanical damage and smaller size of the cells and hence is the most effective technique of extraction.

**Proximate analysis:**

The proximate analysis consisting of moisture, lipids, and protein, ash, and fibre contents along with titratable acidity, pH and soluble solids content of the seeds from *Passiflora edulis* was carried out. [10] Proximate analysis and mineral contents of three varieties of *Passiflora edulis* (*P. edulis* Purple), *P. quadrangularis* and *P. maliformis*) [2]. Proximate analysis was done for the seeds from *Passiflora edulis* and observed high amounts of protein, and oil content [11]. They have observed the presence of minerals and salts viz. sodium, magnesium, calcium, potassium and 17 amino acids. Authors have performed the proximate analysis tests on the seeds of sweet passion fruit (*Passiflora ligularis* Juss) cv. Gumanti and have correlated the maturity level of seeds in the fruits with various parameters. [12] Many other authors have observed that seeds with maturity level I, II and III were rich in carbohydrates, fibre, and crude fat. [12] Other sets of authors have performed the proximate analysis along with mineral safety index and mineral ratios by implementing the regression analysis. [13] The results mentioned by the authors indicate concentrated values of ash, protein, fibre and carbohydrate in the seeds. Among the minerals, high concentrations in potassium, calcium, copper and phosphorus.

**Phytochemical properties:**

Several studies have been performed to identify the phytochemical properties of the seeds from *Passiflora edulis* and *Passiflora edulis* f. flavicarpa. Most of the raw material used for these studies were the waste products like seeds and seed cake obtained from the food industry (juice industry, oil industry).

**Phytochemical constitution:**

Elaborate review on the constituents of *Passiflora edulis* and mentioned about the presence of flavonoids and triterpenoids in

large quantities. [4] Authors have observed high total phenolic content in the ethanolic extract of the seeds from *Passiflora edulis*. [5,14,7] The authors have performed liquid chromatography-electrospray ionization-tandem mass spectrometry and identified the stilbene piceatannol as a major component in the extract. [6] Purified and characterized a plant peptide of 50 KDa (Pe-AFP1) from *Passiflora edulis*. The peptide was purified by affinity column chromatography and further assayed for its properties. [15] Authors have isolated a polyphenolic compound scirpusin B and identified it as a second major compound found in the extracts of passiflora seeds. [16] Another set of authors observed compounds with high sun protection factor comparable to ferulic acid, chlorogenic acid, rosmarinic acid and quercetin. Meanwhile, large amounts of kojic acid and gallic acid were observed in the aqueous extracts. [7] The identified the acidity index to be 4.0 mg KOH/g i.e. in the permissible limits. [10] Reports about the articles mentioning the presence of piceatannol along with a myriad of various other important compounds in the seed extracts of *Passiflora edulis*. [4]

**Oil content:**

The seeds from *Passiflora edulis f. flavicarpa* in soxhlet and observed 30.39% oil content. Further studies on this oil revealed the presence of 87.59% of unsaturated fatty acids, 73.14% of linoleic acid, 13.83% of oleic acid, 499.30% of tocopherols and 1,314.13 mg GAE/kg of phenolic compounds. [17] The oils from seeds by solvent and supercritical dioxide carbon method and found them to be golden orange color and liquid at room temperature with a specific gravity of 0.917. Fatty acid composition analysis of this oil showed the presence of two essential fatty acids linoleic acid and linolenic acid. [11] Extraction of the oil rich in the PUFA, tocopherol and tocotrienol. [17] and [10] have mentioned the properties of the oil from these seeds to be similar to that of other edible oils. [9] The oil extracted from all the extracts of *Passiflora edulis* seeds. [8] Other authors have mentioned about the seed being used for edible oil extraction. [4]

**Therapeutic properties:**

The utilization of this fruit as a traditional medicine for several diseases and pharmacological properties is well documented [18]. Several authors [1], [17], [10], [14], [6], [9], [7], [19]. have performed the DPPH method of antioxidant estimation and have corroborated the presence of antioxidant property in the seeds of *passiflora edulis*. DPPH radical scavenging activity, oxygen radical absorbance capacity, β-carotene bleaching assay, and ferric reducing antioxidant power assay techniques to identify the presence of antioxidant property in the extracts of seeds. [6] Assays viz. DPPH, FRAP, ORAC to check the presence of antioxidant property. [20] Presence of anti-hypertensive, anti-tumor, hypo lipidemic, anti-diabetic properties in the fruit juice is mentioned [1]. Reports about sources mentioning the presence of properties like, improvement of skin condition, fat-burning promotion effects, and hypoglycemic effects. [14] Investigations on the antidiabetic, antiglycation, and antioxidant properties from the ethanolic extracts of seeds from passiflora. Different assays viz, alpha amylse, alpha –glucosidase, dipeptidyl-peptidase-4 (DPP-4) were performed and observed that the ethanolic extract and piceatannol inhibited the formation of advanced glycation end-products (AGE). The extract and piceatannol also inhibited the formation of β-amyloid fibrils under in vitro conditions up to 100%. The ability to scavenge hypochlorous acid of piceatannol and extract were similar to that of quercetin. [21] Tests on the antioxidant properties of piceatannol and scirpusin B by DPPH assay and have inferred scirpusin B to be a greater antioxidant than piceatannol. [16] Observations on the ferric reducing power and tyrosinase inhibitory effect in the ethyl acetate extract of the seeds. [22] Authors have mentioned about observing a linear

relationship with total phenol content and antioxidant activity in the extract from the seeds of sweet passion fruit *Passiflora ligularis* Juss cv. Gumanti. [12] The antioxidant and hypoglycemic effects of piceatannol in the seeds of *Passiflora edulis* from various other articles. [4] Various inhibition assays viz. collagenase, elastase and tyrosinase enzyme inhibition assays to show the cosmeceutical usage of the ethanolic seed extract. [20]

**Animal testing:**

The authors have performed studies on two sets of Cobb male broilers by feeding them with various percentages of *Passiflora edulis* seed residues mixed with its regular feed. The authors have also determined the energy, protein content and various other parameters along with the effects of seed by products in the feed of broilers. They have observed 3945 kcal kg–1 of nitrogen corrected apparent metabolizing energy and 10.68% of crude protein content. Infusing the regular feed with 5% of seed residues in 1 to 21 day old and 1 to 42 day old broilers would not impair the performance, blood parameters, carcass yield, meat quality or the intestinal morphometry. The same feed was also fed to egg laying hens and observed no variations in their performance and quality of the eggs. [23] Authors have carried out experiments on diabetic rats with streptozotocin induced oxidative stress. They have fed the diabetic rats (oral route) with extracts of *Passiflora edulis* in two concentrations of 250 mg/kg and 500 mg/kg. They have observed a significant ($P < 0.001$) control in the blood glucose levels of diabetic rats during the subacute administration of the extracts. Also, it is reported as the extract protected the end organs by restoring the antioxidant enzymes and the levels of superoxide dismutase was increased whereas catalase and TBARS was decreased. The histopathological studies of the pancreas in these rats treated with 500 mg/kg of extracts had protective effects with attenuation of leukocyte infiltration and morphological changes. [24]

Tests of the acetone fraction of *Passiflora edulis* Sims for neuroprotective activity in murine Alzheimer's disease. The authors have carried out HPLC-DAD-MS analysis and observed maximum content of stilbenes viz. trans-piceatannol, scirpusins A-B and cassigarol E. The total phenolic content was 413.87±1.71 mg GAE eqv/g. They treated the Alzheimer's mice with 100 mg/kg and 200 mg/kg of extract and performed Morris water maze-reference Spatial Memory test. The treated mice spent less than 47% and 66% of time compared to Alzheimer's mice. The researchers observed nanomolar concentrations of Cassigarol E and Scirpusin A were better than positive control (donepezil and tacrine) against AchE and butyrylcholinesterase (BchE). The in silico studies showed trans-piceatannol and trans-resveratrol displaying selectively inhibitory activity against acetylcholinesterase (AchE). [3] Tests on the effects of piceatannol, and scirpusin B from passiflora seed extracts on human keratinocytes. They have treated the human keratinocytes with seed extract and have observed an increase in the GSH levels in a dose dependent manner and decrease in the UVB induced reactive oxygen species. They have recorded a reduced matrix-metalloproteinase (MMP)-1 activity in keratinocytes pre-treated with piceatannol and hence it has been inferred as this reduction leads to drop in ROS generation. [25] Authors have mentioned about the ethanolic extract of the seeds having no cytotoxicity on the human normal bronchial epithelial (BEAS-2B) cells and alpha mouse liver (AML-12) cells upto 100 and 50 µg/ml. [21] Authors have studied the anticancer properties of 10 ethanol extracts from 5 fruits including *Passiflora edulis*. They have performed resazurin reduction assay on leukaemia CCRF-CEM cells and the positive results obtained were again tested on a set of 8 human cancer cell lines. All the extracts had displayed positive results against leukaemia CEM/ADR5000 cells. Especially, the extracts from the leaves and the seeds of *Annona muricata*

and of the fruit of *Passiflora edulis* had appreciable IC50 values against CCRF-CEM cells MDR subline CEM/ADR5000 cells. The flow cytometry was also performed to measure cell cycle, apoptosis, mitochondrial membrane potential (MMP) and ROS. [26] Tests on the vasorelaxation properties of piceatannol compounds by an ex-vivo assay in thoracic aorta of rats respectively. A comparative study revealed scirpusin B to be a greater vasorelaxant than piceatannol. [16] Tests on the ethyl acetate extracts on vero cells at the highest concentration and have observed them to be non-cytotoxic. [22] The authors in [27] have studied the effects of piceatannol isolated from *Passiflora edulis* on 39 human subjects including men and women (overweight and non-overweight). They have studied the effect of piceatannol on glucose metabolism and insulin sensitivity. The authors have also studied other secondary parameters viz. blood pressure, heart rate, endothelial function, lipid levels, inflammation, oxidative stress, mood status, along with Sirt1 and hosphor-AMP-activated kinase (p-AMPK) expression in isolated peripheral blood mononuclear cells (PBMNCs). The authors have reported that the overweight men supplemented with piceatannol had reduced serum insulin levels, homeostasis model assessment–insulin resistance (HOMA-IR), blood pressure and heart rate. No beneficial effects were observed in non-overweight women and overweight individuals (men and women). The other parameters considered in the study were also not affected from the supplementation of piceatannol.

**Antifungal assay:**

The in-vitro assays were performed by [15] using a plant peptide of 50 Kda (Pe-AFP1) isolated from *Passiflora edulis.* The results indicated the peptide to be inhibiting the growth of *T. harzianum, F oxysporum*, and *A fumigatus* with IC50 values of 32, 34, and 40 micro g/ml, respectively. Whereas, *R solani, P brasiliensis* and *C albicans* had no response to the peptide. The N-terminal sequencing of this peptide displayed huge similarities to 2S albumins and hence, the authors have inferred that further research is needed on this peptide to be used as an antifungal drug. Authors have also mentioned about the antifungal property of these seeds in their review. [19]

**Antibacterial assay:**

Many authors have performed antibacterial tests using the *Passiflora edulis* extracts obtained from subcritical fluid extraction, soxhlet extraction and ultrasound assisted extraction. The oil extracted from all these extracts had anti-bacterial activity against *Escherichia coli, Salmonella enteritidis, Staphylococcus aureus* and *Bacillus cereus*. [8] They have observed ethanolic extract of these seeds to contain anti-microbial activity against *Escherichia coli* and *Listeria innocua*. [5]

**Biostatistics and bioinformatics studies:**

The authors of [2] have performed principal component analysis (PCA) of the passiflora seeds with maize, oats, flaxseed, sesame, soybean, almond, groundnut, and seeds of sunflower and pumpkin. They have inferred the presence of a correlation in passiflora seeds with other seeds in parameters such as fiber, sodium, and zinc. The authors from [6] have performed response surface methodology (RSM) to optimize the extraction of polyphenol compounds with antioxidant activity from seeds of *Passiflora edulis.* The authors have considered three parameters (extraction time, ethanol concentration, and temperature) to optimize. The authors of [9] have explained the extraction kinetics based on a mathematical model. Authors have performed the tests on the seeds of sweet passion fruit (*Passiflora ligularis* Juss) cv. Gumanti and have correlated the maturity level of seeds in the fruits with proximate analysis, total anti-oxidant and phenolic content. [12] Other set of authors have applied regression analysis to proximate analysis to quantify the components in various parts of *Passiflora edulis*.[13] . Authors have also performed the

docking studies to identify the binding ability of compounds in the extract such as fisetin, galangin and S-eriodictyol to collagenase and tyrosinase. The molecular stability and rationality of docking results was validated by molecular dynamics and MM/PBSA calculations. Further, the drug-likeness studies have demonstrated the dermato-pharmacokinetics indices to prove the anti-aging property. [20]

**Product development:**

The authors [28] have performed a study to design and characterize the nanostructured lipid carrier based hydrogels with oil from *Pasiflora edulis* seeds. Polymer gels were prepared by ultra-sonication technique using the seed oil and glyceryl distearate. Long term stability tests were also performed on gels stored for 12 months. Several tests such as morphology, in vitro occlusion test, encapsulation efficiency, particle size analysis, polydispersity index analysis, pH measurement, colour analysis, viscosity studies, texture analysis, ex vivo skin penetration study, zeta potential, tyrosinase inhibition activity, in vitro skin permeation experiments and in vitro cytotoxicity studies were carried out by the authors. They have observed the beads to have high encapsulation efficiency followed by good tyrosinase inhibitory activity and skin retention of the nanoparticles. Finally, the formulations developed by these researchers had no cytotoxicity towards HaCat cells. The viscosity and the texture properties were suitable for application on skin and is mentioned as being a good candidate as depigmenting agent. The usage of *passiflora* seed extract in cosmetics and as a sun protectant or antiaging agent is mentioned by [4] and [19].

The authors from [12] have stated a daily consumption of this fruit juice, or extracts from the leaves, stems and peels in a moderate dose is non-toxic and safe. Authors of [2] have suggested the use of passiflora seeds for nutraceutical and pharmaceutical purposes. Authors have detailed and elaborate review on the aspects of using seeds as a source of bio active compounds. They have mentioned various fruit seeds including *Passiflora edulis* to be source of several bio active compounds. [19]

## CONCLUSION

All these studies provide a strong proof on utilizing the Passiflora edulis seeds in treatment and for betterment of health. However, this is an overview of the studies reported on the presence of medicinal compounds in the seeds, and the richness in the nutritional aspects of these seeds. Presence of phytochemicals in seeds from different extracts of passiflora sp. has been identified experimentally by many authors. Followed by testing the compounds in various assays is also reported. However, identifying a compound molecule that can be taken further in drug formulations is not mentioned in detail in any literature. Hence there is a requirement of scientific studies in proving the pharmaceutical properties of the passiflora seeds.

### *Declaration by Authors*

**Ethical Approval:** Not Applicable
**Acknowledgement:** None
**Source of Funding:** None
**Conflict of Interest:** The authors declare no conflict of interest.

## REFERENCES

1. He X, Luan F, Yang Y, Wang Z, Zhao Z, Fang J, et al. Passiflora edulis: An insight into current researches on phytochemistry and pharmacology. Front Pharmacol. 2020;11. https://doi.org/10.3389/fphar.2020.00617
2. Ramaiya S, Bujang J, Zakaria M. Nutritive Values of Passion Fruit (Passiflora Species) Seeds and Its Role in Human Health. J Agric Food Dev. 2018;4(1):23–30. https://doi.org/10.30635/2415-0142.2018.04.4
3. Mostefa N, Djebli N, Khanh PN, Ha NX, Anh HTN, Ha VT, et al. Anti-Alzheimer's Activity of Polyphenolic Stilbene-Rich Acetone Fraction of the Oil-Removed Seeds of Passiflora edulis: in Vivo and in Silico Studies. Chem Biodivers. 2023;

20(5):e202201051. https://doi.org/10.1002/cbdv.202201051
4. Getu W, Belay A, Tadesse E. Passion fruit (Passiflora edulis Sims) by-products as a source of bioactive compounds for non-communicable disease prevention: extraction methods and mechanisms of action: a systematic review. Front Nutr. 2024;11. https://doi.org/10.3389/fnut.2024.1340511
5. Oliveira D, Angonese M, Gomes CL, Roberta S. Valorization of passion fruit (Passiflora edulis sp.) by-products: Sustainable recovery and biological activities. Supercrit Fluids. 2016;111:55–62. https://doi.org/10.1016/j.supflu.2016.01.010
6. de Santana FC, de Oliveira Torres LR, Shinagawa FB, de Oliveira e Silva AM, Yoshime LT, de Melo ILP, et al. Optimization of the antioxidant polyphenolic compounds extraction of yellow passion fruit seeds (Passiflora edulis Sims) by response surface methodology. J Food Sci Technol. 2017;54(11):3552–3561. https://doi.org/10.1007/s13197-017-2813-3
7. Lourith N, Kanlayavattanakul M. Antioxidant Activities and Phenolics of Passiflora edulis Seed Recovered from Juice Production Residue. J Oleo Sci. 2013a;62(4):235–240. https://doi.org/10.5650/jos.62.235
8. Pereira MG, Maciel GM, Haminiuk CWI, Bach F, Hamerski F, de Paula Scheer A, et al. Effect of Extraction Process on Composition, Antioxidant and Antibacterial Activity of Oil from Yellow Passion Fruit (Passiflora edulis Var. Flavicarpa) Seeds. Waste Biomass Valorization. 2018;10(9):2611–2625. https://doi.org/10.1007/s12649-018-0269-y
9. Barrales FM, Rezende CA, Martínez J. Supercritical CO2 extraction of passion fruit (Passiflora edulis sp.) seed oil assisted by ultrasound. J Supercrit Fluids. 2015;104:183–192. https://doi.org/10.1016/j.supflu.2015.06.006
10. Silva RM, Placido GR, Silva MAP, Castro CFS, Lima MS, Caliari M. Chemical characterization of passion fruit (Passiflora edulis f. flavicarpa) seeds. Afr J Biotechnol. 2015;14(14):1230–1233. https://doi.org/10.5897/ajb
11. Liu S, Yang F, Li J, Zhang C, Ji H, Hong P. Physical and chemical analysis ofPassifloraseeds and seed oil from China. Int J Food Sci Nutr. 2008;59(7-8):706–715. https://doi.org/10.1080/09637480801931128
12. Andasuryani A, Zainal PW, Ifmalinda I. Chemical characteristic of sweet passion fruit (Passiflora lingularis Juss) seeds from Indonesia based on maturity levels. J Phys Conf Ser. 2020;1469.
13. Emmanuel IA, Matthew OA. Chemical Composition of the Raw Fruit Coat, Seed and Pulp. FUW Trends Sci Technol J. 2017;2(1B):334–341.
14. Kawakami S, Morinaga M, Tsukamoto-Sen S, Mori S, Matsui Y, Kawama T. Constituent Characteristics and Functional Properties of Passion Fruit Seed Extract. Life (Basel). 2021;12(1):38. https://doi.org/10.3390/life12010038
15. Pelegrini PB, Noronha EF, Muniz MAR, Vasconcelos IM, Chiarello MD, Oliveira JTA, et al. An antifungal peptide from passion fruit (Passiflora edulis) seeds with similarities to 2S albumin proteins. Biochim Biophys Acta Proteins Proteom. 2006; 1764(6):1141–1146. https://doi.org/10.1016/j.bbapap.2006.04.010
16. Sano S, Sugiyama K, Ito T, Katano Y, Ishihata A. Identification of the Strong Vasorelaxing Substance Scirpusin B, a Dimer of Piceatannol, from Passion Fruit (Passiflora edulis) Seeds. J Agric Food Chem. 2011;59(11):6209–6213. https://doi.org/10.1021/jf104959t
17. Malacrida CR, Jorge N. Yellow passion fruit seed oil (Passiflora edulis f. flavicarpa): physical and chemical characteristics. Braz Arch Biol Technol. 2012;55(1):127–134. https://doi.org/10.1590/s1516-89132012000100016
18. Zibadi S, Watson RR. Passion Fruit (Passiflora edulis). Evid Based Integr Med. 2004;1(3):183-7. https://doi.org/10.2165/01197065-200401030-00005
19. Fidelis M, Moura K, Kabbas Junior R, Pap N, Mattila P, Mäkinen S, et al. Fruit seeds as sources of bioactive compounds: Sustainable production of high value-added ingredients from by-products within circular economy. Molecules. 2019;24(21):3854. https://doi.org/10.3390/molecules24213854
20. Yepes A, Ochoa-Bautista D, Murillo-Arango W, Quintero-Saumeth J, Bravo K,

Osorio E. Purple passion fruit seeds (Passiflora edulis f. edulis Sims) as a promising source of skin anti-aging agents: Enzymatic, antioxidant and multi-level computational studies. Arabian J Chem. 2021;14(1):102905. https://doi.org/10.1016/j.arabjc.2020.11.011

21. dos Santos FAR, Xavier JA, da Silva FC, Merlin JPJ, Goulart MOF, Rupasinghe HPV. Antidiabetic, Antiglycation, and Antioxidant Activities of Ethanolic Seed Extract of Passiflora edulis and Piceatannol In Vitro. Molecules. 2022;27(13):4064. https://doi.org/10.3390/molecules27134064
22. Lourith N, Kanlayavattanakul M. Antioxidant Activities and Phenolics of Passiflora edulis Seed Recovered from Juice Production Residue. J Oleo Sci. 2013b;62(4):235–240. https://doi.org/10.5650/jos.62.235
23. Leonardo HZ, Alice EM, Diaz-Vargas M, Flávia A, Ivan CO, Guilherme C, et al. By-product of passion fruit seed (Passiflora edulis) in the diet of broilers. Can J Anim Sci. 2017. https://doi.org/10.1139/cjas-2016-0210
24. Kandandapani S, Balaraman AK, Ahamed HN. Extracts of passion fruit peel and seed of Passiflora edulis (Passifloraceae) attenuate oxidative stress in diabetic rats. Chin J Nat Med. 2015;13(9):680–686. https://doi.org/10.1016/s1875-5364(15)30066-2
25. Maruki-Uchida H, Kurita I, Sugiyama K, Sai M, Maeda K, Ito T. The Protective Effects of Piceatannol from Passion Fruit (Passiflora edulis) Seeds in UVB-Irradiated Keratinocytes. Biol Pharm Bull. 2013;36(5):845–849. https://doi.org/10.1248/bpb.b12-00708
26. Kuete V, Dzotam JK, Voukeng IK, Fankam AG, Efferth T. Cytotoxicity of methanol extracts of Annona muricata, Passiflora edulis and nine other Cameroonian medicinal plants towards multi-factorial drug-resistant cancer cell lines. SpringerPlus. 2016;5(1). https://doi.org/10.1186/s40064-016-3361-4
27. Kitada M, Ogura Y, Maruki-Uchida H, Sai M, Suzuki T, Kanasaki K, et al. The Effect of Piceatannol from Passion Fruit (Passiflora edulis) Seeds on Metabolic Health in Humans. Nutrients. 2017;9(10):1142. https://doi.org/10.3390/nu9101142
28. Krambeck K, Silva V, Silva R, Fernandes C, Cagide F, Borges F, et al. Design and characterization of Nanostructured lipid carriers (NLC) and Nanostructured lipid carrier-based hydrogels containing Passiflora edulis seeds oil. Int J Pharm. 2021; 600:120444. https://doi.org/10.1016/j.ijpharm.2021.120444

How to cite this article: Dhanya Bhat, Yashmitha S Raj, Aishwarya Patil, Sharad S Achar. *Passiflora edulis* seeds: phytochemical analysis and therapeutic properties. *International Journal of Research and Review*. 2024; 11(9): 284-291. DOI: *https://doi.org/10.52403/ijrr.20240930*

******