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Arecaceae fruits: Fatty acids, phenolic compounds and *in vitro* antitumor activity

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ABSTRACT

Arecaceae fruits are regarded as raw sources of valuable phytochemicals. In this work, several Arecaceae fruits belonging to eleven taxa were screened for fatty acids (FA) by gas chromatography with flame ionization detector and checked for their *in vitro* antitumor activity against the HT-29 colorectal cancer cells line through the MTT test. The parallel use of two chromatography systems, HPLC-DAD and LC-MS, allowed the precise characterization of all phenolic compounds contained in the fruits. *Howea belmoreana* had the highest FA amounts (11.7 g/100 g on dry weight); *Syagrus romanzoffiana* had a relatively high PUFA content (26.3% of total FA); and *Butia capitata* contains high amounts of medium-chain saturated FA (51.2%). Total phenolics reached 201.8 mg/100 g on dry weight in *Phoenix dactylifera* var. *Medjool*. Among phenolics, occurred benzoic acids, phenylpropanoic acid, and cinnamic acid derivatives. It highlights the great diversity of flavonoids detected as (−)-catechin, quercetin, and kaempferol, as well as phenolic glycosides, such as isorhamnetin-3-*O*-glucoside. The methanol:water (60:40, v/v) extracts of fruits induced dose- and time-dependent inhibitory effects on HT-29 cancer cells. Overall, the fruits of Arecaceae taxa evaluated here constitute suitable candidates to be used as functional foods.

1. Introduction

The Arecaceae (Palmaceae) family is indigenous to the tropical and subtropical regions of the world, and it includes about 217 genera and 2500 species. These plants have multiple uses as they provide timber, fibre, oils, food, wax, wine, and dyes. The oils obtained from the fruit of some of these species have nutritional significance and are relevant to the oily industry (Rodríguez-Leyes et al., 2007).

Palms are considered the most promising plant species capable of producing vegetable oils. The most used palm for obtaining oil is the oil palm (*Elaeis guineensis* Jacq.), that is the principal source of palm oil, with wide applications in the food industry and as a feedstock to produce biodiesel (Khatiwada et al., 2021). Oil palm produces two oils of major economic importance, commonly referred to as palm oil and palm kernel oil, extracted from the mesocarp and the endosperm, respectively. While lauric acid (LaA, 12:0) predominates in the endosperm oil, the major fatty acids (FAs) of the mesocarp oil are palmitic (PA, 16:0) and oleic (OA, 18:1*n*-9) acids. The palm embryo also stores oil, which contains a significant proportion of linoleic acid (LA, 18:2*n*-6) (Dussert et al., 2013).

The healthy properties of Arecaceae oils are partially attributable to their FA profiles, which can be partially due to the occurrence of medium-chain saturated FAs (MCSFAs, C_6–C_{12}) in the fruit and seed oils. Among these, LaA have different uses and could be used for improving human health. In this regard, it has been noticed that although LaA raises total and low-density lipoprotein (LDL) cholesterol concentrations compared with OA-rich oils, it rises preferably high-density lipoprotein (HDL) instead LDL, while is not as potent for increasing cholesterol concentrations as PA (McCarty & DiNicolantonio, 2016). Moreover, LaA and monolaurin have high antimicrobial activity against gram positive bacteria and several fungi and viruses. For this reason there are

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Abbreviations

ALA	α-linolenic acid (18:3*n*-3)
ArA	arachidic acid (20:0)
AI	atherogenic index
CA	capric acid (10:0)
DAD	diode-array detector
DFA	desirable FA
dw	dry weight
ESI	electrospray ionization
FA	fatty acid
FAME	FA methyl ester
FID	flame ionization detector
GAE	Gallic Acid Equivalent
GC	Gas-Chromatography
GI_{50}	growth inhibition of 50%
HDL	high-density lipoprotein
HSFA	hypercholesterolaemic SFA
LaA	lauric acid (12:0)
LA	linoleic acid (18:2*n*-6)
LC-MS	liquid chromatography–mass spectrometry
LCSFA	long-chain saturated FAs
LDL	low-density lipoprotein
MA	myristic acid (14:0)
MCSFA	medium-chain saturated FA
MTT	Bromuro de 3-(4,5-dimetiltiazol-2-ilo)-2,5-difeniltetrazol
MUFA	monounsaturated FA
NMR	Nuclear magnetic resonance
OA	oleic acid (18:1*n*-9)
PA	palmitic acid (16:0)
PUFA	polyunsaturated FA
UFA	unsaturated FA
QE	quercetin equivalents
SA	stearic acid (18:0)
SFA	saturated FA
TI	thrombogenic index
TFC	total flavonoids content
TPC	total phenolics content

LaA-based many commercial products that use LaA or monolaurin as antimicrobial agents, and LaA-containing oils have use as salad oils and in cooking applications (Dayrit, 2015). Other related effects of LaA are neuroprotective (McCarty & DiNicolantonio, 2016). Unlike long-chain SFAs (LCSFAs), MCSFAs are less prone to be stored in adipose tissue, while lacking effects on insulin resistance and inflammation, and this is the reason why coconut oil is easily absorbed and LaA is transported directly to the liver where is subjected to energy production (McCarty & DiNicolantonio, 2016).

As for monounsaturated FAs (MUFAs), OA display modulatory effects in a wide range of physiological functions, having anti-atherogenic properties. It develops anticarcinogenic actions, and acts against inflammatory autoimmune diseases, besides its ability to facilitate wound healing and to improve the immune response associated to a more successful elimination of pathogens (Sales-Campos et al., 2013). Furthermore, Arecaceae oils contain LA and α-linolenic acid (18:3*n*-3), which are two polyunsaturated FAs (PUFAs) that are considered as essential for human health, since they cannot be biosynthesized in the body and, hence, must be provide by the diet.

The fruits of the Arecaceae family are reported to be good sources of FAs and antioxidants compounds such as phenolics (see Supplemental file 1). Therefore, such fruits have the potential to promote health and are worthy of research, so that the possible mechanisms involved in the prevention of chronic non-communicable diseases are elucidated (de Souza et al., 2020). Metanalytical studies demonstrated the beneficial effects of consumption of Arecaceae fruits, and those for whom this consumption would cause certain pathologies or aggravate certain diseases. Among other pathologies, it highlights the role of such fruits in preventing overweight, cardiovascular diseases, diabetes, and cancers (Absalome et al., 2020). However, knowledge on FA profiles, phenolic composition, and antitumor actions of the fruits of most Arecaceae species is undeveloped. In this context, the guiding hypothesis of this research was that the fruits of several understudied Arecaceae species constitute a raw source of healthy FAs and phenolic compounds, having antitumor activity. To verify this hypothesis, we collected and studied several fruits of this family belonging to different species. Specifically, we have selected nutritionally unexplored edible species (*Butia odorata*, *Howea belmoreana*, *H. forsteriana*, *Livistona fulva*, and *L. saribus*), others partially studied ones (*Syagrus romanzoffiana* and *Chamaerops humilis*), to be compared with nutritionally better-known Arecaceae fruits (those of *Sabal palmetto*, two widely consumed *Phoenix dactylifera* varieties, and *Livistona chinensis*). In all fruits, the FAs and phenolic compound profiles have been scrutinized, as well as their *in vitro* antitumor activity against human colorectal cancer cells, seeking to unravel their health benefits.

2. Materials and methods

2.1. Plant material and chemicals

Table 1 shows data on collected fruits. Fruits were supplied by the botanical gardens detailed in Table 1, date palms were purchased on local markets, and other samples were collected in gardens. The samples sent by the botanic gardens listed in Table 1 were analyzed in triplicate. The data corresponding to the samples collected in the wild or purchased represent the mean values of three independent collections or purchases, each of them analyzed in triplicate. Upon arrival to the laboratory, the fruits were labeled, dried until constant weight in an air-forced oven (60 °C) and keep into a refrigerator until analyses. Before analyzing the samples, fruits were ground until obtaining a fine powder with a mortar. All results are reported on a dry weight (dw) basis. Samples from botanical gardens were received dehydrated. Samples taken from the wild or purchased were dehydrated as described, and their moisture content were 15.3, 17.4, 18.9, and 56.7 g/100 g for *C. humilis* 8B, *P. dactylifera* var. *Deglet Nour*, *P. dactylifera* var. *Medjool,* and *S. romanzoffiana*, respectively.

Unless otherwise indicated, all chemicals and solvents were purchased in high purity grade from Sigma- Aldrich Química SA (Madrid, Spain).

2.2. Fatty acids analyses

Supplemental file 2 shows all details about this methodology. Direct derivatization of the pulp oils to FA methyl esters (FAMEs) was accomplished as described by Rodríguez-Ruiz et al. (1998). FAMEs were analyzed in a Focus GC equipped with a flame ionization detector (FID) and an Omegawax™ 250 Fused Silica Capillary as previously described (Lyashenko et al., 2019).

Table 1
Data collection of samples.

Code	Species	Common name	Sample location	Geographical coordinates	Year
Subfamily Arecoideae					
Tribe Areceae					
1	*Howea belmoreana* (C. Moore & F. Muell.) Becc.	Curly Palm	Botanic gardens of wood Rui Vieira, Portugal	32.662316, −16.894604	2020
2A	*Howea forsteriana* Becc.	Kentia palm	Botanic gardens of wood Rui Vieira, Portugal	32.662316, −16.894604	2020
2B	*Howea forsteriana* Becc.	Kentia palm	Botanischer Garten Berlin-Dahlem 3550, Germany	52.456684, 13.304710	2020
	Tribe Cocoseae				
3	*Butia capitata* (Mart.) Becc.	Butià, Wine palm	Botanic gardens of wood Rui Vieira, Portugal	32.662316, −16.894604	2020
4	*Syagrus romanzoffiana* (Cham.) Glassman	Queen palm	Collected from gardens in Almería, Spain	36.829694, −2.404185	2022
Subfamily Coryphoideae					
Tribe Phoeniceae					
5	*Phoenix dactylifera* L. var. *Deglet Nour*	Date palm	Purchased in Spain, sample from Algeria	-	2021
6	*Phoenix dactylifera* L. var. *Medjool*	Date palm	Purchased in Spain, sample from Spain	-	2021
	Tribe Sabaleae				
7	*Sabal palmetto* (Walter) Schult. & Schult.f.	Cabbage palm	Florida, Miami, Coral Gables	25.294750, −76.188889	2020
Tribe Trachycarpeae					
8A	*Chamaerops humilis* L.	Mediterranean fan palm	Luz, Alagoas, Steilkuste	−9.12055107,-36.6077802	
8B	*Chamaerops humilis* L.	Mediterranean fan palm	Collected from the wild, El Toyo, Almería, Spain	36.836508, −2.326255	2021
Trible Corypheae					
9	*Livistona chinensis* (Jacq.) R.Br. ex Mart. sf.	Chinese fan palm	Botanic gardens of the University, Bulgaria	42.697102, 23.334565	2020
10	*Livistona fulva* Rodd	Chinese fan palm	Valencia, University Botanic gardens	39.475663, −0.386351	2022
11	*Livistona saribus* (Lour.) Merr. ex A.Chev.	Chinese fan palm	Valencia, University Botanic gardens	39.475663, −0.386351	2022

2.3. Nutritional quality indices of lipids

The indicators of the quality of fruit lipids based on the FA profiles were calculated according to Barłowska et al. (2018), and details for the calculation of such indicators are given in Supplemental file 2.

2.4. Extraction of phenolic compounds from Arecaceae fruits

Supplemental file 2 provides the complete sequence of this procedure, which was carried out according to Lyashenko et al. (2021).

2.5. Characterization of phenolic compounds by HPLC-DAD

Supplemental file 2 gives all details about this methodology. HPLC analyses of phenolic compounds were effected in a Finnigan Surveyor chromatograph equipped with a diode-array detector (DAD) and a reverse-phase C18 column. To separate the compounds, it was used a gradient elution mode composed by acidified water (4% acetic acid) (A) and methanol (B) as mobile phase at 25 °C. Quantification of the compounds was made using external calibration curves obtained from pure standards (Sigma-Aldrich, St. Louis, MO, USA) in the HPLC-DAD system.

2.6. Characterization of phenolic compounds by LC-MS

Supplemental file 2 provides all details on this methodology, while the HPLC-DAD and LC-MS parameters for the analysis of phenolic-enriched extracts of Arecaceae fruits are detailed in Supplemental file 3. The chromatographic separations were performed on a Vanquish Flex Quaternary LC equipped with a reverse-phase C18 column (Hypersil Gold, 100 mm × 2.1 mm, 1.9 μm). The compounds were separated with gradient elution using acidified water (H_2O containing 0.1% formic acid and 4 mM ammonium formate) (A) and methanol (B) as eluents at room temperature (25 °C). The LC system was coupled to a hybrid mass spectrometer Q-Orbitrap Thermo Fisher Scientific using electrospray ionization (ESI) in positive and negative ion mode.

2.7. Antitumor assays

This methodology is fully detailed in Supplemental file 2. The antiproliferative activity of hydroalcoholic extracts (methanol: water, 60:40, v/v) from Arecaceae fruits was assayed on the HT-29 human colon cancer cell line, following previous protocols for the MTT assay from Lyashenko et al. (2021).

2.8. NMR analysis of the MeOH–H_2O extract of highly bioactive fruits

The solvent of each one of the MeOH–H_2O extracts was removed by lyophilization. 20 mg of the dry powder were dissolved in CD_3OD (0.5 mL). Nuclear magnetic resonance (NMR) spectra were obtained at 298 K using a Bruker Avance spectrometer (Bruker BioSpin GmbH, Germany) of 14,09 T operating at 600 MHz for ^1H and 125 MHz for ^{13}C. Chemical shifts are reported as ppm using residual CH_3OH as internal standard. Recorded spectra are reported in Supplemental file 4.

2.9. Statistical analysis

All samples were analyzed in triplicate. Data were assessed for normality using a Shapiro-Wilk test and submitted to one-way ANOVA, and the comparison of means was made using Duncan's Multiple Range Test. Statistical analyses were performed using Statgraphics© centurion XVI (StatPoint Technologies, Warrenton-Virginia, USA).

3. Results

3.1. Fatty acids content

The FA profiles of Arecaceae fruits are detailed in Table 2. Among fruits, *H. belmoreana* and *L. saribus* had the highest amount of total FAs on dw, with 11.7 and 11.3 g/100 g, while the lowest amounts were found in *P. dactylifera* varieties (0.2–0.3 g/100 g dw). In fruits tissues the following FAs were detected: caproic acid (6:0), caprylic acid (8:0), capric acid (CA, 10:0), LaA, myristic acid (MA, 14:0), PA, stearic acid (SA, 18:0), OA, LA, ALA, and arachidic acid (ArA, 20:0). Caproic acid was found only in Cocoseae, and *Butia capitata* had the highest percentage (1.2% of total FAs). Caprylic acid had low values in all species, ranging from undetectable levels in several species to 12.9% in *B. capitata*. CA ranged from an absence in *H. belmoreana* and *P. dactylifera* var. *Deglet Nour* to 9.6% in *B. capitata*. LaA had very different values according to tribes: in *Howea* species (Areceae) had very low values, from undetectable percentages in *H. belmoreana* to 4.2% in *H. forsteriana*; Trachycarpeae showed also low values, from 1.4% (*Livistona saribus*) to 13.5% (*C. humilis* 8A; in Cocoseae this FA showed high values, especially in *B. capitata* (28.5%), while in Phoeniceae and Sabaleae it was ~9–13%. MA had also very disparate values according to taxa, and it was relatively abundant in Sabaleae (13%); Phoeniceae and Cocoseae (~5–9%); and Trachycarpeae (~2–10%); conversely, Areceae display low percentages (0.4–2.5%). PA showed characteristic

Table 2
Fatty acid profiles of the Arecaceae fruits focused in this study[a,b,c,d]

Code	Species	FA% of total FAs											Total FA (g/100 g)
		6:0 Caproic acid	8:0 Caprylic acid	10:0 (CA) Capric acid	12:0 (LaA) Lauric acid	14:0 (MA) Miristic acid	16:0 (PA) Palmitic acid	18:0 (SA) Stearic acid	18:1*n*-9 (OA) Oleic acid	18:2*n*-6 (LA) Linoleic acid	18:3*n*-3 (ALA) α-linolenic acid	20:0 (ArA) Arachidic acid	
Subfamily Arecoideae													
Tribe Areceae													
1	*Howea belmoreana*	n.d	n.d	n.d	n.d	0.4 ± 0.0[g]	41.7 ± 1.8[e,f]	3.5 ± 0.1[b]	37.9 ± 0.9[c]	13.2 ± 0.1[b,c]	3.3 ± 0.5[c,d,e]	n.d.	11.7 ± 0.9[a]
2A	*H. forsteriana*	n.d	0.3 ± 0.1[c,d]	0.9 ± 0.1[e]	4.0 ± 0.2[f]	2.5 ± 0.1[f]	49.8 ± 0.6[a]	4.5 ± 0.1[a]	15.8 ± 1.1[f]	15.7 ± 1.8[b]	6.4 ± 0.1[b]	1.3 ± 0.1[d,e]	9.1 ± 1.2[b]
2B	*H. forsteriana*	n.d	0.6 ± 0.1[b,c]	1.0 ± 0.1[d,e]	4.2 ± 0.2[f]	2.3 ± 0.1[f]	47.2 ± 3.6[b]	2.9 ± 0.1[c,d]	15.6 ± 1.5[f]	16.7 ± 1.7[a]	7.3 ± 0.1[b]	2.2 ± 0.1[b]	8.5 ± 0.2[b,c]
Tribe Cocoseae													
3	*Butia capitata*	1.2 ± 0.0[a]	12.9 ± 0.3[a]	9.6 ± 0.9[a]	28.5 ± 1.6[a]	7.0 ± 0.1[c]	11.0 ± 0.1[k]	1.6 ± 0.2[e,f]	21.2 ± 2.0[d]	8.6 ± 0.4[d,e]	0.6 ± 0.1[g]	n.d	0.6 ± 0.0[f,g]
4	*Syagrus romanzoffiana*	0.4 ± 0.0[b]	1.6 ± .02[b]	3.0 ± 0.1[b]	10.2 ± 0.6[d,e]	6.3 ± 0.3[d]	44.5 ± 1.2[c]	n.d	8.1 ± 0.6[g]	13.9 ± 0.9[b,c]	12.4 ± 0.3[a]	n.d	2.6 ± 0.3[e]
Subfamily Coryphoideae													
Tribe Phoeniceae													
5	*Phoenix dactylifera* var. *Deglet Nour*	n.d	n.d	n.d	13.0 ± 0.7[b,b,c]	5.5 ± 0.4[e]	25.7 ± 1.0[h]	n.d	44.8 ± 0.2[b]	5.1 ± 1.3[f]	4.2 ± 0.1[b]	2.1 ± 0.1[b,c]	0.2 ± 0.1[g]
6	*P. dactylifera* var. *Medjool*	n.d	1.0 ± 0.5[b,c]	1.1 ± 0.5[c,d,e]	10.3 ± 0.7[e]	9.5 ± 0.2[b]	24.9 ± 0.8[h]	n.d	41.9 ± 1.2[b]	7.8 ± 1.6[d,e]	2.4 ± 0.2[d]	1.6 ± 0.1[c,d]	0.3 ± 0.2[g]
Tribe Sabaleae													
7	*Sabal palmetto*	n.d	n.d	1.2 ± 0.3[c,d,e]	10.6 ± 1.1[d,e]	13.0 ± 1.5[a]	20.2 ± 1.8[j]	2.1 ± 1.3[d,e]	38.9 ± 0.3[c]	9.3 ± 0.9[d]	3.7 ± 0.2[c,d]	1 ± 0.1[e]	4.7 ± 0.1[d]
Tribe Trachycarpeae													
8A	*Chamaerops humilis*	n.d	0.5 ± 0.0[c]	1.4 ± 1.4[b,c]	13.5 ± 0.7[b]	9.4 ± 0.9[b]	44.1 ± 1.0[c]	n.d	18.4 ± 0.3[e,f]	7.2 ± 0.4[e]	2.6 ± 0.3[d,e]	2.9 ± 0.1[a]	0.7 ± 0.1[f,g]
8B	*C. humilis*	n.d	0.6 ± 0.0[b,c]	1.3 ± 0.6[b,c]	12.6 ± 0.8[b,c,d]	8.8 ± 1.7[b]	45.1 ± 0.4[b,c]	n.d	19.5 ± 0.9[e]	7.2 ± 0.4[e]	2.7 ± 0.1[d,e]	2.2 ± 0.8[b]	1.7 ± 0.1[e,f]
9	*Livistona chinensis*	n.d	n.d	1.0 ± 0.2[d,e]	11.3 ± 0.1[c,d,e]	5.8 ± 0.5[d,e]	43.4 ± 0.4[c,e]	0.8 ± 0.2[f,g]	28.1 ± 0.4[d]	7.1 ± 0.1[e]	1.2 ± 0.1[f]	1.2 ± 0.1[d,e]	8.3 ± 0.5[b,c]
10	*L. fulva*	n.d	n.d	1.3 ± 03[c,d]	8.8 ± 0.2[e]	9.1 ± 03[b]	45.4 ± 0.4[c]	1.0 ± 0.5[f]	18.4 ± 0.4[e,f]	9.0 ± 0.3[d,e]	6.6 ± 0.6[b]	0.4 ± 0.0[f]	7.3 ± 0.1[c]
11	*L. saribus*	n.d	n.d	1.6 ± 0.1[c]	1.4 ± 0.1[j]	1.9 ± 0.2[f,g]	22.4 ± 0.9[i]	1.3 ± 0.3[e,f]	56.0 ± 1.2[a]	12.5 ± 0.4[c]	1.4 ± 0.1[f]	1.5 ± 0.1[d,e]	11.3 ± 0.2[a]

[a] Other FA of undetermined structure accounted for 100% of the total FA.
[b] Data represent means ± standard deviation of samples analyzed in triplicate.
[c] Differences in FA amounts were tested according to one-way ANOVA followed by Duncan's test.
[d] In a column. means followed by different letter are significantly different at $P < 0.05$.; n.d. not detected.

values for each of the checked tribes. That is, ~40–50% in Areceae; ~11–45% in Cocoseae; ~25–26% in Phoeniceae; 22–46% in Trachycarpeae; and 20.2% in Sabaleae. SA was undetected in Phoeniceae species and *C. humilis*, while in the remaining species it was ~1–4%. OA reached high values in Sabaleae, and Phoeniceae (~40–45%); in Areceae ~15–38%; Cocoseae ~8–21%; and for Trachycarpeae ~18–56%. The higher LA percentages were found in Areceae (~13–17%); Cocoseae showed ~8–14%; Phoeniceae ~5–8%; Trachycarpeae ~7–12%; and Sabaleae 9.3%. ALA percentages were low in all cases, especially in Cocoseae, from 0.6% (*B. capitata*) to 12.4% (*S. romanzoffiana*); in Areceae ~3–7%; in Phoeniceae ~2–4%; in Trachycarpeae ~1–7%; and in Sabaleae 3.7%. Finally, ArA was found in low amounts, ranging from an absence in several species to 2.9% in *C. humilis*.

3.2. Nutritional quality indices for fatty acids

Concerning FA groups and ratios, SFAs were found in high proportions in *C. humilis* samples and *B. capitata* (~71% of total FAs). This last species also highlights because its high MCSFA percentages (51.2%). LCSFAs stands out in *H. forsteriana* (58%) and both *C. humilis* samples (~56%). MUFAs reached the highest values in *L. saribus* (51%) and both *P. dactylifera* varieties (~42–44%). *S. romanzoffiana* highlights due to its high PUFAs percentage (26.3%) and its low *n*-6/*n*-3 PUFA ratio (1.1). *L. saribus* had the best PUFA/SFA, MUFA/SFA, desirable FA (DFA), hypercholesterolaemic saturated FAs (HSFA), atherogenic (AI), and thrombogenic (TI) indices (0.46, 1.86, 71.16, 25.70, 9.32, and 0.66, respectively).

3.3. Phenolic compounds content

The HPLC-DAD and LC-MS systems were used for qualitative and quantitative characterization of phenolics. The phenolic compound profiles quantified by HPLC-DAD are shown in Table 3, while a HPLC-DAD chromatogram of *B. capitata* extract is shown in Fig. 1. All investigated compounds had good molar extinction coefficients at 280, 300 and 320 nm, at which were screened the various chromatograms (Supplemental file 3). The phenolics compounds were identified by the recorded absorption spectra of all peaks from the various chromatograms in comparison with pure standards. The LC-MS system was used to confirm the structures of all identified compounds present in the fruit extracts of Arecaceae species. Supplemental file 3 shows the results of the linearity range, regression equation, LOQ, LOD, and recoveries for all quantified compounds. Precision/injection repeatability test showed good precision in peak retention time (±2%) and peak area (standard deviation < 1%). All phenolic compounds were detected trough the LC-MS system by the m/z ions and are listed in Supplemental file 3, but

Table 3
Fatty acids indices of the Arecaceae fruits focused in this study[a,b]

Code	Species	SFA	MCSFA	LCSFA	MUFA	PUFA	*n*-6/*n*-3	PUFA/SFA	MUFA/SFA	DFA	HSFA	AI	TI
Subfamily Arecoideae													
Tribe Areceae													
1	*Howea belmoreana*	45.60	0.00	45.60	37.90	16.51	3.99	0.36	0.83	57.91	42.10	2.37	1.28
2A	*H. forsteriana*	63.22	5.20	58.02	14.60	21.00	2.28	0.33	0.23	40.05	56.27	15.40	1.66
2B	*H. forsteriana*	60.40	5.80	54.60	15.60	24.00	2.29	0.40	0.26	42.50	53.70	14.59	1.36
Tribe Cocoseae													
3	*Butia capitata*	70.80	51.20	19.60	20.10	9.20	14.33	0.13	0.28	30.90	46.50	56.88	1.21
4	*Syagrus romanzoffiana*	65.90	15.10	50.80	8.10	26.30	1.12	0.40	0.12	34.40	60.90	36.59	1.03
Subfamily Coryphoideae													
Tribe Phoeniceae													
5	*Phoenix dactylifera* var. *Deglet Nour*	45.90	13.00	32.90	44.40	9.30	1.21	0.20	0.97	53.70	43.80	33.88	0.81
6	*P. dactylifera* var. *Medjool*	47.40	12.40	35.00	41.90	10.20	3.25	0.22	0.88	52.10	43.70	46.77	1.03
Tribe Sabaleae													
7	*Sabal palmetto*	48.10	11.80	36.30	38.90	13.00	2.51	0.27	0.81	54.00	43.80	62.99	0.99
Tribe Trachycarpeae													
8A	*Chamaerops humilis*	71.80	15.40	56.40	18.40	9.80	2.77	0.14	0.26	28.20	67.00	52.66	2.55
8B	*C. humilis*	70.60	14.50	56.10	19.50	9.90	2.67	0.14	0.28	29.40	66.50	49.33	2.47
9	*Livistona chinensis*	63.55	12.30	51.25	28.10	8.30	5.92	0.13	0.44	37.25	60.50	35.69	2.34
10	*L. fulva*	66.06	10.16	55.90	18.40	15.56	1.37	0.24	0.28	34.96	63.36	46.60	1.63
11	*L. saribus*	30.07	3.00	27.07	56.00	13.89	8.99	0.46	1.86	71.16	25.70	9.32	0.66

[a] Abbreviations: SFA – saturated FAs; MCSFA –medium-chain saturated FAs; LCSFA – long-chain saturated FAs; MUFA – monounsaturated FAs; PUFA – polyunsaturated FAs; DFA – desirable FAs = (MUFA + PUFA + C18:0); HSFA – hypercholesterolaemic saturated FAs = (C12:0 + C14:0 + C16:0); AI – atherogenic index = (C12:0 + 4 x C14:0 + C16:0)/(MUFA + PUFA); TI – thrombogenic index = (C14:0 + C16:0 + C18:0)/(0.5 x MUFA + 0.5 x *n*-6+3 x *n*-3 + *n*-3/*n*-6).
[b] In the analyzed fruits, MUFA, *n*-6 PUFA, and *n*-3 PUFA correspond to OA, LA, and ALA, respectively.

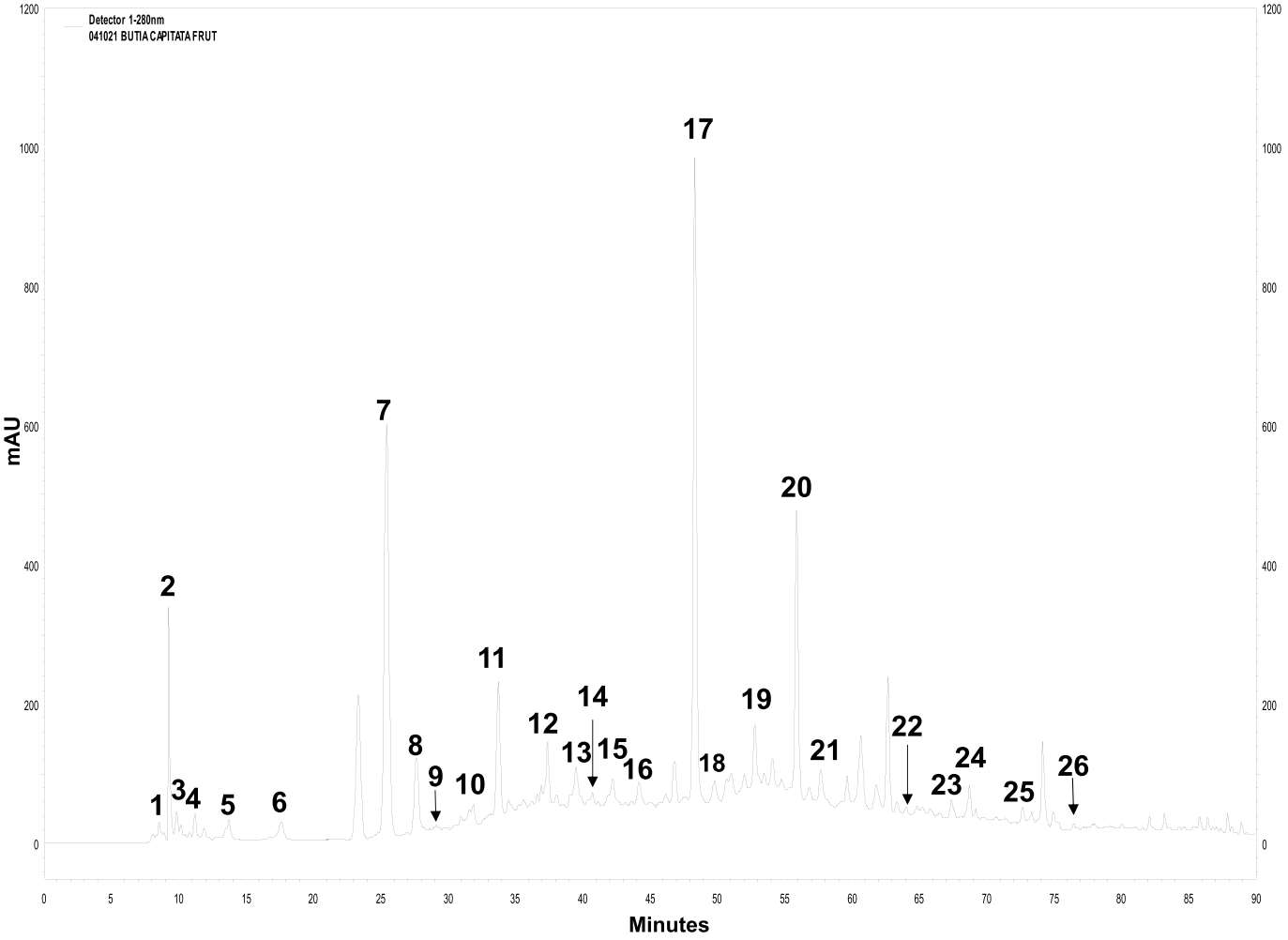

Fig. 1. 280 nm-HPLC chromatogram of the phenolic-containing water:methanol extract of *Butia capitata* pulp fruit. 1. Quinic acid; 2. Chelidonic acid; 3. *Trans*-aconitic acid; 4. Gallic acid; 5. Vanillic acid; 6 Protocatechuic acid; 7. Salicylic acid; 8. 4-hydroxybenzoic acid; 9. DL-p-Hydroxyphenyllactic acid; 10. 3,4-Dihydroxyhydrocinnamic acid; 11. Chlorogenic acid; 12. Caffeic acid; 13. (−)-Catechin; 14. Syringic acid; 15. Dactylifric acid; 16. *Trans*-p-Coumaric acid; 17. Ferulic acid; 18. Sinapic acid; 19. Eriodictyol; 20. Rutin; 21. Rosmarinic acid; 22. 2-Hydroxy-4-methoxybenzoic acid; 23. Naringenin; 24. Quercetin; 25. Luteolin; 26. Kaempferol.

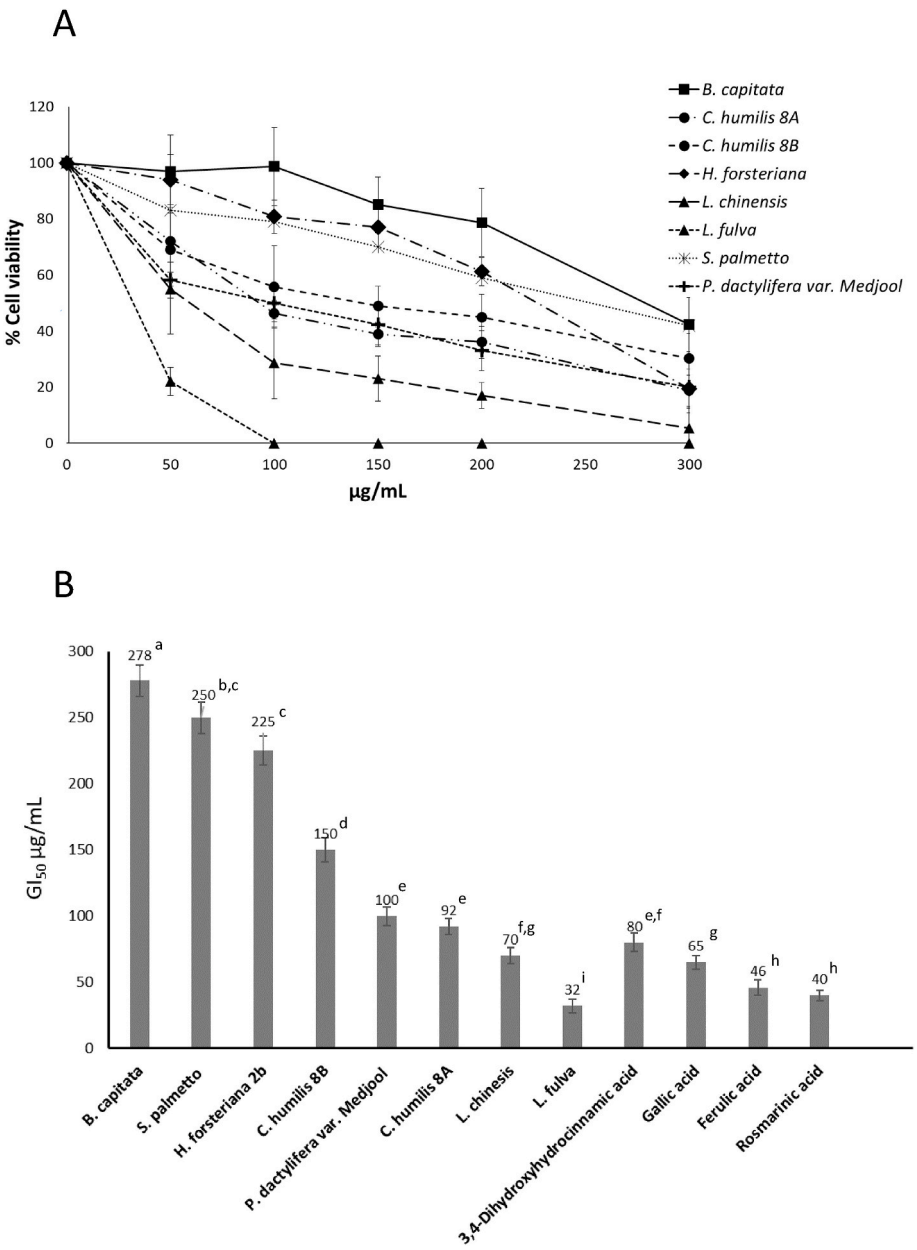

Fig. 2. MTT assay. A: Concentration-response plot for HT-29 cells after exposure to Arecaceae fruits extracts for 72 h. B: GI_{50} after HT-29 cells exposure for 72 h to fruits extracts, and gallic, 3,4-dihydroxyhydrocinnamic, ferulic, and rosmarinic acids. Data represents the mean of three complete independent experiments ± SD (error bars). In a bar, means followed by different letter are significantly different at $P < 0.05$.

some of these could not be clearly assigned to the chromatographic peaks obtained by the HPLC-DAD system. Besides phenolic compounds, three organic acids were detected and quantified: quinic acid, a cyclic polyol; chelidonic acid, a dicarboxylic acid belonging to pyranones and derivatives; and *trans*-aconitic acid, which is a tricarboxylic acid derivative. Among phenolic compounds, seven consisted of hydroxylated derivatives of benzoic acids (gallic, vanillic, protocatechuic, salicylic acid, 4-hydroxybenzoic acid, syringic, and 2-hydroxy-4-methoxybenzoic acids), one was a phenylpropanoic acid derivative (D-L p-hydroxyphenyllactic), nine were cinnamic acid derivatives (2,4-dihydroxycinnamic, 3,4-dihydroxycinnamic, caffeic, chlorogenic, dactylifric, *trans*-coumaric, ferulic, sinapic, and rosmarinic acids), and several flavonoids were also quantified ((−)-catechin, eriodictyol, rutin, naringenin, quercetin, luteolin, and kaempferol). Other phenolics and related compounds detected by the LC-MS system are detailed in Supplemental file 3. Among these, it highlights the occurrence of stilbenes (piceatannol), flavonoids (formononetin, phloretin, (−)-epicatechin, myricetin, malvidine, pelargonidin), phenolic glycosides (ferulic acid hexoside, phloridzin, kaempferol-3-*O*-rutinoside, isorhamnetin-3-*O*-glucoside, isorhamnetin-3-*O*-rutinoside), and sesquiterpenes (bilobalide).

3.4. Antitumor assay

Fig. 2A shows the effects of Arecaceae fruits extracts on HT-29 cancer cells viability after 72 h exposure. The various extracts exercised ~25–35% lower effects on cell viability at 48 h (data not shown) in comparison to that obtained at 72 h. The doses of extracts that inhibited the cell growth by 50% (GI_{50}) and those of some pure phenolic compounds are drawn in Fig. 2B. GI_{50} values of the extracts from *B. capitata*, *S. palmetto*, *H. forsteriana* 2B, *C. humilis* 8B, *P. dactylifera* var. *Medjool*, *C. humilisis* 8A, *L. chinensis*, and *L. fulva* were 278, 250, 225, 150, 100,

92, 70, and 32 μg/mL, respectively. The extracts of the remaining species showed GI_{50} values above 300 μg/mL.

4. Discussion

4.1. Uses of the fruits of the Arecaceae species focused in this work

There is a great diversity of palm species, which occurs mainly in tropical countries, and several understudied species/varieties were selected to be analyzed in this work. The uses of the taxa analyzed here are detailed in Supplemental file 5. Some of them are universally consumed, such as *P. dactylifera* varieties; others have more restricted consumption, as is the case of the species of the Cocoseae and Sabaleae tribe (Agostini-Costa, 2018). The fruits of *S. palmetto* have been used by Native Americans since ancient times due to its healthy properties. Such fruits are used to make extracts to be drunk to solve male sexual diseases and for topical use to treat hair loss problems. Today, *S. palmetto* extract is widely distributed around the world by many companies as a remedy for hair loss and for relieving symptoms of benign prostatic hyperplasia (Marks et al., 2000). As for the Tribe Trachycarpeae, *C. humilis* and *L. chinensis* are widely reported as locally consumed. Concerning *L. fulva* and *L. saribus*, both are reported for consumption as *L. chinensis* fruits (Alia et al., 2017). Finally, after an extensive scrutiny (data not shown) two underutilized *Howea* species were selected, which were locally consumed in the past.

4.2. Fatty acids content

Most usually consumed fruits contains very low FA amounts. However, this is not the case of several Arecaceae species. Until now, palm fruits (*E. guineensis* ones) have been used extensively due to their high lipid content (Absalome et al., 2020), however, little attention has been paid to the rest of the species of this family. In this study, we have found two *Howea* species (tribe Areceae) and some species of the tribe Trachycarpeae that contain noticeable FA amounts. Concerning *Howea* species, to the best of our knowledge, this is the first report on their FAs composition. The total FAs content of *Howea* samples was relatively high, considering that fruits are not usually a source of FA. The FA profiles of the pulp of both *Howea* species showed a close similarity with that of palm (*E. guineensis*) oil considering PA percentage, which is usually reported for palm oils in amounts ranging between ~36 and 43% of total FAs depending on the geographical origin (Tres et al., 2013). However, *H. belmoreana* and *H. forsteriana* fruit oils analyzed here showed higher amounts of both *n*-6 and *n*-3 PUFA (~13 and ~16% LA, ~3 and ~7% ALA, respectively) than palm oil, for which Absalome et al. (2020) reported LA and ALA at 10.2 and 0.3%, respectively; thus, *Howea* pulp oils are presumably healthier than the former. In this regard, ALA and LA are *n*-3 and *n*-6 PUFAs precursors, which are related to an increase in HDL cholesterol and decrease in LDL cholesterol, triacylglycerol, lipid oxidation and LDL susceptibility to oxidation (Barros et al., 2010).

Two Cocoseae species have been analyzed in this work. As for *B. capitata*, the total FAs content was not very high in the pulp, and this agree with previous reports from Lopes et al. (2012); however, this species constitute a rich source of healthy MCSFA. Specifically, in decreasing order *B. capitata* contains LaA, OA, caprylic acid, PA, CA, and LA. As previously exposed, MCSFAs are important substrates of the energy metabolism and anabolic processes in mammals (McCarty & DiNicolantonio, 2016). In addition, such SFAs modulate tissue metabolism of carbohydrates and lipids, as manifested by a mostly inhibitory effect on glycolysis and stimulation of lipogenesis or gluconeogenesis (Schönfeld and Wojtczak, 2016). Overall, the results of this work showed higher percentages of MCSFAs and lower of UFAs than those reported for this species by Lopes et al. (2012). As for *S. romanzoffiana*, its relatively high total FAs content allows to consider it as a future source of food oils, given that its PUFAs percentage reached the highest value among all analyzed taxa. Moreover, its *n*-6/*n*-3 PUFA ratio is the healthier one of all samples. Our results differ from those of Coimbra and Jorge (2012) and Lescano et al. (2018) concerning PA amounts in this fruit. Higher amounts of this SFA and lower OA and LA percentages than that reported by these authors were found, although the results of this work for ALA were in good agreement with those of Lescano et al. (2018). Such differences in UFAs content could be related to the climate in which the samples were collected, taking into account that ALA and other UFAs provide fluidity to cell membranes (Chileh Chelh et al., 2022), although agricultural practices and/or the analysis of different varieties cannot be ruled out.

The FA profiles of *P. dactylifera* varieties has been scarcely reported until now. The results of this work agree with those of Devshony et al. (1992) for the two *P. dactylifera* varieties analyzed *-Deglet Nour* and *Medjool-*, especially concerning OA content, although higher PA and lower LaA percentages than that of the last authors were found here. Any case, the total FAs content of *P. dactylifera* varieties is very low and, therefore, it has no special nutritional significance, besides its healthy UFA-rich FA profiles.

Concerning the Tribe Sabaleae, Saw Palmetto (*Sabal palmetto*) fruit oil has been analyzed. It has been hypothesized that the variation in the efficacy of saw palmetto extracts may be a result of differences in the putative active components, i.e., FA and phytosterols (Penugonda & Lindshield, 2013). These authors reported the FAs profile obtained directly from the fruit (Supplemental file 1). The results of this work agree with those from Rodríguez-Leyes et al. (2007) and Priestap and Bennett (2011); that is, OA was the main FA followed by PA, MA and LaA. However, higher MA and PA amounts than that of the last authors were found here.

4.3. Nutritional quality indices for fatty acids

Focusing on healthy FA groups, MCSFAs were especially relevant in *B. capitata*; MUFAs in *P. dactylifera* varieties, *H. belmoreana*, and *L. saribus*; and PUFAs in *S. romanzoffiana*. The *n*-6/*n*-3 PUFA ratio is used for the nutritional assessment of lipids. A recent systematic review and meta-analysis study reported that a diet having low values for this ratio (≤5) could significantly decrease the serum concentration of inflammatory markers such as the tumour necrosis factor α (TNF-α) and interleukin 6 (IL-6) (Wei et al., 2021). All fruits showed appropriate values for this ratio, except *L. chinensis* (due to high LCSFAs levels), *L. saribus* (a MUFAs-rich species), and *S. romanzoffiana*. The PUFA/SFA ratio is one of the indices traditionally used to assess the nutritional quality of the lipid fraction of foods, and values higher than 0.4 are desirable to decrease CVD risk. However, the relationship between SFAs intake and an increase of the risk of CVD is unclear, and other nutritional indices are recently used to assess the nutritional quality of the lipid fraction of foods, such as AI and TI, (Chen & Liu, 2020). Appropriate PUFA/SFA ratio were found in *H. forsteriana* 2B (0.40), *S. romanzoffiana* (0.40), and *L. saribus* (0.46). The MUFA/SFA ratio has been reported as characteristically high in the Mediterranean diet, and as effective in suppressing disease activity in rheumatoid arthritis (Matsumoto et al., 2018). This ratio was especially good in *L. saribus*, followed by *H. belmoreana*. The DFAs was found to be high in *L. saribus* and *H. belmoreana*, followed by Phoeniceae and Sabaleae species, and consequently these species had low levels of hypercholesterolaemic saturated FAs (HSFA). The AI is the ratio between those SFAs considered pro-atherogenic and UFAs, i.e., MUFAs and PUFAs, which are considered anti-atherogenic, and AI values lower than 1.5 are desirable (Chen & Liu, 2020). None of the analyzed samples fulfilled this criterion, the lowest figure found in *H. belmoreana* (2.37). The TI estimates the thrombogenic potential of the FAs contained in foods and represents the ratio between SFAs (14:0, 16:0, and 18:0) and UFAs, although conferring more weight to *n*-3 PUFAs, which are recognized as cardiovascular health-promoting PUFAs. TI values are interpreted as the lower the value, the lower the thrombogenic risk, and values of TI < 1.15 are

Table 4
Phenolic compounds and organic acid profiles of the Arecaceae fruits focused in this study (mg/100 g dry weight).[a,b,c]

Code	Species	*Quinic acid* [d]	*Chelidonic acid* [d]	*Trans-aconitic acid* [d]	Gallic acid	Vanillic acid	Protocatechuic acid	Salicylic acid	4-hydroxybenzoic acid	D-L p-hydroxyphenyllactic acid	2,4-Dihydroxycinnamic acid	3,4-Dihydroxycinnamic acid	Chlorogenic acid	Caffeic acid	Catechin
Subfamily Arecoideae															
Tribe Areceae															
1	*Howea belmoreana*	$1.7 \pm 0.1^{g.h}$	16.1 ± 0.8^{e}	7.4 ± 0.4^{c}	1.4 ± 0.1^{h}	0.5 ± 0.0^{d}	1.8 ± 0.3^{b}	3.7 ± 0.3^{d}	1.7 ± 0.2^{ef}	2.7 ± 0.0^{c}	7.8 ± 0.3^{b}	6.3 ± 0.4^{b}	20.2 ± 0.8^{b}	0.6 ± 0.0^{f}	2.4 ± 0.3^{e}
2A	*H. forsteriana*	0.6 ± 0.0^{h}	13.1 ± 0.3^{f}	5.3 ± 0.7^{d}	5.2 ± 0.3^{d}	1.2 ± 0.2^{d}	0.2 ± 0.0^{e}	8.2 ± 0.1^{c}	4.5 ± 0.3^{b}	1.6 ± 0.0^{de}	0.1 ± 0.0^{h}	5.1 ± 0.1^{c}	3.9 ± 0.3^{g}	7.6 ± 0.3^{b}	1.9 ± 0.1^{ef}
2B	*H. forsteriana*	$1.9 \pm 0.0^{f.g.h}$	18.0 ± 0.9^{e}	12.3 ± 0.3^{b}	3.2 ± 0.3^{f}	4.8 ± 0.5^{bc}	0.5 ± 0.1^{d}	2.1 ± 0.1^{efg}	2.7 ± 0.1^{c}	0.6 ± 0.5^{f}	0.4 ± 0.0^{h}	1.2 ± 0.2^{f}	10.3 ± 1.1^{de}	0.9 ± 0.0^{ef}	1.4 ± 0.0^{efg}
Tribe Cocoseae															
3	*Butia capitata*	$1.3 \pm 0.1^{g.h}$	9.7 ± 0.6^{g}	2.6 ± 0.4^{e}	0.2 ± 0.1^{i}	1.1 ± 0.2^{d}	1.3 ± 0.1^{c}	8.1 ± 1.1^{c}	2.1 ± 0.4^{cd}	1.9 ± 0.3^{d}	n.d	0.2 ± 0.0^{h}	12.3 ± 0.3^{cd}	2.4 ± 0.1^{cd}	1.3 ± 0.0^{efg}
4	*Syagrus romanzoffiana*	10.1 ± 0.1^{d}	8.5 ± 0.7^{g}	n.d	5.3 ± 0.1^{d}	0.9 ± 0.0^{d}	0.4 ± 0.0^{de}	3.9 ± 0.3^{d}	n.d	n.d	10.8 ± 0.6^{a}	n.d	2.3 ± 0.2^{g}	n.d	1.1 ± 0.2^{gh}
Subfamily Coryphoideae															
Tribe Phoeniceae															
5	*Phoenix dactylifera* var. *Deglet Nour*	20.9 ± 1.5^{b}	20.4 ± 2^{d}	0.5 ± 0.1^{f}	7.5 ± 0.1^{c}	13.4 ± 1.9^{a}	0.2 ± 0.0^{e}	2.9 ± 0.1^{de}	2.2 ± 0.3^{cd}	0.5 ± 0.0^{ef}	2.5 ± 0.0^{de}	1.7 ± 0.2^{e}	2.6 ± 0.0^{g}	8.3 ± 0.3^{a}	20.5 ± 0.3^{a}
6	*P. dactylifera* var. *Medjool*	26.4 ± 0.7^{a}	48.6 ± 3.1^{a}	7.1 ± 03^{c}	2.6 ± 0.3^{g}	14.6 ± 2.5^{a}	n.d	1.3 ± 0.0^{gh}	1.4 ± 0.1^{f}	1.6 ± 0.4^{de}	2.8 ± 0.1^{d}	0.9 ± 0.0^{fg}	2.1 ± 0.4^{g}	2.3 ± 0.4^{cd}	7.8 ± 0.7^{b}
Tribe Sabaleae															
7	*Sabal palmetto*	10.8 ± 0.5^{d}	28 ± 0.7^{c}	5.7 ± 0.2^{d}	7.7 ± 0.1^{c}	3.8 ± 0.4^{c}	0.4 ± 0.0^{de}	2.5 ± 0.2^{ef}	1.8 ± 0.4^{ef}	0.2 ± 0.0^{f}	2.5 ± 0.1^{de}	3.6 ± 0.2^{d}	9.3 ± 0.4^{e}	8.4 ± 0.7^{a}	20.0 ± 2.4^{a}
Tribe Trachycarpeae															
8A	*Chamaerops humilis*	3.3 ± 0.1^{f}	2.9 ± 0.2^{h}	5.1 ± 0.3^{d}	4.8 ± 0.2^{e}	0.6 ± 0.0^{d}	5.6 ± 0.3^{a}	10.4 ± 0.8^{b}	1.9 ± 0.1^{ef}	3.4 ± 0.1^{b}	2.9 ± 0.0^{cd}	4.9 ± 0.2^{c}	7.8 ± 0.6^{f}	2.1 ± 0.0^{cd}	6.7 ± 0.6^{c}
8B	*C. humilis*	2.4 ± 0.0^{fg}	2.1 ± 0.0^{h}	0.3 ± 0.0^{f}	1.8 ± 0.0^{h}	1.7 ± 0.1^{d}	1.0 ± 0.1^{c}	18.0 ± 1.6^{a}	15.1 ± 1.1^{a}	2.8 ± 0.1^{c}	3.1 ± 0.4^{c}	9.0 ± 0.7^{a}	32.0 ± 3.6^{a}	2.4 ± 0.2^{c}	4.9 ± 0.0^{d}
9	*Livistona chinensis*	13.7 ± 0.8^{c}	45.2 ± 3.7^{b}	26.3 ± 0.8^{a}	1.6 ± 0.4^{h}	5.6 ± 0.3^{b}	1.7 ± 0.1^{b}	1.7 ± 0.2^{fg}	1.6 ± 0.0^{f}	3.5 ± 0.2^{b}	2.2 ± 0.1^{f}	0.6 ± 0.0^{gh}	12.9 ± 0.1^{c}	1.8 ± 0.2^{d}	1.7 ± 0.2^{efg}
10	*L. fulva*	6.5 ± 0.4^{e}	26.8 ± 1.2^{c}	26.3 ± 0.3^{a}	18.1 ± 0.6^{a}	0.9 ± 0.1^{d}	0.3 ± 0.0^{de}	2.4 ± 0.1^{ef}	0.1 ± 0.0^{g}	5.3 ± 0.4^{a}	2.9 ± 0.2^{d}	n.d	12.4 ± 2.4^{cd}	1.1 ± 0.2^{e}	1.9 ± 0.2^{ef}
11	*L. saribus*	6.1 ± 0.3^{e}	4.1 ± 0.2^{h}	5.2 ± 0.3^{d}	9.6 ± 0.3^{b}	1.4 ± 0.2^{d}	0.1 ± 0.0^{e}	0.4 ± 0.0^{h}	0.3 ± 0.0^{g}	1.2 ± 0.3^{a}	0.9 ± 0.1^{g}	n.d	4.0 ± 0.6^{g}	1.4 ± 0.3^{e}	0.7 ± 0.0^{h}

Code	Species	Syringic acid	*Dactylifric acid* [d]	*Trans-*coumaric	Ferulic acid	Sinapic acid	*Eriodictyol* [e]	Rutin	Rosmarinic acid	2-Hydroxy-4-methoxybenzoic acid	Naringenin	Quercetin	Luteolin	Kaempferol	Total Phenolics mg/100 g
Subfamily Arecoideae															
Tribe Areceae															
1	*Howea belmoreana*	0.9 ± 0.1^{hi}	5.3 ± 0.0^{c}	3.2 ± 0.0^{d}	3.6 ± 0.1^{fg}	5.8 ± 0.2^{b}	2.7 ± 0.0^{d}	10.6 ± 1.1^{c}	4.8 ± 0.1^{cde}	2.4 ± 0.2^{d}	5.7 ± 0.2^{b}	3.3 ± 0.3^{bc}	4.1 ± 0.1^{d}	1.8 ± 0.1^{def}	128.5 ± 5.4^{de}
2A	*H. forsteriana*	2.3 ± 0.1^{e}	2.3 ± 0.2^{ef}	1.9 ± 0.1^{ef}	4.9 ± 0.3^{f}	6.1 ± 0.3^{b}	4.8 ± 0.1^{b}	3.2 ± 0.2^{ef}	9.2 ± 0.1^{b}	1.7 ± 0.1^{def}	2.6 ± 0.1^{de}	3.4 ± 0.2^{bc}	6.4 ± 0.1^{b}	14.7 ± 0.9^{a}	122.0 ± 3.8^{e}
2B	*H. forsteriana*	1.8 ± 0.0^{f}	4.1 ± 0.2^{d}	1.1 ± 0.1^{gh}	10.9 ± 1.1^{d}	18.5 ± 1.2^{a}	3.4 ± 0.2^{c}	3.5 ± 0.2^{ef}	2.3 ± 0.2^{fg}	18.6 ± 1.3^{a}	3.4 ± 0.2^{cd}	4.6 ± 0.1^{a}	7.8 ± 0.5^{a}	5.8 ± 0.2^{c}	146.1 ± 5.3^{c}
Tribe Cocoseae															
3	*Butia capitata*	0.7 ± 0.1^{i}	1.1 ± 0.1^{i}	$0.9 \pm 0.0^{g.h}$	33.2 ± 1.0^{b}	1.4 ± 0.1^{e}	6.2 ± 0.1^{a}	42.5 ± 2.7^{a}	3.5 ± 0.1^{def}	0.1 ± 0.0^{f}	2.7 ± 0.3^{de}	2.9 ± 0.3^{cd}	1.4 ± 0.2^{fg}	1.2 ± 0.2^{def}	142.3 ± 6.1^{cd}
4	*Syagrus romanzoffiana*	n.d	2.1 ± 0.5^{e}	0.6 ± 0.0^{h}	30.1 ± 2.5^{c}	2.6 ± 0.3^{cd}	5.2 ± 0.5^{b}	6.9 ± 0.4^{d}	2.9 ± 0.3^{f}	n.d.	17.1 ± 1.3^{a}	3.6 ± 0.3^{b}	1.3 ± 0.3^{fg}	2.2 ± 0.1^{d}	117.9 ± 3.5^{e}
Subfamily Coryphoideae															
Tribe Phoeniceae															
5	*Phoenix dactylifera* var. *Deglet Nour*	24.2 ± 0.7^{a}	6.8 ± 0.2^{b}	6.9 ± 0.2^{c}	9.7 ± 0.3^{d}	3.3 ± 0.1^{c}	2.8 ± 0.1^{d}	1.9 ± 0.1^{f}	2.3 ± 0.2^{fg}	1.7 ± 0.1^{def}	2.5 ± 0.1^{de}	1.2 ± 0.0^{fg}	1.3 ± 0.0^{fg}	0.7 ± 0.0^{f}	169.4 ± 6.0^{b}
6	*P. dactylifera* var. *Medjool*	2.3 ± 0.2^{d}	1.9 ± 0.1^{fg}	3.2 ± 0.1^{d}	58.1 ± 3.2^{a}	5.9 ± 0.3^{b}	0.9 ± 0.0^{gh}	$2.2 \pm 0.2^{f.}$	3.2 ± 0.3^{ef}	0.1 ± 0.0^{f}	0.9 ± 0.0^{g}	0.7 ± 0.0^{g}	1.5 ± 0.0^{fg}	1.4 ± 0.0^{def}	201.8 ± 6.9^{a}
Tribe Sabaleae															

(*continued on next page*)

Table 4 (*continued*)

Code	Species	Syringic acid	*Dactylifric acid* [d]	*Trans*-coumaric	Ferulic acid	Sinapic acid	*Eriodictyol* [e]	Rutin	Rosmarinic acid	2-Hydroxy-4-methoxybenzoic acid	Naringenin	Quercetin	Luteolin	Kaempferol	Total Phenolics mg/100 g
7	*Sabal palmetto*	9.3 ± 0.2^{b}	30.1 ± 2.1^{a}	25.6 ± 1.5^{a}	3.5 ± 0.2^{g}	1.6 ± 0.1^{e}	1.4 ± 0.1^{fg}	$3.\pm0.1^{ef}$	0.5 ± 0.1^{h}	0.7 ± 0.0^{def}	0.6 ± 0.0^{g}	1.3 ± 0.0^{f}	2.0 ± 0.0^{ef}	8.6 ± 1.1^{b}	189.1 ± 3.8^{a}
Tribe Trachycarpeae															
8A	*Chamaerops humilis*	3.2 ± 0.1^{d}	5.3 ± 0.6^{c}	18.6 ± 1.1^{b}	6.6 ± 02^{e}	0.6 ± 0.0^{g}	1.8 ± 0.1^{ef}	29.3 ± 3.1^{b}	30.8 ± 2.6^{a}	14.5 ± 1.3^{b}	1.3 ± 0.1^{fg}	0.9 ± 0.0^{fg}	1.4 ± 0.0^{fg}	6.4 ± 0.3^{c}	178.3 ± 12.0^{b}
8B	*C. humilis*	7.3 ± 0.4^{c}	1.5 ± 0.0^{gh}	1.4 ± 0.1^{fgh}	10.2 ± 0.4^{d}	2.3 ± 0.2^{d}	0.6 ± 0.1^{h}	6.0 ± 0.3^{de}	5.8 ± 0.2^{c}	2.1 ± 0.1^{de}	3.9 ± 0.3^{c}	2.4 ± 0.3^{de}	1.2 ± 0.0^{g}	0.8 ± 0.0^{de}	142.1 ± 7.1^{cd}
9	*Livistona chinensis*	3.1 ± 0.0^{d}	1.0 ± 0.1^{i}	2.2 ± 0.1^{e}	3.0 ± 0.2^{g}	0.2 ± 0.0^{g}	1.6 ± 0.1^{ef}	1.2 ± 0.1^{f}	5.2 ± 0.2^{cd}	0.5 ± 0.0^{ef}	0.3 ± 0.0^{g}	1.2 ± 0.0^{fg}	5 ± 0.4^{c}	0.9 ± 0.0^{ef}	145.5 ± 6.7^{cd}
10	*L. fulva*	1.1 ± 0.1^{gh}	1.2 ± 0.1^{hi}	1.4 ± 0.2^{fg}	4.1 ± 0.5^{fg}	1.3 ± 0.2^{ef}	1.2 ± 0.3^{fg}	2.3 ± 0.1^{f}	1.1 ± 0.0^{gh}	15.6 ± 0.3^{b}	3.0 ± 0.2^{cd}	1.1 ± 0.3^{fg}	2.7 ± 0.2^{e}	1.1 ± 0.0^{def}	135.7 ± 11.9^{c}
11	*L. saribus*	1.3 ± 0.0^{g}	2.3 ± 0.3^{ef}	1.5 ± 0.1^{efg}	1.3 ± 0.1^{h}	0.5 ± 0.0^{g}	1.9 ± 0.2^{e}	3.8 ± 0.3^{def}	0.7 ± 0.1^{gh}	8.1 ± 0.6^{c}	2.3 ± 0.3^{ef}	1.9 ± 0.2^{e}	1.8 ± 0.5^{fg}	1.9 ± 0.2^{de}	64.7 ± 4.6^{f}

[a] Compounds in italics were quantified using other equivalent phenolic standards. [b]Data represent means ± standard deviation of samples analysed in triplicate, and differences in FA amounts were tested according to one-way ANOVA followed by Duncan's test. [c]In a column. means followed by different letter are significantly different at $P < 0.05$. [d]Gallic acid equivalents. n.d.: not detected.

[a] Compounds in italics were quantified using other equivalent phenolic standards. [b]Data represent means ± standard deviation of samples analysed in triplicate, and differences in FA amounts were tested according to one-way ANOVA followed by Duncan's test. [c]In a column. means followed by different letter are significantly different at $P < 0.05$. [d]Syringic acid equivalents. [e]Quercetin equivalents. n.d.: not detected.

considered beneficial for cardiovascular health (Roy et al., 2022). All samples showed TI figures lower than 2.55, and best values were found in *L. saribus* (0.66), followed by Cocoseae, Phoeniceae, Sabaleae, and Areceae species. Overall, according to nutritional lipid quality indices, most evaluated ones for *L. saribus* and *H. belmoreana* can be classified as very suitable to decrease the risk of CVD.

4.4. Phenolic compounds content

Table 4 shows the phenolic profiles of samples quantified by the HPLC-DAD system, while Supplemental file 3 details the compounds identified by LC-MS and the parameters used for both chromatographic systems. The compound for which pure standards were not available were quantified using related compounds (see details in Table 3). Notice that there were some phenolics compounds identified by the m/z ions but lacking quantification, given an absence of specific peaks to be assigned in the HPLC-DAD chromatograms. Table 4 details the occurrence of compound detected by LC-MS in the various taxa.

A low number of Arecaceae species were previously examined for phenolic compounds, and results are summarized in Supplemental file 1. The total phenolics compounds (TPC) content has been previously researched in *B. capitata* as Gallic Acid Equivalents (GAE), ranging from 63.2 to 494 mg GAE/100 g fresh weight (fw), and from 256 to 800 mg/100 g fw when quantified by HPLC. The results of this work (142.3 mg/100 g dw) were slightly lower than these figures. For *S. romanzoffiana* reports on TPC were 197–851 GAE/100 g, and in this work it was 117.9 mg/100 g dw, computed as the sum of individual phenolics. *P. dactylifera* var. *Deglet Nour* has been researched for phenolic compounds, and TPC ranged from 3333.39 μg/100 g dw (HPLC methodology) and 6.73 mg GAE/100 g fw to ~359.46 mg GAE/100 g fw, being the figures obtained here within this range (169.4 mg/100 g dw). Total flavonoids reported for this data variety sum up a quarter approximately of the amount of total phenolics. As for *P. dactylifera* var. *Medjool*, Khallouki et al. (2018) indicated TPC at 61.28 mg/100 g fw, and this amount was lower than that detected for this variety in this research (201.8 mg/100 g dw). As for *S. palmetto*, TPC was detected here at 189.1 mg/100 g dw, which agree with previous results (Supplemental file 1). Finally, for *L. saribus* TPC and TFC were reported by Alia (2017) in quantities as large as to be physiologically unattainable. Overall, the data on total phenolic compounds obtained by HPLC-DAD in Arecaceae species are lower than those reported by other authors using the Folin-Ciocalteau methodology (which provides GAE or similar phenolic equivalents). This fact could be due to that while the Folin-Ciocalteau method informs on total phenolic compounds, while chromatographic methods report only on the concentration of identified compounds. This way, an inspection of the chromatogram depicted in Fig. 1 reveals several unidentified compounds present in the analyzed sample, thus decreasing the total quantified phenolics. Furthermore, it has been argued that the widely used spectrophotometric Folin-Ciocalteu method should be avoided for phenolic compounds quantification, as it leads to an overestimation of actual contents (Martins et al., 2022). In addition, the dissimilarity between data could also depends on several factors, i.e., extraction methodology, maturity, growing conditions, storage variables, fertilizer, soil type, time of collecting, geographic origin, plant chemotypes, and sunlight exposure.

As for phenolic compound profiles, the fruits of the Arecaceae species analyzed in this work have been scarcely reported until now. Some organic acids were also identified and quantified together with phenolic acids, i.e., quinic, chelidonic, and *trans*-aconitic acids, which were present in most samples, especially in *P. dactylifera* var. *Medjool* with 26.4, 48.6, and 7.1 mg/100 g dw, respectively. Among hydroxylated derivatives of benzoic acids, gallic acid reached low values in most taxa; vanillic was found to be high in both *P. dactylifera* varieties (~14 mg); all taxa showed low amounts of protocatechuic acid; salicylic acid was found in high amounts in *C. humilis* (10.4 and 18.0 mg in 8A and 8B samples); syringic acid was especially high in *P. dactylifera* var. *Deglet*

Table 5
Phenolics compounds detected by LC-MS in the fruits of Arecaceae species focused in this work.[a]

Code	*Species*	Resveratrol	Piceatannol	Pinocembrin	Formononetin	Apigenin.[b]	Phloretin	Luteolin.[c]	Epicatechin(−)	Hesperetin	Epigallocatechin(−)	Gallocatechin(−)	Isorhammetin.[d]	Myricetin	Bilobalide	Malvidine	Ferulicacidhexoside	Apigenin − 6 − C − glucoside(vitexin).[e]
Subfamily Arecoideae																		
Tribe Areceae																		
1	*Howea belmoreana*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
2A	*H. forsteriana*	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
2B	*H. forsteriana*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tribe Cocoseae																		
3	*Butia capitata*	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-
4	*Syagrus romanzoffiana*	+	+	-	-	-	+	-	+	+	-	+	-	-	-	-	-	-
Subfamily Coryphoideae																		
Tribe Phoeniceae																		
5	*Phoenix dactylifera* var. *Deglet Nour*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	*P. dactylifera* var. *Medjool*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tribe Sabaleae	-	-	-														
7	*Sabal palmetto*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Tribe Trachycarpeae																		
8A	*Chamaerops humilis*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
8B	*C. humilis*	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-		-
9	*Livistona chinensis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
10	*L. fulva*	-	-	+	-	+	+	+	+	-	+	+	+	+	+	-	-	-
11	*L. saribus*	-	-	-	-	-	+	-	+	-	+	-	+	+	+	+	-	+

[a] Other isomers related to detailed compounds are identified by a superscript letter.
[b] Baicalein.
[c] Fisetin.
[d] Tamarixetin.
[e] Apigenin-6-C-glucoside (isovitexin).

Nour (24.2 mg); 4-hydroxybenzoic was high in *C. humilis* 8B (15.1 mg); and 2-hydroxy-4-methoxybenzoic acid highlights in *H. forsteriana* 2B (18.6 mg). Concerning the phenylpropanoic acid derivative detected (D-L p-hydroxyphenyllactic), it reached low amounts in all samples. As for cinnamic acid derivatives, 2,4-dihydroxycinnamic and 3,4-dihydroxycinnamic acids were detected in all cases at low amounts; chlorogenic acid was present in most samples and reached the highest value in *C. humilis* 8B (32 mg); caffeic acid was present in most samples at low amounts; sinapic acid highlights in *H. forsteriana* 2B (18.5 mg); rosmarinic acid stood out in *C. humilis* 8A (30.8 mg); dactylifric and *trans*-coumaric acids highlight in *S. palmetto* (30.1 and 25.6 mg); and ferulic acid was found in high amounts in *P. dactylifera* var. *Medjool* (58.1 mg) as well as in both Cocoseae species (~30 mg).

A wide variety of flavonoids were identified by LC-MS and HPLC-DAD, and the latter system allowed quantifying (−)-catechin, eriodictyol, rutin, naringenin, quercetin, luteolin, and kaempferol. These compounds were present in most samples at low amounts, but rutin reached high amounts in *B. capitata* (42.5 mg) and *C. humilis* 8A (29.3 mg). This is an interesting finding, given that rutin shows anticancer properties, which are mediated through the induction of apoptosis, the suppression of cell proliferation, and the hindering of metastasis (Farha et al., 2022).

Total phenolics content, calculated as the sum of the various quantified phenolics, ranged from 64.7 (*L. saribus*) to 201.8 mg/100 g dw (*P. dactylifera* var. *Medjool*).

The occurrence of other phenolics and related compounds detected by the LC-MS system is reported on Table 5. Most of these compounds occur occasionally in some taxa, but (−)-epicatechin was found in most samples of Cocoseae and Trachycarpeae species, while isorhamnetin-3-*O*-glucoside was present in all samples except in *P. dactylifera* var. *Medjool* and L. *fulva*. On the other hand, *L. fulva* and *L. saribus* contained a great variety of all these compounds. Among the 28 compounds detected by LC-MS, *L. saribus* and *L. fulva* contained 19 and17, respectively. Interestingly, most of the compounds listed in this table were detected only in the two last species.

Relevant results for phenolics reported for Arecaceae fruits in previous works are exposed in Supplemental file 1. Hong et al. (2006) reported for *P. dactylifera* var. *Deglet Nour* harvested at the "khalal" stage of maturity, which is a polyphenol-rich edible stage of date palm, procyanidin oligomers and thirteen flavonoid glycosides of luteolin, quercetin, and apigenin. which were not found in this study. This can be due to that the fruits analyzed in this work were at the "tamer" stage, which is the fully ripe stage. Mansouri et al. (2005) reported for this date palm variety ferulic, *p*-coumaric, and sinapic acids, as well as 5-*O*-caffeoyl-shikimic acid (dactylifric acid) derivatives, and flavonoid glycosides, being all these compounds detected for this date palm variety in this study. Saafi et al. (2011) reported some phenolics for *P. dactylifera* var. *Deglet Nour*, which are among the compounds quantified here for this taxon. Kchaou et al. (2016) quantified some phenolics in this date palm, which agree with the compounds detected here. *P. dactylifera* var. *Medjool* has also been scrutinized for phenolics: Abu-Reidah et al. (2017) detailed the occurrence of flavonoid-*O*-glycosides and ferulic acid, which are included among the compounds detected here; and Khallouki et al. (2018) reported chelidonic acid and several caffeoyl shikimic acid derivatives and phenolics glycosides, which are among the compounds quantified in this work. Concerning *C. humilis*, Bouhafsoun et al. (2018), Delle Monache et al. (1972), and Cadi et al. (2021) reported a scarce number of phenolic compounds, and all of them were detected in this work. As for *L. chinensis*, several studies have been performed on its phenolics composition. Such interest is due to that its fruits are used as an anticancer agent in traditional Chinese medicine (Singh & Kaur, 2008). The compounds detected by Yuan et al. (2009) and Wu et al. (2019) included flavonoid as catechin, flavonoid glycosides and phenolic acids, in line with the compounds reported here. Several compounds described by Zeng et al. (2012) in *L. chinensis* agree with those detailed here: 4-hydroxybenzyaldehyde, hydroxybenzoic acids, and several caffeoylquinic acid derivatives, e.g., chlorogenic acid (3-*O*-caffeoylquinic acid). But additionally, these authors detected some minor phenolics through fractionation of extracts by chromatographic processes (see Supplemental file 1), which were not identified in this work. Finally, Yao et al. (2012) reported for *L. chinensis* isorhamnetin-3-*O*-glucoside, orientin, isorientin, vitexin, and isovitexin, which are compounds detailed for the species belonging to this genus in Table 5.

Among the analyzed species, highlights *Livistona* ones, because their richness in flavonoid glycosides, for which a wide spectrum of biological activities has been documented, including antioxidant, immunomodulatory, and anticancer ones (Kim et al., 2015). Thus, their use in phytotherapy is fully justified given the great variety of phenolic glycosides they contain.

4.5. Antiproliferative activity of the water: methanol extracts of Arecaceae fruits on HT-29 cancer cells

Fig. 2A shows the results of the MTT assay on HT-29 cells for all assayed extracts. After 48 and 72 h of treatment it was noted concentration- and time-dependent inhibitory effects. Fig. 2B shows the doses of extracts that inhibited the cell growth by 50% (GI_{50}) below 300 μg/mL as well as those of some pure phenolic compounds. After 72 h culture, cell growth inhibition was exercised much better by *L. fulva* and *L. chinensis* (GI_{50} of 32 and 70 μg/mL). The extracts of *L. chinensis* fruits develop *in vitro* antiangiogenic, antiproliferative, and haemolytic activities, which are related to the phenolics content, which exert astringent and membrane damaging activities (Singh & Kaur, 2008). Flavonoids-containing fruits from *L. chinensis*, including flavonoid glycosides, have been reported as ameliorative of lipopolysaccharide/D-galactosamine-induced acute liver injury by inhibiting oxidative stress and inflammation (Wu et al., 2019). Other phenolics from *L. chinensis* fruits were isolated by Zeng et al. (2012) and characterized as cytotoxic for several cancer cells lines, although these were not checked in HT-29 cells. Later, it was reported autophagy-related apoptosis in hepatocellular carcinoma cells mediated by some phenolics isolated from *L. chinensis* fruits (Cheng et al., 2016). Either way, high antitumor activity for the crude extract of *L. chinensis* fruits was found in this work, instead for isolated pure phenolics. Need to be considered that most studies on the antitumor activity of *L. chinensis* have been accomplished using seeds or root extracts and, thus, research on the activity of *L. chinensis* fruits on cancer cells still are in their infancy. Interestingly, *L. fulva* demonstrated higher antitumor potency than *L. chinensis*. Data presented in Tables 3 and 4 showed a very high diversity of phenolics and organic acids in the pulp of this fruit: it contains high percentages of chelidonic, *trans*-aconitic, and 2-hydroxy-4-methoxybenzoic acids. Moreover, data from Table 4 indicated that the pulp of this fruit is very rich in other phenolics as phloretin, (−)-epicatechin, myricetin, bilobalide, phloridzin, procyanidin B1, pelargonidin and kaempferol-3-*O*-rutinoside. Thus, probably the high antitumor activity showed by the extract of this fruit was due to a synergy between a wide variety of phenolic compounds.

Until now, the antitumor activity of extracts of Arecaceae fruits was focused mainly on *P. dactylifera* varieties. The anticancer effects of the extract of *P. dactylifera* var. *Ajwa* were evaluated on human breast adenocarcinoma (MCF7), prostate cancer cell line (PC3), and human squamous cell carcinoma cell line (HSC-2) with positive results. The extracts demonstrated to exert significant dose-dependent inhibitions of cell proliferation measured by the MTT test, and showed also apoptotic activity (Khan et al., 2016; Mirza et al., 2018; Shahbaz et al., 2022). However, other authors found low activity of the *P. dactylifera* extracts on cancer cell proliferation: Zhang et al. (2017) assayed the water and methanolic extracts of 29 varieties of such fruit on six human tumor cell lines, which at 250 μg/mL exhibited moderate activity, and authors concluded that varietal difference is not a significant factor when compared for health-beneficial effects. Kchaou et al. (2016) checked

second-grade date acetone/H_2O extracts from three Tunisian *P. dactylifera* varieties, including Deglet Nour, on Hela cancer cells. The authors indicated that the tested extracts induced a significant decrease in human cells growth in a dose-dependent manner, as revealed by the MTT test. A relatively high antitumor activity for *P. dactylifera* var. *Medjool* was found in this work (GI_{50} at 100 μg/mL), and this could be attributed to its high content in ferulic acid (Table 3), as explained below. Concerning *C. humilis*, their polysaccharides have been tested against HepG2 and MCF-7 cancer cell lines, and an IC_{50} of 38 and 64.4 were reported (Dawood et al., 2020).

The antiproliferative activity against HT-29 cells of compounds found at high concentrations in some Arecaceae extracts was also checked in this work: 3,4-dihydroxycinnamic acid (distributed in most samples), gallic acid (high in *L. fulva*), ferulic acid (high in several samples), and rosmarinic acid (high in *C. humilis*), which showed GI_{50} values of 80, 65, 46, and 40 μg/mL, respectively. Interestingly, the antiproliferative activity of the extracts of *L. fulva* was higher than that of pure phenolics, which was probably due to the concurrence in this extract of several compounds performing a synergistic action.

To have a better understanding of the composition of the extract that caused the inhibition of the proliferation of HT-29 cells, ^1H NMR and ^{13}C NMR spectra of the MeOH–H_2O extracts of highly bioactive extracts were carried out, i.e., those of *L. fulva*, *H. forsteriana*, *P. dactylifera* var. *Medjool*, *C. humilis*, *L. chinensis*, *B. capitata*, and *S. palmetto* (see Supplemental file 4). The presence of phenolic compounds signals (8.0–6.2 μg/mL) and carbohydrates (4.5–3.3 μg/mL) can be easily deduced in most of them. On the other hand, the presence of amino acids can be ruled out due to the absence of their characteristic signals in the 3.2–0.8 μg/mL range. Such activity against HT-29 cells exercised by the phenolic fractions is interesting since these cells have been typified as unresponsive to phenolic compounds (Gorlach et al., 2011). Given that some polysaccharides from Arecaceae species display antitumor activity (Dawood et al., 2020), it cannot be ruled out that the phenolics-containing extracts acted synergically with some polysaccharides, and the antitumor activity noted for the various extracts against HT-29 cells was due to such synergy.

To take advantage of this potential antitumor activity, the direct consumption of the fruit is recommended. In the event that the oil of these fruits was objectified, it would be advisable to carry out the extraction of different oils of Arecaceae fruits by cold pressure or else aqueous extraction, since the phenolic compounds would not be extracted in the oil fractions. It is well known that the oils extracted using organic solvents, e.g., *n*-hexane, are not expected to contain high amounts of phenolic compounds, due to their high polarity.

5. Conclusions

Several understudied Arecaceae fruits analyzed in this work, as those of *Howea* and *Livistona* species, have been revealed to be good sources of PUFAs, while they contain relative high amounts of FAs. The Cocoseae species analyzed here highlight due to their high MCSFAs content, although *S. romanzoffiana* showed also a high PUFA percentage and a suitable *n*-6/*n*-3 PUFA ratio, while *B. capitata* demonstrated to be a good source of LaA. Total phenolics content reached high amounts in some taxa, as in *P. dactylifera* var. *Medjool*. Besides phenolic acids, a wide variety of flavonoids were identified, especially in *L. saribus* and *L. fulva*. The phenolic extracts of most fruits showed dose- and time-dependent inhibition exercised on the human colorectal cancer cell line HT-29, being noticeable the high cell growth inhibition exercised by *L. fulva* and *L. chinensis*. Overall, given their richness in bioactive compounds and antitumor activities, all fruits analyzed here and especially the nutritionally novel ones, could be marketed as functional foods or as valuable ingredients for the food industry to make different smoothie fruits. Further research involving purification of the various phenolic fractions from Arecaceae extracts and one-to-one antitumor tests against several cancer cell lines could evidence more clearly their *in vitro* antiproliferative activity. Other actions to be developed should focus on revealing changes in the concentrations of bioactive compounds and/or bioactivity in Arecaceae fruits for multi-year periods.

CRediT authorship contribution statement

Abdallah Lahlou: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Tarik Chileh-Chelh:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft. **Svetlana Lyashenko:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization. **Miguel Ángel Rincón-Cervera:** Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Software, Validation, Visualization. **Ignacio Rodríguez-García:** Formal analysis, Methodology, Visualization, Writing – original draft, Validation. **Rosalía López-Ruiz:** Formal analysis, Methodology, Visualization, Writing – original draft, Validation. **Miguel Urrestarazu:** Conceptualization, Formal analysis, Visualization, Writing – original draft, Software, Visualization. **José Luis Guil-Guerrero:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing, All authors have read and approved the final version of this manuscript.

Declaration of competing interest

The authors declare no conflict of interest.

Data availability

I have shared the link to my data at the Attach File step

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Appendix A. Supplementary data

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