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Local grape cultivars in Egypt: exploring their potential health benefits

Cultivares de uva locales en Egipto: explorando sus posibles beneficios para la salud

Cultivares de uvas locais no Egito: explorando seus potenciais benefícios para a saúde

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Abstract

The biological activities of phytochemical compounds in grapes have recently attracted increasing attention due to their potential health benefits for humans. In this study, seven local grape cultivars of Egypt (Gharibi, Fayoumi, Bez El-Naka, Romy Ahmer, Edkawy, Matrouh Eswid and Baltim Eswid) were investigated to determine their phytochemical composition, antioxidant and antimicrobial activities. Tannins, total phenols, total flavonoids and resveratrol content of grape pulp and seed extract were measured. The 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging and the ferric reducing antioxidant power (FRAP) assays were used to determine the level of antioxidant activity. Polyphenolic compounds were identified using Liquid Chromatography-Tandem Mass Spectrometry Technique (LC-MS/MS). The findings revealed that, the Edkawy and Baltim Eswid cultivars presented the highest content of tannins in the seeds (0.68 and 0.65 %, respectively), and total flavonoids in the pulp and seeds (0.06 and 0.08 %, respectively). Baltim Eswid showed the best total phenols content (0.11 %) in the pulp. Overall antioxidant capacity of grape seed extracts was extremely superior to that of the pulp, where Baltim Eswid was the best in this concern. The maximum values of resveratrol for pulp and seed (46.24 and 307.12 mg.100 g^{-1}, respectively), were observed in Baltim Eswid. The main compounds found in the seed extract were the catechins, ranging from 26.51 % in Fayoumi to 35.8 % in Bez El-Naka. The study demonstrated that grape seed extract has antimicrobial properties with potential application as an antimicrobial agent in the industrial area and as an alternative treatment in the medical sector.

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Resumen

Las actividades biológicas de los compuestos fitoquímicos presentes en la uva han atraído recientemente una creciente atención debido a sus posibles beneficios para la salud humana. En este estudio, se investigaron siete cultivares locales de uva de Egipto (Gharibi, Fayoumi, Bez El-Naka, Romy Ahmer, Edkawy, Matrouh Eswid y Baltim Eswid) para determinar su composición fitoquímica y sus actividades antioxidantes y antimicrobianas. Se midieron los taninos, fenoles totales, flavonoides totales y resveratrol en la pulpa de uva y el extracto de semilla. Se utilizaron ensayos de eliminación de radicales 2,2-difenil-1-picrilhidrazilo (DPPH) y de potencia antioxidante reductora férrica (FRAP) para determinar el nivel de actividad antioxidante. Los compuestos polifenólicos se identificaron mediante cromatografía líquida-espectrometría de masas en tándem (LC-MS/MS). Los resultados revelaron que los cultivares Edkawy y Baltim Eswid presentaron el mayor contenido de taninos en las semillas (0,68 y 0,65 %, respectivamente) y de flavonoides totales en la pulpa y las semillas (0,06 y 0,08 %, respectivamente). Baltim Eswid presentó el mayor contenido de fenoles totales (0,11 %) en la pulpa. La capacidad antioxidante general de los extractos de semilla de uva fue extremadamente superior a la de la pulpa, siendo Baltim Eswid el mejor en este aspecto. Los valores máximos de resveratrol para la pulpa y la semilla (46,24 y 307,12 mg.100 g^{-1}, respectivamente), se observaron en Baltim Eswid. Los principales compuestos presentes en el extracto de semilla fueron las catequinas, con concentraciones que oscilaron entre el 26,51 % en Fayoumi y el 35,8 % en Bez El-Naka. El estudio demostró que el extracto de semilla de uva tiene propiedades antimicrobianas con potencial aplicación como agente antimicrobiano en el área industrial y como tratamiento alternativo en el sector médico.

Palabras clave: uva, fitoquímicos, resveratrol, antioxidante, catequinas, antimicrobiano, beneficios para la salud.

Resumo

As atividades biológicas dos compostos fitoquímicos presentes nas uvas têm atraído cada vez mais atenção devido aos seus potenciais benefícios à saúde humana. Neste estudo, sete cultivares de uva locais do Egito (Gharibi, Fayoumi, Bez El-Naka, Romy Ahmer, Edkawy, Matrouh Eswid e Baltim Eswid) foram investigadas para determinar sua composição fitoquímica e atividades antioxidantes e antimicrobianas.Foram medidos os teores de taninos, fenóis totais, flavonoides totais e resveratrol da polpa de uva e do extrato de semente. Os ensaios de sequestro de radicais 2,2-difenil-1-picril-hidrazila (DPPH) e de poder antioxidante redutor de ferro (FRAP) foram utilizados para determinar o nível de atividade antioxidante. Os compostos polifenólicos foram identificados pela técnica de cromatografia líquida-espectrometria de massas em tandem (LC-MS/MS). Os resultados revelaram que as cultivares Edkawy e Baltim Eswid apresentaram os maiores teores de taninos nas sementes (0,68 e 0,65 %, respectivamente) e flavonoides totais na polpa e nas sementes (0,06 e 0,08 %, respectivamente). A cultivar Baltim Eswid apresentou o melhor teor de fenóis totais (0,11 %) na polpa. A capacidade antioxidante geral dos extratos de sementes de uva foi extremamente superior à da polpa, sendo o Baltim Eswid o melhor nesse aspecto. Os valores máximos de resveratrol para polpa e semente (46,24 e 307,12 mg.100 g^{-1}, respectivamente), foram observados no Baltim Eswid. Os principais compostos encontrados no extrato de semente foram as catequinas, variando de 26,51 % em Fayoumi a 35,8 % em Bez El-Naka. O estudo demonstrou que o extrato de semente de uva possui propriedades antimicrobianas com potencial aplicação como agente antimicrobiano na área industrial e como tratamento alternativo no setor médico.

Palavras-chave: uva, fitoquímicos, resveratrol, antioxidante, catequinas, antimicrobiano, benefícios para a saúde.

Introduction

The need for "healthier" or "functional foods" is always rising, as maintaining health and preventing diseases that go beyond the requirements of basic nutrition are the main factors influencing consumer food choices today (Adefegha, 2017). Grape (*Vitis vinifera* L.) and products made from grapes are among the most important horticultural products in the world. Numerous nutrients and health-promoting substances are found in grape berries. The biological activities of grape phenolic compounds that link to human health advantages, such as antioxidant, cardioprotective, anti-cancer, anti-inflammation, antiaging, and antibacterial characteristics, have recently attracted increased attention (Xia *et al*., 2010). Many factors, including genotype, cultivation techniques, vineyard characteristics (soil, sanitary stage), and climate, influence the content of polyphenols in grapes (Paredes-López *et al*., 2010). A member of the viniferins family of polyphenols, resveratrol (3,5,4′-trihydroxystilbene), a phytoalexin with a variety of physiological and biochemical characteristics, has anti-inflammatory, antiplatelet, and estrogenic effects, providing a range of health advantages (Perrone *et al*., 2017).

Antimicrobial resistance has become one of the major public health burdens in the 21st century and threatens the effective prevention and treatment of a variety of infections (Prestinaci *et al*., 2015). Antimicrobial compounds may be found in plants, and numerous researchers worldwide are examining the antimicrobial abilities of medicinal plants that are used in conventional or alternative healthcare systems (Vaou *et al*., 2021). Because of its antibacterial and antioxidant properties, grape extract is widely accepted as a safe food additive. The partial hydrophobicity of their phenolic components is what gives them their antibacterial properties (Rababah *et al*., 2004).

The genetic resources of local grapes vary across Egypt's governorates, demonstrating their ability to adapt to a wide range of environmental conditions; among these are black ones that have long been widespread along the Mediterranean coast under rain-fed conditions. The country has a rich history of grape cultivation, and local varieties are often tied to ancient agricultural practices and traditions. Different grape varieties may have unique nutritional profiles, including varying levels of antioxidants (resveratrol and flavonoids), vitamins, and minerals. Understanding how local grape varieties affect human health help highlight specific varieties that offer superior health benefits compared to others and could inspire innovative food products, supplements, or functional foods tailored to both local and global markets. Thus, the aim of this study was to investigate seven local grape cultivars to determine their phytochemical composition and antioxidant and antimicrobial activities and explore their potential application as antimicrobial agents in industrial and medical sectors.

Materials and methods

Plant Material

Matures berry of seven local grape cultivars in Egypt (Gharibi, Fayoumi, Bez El-Naka, Romy Ahmer, Edkawy, Matrouh Eswid and Baltim Eswid) were collected from Kaha Horticulture Research

Station (Kaluobia Governorate, Egypt) in the seasons of 2023 and 2024, and data were recorded as average of the two seasons. There were three grapevines (three years) for each cultivar. Standard fertilizer, irrigation, trimming, and disease and pest control were applied to every vine. From each vine, about 100 representative berries were taken. Before each sample was frozen and kept at -80 °C for additional processing, several measurements were conducted on grape berry included:

-Fresh weight of berry (g) as average of 100 berries.

-Seed yield % per berry as average of weighted 100 berries.

-Seed oil content (%): Fixed oil extraction was performed with a Soxhlet apparatus using n-hexane as the solvent (Gómez *et al*., 1996).

Phytochemical Assays

Grape pulp and seed were extracted by cold maceration (3 times, 24 hours) in ethanol (70 %). The extracts were vacuum-filtered and stored at -20 ˚C for further analysis.

Quantitative determination of tannins was performed by titrating the sample with a standardized solution of potassium permanganate in the presence of indigo carmine indicator (Atanassova & Christova-Bagdassarian, 2009). Total phenols content of grape pulp and seed extract were measured as described by McDonald *et al*. (2001) with minor changes, using the Folic Ciocalteu reagent assay with gallic acid as a reference standard. With little alterations, a colorimetric assay (Zhishen *et al*., 1999) was used to determine the total flavonoid concentration, catechin was used as a standard for the calibration curve. The 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging technique was performed according to Blois (1958), with little modifications. The scavenging effect of DPPH was reported as a percentage decline of absorbance in the presence of the tested extracts compared to the control reaction. The ferric reducing antioxidant power (FRAP) assay was used to determine the overall level of antioxidant activity (Quisumbing, 1978), the reducing power of the samples was compared with that of ascorbic acid used as standard.

Identification and Quantitative of Resveratrol by High Performance Liquid Chromatography

Identification of resveratrol (Nour *et al*., 2012) by High Performance Liquid Chromatography (HPLC) was carried out in the reverse phase mode. Separation was done after direct injection using C18 column (250 × 4.6 mm) with gradient elution (solvent (A): 2 % acetic acid, solvent (B): acetonitrile). Resveratrol was detected at a wavelength of 306 nm.

Phytochemical Analysis using Liquid Chromatography–Tandem Mass Spectrometry (LC–MS/MS) Technique

Identification of phytochemical compounds by LC -MS/MS was carried out in the reverse phase mode with C18 column. Separation was performed as follows; solvent A; 99 % water, 1 % acetonitrile and 0.1 % formic acid and solvent B; 99 % acetonitrile, 1 % water and 0.1 % formic acid. The flow rate was set to 0.4 $mL.min^{-1}$, column temperature at 20 °C and the injection volume of 3 µL (Jaitz *et al*., 2010).

Anti-Microbial Activity

For sample preparation, fresh grape seeds were ground to be powder. An amount of 5 g of dried powder of each cultivar separately was soaked in 10 mL of 95 % ethyl alcohol for 2 h with intermittent shaking and then filtered. The residue was re-extracted with addition of 95 % ethanol, and after 4 h it was filtered again. Combined filtrates were concentrated on a rotary evaporator at 45 °C for ethanol elimination, and the supernatant was collected and dried to be powder, 0.25 g of dried powder was dissolved in 1 mL serial water (solution) to be tested for the anti-microbial activity and to determine the most active extract.

Cultures of *E. coli* (ATCC 8739), *Staphylococcus aureus* (ATCC 6538), *Bacillus subtilis* (ATCC 6633), *Pseudomonas aeroginosa* (ATCC 9027) and *Candida albicans* (ATCC 10231) were prepared in accordance with the method of Wiegand *et al*. (2008), using a concentration of 100 $cfu.mL^{-1}$.

Screening of antimicrobial activity against grape seeds

Anti-microbial activity was screened using the agar well diffusion method as described by the National Committee for Clinical Laboratory Standards (NCCLS) according to Clinical and Laboratory Standards Institute (CLSI) (2008). The antibacterial activity was evaluated by measuring the zone of inhibition for each bacterial culture by the agar disk-diffusion method, as described previously (Balouiri *et al*., 2016). At the end of incubation period, diameter of inhibition zones (clear zone in the agar) was measured to the nearest millimetre.

Determination of minimum inhibitory concentration (MIC)

Determination of MIC was carried out using resazurin-based 96-well plate microdilution method (Karuppusamy & Rajasekaran, 2009). The MIC value was defined as the lowest concentration at which color change was observed.

Statistical analysis

The data were statistically analyzed in a complete randomized design (CRD) with three replicates using CoStat version 6.45 software. Difference within mean values was assessed using the Duncan multiple range test with a 0.05 probability (Waller & Duncan, 1969). The average means were reported, along with their standard errors (SE).

Results and discussion

Physico-chemical characteristics

There were significant differences between all the cultivars under study in berry weight, seed yield percentage, and seed oil content (table 1). Matrouh Eswid gave the heaviest berry weight (4.617 g), Gharibi exhibited the highest seed yield percentage (3.878 %) and both Baltim Eswid and Edkawy had the best seed oil content (5.787 and 5.701 %, respectively). On the contrary, the lowest values of berry weight (3.339 g), seed yield percentage (1.401 %) and seed oil content (1.696 %) were recorded with Gharibi, Matrouh Eswid and Romy Ahmer, respectively. The obtained results agreed with other studies for different grape cultivars (Gaser *et al*., 2023; Ahmed & Abd EL-Aziz, 2021; Martin *et al*., 2020).

Phytochemical composition of grapes pulp and seed extract

Gharibi cultivar exhibited high tannin content in the pulp (0.08 %), and Edkawy and Baltim Eswid cultivars gave high tannin content in the seed (0.68 and 0.65 %, respectively). Significant differences between the total phenols content (TPC) in the pulp extracts were observed and there were no appreciable variations in the seed extracts, which ranged from 1.38 to 1.45 %. The highest TPC in the pulp (0.11 %) was recorded with Baltim Eswid, on the contrary, Romy Ahmer gave the lowest TPC (0.03 %). Compared to pulp extracts, the total flavonoid content (TFC) was greater in the seed. The highest value for the TFC in the pulp and seed was found in the Edkawy and Baltim Eswid (0.058 and 0.08 %, respectively) (Table 2). This result agrees with those obtained by Wongnarat & Srihanam (2017) who reported that grape seeds are richer in phenolic compounds than the grape pulp. This may be due to the seeds acting as a reservoir for the development of the sprouts (Pająk *et al*., 2014).

Table 1. Berry weight, seed yield percentage and seed oil content for seven local grape cultivars.

Grape cultivars	Berry weight (g)	Seed yield (%)	Seed oil (%)
Gharibi	3.339±0.058d	3.878±0.069a	4.177±0.070d
Fayoumi	3.702±0.115c	2.359±0.023c	4.930±0.069c
Bez El-Naka	4.171±0.068b	2.823±0.064b	5.215±0.058b
Romy Ahmer	3.435±0.029cd	2.799±0.058b	1.696±0.060e
Edkawy	3.675±0.173c	2.454±0.075c	5.701±0.144a
Matrouh Eswid	4.617±0.052a	1.401±0.115e	5.003±0.002bc
Baltim Eswid	4.361±0.058ab	2.123±0.006d	5.787±0.063a

Data are mean value ± SE, different letters in the column indicate significant differences (p<0.05).

Generally, antioxidant capacity, represented by DPPH scavenging activity and ferric reducing antioxidant power (FRAP), of grape seed extracts was extremely superior comparable to that of the pulp (Table 2). Among all of the cultivars, Baltim Eswid exhibited the highest antioxidant potential for pulp and seed (0.13 and 48.36 % for DPPH, 0.48 and 51.48 $mg.g^{-1}$ for FRAP, respectively), while Gharibi gave the lowest values for pulp (0.01 % and 0.12 $mg.g^{-1}$ for DPPH and FRAP, respectively), whereas Romy Ahmer was the least for seed (17.92 % and 12.02 $mg.g^{-1}$ for DPPH and FRAP, respectively).

Our results agreed with those reported by Wongnarat & Srihanam (2017) who indicated that, the grape seed extracts contained higher amounts of total phenol contents than the pulp. Moreover, red grape cultivars had the highest phenols content followed by white grape cultivars. Elejalde *et al*. (2024) concluded that, among the phenolic compounds, grape seed contains mainly gallic acid, catechin, epicatechin, procyanidins and proanthocyanidins or condensed tannins, which are known for their antioxidant activity.

Resveratrol content

The results of HPLC chromatographic of resveratrol content in various local grape cultivars pulp and seed are presented in Figure (1 A and B).

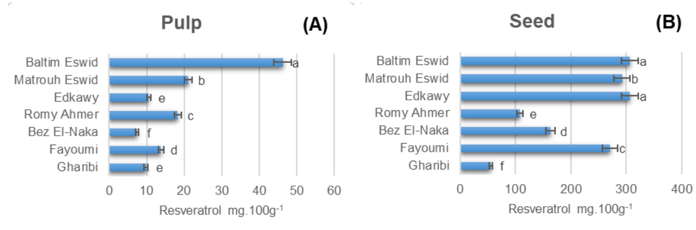

Figure 1. Resveratrol content in local grape genotypes pulp (A) and seed (B). Bars with different letters are significantly different at $p \leq 0.05$.

In general, the grape seed ethanolic extracts showed higher resveratrol values, which were approximately 12 times (on average) higher than all the grape pulp extracts. Baltim Eswid gave the highest resveratrol content for pulp and seed (46.235 and 307.119 $mg.100\ g^{-1}$, respectively). On the other hand, Bez El-Naka and Gharibi showed the lowest values for pulp (7.432 $mg.100\ g^{-1}$) and seed (55.271 $mg.100\ g^{-1}$). In this regard, Mohammadparast *et al*. (2024) concluded that, resveratrol is primarily present in grapes, and their concentrations can vary depending on grape cultivar.

Phytochemical analysis of grape cultivars seed ethanolic extract by LC-MS/MS

The proportional composition of the analyzed phytochemicals of the grape seeds extract (Table 3) revealed many differences between the samples in the percentage of polyphenols. Catechins (ctechin and epicatechin) were the main polyphenolic phytochemicals found in the ethanolic extract of grape seeds, whose values ranging between 26.51 % in Fayoumi and 35.8 % in Bez El-Naka. According to the standards used; catechin was higher in Gharibi, Bez El-Naka, Edkawy, Matrouh Eswid and Baltim Eswid representing 23.2, 22.2, 21.9, 22.1 and 18.0 %, respectively, while epicatechin was the most in Fayoumi and Romy Ahmer with 21.7 and 25 %, respectively. Other main compounds following catechins were caffeic in Fayoumi (25.3 %) and Gharibi (20 %), Narirutin in Bez El-Naka (22.2 %), Edkawy (21.9 %) and Baltim Eswid (21.3 %), and Rutin only for Romy Ahmer with 18.8 %. Results are corroborated by earlier studies (Karageçili *et al*., 2023).

Table 2. Phytochemical composition of grapes pulp and seed extract.

Grape cultivars	Tannins (%)	TPC (%)	TFC (%)	DPPH (%)	FRAP ($mg.g^{-1}$)
			Pulp		
Gharibi	0.08±0.060a	0.05±0.002d	0.004±0.001e	0.01±0.001e	0.12±0.011e
Fayoumi	0.02±0.001ab	0.08±0.006b	0.001±0.001f	0.12±0.002c	0.36±0.017c
Bez El-Naka	0.01±0.001b	0.06±0.001c	0.006±0.002d	0.12±0.001c	0.26±0.013d
Romy Ahmer	0.02±0.001ab	0.03±0.001e	0.006±0.001d	0.04±0.002d	0.14±0.011e
Edkawy	0.02±0.001ab	0.08±0.003b	0.058±0.003a	0.13±0.002b	0.43±0.007b
Matrouh Eswid	0.04±0.001ab	0.09±0.001b	0.031±0.002b	0.13±0.001b	0.43±0.009b
Baltim Eswid	0.02±0.001ab	0.11±0.010a	0.024±0.001c	0.13±0.003a	0.48±0.009a
			Seed		
Gharibi	0.49±0.012c	1.38±0.045a	0.07±0.001b	29.09±0.36f	25.48±0.44f
Fayoumi	0.33±0.005d	1.44±0.052a	0.05±0.001d	31.41±0.31e	33.47±0.37e
Bez El-Naka	0.45±0.013c	1.41±0.009a	0.07±0.003b	38.50±0.43d	35.74±0.04d
Romy Ahmer	0.34±0.024d	1.42±0.033a	0.05±0.001c	17.92±0.13g	12.02±0.03g
Edkawy	0.68±0.017a	1.38±0.017a	0.07±0.001b	41.78±0.19b	41.65±0.11c
Matrouh Eswid	0.56±0.011b	1.40±0.065a	0.07±0.001b	40.83±0.12c	44.32±0.36b
Baltim Eswid	0.65±0.023a	1.45±0.035a	0.08±0.001a	48.36±0.36a	51.48±0.35a

TPC; Total phenol content. TFC; Total flavonoid content. Data are mean value ± SE, different letters in the column indicate significant differences (p<0.05).

Table 3. Names, molecular ions, fragment ions and proportional composition of the phytochemicals (%) in ethanolic extract of grape seeds by LC-MS/MS analytical method.

Analytes %	MI (m/z)	FI (m/z)	Gharibi	Fayoumi	Bez El-Naka	Romy Ahmer	Edkawy	Matrouh Eswid	Baltim Eswid
Maleic	115.2	71.1	2.10	4.81	6.17	6.25	3.29	4.42	4.09
Coumarin	146.5	103	6.31	12.0	2.46	12.5	2.19	5.30	2.45
Gallic	169.2	125	13.7	1.20	2.46	6.25	6.6	5.30	7.37
Caffeic	179.3	59	20.0	25.3	14.8	12.5	18.7	18.6	12.3
Catechin	289.2	203	23.2	4.82	22.2	6.25	21.9	22.1	18.0
Isorhamnetin-3-o D-glucoside	349.3	315	4.21	1.20	9.87	6.25	9.89	13.3	5.73
Epicatechin gallate	439.5	289	5.26	21.7	13.6	25.0	6.59	6.19	12.3
Narirutin	577.7	271	12.6	20.5	22.2	6.25	21.9	12.4	21.3
Rutin	609.5	301	12.6	8.43	6.17	18.8	8.79	12.4	16.4

MI (m/z); molecular ions of the standard analytes (m/z ratio). FI (m/z); fragment ions.

Anti-microbial evaluation

Screening of antimicrobial activity against grape cultivars seed

In the current study, the evaluation of antimicrobial activity by the agar-well diffusion method indicated that all the tested organisms showed growth inhibition towards the grape seed extract, with differing sensitivity. Among the bacterial pathogens, *B. subtilis* is more sensitive when compared to other bacteria. Gram-positive bacteria exhibited more sensitiveness to grape seed extracts when compared to Gram-negative bacteria. The diameters of the inhibition zones of the microbial growth by the ethanolic extract of different grape seeds presented in table 4 revealed that, the investigated extracts were potentially effective in suppressing the growth of selected strains within the range of 11-25 mm.

Baltim Eswid seed extract had the highest growth-inhibitory action against all tested micro-organisms, with the highest activity being observed against *Candida albicans* with an inhibition zone diameter of 25 mm. On the other hand, Romy Ahmer seed extract had the lowest growth-inhibitory action against all tested micro-organisms. In our study the results were similar to those obtained by Ranjitha *et al*. (2014) in grape seed extracts. They reported that, grape seed extracts inhibited Gram-positive bacteria, such as *S. aureus* and *B. cereus* more easily than Gram-negative ones, such as *E. coli*.

The partially hydrophobic phenolic contents in grape seeds are thought to interact with the lipopolysaccharide and bacterial cell wall interfaces by reducing membrane stability (Shrestha *et al*., 2012). The antibacterial capabilities of grape seed extract have been found to be directly associated with its phenolic content (Baydar *et al*., 2006).

Minimum Inhibitory Concentration (MIC)

After 18 hours of incubation at 37 °C, the MIC, which is the lowest concentration of the test substances that prevented observable growth, was visually ascertained. The results recorded in table 5 showed that, the MIC of Gram-positive bacteria ranged from 4 - 64 $mg.mL^{-1}$, while Gram- negative bacteria was 8 - 128 $mg.mL^{-1}$. Baltim Eswid seed extract was the highest effect on all tested microorganisms with lowest MIC (4 - 8 $mg.mL^{-1}$). Numerous investigations have demonstrated the antibacterial action of flavan-3-ols. It is possible for catechins to bind to synthetic lipid bilayers (Caturla *et al*., 2003). Additionally, it has been found that epicatechin gallate and epigallocatechin gallate reduced β-lactam MICs to the antibiotic break point and functioned as norA gene suppressors, enhancing the antibacterial efficacy of those antibiotics (Stapleton *et al*., 2004).

Table 4. Antimicrobial screening of seed ethanolic extract of different grape cultivars.

Grape cultivars seed alcoholic extract	Inhibition zone diameter (mm)				
	Gram-positive bacteria		Gram-negative bacteria		Fungi
	S. aureus	*B. subtilis*	*E. coli*	*P. aeruginosa*	*C. albicans*
Gharibi	14±0.577c	16±0.58c	11±0.577c	18±0.58ab	15±0.87c
Fayoumi	14±0.289c	18±1.15bc	12±0.578c	19±1.15a	14±0.58c
Bez El-Naka	14±0.577c	19±0.57b	12±0.289c	16±0.57bc	14±1.2c
Romy Ahmer	14±1.155c	16±0.29c	11±0.433c	15±0.29c	13±0.57c
Edkawy	22±1.15ab	22±0.58a	17±0.462b	18±1.2ab	21±1.2b
Matrouh Eswid	20±0.577b	20±1.2ab	16±0.577b	18±0.43ab	20±0.29b
Baltim Eswid	23±0.289a	22±0.87a	21±0.434a	20±0.28c	25±0.58a

S. aureus (*Staphylococcus aureus*), *B. subtilis* (*Bacillus subtilis*), *E. coli* (*Escherichia coli*), *P. aeruginosa* (*Pseudomonas aeruginosa*) and *C. albicans* (*Candida albicans*). Data are mean value ± SE, different letters in the column indicate significant differences (p<0.05).

Table 5. Minimum Inhibitory Concentration (MIC) of grape seeds ethanolic extract against the tested organisms.

Grape cultivars seed alcoholic extract	Minimum Inhibitory Concentration (mg.mL^{-1})				
	Gram-positive bacteria		Gram-negative bacteria		Fungi
	S. aureus	*B. subtilis*	*E. coli*	*P. aeruginosa*	*C. albicans*
Gharibi	64±1.15a	32±0.69a	128±1.7a	16±0.57b	64±1.7a
Fayoumi	64±0.577a	32±0.58a	128±0.58a	16±1.2b	64±1.2a
Bez El-Naka	64±0.578a	16±0.43b	128±1.2a	32±0.58a	64±0.58a
Romy Ahmer	64±1.16a	32±0.57a	128±0.29a	32±0.29a	64±1.4a
Edkawy	8±0.289c	8±0.29c	64±1.1b	16±0.57b	8±0.57b
Matrouh Eswid	16±0.577b	16±0.43b	32±0.58c	16±0.43b	8±0.46b
Baltim Eswid	4±0.144d	8±0.58c	8±0.43d	8±1.1c	4±0.58c

S. aureus (*Staphylococcus aureus*), *B. subtilis* (*Bacillus subtilis*), *E. coli* (*Escherichia coli*), *P. aeruginosa* (*Pseudomonas aeruginosa*) and *C. albicans* (*Candida albicans*). Data are mean value ± SE, different letters in the column indicate significant differences (p<0.05).

Conclusion

The current study demonstrated that the main phytochemical components found in the seeds of seven local grape cultivars -phenols, flavonoids, and resveratrol in particular- are superior to those found in the pulp. The grape seeds showed a high rate of antioxidant activity in both DPPH radical scavenging and Ferric Reducing Antioxidant Power assays. The main compounds found in the ethanolic extract of grape seeds were catechins polyphenolic phytochemicals. Gram-positive bacteria exhibited more sensitiveness to grape seed extracts compared to Gram-negative bacteria. Finally, Baltim Eswid seed extract had the highest growth-inhibitory action against all tested microorganisms comparing to other tested local grape cultivars. This study highlights the potential of grape fruits as a sustainable source of bioactive molecules that contribute to the health benefits. The outstanding antioxidant activity observed in these local grape cultivars suggests they could play a significant role in combating oxidative stress-related diseases. Furthermore, the antimicrobial properties identified may offer promising avenues for natural preservative applications and alternative therapeutic options in food safety and health management.

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