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Syagrus coronata seed oils have antimicrobial action against multidrug-resistant *Staphylococcus aureus*

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Syagrus coronata **(Mart.) Becc. (Arecaceae) is a native Brazilian palm (*ouricuri*) and despite the use of its derived products by traditional communities, few scientific reports have been published regarding its biomedical activity. This study investigates the chemical composition and anti-*Staphylococcus aureus* effects of both manufactured oil (SCO) and essential oil (SCEO) from *S. coronata* seeds. SCO was provided by rural inhabitants, while SCEO was obtained by hydrodistillation. Chemical characterization was performed by gas chromatography-mass spectrometry (GC/MS). *In vitro* antimicrobial activity was determined against 17 *S. aureus* strains, including multidrug-resistant strains. Eleven compounds were detected in the SCEO, octanoic (28.61%) and dodecanoic acids (22.97%) were the major constituents. On the other hand, nineteen fatty acids (FA) were identified in the SCO, the major ones were dodecanoic acid (41.58%) and 9-octadecenoic acid (23.81%). Both oils showed strong activity against all tested strains. Most strains (68.75%) were sensitive to SCEO at minimum inhibitory concentrations (MIC) between 0.002 and 0.01 µL/mL; and minimum bactericidal concentrations (MBC) ranging from 0.002 to 0.312 µL/mL. SCO inhibited the growth of 52.94% of strains with MIC between 0.16 and 0.625 µL/mL. MBC values for SCO were between 0.16 and 5 µL/mL; however, 47.05% of isolates were killed by 2.5 µL/mL of SCO. These results encourage further research into the toxicological and pharmacological aspects of SCO and SCEO. Such work would likely support their use in the development of new antimicrobial agents for the pharmaceutical, food and cosmetic industries.**

Key words: Caatinga, essential oil, anti-*Staphylococcus aureus*, natural products.

INTRODUCTION

Bacteria, with their increasing drug resistance and their capacity to spread around the world, have become the most complex threats to a global public health system that is increasingly in need of effective antimicrobial treatments (Gould et al., 2012). Among human and animal pathogens, *Staphylococcus aureus* is of particular concern due to its ability to express a variety of virulence factors that facilitate cell adhesion, immune evasion, host

cell damage, and provoke symptoms of disease (Du Toit et al., 2014). Furthermore, *S. aureus* strains have developed increased resistance to antimicrobial agents. In fact, methicillin-resistant *S. aureus* (MRSA) and multidrug-resistant *S. aureus* (MDRSA) have been found to be the major cause of hospital-acquired infections (Davis et al., 2013).

The use of plants or their derived products (extracts, oils, infusions, etc.) to treat infections is an age-old practice in many parts of the world, especially in developing countries such as Brazil, where folk medicine is widely used for a variety of diseases (Nascimento et al., 2013). These plant materials apparently have less toxicity compared to synthetic drugs, which make them attractive candidates for drug development. Brazil is the fifth-largest country in the world and is characterized by a huge biological and cultural diversity. Amongst Brazilian biomes, one in particular stands out for being exclusively Brazilian: the Caatinga, which occupies a large portion of the Brazilian Northeast. The Caatinga is marked by an accentuated dryness (rainfall is usually less than 900 mm/year) and is, therefore, considered a semi-arid region. It supports a great diversity of plant species (Albuquerque et al., 2012). As a result of the environmental conditions to which they are exposed, Caatinga plants have developed interesting chemical features, some of which have been described as excellent weapons against microorganisms (Castelo Branco Rangel de Almeida et al., 2012; Oliveira et al., 2012; Da Silva et al., 2013).

Paradoxically, the Caatinga ecosystem harbors many under-utilized plant species with biotechnological and economic potential. *Syagrus coronata* (Mart.) Becc. (Areaceae), a palm species native to the Brazilian semi-arid and cerrado regions, is a good example of this situation. This species is popularly known as *licuri* or *ouricuri* and its derived products have played a vital role in the diet and subsistence economy of traditional communities of the Brazilian Northeast region. Nevertheless, few scientific reports have been published regarding the biomedical activity of *S. coronata*. Recent studies have demonstrated that crude extracts or fractions of this plant have anti-*Leishmania amazonensis* (Rodrigues et al., 2011), antimicrobial (Hughes et al., 2013), and antioxidant (Belviso et al., 2013) activities. Specifically, oils from *S. coronata* have been evaluated for use as biodiesel (Teixeira da Silva de La Salles et al., 2010) and topical emulsion (Leal et al., 2013).

This study provides the chemical characterization and reports the anti-*S. aureus* activity of two oils from seeds of *S. coronata*. The first seed oil is a commercial available and is extracted by traditional rural inhabitants of Catimbau National Park, a national park of Brazil for Caatinga preservation. The second is an essential oil extracted in our laboratory. This is the first report of the chemical profile of an essential oil from *S. coronata* and antimicrobial activity of both materials.

MATERIALS AND METHODS

Plant

Samples of fruits were collected at Catimbau National Park (Pernambuco, Brazilian Northeast) in mature fruit stage, during the month of March 2013. The identification of this material was made by Dr. Alexandre Gomes da Silva, and a voucher specimen (IPA 86950) was deposited at the Agronomic Institute of Pernambuco (IPA/PE). The seeds were removed from mature fruits and dried (at 33°C) in an open area with active ventilation until constant weight was attained (three weeks). Lastly, the seeds were ground using a household grinder.

Extraction and analysis of the essential oil from *S. coronata* seeds (SCEO)

Samples of *S. coronata* seeds (250 g) were submitted to hydrodistillation for 4 h, in a Clevenger-type apparatus. The oils were dried over anhydrous Na_2SO_4. The oils were stored at 4°C until further analysis. All experiments were done in triplicate and results were expressed in terms of dry mass. The main constituents were analyzed by GC/MS, which were performed in the EI mode on a Hewlett Packard-6890 GC system with a fused capillary column (30 m × 0.25 mm × 0.25 µm, HP-5MS, Crossbond 5% phenyl/95% dimethylpolysiloxane) directly coupled to a Hewlett Packard 5973 selective mass detector. The mass spectrometer was operated at 70 eV. The constituents of the essential oils were identified by comparison of their mass spectral pattern and retention indices (RI) with those reported in the literature (Adams, 2009).

S. coronata seed oil (SCO) and its fatty acid composition

The commercial oil from seeds of *S. coronata* was kindly provided by traditional rural inhabitants of Catimbau National Park in March 2013. Fatty acid methylation was performed by the saponification and esterification procedure described by Metcalfe et al. (1966). Dosage of methyl esters was achieved using gas chromatography coupled with mass spectrometry (GC/MS). A GC/MS/QP 2010 Shimadzu instrument was used, equipped with a capillary column of type HP5 MS, 30 mm long by 250 µm internal diameter; the thickness of the film was 0.250 µm. The temperature of the injector was 250°C. Helium was used as the carrier gas at a flow rate of 0.8 mL/min, the injection mode was Split 50:1 and the temperature

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program was set at 150 to -240°C (5°C/min).

Isolation, identification and resistance profile of *S. aureus* isolates

Sixteen *S. aureus* strains were isolated from samples processed in the microbiology laboratories of referral health care institutions in Recife (Pernambuco, Brazil) between September and December 2012. The isolates were cultured on sheep blood agar and the phenotypic identification of *S. aureus* was based on colony morphology, Gram stain, positive plasma coagulase reaction (slide and tube test) and growth in mannitol salt agar (positive colonies changed the medium color from red to yellow).

The antibiotic-susceptibility profile of isolates was performed using a disc diffusion assay on Müeller-Hinton agar (MHA) according to the recommendations of CLSI (2011). In brief, each *S. aureus* isolate was grown overnight on Mueller-Hinton agar at 37°C and the colonies were suspended in sterile saline water equivalent to 0.5 McFarland standard. The suspension (100 µL) was spread over a medium plate and an antibiotic disk was applied aseptically onto the surface. Afterwards, the plates were incubated at 37°C for a period of 24 h. The antibiotics used were erythromycin, clindamycin, oxacillin, penicillin, linezolid, tetracycline, vancomycin, chloramphenicol and gentamicin. The multiple antibiotic resistance (MAR) index was calculated as previously described by Krumperman (1983) using the formula MAR = x/y, where "x" is the number of antibiotics to which the isolate demonstrated resistance and "y" is the total number of antibiotics tested.

Determination of minimal inhibitory concentration (MIC) and minimum bactericidal concentration (MBC)

The antimicrobial activity was determined using broth microdilution assay against all sixteen *S. aureus* strains identified in this work and a standard *S. aureus* strain (UFPEDA 02), which was provided by the Culture Collection from Department of Antibiotics, Federal University of Pernambuco (UFPEDA). Solutions of both oils used in the antimicrobial assays were obtained according to the following procedure: 400 µL of the SCEO or SCO were mixed with 40 µL of Tween 80 and 5 mL of sterile water (q. s. f.) in a sterile tube and shaken using a vortex (Fanem). After 5 min, solutions with a final concentration of 80 µL/mL were obtained from both samples, SCEO or SCO.

MIC was determined by the microdilution method (CLSI, 2011). Twofold serial dilutions of each solution containing SCEO or SCO (40 to 0.002 µL/mL) were prepared in Müeller-Hinton broth (MHB) and 10 µL of bacterial suspension (approximately 1.5×10^8 CFU/ml) were added. The samples were incubated for 24 h at 37°C. Resazurin solution (0.01%) was used as an indicator by color change visualization: any color changes from purple to pink were recorded as bacterial growth. The lowest concentration at which no color change occurred was taken as the MIC. Afterwards, cultures were seeded in MHA and incubated for 24 h at 37°C to determine the minimum bactericidal concentration (MBC), which corresponds to the minimum concentration of the sample that eliminated the bacteria.

Statistical analysis

All tests were performed in triplicate. Statistical analysis was performed using the Student's t-test. Differences were considered significant at $p<0.05$. The correlation indices were calculated using the Pearson coefficient (ρ).

RESULTS

Chemical composition of SCEO

The GC/MS analysis of SCEO is shown in Table 1. A total of 11 compounds were detected in the SCEO, of which the major constituents were octanoic acid (28.61%) and dodecanoic acid (22.97%), followed by hexanoic acid (17.9%) and decanoic acid (14.04%). Thus, fatty acids are the predominant component of the oils, as they accounted for 86.87% of the total SCEO (including tetradecanoic acid and methyl octanoate). α-Cubebene was the major sesquiterpene detected (9.16%), followed by Δ-cadinene and ɣ-cadinene (2.08 and 1.36%, respectively). Finally, α-humulene and 1H-cycloprop[e]azulene were found as minor components of the SCEO (<1%).

Fatty acid composition of SCO

The fatty acid composition of *S. coronata* seed oil is shown in Table 2. In total, 19 fatty acids were identified in this oil, which correspond to 99.84% of the total. A predominance of saturated fatty acids was observed (72.3%), while unsaturated fatty acids represented 27.49% of total fatty acid content (23.9% for monounsaturated, and 3.6% for polyunsaturated fatty acids). The most represented fatty acids were dodecanoic acid (41.58%) and 9-octadecenoic acid (23.81%), followed by tetradecanoic acid (9.68%), hexadecanoic acid (7.19%) and octanoic acid (5.32%). All fatty acids with odd numbers of carbon atoms (C7, C9, C11, C13 and C15) were found in trace concentrations. It is noteworthy that medium-chain fatty acids accounted for 51.44% of total fatty acid content, namely hexanoic, heptanoic, octadecanoic, nonanoic, decanoic, undecanoic and dodecanoic acids. The levels of saturated fatty acids were approximately three times higher than unsaturated fatty acids.

Antibiotic susceptibility of *S. aureus* strains

The tested *S. aureus* strains had their antibiotic-susceptibility profile analyzed. All of them were susceptible to vancomycin and linezolid, and susceptible or intermediately susceptible to chloramphenicol (Table 3). On the other hand, all strains were resistant to penicillin-G. Higher resistance was seen against erythromycin (62.5% of the strains), clindamycin (50%), oxacillin (43.75%), tetracycline and gentamicin (31.25% for both). Oxacillin resistance is a marker characterizing MRSA/ORSA strains, and we used this to classify the clinical isolates of *S. aureus* used in this study as resistant (MRSA) or sensitive (MSSA) to methicillin, as

Table 1. Chemical composition of essential oil from *S. coronata* seeds.

Compounds[a]	Retention Indices		EO (%)
	Caculated[b]	Literature[c]	
Hexanoic acid	975	974	17.9
Methyl octanoate	991	988	1.25
Octanoic acid	1003	1002	28.61
Decanoic acid	1008	1004	14.04
1H-Cycloprop[e]azulene	1024	1022	0.23
α-Humulene	1049	1044	0.3
ɣ-Cadinene	1100	1095	1.36
Δ-Cadinene	1177	1174	2.08
Dodecanoic acid	1190	1186	22.97
Tetradecanoic acid	1337	1335	2.1
α-Cubebene	1444	1444	9.16
Total	-	-	100

[a]Calculated on DB-5MS column; [b] According to Adams (2009).

Table 2. Fatty acid composition of *S. coronata* seed oil.

Fatty acid	Commun name	Lipid numbers	% of the total fatty acids
Saturated fatty acids:			72.35
Hexanoic acid	Caproic Acid	C6:0	Tr
Heptanoic acid	Enanthic acid	C7:0	Tr
Octadecanoic acid	Stearic acid	C8:0	5.32
Nonanoic acid	Pelargonic acid	C9:0	Tr
Decanoic acid	Capric acid	C10:0	4.54
Undecanoic acid	Undecylic acid	C11:0	Tr
Dodecanoic acid	Lauric acid	C12:0	41.58
Tridecanoic acid	Tridecylic acid	C13:0	Tr
Tetradecanoic acid	Myristic acid	C14:0	9.68
Pentadecanoic acid	Pentadecylic acid	C15:0	Tr
Hexadecanoic acid	Palmitic acid	C16:0	7.19
Heptadecanoic acid	Margaric acid	C17:0	Tr
Octadecanoic acid	Stearic acid	C18:0	3.54
Eicosanoic acid	Arachidic acid	C20:0	0.21
Docosanoic acid	Behenic acid	C22:0	0.22
Tetracosanoic acid	Lignoceric acid	C24:0	0.07
Monounsaturated fatty acids			23.90
9-octadecenoic acid	Oleic acid	C18:1	23.81
11-eicosenoic acid	Gondoic acid	C20:1	0.09
Polyunsaturated fatty acids			
9,12-octadecadienoic acid	Linoleic acid	C18:2	3.59

Tr: Trace concentrations.

shown in Table 3. Six strains (37.5%) could be classified as MRSA. These isolates showed the highest MAR indices (0.44-0.67) and the following resistance patterns: penicillin G-clindamycin-erythromycin-gentamicin-tetracycline-oxacillin (6.25%; MAR index: 0.67), penicillin G-clindamycin-erythromycin-gentamicin-oxacillin (12.5%;

Table 3. Antibiotic-resistance profile and clinical source of *S. aureus* strains.

Strain	Source	Ery	Clin	Oxa	Pen	Lin	Tetra	Van	Chlor	Gen	MAR INDEX
MSSA 1	Oropharynx	R	S	S	R	S	S	S	S	S	0.22
MSSA 2	Eye discharge	S	S	S	R	S	I	S	S	S	0.11
MRSA 3	Blood	R	R	R	R	S	S	S	S	S	0.44
MRSA 4	Wound secretion	R	R	R	R	S	S	S	S	S	0.44
MSSA 5	Oropharynx	S	S	S	R	S	I	S	S	S	0.11
MSSA 6	Blood	S	S	S	R	S	I	S	S	S	0.11
MSSA 7	Wound secretion	I	S	S	R	S	S	S	S	S	0.11
MSSA 8	Wound secretion	S	S	S	R	S	S	S	S	S	0.11
MRSA 9	Blood	R	R	R	R	S	S	S	I	R	0.56
MSSA 10	Blood	R	R	S	R	S	R	S	S	S	0.44
MRSA 11	Blood	R	R	R	R	S	S	S	S	S	0.44
MSSA 12	Wound secretion	R	S	S	R	S	S	S	S	S	0.22
MSSA 13	Blood	R	S	S	R	S	S	S	S	S	0.22
MSSA 14	Blood	S	S	S	R	S	S	S	S	S	0.11
MRSA 15	Blood	R	R	R	R	S	I	S	I	R	0.56
MRSA 16	Blood	R	R	R	R	S	R	S	I	R	0.67

Ery: Erythromycin, Clin: clindamycin; Oxa: oxacillin; Pen: penicillin; Lin: linezolid; Tetra: tetracycline; Van: vancomycin; Chlor: chloramphenicol; Gen: gentamicin. R: resistant; S: sensitive; I: intermediate (CLSI, 2011). MRSA: Methicillin-resistant *S. aureus* strain; MSSA: Methicillin-sensitive *S. aureus* strain.

MAR index: 0.56), penicillin G-clindamycin-erythromycin-oxacillin (18.75%; MAR index: 0.44). These strains are also considered multidrug-resistant according to Magiorakos et al. (2012). Among the MSSA strains, the resistance profile was the following: penicillin G-clindamycin-erythromycin-tetracycline (6.25%; MAR index: 0.44 - multidrug-resistant) and penicillin G-erythromycin (18.75%; MAR index: 0.22), other isolates were only resistant to penicillin G (37.5%).

Antimicrobial activity of SCEO

The essential oil from *S. coronata* seeds showed very strong activity against the standard *S. aureus* strain (UFPEDA 02) and also against both MRSA and MSSA strains (Table 4). The values of MIC ranged from 0.002 µL/mL to 0.08 µL/mL. The growth of the *S. aureus* UFPEDA 02 was inhibited by 0.002 µL/mL of SCEO. Among the clinical isolates, the majority (68.75%) were sensitive to concentrations between 0.002 and 0.01 µL/mL. Regarding the MBC values, a variation of 0.002 to 0.312 µL/mL was observed, as well as a strong correlation between MIC and MBC values (ρ= 0.89). The MBC/MIC ratios ranged from 1 to 4, thus SCEO is a bactericidal agent (Pankey and Sabath, 2004). Finally, a weak correlation was observed between the MAR indexes and MIC (ρ = 0.17) or MBC (ρ = 0.01) values, indicating that there is no relationship between the SCEO efficacy and the multidrug-resistance profile of *S. aureus* strains. A weak correlation between SCEO and chloramphenicol was also detected (ρ values of -0.18 and -0.19 for MIC and MBC, respectively), revealing that SCEO was effective against *S. aureus* strains less sensitive to the drug's action.

Antimicrobial activity of SCO

The oil obtained from *S. coronata* also showed a strong anti-*S. aureus* activity (Table 4). The SCO, at a concentration of 0.16 µL/mL, inhibited the growth of 41.18% of the strains (including UFPEDA 02). The remaining strains were sensitive to oil at 0.625 µL/mL (11.76%), 1.25 µL/mL (23.53%) and 2.5 µL/mL (23.53%). The MBC values of SCO ranged from 0.16 to µL/mL; however, 47.05% of isolates were killed by 2.5 µL/mL of SCO. Both bactericidal and bacteriostatic effects were observed for SCO (MBC/MIC ratios ranged from 1 to 16), but bactericidal action was more prominent (for 81.25% of strains). The MIC and MBC values were strongly related (ρ = 0.78), while these values were moderately correlated with MAR indices of clinical isolates (ρ = 0.49 for MIC/MAR correlation and ρ = 0.56 for MBC/MAR correlation). Unlike SCEO, the MIC and MBC values found for the SCO were substantially correlated to chloramphenicol (ρ = 0.43 for MIC; ρ = 0.58 for MBC).

DISCUSSION

S. aureus is an extremely versatile, worldwide pathogen, which is able to cause from superficial to deep-seated skin infections that can lead to sepsis (Du Toit, 2014).

Table 4. Anti-*S. aureus* activity of oil and essential oil from seeds of *S. coronata*.

Strain	SCEO			SCO			Control		
	MIC[a]	MBC[a]	MBC/MIC	MIC[a]	MBC[a]	MBC/MIC	MIC[b]	MBC[b]	MBC/MIC
UFPEDA 02	0.002	0.002	1	0.16	0.16	1	0.04	0.04	1
MSSA 1	0.01	0.02	2	0.16	1.25	8	0.04	0.625	16
MSSA 2	0.01	0.04	4	0.16	2.5	16	0.04	0.625	16
MRSA 3	0.01	0.01	1	0.16	1.25	8	0.04	0.625	16
MRSA 4	0.005	0.02	4	1.25	2.5	2	0.312	10	32
MSSA 5	0.002	0.004	2	0.16	0.63	4	0.04	1.25	31
MSSA 6	0.01	0.01	1	0.63	2.5	4	0.04	0.625	16
MSSA 7	0.01	0.02	2	0.16	1.25	8	0.04	0.625	16
MSSA 8	0.01	0.02	2	0.16	0.16	1	0.04	0.625	16
MRSA 9	0.04	0.04	1	1.25	2.5	2	0.08	1.25	16
MSSA 10	0.04	0.04	1	1.25	2.5	2	0.08	1.25	16
MRSA 11	0.04	0.16	4	0.63	0.63	1	0.04	0.08	2
MSSA 12	0.08	0.31	4	2.5	2.5	1	0.08	0.625	8
MSSA 13	0.02	0.02	1	2.5	2.5	1	0.04	0.08	2
MSSA 14	0.01	0.02	2	1.25	2.5	2	0.625	10	16
MRSA 15	0.01	0.02	2	2.5	5	2	0.312	5	16
MRSA 16	0.01	0.02	2	2.5	5	2	0.312	10	32

[a]MIC and MBC values are expressed in µL/mL; [b]MIC and MBC values are expressed in µg/ml; MRSA: Methicillin-resistant *S. aureus* strain; MSSA: Methicillin-sensitive *S. aureus* strain. UFPEDA02: Standard *S. aureus* strain provided by the Culture Collection UFPEDA.

This bacterium has an exceptional capacity to acquire resistance to antibiotics (Gould et al., 2012). These combined features make *S. aureus* the most important pathogen in the Twenty-first Century and point to the urgent need for new anti-*S. aureus* agents. In the present study, we reports the antimicrobial action of *S. coronata* seed oils against MRSA and MSSA *S. aureus* strains and the chemical composition and fatty acid content of SCEO and SCO, respectively. While both oils showed antimicrobial activity, SCEO was more active (15.6 to 250 times greater) than SCO. Their MIC values were moderately correlated between themselves (ρ = 0.43). Nevertheless, while SCEO is a more effective bactericidal agent, SCO showed both bactericidal and bacteriostatic actions. The antimicrobial activity of compounds derived from *S. coronata* has been evaluated for aqueous and methanol extracts from different tissues (leaves, inflorescence, nut-shell, liquid and solid endosperm nuts). In that study, only the extracts obtained from inflorescence tissue showed antimicrobial activity by inhibiting *S. aureus* (including strains with antibiotic resistance) and *Bacillus cereus*. The authors did not report the chemical characterization of these active extracts (Hughes et al., 2013).

To the best of our knowledge, the composition of *S. coronata* essential oil and its biological activity have not been reported before. Only one study on the volatile fraction of *S. coronata* is known (Belviso et al., 2013). The study's authors evaluated the volatile fraction of raw and roasted seeds. A total of 59 volatile compounds were identified in *S. coronata* (34 in raw and 55 in roasted) belonging to 8 chemical classes. Among these, 30 compounds were found in both raw and roasted seeds. Carboxylic acids (such as octanoic and hexanoic acids) prevailed in raw *S. coronata* seeds, while after roasting, Strecker aldehydes (δ-lactones and alkyl pyrazines) were the most abundant. These data corroborate with our results, which showed that the essential oil of *S. coronata* seeds is also predominantly composed of fatty acids such as octanoic, dodecanoic and hexanoic acids.

Although less active than SCEO, the seed oil of *S. coronata* also showed a significant anti-*S. aureus* activity. SCO is predominantly composed of saturated fatty acids, with lauric acid (dodecanoic acid) the main constituent. The levels of saturated fatty acids were approximately three times higher than unsaturated fatty acids. Saturated fatty acids with medium chain length, such as lauric acid, have been found to be major components of other oils from Arecaceae plants, such as *Syagrus oleraceae, Syagrus romanzoffiana* and *Acrocomia aculeate* (Coimbra and Jorge, 2011). This study demonstrated that *S. coronata* seed oil is a rich source of medium-chain fatty acids, which could be suitable for biomedical applications (cosmetic and pharmaceutical industries), as showed by Leal et al. (2013). Our data are in agreement with the work of Bauer et al. (2013), which showed that saturated fats with high levels of medium-chain fatty acids (such as lauric and myristic fatty acids) are

prevalent in kernel and fruit oil of *S. coronata* collected in Bahia, Brazil. These authors commented that this composition is very similar to coconut oil. The presence of saturated chains made a biodiesel derived from *S. coronata* less viscous and more stable to oxidation and these physico-chemical properties showed that it has good potential for use in engines (Iha et al., 2014).

Various studies have reported the antimicrobial action of saturated and unsaturated fatty acids, in the form of oil (mixture) or individual compounds (Dilika et al., 2000; Yff et al., 2002; Kitahara et al., 2006; Narasimhan et al., 2006). For instance, lauric acid and related compounds have shown inhibitory action against a range of bacteria, such as *S. aureus* (Kitahara et al., 2006). Likewise, the second-most important compound of SCO, oleic acid (an unsaturated fatty acid), has shown anti-*S. aureus* activity, as has olinoleic acid (9,12-octadecadienoic acid), the only polyunsaturated fatty acid detected (Dilika et al., 2000). Other fatty acids present in SCO have antimicrobial action, such as myristic (tetradecanoic acid) (Narasimhan et al., 2006) and palmitic acid (hexadecanoic acid) (Yff et al., 2002).

In this study, the strong anti-staphylococcal properties of *S. coronata* seed oils were demonstrated. These are promising results that encourage further research on the toxicological and pharmacological aspects of this species, as well the determination of the action mechanisms involved. Such research would clarify these substances' suitability in any potential application as antimicrobial agents for therapy, food practices and/or cosmetic industry.

Conflict of Interests

The authors have not declared any conflict of interests.

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