Phytochemical study, polyphenols determination and evaluation of antioxidant activity of *Origanum compactum* and *Satureja calamintha nepeta* from the region of Ouazzane (Morocco)

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Abstract: Among natural remedies, aromatic and medicinal plants constitute an essential source that deserves scientific attention. Thus, our study aims to promote the virtues of two aromatic and medicinal plants found in the wild in the region of Ouazzane (Morocco). The phytochemical tests of these species have shown the presence of flavonoids, gallic and catechic tannins, cyanidin, sterols and triterpenes. However, alkaloids, carotenoids, saponosides and reducing compounds were not detected. Then, extraction of total polyphenols from *Origanum compactum* and *Satureja calamintha nepeta* was conducted for 48 hours by maceration with a mixture of methanol/water (80/20) used as a solvent. Extractions yielded 35.2% crude extracts for *Origanum compactum* and 34.4% for *Satureja calamintha nepeta*. The fractionation of these crude methanol extracts was performed with three organic solvents of increasing polarity (chloroform, ethyl acetate and n-butanol). Total phenol content of the extracts and fractions was assessed by the method of Folin-Ciocalteu. This revealed that the phenol-rich fractions were the crude extract for *Origanum compactum* and the butanol fraction for *Satureja calamintha nepeta*. Finally, the evaluation of the antioxidant power which was carried out using the method of trapping the free radical DPPH and the reduction of iron by the method of FRAP. The DPPH test showed a high antioxidant activity of the samples: 53.1 µg/ml of crude extract of *Origanum compactum* was needed to reduce 50% of DPPH. The same IC50 was obtained for ascorbic acid (standard antioxidant). For *Satureja calamintha nepeta*, the IC50 was 67.5 µg/ml. On the other hand, the FRAP test revealed that the methanolic extract of *origanum compactum* has higher reducing power than that of n-butanol extract of *satureja calamintha nepeta*. Still, it remains relatively low compared to ascorbic acid. The high antioxidant activity of these two species could justify their use in traditional medicine for the treatment of many diseases.

Keywords: Medicinal plants; *Origanum compactum*; *Satureja calamintha nepeta*; phytochemical study; polyphenol; antioxidant activity; Ouazzane.

1. Introduction

Medicinal plants have always been an essential source of medicines. They continue to significantly meet people’s need despite the growing influence of the modern health system. Moreover, plants are being sought as sources of natural antioxidants since the use of synthetic antioxidants is currently being questioned because of their potential toxicological risks 1,2.

Besides, the interest for medicinal plants is supported by their therapeutic properties that are due to hundreds or thousands active ingredients contained therein. These bioactive compounds predominantly belong to secondary metabolites such as polyphenols, components of essential oils and alkaloids 3. Their role as natural antioxidants is attracting more interest in research areas related to the prevention and the treatment of cancer, inflammatory and cardiovascular diseases 4.

In this context, we worked on the valorization of extracts from two medicinal plants *Origanum compactum*, and *Satureja calamintha nepeta* grow naturally in Ouazzane region (Morocco). Both species belong to the *Lamiaceae* family which encompasses about 210 genera and 4000 species of dicots 5.

In Morocco, both species could be found in the middle atlas, the rif and the Atlantic side of the country and can be recognized by their botanical features. *Origanum compactum* is a perennial plant (30 to 80 cm) with ovate-ovoid, hairy leaves attached to pubescent hairy stems. The purple inflorescences are structured in dense and short spikes. The floral bracts are oval-lanceolate rigid and leathery. They

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protect a large flower that consists of 5-sepal ciliated calyces and 5-petal corollas. *Origanum compactum* is used against colds, flu, ENT disorders and bronchitis. It is also used against mouth sores and inflammation (mouth ulcers and gingivitis) 6.

*Satureja calamintha Nepeta* is also a perennial plant (40 cm- height). It exhibits soft and hairy stems that carry opposite and slightly serrated leaves attached with the medium petiole. Its menthol scent can also recognize the species. It is widely popular in Morocco as a remedy for coughs, flatulence, indigestion, and mild respiratory infections. This plant has antiseptic, antispasmodic and carminative properties 7.

We are interested in the study of the species *Satureja calamintha Nepeta* which is very appreciated in Morocco as a remedy and which grows spontaneously in the region of Ouazzane (masmouda). This very abundant species in this mountainous region 7 and used frequently by the local population. During our ethnobotanical 8 survey, we noticed that the local population uses *satureja calamintha nepeta* as a medicinal plant to treat indigestion and mild respiratory tract infections. This plant has antiseptic, antispasmodic and carminative properties 9.

Previous studies on the Lamiaceae have shown their richness in a vast range of compounds such as terpenoids, phenolics and flavonoids 10. We also have performed a phytochemical investigation of the species from Ouazzane which were not yet studied. We have conducted the quantification of phenolic contents in *Origanum compactum* and *Satureja calamintha Nepeta* extracts. For this, we are interested in the phytochemical study and the quantification of the contents in phenolic compounds of the extracts of *origanum compactum* and *Satureja calamintha nepeta* and the evaluation of their antioxidant power by the method of DPPH 11 and FRAP as a contribution to finding efficient antioxidant from natural sources.

2. Material and methods

2.1. Plant material: species selection
As a contribution to the valorization of Ouazzane plant biodiversity, we have studied two species: *Origanum Compactum* and *Satureja calamintha Nepeta* (Lamiaceae) 11,12. This choice was based on information that we have gathered through bibliographic work. It also relies on the results of our previous ethnobotanical survey with the local population on plant uses in traditional medicine (the traditional use in the treatment of diseases) 11. The abundance of the species in the region was also taken into account.

2.2. Harvesting, geographical location, identification and conservation:
*Origanum compactum* and *Satureja calamintha nepeta* were manually collected in June 2015 in Ouazzane, precisely in Masmouda area, Morocco. This area is well known for its abundance of aromatic and medicinal plants.

Ouazzane is a city of approximately 1861.2 Km². It is located in the Moroccan north-west (Latitude 34°48'36"N and Longitude 54°43'48"W). It is situated between the rugged hills of the pre-Rif and the agricultural plain of Gharb. The Loukous river limits the South-west of the region. Ouazzane territory is subdivided into several zones, namely: Masmouda, Rhouna, Ghzaoua and Beni Mestara.

Herbaria of both species have been prepared, and then, the species were identified by Professor M. Benattou at the scientific institute of Rabat.

The harvested samples of *Origanum Compactum* and *Satureja calamintha Nepeta* were then shade dried at room temperature for fifteen days to preserve as much as possible the integrity of their molecules.

2.3. Phytochemical study

2.3.1. Determination of water content
The determination of the water content corresponds to the loss of mass of the sample after heating in an oven at 105 ± 5°C in an isothermal oven ventilated at atmospheric pressure until a constant weight is obtained 11. The moisture content is calculated according to the following formula:

\[
\text{TH\%} = \frac{\text{Ms} - \text{Mf}}{\text{Mf}} \times 100
\]

With:

\( \text{Mf} = \text{mass in g before the oven} \)
\( \text{Ms} = \text{mass in g after the oven} \)

2.3.2. Phytochemical Screening
The samples were submitted to phytochemical tests to detect the presence of the leading chemical families of natural compounds. The detection process is called phytochemical screening. It consists in characterization of compounds by complex-forming and staining reactions 13,14. A specific color is induced by the use of an appropriate reagent in the presence of the proper compound. This is due to the formation of conjugation or an unsaturation within the molecule.

Experimentally, samples of each species are dried and then reduced in a fine powder that is used for the phytochemical tests. Several reagents are also required. The characterization of alkaloids needs Dragendorff’s reagent, catechic tannins’ characterization requires isoamyl alcohol and hydrochloric acid. Gallic tannins are detected by Stiasny’s reagent, sodium acetate and iron (III) chloride. To identify sterols and triterpenes, we used acetic anhydride and concentrated sulfuric acid. For flavonoids, we used dilute hydrochloric acid, magnesium chips and isoamyl alcohol. Chloroform, dilute chlorhydric acid, and ammonium chloride is used to find quinones.
2.3.3. Polyphenol extraction
Polyphenol extraction was performed by maceration. Polyphenol compounds are mainly extracted by solid-liquid extraction using a solvent with medium to high polarity \(^ {13}\). In our study, the solution is prepared with methanol 80%.

An amount of 20 g of each plant powder was macerated in 200 ml of the solvent (methanol 80%) for 48 hours. After this period, we proceeded to filtration, and the obtained filtrates were evaporated using a rotary evaporator at 50°C.

2.3.4. Fractionation of polyphenol extracts
Polyphenol extraction depends on the solubility of polyphenolics in organic solvents. Thus, the methanol crude extract was fractionated by the continuous use of three organic solvents of increasing polarity: chloroform, ethyl acetate and n-butanol. This led to the formation four fractions: the hydromethanolic fraction (F0), the chloroform fraction (F1), the ethyl acetate fraction (F2), the butanol fraction (F3) and the aqueous fraction (F4). These fractions were kept until their use. Figure 1 summarizes the fractionation steps of the crude polyphenol extracts. The yield of each extract was determined according to the following formula:

\[
R\% = \frac{\text{Mass of extract residue}}{\text{Mass of vegetable powder}} \times 100
\]

![Figure 1. Fractionation process of polyphenols](image)

2.3.5. Determination of total phenols
This analysis is an estimate of the total phenol content in the plant fractions. The determination of total phenols was performed by a method adapted from Singleton and Rossi using the Folin-Ciocalteu reagent \(^ {15-18}\).

In a 100 ml volumetric flask, 100 μl of each plant fraction is mixed with 1.5 ml of freshly prepared 10% Folin-Ciocalteu reagent and 1.5 ml of 7.5% aqueous sodium carbonate solution (m/v).

Then, the flasks are supplemented with distilled water. The whole is incubated at room temperature for 30 minutes. The coloration, developed after the incubation period, is proportional to the polyphenol content in the extract and can be quantified by spectrophotometry.

To better assess the polyphenol content in extracts, a calibration curve was established in with gallic acid under the operating conditions and the steps stated above with concentrations ranging from 50μg/ml (5mg/100 ml). The results are expressed in milligrams.
equivalent of gallic acid per gram of extract (mg GAE / g). All measurements are repeated thrice.

\[ T = \frac{C \times V}{m \text{ extract}} \times D \]

C: Concentration evaluated according to the calibration curve. 
V: Volume of the global extract. 
D: Dilution factor with D = \( \frac{V_f}{V_i} \) 
V_f: Final volume to be measured by spectrophotometer. 
V_i: Volume withdrew from the extract to be tested.

2.3.6. Determination of total flavonoids

The quantification of flavonoids was carried out by the colorimetric method 19,20. From the methanolic solution (0.1 g/L) of quercetin, concentration ranges from 5, 10, 15, 20, 25 to 30 μg/ml were prepared in test tubes. Each tube is completed by 3ml of distilled water. After 5 min, 10 μl of aluminum trichloride (AlCl3) at 10% (m / v) and 2 ml of pure methanol are added, shaken immediately and are kept in the dark for 30 min at room temperature. The quantitative analysis of flavonoids from our sample extracts was performed using the same protocol used for the calibration curve. The concentration of flavonoids in each extract was calculated from the regression equation of the calibration range established with quercetin. The absorbance was determined at 433 nm with a Shimadzu UV MINI spectrophotometer. The total flavonoid content was calculated according to the following formula:

\[ T = \frac{C \times V}{m \text{ extract}} \times D \]

2.4. Evaluation of antioxidant activity

2.4.1. DPPH-assay

Because of its stability and the simplicity of analysis, DPPH• is a substrate widely used for rapid and direct assessment of the antioxidant activity.

It absorbs at a wavelength of 515 nm2 12,17,21,22. Origanum compactum's crude extract (F0) and the butanolic fraction (F3) of Satureja calamintha nepeta were used to prepare a series of dilution with ethanol to obtain range concentrations from 0 to 200μg/ml. An aliquot of 200 μl from each concentration was mixed with 2.8 ml of DPPH in ethanol. Then, after stirring, the tubes were incubated in the dark at room temperature for 30 minutes. The tests were performed with three repetitions for each concentration.

The negative control was prepared by mixing 2.8 ml of DPPH• solution and 200 μl of ethanol. Ascorbic acid, known for its remarkable antioxidant power, is chosen as a positive control. It was used in the same conditions as the test samples. The results were expressed as a percentage of DPPH• reduction (PI%).

\[ \text{PI} \% = \left( \frac{\text{Abs}_{\text{control}} - \text{Abs}_{\text{test}}}{\text{Abs}_{\text{control}}} \right) \times 100 \]

PI % : Percentage of antioxidant activity. 
Abs control: Absorbance of the negative control solution. 
Abs test: absorbance of the samples to be tested.

2.4.2. FRAP assay

The FRAP method is based on the redox reaction of ferric iron (Fe³⁺) present in the K₃Fe(CN)₆ complex to ferrous iron (Fe²⁺) by an antioxidant, the reaction is revealed by transferring the yellow color of ferric ion (Fe³⁺) to the blue-green color of ferrous iron (Fe²⁺) 8. The test consists of taking 0.5 ml of the phenolic extract at different concentrations (0.2-1mg/ml) and mixing them with 1.25 ml of a 0.2 M phosphate buffer solution (pH= 6.6) and 1,25 ml of a potassium ferricyanide solution K₃Fe(CN)₆ to 1%. The mixture is incubated at 50°C for 20 min and then cooled to room temperature. Add 2.5 ml of 10% trichloracetic acid to stop the reaction, after placing the tubes in a centrifuge at 3000 rpm for 10 min. Then add 1.25 ml of the supernatant to 1.25 ml of distilled water and 250 μl of an iron chloride solution (FeCl₃, 6H₂O) to 0.1%. The absorbances are read by spectrophotometry at a wavelength of 700 nm. The positive control is represented by a solution of a standard antioxidant, ascorbic acid. The absorbance of which has been measured under the same conditions as the samples. An increase in absorbance corresponds to an increase in the reducing power of the test extracts.

3. Results and discussion

3.1. Determination of the water content

The determination of the water content for both species revealed: 18% for Satureja calamintha nepeta and 13.6% for Origanum compactum, which correspond successively in the dry matter to 82 % and 86.4%. The table below shows the species names, the date of harvest, the part used and the percentage of the water content of each plant.

| Name of the plant         | harvest date | Part used | Water content (%) |
|---------------------------|--------------|-----------|-------------------|
| S. calamintha nepeta     | May 2015     | Aerial part | 18                |
| O. compactum             | May 2015     | Leaves    | 13.6              |
3.2. Phytochemical screening

The phytochemical screening carried out on the plants from the region of Ouazzane, showed the results mentioned in Table 2.

### Table 2. Phytochemical screening of *Origanum compactum* and *Satureja calamintha nepeta*.

| Secondary metabolites       | Results        |
|-----------------------------|----------------|
|                             | *O. compactum* | *S. nepeta* |
| Gallic tannins              | ++             | ++          |
| Catechic tannins            | -              | +           |
| Sterols and triterpenes     | +              | +           |
| coumarins                   | -              | -           |
| flavonoids                  | ++             | ++          |
| alkaloids                   | -              | -           |
| cyanidins                   | +              | -           |
| saponosides                 | +              | -           |
| anthocyanins                | -              | -           |
| leucoanthocyanins           | -              | -           |

(+) = presence; (++) = abundance; (-) = absence

Phytochemical tests help highlight the presence of the secondary metabolites contained in each plant. In *Origanum compactum*, flavonoids, gallic tannins, cyanidins, sterols and triterpenes and saponosides have been found. Previous work related to the phytochemistry of *O. vulgare* provides similar results of ours with regard to the presence of tannins, saponosides and flavonoids [23]. For *satureja calamintha nepeta*, the tests showed the presence of flavonoids, gallic tannins, catechin tannins and sterols and triterpenes. But there was no sign of alkaloid, carotenoid and saponoside. These results are similar to several studies [12,14], and who remarked the presence of the same chemical groups during their phytochemical studies. The presence of these secondary metabolites in the two species studied may explain their strong therapeutic power. It is for this reason that we are convinced that it is necessary to carry out extractions of these compounds to determine their contents and their biological activities [13]. Their role as natural antioxidants is arousing increasing interest in the prevention and treatment of cancer, inflammatory and cardiovascular diseases [24].

### Table 3. Extraction yields of *Origanum compactum* and *satureja calamintha nepeta*.

| Plant material | Extraction yield % |
|----------------|--------------------|
|                | Crude extract      | Chloroform fraction | Ethyl acetate fraction | n-butanol fraction | aqueous fraction |
| *O. compactum* | 35.2               | 9.05                | 8.3                     | 12.57             | 5.02             |
| *S. nepeta*    | 34.4               | 7.6                 | 4.9                     | 17.6              | 3.2              |

3.3. Extraction of phenolics

3.3.1. Extraction yields

Methanol extraction of phenolics from *Origanum compactum* and *satureja calamintha nepeta* produced 35.2% of crude extracts for *Origanum compactum* and 34.4% for *Satureja calamintha nepeta*. After fractionation of these crude extracts with chloroform, ethyl acetate and butanol, the yields were 12.57% and 17.6% for n-butanol fractions, 9.05% and 7.6% for chloroform fractions, 8.3% and 4.9% for the ethyl acetate fractions. The lowest yields were obtained with the aqueous fractions, which were about 5.02% and 3.2% for *Origanum compactum* and *satureja calamintha nepeta* respectively (Table 3). The yields are determined with dry plant matter.

### Table 3. Extraction yields of *Origanum compactum* and *satureja calamintha nepeta*.

3.3.2. Total phenol content

The UV / Visible spectrophotometry made it possible to quantify the level of polyphenols present in the prepared extracts of the two species studied; the results are expressed in mg equivalent of gallic acid (EAG) per g of extract in Tables 4 and 5.
Table 4. Polyphenol contents of *Origanum compactum*’s fractions expressed as milligrams equivalents of gallic acid per gram of extract (mg EAG / g).

| Fractions            | Polyphenol content   |
|----------------------|----------------------|
| F0  Crude extract    | 30.8 ± 0.001         |
| F1  Chloroform fraction | 20.53 ± 0.008       |
| F2  Ethyl Acetate fraction | 29.9 ± 0.007       |
| F3  n- Butanol fraction  | 28.63 ± 0.0015      |
| F4  Aqueous extract   | 24.21 ± 0.042       |

Table 5. Polyphenol contents of *Satureja calamintha nepeta*’s fractions expressed as milligrams equivalents of gallic acid per gram of extract (mg EAG / g).

| Fractions            | Polyphenol content   |
|----------------------|----------------------|
| F0  Crude extract    | 25.36±0.001          |
| F1  Chloroform fraction | 15.26±0.0075        |
| F2  Ethyl Acetate fraction | 27.79±0.002        |
| F3  n- Butanol fraction  | 33.48±0.0235       |
| F4  Aqueous extract   | 20.42±0.004         |

The results show that both plants are rich in polyphenols with total phenol contents for all fractions that vary between 20.53± 0.008mg GAE/ g and 30.8±0.001mg GAE/g for *Origanum compactum*. These contents vary between 15.26±0.00752mg GAE/g and 33.48±0.0235mg GAE/g for *Satureja calamintha nepeta*. The results also revealed that the fractions that contain the highest concentrations of polyphenols are: the crude extract for *Origanum compactum* (30.8±0.001mg GAE/g) and the n-butanol fraction for *satureja calamintha nepeta* (33.48± 0.0235mg GAE /g). For *Satureja calamintha nepeta*, our results confirmed the work of Ćetković. In their study, they showed that phenol concentrations in ethyl acetate fraction (969.43 μg/g) and an n-butanol fraction (1358.14 μg / g) were significantly higher (p<0.001) than that of other fraction. Besides, Bougandoura showed in its studies in 2012 that the aqueous extract has a high total phenol content compared to the methanol extract. Other studies has been demonstrated that *Origanum compactum’s* content in polyphenols is higher than that of *Origanum glandulosum*. Studies have also shown richness in total phenolic content. These yields can be influenced by several parameters. They also depend on the chemical composition as well as the method and conditions of extraction. Generally, methanol is the most used solvent for the extraction of phenol substances from Lamiaceae.

3.3.2. Determination of total flavonoids
A calibration curve was performed with quercetin at a wavelength of 433nm. The formula for the linear regression of this curve is $y = 0.073x - 0.081$ with a correlation coefficient $R^2 = 0.995$. The flavonoid contents of the fractions expressed in mg equivalent of quercetin per g of the dry matter or the extract. The different extracts (crude and fractionated) obtained during the extraction by maceration of the aerial part of satureja calamintha nepeta and the origanum compactum leaves, were quantitatively analyzed by UV-visible spectrophotometer to determine the total flavonoids. The quantitative estimation of flavonoids by the colorimetric method has shown that methanolic extracts are rich. *Table 6*, shows that satureja calamintha nepeta, contain more flavonins in terms of methanolic extract 14.71 ± 0.033 mg QE/g and n-butanol extract 11.55 ± 0.025 mg QE/g. In contrast, for origanum compactum the highest content of flavonoids was characterized in terms of methanolic extract with a value of the order of 10.1 ± 0.045 mg QE/g.

Table 6. Total flavonoid contents of the origanum compactum and Satureja calamintha Nepeta fractions expressed in milligrams of quercetin equivalents per gram of extract (mg QE/ g).

| Les fractions            | *Origanum compactum* | *Satureja calamintha nepeta* |
|--------------------------|----------------------|------------------------------|
| crude extract            | 10.1±0.045           | 14.71±0.033                  |
| Chloroform extract       | 3.90±0.018           | 8.29±0.020                   |
| Ethyl acetate extract    | 5.1±0.020            | 4.13±0.013                   |
| Butanolic extract        | 2.4±0.0015           | 11.55±0.025                  |
| Aqueous extract          | 6.8±0.022            | 9.78±0.028                   |
The comparison of our results obtained from satureja calamintha nepeta with those of the works of Boughandoura are not similar. Our results are higher than those found by boughandoura in 2012 (1.280mg / g), which shows the richness of flavonoids in the Ouazzane region of satureja calamintha nepeta. Other works have proven the richness of oregano in total flavonoids, showed during their study that oregano vulgar is rich in flavonoids. This difference in flavonoid content may be due to several factors such as climate, soil, harvest period, storage condition.

3.4. Antioxidant activity of the plant extracts

3.4.1. DPPH• test

The antioxidant activity of Satureja calamintha nepeta and Origanum compactum’s extracts was evaluated by spectrophotometry. The ascorbic acid was used as standard antioxidant. In this essay, the most crucial parameter is the kinetics of the DPPH• reduction. This reduction is proved by the solution coloration that changes from purple (DPPH•) to yellow (DPPH-H). This coloration change which is proportional to DPPH reduction is measurable with a spectrophotometer at 515nm.

Results show that Origanum compactum’s crude extract (F₀ fraction) and Satureja calamintha nepeta’s butanol fraction (F₃ fraction) exerted a very high antioxidant activity with IC₅₀ values equal to 53.1 μg/ml and 67.5 μg/ml for Origanum compactum and Satureja calamintha nepeta respectively. The IC₅₀ of ascorbic acid is 53.1μg/ml.

Figure 2

Percentage inhibition of DPPH • as a function of the concentrations of the fractions of Origanum Compactum and Satureja calamintha Nepeta

PI OC = percentage of DPPH• inhibition exerted by Origanum compactum
PI SN = percentage of DPPH• inhibition exerted Satureja calamintha nepeta
PI ACS = percentage of DPPH• inhibition exerted by ascorbic acid

Figure 3

Concentrations of reduction of 50% of DPPH •
*Origanum Compactum* and *Satureja calamintha nepeta* exhibit a very high antioxidant activity with $IC_{50} = 53.1 \mu g/ml$ and $IC_{50} = 67.5 \mu g/ml$ respectively. A low $IC_{50}$ value indicates a strong antioxidant activity. When it comes to comparing the activity of these plants from the family of *Lamiaceae* with ascorbic acid which has been taken as a standard antioxidant, we note that *Satureja calamintha nepeta* ($IC_{50} = 67.5 \mu g/ml$) exerts a lower antioxidant effect than ascorbic acid ($IC_{50} = 53.1 \mu g/ml$). *Origanum compactum* has the same effect as the standard antioxidant (ascorbic acid). Gonçalves showed that the methanolic extract of *origanum vulgare* had a stronger DPPH trapping capacity than *calamintha nepeta*. Other work by on *Origanum glandulosum* revealed that its methanol extract had a greater capacity to trap the DPPH • radical compared to essential oils. Our work on *satureja calamintha nepeta* is coherent with the work of Ćetković who showed that the highest antioxidant activity was observed for n-butanol extract of *Satureja montana* L., while at the same concentration, ethyl acetate extract exerted a slightly lower activity.

### 3.4.2. FRAP test

The reducing power of a substance indicates its ability to transfer an electron or a hydrogen atom by reducing Fe (III) to Fe (II) in the presence of the $K_3Fe(CN)_6$ complex. The values obtained made it possible to plot the curves shown in the figure below. The standard used as a reference is ascorbic acid. The values obtained made it possible to plot the curves shown in the figure below. The standard used as a reference is ascorbic acid.

![Figure 4](image)

**Figure 4.** Reducing power of the extracts of the two plants studied, obtained by Maceration

ACS ABS = Absorbance of ascorbic acid  
OC ABS = Absorbance of *origanum compactum*  
SN ABS = Absorbance of *satureja calamintha nepeta*

The results obtained with the maceration method show that the extracts of the two plants tested are characterized by a very pronounced increase in the reduction of iron as a function of the increase in concentration. **Figure 4** shows significant differences between the reducing power of the extract of *origanum compactum* leaves, the aerial part of *satureja calamintha nepeta* and the positive control (ascorbic-acid).

| Espèces            | Extract          | Absorbance | CE50 mg/ml |
|--------------------|------------------|------------|------------|
| *Origanum compactum* | méthanolic       | 1.67       | 0.26       |
| *Satureja calamintha nepeta* | n-butanolic       | 0.93       | 0.55       |
| Ascorbic Acid      | -                | 1.58       | 0.12       |

Table 7. Determination of the effective concentration ($EC_{50}$) that corresponds to an absorbance of 0.5.
Table 7 shows that the extraction by maceration, the leave extracts of origanum compactum and satureja calamintha nepeta cause the reduction of Fe⁴⁺ present in the ferricyanide complex of potassium in ferrous iron (Fe²⁺). Their effective concentrations (EC₅₀) to reduce 50% of Fe⁴⁺ ions are 0.26 and 0.55 mg / ml respectively. *Origanum compactum* has shown a much higher reducing capacity than that found with *satureja calamintha nepeta*. Still, it remains lower than that of the standard (ascorbic acid) which has a concentration of 0.12 mg/ml. These results have been confirmed by several studies which have shown that origanum vulgara has a great capacity for ferric reduction compared to calamintha nepeta.

4. Conclusion

Morocco’s geographical location, ecosystems and water resources, make it a country full of plant species endowed with various therapeutic virtues. *Origanum compactum* and *satureja calamintha nepeta*, both harvested in the region of Ouazzane were studied, through phytochemical tests, polyphenol extraction and antioxidant activity evaluation. We found that both plants are rich in secondary metabolites, mainly in polyphenols. Their contents ranged from 20.53±0.008 mg EGA/g to 30.8≈0.001 mg EGA/g for *Origanum compactum*. For *Satureja calamintha nepeta* polyphenol contents ranged from 15.26±0.00752 mg EGA/g to 33.48 ± 0.0235 mg EGA/g. The assessment of antioxidant activity of *origanum compactum* and *Satureja calamintha nepeta’s* extracts and fractions by the DPPH⁺ method showed that both *origanum compactum’s* crude extract and *Satureja calamintha nepeta’s* n-butanol fraction have a very significant antioxidant activity. Inhibitory concentrations (IC₅₀) were 53.1 μg/ml and 67.5 μg/ml for *Origanum compactum* and *Satureja calamintha nepeta*, respectively. The FRAP test also revealed that the methanolic extract of *origanum compactum* showed a higher reducing power than that of the n-butanol extract of *satureja calamintha nepeta* but it remains relatively weak than that of ascorbic acid. These potential sources of natural antioxidants could be exploited in food, pharmaceutical and cosmetic preparations.

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