

## Biochemical composition and biological potential of ora-pro-nobis fruit: an overview

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### ABSTRACT

Exotic fruit crops, such as ora-pro-nobis, play an important role in human nutrition, making them an excellent base for low-calorie diets. Recent research has shown that ora-pro-nobis fruit is rich in many nutritional and bioactive compounds, making it highly valued for its unique taste, aroma, and color. As the popularity of this fruit grows in economic markets, it is important to have a comprehensive reference for its nutritional and bioactive benefits. This review provides a valuable source for current knowledge about nutritional and bioactive compositions, as well as the relationship of its biologically active components with beneficial and functional effects on human health, through scientifically proven information. By harnessing the rich properties of ora-pro-nobis fruit, we can pave the way for further development of functional foods, as well as its applications in the nutraceutical, cosmetic, and pharmaceutical industries.

**Keywords:** *Pereskia aculeata* Miller, *Cactaceae*, Unconventional vegetables, Nutrient content, Potential benefits.

### Composição bioquímica e potencial biológico do fruto de ora-pro-nóbis: uma visão geral

#### RESUMO

Frutos exóticos como os da ora-pro-nóbis desempenham um papel importante na nutrição humana tornando-se excelente base para dietas de baixo teor calórico. Altamente valorizado por seu sabor, aroma e cor únicos, pesquisas recentes mostram que os frutos da ora-pro-nóbis podem ser ricos em muitos compostos nutricionais e bioativos. Com a crescente popularidade deste fruto em mercados econômicos é importante ter uma referência abrangente por seus benefícios nutricionais e bioativos. Esta revisão fornece uma fonte valiosa para o conhecimento atual sobre a composição nutricional, bioativa e a relação dos seus componentes biologicamente ativos com efeitos benéficos e funcionais na saúde humana, através de informações cientificamente comprovadas e desenvolvimento adicional de frutos de ora-pro-nóbis para alimentos funcionais, bem como aplicações nas indústrias nutraceuticas, cosméticas e farmacêuticas.

**Palavras-chave:** *Pereskia aculeata* Miller, *Cactaceae*, Vegetais não convencionais, Teor de nutrientes, Benefícios potenciais.



## 1. Introduction

Ora-pro-nobis (*Pereskia aculeata* Miller) is known as American gooseberry, Barbados gooseberry, Antilles gooseberry, and blade-apple cactus all over the world (Agostini-Costa et al., 2012). *Pereskia* species are naturally occurring and grown in a wide range of countries, including South and Central America and tropical America (Sharif et al., 2013). Ora-pro-nobis is a woody shrub that is juicy and perennial and grows in tropical and subtropical zones. Its fruit is golden marble-sized spheres, fleshy and cacti-like, with a pleasing taste. They are also protected by papery husks that act as a protective shield against insects, birds, diseases, and adverse climatic situations (Pérez-Molphe-Balch et al., 2015).

After peeling, ora-pro-nobis fruit can be eaten fresh or used in juices, jams, and liqueurs. The nutritious pulp contains high levels of bioactive compounds, including proteins, vitamins, carotenoids, flavonoids, and polyphenols (Agostini-Costa et al., 2012; Silva et al., 2018; Silva et al., 2019; Moraes et al., 2021; Carnevalli et al., 2022). This fruit is renowned for its therapeutic properties and has been used extensively for medicinal purposes. In addition to these properties, it also possesses noteworthy bioactivities such as antioxidant, anti-inflammatory, and antinociceptive effects, among others (Silva Júnior et al., 2010; Agostini-Costa et al., 2012; Barbalho et al., 2016; Silva et al., 2018; Agostini-Costa, 2020; Moraes et al., 2021).

Due to its high antioxidant, mineral, and vitamin contents, as well as its diverse biological potentials, ora-pro-nobis fruit has gained commercial attention for its nutritional and bioactive properties. However, despite its beneficial effects, only a limited number of studies have investigated its nutritional composition and bioactivities. Therefore, this review serves as a valuable

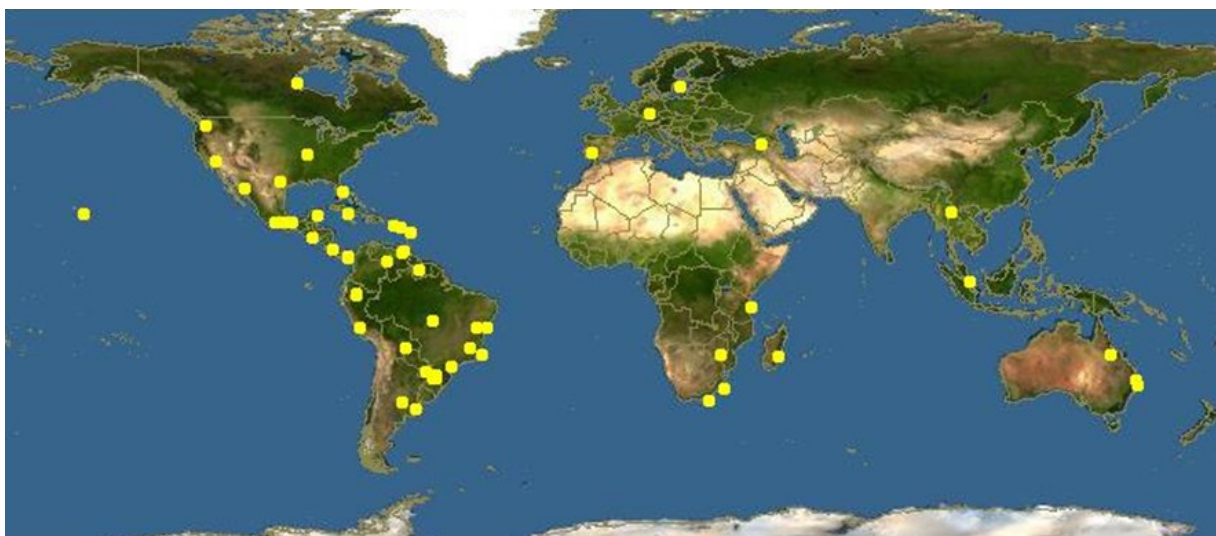
source of information on nutritional composition, pharmacological properties, and potential use of ora-pro-nobis in functional foods, nutraceuticals, and pharmaceuticals.

## General aspects

Ora-pro-nobis is a plant belonging to the *Pereskia* genus of the *Cactaceae* family, which includes over 1400 species and more than 230 genera of mainly trees and shrubs found in tropical, subtropical, and temperate regions. In Brazil, there are about 230 species of 37 genera distributed throughout the country. Its fruit is known by various names worldwide, including American gooseberry, Barbados gooseberry, Antilles gooseberry, and blade-apple cactus (Agostini-Costa et al., 2012; Sharif et al., 2013; Soller et al., 2014) (Figure 1).

Furthermore, *P. aculeata* has fast growth and can thrive in a variety of soil types. It is a perennial, succulent, shrubby, or creeping plant, characterized by its woody stem covered with evenly distributed thorns. Its broad leaves are also thorny and single or clustered terminal flowers appear at the end of their stems. Like Figure 2, its perigynous flowers are initially green and have a fleshy consistency, occurring in the hypanthium.

Fruit is pomaceous, fleshy, cacti-like, and globe-shaped, turning orange-yellow when ripe and often losing its bracteoles and spines (Rosa and Souza, 2003; Duarte and Hayashi, 2005; Madeira et al., 2013; Pérez-Molphe-Balch et al., 2015). This plant is valuable for its economic significance, with fruit used to make juices, jams, and alcoholic beverages. In temperate countries, *Pereskia*, which includes tropical fruit trees, is highly prized for its commercial value and suitability for domestication (Agostini-Costa et al., 2012; Agostini-Costa et al., 2014).



**Figure 1.** Distribution and occurrence of ora-pro-nobis in several regions of the world (Source: Discover Life, 2022)



**Figure 2.** Plant (A), flowers (B), leaves (C), and fruit (D) of ora-pro-nobis (Source: Biodiversity4all, 2022; B4fn, 2022).

This plant also represents an alternative crop that can help diversify horticultural production and increase productivity in low-fertility soil regions. However, further research is still needed to understand its fruit physiology and post-harvest management to improve commercial traits, including physicochemical and nutritional characteristics, as well as bioactive potential (Agostini-Costa et al., 2012; Silva et al., 2018). Despite its economic relevance, ora-pro-nobis has also been in continuous use for different purposes, including nutritional, medicinal, and agricultural ones.

In Brazil, its fruit is typically consumed fresh or processed into juices and jams. Its potential for use in the food and pharmaceutical industries is also on the rise, owing to its high content of carotenoids and antioxidant activity. Furthermore, research has suggested that bioactive compounds found in ora-pro-nobis fruit may help to reduce the risk of developing degenerative diseases like cancer by enhancing the immune system (Agostini-Costa et al., 2012; Agostini-Costa et al., 2014; Agostini-Costa, 2020).

### Biochemical composition

Table 1 displays the physicochemical, proximate composition, minerals, and vitamin parameters of ora-pro-nobis fruit reported in several studies. As previously mentioned, the *Pereskia* genus is highly valued for its commercial and nutritional properties, with ora-pro-nobis being one of the most widely cultivated species (Soller et al., 2014). However, the nutritional values of its fruit can vary significantly due to factors such as soil and climate conditions, as well as maturation and storage practices. These variables may contribute to the discrepancies observed in the literature regarding the

fruit's nutritional composition. To fully realize the potential of ora-pro-nobis as a valuable crop, it is important to continue researching the factors that affect its nutritional profile.

Besides its potential as a commercial crop, the fruit of this Cactaceae is also valued for its high nutritional content. Edible fruits like ora-pro-nobis contain a range of constituents with nutritional properties, including carbohydrates, proteins, and fiber. Although some of these compounds are present in low concentrations, they can still have a significant impact on human health. Ora-pro-nobis fruit, in particular, is a rich source of vitamin C, calcium, and phosphorus, with 6.30% carbohydrates, 1.00% proteins, 0.90 mg/100g niacin, 9.00 °Brix soluble solids, 1.06% citric acid, and 9.40% fibers (Agostini-Costa et al., 2012; Silva et al., 2018; Moraes et al., 2021).

Considering the nutritional and functional properties already mentioned in the literature, fruit is universally promoted as healthy and includes a diverse group of plant foods that vary greatly in energy and nutrient content. Ora-pro-nobis fruit provides vitamins and minerals to the diet and is a source of nutritional compounds that function as an antioxidant and anti-inflammatory agents and act through other protective mechanisms (Silva Júnior et al., 2010; Agostini-Costa et al., 2012; Barbalho et al., 2016; Silva et al., 2018; Agostini-Costa, 2020; Moraes et al., 2021).

Furthermore, the bioactive composition of ora-pro-nobis fruit is quite diverse and has been the subject of phytochemical investigations over the years. These studies have revealed a wide variety of chemical substances, such as carotenoids, anthocyanins, flavonoids, and other phenolic compounds, as shown in Table 2.

**Table 1.** Physicochemical, proximate composition, minerals and vitamin parameters of ora-pro-nobis fruit.

Compounds	Agostini-Costa et al. (2012)	Silva et al. (2018)	Moraes et al. (2021)
Soluble solids	N.e.	5.65	9.00
Acidity	N.e.	1.06	N.e.
SS/TA	N.e.	5.29	N.e.
pH	N.e.	3.58	4.65
Water activity	N.e.	N.e.	N.e.
Moisture	N.e.	N.e.	N.e.
Carbohydrates	6.30	N.e.	N.e.
Proteins	1.00	N.e.	N.e.
Lipids	0.70	N.e.	N.e.
Fibers	9.40	N.e.	N.e.
Ashes	N.e.	N.e.	N.e.
Energy	N.e.	N.e.	N.e.
Calcium	206.00	N.e.	N.e.
Sodium	N.e.	N.e.	N.e.
Potassium	N.e.	N.e.	N.e.
Iron	N.e.	N.e.	N.e.
Phosphorus	26.00	N.e.	N.e.
Vitamin A	N.e.	N.e.	N.e.
Thiamine	N.e.	N.e.	N.e.
Riboflavin	N.e.	N.e.	N.e.
Niacin	0.90	N.e.	N.e.
Vitamin C	125.00	N.e.	N.e.

Fw - Fresh weight; N.e. - Not evaluated; Soluble solids - °Brix; Acidity - % citric acid; Moisture, carbohydrates, proteins, lipids, fibers, ashes - %; Energy - kcal/100g; Minerals and vitamin - mg/100g.

**Table 2.** Bioactive compounds present in ora-pro-nobis fruit.

Compounds	Agostini-Costa et al. (2012)	Agostini-Costa et al. (2014)	Silva et al. (2018)	Moraes et al. (2021)
Total carotenoids	71.70	76.20	2.14	N.e.
Total anthocyanins	N.e.	N.e.	N.e.	N.e.
Total flavonoids	N.e.	N.e.	N.e.	N.e.
Total phenolics	64.90	N.e.	120.09	1.57

Fw - Fresh weight; N.e. - Not evaluated; Total carotenoids - µg.g; mg/100g; Total anthocyanins - mg/100g; Total flavonoids - mg/100g; Total phenolics - mg GAE/100g.

The bioactive compounds found in ora-pro-nobis have potential health benefits, including antioxidant and anti-inflammatory effects, and could be used as functional food ingredients and natural additives in the food and pharmaceutical industries (Agostini-Costa et al., 2012; Agostini-Costa et al., 2014; Silva et al., 2018; Ciriaco et al., 2021; Moraes et al., 2021). Other notable compounds have also been detected in considerable amounts in ora-pro-nobis fruit, such as fatty acids, hydrocarbons, and terpene compounds. Flavonoids, such as quercetin and epicatechin, are found in abundance, especially in the fruit of the species (Agostini-Costa, 2020; Moraes et al., 2021).

In the available literature, little information was found regarding the methods of determination and identification of the total antioxidant capacity present in ora-pro-nobis fruit. Silva et al. (2018) and Moraes et al. (2021) studied this fruit by various methods of determination and found a high total antioxidant capacity. Overall, the bioactive compounds found in ora-pro-nobis have important roles in living systems. Polyphenols, which are known for their antioxidant properties and their potential to prevent chronic diseases, are of particular interest. However, while some studies have investigated the bioactive composition of fruits of the genus *Pereskia*, particularly the species *Pereskia aculeata* Miller, the complete

bioactive composition has not been well reported, and only partial information is available. Therefore, further research is urgently needed to better understand the functional properties of this fruit.

### Biological potential

The presence of natural antioxidants in plant products has made them increasingly popular in international markets. Native and exotic fruit species in Brazil, such as *ora-pro-nobis*, have the potential to be exploited by the agro-industrial sector due to their exotic and functional properties. This cactus species may have high nutritional and medicinal values since its functional compounds can prevent many diseases and be potential sources of natural antioxidants, which are valuable traits in economic markets.

Bioactive compounds with antioxidant properties naturally found in plants are known to exhibit beneficial effects on human health. Medicinal use of fruits has been known since antiquity, and research over the years has revealed their uncountable applications to prevent and/or treat numerous diseases. Studies have shown that *ora-pro-nobis* fruits have anti-inflammatory and antinociceptive effects, among others, in addition to the high antioxidant capacity of the polyphenols present in them (Silva Júnior et al., 2010; Agostini-Costa et al., 2012; Barbalho et al., 2016; Silva et al., 2018; Agostini-Costa, 2020; Moraes et al., 2021). However, there is a lack of scientific evidence for most of the cited biological activities. On the other hand, the secondary metabolites present in this genus may explain some of the biological activities that have already been proven, as well as those that are claimed.

Moreover, research has been conducted on the bioavailability and biological activity of plant products, including *ora-pro-nobis*, to identify the potential health benefits of these compounds in preventing and decreasing the risk of chronic diseases such as cardiovascular diseases, cancers, diabetes, Alzheimer's disease, and arthritis (Ordóñez and Rodríguez, 2013; Maciel et al., 2019; Moraes et al., 2021). These beneficial compounds are found naturally in fruits, and there is strong evidence linking fruit intake to a lowered risk of the aforementioned chronic diseases. Therefore, the potential health effects of these compounds are mainly attributed to their natural properties.

Finally, there are many plant species, such as *ora-pro-nobis*, that have a wide range of ethnobotanical uses, including food, medicine, and wood for general purposes. Despite this, most of the available scientific information on these species is limited to only a few with economic potential, and information on their pharmacological properties is still relatively new. While some compounds have been isolated and shown to have

bioactive properties, further investigations are necessary to fully explore the potential of these exotic species for use in food, cosmetics, and pharmaceuticals. This would ensure the proper exploitation of these resources and help advance our understanding of their pharmacological properties.

### 4. Conclusions

Furthermore, *ora-pro-nobis*, particularly its fruit, has been used for many centuries in folk medicine. Recent scientific studies have reviewed its nutritional and bioactive properties, and the results have pointed out that it is a rich source of various nutrients and compounds with functional properties, including vitamins, minerals, carotenoids, flavonoids, and other polyphenols. However, most of these have not yet been fully measured and quantified, highlighting the need for further research to better understand the potential health benefits of *ora-pro-nobis*.

The compounds found in *ora-pro-nobis* play critical roles in disease treatment and health maintenance. Recent studies have shown that *ora-pro-nobis* is effective against inflammation, liver disorders, tumor formation, and heart disease, indicating that it is a functional food with potential health benefits. Given its potential in the food, pharmaceutical, and cosmetic industries, there is a growing interest in exploring and diversifying the use of *ora-pro-nobis*.

Therefore, there is an urgent need for more systematic and in-depth biological studies to fully explore the potential health benefits of this fruit. In conclusion, this review serves as a valuable reference for researchers seeking to conduct new nutraceutical and functional studies and for the industrial exploitation of *ora-pro-nobis* in economic markets.

### Authors' Contribution

Leirson Rodrigues da Silva: Conceptualization, Methodology, Writing (original draft and Writing), Review and Editing. Ana Rosa de Figueiredo: Writing – original draft. Milena Maria Tomaz de Oliveira and Pedro Augusto Resende Rimoli: Writing, Review and Editing. Cristiane Maria Ascari Morgado: Investigation and Writing – Review and Editing. Lilia Aparecida Salgado de Morais: Methodology and Writing – Review and Editing. All authors contributed revising and improving the paper.

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