

The effect of solvent extracts on the measurement of total polyphenol, flavonoid and tannin contents and its relation to antioxidant capacities from various parts of Terebinth (*Pistacia terebinthus* L.)

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Abstract

Currently there is much interest to find new natural antioxidants, especially antioxidants of plant-based. In order to discover the group of polyphenols, which could be a potential new and reliable source of natural antioxidants. The fruits, twigs and leaves of Terebinth (*Pistacia terebinthus* L.) were investigated for their phytochemical constituents, hydrolysable tannin contents, total polyphenol and flavonoid contents as well as antioxidant capacities. Twelve crude extracts were prepared from various parts of Terebinth using solvents of different polarity (water, ethanol, ethyl acetate and hexane). The hydrolysable tannin content (HTC) expressed in terms of tannic acid equivalent using the ammonium ferric citrate assay and total polyphenol and flavonoid contents (TPC and TFC) presented in terms of gallic equivalent using the Folin-Ciocalteu assay and in terms of catechin equivalent employing the aluminum chloride colorimetric method, respectively. Antioxidant capacities were carried by two different ways the TAC (phosphomolybdenum) and the DPPH (2,2-dyphenyl-1-picrylhydrazyl) scavenging. Screening tests revealed the existence of sterols, triterpenes, saponins, oses, holosides, tannins, flavonoids and reducing sugars. This study proved that the aqueous extract of Terebinth leaves is a wondrous natural antioxidant compared to standards (BHA and Quercetin). The results show a highly significant correlation between the HTC in relation to antioxidant capacities.

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1. Introduction

Many plants, particularly medicinal plants play great important roles in our daily life to treat many illnesses and ailments. However, research in medicinal plants reflects the acknowledgement of the validity of many natural product compounds. Plants have been an inexhaustible source of natural products and medicines [1]. Research in the last few years heavily supports in the role for polyphenols (also known as phenolic compounds) in the prevention of cardiovascular and neurodegenerative diseases, degenerative diseases especially cancers. Phenolic compounds are great antioxidants that supplement and enrich the functions of antioxidant enzymes and vitamins as a protection against oxidative stress due to excess reactive oxygen species. While most of the proofs of the antioxidant activity of polyphenols are based on in-vitro studies, the in-vivo increasing proof indicates they may act in ways beyond the functions of the antioxidant [2]. The three important groups of polyphenols (Phenolic acids, flavonoids and hydrolysable tannins) are the most important phytochemical group of plants. Extensive biological, pharmacological and chemical investigations of tannins hydrolysable, especially those of the ellagitannins and their congeners, as well as of related polyphenols of various constant structures, are modifying the concept and significance of tannins in human life. These findings are opening new avenues to classify and study the biological, pharmacological and chemical properties of tannins [3]. Although the Tannins exert diverse pharmacological effects, including the free radical scavenging, antioxidant activity, also they are cardio protective, anti-nutritional, antimicrobial, and anti-cancer properties. In addition, they are appear to apply beneficial impacts on metabolic disorders and prevent the emergence of various oxidative stress-related diseases [4]. Widely recent studies have focused on flavonoids from plant-based because of their versatile health benefits for humans. Many flavonoids are indicated to have free radicals scavenging capacity, antioxidant activity, coronary heart disease prevention, as well as anti-inflammatory, hepatoprotective, and anticancer activities, although a few flavonoids offer potential for antiviral activities [5]. For this very reason, we chose Terebinth among medicinal plants because it has rich in phenolic, although relatively abundant and widely employed in traditional medicine. Different parts of Terebinth have been reported having several traditional and medicinal utilizations, and pharmacological activities such as antioxidant, antidiabetic, antiviral, antimicrobial, antiseptic, diuretics, wounds, burns, stomach, mycosis, antidiabetic, stimulant, urinary inflammations, antihypertensive, treatment of jaundice, cephalalgic, antiprostatis, cold, flu, rheumatism and antidiarrhea [6-8]. The purpose of this research was undertaken with the main objective to screen the leaves, twigs and fruits of Terebinth to evaluate their phytochemical compounds. The hydrolysable tannin content, the total polyphenol and flavonoid contents along with the antioxidant activities of various solvent extracts from fruits, twigs and leaves of Terebinth, were evaluated to find the polyphenol group (flavonoids or hydrolysable tannins) that could be potential and reliable sources of new natural herbal antioxidants.

2. Material and methods

2.1. Plant material

The leaves, fruits and twigs of Terebinth were collected from Moulay Idriss Zerhoun a town in northern Morocco. The Geographical coordinate: N 33° 50' 50,4636" ; W 5° 19' 0,3972". The different parts (fruits, leaves, and twigs) of Terebinth were air-dried for twenty days at room temperature and then was powdered separately and stored prior to further use.

2.2. The water contents

2.2.1. Technical

The water content is given according to the French standard NF V 03-909. It corresponds to the loss of mass experienced by the sample after drying in an oven at temperature of 103 ± 2 °C to constant weight.

2.2.2. Calculation

The water content (w) expressed, as a percentage of the mass of the sample, is equal to: m_0 = stands for weight of the sample before drying. And m_1 = stands for weight of the sample after drying.

$$w(\%) = \frac{m_0 - m_1}{m_0} \times 100$$

2.3. Phytochemical screening

The phytochemical constituents from the leaves, fruits and twigs of Terebinth, were determined by different qualitative tests such as the anthraquinones, triterpenes, sterols, alkaloid, holosides, oses, as well as the flavonoids, saponins, mucilages, tannins and reducing sugars. The tests were performed by the methods described below: [9-10].

2.4. Crude extracts preparation

The various extraction methods were followed to prepare crude extracts of leaves, twigs and fruits from Terebinth, by different solvents (water, ethanol, ethyl acetate and hexane).

2.4.1. Aqueous extraction

For the aqueous extracts, powdered of 25 g for each plant parts (leaves, twigs and fruits) of Terebinth was extracted with boiling water (300 mL) for 6h. The aqueous extracts were filtered and evaporated.

2.4.2. Organic extraction

Soxhlet equipment was used in this work. Powdered plant material (25 g) was extracted with solvents of different polarity (ethyl acetate, hexane and ethanol) for 6h in about (300 mL).

2.5. Instrumentation

All spectrophotometric data were learned using SHIMADZU UVmin-1240 UV-VIS spectrophotometer. Glass cuvettes (1 cm × 1 cm × 4.5 cm).

2.6. Determination of total polyphenol content (TPC)

TPC in Terebinth extracts was determined spectrophotometrically using the Folin-Ciocalteu assay as set out by [11]. A volume of 0.3 mL of the crude extract from twigs, fruits and leaves of Terebinth (1 mg/mL) was added to 1.5 mL Folin-Ciocalteu reagent (10/100). The mixing was left to stand still for six minute in the dark, then a volume of 1.2 mL of Na_2CO_3 (7.5%) was added. The prepared samples of Terebinth were incubated in darkness for two hours, the absorbance made at wavelength of 760 nm. The data were presented on average \pm SD for the triplicates.

The TPC were calculated using the linear equation from the calibration curve (1) and were expressed in terms of Gallic acid equivalents (GAE) in mg/g of crude extract. Where A is the absorbance and B in mg/g (presented TPC).

$$A = 0.0099B + 0.0289 ; R^2 = 0.999 \quad (1)$$

2.7. Determination of total flavonoid content (TFC)

The TFC in Terebinth extracts was determined spectrophotometrically using the Aluminium Chloride (AlCl_3) assay as set out by [12]. Briefly, a volume of 2.4 mL of distilled water and 1 mL of Terebinth extract (1 mg/mL) was added to 0.3 mL of NaNO_2 (5%) solution. The mixing was left to stand still for six minute, followed by the addition of 0.3 mL of AlCl_3 (10%) and allowed to stand still for five minute, then a volume of 1 mL of NaOH (1M) was added . After teen minute of incubation, the mixture turned to pink and the absorbance made at wavelength of 510 nm. The data were presented on average \pm SD for the triplicates. The TFC were determined using the using the following linear

equation (2) and were presented in terms of Catechin equivalents (CE) in mg/g of crude extract. Where B in mg/g expressed TFC and A is the absorbance.

$$A = 0.0046B + 0.0315 ; R^2 = 0.999 \quad (2)$$

2.8. Determination of hydrolysable tannin content (HTC)

The HTC was determined spectrophotometrically using the Ammonium ferric citrate assay as set out by [13]. A volume of 0.2 mL of the crude extract from twigs, fruits and leaves of Terebinth (1 mg/mL) was added to 0.2 mL of ammonium ferric citrate (3.5 g/L), 1 mL of distilled water and 0.2 mL of ammoniac (20%) were mixed. After 10 min, the absorbance made at wavelength of 525 nm. The HTC were calculated using the linear equation from the calibration curve (3) and expressed in terms of Tannic acid equivalents (TAE) in mg/g of crude extract. V

$$A = 0.0014B - 0.006 ; R^2 = 0.997 \quad (3)$$

2.9. Antioxidant activities

2.9.1. TAC total antioxidant capacity assay

TAC in the Terebinth extracts was based to use the phosphomolybdenum according to the protocol described by [14]. A volume (0.3 mL) of each sample was mixed with 3 mL from reagent solution (28 mM Na₃PO₄, 0.6 M H₂SO₄ and 4 mM (NH₄)₆Mo₇O₂₄). The samples prepared in the tubes incubated during 90 min at 95°C. After cooling, the absorbance made at wavelength of 695 nm against the white (methanol) and is incubated within the same basic conditions as the samples. The TAC assay calculated using the linear equation from the calibration curve (4) and presented in terms of ascorbic acid equivalents (AAE) in mg/g of crude extract. Where A is the absorbance and B in mg/g (presented TAC).

$$A = 0.0027B + 0.0117 ; R^2 = 0.999 \quad (4)$$

2.9.2. DPPH free radical scavenging activity assay

The Antioxidant activity of Terebinth extracts was conducted following the method [15]. Briefly, a volume of 0.05 mL of the crude extracts was added to 1.95 mL of DPPH solution freshly prepared (24 mg of DPPH in 100 mL ethanol). After 1/2 hours of the incubation of samples in darkness, the absorbance made at wavelength of 515 nm, with a positive control (BHA and Quercetin). The percentages of inhibition (I%) were determined to employ the equation (5):

$$I(\%) = [(A_{\text{Control}} - A_{\text{Test}})/A_{\text{Control}}] \times 100 \quad (5)$$

The antioxidant capacity has been expressed from the IC₅₀ value, which is the concentration of the antioxidant (Terebinth extract) that is necessary to trap 50% of DPPH in the test solution. The efficient concentration EC₅₀ was expressed in terms of the concentration of sample extract used for the test (mg/ml) and the quantity of extract in relation to the original amount of DPPH (mg/mg DPPH), following to the formula (6).

$$EC_{50} = [IC_{50}(\text{mg/mL}) / \text{Concentration of DPPH}(\text{mg/mL})] \quad (6)$$

For rational reasons of clarity, the antiradical power ARP was given as the reciprocal value of the efficient concentration EC₅₀, following to the equation (7) [16].

$$ARP = 100/EC_{50} \quad (7)$$

2.10. Statistical analyses

All tests were conducted in triplicates and the data were given on an average \pm SD. The result was statistically examined according one-way ANOVA with Duncan's assay. Average values were provided statistically significant when $P < 0.05$. The correlation between the contents of hydrolysable tannin, total polyphenol, total flavonoid, and antioxidant activities was determined as Pearson's correlation coefficient.

3. Results and discussion

3.1. The water contents

The results of the water contents (Figure 1) of different parts (twigs, leaves and fruits) of Terebinth reveal a significant ($p < 0.05$) difference between the different parts of Terebinth. From the results, we find that our plants are rich in water like most plants. The fruits have a higher water contents compared to the leaves and twigs of Terebinth.

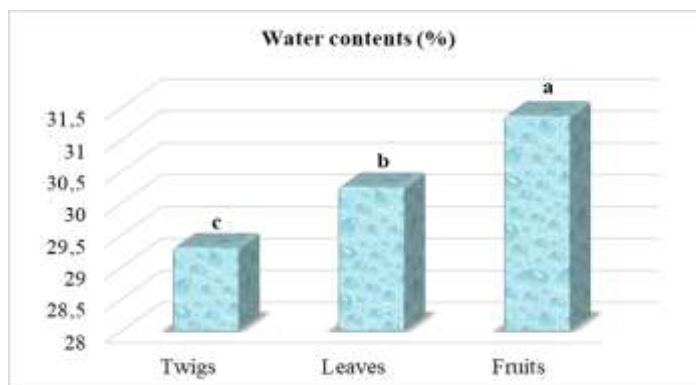


Figure 1. The water contents between the different parts (twigs, leaves and fruits) of Terebinth; Means with different letters in the columns are significantly different ($p < 0.05$).

3.2. Phytochemical screening

The phytochemical screening of the leaves, twigs, and fruits from Terebinth, (Table 1) showed the high presence of oses, holosides, tannins, flavonoids, saponins, sterols, triterpenes and reducing sugars, as well as low presence of anthraquinones combined and mucilage. Although, the alkaloids and the anthraquinones free present in twigs but absent in the fruits and leaves.

Table 1. Results of the phytochemical screening of Terebinth (leaves, twigs and fruits)

Phytoconstituent	Test	Terebinth		
		Twigs	Leaves	Fruits
Alkaloides	Dragendorff's and Mayer's	++	----	----
Tannins Catechics	Stiansy reaction	+++	+++	++
Tannins Gallics	Lead acetate	+++	+++	+++
anthraquinons Free	Borntrager's	----	+	----
Anthraquinons combined	O-heterosides	----	+	+
	Reduced Genins	+	----	----
	C-heterosides	+	----	----
Flavonoids	Shinoda's	++	+++	++
Saponins	Foam Index : positive if >100	+++ 200	+++ 200	++ 100
Sterols and Triterpenes	Liberman-burchard	+++	+++	+++
Oses and holosides	saturated alcohol with thymol	+++	+++	++
Mucilages	Alcohol 95%	+	+	+
Reducing sugars	Fehling's	+++	+++	++
Coumarines	Fluorescence	----	----	----
High concentration (+++) ; moderate concentration (++) ; low concentration (+) ; absence (----)				

3.3. Extraction yields of *Terebinth*

It is obvious through observing the extraction yields presented in Figure 2, they differ significantly ($p < 0.05$) on the one hand, according to the plant parts, on the other hand, the solvent used. Methanol gives the best extraction yield an average of 28.06% on three samples (leaves, fruits, and twigs) of *Terebinth*, followed by ethanol and water, while ethyl acetate and hexane gives the lowest yields of 12.09% and 11.35% on average, respectively. As for the plant parts usually, regardless of the extraction solvent, the extracts of *Terebinth* leaves recorded the highest yields. With the exception of hexane extracts, the best yields are given for *Terebinth* fruits.

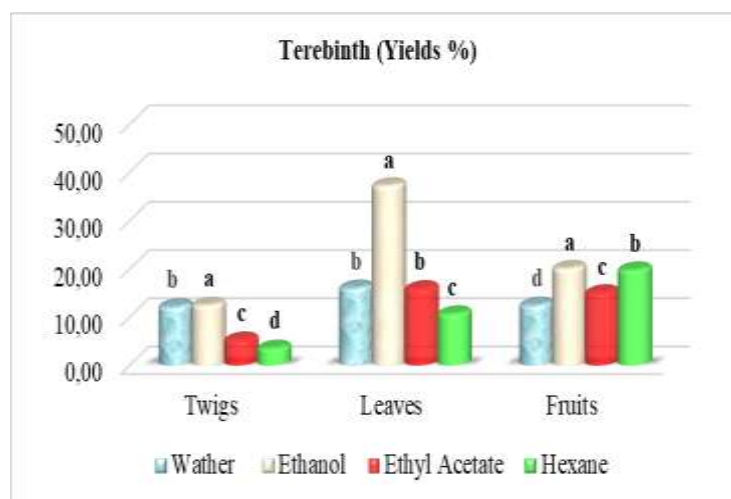


Figure 2. Yields of the extracts from various parts of *Terebinth*; Mean values \pm standard deviations of triplicate determinations are reported; Means with different letters in the columns are significantly different ($p < 0.05$).

3.4. Total polyphenol content (TPC)

The results of the TPC in all twelve studied extracts of the leaves, twigs, and fruits from *Terebinth* with different solvents (Table 2) reveal a significant ($p < 0.05$) difference between the different solvents. The higher distinction among the leaves, fruits, and twigs of *Terebinth* appears due to the wealth of some and the poverty of others, and could also be attributed to extraction solvents employed. The results revealed that the *Terebinth* plant are very rich in TPC. Water gives the best extraction of phenolic compounds an average of 331.53 mg of GAE/g of extract on three samples (leaves, fruits, and twigs) of *terebinth*, followed by ethyl acetate and ethanol, while the hexane gives the lowest amount of phenolic compounds (ranged between 88.98 to 39.88 mg of GAE/g of extract). There are several studies have confirmed that the genus *Pistacia* is rich in phenolic compounds, this wealth this varying with the variation of the polarity from extraction solvents used [17-19]. On the other hand, due to their good solubilities of different plant parts. The results obtained in Table 2 show that the TPC of *Terebinth* fruits increases as and when the polarity of extraction solvents used increases (varied from 39.88 to 254.59 mg of GAE/g of extract). However, the TPC of *Terebinth* twigs is great in ethyl acetate extract with a value of 319.62 mg of GAE/g of extract, followed by aqueous, ethanolic and hexanic extracts with a values of 305.09, 201.97 and 82.18 mg of GAE/g of extract, respectively. As regards of *Terebinth* leaves their TPC is higher in the aqueous extract with a value of 434.89 mg of GAE/g of extract, followed by ethyl acetate, ethanolic and hexanic extracts with a values of 230.53, 196.32 and 88.98 mg of GAE/g of extract, respectively. It can be concluded that higher TPC from all parts (leaves, fruits, and twigs) of *Terebinth* depends on the polarity of the solvents used this means that they depends to their good solubilities in the extraction medium.

Table 2. Total polyphenol contents (TPC), Total flavonoid contents (TFC), hydrolysable tannin content (HTC), total antioxidant capacity (TAC) and anti-radical power (ARP) of the extracts from various parts of Terebinth*

Bioactive compounds of Terebinth		TPC (mg GAE/g)	TFC (mg CE/g)	HTC (mg TAE/g)	Antioxidant activities	
					TAC (mg AA/g)	DPPH (ARP)
Aqueous extract	Twigs	305.09 ± 0.04 ^c	74.89 ± 0.19 ^f	134.76 ± 0.63 ^c	339.02 ± 1.32 ^c	12.73 ± 0.04 ^e
	Leaves	434.89 ± 1.30 ^a	119.24 ± 0.14 ^a	262.38 ± 1.75 ^a	493.96 ± 1.48 ^a	26.75 ± 0.05 ^a
	Fruits	254.59 ± 0.04 ^d	63.23 ± 0.10 ^h	90.71 ± 0.95 ^e	293.72 ± 0.66 ^d	07.40 ± 0.06 ^f
Ethanollic extract						
	Twigs	201.97 ± 0.76 ^c	73.30 ± 0.34 ^g	87.86 ± 0.48 ^f	209.40 ± 1.65 ^f	03.76 ± 0.00 ^g
	Leaves	196.32 ± 0.90 ^f	75.11 ± 0.58 ^f	109.05 ± 0.79 ^d	226.43 ± 0.66 ^e	03.44 ± 0.03 ⁱ
Ethyl acetate extract	Fruits	177.66 ± 0.49 ^g	79.17 ± 0.77 ^e	67.38 ± 0.63 ^h	205.94 ± 0.33 ^g	02.99 ± 0.02 ^j
Hexanic extract	Twigs	319.62 ± 0.94 ^b	105.69 ± 0.53 ^b	149.76 ± 1.75 ^b	387.05 ± 1.07 ^b	13.42 ± 0.02 ^d
	Leaves	200.63 ± 0.54 ^c	102.72 ± 0.58 ^c	82.86 ± 1.43 ^g	210.14 ± 0.66 ^f	03.65 ± 0.01 ^h
	Fruits	117.80 ± 0.40 ^h	101.05 ± 0.48 ^d	41.43 ± 0.95 ⁱ	131.99 ± 1.32 ^h	00.56 ± 0.00 ^k
Standards						
	Twigs	82.18 ± 0.49 ^j	59.75 ± 0.48 ⁱ	7.62 ± 0.32 ^k	85.32 ± 0.33 ^j	00.08 ± 0.00 ^m
	Leaves	88.98 ± 0.72 ⁱ	48.66 ± 0.53 ^j	28.10 ± 0.63 ^j	110.26 ± 0.25 ⁱ	00.14 ± 0.00 ^l
	Fruits	39.88 ± 0.22 ^k	11.92 ± 0.68 ^k	8.10 ± 0.63 ^k	67.42 ± 0.33 ^k	00.07 ± 0.00 ^m
	Quercetin					24.03 ± 0.01 ^b
	BHA					15.37 0.01 ^c

*Mean values ± standard deviations of triplicate determinations are reported. Means with different letters in the columns are significantly different ($p < 0.05$).

3.5. Total flavonoids content (TFC)

The results of the TFC in all twelve studied extracts of different parts of Terebinth with different solvents (Table 2) reveal a significant ($p < 0.05$) difference among the various solvents. The TFC of twigs, leaves and fruits extracts of Terebinth with different solvents, ranged from 59.75-105.69, 48.66-119.24 and 11.92-101.05 mg of CE/g of extract, respectively. The variations of TFC between various solvent extracts might be attributed to the varied polarity of the solvents used, while difference of TFC between plant parts might be linked to the chemical composition of the plant parts and their good solubilities in the extraction medium.

3.6. Hydrolysable tannin content (HTC)

Results of the HTC in all fifteen studied extracts of different parts of Terebinth with different solvents (Table 2) reveal a significant ($p < 0.05$) difference between the different solvents. The results obtained in table 2 show that the HTC of Terebinth leaves increases as and when the polarity of extraction solvents used increases (varied from 28.10 to 262.38 mg of TAE/g of extract). However, the HTC of Terebinth twigs is great in ethyl acetate, aqueous and ethanolic extracts with values of 149.76, 134.76 and 87.86 mg of TAE/g of extract, respectively. As well as a low value of the hexanic extract with a 7.62 mg of TAE/g of extract. As regards of Terebinth fruits their HTC is higher in the aqueous extract with a value of 90.71 mg of TAE/g of extract, followed by ethanolic, ethyl acetate, and hexanic extracts with a values of 67.38, 41.43 and 8.10 mg of TAE/g of extract, respectively.

3.7. Antioxidant activities

3.7.1. TAC total antioxidant capacity assay

The results of the TAC for studied extracts of different parts from Terebinth with different solvents (Table 2) show a significant ($p < 0.05$) variance among the various solvents. Water give the best extraction yield an average of 375,57 mg AA/g of extract on three samples (leaves, fruits, and twigs) of Terebinth, followed by ethyl acetate and ethanol, with an average of 243.06 and 213,92 mg AA/g of extract, respectively. While hexane give the lowest yield with an average of 87.67 mg AA/g of extract. The TAC indicates the overall antioxidant activity of a plant, that is, its ability to neutralize free radicals in the human body. In general, the greater the TAC value, the more antioxidant it is.

3.7.2. DPPH Free radical scavenging assay

The antioxidant activity of crude extracts from Terebinth is investigated by the free radical DPPH reduction method. DPPH radical scavenging assay is relatively a rapid and sensitive method to estimate the antioxidant activity of a specific compound or plant extract [20]. In this test, the antioxidant activity is measured colorimetrically in terms of IC_{50} . For rational reasons of clarity, the antiradical power ARP was determined. The higher ARP values reflect the greater potency for antioxidant activity of the extracts. The results obtaining as given in table 2. From these results, the greatest antioxidant activity was found in aqueous extract of Terebinth leaves (ARP: 26.75), who is greater than the two standards: the quercetin (ARP: 24.03) and the BHA (ARP: 15.37) with a significant ($p < 0.05$) variance. However, the aqueous and ethyl acetate extracts of Terebinth twigs were found a moderate antioxidant activity (ARP ranged between 0.56-13.42), while no remarkable antioxidant capacity was found in the hexanic extracts of fruits, twigs and leaves from Terebinth with an ARP of 0.07, 0.08 and 0.14, respectively.

3.8. Correlation

The dependency of antioxidant capacities obtained through each assay, in relationship to the HTC, TFC and TPC, was also evaluated Figure 3, Figure 4, Figure 5 and Table 3. The results show a highly significant correlation in the cases of DPPH scavenging activity ($R^2 = 0.889$) and TAC ($R^2 = 0.989$), in relationship to the TPC. Although, a good correlation existed among the antioxidant activities assessed by DPPH assay and HTC for $R^2 = 0.920$, and between the TAC assay and HTC for $R^2 = 0.938$. There were no significant correlations found between TFC and DDPH radical scavenging ($R^2 = 0.377$), and TFC with TAC ($R^2 = 0.553$). It means, there were no flavonoid compounds which are responsible to the antioxidant potential in Terebinth extracts. The results indicated that the phenolic compounds, especially the hydrolysable tannin in the different parts of Terebinth could be the main contributor to the antioxidant activities. Many previous studies have confirmed the positive correlation between antioxidant activity and the contents of total phenolic [19, 21-24].

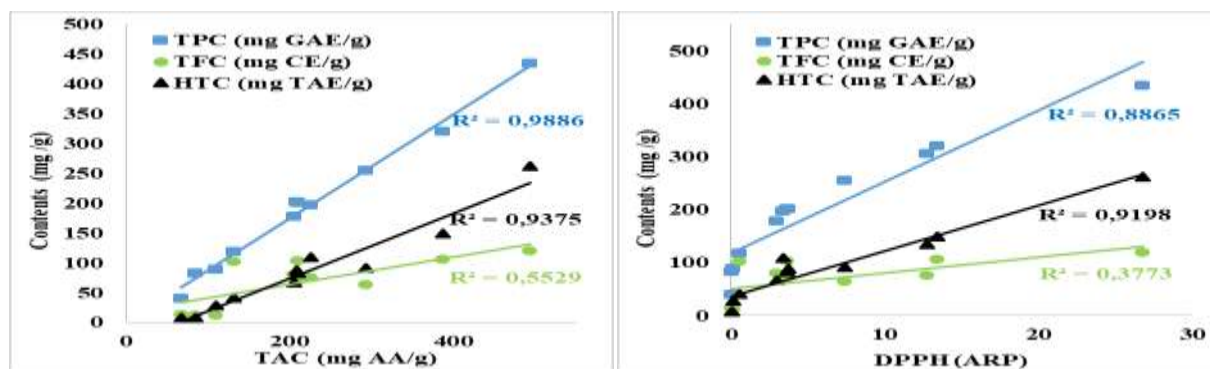


Figure 3. Linear regression between the antioxidant activities (TAC and DDPH) and contents of total phenolic (TPC), flavonoid (TFC) and tannin (HTC).

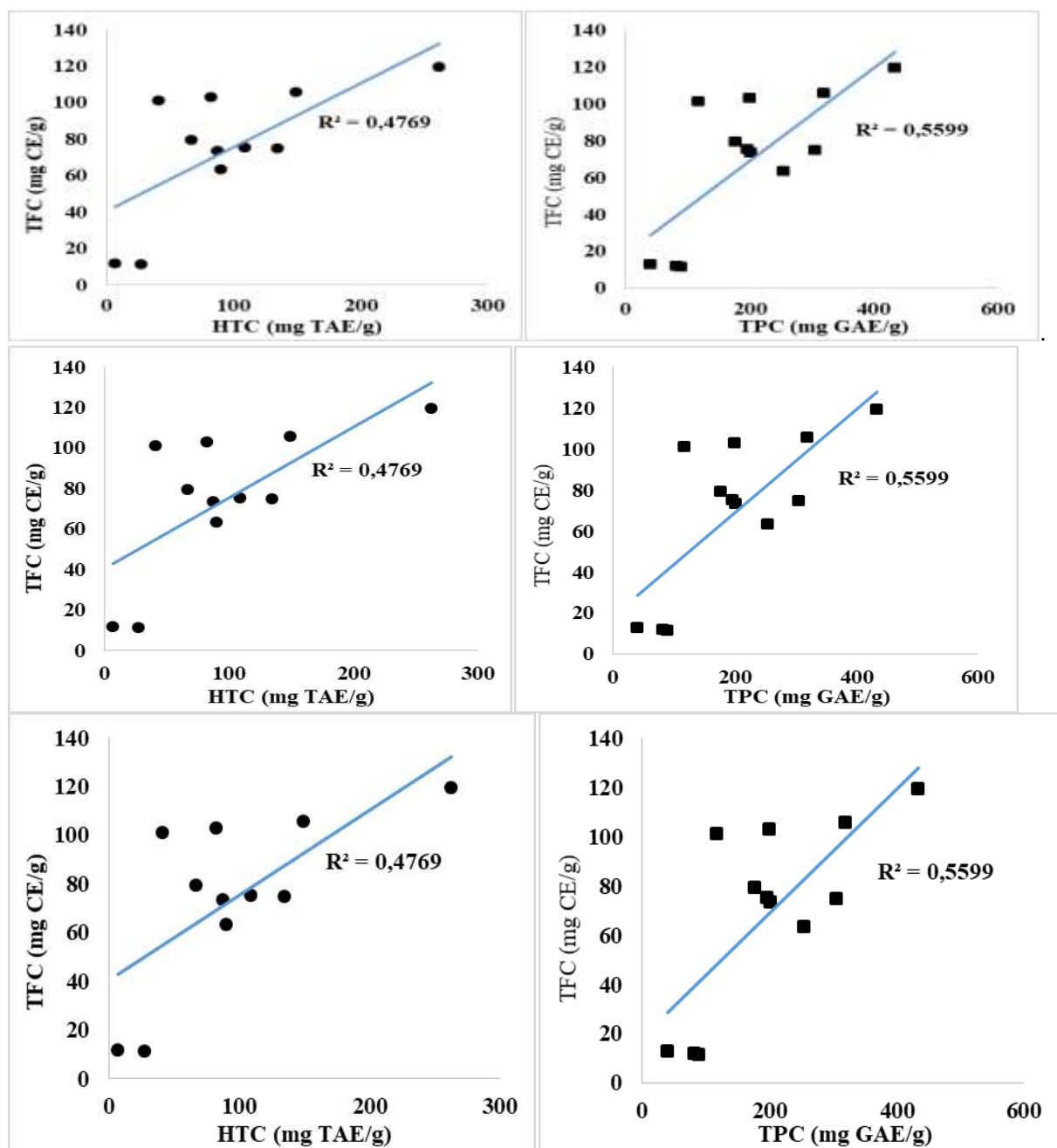


Figure 4. Linear regression between TFC and HTC, and between TFC and TPC.

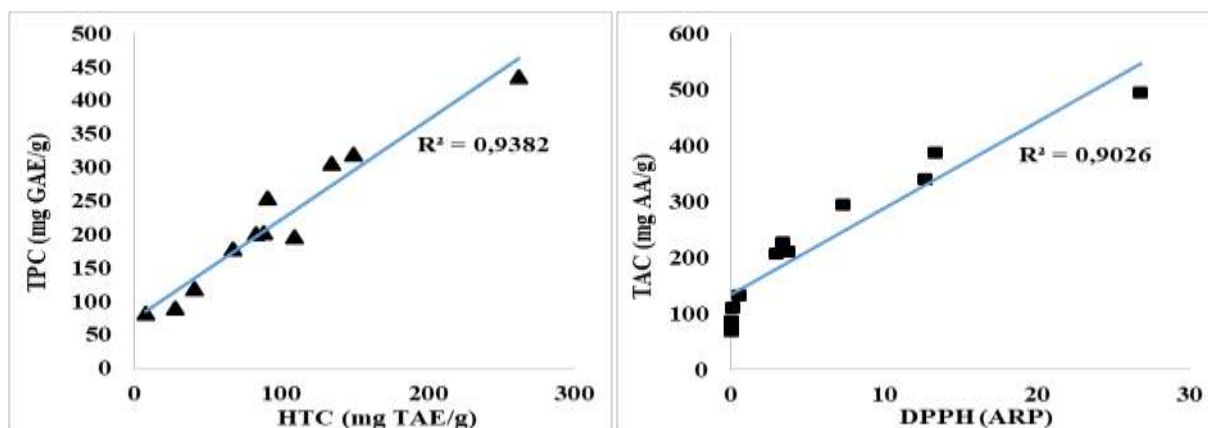


Figure 5. Linear regression between the TPC assay and HTC, and between the TAC and DPPH.

Table 3. Pearson's correlation coefficient of antioxidant activities (TAC and DDPH) and total phenolic contents (TPC), total flavonoid contents (TFC), and hydrolysable tannin contents (HTC).

	Correlation coefficient R ²	TFC	TPC	HTC	TAC	DDPH
TFC	1					
TPC	0.560	1				
HTC	0.477	0.938	1			
TAC	0.553	0.989	0.938	1		
DDPH	0.377	0.889	0.920	0.903	1	

4. Conclusions

In this work, we have opted for the study of the phytochemical screening and to determine the hydrolysable tannin contents, total phenolic contents and total flavonoid contents. As well as the antioxidant activities by DPPH and TAC assays from the leaves, twigs and fruits of Terebinth, collected in northern Morocco. The present study revealed that the employ of different solvents polar in extraction had a big influence significantly ($p < 0.05$) on the hydrolysable tannin content, the total phenolic and flavonoid contents along with the antioxidant capacities of obtained extracts. The results show a highly significant correlation in the cases of antioxidant activities in relationship to the hydrolysable tannin content and the total phenolic contents. The aqueous extracts of Terebinth leaves had the highest contents of a phenolic compound, the hydrolysable tannin contents and the greatest antioxidant activity in the DPPH and TAC assays. This work proved that the different parts from Terebinth rich on hydrolysable tannin content could be a potential natural and reliable source of antioxidants, and can have greater importance as a natural antioxidant. Although further studies are necessary to better clarify the molecules of tannins biological active and their beneficial roles in human health.

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