SUPPLEMENTARY MATERIAL

Article Title: Antifungal activity of mango peel and seed extracts against clinically pathogenic and food spoilage yeasts

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Abstract

The antioxidant and antifungal (antiyeast) properties of mango (*Mangifera indica*) peel and seed byproducts were investigated. Nine extracts were obtained using three cultivars and two extraction methods. Significant differences between cultivars and extraction methods were detected in their bioactive compounds and antioxidant activity. The antifungal property was determined using agar diffusion and broth micro-dilution assays against eighteen yeast species of the genera *Candida*, *Dekkera*, *Hanseniaspora*, *Lodderomyces*, *Metschnikowia*, *Pichia*, *Schizosaccharomyces*, *Saccharomyces* and *Zygosaccharomyces*. All mango extracts showed antifungal activity. The minimum inhibitory concentration (MIC) and the minimum fungicidal concentration (MFC) values were lower for seed than for peel extracts. MICs and MFCs ranged from values <0.1 to 5 and 5 to >30 mgGAE/mL, respectively. The multivariate analysis showed a relationship between antifungal activity, the capacity to inhibit lipid peroxidation and total phenol content. These properties were associated with high levels of proanthocyanidins, gallates and galotannins in the extracts.

Keywords: Antifungal; Mango byproducts; *Mangifera indica*; Phenolic Compound; Yeast.

1. Experimental

1.1. Plant collection and identification

Fruits of Keitt, Sensation and Gomera-3 cultivars (germplasm accessions numbers: NC086003, NC086035, NC085992 ESP048, respectively) of mango (*Mangifera indica*) were collected from the fields of the mango collection (UTM 28R 364451.00 m E 3133070.93 m N; 114 m.a.s.l.) of the Instituto Canario de Investigaciones Agrarias – ICIA (Tenerife, Canary Islands, Spain). The plant material was identified and authenticated in the Department of Tropical Fruit Crops, according to the morphological keys published by Coello Torres et al. (1997). The fruits (20–25 pieces of each cultivar obtained from different trees) were harvested at physiological maturity stage (mature-green) and allowed to ripen (full-ripeness or consumption stage) at 18°C and 80-90% relative humidity. The consumption stage of each mango cultivar was characterized by colour, texture, total soluble solids, pH and titratable acidity (Dorta et al. 2011). After characterisation, the peel and seed (shell of fibrous endocarp, testa and embryo) was manually separated (peel:mango ratio, $31 \pm 1\%$; seed:mango ratio, $4.2 \pm 2.1\%$), cut into small pieces (0.5 x 1 cm) and freeze-dried at -40°C in a vacuum (50 mPa) for 5 days. The dried mango peels and seeds were ground to a fine powder (particle size between 355-500 µm). The dried mango peel and seed powder were stored at -20°C until the extractions were performed.

1.2. Chemicals and preparation of mango extracts

HPLC-grade ethanol and acetone were purchased from Scharlau Chemie (Barcelona, Spain). Deionised water with 18 MΩ cm resistivity, purified with a Milli-Q system (Millipore, Bedford, USA) was used. All other reagents used were of analytical grade.

The extraction conditions were previously optimised in terms of maximum extraction of polyphenol content and antioxidant capacity (Dorta et al. 2013a; b). A microwave-assisted extraction (ETHOS 1, Milestone SRL, Sorisole, Italy) at 500 W for 60 min was used. Two types of extractions (A and B) from the peel were performed. These extracts were obtained with ethanol:water (1:1, v:v) at 75°C and a weight-to-solvent volume of 1:50 (w:v) (called type extraction A) or 1:10 (w:v) (type extraction B). On the other hand, the mango seed extraction was performed with acetone:water (1:1, v:v) at 50°C and a weight-to-solvent volume of 1:30 (w:v). After each extraction (seed and peel), the solvent was separated by centrifugation (525xg at 4°C for 20 min), and the supernatant preserved. The pellets were re-extracted twice more, and the supernatants were combined and stored at -80°C until use. The obtained extracts were evaporated to eliminate the organic solvent in a vacuum Heto VR-1 evaporator (Allerod, Denmark) at 40°C. Each extraction process was performed at least in triplicate. Finally, a total of nine byproduct extracts were obtained: KPA (peel from Keitt cultivar with extraction type A), KPB (Keitt cv. peel, extraction B), SPA (Sensation cv. peel, extraction A), SPB (Sensation cv. peel, extraction B), GPA (Gomera-3 cv. peel, extraction A), GPB (Gomera-3 cv. peel, extraction B), KS (Keitt cv. seed), SS (Sensation cv. seed) and GS (Gomera-3 cv. seed).

1.3. Bioactive compound content

All measurements to quantify bioactive compounds were conducted using a Shimadzu UV-visible 160A double-beam spectrophotometer (Kyoto, Japan) equipped with a Hellma (Jamaica, USA) cell (path length 10⁻² cm).

1.3.1. Total phenol content

Total phenolic compound content was estimated by mixing 200 µL of deionised water, 50 µL of the extracts diluted and 50 µL of Folin-Ciocalteu reagent (González-Montelongo et al. 2010). After 6 min, 500 µL of 7% sodium carbonate solution were added to the mixture, which was adjusted to 1.3 mL with deionised water and allowed to stand at room temperature for 60 min. After, the absorbance intensity at 765 nm was read.

A calibration curve employing gallic acid (ranging from 15 to 250 mg/L) was carried out (r^2 0.885-0.992), and the Folin-Ciocalteu index of the mango byproducts was expressed as milligrams of gallic acid equivalents (GAE) per litre of mango peel or seed extract. Additionally, the values were expressed as GAE (g) per 100 g of mango peel or seed on a dry matter basis (DW).

1.3.2. Proanthocyanidins content

Proanthocyanidins content (condensed tannins) was determined throughout an assay based on their oxidative depolymerisation in butanol-HCl (95:5 v:v, solvent:extract ratio, 5:1) (FAO/IAEA 2000) in the presence of iron reagent (2% ferric ammonium sulphate in 2 N HCl). The butanol-HCl-iron mixtures were incubated at 97°C for 60 min, and the proanthocyanidin content was measured at 550 nm. Condensed tannins were expressed as grams leucoanthocyanidin equivalents (LEs)/100 g DW mango seed or peel (Dorta et al. 2011).

1.3.3. Tannin content

Tannin content was determined using the Folin-Ciocalteu method (González-Montelongo et al. 2010) assisted with the use of polyvinylpyrrolidone (PVPP, Sigma) (FAO/IAEA 2000) to precipitate tannins. PVPP was added to the extracts (PVPP:phenolic compound ratio: 100:1 w:w), and the pH was adjusted at 3.0. The absorbance intensity of supernatants, which only contained non-tannin compounds, was assessed at 765 nm. Tannins were quantified by calculating the difference between the total phenolic compounds and the phenols in the supernatant and expressed as grams of tannic acid equivalents TAEs/100 g DW mango peel or seed.

1.4. Antioxidant activity of mango peel and seed

1.4.1. DPPH• Scavenging Activity

The capacity to scavenge the 2,2-diphenyl-1-picrylhydrazyl DPPH• (Sigma) radical was performed according to a slightly modified method described by Brand-Williams et al. (1995) at 515 nm after 15 min. The results were expressed as grams of TE (Trolox equivalent antioxidant capacity)/100 g DW mango seed or peel (González-Montelongo et al. 2010).

1.4.2. β -carotene bleaching method

The capacity to inhibit lipid peroxidation was determined by the β -carotene bleaching method, which is based on the capacity of antioxidants to decrease oxidative losses of β -carotene in a β -carotene/linoleic acid system (González-Montelongo et al. 2010). Oxygenated deionised water and incubation was used at 50°C for 60 min to induce autoxidation and was measured at 470 nm after incubation for 210 min. The antioxidant activity was expressed as the antioxidant activity coefficient (AAC). The repeatability standard deviation of the procedure was always < 10%.

1.5. Antifungal activity of mango peel and seed

1.5.1. Yeast strains and culture conditions

Antifungal activity was checked against 18 yeast species: *Candida bracarensis* (CECT 12000), *C. glabrata* (ATCC 36583), *C. nivariensis* (CBS 9983), *C. parapsilopsis* (ATCC 22019), *Dekkera anomala* (ATCC 58985), *D. bruxellensis* (ATCC 36234), *Hanseniaspora uvarum* (CECT 11105), *Lodderomyces elongisporus* (ATCC 11503), *Metschnikowia pulcherrima* (CECT 11602), *Pichia fermentans* (ATCC 10651), *P. kluyveri* (CECT 11023), *P. ohmeri* (ATCC 46053), *Schizosaccharomyces japonicus* (ATCC 10660), *Saccharomycodes ludwigii* (ATCC 11313), *Zygosaccharomyces bailii* (CECT 11997), *Z. bisporus* (ATCC 52405), *Z. microellipsoides* (ATCC 10605) and *Z. rouxii* (ATCC 2623). The yeasts were obtained from the American Type Culture Collection (ATCC) (Manassas, USA), the Spanish Type Culture Collection (CECT) (Valencia, Spain) or the Centraalbureau voor Schimmelcultures (CBS) (Utrecht, The Netherlands) and were maintained in 30% w/v glycerol at -80°C until use. For experiments, all the yeast strains were grown separately on Yeast Extract Peptone Dextrose (YPD) agar [5 g/L yeast extract (Pronadisa), 3 g/L peptone (Cultimed, Panreac) and 20 g/L dextrose (VWR BDH Prolabo)] at 28°C for 24-48 h, to ensure optimal growth conditions and purity. The antifungal activity of the mango peel and seed extracts was determined using two different bioassays: agar diffusion and micro-dilution.

1.5.2. Agar diffusion assay

Each yeast strain was grown at an optical density at wavelength 600 nm (OD_{600}) of 1 in YPD broth with agitation (250 rpm) at 28°C. The cell suspension was mixed with melted warm YPD 1% agar medium at a final OD_{600} of 0.033 and poured into the sterile Petri plates. Sixty microlitres of each extract was added to 8-mm-diameter wells dug in YPD 1% agar medium plates. After 2 h at 4°C, the plates were incubated at 28°C for 24-48 h. The total inhibition zone diameter formed around the wells was measured in millimetres (mm) and results were expressed by subtracting the negative control. All assays were performed in triplicate. Amphotericin B and cycloheximide were used as positive controls. Sterilized distilled water was used as negative control.

1.5.3. Micro-dilution antifungal assay

The extracts were resuspended to a concentration of 0.1 to 30 mg GAE/mL with sterile Milli-Q water. The minimum inhibitory concentrations (MIC) of the extracts were determined by a serial dilution method in 96-well sterile microtitre plates. Each yeast strain was grown up to exponential phase ($OD_{600}=0.5$) in YPD broth with agitation at 28°C. The cells suspensions were diluted in sterile YPD concentrate (3X) at an OD_{600} of 0.1 and then were mixed with the different extracts. Briefly, 44 μ L of cell suspension ($OD_{600}=0.1$) and 66 μ L of extract were added in each well. The final inoculum contained approximately 2×10^5 CFU/mL in a final volume of 110 μ L/well. The microtitre plates were mixed and incubated under aerobic conditions at 28°C for 24 to 48 h and then examined using a binocular microscope and spectrophotometrically. A positive control (containing yeasts without extracts) and negative control (containing extracts without yeast) were included on each microplate. The MIC was determined as the lowest concentration of extracts inhibiting the visual growth of the yeast culture on the microplate. For the results of the spectrophotometric analysis were determined by using a microdilution automatic reader at a wavelength of 600 nm, and each test sample was considered negative when the yeast growth displayed 90% inhibition compared with the positive control (National Committee for Clinical Laboratory Standards 2002). In addition, the minimum fungicidal concentration (MFC) was determined via serial subcultivation of 10 μ L aliquots of each well in microtitre plates containing 90 μ L of fresh YPD broth per well and further incubation for 24 to 48 h at 28°C. The lowest concentration with no visible growth (at the binocular microscope) and the lowest determined by spectrophotometric analysis was defined as the MFC. Each sample was tested in triplicate in separate experiments.

1.6. Statistical analysis

The data are presented as mean values $\pm$ standard deviation (SD) on three replicate experiments. The analysis of variance (ANOVA) was carried out using the statistical package Statistix 9.0 (Statistix 9, Tallahassee FL, USA) and means were compared using the Tuckey test to determine their statistical significance. Factorial analyses of variance were used to test for differences between type extraction process (A and B) and cultivars. Any probability less than or equal to 0.05 was considered significant.

In addition a principal component analysis (PCA) was performed using SPSS software (versions 19, SPSS Inc, IL, USA). PCA was used to determine the relationship of the mango extracts antifungal activity (halo inhibition zone) with the bioactive compounds content (total phenols, proanthocyanidins and tannins), antioxidant activity (β -carotene and DPPH[•]) and phenolic compounds [determined in a previous work (Dorta et al. 2014)].

Table S1. A: Bioactive compounds and antioxidants activity of mango seed and peel extracts. **B:** The minimum inhibitory and fungicidal concentrations (MIC and MFC) of mango peel and seed extracts against different yeasts.

A	Bioactive and antioxidant activity	Peel extracts						Seed extracts		
		Extraction process A			Extraction process B					
		Gomera-3	Sensation	Keitt	Gomera-3	Sensation	Keitt	Gomera-3	Sensation	Keitt
Total phenols (g GAE/100 g)		16±1 a/A	18±1 a/A	13±3 a/A	13±1 a/A	13±3 a/A	11±1 a/A	15±0.7 A	15±1.2 A	8±0.1 B
Tannins (g TAE/100 g)		16±1 a/A	17±2 a/A	12±3 a/A	12±1 a/A	12±3 a/A	11±1 a/A	14.9±0.6 A	14.8±1.1 A	7.8±0.3 B
Proantocyanidins (mg LEs/100 g)		0.18±0.009 b/A	0.16±0.013 b/A	0.08±0.006 b/B	0.46±0.045 a/A	0.48±0.042 a/A	0.24±0.013 a/B	0.59±0.04 B	0.60±0.06 B	0.80±0.09 A
DPPH* (g TE/100 g)		41±8 a/A	43±8 a/A	43±3 a/A	41±9 a/A	47±2 a/A	47±1 a/A	44±5 A	38±4 A	22±3 B
β-carotene bleaching (AAC)		398±6 b/B	443±12 b/A	361±8 b/C	555±24 a/B	632±28 a/A	587±10 a/B	589±5 A	575±5 A	469±6 B

B Yeasts species		Antifungal activity of mango byproducts extracts (mg GAE/mL)								
<i>Candida</i>	MIC	1	1	0.5	1	1	1	0.5	0.5	1
<i>C. braccarensis</i> CECT 12000	MFC	10	5	5	10	5	5	5	5	5
<i>C. glabrata</i> ATCC 36583	MIC	1	1	1	1	1	1	0.5	0.5	1
	MFC	10	10	10	10	10	10	5	5	>30
<i>C. nivariensis</i> CBS 9983	MIC	0.5	0.5	0.5	0.5	0.1	0.5	0.1	0.1	0.5
	MFC	10	10	10	10	10	10	5	5	10
<i>C. parapsilosis</i> ATCC 22019	MIC	1	1	1	1	1	1	0.5	0.5	5
	MFC	10	10	5	10	5	5	>30	>30	>30
<i>Dekkera</i>	MIC	1	0.5	1	1	0.5	1	0.5	0.5	0.5
<i>D. anomala</i> ATCC 58985	MFC	5	5	5	5	5	5	5	5	5
<i>D. bruxellensis</i> ATCC 36234	MIC	5	5	5	5	5	5	0.5	0.5	5
	MFC	>30	>30	>30	>30	>30	>30	>30	>30	>30
<i>Hanseniaspora</i>	MIC	0.5	<0.1	<0.1	0.1	<0.1	<0.1	0.1	0.1	0.1
<i>H. uvarum</i> CECT 11105	MFC	15	10	10	10	10	10	5	5	10
<i>Lodderomyces</i>	MIC	5	5	5	5	5	5	5	5	5
<i>L. elongisporus</i> ATCC 11503	MFC	10	10	10	10	10	10	10	10	10
<i>Metschnikowia</i>	MIC	0.1	0.5	<0.1	<0.1	0.5	0.5	<0.1	<0.1	<0.1
<i>M. pulcherrima</i> CECT 11202	MFC	5	5	5	5	5	5	5	5	5
<i>Pichia</i>	MIC	5	5	1	5	1	1	1	1	5
<i>P. fermentans</i> ATCC 10651	MFC	10	10	10	10	10	10	10	10	10
<i>P. kluyveri</i> CECT 11023	MIC	1	1	1	1	1	1	0.5	1	1
	MFC	10	10	5	10	5	5	10	10	15
<i>P. ohmeri</i> ATCC 46053	MIC	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	MFC	5	5	5	5	5	5	5	5	5
<i>Saccharomycodes</i>	MIC	5	5	5	5	5	5	1	0.5	0.5
<i>S. ludwigii</i> ATCC 11313	MFC	10	10	5	10	10	10	10	10	10
<i>Schizosaccharomyces</i>	MIC	0.5	<0.1	1	<0.1	0.5	1	<0.1	<0.1	<0.1
<i>S. japonicus</i> ATCC 10660	MFC	10	10	10	10	10	10	5	5	5
<i>Zygosaccharomyces</i>	MIC	1	1	1	1	1	1	0.5	0.5	0.5
<i>Z. bailii</i> CECT 11997	MFC	5	5	5	5	5	5	5	5	5
<i>Z. bisporus</i> ATCC 52405	MIC	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
	MFC	10	10	10	10	10	10	5	5	10
<i>Z. microellipsoides</i> ATCC 10605	MIC	1	1	1	1	1	1	0.5	0.5	0.5
	MFC	5	10	5	10	10	5	5	5	10
<i>Z. rouxii</i> ATCC 2623	MIC	1	1	5	1	1	5	1	1	5
	MFC	10	10	10	10	10	10	15	15	15

Different lower or upper case letters (Table A) denote significant differences ($p < 0.05$) between extraction process (a-c) or between cultivars (A-C) used to obtain the extracts from peel or seed. GAE: Gallic acid equivalents. TAE: Tannic acid equivalents. LEs: Leucoanthocyanidin equivalents. TE: Trolox equivalent antioxidant capacity. AAC: antioxidant activity coefficient.

Table S2. Analysis of variance of the antifungal activity of mango peel extracts as determined by agar diffusion assay.

Yeasts species	Inhibition zone diameter (mm) ^a					Pvalue		
	Extraction process (E)		Cultivars (C)					
	A 66.6 ^b	B 252	Gomera-3 167	Sensation 169	Keitt 142	E	C	ExC
<i>Candida bracarensis</i> CECT 12000	7.5 A	7.5 A	7.8 a	7.8 a	6.3 a	0.4433	0.1551	0.4558
<i>Candida glabrata</i> ATCC 36583	8.7 B	12.0 A	10.0 ab	11.7 a	9.2 b	0.0007	0.0148	0.2569
<i>Candida parapsilosis</i> ATCC 22019	9.7 B	13.3 A	12.0 a	11.2 a	11.2 a	0.0001	0.0525	0.5724
<i>Dekkera anomala</i> ATCC 58985	5.2 B	8.7 A	7.3 a	7.3 a	6.3 a	0.0042	0.464	1.0000
<i>Dekkera bruxellensis</i> ATCC 36234	6.0 B	9.5 A	8.5 a	7.8 a	7.0a	0.0003	0.0722	0.6249
<i>Hanseniaspora uvarum</i> CECT 11105	6.5 B	12.3 A	10.0 a	10.3 a	8.0 b	0.0001	0.0112	0.0816
<i>Lodderomyces elongisporus</i> ATCC 11503	7.7 B	12.8 A	10.8 a	10.0 a	10.0 a	0.0001	0.1644	0.2227
<i>Metschnikowia pulcherrima</i> CECT 11202	6.0 B	12.0 A	9.0 a	9.7a	8.3 a	0.0002	0.2319	0.3005
<i>Pichia fermentans</i> ATCC 10651	6.7 B	10.2 A	8.8 a	8.3 a	8.3 a	0.0007	0.6404	0.316
<i>Pichia kluyveri</i> CECT 11023	6.8 B	10.7 A	9.0 a	8.8 a	8.5 a	0.0005	0.7107	0.8877
<i>Saccharomycodes ludwigii</i> ATCC 11313	8.5 B	11.3 A	9.5 a	10.0 a	10.3 a	0.0277	0.8034	0.6755
<i>Schizosaccharomyces japonicus</i> ATCC 10660	3.2 B	4.8 A	4.0 ab	3.5 b	4.5 a	0.0005	0.0313	0.1768
<i>Zygosaccharomyces bisporus</i> ATCC 52405	7.3 B	11.2 A	9.5 a	9.3 a	9.0 a	0.0006	0.7313	0.508
<i>Zygosaccharomyces rouxii</i> ATCC 2623	6.7 B	10.3 A	9.5 a	8.3 a	7.8 a	0.0009	0.0896	0.903
Extraction process x Cultivar (mm-inhibition diameter) ^a								
Extraction process A			Extraction process B				Pvalue (ExC)	
Gomera-3 72 ^b	Sensation 74	Keitt 54	Gomera-3 262	Sensation 264	Keitt 230			
<i>Candida nivariensis</i> CBS 9983	7.5 c	7.5 c	7.5 c	10.5 b	12.0 a	11.5 ab	0.0355	
<i>Pichia ohmeri</i> ATCC 46053	4.5 c	5.0 c	5.0 c	10.5 ab	11.5 a	8.5 b	0.0411	
<i>Zygosaccharomyces baillii</i> CECT 11997	5.5 cd	5.0 d	4.5 d	9.0 ab	11.0 a	7.5 bc	0.0215	
<i>Zygosaccharomyces microellipsoides</i> ATCC 10605	7.0 b	5.5 bc	4.5 c	11.0 a	11.5 a	11.0 a	0.0446	

^a data shown the mm of clear zone of test, subtracted from a negative control. ^b values are expressed as means of mg GAE/mL. Different letters indicate that there are statistically significant differences between different extraction process (E), cultivars (C) or extraction process x cultivar (ExC) in each yeast species (Tuckey, $p < 0.05$).

Table S3. Analysis of variance of the antifungal activity of mango seed extracts as determined by agar diffusion assay.

Yeasts species	Inhibition zone diameter(mm) ^a			Pvalue
	Gomera-3 196 ^b	Sensation 190	Keitt 106	
<i>Candida bracarensis</i> CECT 12000	6.5 a	6.0 a	6.0 a	0.9761
<i>Candida glabrata</i> ATCC 36583	9.0 a	8.5 a	7.5 a	0.0860
<i>Candida nivariensis</i> CBS 9983	11.5 ab	14.0 a	11.0 b	0.0099
<i>Candida parapsilosis</i> ATCC 22019	12.0 a	12.5 a	11.5 a	0.3536
<i>Dekkera anomala</i> ATCC 58985	6.5 a	7.0 a	5.0 b	0.0333
<i>Dekkera bruxellensis</i> ATCC 36234	8.5 a	10.5 a	9.0 a	0.3921
<i>Hanseniaspora uvarum</i> CECT 11105	11.5 a	12.5 a	8.0 b	0.0408
<i>Lodderomyces elongisporus</i> ATCC 11503	12.0 a	11.5 a	10.0 a	0.2213
<i>Metschnikowia pulcherrima</i> CECT 11202	9.0 a	9.5 a	7.5 a	0.0812
<i>Pichia fermentans</i> ATCC 10651	10.0 a	10.0 a	6.5 b	0.0051
<i>Pichia kluyveri</i> CECT 11023	10.0 a	9.0 a	7.5 b	0.0198
<i>Pichia ohmeri</i> ATCC 46053	8.0 a	7.5 a	6.0 a	0.2213
<i>Saccharomycodes ludwigii</i> ATCC 11313	10.0 a	11.0 a	10.0 a	0.4648
<i>Schizosaccharomyces japonicus</i> ATCC 10660	5.5 a	6.0 a	4.5 a	0.4219
<i>Zygosaccharomyces bailii</i> CECT 11997	7.0 a	7.0 a	5.5 a	0.0540
<i>Zygosaccharomyces bisporus</i> ATCC 52405	4.5 b	10.5 a	4.0 b	0.0126
<i>Zygosaccharomyces microellipsoides</i> ATCC 10605	13.0 a	12.0 a	8.0 b	0.0442
<i>Zygosaccharomyces rouxii</i> ATCC 2623	7.5 a	9.0 a	7.5 a	0.1250

^a data shown the mm of clear zone of test, subtracted from a negative control. ^b values are expressed as means of mg GAE/mL. Different letters indicate that there are statistically significant differences between cultivars in each yeast species (Tuckey, $p < 0.05$).

Figure S1. Factor loadings plot resulting of principal component analysis (PCA) of phenolic compounds, bioactive compound content, antioxidant activity and antifungal activity of mango peel and seed extracts (A). Score plot of the principal components and distribution of samples of mango peel and seed extracts (B).

Phenolic compounds identified in mango peel and seed extracts (Dorta et al. 2014): 1, galloyl glucose; 2, gallic acid; 3, theogallin; 4, maclurin 3-C- β -D-glucoside; 5, Di-galloyl-glucose; 6, methyl gallate; 7, maclurin 3-C(2-O-galloyl)- β -D-glucoside; 8, Iriflophenone 3-C(2-O-galloyl) β -D-glucoside; 9, maclurin 3-C(2,3-di-O-galloyl)- β -D-glucoside; 10, ethyl gallate; 11, mangiferin; 12, methyl gallate ester; 13, tetra-O-galloyl-glucoside; 14, quercetin 3-O-diglycoside; 15, isoquercitrin; 16, ellagic acid; 17, valoneic acid dilactone; 18, penta-O-galloyl-glucoside; 19, quercetinpentoside; 20, quercitrin; 21, quercetin 3-O-rutinoside; 22, rhamnetin derivative; 23, ethyl 2,4-dihydroxy-3-(3,4,5-trihydroxybenzoyl)-oxybenzoate; 24, ethyl p-trigallate; 25, rhamnetin hexoside.

Mango byproducts extracts: GPA (Gomera-3 cv. Peel, extraction A); SPA (Sensation cv. Peel, extraction A); KPA (Keitt cv. Peel, extraction A); GPB (Gomera-3 cv. Peel, extraction B); SPB (Sensation cv. Peel, extraction B); KPB (Keitt cv. Peel, extraction B); GS (Gomera-3 cv. Seed); SS (Sensation cv. Seed); KS (Keitt cv. Seed). HALO: diameter of inhibition zone.

References

- Brand-Williams W, Cuvelier ME, Berset C. 1995. Use of a free radical method to evaluate antioxidant activity. *Lebensm Wiss Technol.* 28: 25-30.
- Coello Torres A, Fernández Galván D, Galán Saúco V. 1997. Guía Descriptiva de Cultivares de Mango. Departamento de Fruticultura Tropical. Serie Monografías Técnicas. Instituto Canario de Investigaciones Agrarias. Cons. Agric. y Alim. Gobierno de Canarias. Spain.
- Dorta E, Gonzalez M, Lobo MG, Sanchez-Moreno C, de Ancos B. 2014. Screening of phenolic compounds in by-product extracts from mangoes (*Mangifera indica* L.) by HPLC-ESI-QTOF-MS and multivariate analysis for use as a food ingredient. *Food Res Int.* 57; 51-60.
- Dorta E, Lobo MG, González M. 2013a. Optimization of factors affecting extraction of antioxidants from mango seed. *Food Bioprocess Tech.* 6: 1067-1081.
- Dorta E, Lobo MG, González M. 2013b. Improving the efficiency of antioxidant extraction from mango peel by using microwave-assisted extraction. *Plant Foods Hum Nutr.* 68 (2): 190-199.
- Dorta E, Lobo MG, González M. 2011. Reutilization of mango byproducts: Study of the effect of extraction solvent and temperature on their antioxidant properties. *J Food Sci.* 77: C80-88.
- FAO/IAEA. 2000. Quantification of tannins in tree foliage. Vienna: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.
- González-Montelongo R, Lobo MG, González M. 2010. The effect of extraction temperature, time and number of steps on the antioxidant capacity of methanolic banana peel extracts. *Sep Purif Technol.* 71: 347-355.
- National Committee for Clinical Laboratory Standards. 2002. Reference method for broth dilution susceptibility testing of yeasts: approved standard, 2nd ed. Document M27-A2. NCCLS, Wayne, PA.