MICRORGANISMOS FOTOSSINTÉTICOS COMO FONTES DE COMPOSTOS BIOATIVOS ANTIOXIDANTES E ANTIBACTERIANOS DE INTERESSE NA INDÚSTRIA ALIMENTÍCIA

MICROORGANISMOS FOTOSINTÉTICOS COMO FUENTES DE COMPUESTOS BIOACTIVOS ANTIOXIDANTES Y ANTIBACTERIANOS DE INTERÉS EN LA INDUSTRIA ALIMENTARIA

PHOTOSYNTHETIC MICROORGANISMS AS SOURCE OF ANTIOXIDANT AND ANTIBACTERIAL BIOACTIVE COMPOUNDS OF INTEREST IN THE FOOD INDUSTRY

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Resumo

Compostos bioativos de microalgas e cianobactérias têm sido frequentemente investigados como conservantes de alimentos devido a suas várias atividades biotecnológicas. Portanto, este estudo teve como objetivo avaliar as atividades antimicrobiana e antioxidante dos extratos aquoso e etanólico das microalgas *Dunaliella tertiolecta, Tetradesmus obliquus* e *Chlorella vulgaris* e da cianobactéria *Arthrospira platensis*. Os extratos foram obtidos através do método de sonicação e a atividade antioxidante foi determinada pelos métodos ABTS e DPPH, enquanto a atividade antimicrobiana foi avaliada por ensaio de microdiluição. Em geral, os extratos etanólicos de todas as microalgas mostraram maior atividade antioxidante em comparação com os extratos aquosos, especialmente usando o método ABTS. Todas as bactérias mostraram maior resistência utilizando os extratos aquosos. Especificamente, a gram-negativa *Pseudomonas aeruginosa* foi o patógeno mais suscetível e foi inibido por todas as microalgas. As maiores atividades antioxidante e antimicrobiana foram obtidas pelo extrato etanólico de *Arthrospira platensis*. Esses dados mostram que o extrato etanólico de *Arthrospira platensis* deve ser uma fonte potencial de compostos antioxidante e antimicrobiano com propriedades de conservação de alimentos.

PALAVRAS CHAVE: microalgas. antimicrobianos. compostos naturais. cianobactérias.

Resumen

Los compuestos bioactivos de microalgas y cianobacterias se investigan con frecuencia como conservantes de alimentos debido a sus diversas actividades biotecnológicas. Por esto, la investigación tiene como objetivo evaluar la actividad antimicrobiana y antioxidante de los extractos acuoso y etanólico de *Dunaliella tertiolecta*, *Tetradesmus obliquus*, *Chlorella vulgaris* y *Arthrospira platensis*. Los extractos fueron obtenidos por el método de sonicación, la atividade antioxidante per los métodos ABTS y DPPH y la actividad antimicrobiana por microdilución. En general, los extractos etanólicos de todas las microalgas mostraron una mayor actividad antioxidante en comparación con los extractos acuosos, especialmente

utilizando el método ABTS. Todas las bacterias mostraron mayor resistencia al utilizar extractos acuosos. Específicamente, el gramnegativo *Pseudomonas aeruginosa* fue el patógeno más susceptible y fue inhibido por todas las microalgas. Las mayores actividades antioxidantes y antimicrobianas fueron obtenidas por el extracto etanólico de *Arthrospira platensis*. Estos datos muestran que el extracto etanólico de Arthrospira platensis debería ser una fuente potencial de compuestos antioxidantes y antimicrobianos con propiedades de conservación de alimentos.

PALABRAS CLAVE: microalgas. antimicrobianos. compuestos naturales. cianobacterias.

Abstract

Bioactive compounds from microalgae and cyanobacteria have been frequently investigated as food preservatives due to their various biotechnological activities. Therefore, this study aimed to evaluate the antimicrobial and antioxidant activities of the aqueous and ethanolic extracts from *Dunaliella tertiolecta*, *Tetradesmus obliquus*, and *Chlorella vulgaris* microalgae and *Arthrospira platensis* cyanobacteria. The extracts were obtained through the sonication method and the antioxidant activity was determined by ABTS and DPPH methods, whereas antimicrobial activity was evaluated by microdilution assay. In general, ethanolic extracts of all microalgae showed higher antioxidant activity compared to aqueous extracts, especially using ABTS method. All bacteria exhibited higher resistance using the aqueous extracts. Specifically, the gram-negative *Pseudomonas aeruginosa* was the most susceptible pathogen and was inhibited by all microalgae. The highest antioxidant and antimicrobial activities were obtained by the ethanolic extract from *Arthrospira platensis*. These data show that ethanolic extract from *Arthrospira platensis* may be a potential source of antioxidant and antimicrobial compounds with food preservative properties.

KEYWORDS: microalgae. antimicrobial. natural compounds. cyanobacteria.

1. Introduction

Food contamination with food-borne disease microorganisms is a public health problem by causing foodborne diseases, leading to about 420,000 deaths annually, especially in developing countries and can lead to high economic losses for the food industry and the society (ABEBE, 2020; WORLD ORGANIZATION HEALTH, 2021). Among the main microorganisms that affects food quality and cause severe risks for human health by foodborne diseases stand out *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Bacillus subtilis*, and *Staphylococcus aureus*.

In this context, several synthetic preservatives are commonly used to inhibit the growth and spoilage of microorganisms, extend food shelf-life and avoid food deterioration. However, these chemicals products frequently affect the organoleptic and sensory characteristics such as the taste, odor, color, and textural properties of food (EL-SABER BATIHA *et al.*, 2021; GUTIÉRREZ-DEL-RÍO; FERNÁNDEZ; LOMBÓ, 2018). In addition, due to the various health risks linked to foods processed using synthetic preservatives, the search for safe and natural food products has increasing worldwide (LUCERA *et al.*, 2012).

In order to reduce the application of these synthetic products, significant effort has been made to discover new sources of natural compounds with preservatives properties that ensure the quality of food and improve its shelf-life (PISOSCHI *et al.*, 2018). Photosynthetic microorganisms may be an effective alternative since they possess potential application as antibacterial and antioxidant agents linked to their biologically active compounds (e.g. polysaccharides, pigments, and fatty acids) (ALSENANI *et al.*, 2020; FELLER *et al.*, 2018; NETANEL LIBERMAN *et al.*, 2021).

Some cyanobacteria and microalgae species such as *Arthrospira platensis*, *Chlorella vulgaris*, *Dunaliella tertiolecta*, and *Tetradesmus obliquus* had been shown antibacterial activity against microbial pathogens as well as antioxidant effects (PAN-UTAI; IAMTHAM, 2019; SANTHAKUMARAN; AYYAPPAN; RAY, 2020; SILVA-JÚNIOR *et al.*, 2019; YU *et al.*, 2019). Thus, based on this background, this study aims to investigate the potential antioxidant and antibacterial of the aqueous extracts (AE) and ethanolic extracts (EE) from photosynthetic microorganisms against *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, *Bacillus subtilis*, and *Staphylococcus aureus* pathogens for future applications of the food industry.

2. Material and Methods

2.1. Chemicals

All chemicals and reagents were of analytical grade and purchased from Sigma–Aldrich (St. Louis, MO, USA).

2.2. Microalgae strains and culture conditions

Cultures of *Chlorella vulgaris* (UTEX 1803), *Dunaliella tertiolecta* (UTEX 999), and *Arthrospira (Spirulina) platensis* (UTEX 1926) were obtained from Culture Collection of Algae, University of Texas (Austin, Texas, United States), while *Tetradesmus obliquus* (SISGEN A5F5402) was isolated from Açude of Apipucos (Recife, Pernambuco, Brazil, coordinates 8° 1’ 13.08” S; 34° 55’ 56.51” W).

C. vulgaris, *D. tertiolecta*, *T. obliquus*, and *A. platensis* were cultivated in Bold’s Basal medium, F/2 medium, BG-11 medium, and Schlösser medium, respectively (ALLEN; STANIER, 1968; GUILLARD; RYTHER, 1962; SCHLOSSER, 1982; STEIN, 1973). Microalgae and cyanobacterium were cultivated in 1L Erlenmeyer flasks containing 400 mL of the culture media with initial cell concentration of 50 $mg \cdot L^{-1}$ at room temperature, under light intensity of 70 ± 1 μmol photons $m^{-2} \cdot s^{-1}$. *C. vulgaris*, *D. tertiolecta*, and *T. obliquus* were cultivated under continuous aeration while *A. platensis* was maintained in orbital shaking at 100 rpm. Each culture was carried out in duplicate.

Cell growth of *C. vulgaris*, *D. tertiolecta*, *T. obliquus* and *A. platensis* was measured daily by spectrophotometry at 685 nm, 680 nm, 650 nm and 560 nm, respectively, until to reach the end of the exponential growth phase (CHEN *et al.*, 2011; MARTÍNEZ SANCHO; JIMÉNEZ CASTILLO; EL YOUSFI, 1999; WANG *et al.*, 2010). Biomass was centrifugated (10,000 rpm for 10 min, at 4° C), freeze-dried and stored at -20°C for further extraction.

2.3. Extraction procedure

Different extracts (aqueous, in distilled water and pure ethanolic) were obtained from dried microalgae biomass with classic solid-liquid extraction. For antioxidant activity was used a cell concentration of 10.00 mg/mL and for antibacterial activity was used 100 mg/mL of dried biomass. The samples were extracted by sonication for 20 min on ice bath, followed by centrifugation (15.000 rpm) for 10 min at 4 °C to obtain the supernatant liquid. The extraction was performed in the dark at room temperature (25 °C). After extraction, ethanolic extracts were concentrated under reduced pressure in a rotary evaporator, while aqueous extracts were then lyophilized. All extracts were stored at –20◦C until use.

2.4. Antioxidant activity using 2,2-azino-bis-(3-ethylbenzothiazoline)-6-sulfonic acid (ABTS)

The antioxidant activity was measured according to their ability to scavenge $ABTS^{\bullet+}$ radical cation (RE *et al.*, 1999). Briefly, $ABTS^{\bullet+}$ solution was mixed with AE or EE at 10 mg/mL. The mixture was incubated at room temperature and kept in darkness for 12-16h. After, the absorbances were measured at

734 nm (Trolox was used as the reference standard). The percentage results of scavenging activity were calculated as % inhibition.

2.5. DPPH radical-scavenging activity

The DPPH (1,1-diphenyl-2-picryl-hydrazil) radical-scavenging activity was determined according to Brand-Williams; Cuvelier; Berset (1995), modified by Fukumoto; Mazza (2000). Initially, sample was mixed with DPPH radical solution and incubated at room temperature in the dark for 2h. Then, the absorbance of samples was measured at 450 nm using a Microplate Lector LM-LGC (LGC Biotechnologies Ltda, São Paulo, Brazil). The DPPH radical activity was calculated through a previous calibration curve using ascorbic acid as standard.

2.6. Antibacterial activity

A plate microdilution method was used to determine antibacterial activity (NCCLS, 2003). A panel of microorganisms, being main agents of food deteriorating, including *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Enterococcus faecalis* ATCC 6057, *Bacillus subtilis* ATCC 6633 and *Staphylococcus aureus* ATCC 6538 were used.

The pre-inoculum for each standard strain was prepared in Müller Hinton broth. All strains were aerobically incubated at 37°C for 18 h. The 0.5 McFarland standard was prepared and used to approximate the concentration of the bacteria (1.5×10^8 CFU mL^{-1}). The negative controls contained no bacteria, and the positive controls contained bacteria and Müller Hinton broth. The samples contained 50 µL of the microalgae extracts. The microalgae extracts dilutions were 100 mg/mL and 50 mg/mL. All experiments were performed in triplicate in a 96-well microplate (NUNC®), and the absorbance at 630 nm (Microplate Lector LM-LGC, LGC Biotecnologia Ltda, São Paulo, Brazil) was read after incubation for 24 h. The result was determined as the percentage inhibition.

2.7. Statistical analysis

Three replicates of each sample were used for statistical analysis and the values were reported as value ± the standard deviation and compared by one-way analysis of variance (ANOVA). The results were considered statistically significant with p values ≤ 0.05.

3. Results and discussion

A screening of AE and EE from *C. vulgaris, D. tertiolecta* and *T. obliquus* microalgae and *A. platensis* cyanobacterium was carried out to evaluate *in vitro* antioxidant and antibacterial activity.

3.1. Antioxidant activity

Antioxidant effects of bioactive compounds is directly linked to the assay performed, then, at least two different methods are need to determine the antioxidant potential (BEN ATITALLAH *et al.*, 2019). DPPH assay is applicable to hydrophobic systems only, while that $ABTS^{\bullet+}$ method can be measured both hydrophilic and lipophilic compounds (FLOEGEL *et al.*, 2011). In this way, DPPH radical scavenging and $ABTS^{\bullet+}$ were performed this study.

All microalgal extracts showed antioxidant activity using both methods. A comparison between these two methods showed higher values using $ABTS^{\bullet+}$ assay in all cells extracts (Table 1). Previous studies using microalgae extracts also demonstrated higher $ABTS^{\bullet+}$ scavenging effect compared to DPPH scavenging activity (COULOMBIER *et al.*, 2020; EL-FAYOUMY *et al.*, 2021). As well know, DPPH scavenging activity use lower wavelengths in the visible region when compared to ABTS scavenging activity leading to high interference mainly in pigmented sample (ARNAO, 2000; DUDONNÉ *et al.*, 2009). By the way, AE and EE showed lower antioxidant activity using DPPH method.

In general, EE showed higher antioxidant activities than AE in both $ABTS^{\bullet+}$ and DPPH methods (Table 1). These results are similar to Maadane *et al*., (2015) and Jerez-Martel *et al*., (2017) which reported that EE of *Dunaliella* sp., *Dunaliella salina*, *Tetraselmis* sp., *Chlorella* sp., and *A. platensis* shows higher antioxidant activity compared to AE. Solvents types influence on compounds extraction. Carotenoids and phenolic content are associated with antioxidant activity of microalgal extracts and they are extracted from microalgae biomass in high quantity when ethanol is used as solvent when compared to water (CHATATIKUN; CHIABCHALARD, 2017; MIAZEK *et al.*, 2017; MONTEIRO *et al.*, 2020; SATHASIVAM *et al.*, 2019; USMAN; BAKAR; MOHAMED, 2016).

The highest values of antioxidant activities were obtained in *A. platensis* (Table 1), mainly in their ethanolic extracts ($ABTS^{\bullet+}$ = 66.09% ± 2.00 and DPPH = 55.73% ± 0.18). Ismaiel; El-Ayoutu; Piercey-Normore (2016) and Aydi *et al*., (2020) also showed high antioxidant activity of aqueous extract and methanolic extract from *A. platensis*, respectively. This activity apparently is associated to the high polyphenols and phycobiliproteins, especially C-phycocyanin, present in *A. platensis* biomass (AYDI *et al.*, 2020).

Table 1. Antioxidant activity using $ABTS^{\bullet+}$ and DPPH methods of microalgal AE and EE.

Antioxidant activity (%)		
ABTS Method	Aqueous extract	Ethanolic extract
Arthrospira platensis	25.73 ± 0.18 [a]	66.09 ± 2.00 [a]
Chlorella vulgaris	13.75 ± 0.33 [b]	31.26 ± 4.00 [b]
Dunaliella tertiolecta	7.23 ± 0.49 [c]	28.16 ± 0.01 [c]
Tetradesmus obliquus	19.07 ± 0.11 [d]	42.41 ± 1.00 [d]
DPPH Method	Aqueous extract	Ethanolic extract
Arthrospira platensis	16.73 ± 0.12 [a]	55.73 ± 0.18 [a]
Chlorella vulgaris	10.75 ± 0.31 [b]	23.75 ± 0.33 [b]
Dunaliella tertiolecta	5.43 ± 0.24 [c]	11.23 ± 0.49 [c]
Tetradesmus obliquus	13.07 ± 0.1 [d]	39.07 ± 0.11 [d]

Data expressed as means ± standard deviations of triplicate experiments measurements. [a, b, c, d] Different superscript letters indicate statistically significant differences ($p < 0.05$).

3.2. Antibacterial activity

The AE from *D. tertiolecta*, *C. vulgaris*, *T. obliquus* microalgae and *A. platensis* cyanobacteria were tested to antibacterial activity against six bacteria. *D. tertiolecta*, *C. vulgaris*, *T. obliquus* microalgae and *A. platensis* cyanobacteria AE obtained no or low antibacterial activity against gram-positive bacteria *S. aureus*, *B. subtilis* and *E. faecalis* (Table 2). Similar results were observed by Kocberber Kilic; Erdem; Donmez (2019) and Marrez *et al*., (2019) using AE from *Dunaliella* sp. and *Tetradesmus obliquus* against *B. subtilis* and *S. aureus*. On the other hand, preview studies showed that the AE from *C. vulgaris* and *A. platensis* inhibited *E. faecalis* and *B. subtilis* growth, respectively (DE MELO *et al.*, 2019; DUDA-CHODAK, 2013; MOHITE; SHRIVASTAVA; SAHU, 2015). These different results in the inhibitory activity of AE can be explained by the different extraction methods. Whereas Mohite *et al*., (2015) and De Melo *et al*., (2019) used homogenization and ten pulses sonication during 1 min, respectively, in this work, it was used sonication during 20 min. As well known, the increase in time of sonication leads to a denaturation of bioactive compounds present in AE when compared to short-time sonication or homogenization methods (CHAN *et al.*, 2017; PLAZZOTTA; MANZOCCO, 2018).

No inhibitory activity was observed against gram-negative *E. coli* and low antibacterial activity against *P. aeruginosa* (Table 2), which was the most susceptible gram-negative pathogen, and was inhibited by all the AE from microalgae and cyanobacteria with inhibition from 20.0±0.01 to 40.0±0.01% (Table 3). Previews reports also observed that the AE of *T. obliquus*, *Dunaliella sp.*, *A. platensis*, and *C. vulgaris* showed low inhibition in the *E. coli* growth (KOCBERBER KILIC; ERDEM; DONMEZ, 2019; MARREZ *et al.*, 2019; MOHITE; SHRIVASTAVA; SAHU, 2015; ZIELINSKI *et al.*, 2020). On the other

hand, Marrez *et al*., (2019) and Mohite *et al*., (2015) reported that *T. obliquus* and *A. platensis* had moderate antibacterial activity against *P. aeruginosa.* Differences between gram-negative *E. coli* and *P. aeruginosa* susceptibility can be associated to their biochemical composition (GUGALA *et al.*, 2019). *E. coli* represents a major reservoir of resistance genes acquired by horizontal gene transfer. This pathogen acts as a donor or a recipient of resistance genes and, therefore, can obtain resistance genes to other bacteria and also pass its resistance genes to other bacteria. Thus, *E. coli* antibacterial resistance is an important challenge in the food industry worldwide (POIREL *et al.*, 2018).

The gram-positive *S. aureus* was not inhibited by EE of any microalgae or cyanobacteria (Table 3). Iglesias *et al*., (2019), Alwathnani; Perveen, (2017), and Esquivel-Hernández *et al*., (2017) also showed no or low antimicrobial activity of *D. salina* (hexane, methanol, and ethanol ethyl acetate extract), *C. vulgaris* (acetone, methanol, and diethyl ether), and *A. platensis* (extract of ammonium acetate combined with ethanol) organic extract against *S. aureus.* On the other hand, Marrez *et al*., (2019) reported that EE of *T. obliquus* inhibited *S. aureus* growth. This activity can be related by use of two methods combined to extract preparation. Dried biomass was homogenized in ethanol solvents and then sonicated. The pellet was re-extracted twice as mentioned above. This methodology may have increased bioactivities extraction. Gram-positive *B. subtilis* and *E. faecalis* were inhibited by all microalgae EE (Table 3). The highest activities were obtained by *A. platensis, T. obliquus* and *C. vulgaris,* respectively. These results are in agreement with Alwathnani *et al*., (2017), Ibrahim *et al*., (2015), Aydi *et al*., (2020), and Alsenani *et al*., (2020) that also reported the *B. subtilis* and *E. faecalis* growth inhibition by *A. platensis, T. obliquus,* and *C. vulgaris.* The antibacterial activity of microalgae organic extracts is frequently associated to presence of bioactive compounds including lauric, linolenic, oleic acids, phenolic compounds, tannins, and iridoids (MADDOX; LAUR; TIAN, 2010; MENDIOLA *et al.*, 2007; TOMIYAMA *et al.*, 2016; WANG *et al.*, 2018).

Only EE from *A. platensis* showed inhibition against gram-negative *E. coli* growth, while *P. aeruginosa* growth was inhibited by all microalgae EE (Table 3). The highest activity was obtained by *A. platensis* with inhibition of 80.0±0.01% against *P. aeruginosa*. Similarly, Elshouny *et al*., (2017) reported that *A. platensis* EE shows high antimicrobial activity against *E. coli* and *P. aeruginosa*. These pathogens are known to spoilage of various types of foods, mainly meat, fresh and smoked fishes, and seafood. Studies reported the resistance of *P. aeruginosa* to some antibiotics and high *E. coli* contamination in food highlighting the importance of new antimicrobials (AL-SHABIB *et al.*, 2017; BOSS; OVERESCH; BAUMGARTNER, 2016; CKD *et al.*, 2017; GU *et al.*, 2016; PENHA *et al.*, 2017). Therefore, as demonstrated in this work, microalgae EE shows a promising antimicrobial activity against these pathogens.

In fact, EE were more effective than AE, showing that probably low polarity of organic solvents contributes to more efficient extraction of antibacterial compounds from microalgae as reported by Herrero *et al*., (2006) and Santhakumaran; Ayyappan; Ray (2020).

Table 2. Inhibition percentage (%) of antibacterial activity of the aqueous extracts of microalgae and cyanobacteria.

		Arthrospira platensis		***Chlorella vulgaris***		***Dunaliella tertiolecta***		***Tetradesmus obliquus***	
		100	**50**	**100**	**50**	**100**	**50**	**100**	**50**
Strains	*Staphylococcus aureus* (ATCC 6538)	ND	ND	ND	ND	ND	ND	ND	ND
	Bacillus subtilis (ATCC 6633)	34.8±0.14	ND	ND	ND	ND	ND	10.8±0.14	ND
	Enterococcus faecalis (ATCC 6057)	20.3±0.05	18.9±0.03	19.0±0.03	ND	ND	ND	17.6±0.05	13.9±0.05
	Escherichia coli (ATCC 25922)	ND	ND	ND	ND	ND	ND	ND	ND
	Pseudomonas aeruginosa (ATCC 27853)	40.0±0.01	ND	30.0±0.01	23.3±0.01	20.0±0.01	13.7±0.01	25.0±0.01	ND

Cell extract concentration values given as mg/mL.

Table 3. Inhibition percentage (%) of antibacterial activity of the ethanolic extracts of microalgae and cyanobacteria.

		Arthrospira platensis		***Chlorella vulgaris***		***Dunaliella tertiolecta***		***Tetradesmus obliquus***	
		100	**50**	**100**	**50**	**100**	**50**	**100**	**50**
Strains	*Staphylococcus aureus* (ATCC 6538)	ND	ND	ND	ND	ND	ND	ND	ND
	Bacillus subtilis (ATCC 6633)	64.8±0.14	ND	34.8±0.14	ND	24.8±0.14	ND	54.8±0.14	ND
	Enterococcus faecalis (ATCC 6057)	78.3±0.03	59.9±0.04	70.0±0.03	ND	37.0±0.02	ND	71.1±0.02	60.1±0.05
	Escherichia coli (ATCC 25922)	40.0±0.01	ND	ND	ND	ND	ND	ND	ND
	Pseudomonas aeruginosa (ATCC 27853)	80.0±0.01	74.4±0.02	60.0±0.01	53.3±0.01	30.0±0.01	23.7±0.01	72.7±0.01	62.0±0.01

Cell extract concentration values given as mg/mL.

4. Conclusions

Different extracts (aqueous and ethanolic) obtained from *Chlorella vulgaris, Dunaliella salina* and *Tetradesmus obliquus* microalgae and *Arthrospira (Spirulina) platensis* cyanobacterium were evaluated *in vitro* antioxidant activity using ABTS and DPPH methods, as well as antibacterial activity against mainly pathogenic bacteria for food industry. Ethanolic extracts shows higher antioxidant and antibacterial activities when compared to aqueous extract. The highest antioxidants and antibacterial activities were obtained from *A. platensis* extracts, followed by *T. obliquus* and *C. vulgaris* extracts. Results also demonstrated that ethanolic extract of *A. platensis* showed effective antibacterial activity mainly against *Pseudomonas aeruginosa* ATCC 27853, *Enterococcus faecalis* ATCC 6057, and *Bacillus subtilis* ATCC 6633. These results suggest that the ethanolic *A. platensis* extracts could be considered as a potential promising source of natural antioxidants and antibacterial, presenting as an accessible and safe alternative to synthetic compounds, being therefore, a valuable tool for the food biotechnology field.

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