

## Physico-Chemical analysis of some medicinal plants growing in Algeria: *Allium sativum*, *Allium cepa* and *Foeniculum vulgare*.

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### Abstract

This study aims to investigate, the physico-chemical characterization of *Allium sativum*, *Allium cepa* and *Foeniculum vulgare*. The analysis which carried out on these plants includes pH, titratable acidity, fiber, fat, sugars, soluble solids, pectin and protein. The results from the study of three medicinal plants, show that: *Allium sativum*, present a low acid vegetable ( $6.10 \pm 0.005$ ), rich in water ( $63.67\% \pm 0.1131$ ) and sugars ( $25.6\text{g} / 100\text{g} \pm 0.034$ ), its pectin content is ( $2.89\% \pm 0.1619$ ) and fiber ( $1.47\% \pm 0.007$ ), but contains a low protein content of ( $0.04\text{mg} / \text{ml} \pm 0.0028$ ) and traces of lipids. *Allium cepa* had a low acid vegetable ( $5.42 \pm 0.0707$ ), rich in water ( $92.20\% \pm 0.0212$ ), sugars ( $13.16\text{g} / 100\text{g} \pm 0.1416$ ), pectin ( $3.102\% \pm 0.0459$ ), and fiber ( $2.12\% \pm 0.070$ ). Its protein content ( $0.1\text{mg} / \text{ml} \pm 0.007$ ) was low, and traces of lipids. For, *Foeniculum vulgare*, a slightly acidic vegetable ( $6.02 \pm 0.0057$ ), highly rich in water ( $95.34\% \pm 0.00$ ), sugars ( $16.80\text{g} / 100\text{g} \pm 0.1983$ ), dietary fiber ( $12.20\% \pm 0.0785$ ), and pectin ( $3.79\% \pm 0.07$ ). However, contains low protein content ( $0.034\text{mg} / \text{ml} \pm 0.0098$ ), and traces of lipids. The results obtained from this study show that the three plants garlic, onion and fennel have a good chemical composition.

**Keywords:** Medicinal plants, *Allium sativum*, *Allium cepa*, *Foeniculum vulgare*, physicochemical analysis.

### Introduction

The evolution of aromatic and medicinal plants is associated with the development of civilization. Around the world, these plants have played a role in traditional medicine and in culinary preparations (Bouzouita et al., 2008). Researchers continue to explore the value of using these plants as sources of natural bioactive substances (El-Hacil et al., 2012). Currently, between 20,000 and 25,000 plants are used in pharmacology. The majority of these drugs are of plant origin and contain at least one active molecule (Tardivon and Chadouli, 2012).

Algeria, due to its biogeographical position, offers rich ecosystem diversity. As a result, it is one of the Mediterranean countries whose population has devoted itself, for centuries, to traditional medical practices and have acquired knowledge in this area through the use of medicinal plants (Fadil et al., 2015). Onion (*Allium cepa*), garlic (*Allium sativum*) and fennel (*Foeniculum vulgare*) are among the ancient foods cultivated in Algeria, which are known for their medicinal properties and applications. The latter is a rich source of phytonutrients recommended as an

important part of the Mediterranean diet (Lanzotti, 2006; Lazouni, et al., 2007).

These plants are used to treat a variety of diseases related to: digestive disorders (gastric and intestinal), urinary system, cardiovascular diseases and respiratory tract disorders, etc. (Eddouks et al., 2007). Our work is concerned with the physico-chemical study of (*Allium sativum* L., *Allium cepa* L., and *Foeniculum vulgare* L.).

## Materials and Methods

### Plant material

The plant material used in our study consists of three plants: Garlic, Onion and Fennel (*Allium cepa*, *Allium sativum* and *Foeniculum vulgare*) (Fig. 1). These plants were bought from the market in the town of Tiaret in fresh form. The plants are first separated from the maximum of impurities, then cut into small pieces and dried in the open air while being protected from light. The dry material was ground using a domestic crusher of the type (Moulinex), and sieved using a sieve of 250  $\mu$ m pore diameter. The result created a product in the form of a powder.



**Figure 1.** Plant material (*Allium cepa*, *Allium sativum* and *Foeniculum vulgare*)

### Methods Physico-chemical analyzes

#### ▪ Determination of pH

100 ml of distilled water was added to 10 g of each fresh plant cut into pieces. The whole was stirred for 5 minutes. The measurement was carried out by immersing the electrode of the pH meter in the solution (AOAC, 2002).

#### ▪ Determination of titratable acidity

The solution obtained previously was to determine the pH, and the titratable acidity. The acidity was measured by neutralization of the total free acidity contained in 25 ml of juice obtained from each plant with a solution of NaOH (0.1 N) until a pH of 8.1 was reached in the presence of phenol phthalic as indicator coloured (AOAC, 2002).

#### ▪ Determination of water content

In previously weighed and tared crucibles, 5g of each fresh plant cut into small pieces were added. These crucibles were then placed in the oven at 105 °C. After 3 hours of drying, the crucibles were removed, placed in a desiccator, and weighed after cooling (AOAC, 2000).

▪ *Determination of ash content*

In porcelain capsules, 10g of each plant cut into small pieces was weighed and placed in a muffle oven at 600 ° C for 5 hours until a gray, light, or whitish colour was obtained. The capsules were removed from the oven, placed in a desiccator and then weighed (AOAC, 2000).

▪ *Determination of lipid content*

About 10g of each plant was weighed and poured into a cartridge, which was sealed with a piece of cotton, and placed in the "Soxhlet" extractor. 150 ml of petroleum ether were poured into a pre-tared and dried flask. 100 ml of the same solvent was put in the extractor. After 6 hours of extraction, all of the solvent was recovered by a rotavapor. To determine the level of total lipids, the flasks were weighed after drying in an oven at 105 ° C in order to remove traces of the solvent (AOAC, 1995).

▪ *Determination of fiber content*

1g of each sample previously dried by steaming at 105°C. for 3 hours was ground. Subsequently, 150 ml of sulfuric acid (1.25%) was added and the mixture was brought to a boil. After 30 minutes of boiling, the residue was filtered and washed 3 times with hot distilled water. 150 ml of potassium hydroxide (1.25%) was added to the residue and the mixture was brought to the boil for 30 minutes. Thereafter, washing was performed three times with hot distilled water and then with cold distilled water. A final wash was performed three times with 25 ml of acetone. Subsequently, drying was carried out by steaming at 105° C to constant weight. The residue (crude fibers + ash) was calcined in a muffle furnace for 3 hours at 550°C, then reweighed after cooling in a desiccator (AOAC, 2000).

▪ *Determination of the total sugars content*

The sugars were extracted from 0.1g of each sample by adding 30 ml of ethanol (80%), and the mixture was left for 48 hours at room temperature. At the time of the assay, the tubes were placed in an oven at 80 ° C for the evaporation of the alcohol. 20 ml of distilled water was then added to the extract (solution to be analysed) (Cuiyand et Brummer, 2005). In a test tube, 1ml of phenol (5%), and 5ml of concentrated sulfuric acid (96%) were added to 1ml of the test solution. After 10 minutes the mixture was placed in a water bath for 20 minutes at 25-30°C. The absorbance reading was taken at 490 nm, and the concentration of total sugars was determined by referring to the calibration curve obtained using glucose as the standard calibration solution (Dubois *et al.*, 1956).

▪ *Determination of the level of reducing sugars*

The sugars were extracted twice with hot ethanol (80%) (5 ml each time) from 0.1 g of each sample. The supernatant was collected and evaporated by keeping it in a water bath at 80 ° C. 10 ml of distilled water was then added to dissolve the sugars (solution to be analysed). In a test tube, 1ml of the solution to be analysed was taken and 1ml of DNSA reagent was added after 5 minutes of heating in a bath at 100 ° C. When tubes were cool, the absorbance reading was taken at 540 nm (Miller, 1972). The concentration of reducing sugars was determined by referring to the calibration curve obtained by using glucose as a calibration standard and calculated by the formula of (Sadasivam et Manickarn, 1996).

▪ *Determination of the pectin content*

In a 100 ml ground-jointed conical flask, 2.5 g of each ground sample was placed, then 50 ml of hydrochloric acid (1/30 N) was added. The flask was stoppered in a freezer and brought to a water bath at 80 °C. After 30 minutes of heating, filtration and washing with hot distilled water of the residue was carried out, and a filtrate was collected (1st filtrate). The residue was collected in a conical flask suitable for a condenser, and 50 ml of oxalic acid was added before the mixture was brought to a boil at 100°C. After 20 minutes of boiling, the mixture was filtered and washed with hot distilled water; afterwards, a filtrate was collected (2nd filtrate). The two filtrates were introduced into a 200 ml volumetric flask and neutralized with caustic soda (15%) in the presence of phenolphthalein then the volume was made up to the mark with distilled water.

In a 200 ml flask, 50 ml of the filtrate obtained was poured, then 50 ml of caustic soda (0.4%) was added. In order to pass the saponification of the complex bonds, the mixture was allowed to stand for 15 minutes. After saponification, 50 ml of acetic acid (1N) and 50 ml of calcium chloride solution (11.1%) were added. Thereafter, the mixture was allowed to react for 30 minutes.

The precipitate was filtered off with filter paper previously dried and tared. Washing was carried out with calcium chloride solution (0.5%), cold distilled water, and finally with hot distilled water until the complete elimination of chloride ions. The filter paper and the precipitate were dried by baking at 105 °C to constant weight. The pectin content is expressed by the following formula (Multon, 1991).

#### ▪ Determination of the protein level

Add 5 ml to 1 ml of the extract in a tube. Mix and leave for 5 to 15 min in the dark. After mixing, the intensity of the colorant ion was determined with a spectrophotometer at 515 nm with a solution containing all the reagents except the protein extract as a control. The calibration line obtained under the same conditions made it possible to convert the optical density into an amount of protein. Bovine serum albumin (BSA) was used as a reference protein (Bradford, 1976).

#### ▪ Determination of soluble solids content

A drop of juice from each plant was put on the refractometer plate previously cleaned with paper soaked in distilled water. The Brix degree was read directly from the scale at the intersection of the boundary between the light fringe and the dark fringe (AOAC, 2000).

#### ▪ Statistical analysis

Statistical software (SPSS version 20) was used for the analysis of the physicochemical data. Results were compared at a 95% confidence level with One Way Analysis of Variance (ANOVA 1) to detect any statistical differences, The results were also subjected to a post-hoc analysis based on Tukey model in order to compare means among the studied groups, descriptive statistics were expressed as mean values  $\pm$  standard deviation.

## Results and discussion

The results of the physicochemical parameters of *A. cepa*, *A. sativum* and *F. vulgare*, are presented in the following (Table1) and shows a clear significant difference (p.value  $<<0.05$ ) regarding many physicochemical parameters into the three plants.

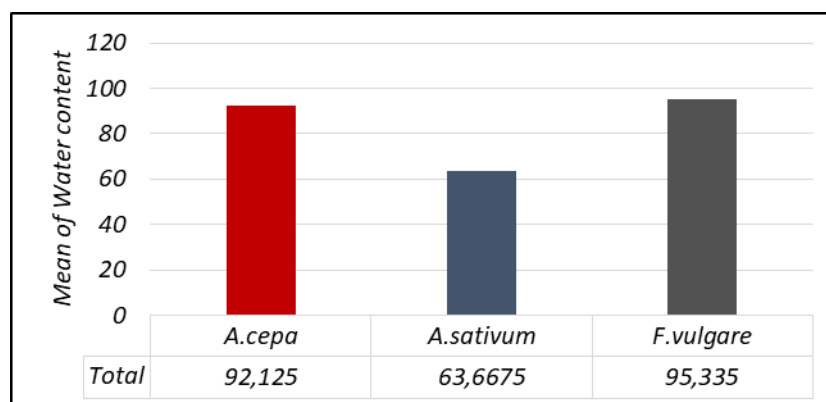
**Table 1.** Descriptive results of the physicochemical analyses of the three plants

Parameters	Results		
	<i>A. sativum L.</i>	<i>A. cepa L.</i>	<i>F. vulgare L.</i>
Water content (%)	63,67 $\pm$ 0,3399	92,125 $\pm$ 0,2217	95,34 $\pm$ 0,3771
Ash (%)	2,5 $\pm$ 0,2943	0,41 $\pm$ 0,0341	0,72 $\pm$ 0,0309
pH	6,10 $\pm$ 0,1639	5,42 $\pm$ 0,0850	6,02 $\pm$ 0,1620
Titratable acidity (%)	0,84 $\pm$ 0,0189	0,37 $\pm$ 0,0670	0,11 $\pm$ 0,0129
Fat (%)	Traces	Traces	Traces
Fiber (%)	1,47 $\pm$ 0,0450	2,12 $\pm$ 0,2145	12,20 $\pm$ 0,0816
Total sugars (g / 100 g)	25,6 $\pm$ 0,0716	13,16 $\pm$ 0,0420	16,80 $\pm$ 0,1825
Reducing sugars (g / 100g)	8,4 $\pm$ 0,1707	8,68 $\pm$ 0,0771	5,58 $\pm$ 0,0875
Soluble solids (%)	33,68 $\pm$ 0,4112	11,68 $\pm$ 0,5320	7,62 $\pm$ 0,1793
Pectin (%)	2,89 $\pm$ 0,1611	3,102 $\pm$ 0,0017	3,79 $\pm$ 0,0822
Protein mg/ml	0,04 $\pm$ 0,0216	0,1 $\pm$ 0,0741	0,034 $\pm$ 0,0086

#### ▪ Water content

Water is one of the essential constituents of the plant, and contents are a fundamental parameter for fundamental reasons: Technological, commercial, and regulatory necessity (Multon, 1991). Water

content was tested using One way Analysis of variance ANOVA-1 (Table2) and provided a significant overall P.value (Pr <<0.05)



**Figure 2:** Water content according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among all the analysed groups, for that reason the studied species appears very distinguished in terms of the studied parameter (Water content).

**Table 2:** Results of One-way ANOVA and Tukey's pairwise tests for Water content

Species comparison	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>		< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>	< 0.001	< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001

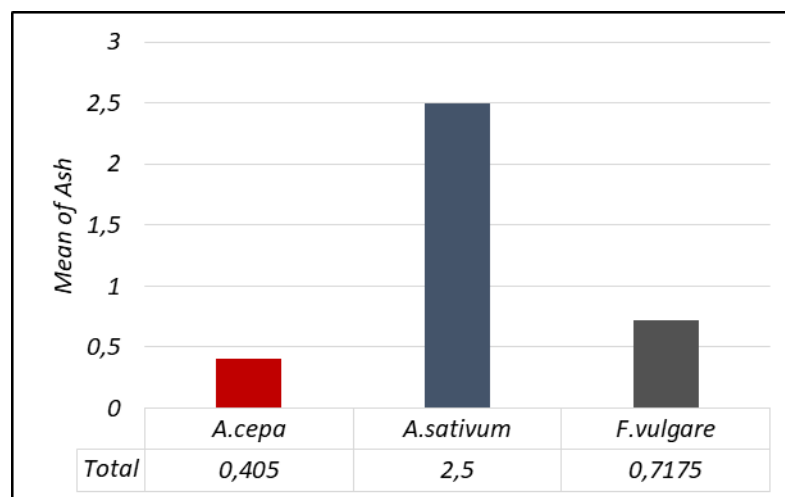
The water content of *A. sativum* studied is  $63.67\% \pm 0.1131$  (Figure2). This value exceeds the norm (U.S.D.A, 2014), which is 58.58%, and lies in the range 62 - 68% cited by Lawson, 1996 and Rahman, 2003, May U.S.D.A (2013) and Abdou *et al.* (1972) found results superior to our results which are 65% and 69.2% respectively.

$92.125\% \pm 0.0212$  is the water content of *A. cepa* studied (tab 1). Our result is superior to that found by Kumar *et al.*, (2010); Bajaj *et al.* (1980) which are 86.6% and 89.11% respectively. Petropoulos *et al.* (2015) did a study on two varieties of red onion, and they found inferior results compared to our result which are  $88.90\% \pm 0.54$  and  $83.98\% \pm 1.41$ , respectively.

*F. vulgare* has  $95.48\% \pm 0.010$  of water content (Tab. 1), by comparing the water content of our fresh plant which is much higher compared to the standard U.S.D.A (2013) which is 5.39%. This value is much higher than the results found by Lazouniet *et al.* (2006) and Barros *et al.* (2010) on the same plant, which are 76.5%,  $73.88\% \pm 0.83$  respectively. The variation in water content is due to different environmental conditions such as: availability of water, geographic distribution as well as exposure to sun and wind which can contribute to desiccation of the plant (Ruiz-Rodriguez *et al.*, 2011). According to Athamena (2009), the factors which can influence the water content are: the age of the plant, the period of the vegetative cycle, or even genetic factors.

#### ▪ Ash rate

Determining the mineral content tells us about the nutritional quality of the sample to be analyzed. Indeed, the ash content of foods must have a threshold not to be exceeded for human and animal consumption; the Ash content represents the total quantity of mineral salts present in a sample (Messaid, 2008). Ash rate was tested using One way Analysis of variance ANOVA-1 (Table3) and provided a significant overall P.value (Pr <<0.05)



**Figure 3:** Ash rate according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among the analysed groups *A. cepa* – *A. sativum* and *F. vulgare* – *A. sativum*, in terms of Ash rate while for *A. cepa* – *F. vulgare* it appears to be the same with a non-significant *P. value* of 7%

**Table 3:** Results of One-way ANOVA and Tukey's pairwise tests for Ash rate

Species comparaison	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>	< 0.001	< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>		0.07 (NS)*
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001

\*: Non-significant result according to 95% confidence level

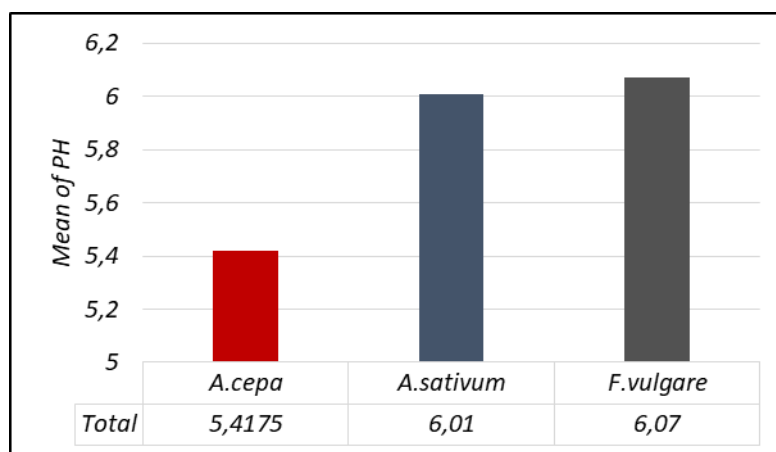
The analytical result of the ash rate of *A. sativum* is  $2.5\% \pm 0.4242$  (Figure3). Our score is above the standard for U.S.D.A, (2014) which is 1.50%. Is close to 2.3% cited by Rasul Suleria *et al.* (2015), but higher than that found by Abdou *et al.*, (1972 and Garnier *et al.* (1961), which is 1.3%, 1.44% and respectively but remains lower compared to those found by Gloria *et al.* (2010), which is  $4.08\% \pm 0.10$ .

The Ash rate of *A. cepa* is  $0.41\% \pm 0.007$  (Tab. 1). Our result is slightly higher than that found by Bajaj *et al.*, (1980) which is 0.35% but remains lower compared to those found by Capel Abad, (2014) and Shenoy *et al.* (2009) which are  $4.43\% \pm 0.05$  and  $4.22\%$  respectively. Petropoulos *et al.*, (2015), carried out a study on two varieties of red onion and they found results one close to our result which is  $0.40\% \pm 0.01\%$  and the other slightly higher which is  $0.58\% \pm 0.01$ .

The analytical result of the ash content of *F. vulgare* is  $0.72\% \pm 0.0212$  (Tab. 1). This value is lower than that cited by Lazouni *et al.* (2006); Ibrahim et El-Khateeb (2013), which are 6%, 8% respectively. Indeed, Barros *et al.* (2010) estimated a much higher value which is  $2.39\% \pm 0.02$ . According to Bezzala (2005) and Athamena (2009), the variation of the ash content can be explained by the geographical origin of the samples, in particular the climatic conditions and the edaphic characteristics of the soils, the age of the plant, the period of vegetative cycle, or even genetic factors.

#### ▪ pH

The pH of *A. sativum* studied is  $6.1066 \pm 0$ , (Figure4). This value is greater than that found by Yin et Cheng (2003), which is from 5.3 to 5.7. Indeed, our result is close to the values evaluated by Hesterjet Cavallitaond (1944), which are 5.7 to 6.0 and 6.5 respectively. PH level was tested using One way Analysis of variance ANOVA-1 (Table4) and provided a significant overall P.value (Pr <<0.05)



**Figure 4:** pH rate according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among the analysed groups *A. cepa* – *A. sativum* and *A. cepa* – *F. vulgare*, in terms of Ash rate while *F. vulgare* – *A. sativum* appears to be very similar with a non-significant P.value of 82%.

**Table 4:** Results of One-way ANOVA and Tukey's pairwise tests for pH

Species comparison	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>		< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>	< 0.001	< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		0.825 (NS)*

\*: Non-significant result according to 95% confidence level

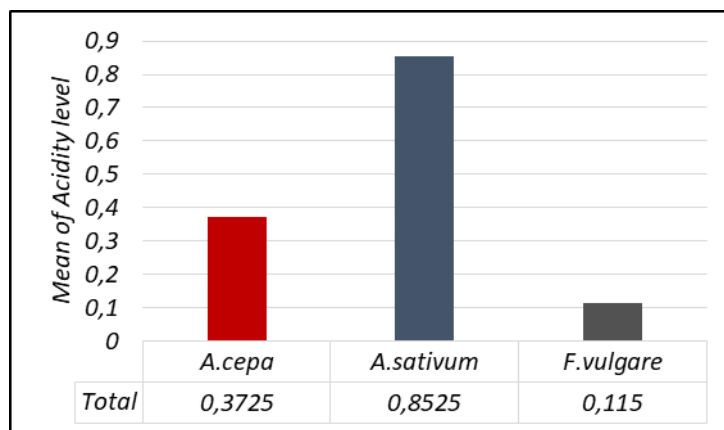
*A. cepa* studied has  $5.42 \pm 0.0707$  of pH (Tab. 1). This value is almost identical to that found by Capel Abad (2014), which is  $5.96 \pm 0.23$ . Indeed, Dallocca-Berno *et al.* (2014); Shenoy *et al.* (2009), gave pH values of 5.50 and 6.5 respectively. Petropoulos *et al.* (2015), did a study on two varieties of red onion, and they found results close to our results which are  $5.50 \pm 0.1$  and  $5.2 \pm 0.2$  respectively.

The pH of *F. vulgare* is  $6.07 \pm 0.0057$  (Tab. 1.), which is close to that found by Hussein *et al.* (2002) is 7.8. According to Messaid (2008), the differences noted are due to many factors including climate and degree of ripening. So, this difference may be due not only to the diversity of the variety but also to the growing conditions (Grechkin *et al.*, 1995).

#### ▪ Titratable acidity

The titratable acidity tells us about the amount of organic acids present in the sample (Ferhoum, 2010). *A. sativum* plant studied has an acidity of  $0.84\% \pm 0.1686$ . *A. cepa* has an acidity of  $0.37\% \pm 0.0386$  (Figure5); this value is close to that found by Petropoulos *et al.* (2015) which is  $0.038\% \pm 0.0$ . This value is much lower than that reported by Caruso *et al.* (2014) who found values from 1.97% to 2.23%. *F. vulgare* studied has an acidity of  $0.115\% \pm 0.1345$ . The significant difference in acidity may be due to climatic conditions and the ripening process of plants (Messaid, 2008). Acidity was tested using One way Analysis of variance ANOVA-1 (Table5) and provided a significant overall P.value (Pr <<0.05)





**Figure 5:** Acidity level according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among all the analysed groups, for that reason the studied species appears very distinguished in terms of the studied parameter (Titratable acidity).

**Table 5:** Results of One-way ANOVA and Tukey's pairwise tests for Acidity level

Species comparaison	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>		< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>	< 0.001	< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001

#### ▪ Lipid level

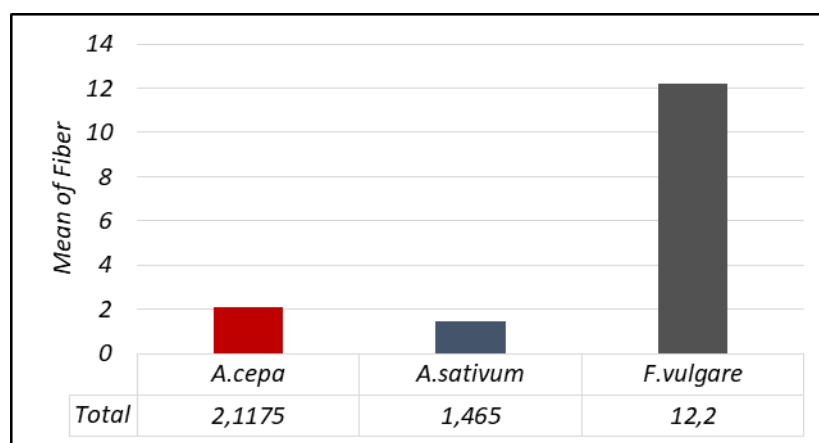
Fat is a nutritionally important biological building block for calories and essential fatty acids and fat-soluble vitamins. They are organic matter insoluble in water, but soluble in organic solvents (Gaouar, 2011). We found traces of lipids in *A. sativum*. This value agrees with those found by Garnier *et al.* (1961) which is 0.06%. Lawson (1996); Rahman (2003) and Gorinstein *et al.* (2008), which recorded values between 0.1 and 0.2%. Thus, Kallel *et al.* (2014) found a higher value which is  $0.86\% \pm 0.04$ . We have recorded traces of lipids in *A. cepa* (Tab. 1). This value is close to that found by Petropoulos *et al.* (2015), which is  $0.07\% \pm 0.01$ . Our result is lower than the standards (U.S.D.A, 2013), which is 0.3%. Kumar *et al.* (2010) and Bajaj *et al.* (1980) found a value of 0.1%. We notice that our result is lower compared to that found by Atanassova *et al.* (2009), which is 1.04%. According to the results presented in (Tab. 1), it can be seen that *F. vulgare* is low in fat; this result is close to that which was cited by Barros *et al.* (2010) as  $0.49\% \pm 0.05$ . Gerbi (2000) found a value higher, which is 2.01%. Many parameters influence the lipid content such as particle size, humidity, the nature of the solvent and the extraction method used (Gaouar, 2011). Djouab (2007) added the edaphic conditions as a parameter to influence the lipid content; while Rather *et al.* (2012); Lazouni *et al.* (2006); Ibrahim et El-Khateeb (2013) and Kjeldhal (1883), found values of and 10%, 12%, 13%, and 20% respectively.

#### ▪ Fiber rate

Dietary fibers are carbohydrate polymers of plant origin, whether or not associated in the plant with lignin or other non-carbohydrate constituents (polyphenols, waxes, saponosides, phytosterols, etc.) (AFSSA, 2002). Most of the fiber intake comes from the plants that make up our diet: fruits, vegetables, various seeds, and cereals (Bruneton, 1999). Dietary fiber has several beneficial effects on health, including increased fecal bolus, lowering cholesterolemia and plasma LDL (Low Density Lipoprotein) levels, and lowering blood sugar and postprandial insulinemia (Bruneton, 1999). Fiber



rate was tested using One way Analysis of variance ANOVA-1 (Table6) and provided a significant overall P.value (Pr <<0.05)



**Figure 6:** Fiber rate according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among all the analysed groups, for that reason the studied species appears very distinguished in terms of the studied parameter (Titratable acidity).

**Table 6:** Results of One-way ANOVA and Tukey's pairwise tests for Fiber rate

Species comparaisn	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>	< 0.001	< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>		< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001

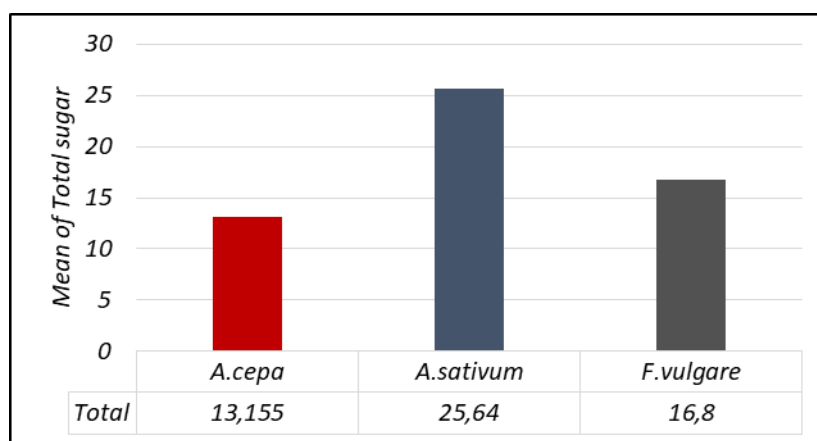
The result of the dietary fiber assay performed on *A. sativum* is  $1.47\% \pm 0.007$  (Figure6). This value is close to that evaluated by Rasul Suleria *et al.* (2015); Lawson (1996) and Rahman (2003) which is 1.5%. We note that our result is present a more in-depth study than [1] who estimated a slightly low value in dietary fiber, which is 1.1%.

In their work, Gloria *et al.* (2010) found a higher value which is  $2.10\% \pm 0.01$ . The result of the dietary fiber assay carried out on the *A. cepa* plant is  $2.12\% \pm 0.0707\%$  (Tab 1). This value is close to that quoted by Capel Abad (2014) is  $2.16\% \pm 0.53$ . Indeed, Kumar *et al.* (2010) and Bajaj *et al.* (1980) estimated a low dietary fiber value for the same plant, which is 0.4% and 1.7% respectively.

By comparing the fiber rate of our fresh *A. cepa* plant, which is much lower compared to that of the powder cited by the standard U.S.D.A (2013) which is 15.2%. According to the results presented in (Tab. 1), the fiber content of *F. vulgare* is  $12.20\% \pm 0.0785$ . This value is much lower than the results found by Middleton *et al.* (2013); Rather *et al.* (2012) and Lazouni *et al.* (2006), which are 27.50%, 26.5%, 18.5% and 40% respectively. According to Ramlu et Rao (2003), geographic location, soil condition, genetic makeup, agronomic and climatic conditions of the crop can also influence the fiber content. Differences in fiber content may also be due to differences in the methods used to determine them.

### • Total sugars

Sugars are the most important constituents in all three plants. They are also responsible for the flavor of the food (Amella, 2008). Tab. 1 show that *A. sativum* contains 25.6g / 100g  $\pm$  0.034 in total sugars (Figure7). This value is higher compared to the results found by Gorinstein *et al.* (2008). Abdou *et al.* (1972), who recorded values of 5-15g / 100g and 22.17g / 100g respectively. Further, Lawson (1996); Rasul Suleria *et al.* (2015) found results of 26-30g / 100g and 28g / 100g respectively. Total sugars was tested using One way Analysis of variance ANOVA-1 (Table7) and provided a significant overall P.value (Pr <<0.05).



**Figure 7:** Total sugar according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among all the analysed groups, for that reason the studied species appears very distinguished in terms of the studied parameter (Total sugars).

**Table 7:** Results of One-way ANOVA and Tukey's pairwise tests for Total sugars

Species comparaison	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>	< 0.001	< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>		< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001

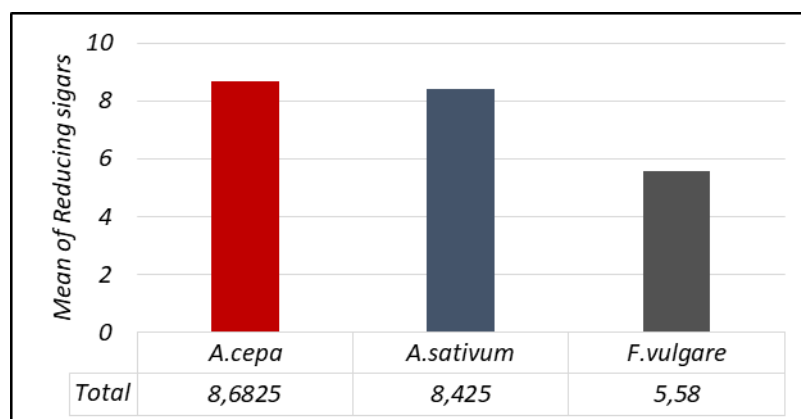
*A. cepa* contains a content of 13.16 g / 100g  $\pm$  0.1416 in total sugars (Tab. 1). This value is greater than that found by Bajaj *et al.* (1980); Atanassova *et al.* (2009) and Kumar *et al.* (2010) which are 9.34g / 100g, 10.5g / 100g, 11g / 100g respectively. Petropoulos *et al.* (2015) and Charles (2013) found much lower results from our results which are 6.63g / 100g, 3.41  $\pm$  0.12 g / 100g respectively. From the results given in (tab. 1), *F. vulgare* contains a content of 16.80 g / 100g  $\pm$  0.1983 in total sugars. This value is lower compared to the results found by Barros *et al.* (2010); Singh *et al.* (2010), which are 18.44 g / 100g  $\pm$  0.06, 19.39 g / 100g  $\pm$  0.65 respectively.

Ibrahim et El-Khateeb (2013) and Rather *et al.* (2012) recorded values higher than our results which are 21.91 g / 100g  $\pm$  0.55 and 22.82 g / 100g  $\pm$  3.06 respectively. Gerbi (2000) found a much lower result which is 6.17%. This difference may be due to variety, geographic origin, and storage conditions (Djouab, 2007). Many researchers including Munier (1973); Nixon et Carpenter. (1978) and Sawaya *et al.* (1983) agree that sugars vary with climate and stage of ripening.

According to Hartl (2011), the sugar content of plants is a complex, which is strongly influenced by the environment. In addition, other factors were added by Kader (1986), such as, the date of harvest, handling, techniques, and storage conditions; which can also modify the sugar profile of the plants. The results from different studies depend in part on the method used in the assay.

### ▪ Reducing sugars

Reducing sugars was tested using One way Analysis of variance ANOVA-1 (Table8) and provided a significant overall P.value (Pr <<0.05)



**Figure 8:** Reducing sugar rate according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among all the analysed groups, for that reason the studied species appears very distinguished in terms of the studied parameter (Reducing sugars).

**Table 8:** Results of One-way ANOVA and Tukey's pairwise tests for Reducing sugars

Species comparaisn	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>	< 0.001	< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>		< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001

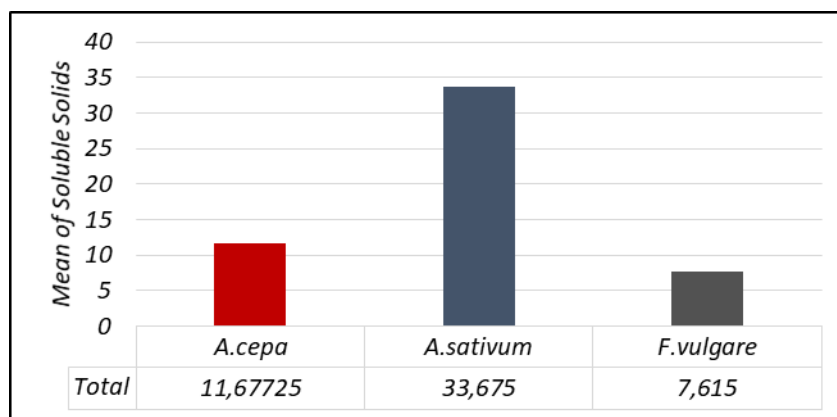
The content of reducing sugars in *A. sativum* studied is 8.4 g / 100g  $\pm$  0.1221 (Figure8), this value is higher compared to the results of research carried out by Garnier *et al.* (1961), which mentioned a value of 1.2 g / 100g.

The value of reducing sugars in *A. cepa* studied is 8.68 g / 100g  $\pm$  0.023 (Tab. 1). This value is lower than that found by Bajaj *et al.* (1980), which is 12.00g / 100g. According to Petropoulos *et al.* (2015), the majority of sugars in *A. cepa* is represented mainly by glucose 0.97 mg / 100g  $\pm$  0.04 and fructose 0.36 mg / 100g  $\pm$  0.01.

*F. vulgare* has 5.58 g / 100g  $\pm$  0.1906 of reducing sugars content (Tab. 1). This value is much lower compared to the result found by Barros *et al.* (2010), which is 1.49 g / 100g  $\pm$  0.29. According to Barros *et al.* (2010), the majority of the sugars of *F. vulgare* are represented mainly by glucose 4.71%  $\pm$  0.15, and fructose 1.51%  $\pm$  0.06. Several parameters influence the content of reducing sugars, including climatic conditions, the stage of maturation, and the physiological state of the plant during the analysis. However, it should be reiterated that reducing sugars are easily absorbed during digestion and quickly increase blood sugar levels (Al-Farsi *et al.*, 2005).

### • Soluble solids

The total soluble solids content of *A. sativum* is  $33.68\% \pm 0.2393$  (Figure9). Due to the lack of relative standards, as well as the work carried out on this parameter, we compared our result with that of *A. cepa* because they belong to the same family and have the same physicochemical characteristics. Petropoulos *et al.* (2015), conducted a study on two varieties of red onion, and found inferior results compared to our results which are  $9.95\% \pm 0.9$ ,  $14.00\% \pm 0.2$  respectively. Soluble solids rate was tested using One way Analysis of variance ANOVA-1 (Table9) and provided a significant overall P.value ( $Pr < 0.05$ ).



**Figure 9:** Soluble solids rate according to each species

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among all the analysed groups, for that reason the studied species appears very distinguished in terms of the studied parameter (Soluble solids).

**Table 9:** Results of One-way ANOVA and Tukey's pairwise tests for Soluble solids

Species comparaison	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>	< 0.001	< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>		< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001

$11.68\% \pm 0.375$  is the total soluble solids content of *A. cepa* (Tab. 1). This value is identical to that found by Dallocca-Berno *et al.* (2014), which is 11%, and close to that found by Capel Abad (2014), which is  $10.95\% \pm 0.25$ .

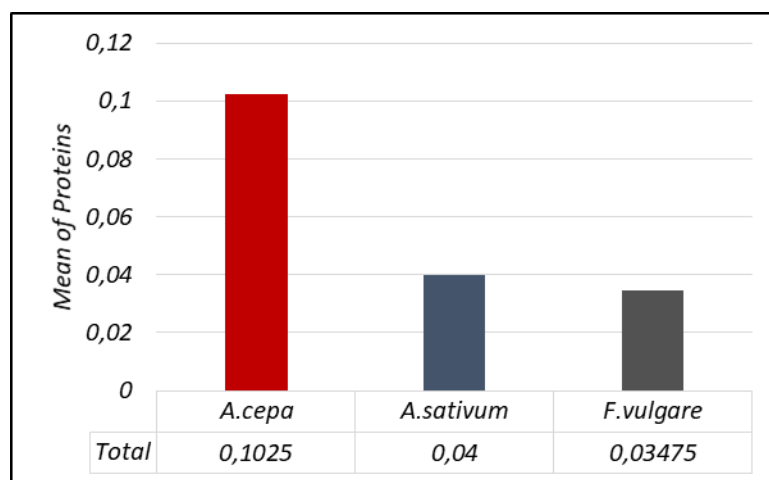
The total soluble solids content of *F. vulgare* is  $7.62 \pm 0.25$ . According to Messaid (2008), the different parameters that can influence the soluble solids level are: climate, soil type and plant maturation process.

### ▪ The protein contents

Proteins are made up of amino acids. Many of the protein assay methods use properties of amino acids. Protein contents were also tested using One way Analysis of variance (ANOVA-1) and provided a non-significant overall P.value ( $Pr < 0.112$ ).

We recorded a low protein content of *A. sativum*, which is  $0.04 \text{ mg / ml} \pm 0.0028$  (Figure10). This value is lower compared to the results of research carried out by Gorinstein *et al.* (2008); Rahman (2003) and Rasul Suleria *et al.* (2015), which are 1 to 2g / 100g, 1.5 to 2.1% and 2g / 100g respectively.

The protein content of *A. cepa* studied is 0.1 mg / ml  $\pm$  0.007 (tab 1). Our result is much lower than the standards U.S.D.A (2013) which shows 10.41g / 100g. This value is close compared to that found by Petropoulos *et al.* (2015), which is 0.62 g / 100g  $\pm$  0.03 and lower compared to the results of research carried out by Bajaj *et al.* (1980); Kumar *et al.* (2010); Atanassova *et al.* (2009) and Lim (2015), which are 1.10%, 1.2%, 1.7%, 1.1g / 100g respectively. Caruso *et al.* (2014) mentioned a much higher value which is 12.7g / 100g.



**Figure 10:** Proteins rate according to each species

*F. vulgare* has a low protein content in which is 0.034 mg / ml  $\pm$  0.0098 (tab 1). This value is lower compared to the results cited by Barros *et al.* (2010); Singh *et al.* (2010) and Ibrahim et El-Khateeb (2013), which recorded values of 1.33%  $\pm$  0.04, 6.33% and 5% respectively. Lazouni *et al.* (2006); Kjeldhal (1883) and Rather *et al.* (2012) found much higher values compared to our result which are 17.5%, 20% 9.5% respectively

#### ▪ The pectin content

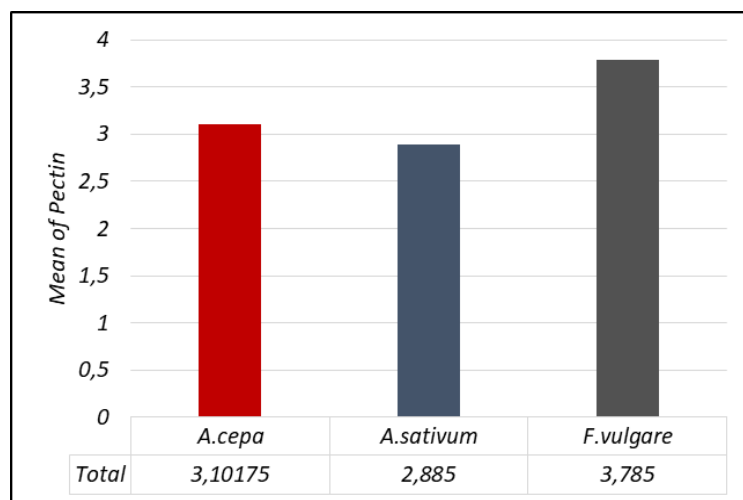
Pectin content was tested using One-Way Analysis of variance (ANOVA-1) and provided a significant overall P.value (Pr <<0.05).

The pectin content in *A. sativum* is 2.89%  $\pm$  0.1619 (tab 1). This value is clearly lower than that found by Michel et Foury (2003), which, is 15 to 20% celluloses, and pectins 3.102%  $\pm$  0.0459 is the pectin content in *A. cepa* (tab. 1). The components of the cell walls: celluloses and pectins are found in significant proportion in the bulbs rich in water. Their share is estimated at 10 to 15% of dry matter in onions (Lutomsky, 1983). The fibers are made up of both celluloses and pectins, which explains the mild laxative effect of cooked onion (Loison, 2006).

According to the Tukey Post-Hoc test, a statistical dissimilarity is recorded among all the analysed groups, for that reason the studied species appears very distinguished in terms of the studied parameter (Pectin content).

**Table 10:** Results of One-way ANOVA and Tukey's pairwise tests for Pectin content

Species comparaisn	Overall P.value of ANOVA	Tukey's P.value (post-Hoc)
<i>A. cepa</i> – <i>A. sativum</i>	< 0.001	< 0.001
<i>A. cepa</i> – <i>F. vulgare</i>		< 0.001
<i>F. vulgare</i> – <i>A. sativum</i>		< 0.001



**Figure 11:** Pectin rate according to each species

*F. vulgare* has  $3.79\% \pm 0.07$  pectin content (Figure11). According to Amellal (2008), this difference may be due to growing conditions and degree of maturity. We can add that the results depend in part on the method used (the dosage). Marcellin et al. (1990) have shown that the content of pectic substances varies with the stage of growth, the season, and the cultivar. The pectin content decreases with the ripening of the vegetables; however, this decrease in content does not seem to affect the texture (Myhara et al., 2000).

## Conclusion

The analytical study of *Allium cepa*, *Allium sativum* and *Foeniculum vulgare* showed that these three plants contain a particular composition including nutrients such as proteins, pectin, fibers, fats, sugars and minerals. This results can be exploited and supplemented in scientific researches in the field of pharmacology, phytochemistry and biochemistry.

## Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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