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Effects of *Butia Capitata* pyrenes extracts on the germination of lettuce seeds

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ABSTRACT

We evaluated the chemical composition of hexane, ethyl acetate and methanol extracts of endocarp and endosperm of *Butia capitata* (Mart.) Becc. palm seeds and their inhibitory effects on seed germination and initial development of lettuce seedlings. The methanol extracts were analyzed using a gas chromatograph coupled to a mass spectrometer (GC/MS). Methanol extracts of endosperm and endocarp did not affect the germination (%), germination speed, fresh and dry weights of radicle and hypocotyl, but decreased the hypocotyl and radicle lengths. The principal allelopathic substances identified were: esters methyl (*Z*)-octadec-9-enoate, methylhexadecanoate and lauric (dodecanoic acid), myristic (tetradecanoic acid), oleic ((*Z*)-octadec-9-enoic acid), palmitic (hexadecanoic acid) and linoleic acid ((9*Z*,12*Z*)-octadeca-9,12-dienoic acid).

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Key words: Allelopathy, Arecaceae, *Butia capitata*, Cerrado, inhibitory substances, *Lactuca sativa*, palm tree, pyrenes.

INTRODUCTION

The "Coquinho-azedo" *Butia capitata* (Mart.) Becc. is a native palm tree in Cerrado (savanna) biome in the Brazilian states of Minas Gerais, Goiás and Bahia. Its fruits are used to produce pulp, juices, ice cream and liquors and are important source of income in northern Minas Gerais State (8), although the advancing agricultural frontiers and intensive harvesting of these fruits threatens its survival. One option to preserve the *B. capitata*, is the large-scale production of its seedlings and reclamation of degraded lands for plantations. The seeds of many species of palm trees have poor and slow germination due to dormancy (20). This phenomenon occurs in *B. capitata* and other *Butia* species, the seeds often requires up to one year to germinate and has low germination i.e. 1 to 25% (4,9). Seed dormancy can be caused by diverse factors (presence of substances inhibitory to germination and seedlings development, known as allelochemicals). These compounds reduce seed germination (%), germination speed indexes, seedling growth and cause abnormal seedling development. The most common effects are observed in roots (growth restrictions, darkening of radicle tissues, less number of root hairs, altered geotropic responses and tissue necrosis) (11,12,17,22).

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Allelochemicals are normally secondary metabolites such as phenols, alkaloids, and terpenoids (2,14,19,32). Other substances, such as esters and fatty acids derived from primary metabolism can also affect the seed germination and the growth of plants, algae, protozoans and bacteria (1,19,21,25). Germination and vigour inhibiting substances produced in palm trees are little studied. The allelochemicals found in fruits and seeds effects the germination and growth of lettuce, cucumbers, cabbage and tomato seedlings (9,15,16,20).

Allelochemicals in extracts of parts of fruits and seeds can be detected through bioassays using the seeds of bioindicator species (such as lettuce, tomato and sesame). These extracts are applied to substrate onto which the bioindicator seeds are sown to evaluate their effects on germination and initial development. Another alternative is to identify the chemical components present in extracts of fruits and seeds using a gas chromatograph coupled to a mass spectrometer (GC/MS). Various workers have employed bioassays and chromatographic analyses to characterize the allelopathic potential of plant species (12,19,23).

This study aimed to evaluate the allelopathic effects of extracts of endocarp and endosperm (without embryo) of *B. capitata* on germination and initial development of lettuce seedlings and chemical composition of these extracts.

MATERIALS AND METHODS

This study was done in Laboratory Analysis and Synthesis of Agrochemicals (LASA/ UFV), Federal University of Viçosa, and in Seed Analysis Laboratory (LAS/ICA), Institute of Agricultural Sciences, Federal University of Minas Gerais, Montes Claros, Minas Gerais, Brazil. The fruits of *B. capitata* were collected in area of their natural occurrence, gathering the largest numbers of fruits from any given plant. Test samples were prepared by harvesting the same number of fruits from each bunch. The pulp was manually removed from the fruits using a knife, leaving just the pyrene (endocarp + seed). The pyrenes were then washed in distilled water and left to dry in shade at ambient room temperature and humidity. The endocarp was removed from all pyrenes using a pair of pliers; the embryo was then removed from the seed using a scalpel, leaving only the endosperm and the tegument. The free endocarps and endosperms obtained were used to prepare the extracts.

Preparation of extracts

The extracts were prepared as per the methodology of Escudero (7) and Fernandes (9), with some modifications. Initially, 100 g of either the endocarp or endosperm were macerated (separately) in porcelain mortars and the resultant material was extracted in 1:5 w/v proportions. The extracts were kept in refrigerator in dark flasks for 24 h, after words the solutions were filtered. All preparations were done under low light conditions.

Germination tests

Lettuce seeds (*Lactuca sativa* cv. *capitata*.) were used in bioassays as per the Rules of Seed Analysis Manual (3). The germination trays were disinfected with 2%

sodium hypochlorite (w/v) and the germination or blotting paper substrates were autoclaved for 20 min (120°C, 15 lb). The germination trays were prepared by 2-layers of filter paper on bottom and then adding 3.0 mL extract as per treatment. The experiments were carried out using 4-replicates with 50 seeds per treatment (40 combinations of solvents x pyrene parts, plus controls). The treatments consisted of 6-extracts: hexane + endocarp, hexane + endosperm, ethyl acetate + endocarp, ethyl acetate + endosperm, methanol + endocarp, and methanol + endosperm. Four additional controls were used: hexane, methanol, ethyl acetate solvents and distilled water. After 24 h (to allow total evaporation of solvents) 3.0 mL distilled water was added to each tray. After the total evaporation of this water, lettuce seeds were sown in trays and 14 mL of water was added to each gerbox, in proportion of 2.5 times the dry weight of paper. The trays were then placed in a BOD incubator and maintained in dark at 25°C.

The germination (%) and germination speed were recorded (18). The lettuce seeds were considered germinated when protrusion of radicals was visible. The germination was recorded daily. After 7-days, the fresh and dry weights, lengths of hypocotyl and radicles were determined. The seedlings dry weights of root and shoot were determined by drying them in oven at 65°C and their lengths were measured with ruler.

The pH of endocarp extracts in hexane, methanol and ethyl acetate were 4.8, 6.7 and 5.4, respectively, and the pH of endosperm extracts in these solvents were 6.7, 6.4 and 5.3, respectively, i.e. the pH of extracts was within adequate pH range (4-10) for germination as per Eberlein (6). The data was subjected to analysis of variance and the Tukey test at a 5% probability level.

Chemical analysis of methanol extracts

The methanol extracts of endosperms and endocarps exerted the greatest allelopathic effects on lettuce seed germination, hence their chemical composition was determined using the chromatographic analysis.

Alkaline hydrolysis: 10 mg of each extract obtained was dissolved in dichloromethane, followed by the addition of 1.8 mL of an aqueous solution of KOH (3.0 mol L^{-1}) and 0.2 mL of methanol in round-bottomed flask (10.0 mL). The mixture was refluxed in nitrogen atmosphere for 1.0 h, cooled to room temperature, acidified with aqueous solution of HCl (3.0 mol L^{-1}) to about pH 2, and extracted with dichloromethane 3 times (10 mL each). The combined organic extracts were dried with anhydrous $MgSO_4$. After filtration, the solvent was completely removed in partial vacuum in a rotary evaporator.

Derivatization: After hydrolysis, 2.0 mg extracts were mixed with 60 μL of pyridine and 100 μL of BSTFA (N,O-*bis* (trimethylsilyl) trifluoroacetamide containing 1% of chlorotrimethylsilane) in derivatization vials. The reaction mixture was heated to 70ºC for 30 min. 1 μL samples of the solutions obtained were injected into the GC/MS.

Analysis with GC/MS

The GC/MS analyses were performed using a Shimadzu GC/MS PQ5050A apparatus, with a DB-5 fused silica capillary column (5% diphenyl and 95% dimethylsiloxane) 30 m long, 0.25 mm internal diameter, and with a 0.25 µm film, with helium being used as the carrier gas. The chromatographic conditions were as under: the

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temperature of injector was 290ºC, initiating at 80ºC for 5 min and then increasing to 290ºC at 4ºC/min; the temperature remained at 290ºC for 40 min. The temperature of detector and the GC/MS interface was 290ºC. The mass spectrometer operated using electron impact ionization at 70 eV and was configured to scan mass ranges from 30 to 600 *m/z*. The identification of extract components were made by comparing the mass spectra with the data bank of apparatus (Wiley 330,000) and with data from literature.

RESULTS AND DISCUSSION

Germination tests

The two parts of pyrene and solvents decreased the radical and hypocotyl lengths, but did not effect their dry or fresh weights, or germination (%) or speed indexes (Tables 1,2,3). These results confirmed the observations of Fernandes (9) on germination (%), germination speed index and fresh weights of hypocotyl and radicle of *B. capitata*. The extracts obtained from the leaves of *Eugenia dysenterica*, *Bothriochloa laguroides* and volatile oil of *Artemisia scoparia* affected the radicle growth of sesame and lettuce seeds and of weeds: *Cassia occidentalis* and *Parthenium hysterophorus* (14,24,28). However, our results were contrary to Khan (16) and Merrow (20), who reported that fruits extracts of other palm trees affected the germination of lettuce, wheat, red cabbage and cucumber seeds. Germination is less sensitive to allelochemicals than the seedlings growth (10). The Germination (%) index is widely used, but it does not provide any detailed information about other aspects of germination viz., delays or inactive periods (5).

The six-extracts (two portions of pyrene in 3-solvents) inhibited the radical (25.5%) and hypocotyl (9.2%) length more than the organic solvent and distilled water controls (Table 1), indicating the presence of allelochemicals in parts of *B. capitata* pyrene, although no effects were seen on seed dry or fresh weights. Allelochemicals affects the length of plant parts and their water content, but not the dry weight (30). As the seedlings were kept in dark during the bioassay, it reduced their photosynthetic activities and limited the weight gains (26).

Table 1. Effects of extracts of *B. capitata*, pure solvents (hexane, ethyl acetate and methanol) and distilled water (control treatments) on the radicle and hypocotyl length (cm) of lettuce

Treatments	Radicle (cm)	Hypocotyl (cm)
Pure solvents and distilled water (controls)	1.968 A	5.412 A
Extracts*	1.475 B	4.912 B
LSD	0.4279	0.8039
CV(%)	13.29	8.17

The Data in parenthesis indicates % Inhibition over Pure solvents and distilled water (controls), Measurements followed by same letter do not differ significantly by F test at 5% probability level. CV: Coefficient of Variation. * Extracts: hexane + endocarp, hexane + endosperm, ethyl acetate + endocarp, ethyl acetate + endosperm, methanol + endocarp e methanol + endosperm.

There was variabilty in the results of different control treatments, the distilled water control significantly differed from the organic solvents and hexane proved most inhibitory to radicle growth (Table 2).

The pure organic solvents inhibited the radicle growth than distilled water and the hexane was most inhibitory (22.7%), followed by methanol (10.4%) and ethyl acetate (9.1%). Hypocotyl growth, on the other hand, was not affected by any pure solvents as compared to distilled water (Table 2 and Fig. 1).

Table 2. Effects of pure solvents (hexane, ethyl acetate and methanol) and distilled water control treatments on the radicle and hypocotyl length (cm) of lettuce

Control Treatments	Radicle (cm)	Hypocotyl (cm)
Water	2.20 A	5.70A
Ethyl acetate	2.00 AB	5.42A
Methanol	1.97 AB	5.42A
Hexane	1.70 B	5.10A
LSD	0.4279	0.8039
CV (%)	13.29	8.17

Measurements followed by same letter do not differ significantly in Tukey test at 5% probability level. LSD: Least Significant Difference. CV: Coefficient of Variation.

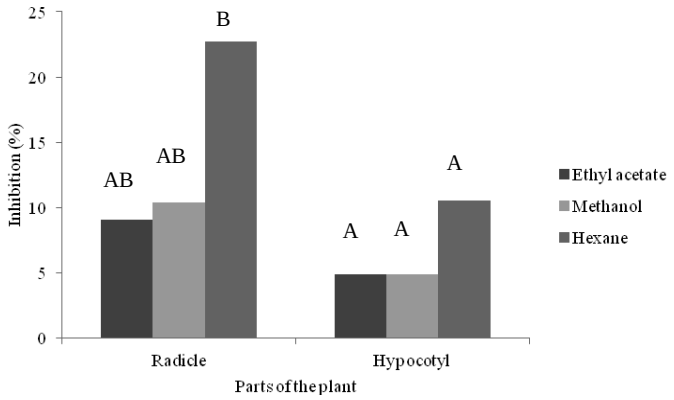

Figure 1. Inhibitory effects (%) of pure solvents (hexane, ethyl acetate and methanol on the radicle and hypocotyl length (cm) of lettuce) over the distilled water control. Measurements followed by same letter do not differ significantly in Tukey test at 5% probability level.

The methanol extract of endosperm of *B. capitata* drastically reduced the radicle growth (Table 3), indicating that methanol dissolved all the substances responsible for allelopathic effects. The hexane and ethyl acetate extracts of endocarp decreased the radicle lengths than endosperm extracts in same solvents. The allelopathic activities generally results from the action of various substances and a single compound may influence the various biological functions, and/or a single function could be affected by more than one compound (29).

Similar to radicle length, the 6-test extracts affected the hypocotyl growth in various ways (Table 1) but the hypocotyl growth was not affected by pure solvents

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controls as compared to distilled water control (Table 2). Among the 6-test extracts, the methanol extract of endocarp restricted the development of hypocotyl lettuce seedlings (Table 3).

Table 3. Effects of extracts of *B. capitata* on the length of lettuce radicle and hypocotyl (cm)

Solvents	Radicle (cm)		Hypocotyl (cm)	
	Endocarp	Endosperm	Endocarp	Endosperm
Hexane	1.550 Ab	1.900 Aa	5.35 Aa	4.95 Aa
Methanol	1.325 Aa	1.000 Bb	4.25 Bb	5.15 Aa
Ethyl acetate	1.350 Ab	1.725 Aa	5.05 Aa	4.72 Aa
LSD COLUMNS	0.3879		0.7288	
LSD ROWS	0.3212		0.6035	
CV (%)	13.29		8.17	

B. Capitata extracts: hexane + endocarp, hexane + endosperm, ethyl acetate + endocarp, ethyl acetate + endosperm, methanol + endocarp and methanol + endosperm. Measurements followed by same lower case letters in rows and upper case letters in the columns do not differ significantly in Tukey test at 5% probability level. LSD COLUMNS: Least Significant Difference among the solvents within the endocarp and endosperm. LSD ROWS: Least Significant Difference among the solvents within the endocarp and endosperm. CV: Coefficient of Variation.

Decrease in radicle and hypocotyl growths reflects the presence of compounds that interrupt the transport of auxins (17,31,32). The allelochemicals decreases the seedling growth by adversely affecting the synthesis of nucleic acids and proteins, the quantity of oxygen that reaches embryos, membrane permeability and photosynthesis (32).

Specifically in terms of root growth, which was most affected by the plant extracts in their study, other workers have shown that secondary metabolites influences the polar auxin transport and thus cause imbalances in plant hormone levels (32). Auxin plays important roles in many plant functions (cell elongation and the development of lateral and adventitious roots). The auxin concentrations > 10^{-8} M may inhibit the root formation, in these cases flavonoids act in equilibrating the auxin levels. Flavonoids have likewise been implicated in lateral root induction, even acting as auxin analogs in some cases and showing the same types of roots growth inhibition at high concentrations (17,31,32). It is possible that the substances present in the endocarp and endosperm of *B. capitata* in this study may act in analogous form to flavonoids in limiting both hypocotyl and root growth.

Allelochemicals also affects the seedling growth and may interrupt the amino acid metabolism and DNA replication. The quantities of oxygen that reach the embryos has also been indicated as a possible limiting factor in the growth of plant organs in allelopathy studies, as certain secondary plant metabolites can sequester O_2 and thus compromise cell respiration. Another consequence of this sequestering is the formation of superoxides (O2-) and hydroxyls (OH-) that are extremely reactive and can damage the cell membranes and cause cell death. Fatty acids are susceptible to this type of oxidation (25), which would affect the cell membrane permeability and cause the loss of large quantities of cellular K^+.

Additionally, photosynthetic rates can be reduced by two mechanisms: inhibition of the photochemical phase and/or the reduction in the quantities of available Chlorophyll a/b. Certain compounds can inhibit the electron transport systems in photosystem II (PSII),

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thus interrupting the electron transfer between platoquinone A and B, or destroy the chlorophyll or limit its synthesis (32). Oliva (21) observed that a methanol extract of *Caryocar brasiliense* leaves compromised the electron transport system in *Zea mays* and diminished the quantum efficiency of photosystem II in *Bidens pilosa*. They also noted that this extract contained large quantities of methyl hexadecanoate and hexadecanoic acids – substances that were observed in the methanol extracts of *B. capitata* in the present study. These substances can also destroy chlorophyll or restrict its synthesis (21).

The methanol extracts seriously affected the seedling growth, hence, were chemically characterized to confirm the presence of allelopathic compounds described in literature.

Chemical composition of methanol extracts

The GC/MS analyses of methanol extract of endocarp revealed the presence of sterols, fatty esters, carbohydrates, alcohols and free fatty acids (Fig. 2). The fatty acids and esters together comprised 86% of chemical components identified in extracts with the notable presence of methyl hexadecanoate (28.7%) and methyl (*Z*)-octadec-9-enoate (34.8%) (Fig. 3 and Table 4).

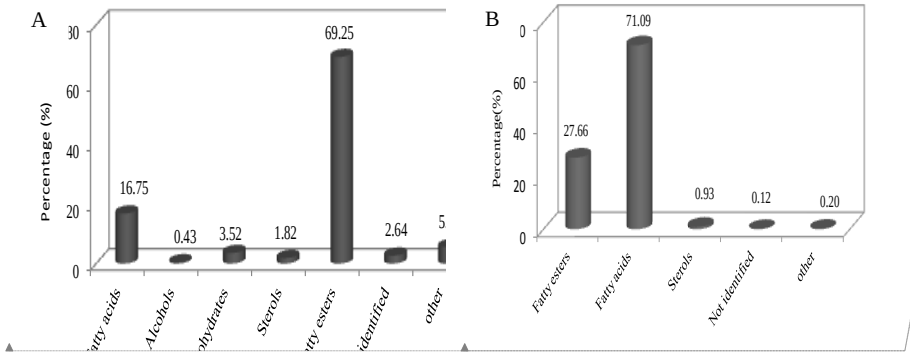

Figure 2. Principal chemical compounds classes present in methanol extract of *B. capitata* endocarp (A) and endosperm after hydrolysis (B), by GC/MS.

The methanol extract of endosperm (before hydrolysis) was found to contain free fatty acids, fatty esters and carbohydrates, (39.3% of sample weight). Due to high number of unidentified compounds, this extract was submitted to alkaline hydrolysis, which revealed the presence of fatty acids, esters, and sterols (Fig. 2); a total of 21 compounds were detected, and these 18 (comprised 85.7 % of material) and unidentified (Fig. 4). Fatty acids were present in largest amounts (71.1% of material), especially lauric acid (dodecanoic acid) (33.5%) and mixture of oleic and linoleic acids ((*Z*)-octadec-9-enoic/(9*Z*,12*Z*)-octadeca-9,12-dienoic acids) (10.2%) (Table 5).

The palmitic (hexadecanoic acid), stearic (octadecanoic acid), myristic

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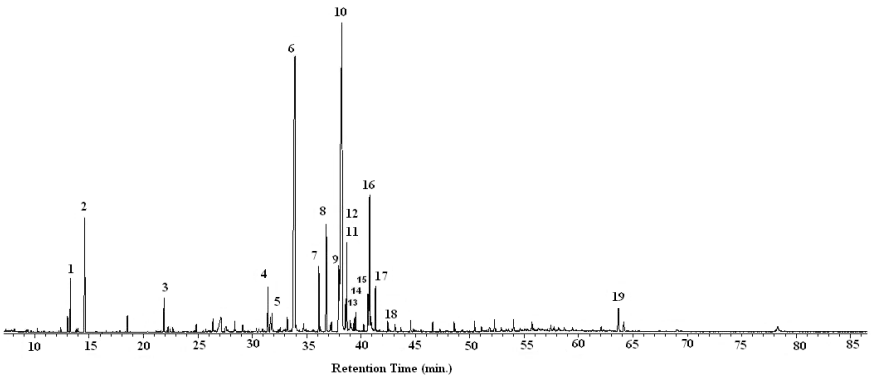

Figure 3**.** Total ion chromatogram of methanol extract of *B. capitata* endocarp by GC/MS. The numbers refer to the compounds listed in Table 4.

Table 4. Chemical components identified in methanol extract of *B. capitata* endocarp. The numbers refer to the chromatogram peaks of Figure 3. The extracts were analyzed using gas chromatograph coupled to a mass spectrometer (GC/MS).

Peak	RT	Compound identified	Peak Area %
1	13.28	Not identified	1.94
2	14.60	Glycerol	5.59
3	21.89	Butanedioic acid	1.39
4	31.43	Unidentified carbohydrate	1.86
5	31.81	Myristic acid (Tetradecanoic acid)	0.71
6	33.92	Methyl hexadecanoate	28.7
7	36.12	Glycopyranose	0.73
8	36.81	Palmitic acid (Hexadecanoic acid)	5.08
9	37.94	Methyl (9*Z*,12*Z*)-octadeca-9,12-dienoate	1.72
10	38.25	Methyl (*Z*)-octadec-9-enoate	34.8
11	38.56	Unidentified carbohydrate	0.93
12	38.69	Methyl octadecanoate	3.57
13	39.35	Octadecan-1-ol	0.43
14	39.50	Not identified	0.7
15	40.63	Linoleic acid ((9*Z*,12*Z*)-octadeca-9,12-dienoic acid)	1.31
16	40.79	Oleic acid ((*Z*)-octadec-9-enoic acid)	6.59
17	41.32	Stearic acid (Octadecanoic acid)	1.67
18	43.13	Methyl eicosanoate	0.4
19	63.67	Stigmasterol	1.82

RT: Retention Time (min.)

(tetradecanoic acid), linoleic ((9*Z*,12*Z*)-octadeca-9,12-dienoic acid), lauric (dodecanoic acid) and capric (decanoic acid) acids found in these extracts were also found in the endosperm of *B. capitata* seeds (8). The reported amounts for lauric (dodecanoic acid) and

Table 5. Chemical components detected in methanol extract of the *B. capitata* endosperm before (BH) and after (AH) alkaline hydrolysis. The extracts were analyzed using a gas chromatograph coupled to a mass spectrometer (GC/MS)

Peak	RT	Identification	Relative area (%)	
			BH	AH
1	8.74	Methyl octanoate		1.65
2	13.92	Caprylic acid (Octanoic acid)		6.85
3	14.58	Glycerol	1.07	0.20
4	15.88	Methyl decanoate		3.45
5	18.08	Not identified		0.01
6	20.55	Capric acid (Decanoic acid)		8.67
7	22.48	Methyl dodecanoate	1.08	14.3
8	23.30	Not identified		0.12
9	24.12	Unidentified carbohydrate	1.21	
10	24.36	Unidentified carbohydrate	1.17	
11	25.16	1,2,3-Trihydroxybenzene	1.08	
12	25.71	Unidentified carbohydrate	4.60	
13	25.93	Unidentified carbohydrate	3.89	
14	26.91	Lauric acid (Dodecanoic acid)		33.5
15	28.20	Not identified	0.90	
16	28.42	Levoglucosan	1.73	
17	28.44	Methyl tetradecanoate		3.01
18	31.91	Myristic acid (Tetradecanoic acid)		6.92
19	33.69	Methyl hexadecanoate		1.26
20	33.73	Glicopyranose	0.77	
21	34.05	Galactopyranose	0.35	
22	34.91	Glucitol	0.53	
23	36.12	Glycopyranose	0.73	
24	36.77	Palmitic acid (Hexadecanoic acid)	0.38	3.09
25	37.17	Unidentified carbohydrate	0.59	
26	37.83	Methyl (9*Z*,12*Z*)-octadeca-9,12-dienoate		0.55
27	38.05	Methyl (*Z*)-Octadec-9-enoate		4.28
28	38.05	Not identified	0.35	
29	38.55	Unidentified carbohydrate	0.44	
30	38.55	Methyl Octadecanoate		0.78
31	38.98	Unidentified hydrocarbonate	0.36	
32	40.75	Oleic/linoleic acids ((*Z*)-octadec-9-enoic/(9*Z*,12*Z*)-octadeca-9,12-dienoic acids)	0.70	10.2
33	41.32	Stearic acid (Octadecanoic acid)	0.53	1.82
34	50.72	Unidentified carbohydrate	22.4	
35	51.55	Not identified	0.94	
36	52.00	Not identified	0.98	
37	52.71	Unidentified sterol		0.26
38	62.95	Not identified	2.95	
39	63.70	β-sitosterol	1.13	0.44
40	65.20	Cycloartenol		0.23
41	69.34	Not identified	9.08	
42	69.57	Not identified	1.90	
43	79.00	Not identified	23.93	
44	92.32	Not identified	5.03	
45	92.96	Not identified	3.2	
46	112.79	Not identified	6.03	

RT: Retention time (min), BH: Before hydrolysis, AH: After hydrolysis.

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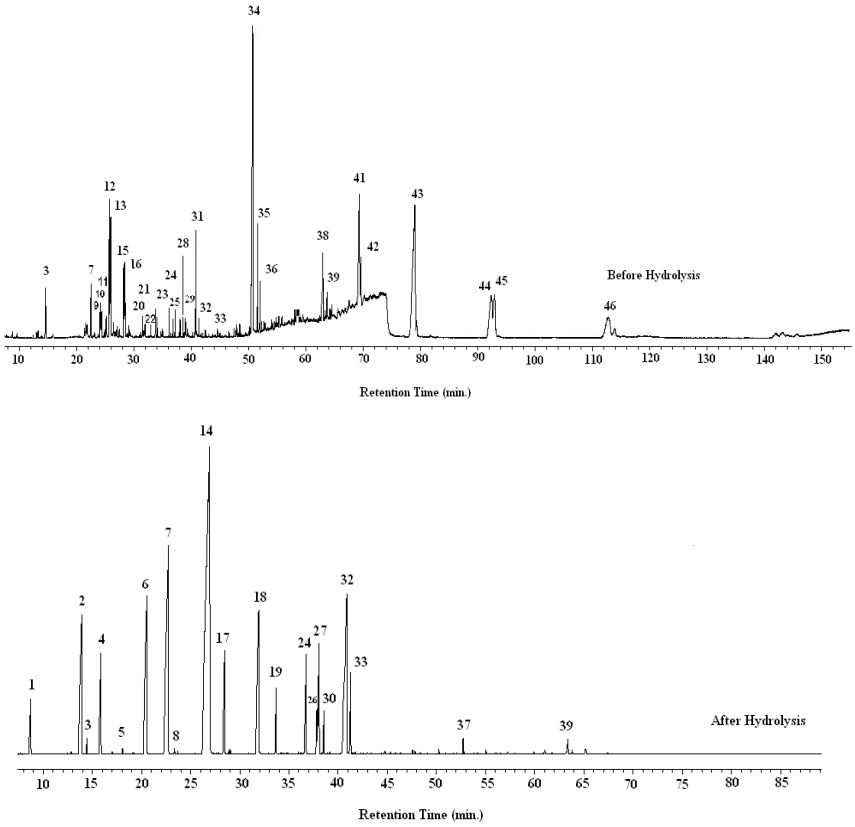

Figure 4. Total ion chromatogram of the methanol extract of *B. capitata* endosperm before and after alkaline hydrolysis by GC/MS. The numbers of peaks refer to compounds listed in Table 5.

capric (decanoic acid) acids were similar to our results. In addition to these acids, butanedioic acid was also identified, which had not been previously reported in this species.

The extracts of *B. capitata* contained compounds [Esters methyl (*Z*)-octadec-9-enoate, methyl hexadecanoate, methyl octadecanoate and hexadecanoic, octadecanoic, tetradecanoic, (9*Z*,12*Z*)-octadeca-9,12-dienoic, (5*Z*,8*Z*,11*Z*,14*Z*, 17*Z*)- eicosa-5,8,11,14,17-pentaenoic, (4*Z*,7*Z*,10*Z*,13*Z*,16*Z*,*19Z*)-docosa-4,7,10,13,16,19-hexaenoic, dodecanoic and (*Z*)-octadec-9-enoic acids] previously described as allelopathic to germination, root and shoot growth of weeds and crops. (1,19,21,23,27).

The fatty esters act allelopathically through exerting the oxidative stress and electrolyte leakage (resulting from alterations in cell membrane permeability), reducing chlorophyll *a* and *b* contents and compromising electron transport rates (21). Fatty acids

can modify the membrane permeability and cause losses of large amounts of cellular potassium (25). Hydrophobic molecules (such as triacylglycerides) can make seed imbibition more difficult by forming a barrier against the movement of water into the seeds, thus interfering with their germination (19).

Most of fatty acids and fatty esters indicated in literature have allelopathic activities except (9*Z*,12*Z*,15*Z*)-octadeca-9,12,15-trienoic, (5*Z*,8*Z*,11*Z*,14*Z*,17*Z*)-eicosa-5,8,11,14,17-pentaenoic and (4*Z*,7*Z*,10*Z*,13*Z*,16*Z*, 19*Z*)- docosa-4,7,10,13,16,19-hexaenoic acids] found in the methanol extracts of endosperm and endocarp of *B. capitata* seeds. Oleic ((Z)-octadec-9-enoic acid), lauric (dodecanoic acid), palmitic (hexadecanoic acid), myristic (tetradecanoic acid) and linoleic acids ((9*Z*,12*Z*)-octadeca-9,12-dienoic acid) were found in large quantities in the extracts and are inhibitors of both germination and seedling growth in higher plants (1,19,21,23,27). The other substances found in these extracts were not inhibitory or phytotoxic and are influenced by various factors: plant species climate, type of substrate, microrganisms and organs of test plants (15,21,23,24,32). The allelopathic studies in palm trees are rare, especially the detailed chemical characterizations of bioassayed extracts. Additional studies with isolated substance are in progress to know their allelopathic activity, besides additional environmental factors (role of soils and microorganisms) need to be considered.

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