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INFLUENCE OF SPROUTING USING BIOTIC AND ABIOTIC ELICITORS ON CHEMICAL COMPOSITION OF RADISH SEEDS (*RAPHANUS SATIVUS*)

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ABSTRACT

Germination is a way to improve agricultural productivity and easily to use by low income families, in particular with using some elicitors in germination for enhancing the nutrition value of the seeds by sprouting. For their highly metabolic activities after harvesting, radish seeds were selected for performance of this study. The effect of using abiotic elicitor (saline water, by NaCl at different concentrations) and biotic elicitor (*Saccharomyces cerevisiae*) on sprouting of radish seed has been investigated. After germinating radish seeds for six days using elicitors, chemical analysis and determination for phytochemicals contents have been carried out. Results showed a promising efficiency by sprouting, where an appreciable increasing in some analysis as protein, carbohydrates, some minerals and amino acids comparing to seed. Besides, germination had a positive effect to present some phyto-compounds as some flavonoids, terpenoids and phenolic compounds. Then, this study and similar ones are an important step towards the future development of value-added foods with elicited phytochemicals and can be used in the development of innovative food products with beneficial effects on human's health.

Key words: Radish seed, Elicitors, Biotic, Abiotic

INTRODUCTION

Demanding for food will continue to increase towards 2050, as a result of population growth. Increases in food production per hectare of land have not kept pace with increasing in population which leads to the global food crisis. The world food crisis is the result of the effects of competition for cropland from the growth in biofuels, low cereal stocks, high oil prices, speculation in food markets and weather events. One possible solution to the global food crisis is to improve agricultural productivity by some means **(Sarinont et al 2014).**

It is worth to mention that many children, under five years, suffer from protein energy malnutrition during the introduction of complementary foods. In matter of fact, infants at this stage of rapid development have high requirements of energy and nutrients per unit body weight. There is need therefore to develop appropriate nutrient-dense complementary foods that could be used by low income families.

Germination brought about significant increases in the micronutrient, phytonutrient content of all selected seeds, thus proving that there is marked increase in the nutritive value of the seeds on sprouting. This ultimately signifies that sprouts should be considered a vital component of the diet and can be incorporated to improve agricultural productivity and easily to use by low income families **(Wagner et al 2013).**

Cruciferous sprouts are distinctive plant foods because of their rich composition in bioactive compounds compared to other plants. Germinating seeds may contain more than doubles of phytochemicals depending the species, cultivar, and environmental conditions. Seven or eight days old sprouts are of appropriate age for harvest allowing post-harvest handling and marketing of this material, maintaining contents of phytochemicals higher than other vegetables. Radish sprouts are very young plants that continue their highly metabolic activities after harvesting **(Baenasa et al 2017).**

Radish belongs to Cruciferous family. Radishes have been cultivated for thousands of years in both China and the Mediterranean area. In general, radish contains carbohydrates, sugars, dietary fibers, protein and fat. Radish was found to have unique bioactive compounds that have been recognized to have potential health benefits to humans **(Aly, Tahany 2015)**.

Many researches have been focused on developing efficient strategy for enhancing production of useful metabolites in food plants without gene modification or breeding **Paskin et al (2002)**. As the biosynthesis of several secondary metabolites in plants is usually a defense response of plants to biotic and abiotic stresses, their performance can be effectively stimulated by biotic and abiotic elicitors, making elicitation is one of the most effective strategies for improving bioactive secondary metabolite production in plant **tissue Mulabagal and Tasy (2004).** Yeast polysaccharide (YPS) is an efficient biotic elicitor for stimulating secondary metabolite production in plant cell **Zhao et al (2010).** Production of many valuable bioactive compounds has been successfully stimulated by YPS elicitors **(Zhao et al 2012).**

Since the scientific information regarding the effect of biotic and abiotic elicitors on bioactive chemical compounds remains limited, this paper aims to fill this knowledge gap. Radish seed was selected for performance of this study. Then a comparing study between the chemical analysis and phytochemical contents of the selected dry seed and their germinated samples and that including using abiotic elicitor (saline water by NaCl salt) and biotic elicitor (*Saccharomyces cerevisiae* yeast)

MATERIALS AND METHODS

This study was carried out in Horticulture Department, Faculty of Agriculture, Ain Shams University, Cairo and the Regional center for Food and Feed (RCFF), Agricultural Research center (ARC), Giza, Egypt**.**

Radish seeds

Seeds of Egyptian radish (*Raphus sativus*), Balady cultivar, were obtained from privet farm in Kalubia government.

Effect of NaCl concentration on radish sprouting

Washing seeds to be sure that it is cleaned and not good seed has been excluded. Sprouting of seeds was done by using tap water (as control) and consequent concentration of NaCl (1000 ppm, 2000 ppm, 3000 ppm and 4000 ppm). Twenty grams of radish seeds were placed in glass jar, containing 200 ml of either tap water or saline water and soaked for 12 hours at room temperature After that, soaking water was removed then seeds were washed every 8 hours using the same soaking solution, for 3 days. At the end of sprouting period, samples of radish sprouts were collected for measuring sprout characters **Eman Tork (2017).**

According to the best results for sprout hypocotyl length and whole sprout length, the appropriate concentration for NaCl was selected for performance the sprouting of radish seed and making the chemical analysis, phytochemical contents of the selected dry seeds and their germinated samples. Samples of harvested germinated and seeds were collected after six days dried in oven at 60°C for 48 h then ground in laboratory Wiley mill to pass through a 40-mesh sieve. The ground sample was stored at 5°C until analysis **Eman Tork (2017).**

Chemical analysis

Proximate analysis

Total protein, fats, fiber and ash were analyzed according to **AOAC (2012),** Total carbohydrates were determine by difference.

Determination of minerals concentration:

Calcium (Ca), magnesium (Mg), Iron (Fe), Copper (Cu), Zinc (Zn), sodium (Na) and potassium (K) were analyzed by ICP/MS/MS Agilent 8800 according to the method described in the **AOAC (2012).**

Amino acids analysis

Amino acids determination was performed according to **AOAC (2012)**, using Eppendorf LC 3000 EZ chrom.

Fatty acids analysis

Saturated and unsaturated fatty acids were determined using methyl esters boron trifluoride method according to **AOAC (2012),** using GC instrument (chemazo).

Screening of phytochemical compounds:

Determination of phytochemicals compounds were performed according to the method described by **Santana et al (2013)** using GC/MS/MS technique.

The analysis was carried out using a GC (Agilent Technology 7890A) coupled with a mass-selective detector (MSD, Agilent 7000 Triple Quad) equipped with Agilent HP-5ms capillary column.

The identification of components was based on a comparison of their mass spectra with the authentic compounds and by computer matching with NIST library as well as by comparison of the fragmentation pattern of the mass spectral data with those registered in the literature.

RESULTS AND DISCUSSION

Effect of NaCl concentrations on sprouting of radish seed:

Table (1) showed radish sprout (6 days old) length, fresh and dry weight and its radical and hypocotyl length. Mean of sprout radical length varied between 3.5 and 4.8 cm at various NaCl concentrations. The longest radical length was observed in the control and in 2000 ppm NaCl. Similar results were show in sprout hypocotyl length and whole sprout length, with significant decrement at 3000 and 4000 ppm NaCl compared with control. On the other hand the results showed that the 2000 ppm NaCl sprout has the heights values for the sprout length, sprout fresh weight and sprout dry weight. Then**,** 2000 ppm NaCl concentration is the appropriate concentration for performance the sprouting of radish seed for making the chemical analysis and phytochemical contents.

Table 1. Effect of NaCl concentration on Egyptian radish sprouts characteristics

NaCl Concentration	Sprout radical length (cm)	Sprout hypocotyl length (cm)	Sprout length (cm)	10 sprouts fresh weight (mg)	10 sprouts dry weight (mg)
Control(Tap water)	4.7[a]	4.5[ab]	9.2[a]	1110[a]	93[a]
1000 ppm	4.5[a]	4.5[ab]	9.0[a]	1070[a]	83[a]
2000 ppm	4.8[a]	4.9[a]	9.7[a]	1253[a]	93[a]
3000 ppm	3.6[b]	3.9[bc]	7.5[b]	460[b]	83[a]
4000 ppm	3.5[b]	3.6[c]	7.1[b]	300[b]	80[a]
LSD at 0.5%	0.7	0.7	1.2	0.3	NS

Means in each column followed by the same letter are not significantly different at the 5% level

Proximate analysis of radish seed sprouts:

Results of proximate analysis of radish seeds and its sprouts using irrigated tap water, saline water (2000 ppm NaCl), tap water with yeast (1%) and saline water with yeast (1%) are shown in **Table (2).** Data in **Table (2)** display that protein, moisture, ash, fiber and carbohydrates noticeable increased in all treatments, while lipid decreased in all treatments. That was comporting with **Fouad & Rehab (2015)** who studied effect of germination for 6 days on proximate analysis of lentil. These results were agreed with **Aly, Tahany *et al*., (2018)** who studied green radish sprouts (8 days old).

Data also showed that yeast had a positive effect on protein, where sprouting with yeast caused an increase in protein content comparing with sprouting with tap or saline water only. The increase in sprout protein content may be due to reduction of seed nitrates into plant protein (metabolic enzymes) or nitrogen fixation during germination**.**

Table 2. Proximate analysis of radish etiolated sprouts using different irrigation treatments

Treatments	Protein	Moisture	ASH	Total lipid	Fiber	Carbohydrates
Seed	22.5	4.5	4.11	32.27	13.63	22.99
Tap water	24.3	5.53	10.11	8.96	17.64	33.46
Tap water + Yeast	25.9	5.91	9.05	10.11	15.47	33.56
Saline water	26.2	5.8	10.08	8.84	17.21	31.87
Saline water + Yeast	28.0	5.9	9.13	9.25	15.11	32.61

Minerals content of Egyptian radish seed sprouts

Minerals contents of sprouts are shown in **Table (3).** There was an increase in Fe, Mg, K and Zn contents in sprouts treated with tap or saline water. Na content was increased in the sprouts treated with saline water and saline water + yeast treatments, which is attributed to the NaCl in the saline solution used for rinsing seeds during germination. The highest increases in Cu and Zn were observed in "Tap water + yeast" treatment. This increasing in these elements was observed too in the study **Aly, Tahany et al (2018)** on green radish sprouts.

Table 3. Mineral content of radish sprouts vs dry seed

Irrigation Treatments	Ca %	Fe %	Mg %	K %	Na %	Cu ppm	Zn ppm
Dry seeds	0.24	0.05	0.24	0.75	0.01	5.42	41.8
Tap water	0.22	0.41	0.41	3.00	0.33	6.92	47.7
Tap water +yeast	0.29	0.48	0.44	2.82	0.29	7.51	59.7
Saline water	0.26	0.48	0.42	3.34	1.85	6.37	50.0
Saline water +yeast	0.25	0.47	0.42	2.69	2.37	6.48	49.3

Fatty acids analysis:

Results of fatty acids in radish seeds and their sprouts are shown in **Table (4).** Some of fatty acids such as linoleic acid, linolenic acid showed an increasing in sprout samples as compared with seeds. Other fatty acids were less than 0.1 % in seed, sprouts with tap and saline water but show markable high concentration in sprouts treated with *Saccharomyces cerevisiae* yeast these fatty acids included Plamitioleic acid (C16:1w9), Lignoceric acid and Nervonic acid. Others Eicosaenoic acid and 11-Eicosaenoic acid were less than 0.1 % in seeds but they were higher in sprouts in all treatment. And other fatty acids have shown decreasing concentration in sprouts samples less than radish seed as: lauric acid, myristic acid and plamitic acid. Similar results for the increasing and decreasing fatty acids content were obtained by **Marton et al 2010** during their research on fatty acid content of sprouts of radish seed after 6 days of germination.

Table 4. Fatty acids content of Egyptian radish sprouts vs. dry seeds (mg/100mg D.W.)

Fatty acid	Dry Seeds	Tap water	Tap water + yeast	Slain water	Slain water +yeast
Lauric acid (C12:0)	0.72	0.49	0.58	0.61	0.42
Myristic acid (C14:0)	1.85	0.74	0.72	1.05	0.53
Plamitic acid (C16:0)	9.94	7.06	6.43	7.9	6.68
Plamitioleic acid (C16:1w9)	< 0.1	< 0.1	0.43	< 0.1	0.49
Plamitioleic acid(C16:1ωh7)	0.62	0.68	0.96	0.56	1.04
Stearic acid (C18:0)	3.69	2.24	2.38	2.66	2.15
Oleic acid (C18:1ω9)	17.39	16.28	16.23	15.71	16.11
Linoleic acid (C18:2ω6)	12.46	12.25	13.75	14.11	13.81
Linolenic acid (C18:3ω3)	9.98	12.24	13.89	11.06	14.15
Stearidonic acid (C18:4ω3)	< 0.1	< 0.1	< 0.1	0.42	0.38
Arachidic acid (C20:0)	1.04	1.07	1.03	1.02	0.98
Gadolic acid (C20:1ω9)	6.45	3.64	5.2	3.36	5.12
Eicosaenoic acid (C20:1ω11)	< 0.1	5.3	2.09	5.19	2.11
9-Eicosaenoic (C20:1ω7)	0.52	< 0.1	0.31	< 0.1	0.32
11-Eicosaenoic (C20:1ω5)	< 0.1	0.48	0.52	0.5	0.5
Eicosadienoic acid (C20:2ω6)	0.62	0.55	0.44	0.53	0.45
Behenic acid (C22:0)	1.13	1.21	1.23	1.21	1.14
Erucic acid (C22:1ω9)	32.96	35.32	30.43	34.06	30.17
Lignoceric acid (C24:0)	< 0.1	< 0.1	1.58	< 0.1	1.77
Nervonic acid (C24:1ω9)	< 0.1	< 0.1	1.6	< 0.1	1.65
Non identified fatty acid	0.63	0.45	0.2	0.05	0.03

Amino acids Results

Table (5) screens the amino acids results for radish seed and its sprouts. In radish sprouts, most of amino acids percentage were noticeably increased for all treatments. This increasing compared to radish seed could be attributed to the increasing in protein contents in all sprout treatments, especially with using saline water with yeast, which showed the highest protein percentage. As long as there was a shift from storage protein to functional protein during sprouting there was an increasing in free amino acids and their availability in sprouts. Besides, the increase in free amino acid percentage depends not only on its amino acid composition but also on the availability of these amino acids as statement by **Aly, Tahany et al (2018).**

Table 5. Amino acids percentage of radish sprouts vs. dry seeds (g/100g)

T.A.A %	Dry Seeds	Tap water	Tap water +yeast	Slain water	Slain water +yeast
Aspartic acid(ASP)	1.88	1.92	1.96	1.91	1.99
Therionine (Thr)	0.89	0.9	0.93	0.91	0.95
Serine (Ser)	0.88	0.91	0.94	0.91	0.95
Glutamic (Glu)	2.0	2.07	2.78	2.03	2.95
Proline (Pro)	0.99	0.98	1.11	1.09	1.13
Glycine (Gly)	0.97	0.95	1.0	0.96	0.99
Alanine (Ala)	1.18	1.22	1.38	1.29	1.48
Valine (Val)	0.94	0.99	1.1	1.01	1.12
Isoleucine (Iso)	0.63	0.7	0.81	0.72	0.81
Leucine (leu)	0.95	1.07	1.29	1.12	1.4
Tyrosin (Tyr)	0.61	0.7	0.73	0.68	0.75
Phenylalanine (Phe)	0.7	0.84	0.91	0.88	0.98
Histidine (His)	0.65	0.66	0.7	0.67	0.7
Lysine (Lys)	0.89	1.04	1.2	1.09	1.26
Arginine (Arg**)**	0.9	1.1	1.2	1.09	1.22
Cyaseine (Cys)	0.32	0.34	0.4	0.34	0.45
Methonine (Meth)	0.19	0.24	0.3	0.26	0.32

Phytochemical screening of seed and sprouts

The obtained chromatogram for phytochemical screening compounds of radish seed are shown in **Fig. (1)** and the chromatogram for phytochemical compounds of radish sprouts using tap water, tap water with *Saccharomyces cerevisiae*, saline water and saline water with *Saccharomyces cerevisiae* are shown in **Figs. 2, 3, 4 & 5,** respectively. The whole recognized compounds are tabled in **Table (7).** It seems from the results in **Table (7)** that germination had a positive effect to present some phyto-compounds which weren't exist in the seed. Some of these compounds are flavenoids like as: Pentahydroxyflavone, 4-Methylthio-3-butenyl isothiocyanate, 3'-Hydroxy-5, 6, 7, 4'-tetramethoxy flavone and Isovitexin. Other compounds are phenolic compounds as Phloroglucinol or terpenoids as β-Terpinyl acetate and phytol. Also the compounds which appear only in sprouts are sulfur compounds such as Thiophene, 2-butyltetrahydro and diNonyl sulfide. It can be said that sprouting radish seed could produce various phytochemicals that improve health.

There were several compounds, that had different activity with saline water and *Saccharomyces cerevisiae* treatment. For example, Pentahydroxyflavone (flavonoid) was noticed to increase in *Saccharomyces cerevisiae* treatment with both tap and saline water. Some other compounds have obviously increased in saline water, with and without *Saccharomyces cerevisiae*, like: β-Curcumene (phenol), Glucofuranosylbenzenesulfonate (sulfur compound)**,** Hydroxy-5,6,7,4'-tetramethoxyflavone (flavonoid) and Isovitexin (flavonoid). That beside to phytol (terpenoid), which wasn't present in seed, but it was existed in all sprouts and greatly increased in sprout treatment with saline water and *Saccharomyces cerevisiae*.

From above, flavonoids, a class of secondary plant metabolites with significant antioxidant and chelating properties were found to increase in sprouting especially with using *Saccharomyces cerevisiae* elicitor. All this reflects the possibility of sprouting on development of new phytochemicals compounds which has been shown by **Dongyan *et* al (2014**) in their study in mung bean sprouts. They cleared that under biotic and abiotic stress, plant physiology dramatically changes. Moreover, there were dynamic changes in metabolites during sprouting process including flavonoids, phenolic compounds, organic acids and amino acids. As a result, accumulation of secondary metabolites in plants provides health benefit foods**.**

From the previous results, it is clear that germination brought significant increases in the micronutrient, phyto-nutrient content of radish seed, thus proving that there is clear increasing in the nutritive value of the seeds on sprouting. Besides, clarification to some extent the behavior of natural and food-grade elicitor responses which is an important step towards the future development of value-added foods with elicited phytochemicals.

This study could help in laying the basis for future research on improving the nutraceutical value of plant foods using natural elicitors.

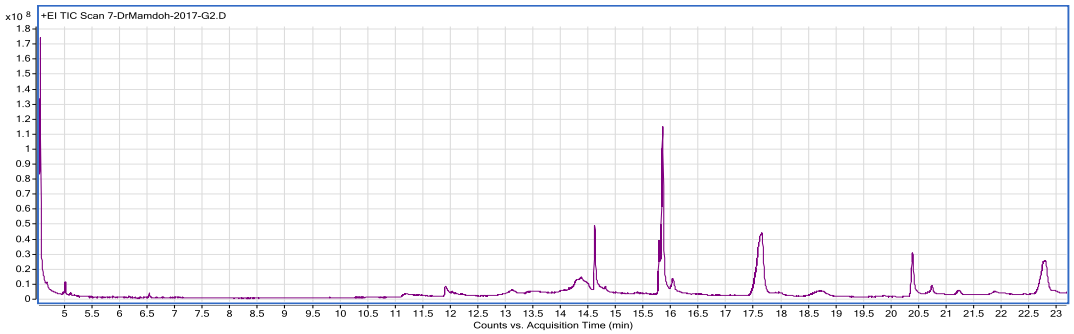

Fig. 1. GC/MS chromatogram for radish seed

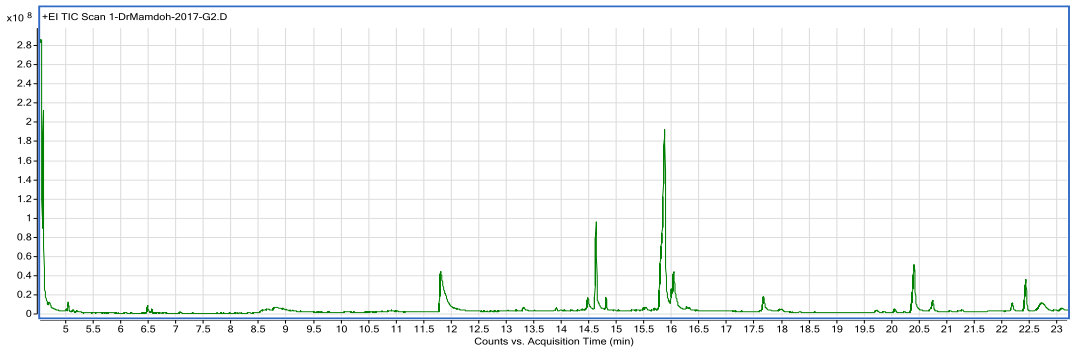

Fig. 2. GC/MS chromatogram for radish sprouts using tap water

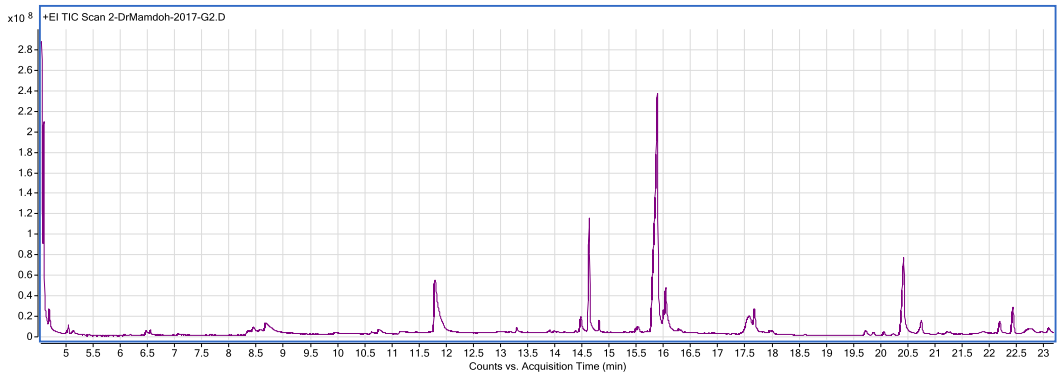

Fig. 3. GC/MS chromatogram for radish sprouts using tap water with SC yeast

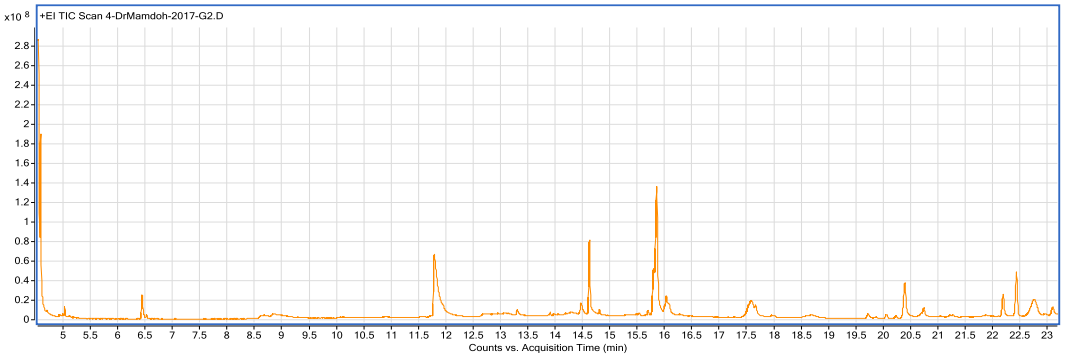

Fig. 4. GC/MS chromatogram for radish sprouts using saline water

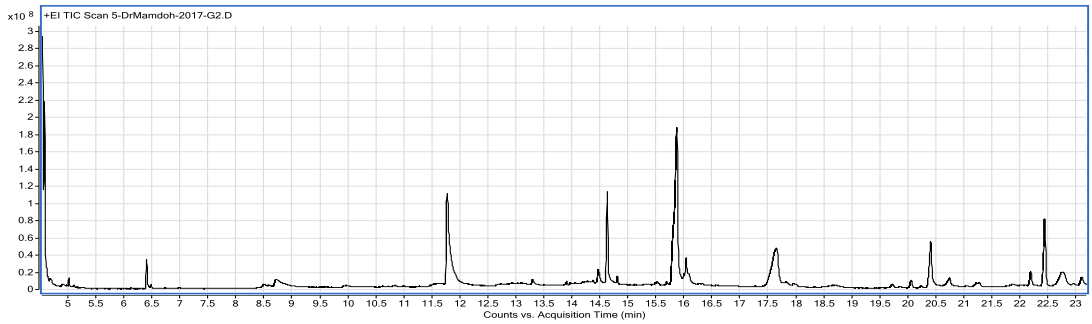

Fig. 5. GC/MS chromatogram for radish sprouts using saline water with SC yeast

Table 6. Phytochemical compounds identified in the ethanolic extract of Egyptian radish seeds and its sprouts using tap and saline water and with *Saccharomyces cerevisiae* yeast

NO	R.T	Name	Area sum %				
			Seed	TW	TW+*Sacch.*	SW	SW+ *Sacch*
1	4.574	3-Methylmercaptopropanoic acid	8.76	9.46	1.85	1.07	7.12
2	4.676	Glycol dimercaptoacetate	0.94	1.20	0.39	0.33	1.29
3	4.997	5,3'-Dihydroxy-6,7,4'-trimethoxyflavone	0.92	0.56	0.38	0.59	0.59
4	5.002	5,7,3',4',5'-Pentahydroxyflavone	-	0.23	0.64	0.38	0.69
5	5.034	L-Cysteine	0.71	0.71	0.32	0.46	0.26
6	5.132	β-Curcumene	0.42	0.52	0.46	2.11	1.48
7	5.197	Tetrahydrothiophenesulfoxide	-	0.48	-	-	-
8	6.48	Phloroglucinol	-	0.83	0.69	0.65	0.59
9	6.566	Methoxyeugenol	0.53	0.70	1.08	0.32	0.60
10	7.083	.β-Terpinyl acetate	-	0.28	0.52	0.47	1.06
11	8.432	3(2H)-Isothiazolone, 2-octyl-	-	-	2.19	1.65	0.55
12	8.468	Thiophene, 2-butyltetrahydro-	-	2.13	3.50	4.28	2.01
13	8.697	4-Methylthio-3-butenyl isothiocyanate	-	4.26	1.62	1.10	1.22
14	10.766	diNonyl sulfide	-	1.06	1.00	0.33	0.78
15	11.173	α-d-Glucofuranosylbenzenesulfonate	1.78	0.78	8.17	16.06	12.42
16	11.78	4-tert-Butyl-o-Thiocresol	3.01	9.47	1.57	1.01	1.01
17	13.288	(+)-α-Tocopherol	1.40	1.75	1.35	0.75	1.24
18	13.895	Linoleic acid	2.85	1.55	1.67	1.58	1.49
19	14.461	Ascorbic acid, permethyl-	7.27	1.63	7.25	5.76	4.92
20	14.62	Eicosanoic acid	5.65	6.05	0.84	0.67	0.52
21	14.799	Oleic Acid	1.21	0.89	0.92	0.83	1.13
22	15.512	Isopropyl linoleate	1.37	-	31.32	3.86	-
23	15.883	Erucic acid	3.96	0.86	-	14.68	20.37
24	16.00	Biotin	-	1.52	-	-	-
25	16.017	Isolongifolol	-	27.38	1.27	-	-
26	16.03	Stearic acid	-	2.38	2.30	3.49	3.09
27	16.266	Quercetin 3,5,7,3',4'-pentamethyl ether	15.88	0.84	0.68	0.89	1.09
28	17.561	Squalane	2.92	-	4.63	4.79	-
29	17.667	Phytol	-	2.24	1.84	2.35	9.12
30	17.814	9-Octadecenamide, (Z)- (CAS)	-	-	0.79	-	-
31	17.94	22-Tricosenoic acid	-	0.74	-	0.55	0.46
32	18.67	γ-Sitosterol	21.88	-	0.87	2.40	2.17
33	19.708	cis-10-Nonadecenoic acid	-	0.85	-	1.23	0.95
34	19.847	Methyl nervonate	4.25	0.56	0.73	0.56	0.31
35	20.038	Octacosane	1.38	0.74	0.83	1.15	0.83

Table 6. Cont.

NO	R.T	Name	Area sum %				
			Seed	TW	TW+*Sacch.*	SW	SW+ *Sacch*
36	20.426	13-Docosenoic acid, methyl ester	5.92	5.54	7.94	4.74	5.10
37	20.731	Palmitic acid, ethyl ester	2.29	1.62	1.07	1.15	0.94
38	21.261	Phytanic acid	-	0.64	1.39	1.40	1.21
39	21.876	3'-Hydroxy-5,6,7,4'-tetramethoxyflavone	-	0.62	0.80	1.40	1.47
40	22.169	1-Hexacosanol	2.34	0.72	1.15	2.88	1.84
41	22.414	Heptadecane, 2,6,10,15-tetramethyl-	2.35	3.39	2.01	4.79	5.08
42	22.723	β-Sitosterol	12.05	3.07	2.90	5.09	2.92
43	22.939	cis-Vaccenic acid	-	0.87	1.11	0.54	0.50
44	23.07	Isovitexin	-	1.09	1.06	1.64	1.58

R.T: Retention time
(Tw):tap water, (TW+Sacch.):tap water + *Saccharomyces cerevisiae*, (SW):Slain water, (SW+SC):Slain water + *Saccharomyces cerevisiae* yeast

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تأثير عملية التنبيت بإستخدام المحفزات الحيوية وغير الحيوية على المكونات الكيميائية لبذور الفجل

[66]

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الموجـــــز

الإنبات هو وسيلة لتحسين الإنتاجية الزراعية وسهلة الإستخدام من قبل الأسر ذات الدخل المنخفض، خاصة مع إستخدام بعض المحسنات فى الإنبات لتحسين القيمة الغذائية لنبت البذور. فِى هذه الدراسة تم إختيار بذور الفجل المصرى نظرا لإرتفاع نشاط معدلات الأيض بعد الحصاد. تم بحث تأثير محفز غير حيوى (الماء المالح بإستخدام كلوريد الصوديوم بتركيزات مختلفة) ومحفز حيوى (*Saccharomyces cerevisiae*) على نبت الفجل المصرى. بعد الإنبات لمدة ستة أيام بإستخدام نوعى المحفزات، تم إجراء تحاليل لتقدير المكونات الكيميائية والتعرف على المركبات النباتية الكيميائية الثانوية بإستخدام أفضل تركيز من الملوحة، أظهرت النتائج كفاءة للتنبيت حيث كانت هناك زيادة ملحوظة فى بعض التحاليل مقارنة بالبذور مثل البروتين، الكربوهيدرات، بعض العناصروالأحماض الأمينية. إلى جانب أن الإنبات له تأثير إيجابى لظهور مركبات نباتية كميائية ثانوية مثل مركبات الفلافينويدز، التربينويدز والفينولات. هذه الدراسة والدراسات المتشابهة خطوة هامة إتجاه التطور كقيمة غذائية مضافة بإستخدام المحفزات الحيوية وغير الحيوية. ويمكن إستخدامها فى تطوير منتجات غذائية مبتكرة ذات تأثير مفيد لصحة الإنسان.

الكلمات الدالة: بذور الفجل، المحفزات، حيوي، غير حيوي

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