République Algérienne Démocratique et Populaire
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
Université A. MIRA - Béjaia

Faculté des Sciences de la Nature et de la Vie
Département des sciences Alimentaire
Spécialité Science des Corps Gras

Réf :.....

Mémoire de Fin de Cycle
En vue de l'obtention du diplôme

MASTER

Thème

Effet du salage sur le profil phénolique et l'activité antioxydant de certaines variétés d'olives produites localement

Présenté par :
Messaoudene Khaled & Chaouch Lounes
Soutenu le : 15/09/2022

Devant le jury composé de :

Mr.Mokrani Abderrahmane	MCA	Promoteur
Mme. Oukil Naima	MCA	Présidente
Mme. ISSAADI Ouarda	MCB	Examinatrice

Année universitaire : 2021 / 2022

People's Democratic Republic of Algeria
Ministry of Higher Education and Scientific Research
A. MIRA University – Bejaia

Faculty of Natural and Life Sciences
Department of Food Science
Fatty Sciences specialty

Réf :.....

End of Cycle Memory

For graduation

MASTER

Theme

Effect of salting on the phenolic profile and on the antioxidant activity of some olive varieties produced locally.

Presented by:
Messaoudene Khaled & Chaouch Lounes
Supported the: 15/09/2022

In front of the jury composed of:

Mr. Mokrani Abderrahmane	MCA	Promotor
Mme. Oukil Naima	MCA	President
Mme. ISSAADI Ouarda	MCB	Examiner

University year : 2021 / 2022

Thanks

Above all, we thank the Almighty God for having given us the courage, the will, the patience and the health during all these years and that thanks to him this work could be carried out.

Then, we would like to express our great consideration and our deep gratitude to our promoter ***Mr. Mokrani*** *for having accepted to supervise our work here, as well as for his patience, his precious advices, his kindness and availability to guide us, which led us to the culmination of this work.*

We also thank ***Mrs. Ouradi Nabila****, the head of the hygiene laboratory of the wilaya of Bejaia for her benevolence towards us throughout the period of the practical internship and also the entire team of the 3BS laboratory of the University, for their assistance throughout the long months of our internship. Please accept all our feelings of gratitude and respect.*

We also thank the members of the Jury for their patience and for agreeing to review our study and comment on its possible quality.

All our respects are addressed to our dear parents who encouraged and supported us a lot during our studies.

Finally, we address our most sincere thanks to all our family and friends, whom had always encouraged us during the realization of this thesis.

Dedication

May this work show my respects

To my parents

Thanks to their tender encouragement and their great sacrifices, they were able to create the affectionate climate conducive to the pursuit of my studies. No dedication could express my respect, my consideration and my deep feelings towards them. I pray the good Lord to bless them, to watch over them, hoping that they will always be proud of me. To my two brothers: ***Djamel*** *and* ***Billal*** *and My little sister* ***Nassima***

They will find here the expression of my feelings of respect and gratitude for the support they have constantly given me. To all my family, especially my cousins and uncles. To my friends ***Billal, lyes, lyes, khaled, Koceila, fatah****,* ***massi*** *and* ***"Hanane"****. They will find here the testimony of loyalty and infinite friendship. To all the Master 2 science of fats promotion, to whom I wish a good professional career. To all my friends from the university whom I met throughout my journey.*

CHAOUCH LOUNES

DEDICATION

To the Almighty God, to whom I owe everything, and above all for having honored and enlightened my path through knowledge.

To my late father "May God keep you in his vast paradise".

To my dear mother who always knew how to be by my side in joy and sorrow, Dear mother, "may God keep you for us".

To my dear sister Sadra and my brother Naim

"I wish you a long life full of joy and success".

To my dear friends Dadi, yanis, yacine, Akli

"They will find here the testimony of an infinite fidelity and friendship".

To all the Master 2 science of fats promotion, to whom I wish a good professional career and all my friends from the university whom I met throughout my journey.

Messaoudene khaled

Summary

Bibliography

Chapter I: General information on olives

ChapitreII :Processes for producing table olives

Materials and methods

Results and disscution

Abbreviations list

AGPI/AGS: AGPI: polyunsaturated fatty acid/**AGS**: saturated fatty acid

HT: hydroxytyrosol

(OL & OLE): oleuropein

FA : fatty acid

UFA: unsaturated fatty acid

RNAm: messenger ribonucleic acid

LDL: Lipoprotein Low Density

COX2: Cyclooxygenase 2, qui fait partie d'une famille d'enzymes inductives par de multiples facteurs pro-inflammatoires

NF-κB: nuclear factor-kappa B is a transcription factor superfamily protein involved in immune response and cellular stress response

ROS: Reactive Oxygen Species

DNA: deoxyribonucleic acid

Caco-2: is an immortalized cell line of human colorectal adenocarcinoma cells

MMP-2: Matrix metalloproteinase-2 and gelatinase A, is an enzyme encoded by the MMP2 gene in humans. The MMP2 gene than is located on chromosome 16 at position 12.2

MMP-9: Matrix metallopeptidase 9 or gelatinase B

TNF-α: Tumor Necrosis Factor is a cytokine with pro-inflammatory properties and immunology functions

cAMP: cyclic nucleotides cyclic adenosine monophosphate

cGMP: cyclic guanosine monophosphate

PD: Alzheimer Disease.

AD: Parkinson Disease

DW: dry weight

Abbreviations list

TPC: total phenolic compounds

TFC: Total flavonoid content

TFLC: Total flavonols content

TFLC: Total anthocyanin content

DPPH-RSA: 2, 2-diphenyl-1-picrylhydrazyl free radical scavenging activity

ABTS-RSA: 2, 2'-azino-bis(3-éthylbenzothiazoline-6-sulphonique) free radical scavenging activity.

FRP: Ferric reducing power

ICA: Iron chelating activity

Tables list

Figures list

Introduction

The traditional Mediterranean diet (MD) is associated with long life and lower prevalence of cardiovascular disease and cancers. The main components of this diet include high intake of fruit, vegetables, red wine, extra virgin olive oil (EVOO) and fish, low intake of dairy and red meat (Boss et al., 2016).

The olive tree (*Oleaeuropaea* L.) is widely cultivated for the production of both oil and table olives and very significant because of its economic value. Olive and olive oil, a traditional food product with thousands of years of history, are the essential components of the Mediterranean diet and are largely consumed in the world. Beside of their economical contribution to national economy, these are an important food in terms of their nutritional value. Olive and olive oil may have a role in the prevention of coronary heart disease and certain cancers because of their high levels of monosaturated fatty acids and phenolic compounds. In addition, olives (*Oleaeuropaea* L.) and olive oils provide a rich source of natural antioxidants. These make them both fairly stable against auto-oxidation and suitable for human health (Uylaşer and Yildiz, 2014).

Accprding to Food and Agricultural Organisation (FAO), world production of olives was more than 12.76 million tons for 2020, primarily coming from Spain (5.78 million tons), Italy (2.97million tons) and Greece (2.44 million tons) followed by Turkey (1.41 million tons) and Morocco (0.93 million tons). Algeria is one of the major olive producing countries ranking in tenth position with a world production of 0.42 million tons(FAOSTAT., 2020). Olive trees ranked first amongst the fruit trees in Algeria (Algerian Ministry of Agriculture). Table olive production has undergone a remarkable evolution in recent years to reach 293.000 tons (campaign 2016/2017), which represent 10% of the world production (Chabane et al., 2020).

Ripe olives contain high levels of bitter phenolic compounds including oleuropein and ligstroside that make the fruit inedible. In order for olives to be considered suitable for human consumption, the fruit must undergo some form of processing, fermentation, or curing to reduce the concentration of these bitter phenolic compounds(Johnson and Mitchell, 2018). Table olive processing is mainly conduced according to threemethods of a great importance in the international trade and are mainly used on an industrial scale, called Spanish-style for green olives, Californian-style and Greek naturally-style for black olives (Garrido-Fernandez et al., 1997; Sanchez et al., 2006). Each method of debittering produces a different style of table olives with a unique texture and chemical, microbial and sensorial properties (Johnson and Mitchell, 2018). However, there are some traditional preparations that have not attractedmuch attention.

One of these involves the use of dry salt to eliminatethe natural bitterness of the fruits and to make them edible.

Table olives are an important component of the Mediterranean diet, a diet linked with the reduction of certain chronic diseases including cardiovascular disease. Table olives contain a range ofbiologically active phenolic compounds. The predominantphenolic compound in fresh olive fruit is oleuropein. Thisphenolic compound is very bitter and must be removed to makeolive fruit palatable. This is generally achieved through salt curingor alkaline hydrolysis. The main hydrolysis products of oleuropein include hydroxytyrosol and tyrosol. Many of the health benefits reported for olives are thought to be associated with the levels of hydroxytyrosol.

Several studies have focused on the phenolic content of olive fruits (Esti et al., 1998; Vinha et al., 2005; Ziogas et al., 2010). However, little work was conducted regarding the effect of processing techniques on the phenolic composition of table olives. Thus, the purpose of this study was (i) to determine the phenolic composition (total phenolic content; TPC, total flavonoid content; TFC, total flavonol content; TFLCand total anthocyanin content; TAC)and the antioxidant potential (total antioxidant activity; TAA, DPPH radical-scavenging activity; DPPH-RSA, ABTS radical-scavenging activity; ABTS-RSA, ferric reducing power; FRP and iron chelating activity; ICA) of three fresh black Algerian olives cultivars (Aharoune, Bouchouk and Sigoise), (ii) to study the effect of three solvents extraction (60% acetone, 60% ethanol and water) on the recovery of phenolics and on the antioxidant capacity of the three olives varieties studied in order to find the best solvent extraction torecovery the maximum phenols from olives and to correlate their levels with the antioxidant activity of the obtained extracts and (iii) to test the effect of dry salting on the phenolic compounds the contents and the antioxidant capacity of the three Algerian black olives cultivars.

Chapter I

Generalities on olives

1. Botanical description and structure of olives:

1.1. Botanical description

Olive (*Oleaeuropaea* L.) belongs to the botanical order of Ligustrals of the Oleaceae family, which includes the genera Jasminum, Phillyea, Ligustrum, Syringa, Fraxinus and Olea. Olive trees are cultivated predominantly for their fruit which is used as table olives and also processed into oil.Olive tree comes from a genus of evergreen trees in the family Oleaceae containing 24 genus and 900 species. *Oleaeuropaea* L. is in the same species such as lilacs, jasmine, Forsythia and the true ash trees (Fraxinus)(Şahin and Bilgin, 2018). Olive trees are cultivated predominantly for their fruit which is used as table olives and also processed into oil(komaki et al., 2003). The Taxonomic classification of olive tree is presented in table I(Şahin and Bilgin, 2018).

Table I: Taxonomic classification of olive tree(Şahin and Bilgin, 2018)

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Lamiales
Family	Oleaceae
Genus	Olea
Binomial name	*Oleaeuropaea*

1.2. Structure of olives

The olive fruit (*Oleaeuropaea*L.) is a drupe, a single-seeded indehiscent fruit with afleshy outer layer. The unripe fruit is pale green; as the fruit ripens, the colour changes frompurple to black. A few varieties are green when ripe, and some turn a shade of copper brown. Olive cultivars vary considerably in size, shape, oil content and flavour. The shapes range fromalmost round to oval or elongated with pointed ends(Hashim et al., 2005; Morelló et al., 2006). The ripe olive fruit exhibits a typical drupe structure, with a thinprotective exocarp, a fleshy mesocarp and a stony endocarp that surrounds the seed(shown in figure1). Most tableolives are harvested in mid-autumn when they are firm and the colour changes from green toyellowish-green. In contrast, oil olives are harvested in late autumn or winter after they haveturned black, with a reduction in the chlorophyll

content and an increase in the anthocyanincontent, and have attained their maximum oil content (Fedeli and Cortesi, 1993; Haralampidis et al., 1998).

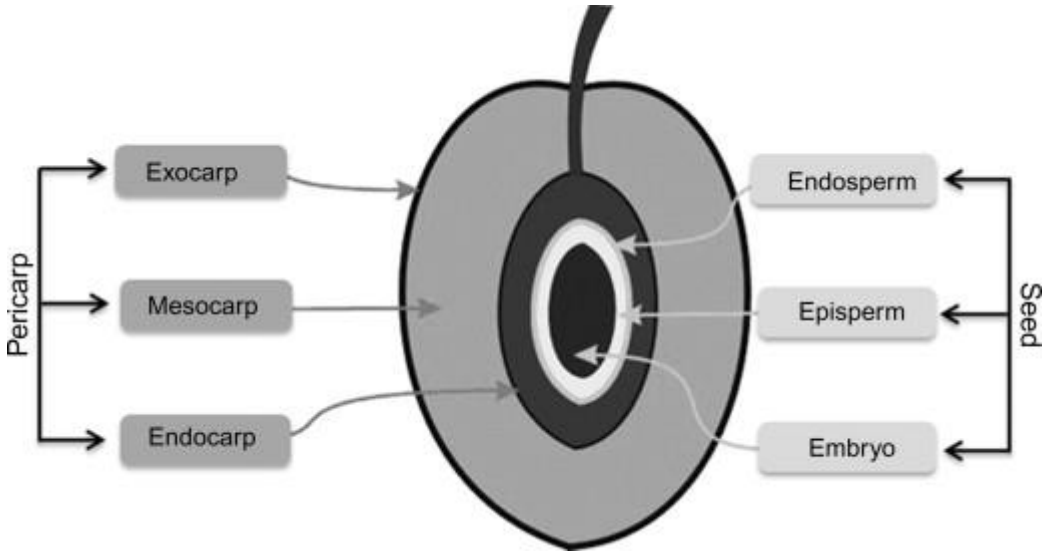

Figure 1: Structure of olive fruit (Calabriso et al., 2015).

1.2.1. Epicarp

This is a protective tissue that accounts for about 1-3% of the drupe weight. The skin itself is covered by alayer of wax, representing 45 to 70% of the skin weight. In the early stages of development the skin is bright green due to the accumulation of chlorophyll, but later it changes to pale-green, straw yellow, pink, purple pink and black. Such marked colour changes are due to unbalanced and varying concentrations of chlorophylls, carotenoids and anthocyanins, the major pigments in olives (Bianchi, 2003).

In table olive processing the structure and composition of the epicarp layers are of paramount importance. The significance lies in the fact, that the cutin and embedded waxes are almost impermeable to water. Other relevant functions of the epicarp include minimising mechanical damage to cells, inhibiting fungal and insect attack. Therefore the outermost layer of skin is most important. It plays a determining role in the processing and the final product quality (Bianchi, 2003).

1.2.2.Mesocarp

This constitutes the major part of the olive. Together withthe skin they represent the edible portion of olives, comprising 70-80% of the whole fruit. It is the reserve supplyof all the constituents, including water (70-75% of themesocarp weight) and oil (ranging from 14-15% in greentable olives to about 30% in black, mature olives). The textural quality of thetable olive, assessed by the consumer at the time of eating, is dependent on cell rupture

and cell separation. These properties are determined by the type of processing to which the olives have been subjected(Bianchi, 2003).

1.2.3. Endocarp

The stone is characteristic of a variety. It represents 18-22% of the olive weight. The enclosed kernels comprise 2-4% of the weight. The kernel contains a relevant amount of oil (22-27%), whilst the woody shell contains, at most, 1%. The size, weight, shell conformation of the stone and its easy separation from the flesh are important parameters that determine the quality of the final product (Bianchi, 2003).

2. Chemical composition of olive

Average content of water, protein and oil in olive fruits are 50%,1.6% and 22%, respectively. Olive fruit contains 19.1% carbohydrate,5.8% cellulose and 1.5% inorganic substances. Other important compounds present in olive fruit arepectin, organic acids, pigments and phenols (Boskou, 2006).Organic acids show metabolic activity and are intermediateproducts resulting from formation and degradation of othercompounds(Cunha et al., 2001).

2.1. Lipids

Lipids represent 8 to 24 g/100gof olives; they are ruled by fatty acids unseated including mono-unsaturated (oleic acid). The level of triglycerides increases with the ripening of the fruit (17% in green olives and 25% in black olives).The lipid content increase during maturation and reach its maximum at full maturity.Oleic acid is the main fatty acid in olives(83%). The AGPI/AGS ratio is low and varies during fruit ripening (Owen et al., 2003; Sakouhi et al., 2008).

2.2.Glucids and organic acids

When analyzing the carbohydrate composition of raw olive fruits, the main sugars are glucose, mannitol, fructose and sucrose with concentrations of 29.2, 10.5, 5.2 and 1.5 g/kg, respectively. These sugars represent 3.5-6% of the flesh. Note that sugar content decreases with fruit maturation. The sugar content in olives is the most important fermentative substrate for the growth of the microorganisms which are responsible for fermentation during the natural style elaboration. The soluble sugars are transformed by microorganisms into organic acids as the product of the fermentation and second metabolites responsible for the desirable organoleptic characteristics in the final product (Chabane et al., 2021).

The polysaccharides and pectic substances, major constituents of intercellular lamellae, have a cementing function and determine the texture of the olive flesh. During olive processing and storage the pectic substances are hydrolysed by pectinolytic enzymes, and ‘hardness texture of the fruit diminishes (Bianchi, 2003).

Organic acids are one of the minor components of olive fruit and their amount is 1.5% of the fleshy part. Organic acids that play an important role in metabolic activity are the products formed during the formation and degradation of the other components in olive fruit like carbohydrates. Malic and citric acids which affect the colour of the olive are the major organic acids found in it (Ergönül and Nergiz, 2010).

2.3.Proteins

Olive fruit contain also proteins. The protein content varies between 1.5%-2.2% of the fruit weight (Bianchi, 2003).Furthermore, the olive fruit flesh contains free amino acids such as arginine, glutamic and aspartic acid.

2.4. Minerals

The overall composition of minerals varies between olive cultivars. Of thevarious elements K is the most abundant element in the fruit, followed by Mg,Ca, Na and Fe (Nergiz and Engez, 2000).

2-5. Volatils compounds

Volatile or aromatic compounds are molecules that define the organoleptique characteristic of the olives. They constitute a quality index of the olives produced by controlling their acceptability by the consumer. The aroma of the table olives is made up of a balanced mixture of hydrocarbons, alcohol,aldehydes, ketones and ester (Sabatini and Marsilio, 2008).

2.6. Antioxidants of olives

2.6.1. Phenolic compounds

The olive drupe, in fact, contains high concentration of phenolic compounds that can range between 1 and 3% of the fresh pulp weight(Fernández et al., 1997). Phenolic compounds constitute an important group of naturally occurring compounds in plants. They are secondary plant metabolites, with a great structural diversely and a wide phytogenetic distribution (Harborne, 1989) The most important classes of phenolic compounds in olive fruit include phenolic acids, phenolic alcohols, flavonoids and secoiridoids(Vinha et al., 2005).

a. Secoiridoids

The predominant phenolic compounds inraw olives are certain secoiridoids derived from oleosides, acombination of elenolic acid and glucose residue. Oleuropein,an heterosidic ester of elenolic acid with 3,4-dihydroxyphenethylalcohol (hydroxytyrosol), demethyloleuropein, the acidderivative of oleuropein and ligstroside, an heterosidic esterof elenolic acid with 4-hydroxyphenethylalcohol (tyrosol)are repeatedly reported as the main secoiridoids of the fruit(Gariboldi et al., 1986; Panizzi et al., 1960; Ragazzi et al., 1973). Olive fruit contains also some other oleuropeinderivatives, e.g. oleuropeinaglycon, hydroxytyrosilelenolate,enololeuropeindiale (Bianco and Uccella, 2000),hydroxytyrosol and tyrosolglucosides, such as hydroxytyrosol-1-O-β-glucoside, tyrosol-1-O-β-glucoside, hydrotyrosol-3'-O-β-glucoside and hydrotyrosol-4'-O-β-glucoside(Bastoni et al., 2001; Bianco and Uccella, 2000)and verbascoside,which is the caffeoylrhamnosylglucoside of hydroxytyrosol(Andary et al., 1982)**.**

b. Phenolic acids

Benzoic, cinnamic, phenylacetic and phenylpropionic acid hydroxyderivatives, such as p-hydroxybenzoic, protocatechuic, vanillic, syringic, *o*- and *p*-coumaric, caffeic, chlorogenic, ferulic, sinapic, p-phenylacetic, 3,4-dihydroxyphenylacetic, homovanillic and dihydrocaffeic acids, are also present in olive at levels depending on fruit variety (Bianco and Uccella, 2000).

c. Flavonoids

Flavonoids present in olive fruit are flavones, mainly luteolin, flavone and flavonolglucosides, mainly rutin and luteolin 7-glucoside, and anthocyanins, mainly cyanidin 3- glycosides(Romani et al., 1999; Vlahov, 1992). Anthocyaninsare responsible for the purple colour of natural black olives and a qualitative study of these pigments was carried out by Vázquez and Maestro(Rovellini et al., 1997; Vlahov, 1992), reporting that cyanidin-3-O-glucoside and cyanidin-3-O-rutinoside were the main anthocyanins in natural black olive fruits.

d.Phenolic alcohols

Tyrosol and hydroxytyrosololeosides and the respectivefree alcohols have been also identified at considerableamounts(Bianco and Uccella, 2000; Soler-Rivas et al., 2000).

e.Tocopherols

These are present in all oils of plant origin, and also in animal lipids. The α-tocopherol comprises 88.5% of all tocopherols in olive oil. The concentrationof α-tocopherol in olive oil is 12–150 ppm. Oils derived from the fruit stonecontain higher concentrations of tocopherols, which play the role of antioxidants (Therios, 2009).

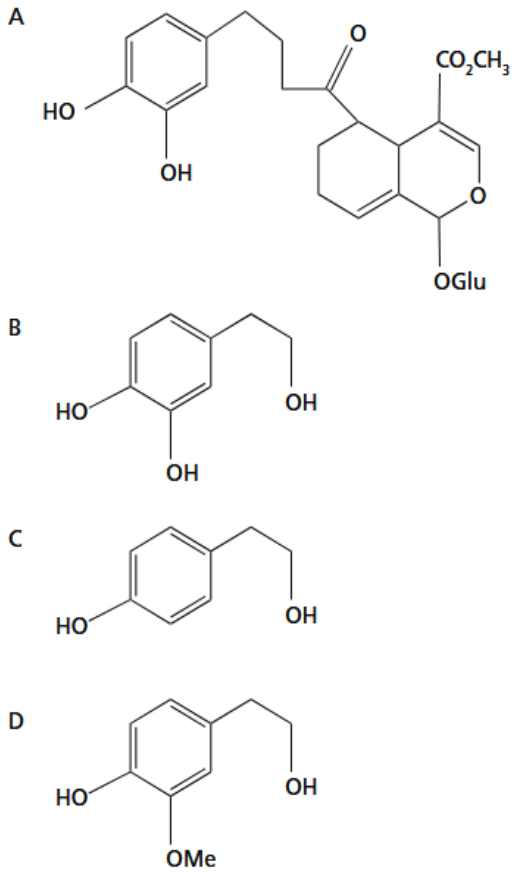

Figure 2: Chemical structures of major bioactive phenolics in olives and olive oil: (A) oleuropein, (B) hydroxytyrosol, (C) tyrosol, (D) homovanillic alcohol.

f.Chlorophyll and carotenoids

Three chloroplast pigments identified in olives are those of all green planttissues and do not undergo any change or modification during the stages ofripening. The carotenoids β-carotene, phytofluene and luteoxanthin arepresent in very small amounts. Both chlorophylls and carotenoids decrease asthe season progresses, almost disappearing at the moment of maturity, whileanthocyanins begin to appear, little by little, invading the skin and later thewhole pulp. The α-chlorophyll is the major component, followed by β-chlorophyll. Carotenoids have been found to be minor components, such aslutein, which is

the major xanthophyll, and β-carotene, the principal carotene. As olive fruit ripens, photosynthetic activity decreases andchlorophyll disappears. As a consequence, the colour of the skin changes fromgreen to yellow, reddish or red. During this period the concentration ofcarotenoids and chlorophylls diminishes, while the proportion of xanthophyllsincreases. Chlorophyll degradation is accompanied by the synthesis of othercompounds, anthocyanins, because the carotenoids do not produce the finalpigmentation of the ripe fruits, i.e. reddish or purple (Therios, 2009).

3.Olive market

The olive tree has been grown for its oil-rich fruit since late prehistoric times. Thecultivated variety, *O. europaea*L. *var. europaea*, has become more adaptable to a wider range ofclimatic and environmental conditions(Carrión et al., 2010). Many cultures have used olive oilprimarily as a lamp fuel, however, in the late 19th and 20th centuries, the demand for olive oildecreased after the development of low-cost solvent extraction techniques for seed oils and theuse of other sources of light (gas and electricity). Today, the olive fruit and oil provide valuablenutrients for humans, and they play important roles in the diets of the people in the areas ofcultivation, in addition to the role in their economy and culture(Blázquez-Martínez, 1996; Civantos, 1998; Uylaser et al., 2008; Vossen, 2007).

3.1.World production of olives

Olive trees possess an amazing ability to survive under unfavourable conditions; however,it is a demanding crop if it is to flourish. Therefore, a suitable environment and proper culturalcare are necessary for the full development of the agronomic characteristics and steadyproduction conditions. The tree is cultivated today in many countries, including Spain, Italy,Greece, Tunisia, Turkey, Portugal, Morocco, Syria, Algeria, Egypt, Israel, Libya, Jordan,Lebanon, Cyprus, Croatia, Slovenia, Argentina, Chile, Mexico, Peru, the United States, andAustralia(Boskou, 2009).

According to the report of the International Olive Oil Council (IOOC, 2011),Mediterranean countries accounted for approximately 97% of the world's olive cultivation,estimated at approximately 10,000,000 hectares. There are more than 800 million olive treescurrently grown throughout the world, of which more than 90% are grown for oil production andthe rest for table olives. It is estimated that more than 2,500,000 tons of olive oil are producedannually throughout the world. Approximately 81% of the total olive production comes from theEuropean Community (EC) (Spain, Italy, Greece, Portugal, and France), with the Near Eastcontributing, approximately 7% and

North Africa supplying approximately 11%. The remaining 1% is of American origin, chiefly from Argentina, Mexico, Peru, and the United States.(Figure 3)shows the main countries where olives areproduced.

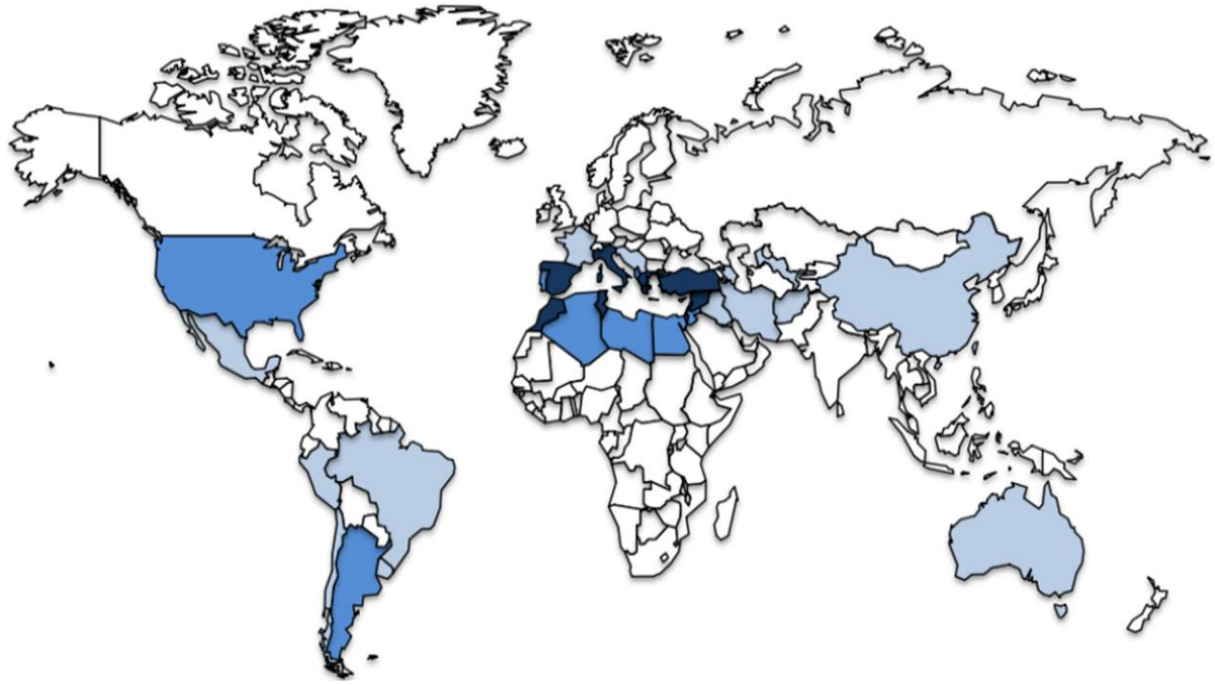

Figure 3: The main countries producing olives, based on production between 2003 and 2013.

Production more than 1E+7 tonnes. Production in the range of 1E+6 to 1E+7 tonnes. Production lower than 1E+6 tonnes.(Guo et al., 2018).

3.2National production of olives

Algeria is one of the major olive producing countries ranking in tenth position with a world production of 0.42 million tons(FAOSTAT., 2020). Olive trees ranked first amongst the fruit trees in Algeria (Algerian Ministry of Agriculture). Table olive production has undergone a remarkable evolution in recent years to reach 293.000 tons (campaign 2016/2017), which represent 10% of the world production (Chabane et al., 2020).

Oliviculture in Algeria has an important and an ancestral place. In 2006, the area covered by olive trees was 263,352 ha (29,995,980 trees) corresponding to 32.5% of total tree growing area except vineyards (810,193 ha). However, the olive oil production is

concentrated mainly in the center of the country, “the Kabylie” with 58.4% of the total oliviculture area (153,708 ha)(Louadj and Giuffrè, 2010)

There are many cultivated and described olive tree cultivars in Algeria; 36 cultivars are homologa- ted by I.T.A.F. (Institut Technique de l’ArboricultureFruitièreet de la Vigne). I.T.A.F. is a national Technical Institute of tree and wine growing created in 1987, the headquarters is situated in Algiers but it has 10 demonstration farms in different regions of Algeria. The most important cultivars of olive are(Louadj and Giuffrè, 2010):

- **Chemlal:** in the Kabylie region, it occupies 40% of the national area for oliviculture, cultivated for olive oil extraction.
- **Sigoise:** in the west of Algeria, it occupies 25% of the national area for oliviculture, it has double destination (olive oil and table olives).
- **Azeradj:** in the Kabylie region (the east center), it occupies 10% of the national area for oliviculture. It has double destination (olive oil and table olives).

ChapterII

Table olives processing and biological activities

1.Table olive definition:

According to the Trade Standard Applying to Table Olives (COI/OT/NC no. 1, 2004), table olives are defined as the product ‘‘prepared from the sound fruits of varieties of the cultivated olive tree (*Oleaeuropaea* L.) that are chosen for their production of olives whose volume, shape, fleshto-stone ratio, fine flesh, taste, firmness and ease of detachment from the stone make them particularly suitable for processing’’. Different kinds of table olives should be classified according to the ripeness stage of the fruit, trade preparation, styles and sizing (Sousa et al., 2008).

2.Olives processing

Most olives are used to produce olive oil. However, many are processed into different types of table olives for direct human consumption (Gandul-Rojas and Gallardo-Guerrero, 2014). Table olives are a chief and traditional fermented food in Mediterranean countries. Contrary to other fermentedfoods (e.g. carrots, cabbage, pumpkins, beans),table olives have low sugar levels (2–5%), high fatcontent (20–35%), and a bitter taste caused byoleuropein(Sakouhi et al., 2008). The texture of theedible flesh varies widely, depending on variety, oilcontent, stage of maturity, soil quality, climate, andother factors that influence the physical and chemicalcomposition of the fruit (Mafra and Coimbra, 2004).

The highly bitter taste caused by oleuropein makes fresh olives hard to eat. Fresh olives must becured and fermented to make them palatable. Lyetreatment removes the bitterness by converting oleuropein into hydroxytyrosol (HT), elenolic acidglucoside (oleoside-11-methyl ester) and oleuropein aglycone under the circumstance of hydrolyticcleavage of the ester and glycosidic bond(figure 4)**.**

There are three main commercial types oftable olives: Spanish-style green olives, Californiastyleblack-ripe olives, and Greek-style natural blackolives in brine (Papadaki and Mantzouridou, 2016).Three different processing methods produce the threekinds of table olive (Figure 5) and give them each adifferent taste.

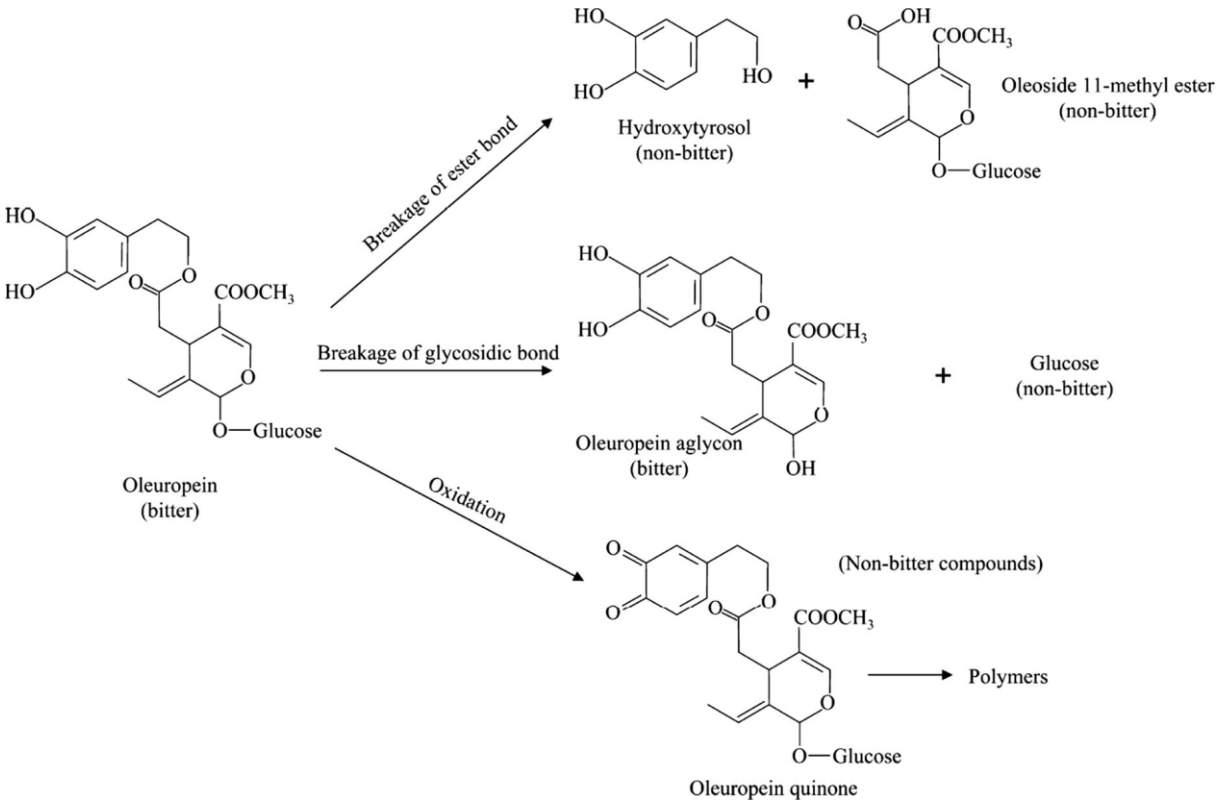

Figure4: Bitterness of oleuropein and products of its chemical transformations (Garcia et al. 2008).

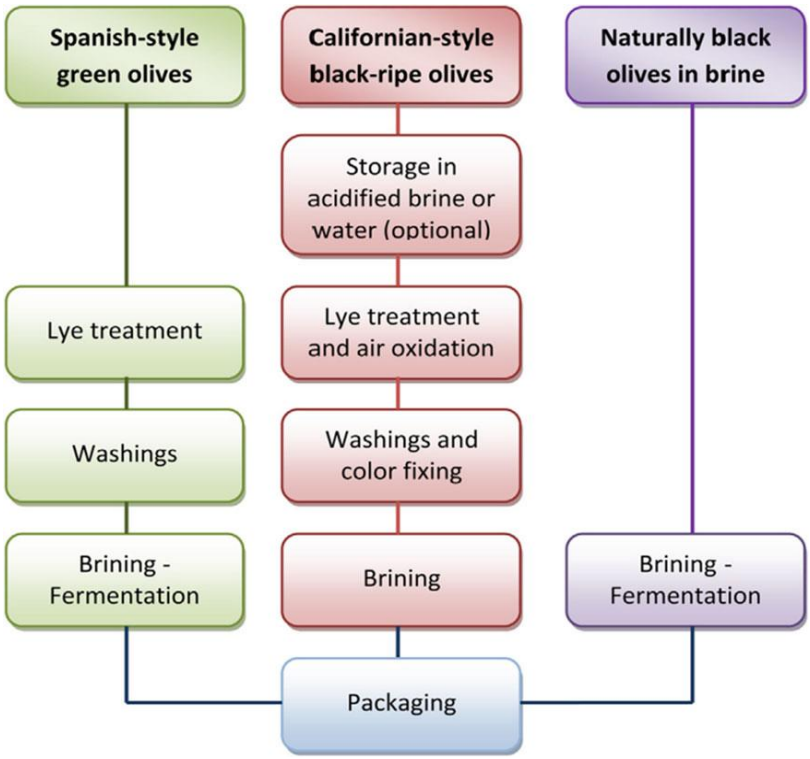

Figure 5: Production process flow charts for Spanish-style green olives, Californian-style black-ripe olives, and naturally black olives in brine(Papadaki and Mantzouridou, 2016).

2.1.Spanish-style green olives

Olive fruits are harvested with colours varying from green to yellow but having reached normal size. Olives are submitted to a sodium hydroxide(NaOH) solution (lye, normally 1.3–2.6 % w/v) until NaOH reaches from two-thirds to three-fourths of the distance between the surface of the olives and the stone(Charoenprasert and Mitchell, 2012). The concentration of NaOH used will depend on thetemperature, cv. and degree of the fruit maturity. The lye treatment hydrolyses the OL into non-bitter HT and oleoside-11-methyl ester. Subsequently, olives are washed with water to remove the excess of lye and submitted to a sodium chloride (NaCl) solution (6–8 % w/v) for a mild lactic fermentation(Mateus, 2016). The levels of OL and other phenolics present in the brine can influence the fermentation rate, as they have antimicrobial activity. Finally, the olives are packed in brine (≥8 % w/v NaCl) and they can be further processed to prolong shelf-life, through the addition of sorbic acid or its salts, or submitted to pasteurization (62.4°C for 15 min)(Charoenprasert and Mitchell, 2012).

2.2.Californian-style black olives in brine

Olive fruits areharvested before they reach their final maturation stage.First, olives are stored in brine (5–10 % w/v NaCl) for a period which varies from 2 to 6 months, with mediumacidification until pH 4 through the addition of lactic andacetic acids and in anaerobic/aerobic conditions to preventfermentation(Charoenprasert and Mitchell, 2012; Pereira et al., 2006). Posteriorly, fruits undergo a treatmentwith two to five NaOH solutions (1–2 % w/v), leading to aprogressive entry of NaOH into the flesh(Charoenprasert and Mitchell, 2012). In intervalsbetween lye treatments, olives are suspended in water or aweak brine solution in which air is bubbled, leading tooxidation by aeration and polymerization of phenoliccompounds, transforming them into different darkcompounds, allowing that a rapid darkening of the fruitoccurs. Iron salts, such as ferrous gluconate or ferrouslactate, can be used to stabilize and maintain the black color of table olives. The change in colour of olives is alsofacilitated by the formation of uncoloured ferrous complexes and the following oxidation to dark ferric iron complexes.Normally after, these table olives are canned in brine andsubmitted to a sterilization treatment(Charoenprasert and Mitchell, 2012).

2.3.Greek-style natural black olives

Olive fruits, when intendedto be processed with this method, are harvested in the final

stage of maturation with a dark colour. After harvesting,olives are washed and directly immersed in a brine solution(8–10 % w/v NaCl), without any debittering treatment(Boskou et al., 2015; Charoenprasert and Mitchell, 2012).A natural and spontaneous fermentation process starts,driven mainly by yeasts, due to high salt concentration used,and also by lactic acid and gram-negative bacteria. It isn't worthy that fermentation may be carried out in eitheranaerobic or aerobic conditions. The microbiota is definedby substrate availability, salt level, temperature and pHvalues, aerobic and anaerobic conditions and antimicrobialcompounds present such as phenolic compounds. Duringfermentation, bitterness of olives is lost because of thediffusion of OL from the fruit to the brine and theposterior acid hydrolysis of this compound(Boskou et al., 2015; Charoenprasert and Mitchell, 2012; Mateus, 2016; Mendes and da Silva Malheiro, 2012).

3.Effect of processing on olive quality

The processing technology greatly influences the chemico-physical composition of the olive and, consequently, the final product. Lye-treatment and fermentation, both commonly used in most table olive preparations, cause chemical and physical changes, affecting the lipid constituents, the phenols, sugars and salts. This usually results in a softening of the olive fruit, which reduces the market value of the final product (Bianchi, 2003).

4.Table olive market

4.1World production of table olives

According to the International Olive Council (IOC), the world table olive production for the2013/2014 season accounted for approximately 2.7 million tonnes.The European Union (EU) contributed 30% of the total production.The EU's largest producers are Spain, Greece and Italy (72, 16 and9% of the total EU production, respectively). Other main producing countries are Egypt (15%) and Turkey (16%).This situationis clearly illustrated in (**Figure 6)** . Also, in(**Figure 6),** the international trade and consumption of table olives for the same period ispresented (based on IOC statistical data). Noticeably, low- or evennon-producing countries such as USA, Russia and Brazil consumesignificant amounts of the product(Papadaki and Mantzouridou, 2016).

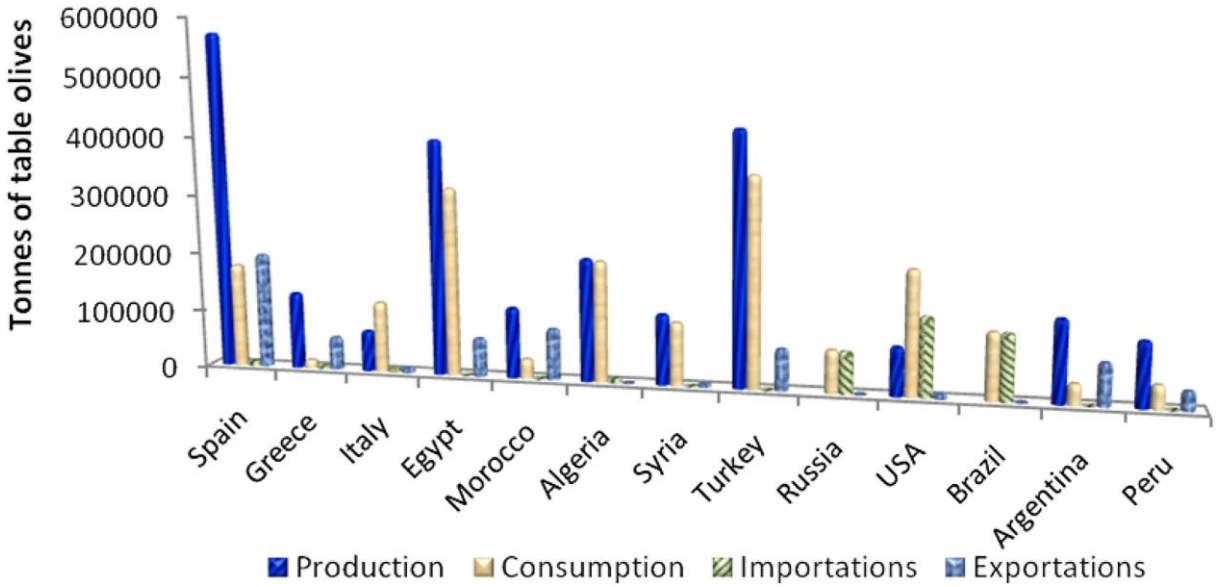

Figure 6: Table olive production, consumption and trade in different countries in 2013/2014(Papadaki and Mantzouridou, 2016).

4.2.Nationalproduction of table olives

Algeria is one of the major table olive-producing countries, with an increased production in recent years estimated at 323,000 tons annually, representing more than 10.5% of the global production (International Olive Council [IOC], 2021).

5. Nutritional properties of table olives

Table olive is a very important fermented food of the Mediterranean countries. Olive-fruit is highly appreciated for its good taste, as well as for its nutritional properties. The nutritional benefits are mainly related to α-tocopherol and FA contents (Ribarova et al., 2003). In fact, UFA participate in the regulation of cholesterol level(DELPLANQUE et al., 1999). Monounsaturated fatty acid stimulates transcription of the RNAm of LDL-cholesterol receptor (Sorci, Wilson, Johnson, &Rudeell, 1989) and reduces breast cancer risks. Moreover, a-tocopherol defends the body against free radical attacks by protecting polyunsaturated fatty acids (Cheeseman and Slater, 1993; Doelman, 1989; Kamal-Eldin and Andersson, 1997) and preventing the body from cancer and arteriosclerosis (Armstrong et al., 1997; Caruso et al., 1999).

6. Medicinal use of Olives

Olives have multiple medicinal uses, including disorders of the gastrointestinal and cardiovascular systems. The olive fruits and leaves are indicated in arrhythmia,

atherosclerosis,cardiopathy, colic (spasm), diarrhea, fever, gout, headache, hepatosis, hypercholesterolemia,and hypertension. Olive oil is used in traditional medicine as a cardioprotective,gastroprotective, and enteroprotective; it is effective in the treatment of cancer, constipation,diabetes, and rheumatism. Phytochemical studies revealed that olives contain multiplecompounds that have been indicated as therapeutics, including aescultin, alpha-tocopherol,apigenin, arabinose, beta-carotene, caffeic acid, catechin, choline, cinchonidine, cinchonine,elenolide, erythrodiol, esculin, estrone, fat, fibre, glucoside, iron, linoleic acid, luteolin, mannitol,myristic acid, oleanolic acid, oleoside, olivine, oleuropeic acid, oleuropein, pectin, palmiticacid,quercetin, quinone, rhamnose, rutin, squalene, tyrosol, verbascoside, tannins, saponins, andsecoiridoids(Gilani et al., 2006).

7. Benefical effects of olives

7.1. Antioxidant effect:

Theantioxidant quality of phenolic compounds is mainly due to their redox properties, which allowthem to act as reducing agents, hydrogen donors, and singlet oxygen quenchers (Ben Othman et al., 2008**).** The antiradical and antioxidant activities of olive and olive oil phenolic compounds are duemainly to the presence of a 3,4-dihydroxy moiety linked to an aromatic ring, and the it was foundthat the effect depended on the polarity of the phenolic compound(Morelló et al., 2005). Olive secoiridoids can directly protect cells from oxidative stress by acting as free radical scavengers, radical chain breakers, or metal chelators(Boss et al., 2016; Bulotta et al., 2013; Fabiani, 2016; Hassen et al., 2015; Pang and Chin, 2018). Olive secoiridoids also act as oxidative stress defenders through the upregulation of asignaling pathway involving the nuclear factor Nrf2, thus resulting inan increased expression of protective phase II detoxifying enzymes(Calabriso et al., 2018; Calahorra et al., 2018; Menendez et al., 2013; Parzonko et al., 2013; Zhu et al., 2010; Zou et al., 2012). HT protection against oxidative damage can also derivefrom the induction of mitochondrial biogenesis (Zhu et al., 2010).

7.2. Antibacterial activity

Some researchers have also demonstrated that the phenolic compounds present in olive products, such as oleuropein and hydroxytyrosol(Bisignano et al., 1999; Furneri et al., 2002)(19, 20) and aliphatic aldehydes(Battinelli et al., 2006), inhibit or delaythe rate of growth of a range of bacteria and micro-fungi, so that they might be used as alternativefood additives or in integrative pest management programs (Pereira et al., 2006).

7.3. Anti-inflammatory effect

Beauchamp et al. (2005) demonstrated that olive secoiridoids (OC) inhibited cyclooxygenase COX1 and COX2 activity in a very similar way to the anti-inflammatory drug ibuprofen (Beauchamp et al., 2005). In particular, hydroxytyrosol (HT) and Oleuropein (Ole) are able to inhibit the inflammatory responses of murine and human monocytes and macrophages *in vitro*, by blocking the expression of COX2 (Bigagli et al., 2017; Maiuri et al., 2005; Rosignoli et al., 2013; Ryu et al., 2015; Scoditti et al., 2014; Zhang et al., 2009). Another key element of chronic inflammation is NF-κB, which when activated, translocated into the nucleus triggering the expression of genes encoding inflammatory mediators such as cytokines, adhesion molecules and chemokines(Killeen et al., 2014). The attenuating action of Ole and HT on NF-κB activation has been described in two main areas: i) *in vitro*, both in immune-competent cells stimulated with lipopolysaccharide (Maiuri et al., 2005; Ryu et al., 2015; Scoditti et al., 2014; Zhang et al., 2009), and in human endothelial cells treated with phorbolmyristate acetate (Scoditti et al., 2012); and ii) *in vivo*, both in a mouse model of chronic colitis induced by dextran sodium sulfate (Giner et al., 2011) and in mice with acute renal injury induced by the treatment of cisplatin(Potočnjak et al., 2016).

7.4. Anticancer activity

Olive secoiridoids may work as "redox-active" compounds inducing cancer cell growtharrest or cell death, by either stimulating ROS production or inhibitingantioxidant defense systems, or a combination of both (Acquaviva et al., 2012; Cusimano et al., 2017; Katsoulieris, 2016; Rosignoli et al., 2016). Juan *et al*., reported a positive association between thephenolic components of olive fruits and the reduction of cancerproliferation, in HT-29 human colon cancer cells(Juan et al., 2006).Further animal studies and human intervention trials, haveinvestigated the effects of olive oil phenols on DNA damage and confirmed the ability of these compounds to inhibit the carcinogenesis process at both initiation and promotion/progression phases (Fabiani, 2016). It was observed that HT inhibits the cytotoxicity in human intestinal epithelial Caco-2 and humancolon adenocarcinoma HT-29 cancer cell lines through theincrement of intracellular capacity to protect against oxidativedamage (Terzuoli et al., 2010; Terzuoli et al., 2016).

Due to the similar structure of the olive polyphenols to oestrogens, these have been hypothesized to interact with oestrogen receptors, thereby reducing the prevalence and progression of hormone related cancers (Boss et al., 2016).

7.5. Cardioprotective effect

Prevention of atherosclerotic lesion development are limitationof oxidative injury and prevention of LDL-c oxidation,reversion of angiogenesis through the inhibition of MMP-2and MMP-9 activity, reduction of inflammatory damageinduced by inflammatory markers such as TNF-α, decreaseof eicosanoid formation and expression of cell adhesionmolecules (Vascular Cell Adhesion Molecule1 (VCAM-1)-1and Intercellular Adhesion Molecule 1 (ICAM-1)(Granados-Principal et al., 2010; Ray et al., 2015; Vilaplana-Pérez et al., 2014).It was observed in human aortic endothelial cells treated withphysiological concentrations of HT and co-incubated withTNF-α that a significant reduction of E-selectin, P-selectin,ICAM-1 and VCAM-1 secretion occurred, as well as adecrease of markers of endothelial dysfunction(Catalán et al., 2015). HTcan also be considered antithrombotic, since it decreasesplatelet aggregation, eicosanoid synthesis such as thromboxane B2, leukotriene B4 and to its capacity to reduce cAMP and cGMP platelet phosphodiesterase and to decrease of cell adhesion molecule expression (Granados-Principal et al., 2010; Manna et al., 2009).

7.6. Neuroprotective effect

Studies demonstrated the antioxidant role of olive oilphenolic compounds in suppressing neurotoxicity, neuroinflammation and amyloid aggregation. The olive polyphenolhave modulatory effects on the cellular pro-inflammation NF-kb pathway,they are involved in the activation of the Nfr2/ Phase II genes and are able to prevent the amyloid aggregates and therefore, have potentialbenefits in the onset and progression of PD and AD. Particular attentionis paid to the effects of hydroxytyrosol, the most biologically active and“intriguing” compound of the olive polyphenols’ family, proven to havean ideal pharmacological profile, i.e. a combination of antioxidant andanti-inflammatory activity with an excellent safety profile, highbioavailability, tissue distribution and multiple mechanisms HT is a product of the hydrolysis of its natural olive esterprecursors, oleuropein (OLE), verbascoside and lingstroside, and isgenerated during the maturation process, preparation and storage oftable olives (Calabrese and Crea, 2016).

Materials and Methods

Materials and methods

1. Chemicals and Reagents

All chemicals and solvents were of analytical grade.Acetone, ethanol and methanol were obtained from Honeywell (Seelze, Germany). Trolox (6-hydroxy-2,5,7,8-tetramethyl chromane-2-carboxylic acid), ABTS (2,2' -Azinobis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt)were purchased from Sigma-Aldrich(Fisher scientific, Fair Lawn, NJ, USA). DPPH (2,2-diphenyl-1- picrylhydrazyl), disodium hydrogen phosphate (Na_2HPO_4), sodiumdihydrogen phosphate (NaH_2PO_4), 4-hydroxy-3-methoxybenzaldehyde (vanillin), ferric chlorid ($FeCl_3$), gallic acid, catechin , quercetin and trichloroacetic acid were purchased from Sigma–Aldrich Chemie GmbH (Steinheim, Germany). Hydrochloric acid (HCl), Sodium carbonate (Na_2CO_3) were purchased from Prolabo (Loire, France). Folin–Ciocalteu's phenol reagent, Potassium ferricyanide ($C_6N_6FeK_3$) and chloride aluminium ($AlCl_3$) were provided from Biochem-chemopharma (Loire, France).

2. Olive samples

Three black olive cultivars, named Aharoune, Bouchouk and Sigoise, harvested at the fully ripe stage were handpicked from three different regions of the locality of Bejaia on December2021. Aharoune cultivar was harvested fromTazmalt, Bouchouk variety from Timezrit and Sigoise sample was harvested from Takerietz. The characteristic of every variety was presented in tableII.

3. Dry-salting process

The black olives were transported to the laboratory within 48 h. On arrival, the fruits were hand selected, washed thoroughly under tap water and left to dry. Olives were devised into two parts. One part of fresh oliveswerepitted and the corresponding pulp was lyophilized(Alpha1-4 LDplus, Christ, Osterode, Germany)and then ground in an electric blender. The ground pulps were kept at 4°C until extraction. The second part of fresh olives (approximately 1,5 kg),was treated with alternating layers of dry salt into baskets and kept at room temperature for 45–60 days depending on the variety(Panagou, 2006). The dry-salting process caused dehydration and the olives appear shriveled. The obtained (salted) olives were treated as described below.

4. Extract preparation

Freeze dried olive pulps (100 mg) were homogenized with 15 mL of different solvent types (60% acetone, 60% ethanol and distilled water). After stirring for30 min, the mixture was centrifuged (nüve NF 200,Ankara, Turkey) at 5000 rpm for 10 min. The supernatant was

collected and filtered, whereas the residue was re-extracted with the same conditions. The filtered extracts were combined, washed with hexane (3×10 mL) and then kept at 4°C until analysis(McDonald et al., 2001).

Table II: Origin and characteristic of the threestudied black olives varieties.

variety	Origin of the variety	Characteristic	Salting time	Fresh olives	Salted olives
Aharoune	High valley of Soummam	Seasonal variety, hardy and self-fertile. Average kernel pulp ratio:06.00 The pulp is difficult to separate from the stone.Productivity is high and little alternating.	52 days		
Bouchouk	Valley of Soummam	Seasonal and hardy variety earlyflowering with low average fruit setrate: 02.60%. Average kernelpulp ratio: 07, 50. The pulp isdifficult to separate from the core.Productivity isaverage and notvery alternating	35 days		
Sigoise	Plain of Sig (Mascara)	Seasonal variety, tolerant to salt water, tolerates cold and drought early flowering of medium intensity.Low fruit set rate: 00.07%.Average kernel pulp ratio: 06,44 The pulp detaches easily from the kernel. Productivity is average and alternating variety in extension throughout the national territory	42 days		

5. Moisture determination

The moisture content is determined by measuring the mass of a sample of olive pulp (5g) before and after the water is removed by evaporation(oven-drying). The percentage of moisture is calculated using the following equation:

% moisture = M initial- M dried/M initial × 100

M initial and M dried are the mass of the sample before and after drying, respectively.

6. Phenolic compounds analysis

6.1.Determination of total phenolic content (TPC)

The Folin–Ciocalteu method ofSingleton et al.(Singleton et al., 1999)was used to determine total phenolic content. Each olive pulp sample extract (0.2 ml) was mixed with 1ml of Folin-Ciocalteu reagent diluted 10 fold for 5 min and 0.8 ml of 75 g/l sodium carbonate (Na_2CO_3) was then added. After incubation at room temperature for 30 min, the absorbance of the reaction mixture was measured at 760 nm against a blank (Shimadzu UV mini1240, Suzhou Jiangsu, China). Gallic acid was used as standard to produce the calibration curve. The mean of four readings was used and the total phenolic content was expressed in g of gallic acid equivalents per 100 g dry weight (g GAE/100 g DW).

6.2.Determination of total flavonoid content (TFC)

The total flavonoid content was determined using the method adapted by Amiri(Amiri, 2014). Briefly, 1 ml of 2% aluminiumtrichloride (AlCl3) in methanol was mixed with the same volume of olive pulp extract. Absorption readings at 430 nm were measured in UV-visible spectrophotometer after 10 min against a blank. The total flavonoid content was determined using a standard curve with quercetinas the standard. The mean of four readings was used and expressed as milligrams of quercetin equivalents per 100 g dry weight (mg QE/100 g DW) of olive pulp.

6.3.Determination of total flavonol content (TFLC)

The total flavonol content was determined using colorimetric method according to (Jimoh et al., 2010). The extract (500 µl) was added to 500 µl of aluminum chloride (2%) and 500 µl of sodium acetate solution (5%). The absorbance at 440 nm was recorded after 2.5 h at room temperature. Quercetin was used to make the standard calibration curve. Results were expressed as milligrams of quercetin equivalents per 100 g (mg RE/100 g DW).

6.4.Determination of total anthocyanin content (TAC)

Total anthocyanin content was determined according to the method of Abdel-Aal and Hucl(Abdel-Aal and Hucl, 1999). A ground olive sample (200 mg) was weighted and 12 mL

of acidified ethanol (ethanol: HCl 1.0*N*, 85:15, v/v) was added. The solution was mixed and adjusted to pH 1. The resulting solution was shaken for 30 min. The tube was centrifuged at 5000 rpmfor 15 min, and the supernatant was poured into a 25-mL volumetric flask and made up to volume with acidified ethanol. Absorbance was measured at 535 nm against a reagentblank.Total anthocyanin content per sample (mg/kg) was calculated as cyanidin 3-glucoside using the following equation:

$C= (A/\varepsilon) \times (vol/1000) \times MW \times (1/sample\ wt) \times 10^6$

$C = (A/\varepsilon) \times (Vol/1000) \times MW \times (1/sample\ wt) \times 10^6$ where *C* is concentration of total anthocyanin (mg/kg), *A* is absorbancereading, ε is molar absorptivity (cyanidin 3-glucoside = 25,965 cm–1 M–1), Vol is total volume of anthocyanin extract, andMW is molecular weight of cyanidin 3-glucoside = 449.

Under test conditions, the equation formula can be simplified to:

$C = (A/25965) \times (50/1000) \times 449 \times (1/3) \times 10^6$

6.5. Antioxidant activities

6.5.1.Determination of total antioxidant activity(TAA)byphosphomolybdenum method

An aliquot of 0.1 mL of olive pulp extract was mixed with 1mLof the prepared reagent solution (0.6 M sulfuric acid, 28 mMsodium phosphate and 4 mM ammonium molybdate). For the blank, 0.1mL solvent extraction was mixed with 1 mL of the reagent.The tubes were incubated at 95°C in a water bath for 90 min. The samples were cooled to room temperature and their absorbance wasrecorded at 695 nm.Ascorbic acid was used as standard. The results were reported as mg equivalents of ascorbic acid per 100g dry weight (mg EAA/100 DW).

6.5.2. Determination of DPPH-radical scavenging activity (DPPH-RSA)

The ability of the olive pulp extract to scavenge the 2,2-diphenyl-1- picrylhydrazyl radical was evaluated according to the method of Blois(Blois, 1958). In the presence of antioxidant which is typical for DPPH free radical decays, the change in absorbency at 517 nm is followed spectrophotometrically. Briefly, 0.9 ml of a freshly preparedmethanolic solution of DPPH (0.04 mg/ml) was mixed with 0.1 ml of olive pulp extract. After 20 min of incubation in the dark, at room temperature, absorbencies were read at 517 nm. All tests were performed in triplicate. DPPH radical scavenging activity was calculated according to the calibration curve prepared with trolox and results were expressed as milligramsequivalents of trolox per 100g dry weight (mg ET/100 DW).

6.5.3. Determination of ABTS-radical scavenging activity (ABTS-RSA)

The radical scavenging capacity of the tested extracts against ABTS (2, 2'-azino-bis 3-ethylbenzthiazoline-6-sulfonic acid) radical cation was measured according to the method ofRe et al.(Re et al., 1999). $ABTS^{\circ+}$ radical cation was produced by reacting 7 mM ABTS in water and 2.45 mM potassium persulfate (1:1, v/v) and allowing the mixture to standfor 12–16 h in the dark before use. The $ABTS^{\circ+}$radical cation solution was then diluted with methanol to obtain an absorbance of 0.700 ± 0.02 at 734 nm. Each extract sample (0.1 ml) was mixed with 1.4 ml of diluted ABTS°+ radical cation solution. After reaction for 7 min, the absorbance at 734 nm was measured.Trolox was used as standard substance for calibration curve and and results were expressed as milligrams equivalents of trolox per 100g dry weight (mg ET/100 DW).

6.5.4. Determination of the ferric reducing power (FRP)

The method of Oyaizu (Oyaizu, 1986) was used to determine the capacity of the olive pulp extracts to reduceferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}). The samples (1 ml) were mixed with sodium phosphate buffer (2.5 ml,0.2 M, pH 6.6) and potassium ferricyanide (2.5 ml, 1%,w/v). Thetubes were incubated for 20 min at 50°C. After incubation, the mixture wasacidifiedwith 2.5 ml of trichloroacetic acid (10%). Finally, a fraction of the reaction mixture (1 ml) was mixed with distilled water (1 ml) and $FeCl_3$ (0.5 ml, 0.1% w/v). Absorbance of all solutions was measured at 700 nm using a UV-VIS spectrophotometer. Ascorbic acid was used as standard to make calibration curve and results are expressed as milligrams equivalents of ascorbic acid per 100g dry weight (mg EAA/100 DW).

6.5.5. Determination of the iron chelating activity (ICA)

Metal ions chelating activity of the olive pulp extracts was determined by the method of Denis et al.(Dinis et al., 1994). Into test tubes, 200 µL of extract was mixed with 400 µL of distilled water and 200 µL of 0.2 mM of $FeSO_4$. The reaction was initiated by the addition of 200 µL of 2 mM of ferrozine. After 10 min at room temperature, the absorbance of the Fe^{2+}-Ferrozine complex was measured at 562 nm. A lower absorbance indicates a stronger chelating power. Solvent extraction was used as positive control instead of sample and distilled water was used as blank instead of ferrozine.Ethylenediaminetetraacetic acid (EDTA) was used as standard to make calibration curve and results were expressed as milligramsequivalents of EDTA per 100g dry weight (mg EEDTA/100 DW).

7. Statistical analysis

Descriptive statistical analysis was performed using Microsoft Excel. The data of moisture contents, antioxidant activities and phenolic compounds are expressed as means ± standard deviations (SD) from four independent assays (n=4). Statistical analysis was performed using analysis of variance (ANOVA) and significant difference between sample means ($P < 0.05$) was calculated using Tukey'spost-hoc test. Difference was considered statistically significant at the level of $p<0.05$. Pearson correlation test was used to determine the correlation among variables.STATISTICA 5.5 (StatSoft Inc., Oklahoma, USA) was used to perform all these analyses.

1. Moisture

a. Fresh olives

The moisture content of the three black olive varieties is presented in the **figure 7** Results showed that moisture ranged from 59% (Bouchouk) to 66% (Aharoune).The results were in the following order from low to high: Bouchouk < Sigoise < Aharoune.

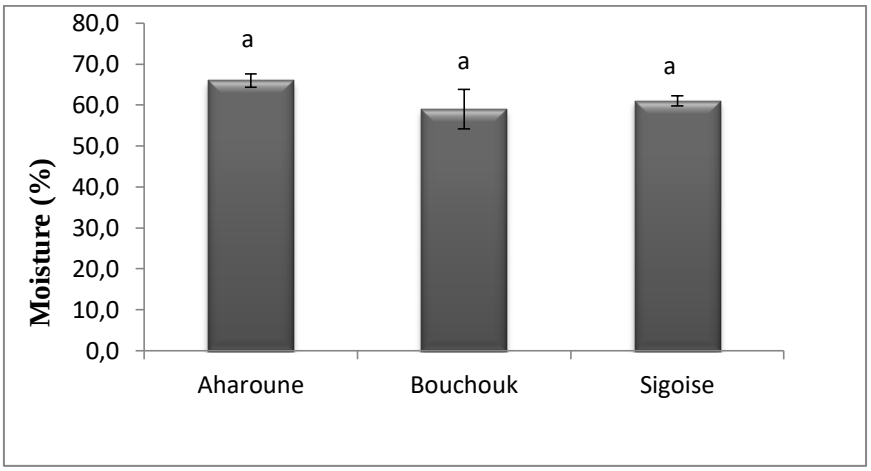

Figure 7: Moisture content of the three fresh olives varieties

The different lowercase letters indicate significant differences ($P< 0.05$) between the varieties studied

Our results were in accordance with those of Uylaser et al., reporting moisture content ranging from 52.81% to 62.19% in Gemlik variety olives grown in Turkey (**Uylaser et al., 2008**). Kemal Ünal and Cevdet Nergiz found that the moisture content of ripened black olives was 55.37 g/100g when harvested**(Ünal and Nergiz, 2003**)**.** Usanmaz et al. reported that moisture content of the olives cv. Ayvalik were found to be different for periods and altitudes and ranged from 25.23% (January - 600 m) to 50.53% (October - 300 m) (USANMAZ et al., 2018).

b.Effect of dry salting

The effect of salting on the moisture of the three black olive varieties is presented in table III. Results showed that salting induced decreases in moisture content of olives which ranged from 62.1% (84.7% (Bouchouk).The moisture content of the salted olives varied from 9% (Bouchouk) to 25% (Aharoune).The moisture was in the following order from low to high: Bouchouk<Sigoise<Aharoune. These decreases in moisture may be due to the dehydration of olives in the presence of salt.

Table III: Effect of dry salting on the moisture content of the three black olive varieties

Variety	Before Salting (%)	After salting (%)	Decreases (%)
Aharoune	66 ± 1.6^{a}	25 ± 0.9^{a}	-62.1
Bouchouk	59 ± 4.8^{a}	9 ± 1.2^{c}	-84.7
Sigoise	61 ± 1.2^{a}	18 ± 0.3^{b}	-70.4

Jimenez et al. found that moisture depended on variety and processing method of olives and ranged from 9.6 to 51.5%. They also noted, in Thasos olives, that the storage period of the dry salted olives caused a decrease in the moisture which is in agreement with our results **(Jiménez et al., 2000**).

2. Phenolics

2.1. Total phenolic content (TPC)

a. Fresh olives

The total phenolic content (TPC) of the three black olive varieties is presented in figure 8,Results showed that solvent extraction affect significantly ($P < 0.05$) the TPC which ranged from 2,3 (Bouchouk) to 4,2 g/100g DW (Aharoune) for 60% acetone solvent extraction, from 2,3 (Bouchouk) to 380 g/100g DW (Sigoise) for 60% ethanol solvent extraction and from 1,9 (Bouchouk) to 2,3g/100g DW (Aharoune) for water extraction.

The TPC yields extracted by the selected solvents were in the following order from low to high: Bouchouk < Sigoise < Aharoune for 60% acetone extraction, Bouchouk < Aharoune< Sigoise for 60% ethanol extraction and Bouchouk < Sigoise < Aharoune for water extraction. These results suggest that 60% acetone was the best solvent for extracting TPC from black olives varieties.

Sousa et al. tested tow solvent (methanol and water) on the extraction of TPC from stoned table olives ‘‘alcaparras’’and found that extraction procedure using water at room temperature wasleast efficient (very low TPC, 3.48 mg/g dry extract) (**Sousa et al., 2008**), which is in agreement with our results.

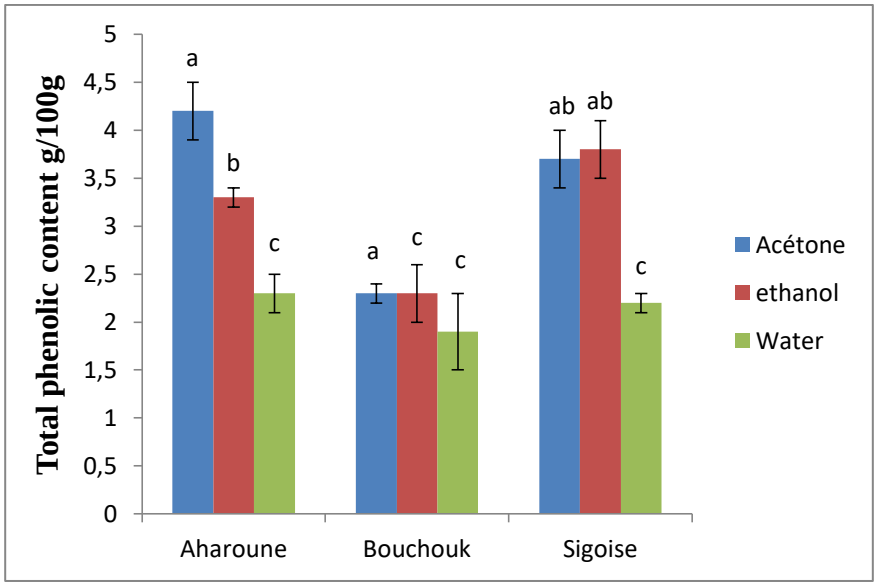

Figure 8: Total phenoliccontent(TPC) of the three fresh olives varieties

b. Effect of dry salting

The effect of salting on the total phenolic content (TPC) of the three black olive varieties is presented in the table IV. Results showed that the dry salting induces decreases, increases or has no effect according to variety and solvent extraction used. TPC decreasesranged from -18.9% (Sigoise, acetone) to -26% (Bouchouk, ethanol). TPC increases ranged from 9.5% (Aharoune, acetone) to 60.8 (Aharoune water). However,no effect of salting was observed on Bouchouk (water) and Sigoise (ethanol).

The TPC of salted olives varied from 1.7 (Bouchouk, ethanol) to 4.6 g/100g DW (Aharoune, acetone). The TPC yields extracted by the selected solvents for salted olives were in the following order from low to high:Bouchouk<Sigoise<Aharoune for 60% acetone, 60% ethanoland water solvents extraction.

These results demonstrated that the dry salting affects the phenolic compound content of black olives which varied depending on the cultivars. These variations might be related to the dry salting duration which depends on the cultivar. On the other hand, these compounds can be also oxidized when the period of the salting is prolonged.

Our findings are in agreement with those of Soufi et al. (2014) who investigated the effect of dry salting on six Algerian olive cultivars and noted a decrease or an increase, depending on the cultivar, when comparing the ratio *o*-diphenols/phenolics between fresh and salted olives (Soufi et al., 2014). This might be due to the characteristics of each cultivar such as diameter of fruit and/or humidity, since the decrease is related to the diffusion of such

compounds. The value obtained for Bouchouk cultivar could be explained by its higher fruit diameter among the other studied cultivars. Borzillo et also found that processing black olives by dry salting induced reduction in total phenols (Borzillo et al., 2000).

Previousliterature data had reported a decrease in oleuropein contentduring table olives processing, paralleled to an increase in hydroxytyrosol which derived from hydrolysis of oleuropein. Furthermore, a quantity of verbascoside is hydrolyzed into caffeic acid and hydroxyltyrosol (Fernández et al., 1997). However, a decrease in hydroxytyrosol may be done. This decrease might be explained by the oxidation of this compoundduring the dry salting (Soufi et al., 2014).

Table IV : Effects of dry salting on the total phenolic content (TPC) of the three olives varieties.

Variety	Solvent	Before Salting (g/100gDW)	After salting (g/100gDW)	Decreases or increases (%)
Aharoune	Acetone	4.2 ± 0.3^{a}	4.6 ± 0.3^{a}	+9.5
	Ethanol	3.3 ± 0.1^{b}	4.3 ± 0.1^{a}	+30.3
	Water	2.3 ± 0.2^{c}	3.7 ± 0.1^{b}	+60.8
Bouchouk	Acetone	2.3 ± 0.1^{a}	1.8 ± 0.1^{d}	-21.7
	Ethanol	2.3 ± 0.3^{c}	1.7 ± 0.1^{d}	-26
	Water	1.9 ± 0.4^{c}	1.9 ± 0.2^{d}	No effect
Sigoise	Acetone	3.7 ± 0.3^{ab}	3 ± 0.1^{c}	- 18.9
	Ethanol	3.8 ± 0.3^{ab}	3.8 ± 0.2^{b}	No effect
	Water	2.2 ± 0.1^{c}	2.6 ± 0.1^{c}	+18.1

Soufi et al. found that TPC in the fresh olives varied from 1,197 (Bouchouk) to 4,355 g GAE/100 g dw (Sigoise from Relizane). The content of these compounds in the salted olives ranged from 1,029 g GAE/100 g dw (Bouchouk) to 2,716 g GAE/100 g dw (Sigoise from Relizane), so decreases of 14.03 and 37.6% reductions. Blekas et al. reported that TPC ranged from 62.3 to 82.9 mg/100g in Thassos black olives cultivar processed in dry salt (Blekas et al., 2002).

2.2. Total flavonoid content (TFC)

a. Fresh olives

The total flavonoid content(TFC) of the three black olive varieties is presented in the figure 9**.** Results showed that solvent extraction affect significantly ($P < 0.05$) the TFC which ranged from 303.1 (Sigoise) to 513.9 mg/100g DW (Aharoune) for 60% acetone solvent extraction, from 264.6 (Bouchouk) to 587.8 mg/100g DW (Aharoune) for 60% ethanol solvent extraction and from 71.6(Bouchouk) to 140.7mg/100g DW (Aharoune) for water extraction.

The TFC yields extracted by the selected solvents were in the following order from low to high: Sigoise<Bouchouk<Aharoune for 60% acetone extraction, Bouchouk<Sigoise<Aharoune for 60% ethanol extraction and Bouchouk<Sigoise<Aharoune for water extraction. These results suggest that 60% ethanol was the best solvent for extracting TFC from black olives varieties.

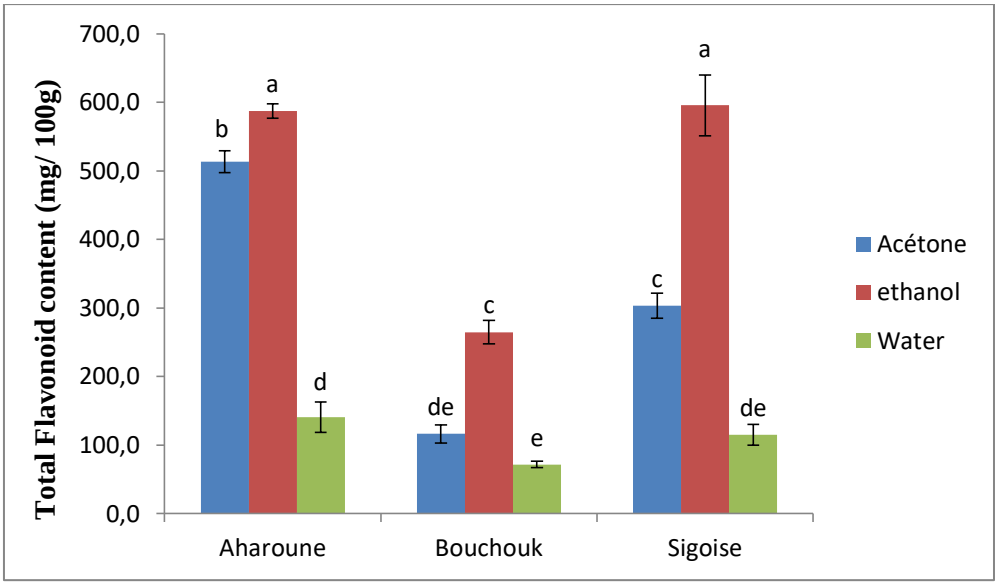

Figure 9: Total flavonoid content (TFC) of the three fresh olives varieties

b. Effect of dry salting

The effect of salting on the total flavonoid content (TFC) of the three black olive varieties is presented in the table V. Results showed that the dry salting induces decreases or increases, according to variety and solvent extraction used. TFC decreases ranged from -25.3% (Aharoune, acetone) to -77.2% (Bouchouk, ethanol). TFC increases ranged from 1.84% (Aharoune, water) to 86.8% (Bouchouk water).

The TFC of salted olives varied from 60.1 (Bouchouk, ethanol) to 406.2 mg/100g DW (Sigoise, acetone). The TFC yields extracted by the selected solvents for salted olives were in the following order from low to high: Bouchouk < Sigoise < Aharoune for 60% acetone solvent, Bouchouk < Aharoune < Sigoise for 60% ethanol solvent and Sigoise < Aharoune < Bouchouk for water solvent extraction.

Table V: Effects of dry salting on the total flavonoid content (TFC) of the three olives varieties

Variety	Solvent	Before Salting (mg/100g DW)	After salting (mg/100g DW)	Decreases or increase (%)
Aharoune	Acetone	513.9 ± 16^{b}	383.5 ± 6.8^{a}	-25.3
	Ethanol	587.8 ± 10.5^{a}	321.2 ± 13.7^{b}	-45.3
	Water	140.7 ± 22.1^{d}	143.3 ± 14^{de}	+1.84
Bouchouk	Acetone	116.2 ± 13.1^{de}	70 ± 3.5^{f}	-39.7
	Ethanol	264.6 ± 17.1^{c}	60.1 ± 5.3^{f}	-77.2
	Water	71.6 ± 4.6^{e}	133.8 ± 5.5^{e}	+86.8
Sigoise	Acetone	303.1 ± 18.2^{c}	182.8 ± 3.7^{c}	-39.6
	Ethanol	595.7 ± 44.5^{a}	406.2 ± 26.3^{a}	-31.8
	Water	114.8 ± 15.3^{de}	170.1 ± 5.1^{cd}	+48.1

Soufi et al. (2016)foundtotal flavonoid contents among Algerian olives cultivars ranged between 872 (Aberkane and Abelout) and 1537 mg CE/100gDW (Azeradj) in fresh olives. These contents are higher than those obtained in this study. However, the flavonoid amounts are comprised only between 394 (Abelout) and 1272 mg CE/100gDW(Azeradj) in salted olives. Consequently, the dry salting caused a decrease in flavonoid contents with a loss rate ranging from 22% (Azeradj) to a mean value of 55% (Abelout and Bouchouk)(Soufi et al., 2016). This decrease can be explained by the diffusion of these compounds under the action of salt and/or their oxidation during salting. Furthermore, the variability of the decrease noted among the studied cultivars can be related to the characteristics of each cultivar such as diameter of fruit, since the decrease is related to the diffusion of such compounds (Bianchi, 2003). In addition, the

difference of the polarity of each flavonoid compound can also influence their diffusion(Tomas-Barberan and Gil, 2008).

2.3. Total flavonols content (TFLC)

a. Fresh olives

The total flavonols content(TFLC) of the three black olive varieties is presented in figure 10 Results showed that solvent extraction affect significantly ($P < 0.05$) the TFLC which ranged from 194.6 (Bouchouk) to 316.4 mg/100g DW (Aharoune) for 60% acetone extraction, from 87.6 (Bouchouk) to 187.3 mg/100g DW (Aharoune) for 60% ethanol extraction and from 21.6 (Sigoise) to 53.5 mg/100g DW (Aharoune) for water extraction.

The TFLC yields extracted by the selected solvents were in the following order from low to high: Bouchouk<Sigoise<Aharoune for 60% acetone and 60% ethanol extractionsand Sigoise < Bouchouk < Aharoune for water extraction. These results suggest that 60% acetone was the best solvent for extracting TFLC from black olives varieties.

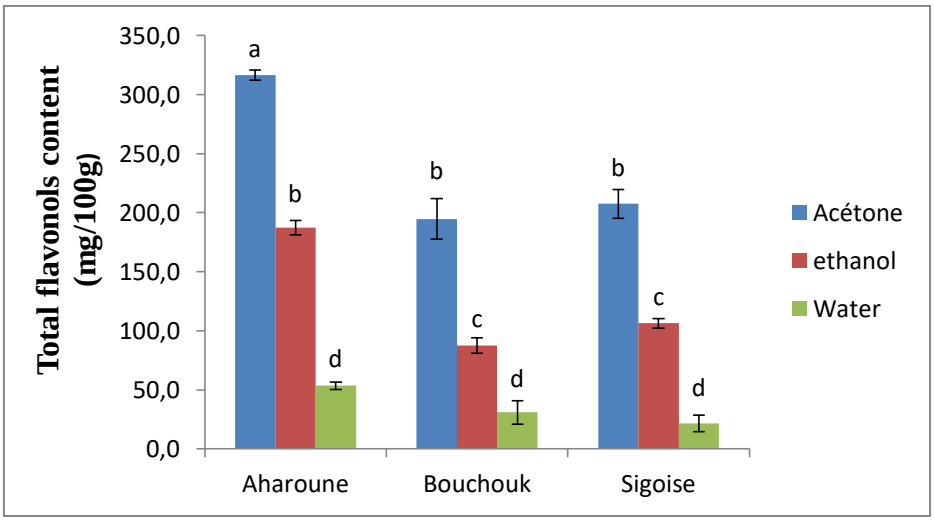

Figure 10: Total flavonols content (TFLC) of the three fresh olives varities.

b. Effect of dry salting

The effect of salting on the total flavonols content (TFLC) of the three black olive varieties is presented in tableVI. Results showed that the dry salting induces decreases or increases, according to variety and solvent extraction used. TFLC decreases ranged from -11.1%

(Aharoune, acetone) to -58.7% (Sigoise, water). TFLC increases ranged from 6% (Sigoise, ethanol) to 189% (Bouchouk water).

The TFLC of salted olives varied from 8.9 (Sigoise water) to 281mg/100g DW (Aharoune, acetone). The TFLC yields extracted by the selected solvents for salted olives were in the following order from low to high: Sigoise<Bouchouk< Aharoune for 60% acetone, 60% ethanoland water solvents.These results suggest that 60% acetone was the best solvent for extracting TFLC from black salted olives varieties.

TableVI: Effects of dry salting on the total flavonols content (TFLC) of the three olives varieties.

Variety	**Solvent**	**Before Salting (mg/100g DW)**	**After salting (mg/100g DW)**	**Decreases or increase (%)**
Aharoune	Acetone	316.4 ± 4.3^{a}	281 ± 23.7^{a}	-11.1
	Ethanol	187.3 ± 6^{b}	153.8 ± 19^{b}	-17.8
	Water	53.5 ± 3.3^{d}	141.2 ± 6.7^{bc}	+163
Bouchouk	Acetone	194.6 ± 17.1^{b}	252.8 ± 5.0^{a}	+29.9
	Ethanol	87.6 ± 6.5^{c}	148.3 ± 14.6^{bc}	+69.2
	Water	31 ± 10.0^{d}	89.7 ± 6.4^{d}	+189
Sigoise	Acetone	207.4 ± 12.0^{b}	152.8 ± 16.6^{b}	-26.3
	Ethanol	106.3 ± 4.1^{c}	112.7 ± 26.9^{cd}	+6.0
	Water	21.6 ± 6.9^{d}	8.9 ± 3.8^{e}	-58.7

Soufi et al. (2016) noted that the effect of dry salting is dependent on the individual flavonoids; it can induce a decrease (rutin) or an increase (luteolin-7-glucoside). (Soufi et al., 2016). This is in agreement with the data reported by Rice-Evans and Packer (Rice-Evans and Packer, 2003), since salt can generate sodium adducts from flavonol-3-glucoside (rutin), and consequently, the content of the latter decreases. By contrast, these adducts are not obtained from flavone glucoside (luteolin-7-glucoside).

2.4. Total anthocyanin content

a. Fresh olives

The total anthocyanin content(TAC) of the three black olive varieties is presented in the **figure11** Results showed that variety affect significantly ($P < 0.05$) the TAC of olives which ranged from 55.5 (Sigoise) to 152.2 mg/100g DW (Aharoune). The TAC yields were in the following order from low to high:Sigoise<Bouchouk<Aharoune.

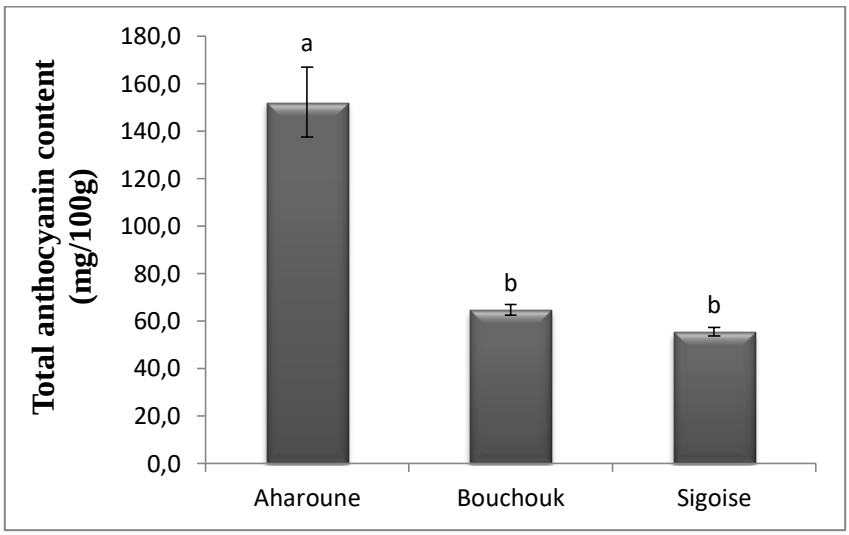

Figure11: Total anthocyanin content (TAC) of the three fresh olives varieties.

b. Effect of dry salting

The effect of salting on the total anthocyanin content(TAC) of the three black olive varieties is presented in tableVII,Results showed that the dry salting induces decreases according to variety. TAC decreases ranged from -26.4% (Aharoune) to -64.6% (Sigoise).The TAC of salted olives varied from 19.6 (Sigoise) to 112 mg/100g DW (Aharoune).

Soufi et al. (2016) observed that dry salting significantly affects (P<0.05) the content of olive pigments: the cyanidin-3- glucoside disappeared, but the cyanidin-3-rutinoside is detected only in three cultivars. This can be explained by the fact that anthocyanins are water-soluble compounds which diffused from the olive to the surrounding medium during dry salting. These substances can also be either transformed or degraded during processing (Soufi et al., 2016). According to Garrido-Fernández *et al*. (1997), the anthocyanin contents may be strongly

influenced by the processing and the cultivar; the total content can decrease to below 50% of its initial value(Garrido-Fernandez et al., 1997), wich in accordance with our results.

Table VII: Effects of dry salting on the total anthocyanin content (TAC) of the three olives varieties.

Variety	Before Salting (mg/100g DW)	After salting (mg/100g DW)	Decreases or increase (%)
Aharoune	152.2±14.7[a]	112.0±8.5[a]	-26.4
Bouchouk	64.7±2.2[b]	31.8±4.6[b]	-50.8
Sigoise	55.5±1.8[b]	19.6±2.5[b]	-64.6

Soufi et al. (2016) observed that dry salting significantly affects (P<0.05) the content of olive pigments: the cyanidin-3- glucoside disappeared, but the cyanidin-3-rutinoside is detected only in three cultivars. This can be explained by the fact that anthocyanins are water-soluble compounds which diffused from the olive to the surrounding medium during dry salting. These substances can also be either transformed or degraded during processing (Soufi et al., 2016). According to Garrido-Fernández *et al*. (1997), the anthocyanin contents may be strongly influenced by the processing and the cultivar; the total content can decrease to below 50% of its initial value, wich in accordance with our results.

2.5. Antioxidant activities

2.5.1. Total antioxidant activity (TAA)

a. Fresh olives

The total antioxidant activity(TAA) of the three black olive varieties is presented in figure12, Results showed that solvent extraction affect significantly (P < 0.05) the TAA which ranged from 3.2 (Bouchouk) to 5.7 g/100g DW (Aharoune) for 60% acetone solvent extraction, from 3.8 (Bouchouk) to 5.4 g/100g DW (For both Aharoune and Sigoise) for 60% ethanol solvent extraction and from 2.8 g/100gDW (Bouchouk) to 6.6 g/100g DW (Aharoune) for water solvent extraction. The TAA values were in the following order from low to high: Sigoise < Bouchouk < Aharoune for 60% acetone extraction, Bouchouk < Sigoise < Aharoune for 60% ethanol and water extraction.

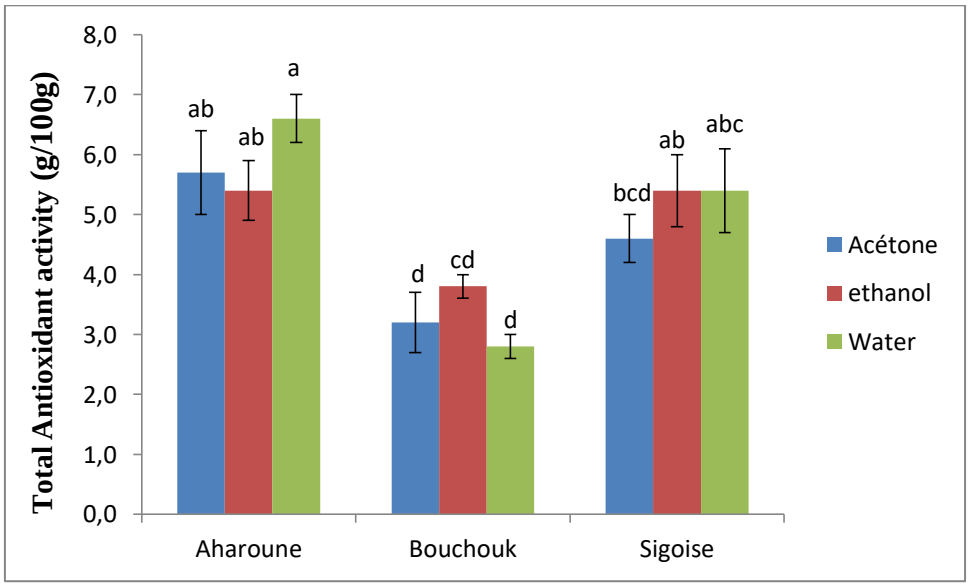

Figure 12: TAAofthe three fresh olives varieties

b. Effect of dry salting

The effect of salting on the total antioxidant activity(TAA) of the three black olive varieties is presented in the tableVIII,Results showed that the dry salting induces decreases or increases according to variety and solvent extraction used. TAA decreases ranged from -0.3% (Aharoune, water) to -28.9% (Bouchouk, ethanol). TAA increases ranged from 3.7% (Sigoise, ethanol) to 19.2% (Aharoune, acetone).

The TAA of salted olives varied from 2.6 (Bouchouk water) to 6.8g/100g DW (Aharoune, acetone). The TAA ofthe salted olives were in the following order from low to high: Bouchouk <Sigoise < Aharoune for 60% acetone,Bouchouk<Aharoune<Sigoise for 60% ethanol andBouchouk<Sigoise<Aharoune for water solvent.

Table VIII: Effects of dry salting on the total antioxidant activity (TAA) of the three olives varieties.

Variety	Solvent	Before Salting (g/100g DW)	After salting (g/100g DW)	Decreasesor increase (%)
Aharoune	Acetone	5.7 ± 0.7^{ab}	6.8 ± 0.4^{a}	+19.2
	Ethanol	5.4 ± 0.5^{ab}	5.3 ± 0.5^{bc}	-1.8
	Water	6.6 ± 0.4^{a}	6.3 ± 0.2^{ab}	-0.3
Bouchouk	Acetone	3.2 ± 0.5^{d}	2.8 ± 0.4^{de}	-4.54
	Ethanol	3.8 ± 0.2^{cd}	2.7 ± 0.4^{e}	-28.9
	Water	2.8 ± 0.2^{d}	2.6 ± 0.4^{e}	-7.14
Sigoise	Acetone	4.6 ± 0.4^{bcd}	3.8 ± 0.3^{d}	-17.3
	Ethanol	5.4 ± 0.6^{ab}	5.6 ± 0.6^{bc}	+3.7
	Water	5.4 ± 0.7^{abc}	4.9 ± 0.4^{c}	-9.2

2.5.2. DPPH-radical scavenging activity (DPPH-RSA)

a. Fresh olives

The DPPH-radical scavenging activity (DPPH-RSA)of the three black olive varieties is presented in the figure13,Results showed that solvent extraction affect significantly ($P < 0.05$) the DPPH-RSA which ranged from 1.1 (Bouchouk) to 2.1 g/100g DW (Aharoune) for 60% acetone solvent extraction, from 1.1 (Bouchouk) to 2.2 g/100g DW (Aharoune) for 60% ethanol solvent extraction and from 0.6 (Bouchouk) to 0.8 g/100g DW (For both Aharoune and Sigoise) for water solvent extraction.

The DPPH-RSA values were in the following order from low to high: Bouchouk < Sigoise <Aharoune for 60% acetone and 60% ethanol extractions and Bouchouk< Aharoune = Sigoise for water solvent extraction.

These results suggest that 60% acetone and 60% ethanol were the best solvent for the DPPH-RSA assay for Aharoune and Bouchouk cultivars since they exhibited the strongest activity. However, for Sigoise variety, 60% acetone seem to be the best solvent for the DPPH-RSA assay This high DPPH-RSA may be due to the highest content of acetonic and ethanolic

extracts on phenolic compounds having a power antiradical activity comparing to the aqueous extract.

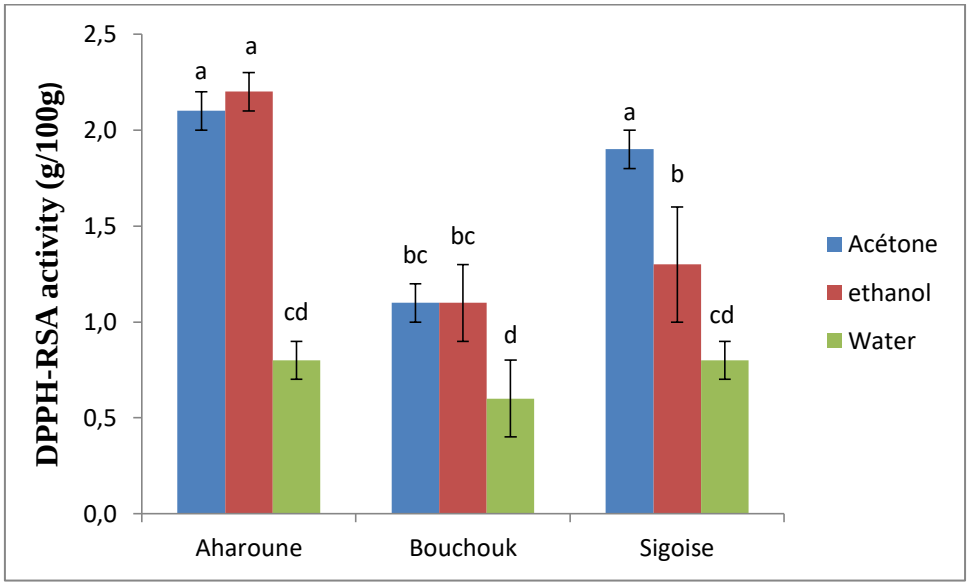

Figure 13: DPPH-RSA ofthe three fresh olives varieties.

Sousa et al. tested tow solvent (methanol and water) on the DPPH-RSA of stoned table olives ‘‘*alcaparras*’’and found that aqueous extract obtained at room temperature scavenged DPPH radicals less effectively (61.3% at 5 mg/mL) than extracts obtained using methanol (94.6% at 5 mg/mL) (**Sousa et al., 2008**), which is in agreement with our results.

b.Effect of dry salting

The effect of salting on the DPPH-RSA of the three black olive varieties is presented in the tableIX. Results showed that dry salting induces decreases or increases according to variety and solvent extraction used. DPPH_RSA decreases ranged from -4.54% (Aharoune, ethanol) to -36.3% (Bouchouk, acetone). DPPH-RSA increases ranged from 7.6% (Sigoise, ethanol) to 50% (Aharoune, water).

The DPPH-RSA of the salted olives varied from 0.7 (Bouchouk, both acetone and water) to 2.1 g/100g DW (Aharoune, ethanol). The DPPH-RSA of salted olives were in the following order from low to high: Bouchouk<Sigoise<Aharoune for 60% acetone, 60% ethanol and water solvent.Soufi el al. (2014) reported a significant antiradical activity loss occurred after salting olives with variable values depending on the cultivars. The decrease rate ranged from29% (Bouchouk and sigoise) to 58% (abelout) (Soufi et al., 2014).

Table IX: Effects of dry salting on the DPPH-RSA of the three olives varieties.

Variety	Solvent	Before Salting (g/100g DW)	After salting (g/100g DW)	Decreases or increase (%)
Aharoune	Acetone	2.1 ± 0.1^{a}	1.7 ± 0.2^{ab}	-19
	Ethanol	2.2 ± 0.1^{a}	2.1 ± 0.1^{a}	-4.54
	Water	0.8 ± 0.1^{cd}	1.2 ± 0.2^{cd}	+50
Bouchouk	Acetone	1.1 ± 0.1^{bc}	0.7 ± 0.2^{e}	-36.3
	Ethanol	1.1 ± 0.2^{bc}	0.8 ± 0.0^{e}	-27.2
	Water	0.6 ± 0.2^{d}	0.7 ± 0.1^{e}	+16.6
Sigoise	Acetone	1.9 ± 0.1^{a}	1.4 ± 0.2^{bc}	-26.3
	Ethanol	1.3 ± 0.3^{b}	1.4 ± 0.1^{bc}	+7.6
	Water	0.8 ± 0.1^{cd}	0.9 ± 0.1^{de}	+12.5

2.5.3. ABTS-radical scavenging activity (ABTS-RSA)

a. Fresh olives

The ABTS-radical scavenging activity (ABTS-RSA)of the three black olives varieties is presented in the figure14.Results showed that solvent extraction affect significantly ($P < 0.05$) the ABTS-RSA which ranged 2.56 (Bouchouk) to 3.34 g/100g DW (Aharoune) for 60% acetone solvent extraction, from 2.77 (Bouchouk) to 3.37 g/100g DW (Aharoune) for 60% ethanol solvent extraction and from 1.7 (Bouchouk) to 2.48 g/100g DW (Aharoune) for water solvent extraction.The ABTS-RSA values as affected by the solvent extraction were in the following order from low to high: Bouchouk < Sigoise < Aharoune for the three solvents extraction used (60% acetone, 60% ethanol and water).

These results suggest that 60% acetone and 60% ethanol were the best solvent for the ABTS-RSA assay since they exhibited the strongest activity. This high ABTS-RSA may be due to the highest content of acetonic and ethanolic extracts on phenolic compounds having a power antiradical activity comparing to the aqueous extract.

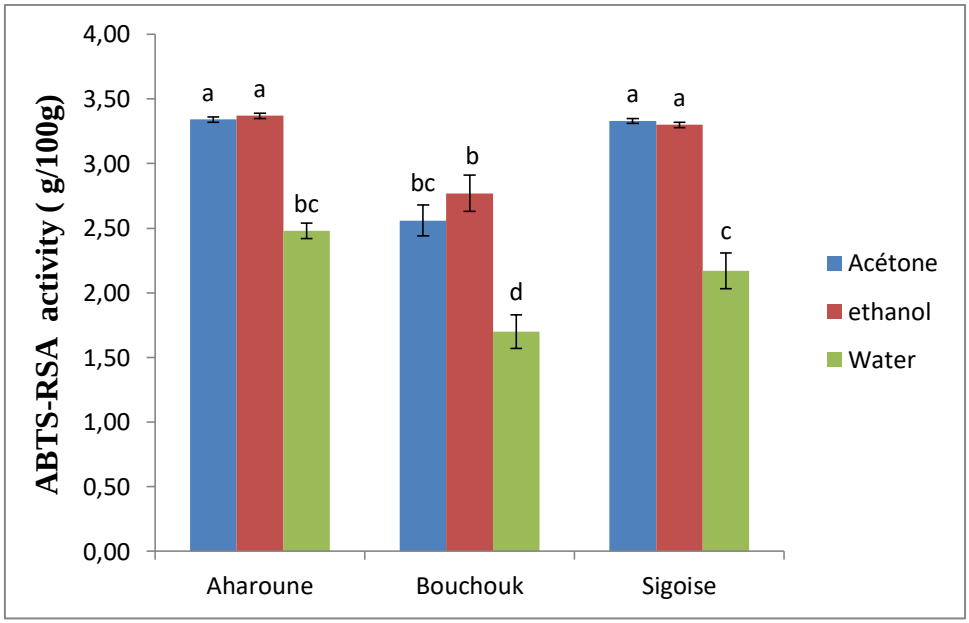

Figure14: ABTS-RSA activity of the three fresh olives varieties.

b. Effect of dry salting

The effect of salting on the ABTS-RSA of the three black olive varieties is presented in the tableX. Results showed that dry salting induces decreases or increases according to variety and solvent extraction used. ABTS-RSA decreases ranged from -0.1% (Sigoise, ethanol) to -36.1% (Bouchouk, ethanol). The ABTS-RSA increases ranged from 23% (Sigoise, water) to 33.4% (Aharoune, water).

The ABTS-RSA of the salted olives varied from 1.63 (Bouchouk, water) to 3.3 g/100g DW (Aharoune, acetone and water). The ABTS-RSAvalues of of the salted olives were in the following order from low to high: Bouchouk <Sigoise<Aharoune for 60% acetone**,** 60 % ethanoland water solvent.

Table X: Effects of dry salting on the ABTS-RSA of the three olives varieties.

Variety	Solvent	Before Salting (g/100g DW)	After salting (g/100g DW)	Decreases or increase (%)
Aharoune	Acetone	3.34±0.02^{a}	3.31±0.01^{a}	-0.89
	Ethanol	3.37±0.02^{a}	3.3±0.003^{a}	-2.07
	Water	2.48±0.06^{bc}	3.31±0.03^{a}	+33.4
Bouchouk	Acetone	2.56±0.12^{bc}	2.39±0.1^{b}	-6.6
	Ethanol	2.77±0.14^{b}	1.77±0.02^{c}	-36.1
	Water	1.7±0.13^{d}	1.63±0.07^{c}	-4.1
Sigoise	Acetone	3.33±0.02^{a}	3.23±0.02^{a}	-0.1
	Ethanol	3.3±0.02^{a}	3.24±0.15^{a}	-3
	Water	2.17±0.14^{c}	2.68±0.18^{b}	+23.5

2.5.4. Ferric reducing power (FRP)

a. Fresh olives

The ferric reducing power (FRP)of the three black olives varieties is presented in the figure15.Results showed that solvent extraction affect significantly ($P < 0.05$) the FRP which ranged 1.8 (Bouchouk) to 3.2 g/100g DW (Aharoune) for 60% acetone solvent extraction, from 1.8 (Bouchouk) to 3.2 g/100g DW (Aharoune) for 60% ethanol solvent extraction and from 1.6 (Sigoise) to 1.9 g/100g DW (Aharoune) for water extraction.

The FRP values as affected by the solvent extraction were in the following order from low to high: Bouchouk < Sigoise < Aharoune for 60% acetone and 60% ethanol extractions and Sigoise < Bouchouk < Aharoune for water extraction. These results suggest that 60% acetone and 60% ethanol were the best solvent for the FRP assay since they exhibited the strongest activity. This high FRP may be due to the highest content of acetonic and ethanolic extracts on phenolic compounds having a strong ferric reducing power comparing to the aqueous extract

Soufi et al. (2014) observed thatlowest reducing power was recorded for Bouchouk cultivar (1.318 g/100g) which is accordance with our results.

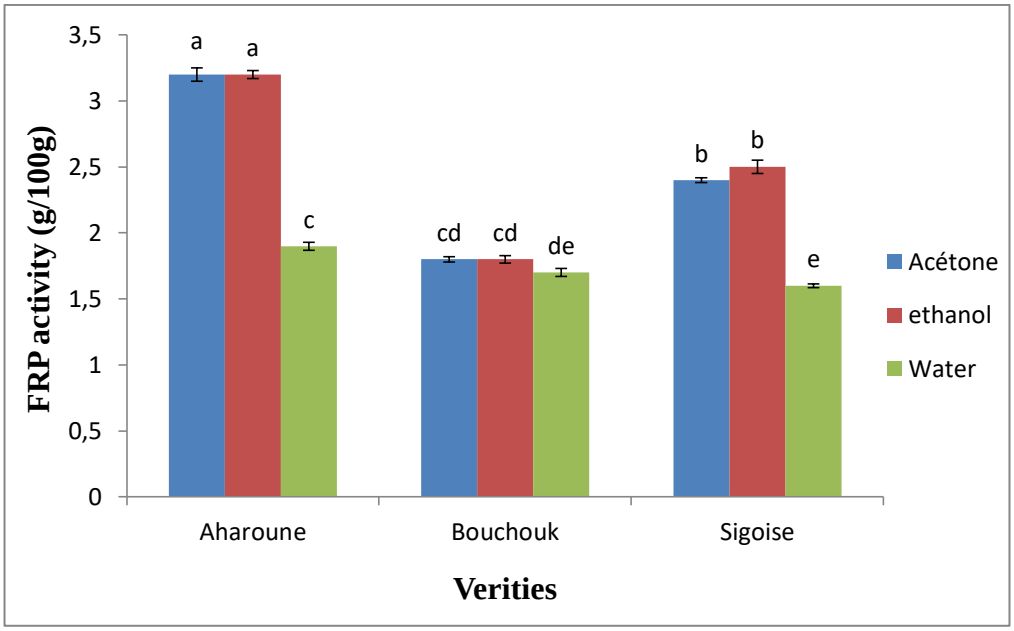

Figure15: FRP of the three fresh olives varieties.

Sousa et al. (Sousa et al., 2008) tested tow solvent (methanol and water) on the FRP of stoned table olives ‘‘alcaparras’’ and showed that aqueous extract obtained at room temperature exhibited the lowest reducing power values (0.70 at 5 mg/mL) than extract obtained with methanol (1.5 at 5 mg/mL) which is in agreement with our results.

b.Effect of dry salting

The effect of salting on the FRP of the three black olives varieties is presented in the tableXI. Results showed that dry salting induces decreases, increases or has no effect on the FRP, according to the variety and the solvent extraction used. FRP decreases ranged from -5.8% (Bouchouk, water) to -27.7% (Bouchouk, acetone). The FRP increases ranged from 3.1% (Aharoune, acetone) to 47.3% (Aharoune, water). However, salting has no effect on Aharoune (ethanol) and Sigoise (ethanol).

The FRP of the salted olives varied from 1.3 (Bouchouk, acetone) to 3.3 g/100g DW (Aharoune, acetone). The FRP values of the salted olives were in the following order from low to high: Bouchouk < Sigoise < Aharoune for 60% acetone and for water solvents.

Soufi et al.(2014) reported adecrease of thereducing power ranging from 10% (Azeradj) to 35% (Sigoise from Mascara) after processing olives by dry salting (Soufi et al., 2014).

Table XI: Effects of dry salting on the FRP of the three olives varieties.

Variety	Solvent	Before Salting (g/100g DW)	After salting (g/100g DW)	Decreases or increase (%)
Aharoune	Acetone	3.2 ± 0.05^{a}	3.3 ± 0.15^{a}	+3.1
	Ethanol	3.2 ± 0.03^{a}	3.2 ± 0.06^{a}	No effect
	Water	1.9 ± 0.03^{c}	2.8 ± 0.01^{b}	+47.3
Bouchouk	Acetone	1.8 ± 0.02^{cd}	1.3 ± 0.02^{g}	-27.7
	Ethanol	1.8 ± 0.03^{cd}	1.4 ± 0.02^{f}	-22.2
	Water	1.7 ± 0.03^{de}	1.6 ± 0.05^{ef}	-5.8
Sigoise	Acetone	2.4 ± 0.02^{b}	2 ± 0.02^{d}	-16.6
	Ethanol	2.5 ± 0.05^{b}	2.5 ± 0.04^{c}	No effect
	Water	1.6 ± 0.013^{e}	1.7 ± 0.04^{e}	+6.2

Soufi et al. (2016)noted a decrease in ferric reducing capacity except for Bouchouk cultivar, which showed a stable activity. The decrease varied between a mean value of 16% (Abelout and Aberkane) and 41% (Azeradj). This result could be explained by the low contents of flavonoids and/ or other reducing agents in salted olives, since, the antioxidant capacity of flavonoids has been attributed to their electron-donating ability (Morales-Soto et al., 2014).

2.5.5. Iron chelating activity (ICA)

a. Fresh olives

The iron chelating activity (ICA)of the three black olives varieties is presented in the figure16.Results showed that solvent extraction affect significantly ($P < 0.05$) the ICA which ranged from2.58 (Sigoise) to 2.66 g/100g DW (Bouchouk) for 60% acetone solvent extraction, from 2.27 (Bouchouk) to 3.32/100g DW (Aharoune) for 60% ethanol solvent extraction and from 0.3 (Aharoune) to 0.45 g/100g DW (Sigoise) for water extraction.

The ICA values of the black fresh olives as affected by the solvent extraction were in the following order from low to high: Sigoise < Aharoune < Bouchouk for 60% acetone extraction Bouchouk < Sigoise < Aharoune for 60% ethanol extraction and Aharoune < Bouchouk < Sigoise for water solvent extraction. These results suggest 60% ethanol were the best solvent for the ICA assay Aharoune variety. However, 60% acetone was the best solvent for the ICA assay

for Bouchouk and Sigoise cultivars since they exhibited the strongest activity. This powerful ICA may be due to the highest content of acetonic and ethanolic extracts on phenolic compounds having a strong iron chelating activity comparing to the aqueous extract.

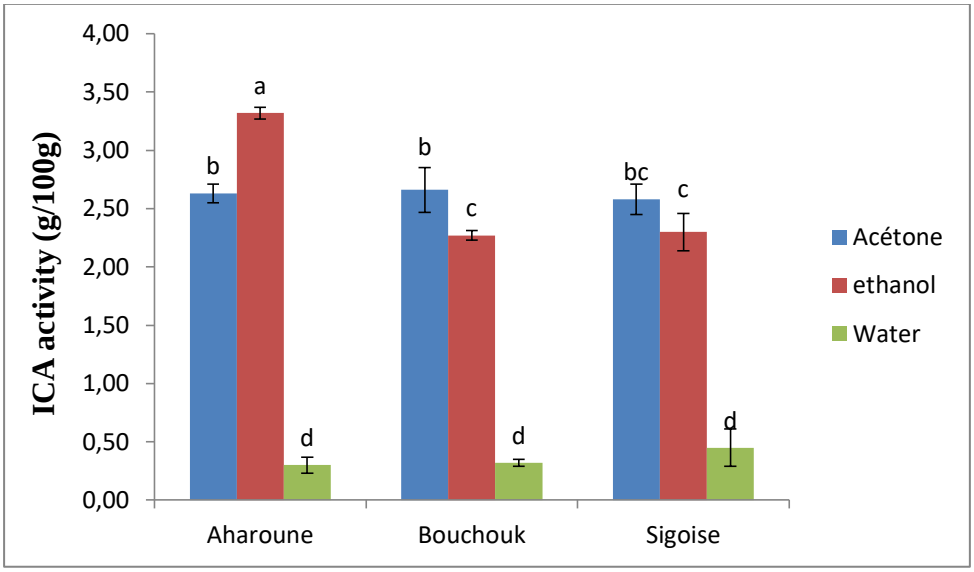

Figure 16:ICA three fresh olives varieties.

b.Effect of dry salting

The effect of salting on the iron chelating activity (ICA) of the three black olives varieties is presented in the tableXII. Results showed that dry salting induces decreases or increases on the ICA, according to the variety and the solvent extraction used. The ICA decreases ranged from -26.6% (Aharoune, ethanol) to -57.5% (Bouchouk, acetone). The ICA increases ranged from 35.5% (Sigoise, water) to 43.3% (Aharoune, water).

The ICA values of the salted olives varied from 0.3 (Aharoune, water) to 3.32 g/100g DW (Aharoune, ethanol). The ICA values of the salted olives were in the following order from low to high:Bouchouk<Sigoise<Aharoune for 60% acetone**,** 60% ethanoland water solvents.

Soufi el al. (2014) found that processing olives by dry salting induced a decreases in ferrous-chelating activity depending on cultivar and ranging from 10% to 48% (Soufi et al., 2014).

Table XII: Effects of dry salting on the ICA of the three olives varieties.

Variety	Solvent	Before Salting (g/100g DW)	After salting (g/100g DW)	Decreases or increases (%)
Aharoune	Acetone	2,63±0.08^{a}	1,63±0.11^{a}	-38%
	Ethanol	3,32±0.05^{b}	2,60±0.31^{a}	-26.6%
	Water	0,30±0.07^{d}	0,43±0.10^{b}	+43.3%
Bouchouk	Acetone	2,66±0.19^{b}	1,13±0.01^{g}	-57.5%
	Ethanol	2,27±0.04^{c}	1,41±0.07^{f}	-37.8%
	Water	0,32±0.03^{d}	0,45±0.06^{ef}	+40.6%
Sigoise	Acetone	2,58±0.13^{bc}	1,56±0.12^{d}	-39.5%
	Ethanol	2,30±0.16^{c}	1,06±0.12^{c}	-53.9%
	Water	0,45±0.16^{d}	0,61±0.19^{e}	+35.5%

3. Pearson correlation analysis

Correlations between different classes of phenolic compounds (TPC, TFC, TFLC, TAC) and the antioxidant activities (TAA, DPPH-RSA, ABTS-RSA, FRP and ICA) were performed using Pearson correlation analysis test (STATISTICA 5.5). (Table XIII)

For fresh olives, high positively Pearson correlation coefficients ($0.41 < r < 0.84$) with p at least <0.05 were found between TPC and antioxidant activities (TAA, DPPH-RSA, ABTS-RSA FRP and ICA). Good linear positive correlations were also observed between antioxidant activities (TAA, DPPH-RSA, ABTS-RSA FRP and ICA) and TFC($0.47 < r < 0.89$)TFLC ($0.7 < r < 0.82$) and TAC($0.37 < r < 0.51$). These correlations suggest that fresh olives phenolic compounds, mainly TPC, TFC, TFLC and secondarily TAC, are the main contributors to their antioxidant activities.

For salted olives, strong positive Pearson correlation coefficients ($0.81 < r < 0.95$), with p at least <0.05, were found between TPC and antioxidant activities (TAA, DPPH-RSA, ABTS-RSA FRP and ICA). Good linear positive correlations ($0.76 < r < 0.99$)were also observed between TFC and antioxidant activities (TAA, DPPH-RSA, ABTS-RSA FRP and ICA). Strong correlation were noted between TAC and TAA ($r= 0.88^{**}$, $p < 0.01$) and FRP ($r=0.86^{*}$, $p< 0.05$). However, no correlation was found between TFLC and the different antioxidant activities. These

correlations suggest that TPC, TFC and TAC are the main contributors to the antioxidant activities of salted olives.

TableXIII : Correlations between TPC, TFC, TFLC, TAC and the antioxidant activities(TAA, DPPH-RSA, ABTS-RSA, FRP and ICA) of the fresh and salted black olives varieties.

	TFC	**TFLC**	**TAC**	**TAA**	**DPPH-RSA**	**ABTS-RSA**	**FRP**	**ICA**
Fresh olives								
TPC	0.84^{***}	0.71^{***}	0.58^{*}	0.41^{*}	0.77^{***}	0.84^{***}	0.82^{***}	0.59^{**}
TFC		0.57^{*}	0.25^{ns}	0.47^{*}	0.78^{***}	0.86^{***}	0.89^{***}	0.67^{***}
TFLC			0.79^{***}	0.09^{ns}	0.82^{***}	0.7^{***}	0.77^{***}	0.80^{***}
TAC				0.06^{ns}	0.51^{**}	0.37^{*}	0.5^{**}	0.40^{*}
TAA					0.33^{ns}	0.45^{*}	0.45^{*}	0.001^{ns}
DPPH-RSA						0.84^{***}	0.88^{***}	0.77^{***}
ABTS-RSA							0.81^{***}	0.77^{***}
FRP								0.67^{***}
ICA								
Salted olives								
TPC	0.98^{***}	0.11^{ns}	0.83^{*}	0.95^{**}	0.81^{*}	0.85^{*}	0.98^{***}	0.92^{**}
TFC		0.19^{ns}	0.87^{*}	0.97^{***}	0.76^{*}	0.82^{*}	0.99^{***}	0.84^{*}
TFLC			0.63^{ns}	0.26^{ns}	-0.3^{ns}	-0.35^{ns}	0.16^{ns}	-0.23^{ns}
TAC				0.88^{**}	0.40^{ns}	0.47^{ns}	0.86^{*}	0.57^{ns}
TAA					0.73^{ns}	0.75^{ns}	0.97^{***}	0.78^{*}
DPPH-RSA						0.85^{*}	0.76^{*}	0.9^{**}
ABTS-RSA							0.84^{*}	0.91^{**}
FRP								0.85^{*}
ICA								

*, ** and *** indicate significant differences at $p< 0.05$, $p < 0.01$ and $p < 0.001$, respectively.

Conclusion

Conclusion

This study aimed to investigate the phenolic contents (total phenolic content; TPC, total flavonoid content; TFC, total flavonol content; TFLC and total anthocyanin content; TAC) and the antioxidant activities (total antioxidant activity; TAA, DPPH radical-scavenging activity; DPPH-RSA,ABTS radical-scavenging activity; ABTS-RSA, ferric reducing power; FRP and iron chelating activity; ICA) of three fresh black Algerian olives cultivars (Aharoune, Bouchouk and Sigoise) cultivated in the region of Bejaia, to study the effect of three solvents extraction (60% acetone, 60% ethanol and water) on the extraction of phenolics and on the antioxidant capacity of the three fresh olives varieties in order to find the best solvent extraction to recovery the maximum phenols from olives and to correlate their levels with the antioxidant activity of the obtained extracts and finally to test the effect of a traditional table olive processing (dry salting) on the phenolic compound contents and on the antioxidant activities of the three Algerian black olives cultivars.

Results showed that variety and solvent extraction affected significantly the TPC, TFC, TFLC, TAC and the antioxidant activities (TAA, DPPH-RSA, ABTS-RSA, FRP and ICA). The TPC ranged from 1.9 g/100g (Bouchouk, water) to 4.2 g/100g DW (Aharoun, aceone), TFC from 71.6 mg/100g (Bouchouk, water) to 595.7 mg/100g DW (Sigoise, acetone), TFLC from 21.6 mg/100g (Sigoise, water) to 316.4 mg/100g DW(Aharoune, acetone) on 60% acetone solvent, TAC from 55.5 mg/100g (Sigoise) to 152.2 mg/100g DW (Aharoune), TAA from 2.8 g/100g (Bouchouk, water) to 6.6 g/100g DW (Aharoune, water), DPPH-RSA from 0.6 (Bouchouk, water) to 2.2 g/100g DW (Aharoune, ethanol). ABTS-RSA from 1.7 (Bouchouk, water) to 3.37 g/100g DW (Aharoune, ethanol), FRP from 1.6 g/100g (Sigoise, water) to 3.2 g/100g (Aharoune, acetone and ethanol) and finally, the ICA activity ranged from 0.3 (Aharoune, water) to 3.32 g/100g DW (Aharoune, acetone). These results suggest that 60% acetone was the best solvent for extracting phenolic compounds from fresh black olives, followed by 60% ethanol and water.

Results showed also that dry salting of black olives induces decreases, increases or had no effect on the phenolic compound contents and on the antioxidant activities of black olives depending on the variety and the solvent extraction used.

The cultivar and the solvent extraction also affected the phenolic compound contents and on the antioxidant activities of the salted olives. The TPC ranged from 1.7 (Bouchouk, ethanol) to 4.6 g/100g DW (Aharoune, acetone), TFC from 60.1 (Bouchouk, ethanol) to 406.2 mg/100g DW (Sigoise, acetone), from 8.9 (Sigoise water) to 281 mg/100g DW (Aharoune, acetone), TAC

from 19.6 (Sigoise) to 112 mg/100g DW (Aharoune), TAA from 2.6 (Bouchouk water) to 6.8 g/100g DW (Aharoune, acetone), DPPH-RSA from 0.7 (Bouchouk, both acetone and water) to 2.1 g/100g DW (Aharoune, ethanol), ABTS-RSA from 1.63 (Bouchouk, water) to 3.3 g/100g DW (Aharoune, acetone and water), FRP from 1.3 (Bouchouk, acetone) to 3.3 g/100g DW (Aharoune, acetone) and finally ICA from 0.3 (Aharoune, water) to 3.32 g/100g DW (Aharoune, ethanol). These results suggest that 60% acetone was the best solvent for extracting phenolic compounds from salted olives, followed by 60% ethanol and water.

Pearson correlation analysis showed good linear positive correlations between phenolic compounds and the several antioxidant activities, suggesting that phenolic compounds are the main contributors to the antioxidant potential of black olives.

Finally, we can conclude that black olives (fresh and salted) are a good source of phenolic compounds displaying high antioxidant activities (antiradical scavenger activity, ferric reducing power and iron chelating activity) and therefore, fresh black olives extracts could be used as potential functional ingredients or additives in food industry, cosmetics and medicine. Additionally, the consumption of black salted olives must be encouraged.

In order to complete this work, it would be interesting to:

- Study other olives varieties and other table olives processing method (Spanich-style, Californian-style).
- Use advanced analysis techniques (HPLC, LC/MS, etc.) to identify the phenolic compounds present in black olives varieties responsible of their antioxidant activities.
- Study other biological activities of the black olives extracts such as antibacterial and antifungal activities.
- Evaluate the cytotoxicity effect of black olives extracts.
- Finally, to realize *in vivo* tests of the black olives extracts in order to determine their effects on animal health such anti-inflammatory, anti-diabetic, anticancer activities,…ect.

Bibliographic References

Bibliographic references

Abdel-Aal E.S., Hucl P. (1999) A rapid method for quantifying total anthocyanins in blue aleurone and purple pericarp wheats. Cereal chemistry 76:350-354.

Amiri H. (2014) Chemical composition and antioxidant activity of essential oil and methanolic extracts of Ferula microcolea (Boiss.) Boiss (Apiaceae). International Journal of Food Properties 17:722-730.

Acquaviva R., Di Giacomo C., Sorrenti V., Galvano F., Santangelo R., Cardile V., Gangia S., D'Orazio N., Abraham N.G., Vanella L. (2012) Antiproliferative effect of oleuropein in prostate cell lines. International journal of oncology 41:31-38.

Armstrong N.C., Paganga G., Brunner E., Miller N.J., Nanchahal K., Shipleyb M., Rice-Evans C.A., Marmot M.G., Diplock A.T. (1997) Reference values for α-tocopherol and β-carotene in the Whitehall II study. Free Radical Research 27:207-219.

Andary C., Wylde R., Laffite C., Privat G., Winternitz F. (1982) Structures of verbascoside and orobanchoside, caffeic acid sugar esters from Orobanche rapum-genistae. Phytochemistry 21:1123-1127.

Battinelli L., Daniele C., Cristiani M., Bisignano G., Saija A., Mazzanti G. (2006) In vitro antifungal and anti-elastase activity of some aliphatic aldehydes from Olea europaea L. fruit. Phytomedicine 13:558-563.

Beauchamp G.K., Keast R.S., Morel D., Lin J., Pika J., Han Q., Lee C.-H., Smith A.B., Breslin P.A. (2005) Ibuprofen-like activity in extra-virgin olive oil. Nature 437:45-46.

Ben Othman N., Roblain D., Thonart P., Hamdi M. (2008) Tunisian table olive phenolic compounds and their antioxidant capacity. Journal of Food Science 73:C235-C240.

Bianchi G. (2003) Lipids and phenols in table olives. European Journal of Lipid Science and Technology 105:229-242.

Bigagli E., Cinci L., Paccosi S., Parenti A., D'Ambrosio M., Luceri C. (2017) Nutritionally relevant concentrations of resveratrol and hydroxytyrosol mitigate oxidative burst of human granulocytes and monocytes and the production of pro-inflammatory mediators in LPS-stimulated RAW 264.7 macrophages. International Immunopharmacology 43:147-155.

Bisignano G., Tomaino A., Cascio R.L., Crisafi G., Uccella N., Saija A. (1999) On the in-vitro antimicrobial activity of oleuropein and hydroxytyrosol. Journal of pharmacy and pharmacology 51:971-974.

Boskou D., Camposeo S., Clodoveo M.L. (2015) Table olives as sources of bioactive compounds, Olive and olive oil bioactive constituents, Elsevier. pp. 217-259.

Boss A., Bishop K.S., Marlow G., Barnett M.P., Ferguson L.R. (2016) Evidence to support the anti-cancer effect of olive leaf extract and future directions. Nutrients 8:513.

Bulotta S., Oliverio M., Russo D., Procopio A. (2013) Biological activity of oleuropein and its derivatives, Springer Berlin/Heidelberg, Germany. pp. 3605-3638.

Bastoni L., Bianco A., Piccioni F., Uccella N. (2001) Biophenolic profile in olives by nuclear magnetic resonance. Food Chemistry 73:145-151.

Bianchi G. (2003) Lipids and phenols in table olives. European Journal of Lipid Science and Technology 105:229-242.

Bianco A., Uccella N. (2000) Biophenolic components of olives. Food Research International 33:475-485.

Blázquez-Martínez J. (1996) Evolution and history. International Olive Oil Council (IOOC)(eds.). World olive encyclopedia. Madrid:17-54.

Boskou D. (2006) Olive oil: chemistry and technology AOCS Publishing.

Boskou D. (2009) Culinary applications of olive oil—Minor constituents and cooking. Olive oil: Minor constituents and health:1-4.

Boss A., Bishop K.S., Marlow G., Barnett M.P., Ferguson L.R. (2016) Evidence to support the anti-cancer effect of olive leaf extract and future directions. Nutrients 8:513.

Blois M.S. (1958) Antioxidant determinations by the use of a stable free radical. Nature 181:1199-1200.

Bianchi G. (2003) Lipids and phenols in table olives. European Journal of Lipid Science and Technology 105:229-242.

Blekas G., Vassilakis C., Harizanis C., Tsimidou M., Boskou D.G. (2002) Biophenols in table olives. Journal of Agricultural and Food Chemistry 50:3688-3692.

Borzillo A., Iannotta N., Uccella N. (2000) Oinotria table olives: quality evaluation during ripening and processing by biomolecular components. European Food Research and Technology 212:113-121.

Chabane F.A., Rovellini P., Boucheffa S., Medina E., Tamendjari A. (2020) Quality of lipid fraction during Spanish-style table olives processing of Sigoise and Azzeradj cultivars. Food Control 111:107059.

Calabrese V., Crea R. (2016) Potential prevention and treatment of Neurodegenerative diseases: Olive polyphenols and hydroxytyrosol. Eur. J. Neurodegener. Dis 5:81-108.

Calabriso N., Gnoni A., Stanca E., Cavallo A., Damiano F., Siculella L., Carluccio M.A. (2018) Hydroxytyrosol ameliorates endothelial function under inflammatory

conditions by preventing mitochondrial dysfunction. Oxidative medicine and cellular longevity 2018.

Calahorra J., Martínez-Lara E., De Dios C., Siles E. (2018) Hypoxia modulates the antioxidant effect of hydroxytyrosol in MCF-7 breast cancer cells. PloS one 13:e0203892.

Caruso D., Berra B., Giavarini F., Cortesi N., Fedeli E., Galli G. (1999) Effect of virgin olive oil phenolic compounds on in vitro oxidation of human low density lipoproteins. Nutrition, Metabolism, and Cardiovascular Diseases: NMCD 9:102-107.

Catalán Ú., López de las Hazas M.C., Rubió L., Fernández-Castillejo S., Pedret A., de la Torre R., Motilva M.J., Solà R. (2015) Protective effect of hydroxytyrosol and its predominant plasmatic human metabolites against endothelial dysfunction in human aortic endothelial cells. Molecular Nutrition & Food Research 59:2523-2536.

Charoenprasert S., Mitchell A. (2012) Factors influencing phenolic compounds in table olives (Olea europaea). Journal of Agricultural and Food Chemistry 60:7081-7095.

Cheeseman K.H., Slater T.F. (1993) An introduction to free radical biochemistry. British medical bulletin 49:481-493.

Cusimano A., Balasus D., Azzolina A., Augello G., Emma M.R., Di Sano C., Gramignoli R., Strom S.C., McCubrey J.A., Montalto G. (2017) Oleocanthal exerts antitumor effects on human liver and colon cancer cells through ROS generation. International journal of oncology 51:533-544.

Calabriso N., Scoditti E., Pellegrino M., Carluccio M.A. (2015) Olive oil, The Mediterranean Diet, Elsevier. pp. 135-142.

Carrión Y., Ntinou M., Badal E. (2010) Olea europaea L. in the north Mediterranean Basin during the Pleniglacial and the Early–Middle Holocene. Quaternary Science Reviews 29:952-968.

Chabane F.A., Rovellini P., Boucheffa S., Medina E., Tamendjari A. (2020) Quality of lipid fraction during Spanish-style table olives processing of Sigoise and Azzeradj cultivars. Food Control 111:107059.

Chabane F.A., Tamendjari A., Rovellini P., Romero C., Medina E. (2021) Chemical parameters and antioxidant activity of turning color natural-style table olives of the Sigoise cultivar. Grasas y Aceites 72:e419-e419.

Civantos L. (1998) The olive tree, the oil, the olive. ADICOM, Madrid.

Cunha S.C., Ferreira I.M., Fernandes J.O., Faria M.A., Beatriz M., Oliveira P., Ferreira M. (2001) Determination of lactic, acetic, succinic, and citric acids in table olives by HPLC/UV. Journal of liquid chromatography & related technologies 24:1029-1038.

DELPLANQUE B., JUSSELIN I., LE ROY B., MOTTA C. (1999) Intérêt nutritionnel des huiles d'olive. OCL. Oléagineux, corps gras, lipides 6:86-93.

Doelman C. (1989) Antioxidant therapy and preventive medicine, Plenum Press: New York, NY, USA.

Dinis T.C., Madeira V.M., Almeida L.M. (1994) Action of phenolic derivatives (acetaminophen, salicylate, and 5-aminosalicylate) as inhibitors of membrane lipid peroxidation and as peroxyl radical scavengers. Archives of biochemistry and biophysics 315:161-169.

Ergönül P., Nergiz C. (2010) Determination of organic acids in olive fruit by HPLC. Czech Journal of Food Sciences 28:202.

Esti M., Cinquanta L., La Notte E. (1998) Phenolic compounds in different olive varieties. Journal of Agricultural and Food Chemistry 46:32-35.

FAOSTAT. (2020) Food and Agricultural Organization of United Nations: Economic and Social Department: The Statistical Division. Retrievable from: https://www.fao.org/faostat/en/#data/QCL/visualize (accessed August 2022).

Fabiani R. (2016) Anti-cancer properties of olive oil secoiridoid phenols: A systematic review of in vivo studies. Food & function 7:4145-4159.

Furneri P.M., Marino A., Saija A., Uccella N., Bisignano G. (2002) In vitro antimycoplasmal activity of oleuropein. International journal of antimicrobial agents 20:293-296.

FAOSTAT. (2020) Food and Agricultural Organization of United Nations: Economic and Social Department: The Statistical Division. Retrievable from: https://www.fao.org/faostat/en/#data/QCL/visualize (accessed August 2022).

Fedeli E., Cortesi N. (1993) Quality, origin and technology of virgin olive oils. La Rivista Italiana delle Sostanze Grasse, Milano 70:419-425.

Fernández A.G., Adams M.R., Fernandez-Diez M. (1997) Table olives: production and processing Springer Science & Business Media.

Fernández A.G., Adams M.R., Fernandez-Diez M. (1997) Table olives: production and processing Springer Science & Business Media.

Garrido-Fernandez A., Fernandez-Diez M., Adams M. (1997) Olives and table olives. Table olives: production and processing, 1st ed. Chapman & Hall, London:10-21.

Gandul-Rojas B., Gallardo-Guerrero L. (2014) Pigment changes during processing of green table olive specialities treated with alkali and without fermentation. Food research international 65:224-230.

Gilani A.H., Khan A.-u., Ghayur M.N. (2006) Ca2+ antagonist and cholinergic activities explain the medicinal use of olive in gut disorders. Nutrition Research 26:277-283.

Giner E., Andújar I., Recio M.C., Ríos J.L., Cerdá-Nicolás J.M., Giner R.M. (2011) Oleuropein ameliorates acute colitis in mice. Journal of agricultural and food chemistry 59:12882-12892.

Granados-Principal S., Quiles J.L., Ramirez-Tortosa C.L., Sanchez-Rovira P., Ramirez-Tortosa M.C. (2010) Hydroxytyrosol: from laboratory investigations to future clinical trials. Nutrition reviews 68:191-206.

Gariboldi P., Jommi G., Verotta L. (1986) Secoiridoids from Olea europaea. Phytochemistry 25:865-869.

Guo Z., Jia X., Zheng Z., Lu X., Zheng Y., Zheng B., Xiao J. (2018) Chemical composition and nutritional function of olive (Olea europaea L.): A review. Phytochemistry Reviews 17:1091-1110.

Garrido-Fernandez A., Fernandez-Diez M., Adams M. (1997) Olives and table olives. Table olives: production and processing, 1st ed. Chapman & Hall, London:10-21.

Hassen I., Casabianca H., Hosni K. (2015) Biological activities of the natural antioxidant oleuropein: Exceeding the expectation–A mini-review. Journal of Functional Foods 18:926-940.

Haralampidis K., Milioni D., Sanchez J., Baltrusch M., Heinz E., Hatzopoulos P. (1998) Temporal and transient expression of stearoyl-ACP carrier protein desaturase gene during olive fruit development. Journal of Experimental Botany 49:1661-1669.

Harborne J. (1989) General procedures and measurement of total phenolics. Methods in plant biochemistry 1:1-28.

Hashim Y.Z., Eng M., Gill C.I., McGlynn H., Rowland I.R. (2005) Components of olive oil and chemoprevention of colorectal cancer. Nutrition reviews 63:374-386.

Juan M.E.l., Wenzel U., Ruiz-Gutierrez V., Daniel H., Planas J.M. (2006) Olive fruit extracts inhibit proliferation and induce apoptosis in HT-29 human colon cancer cells. The Journal of nutrition 136:2553-2557.

Johnson R.L., Mitchell A.E. (2018) Reducing phenolics related to bitterness in table olives. Journal of food quality 2018.

Jimoh F., Adedapo A., Afolayan A. (2010) Comparison of the nutritional value and biological activities of the acetone, methanol and water extracts of the leaves of Solanum nigrum and Leonotis leonorus. Food and Chemical Toxicology 48:964-971.

Jiménez A., Rodríguez R., Fernández-Caro I., Guillén R., Fernández-Bolaños J., Heredia A. (2000) Dietary fibre content of table olives processed under different European styles: study of physico-chemical characteristics. Journal of the Science of Food and Agriculture 80:1903-1908.

Kamal-Eldin A., Andersson R. (1997) A multivariate study of the correlation between tocopherol content and fatty acid composition in vegetable oils. Journal of the American Oil Chemists' Society 74:375-380.

Katsoulieris E.N. (2016) The olive leaf extract oleuropein exerts protective effects against oxidant-induced cell death, concurrently displaying pro-oxidant activity in human hepatocarcinoma cells. Redox report 21:90-97.

Killeen M.J., Linder M., Pontoniere P., Crea R. (2014) NF-κβ signaling and chronic inflammatory diseases: exploring the potential of natural products to drive new therapeutic opportunities. Drug discovery today 19:373-378.

KOMAKI E., YAMAGUCHI S., MARU I., KINOSHITA M., KAKEHI K., OHTA Y., TSUKADA Y. (2003) Identification of anti-α-amylase components from olive leaf extracts. Food Science and Technology Research 9:35-39.

Louadj L., Giuffrè A. (2010) Analytical characteristics of olive oil produced with three different processes in Algeria. Riv. Ital. Sostanze Grasse 87:187-195.

Mafra I., Coimbra M. (2004) Improving the texture of processed fruit: the case of olives. Texture in food: volume 2: solid foods:410-431.

Maiuri M.C., De Stefano D., Di Meglio P., Irace C., Savarese M., Sacchi R., Cinelli M.P., Carnuccio R. (2005) Hydroxytyrosol, a phenolic compound from virgin olive oil, prevents macrophage activation. Naunyn-Schmiedeberg's archives of pharmacology 371:457-465.

Manna C., Napoli D., Cacciapuoti G., Porcelli M., Zappia V. (2009) Olive oil phenolic compounds inhibit homocysteine-induced endothelial cell adhesion regardless of their different antioxidant activity. Journal of agricultural and food chemistry 57:3478-3482.

Mateus T.I.d.P. (2016) Contribuição para o estudo de produção de azeitona de mesa da cultivar Cobrançosa: caraterização microbiológica.

Mendes P.A.F., da Silva Malheiro R.M. (2012) Caracterização da fração fenólica e atividade biológica de azeitonas de mesa ao natural produzidas na região de Trás-os-Montes, Instituto Politecnico de Braganca (Portugal).

Menendez J.A., Joven J., Aragonès G., Barrajón-Catalán E., Beltrán-Debón R., Borrás-Linares I., Camps J., Corominas-Faja B., Cufí S., Fernández-Arroyo S. (2013) Xenohormetic and anti-aging activity of secoiridoid polyphenols present in extra virgin olive oil: a new family of gerosuppressant agents. Cell Cycle 12:555-578.

Morelló J.-R., Vuorela S., Romero M.-P., Motilva M.-J., Heinonen M. (2005) Antioxidant activity of olive pulp and olive oil phenolic compounds of the Arbequina cultivar. Journal of agricultural and food chemistry 53:2002-2008.

Morelló J.R., Romero M.P., Motilva M.J. (2006) Influence of seasonal conditions on the composition and quality parameters of monovarietal virgin olive oils. Journal of the American Oil Chemists' Society 83:683-690.

McDonald S., Prenzler P.D., Antolovich M., Robards K. (2001) Phenolic content and antioxidant activity of olive extracts. Food chemistry 73:73-84.

Morales-Soto A., García-Salas P., Rodríguez-Pérez C., Jiménez-Sánchez C., de la Luz Cádiz-Gurrea M., Segura-Carretero A., Fernández-Gutiérrez A. (2014) Antioxidant capacity of 44 cultivars of fruits and vegetables grown in Andalusia (Spain). Food Research International 58:35-46.

Nergiz C., Engez Y. (2000) Compositional variation of olive fruit during ripening. Food Chemistry 69:55-59.

Owen R., Haubner R., Mier W., Giacosa A., Hull W., Spiegelhalder B., Bartsch H. (2003) Isolation, structure elucidation and antioxidant potential of the major phenolic and flavonoid compounds in brined olive drupes. Food and Chemical Toxicology 41:703-717.

Oyaizu M. (1986) Studies on products of browning reactions: ant oxidative activities of products of browning reaction prepared from glucosamine. Japanese journal of nutrition 44:307-315.

Panagou E.Z. (2006) Greek dry-salted olives: Monitoring the dry-salting process and subsequent physico-chemical and microbiological profile during storage under different packing conditions at 4 and 20 C. LWT-Food Science and Technology 39:323-330.

Pang K.-L., Chin K.-Y. (2018) The biological activities of oleocanthal from a molecular perspective. Nutrients 10:570.

Papadaki E., Mantzouridou F.T. (2016) Current status and future challenges of table olive processing wastewater valorization. Biochemical engineering journal 112:103-113.

Parzonko A., Czerwińska M.E., Kiss A.K., Naruszewicz M. (2013) Oleuropein and oleacein may restore biological functions of endothelial progenitor cells impaired by angiotensin II via activation of Nrf2/heme oxygenase-1 pathway. Phytomedicine 20:1088-1094.

Pereira J.A., Pereira A.P., Ferreira I.C., Valentão P., Andrade P.B., Seabra R., Estevinho L., Bento A. (2006) Table olives from Portugal: phenolic compounds, antioxidant potential, and antimicrobial activity. Journal of Agricultural and Food Chemistry 54:8425-8431.

Potočnjak I., Škoda M., Pernjak-Pugel E., Peršić M.P., Domitrović R. (2016) Oral administration of oleuropein attenuates cisplatin-induced acute renal injury in mice through inhibition of ERK signaling. Molecular nutrition & food research 60:530-541.

Panizzi L., Scarpati M., Orient G. (1960) The constitution of oleuropein, a bitter glucoside of the olive with hypotensive action. Gazz. Chim. Ital 90:1449-85.

Ray N.B., Lam N.T., Luc R., Bonvino N.P., Karagiannis T.C. (2015) Cellular and molecular effects of bioactive phenolic compounds in olives and olive oil, Olive and olive oil bioactive constituents, Elsevier. pp. 53-91.

Ribarova F., Zanev R., Shishkov S., Rizov N. (2003) α-Tocopherol, fatty acids and their correlations in Bulgarian foodstuffs. Journal of Food Composition and Analysis 16:659-667.

Rosignoli P., Fuccelli R., Fabiani R., Servili M., Morozzi G. (2013) Effect of olive oil phenols on the production of inflammatory mediators in freshly isolated human monocytes. The Journal of nutritional biochemistry 24:1513-1519.

Rosignoli P., Fuccelli R., Sepporta M.V., Fabiani R. (2016) In vitro chemo-preventive activities of hydroxytyrosol: The main phenolic compound present in extra-virgin olive oil. Food & function 7:301-307.

Ryu S.-J., Choi H.-S., Yoon K.-Y., Lee O.-H., Kim K.-J., Lee B.-Y. (2015) Oleuropein suppresses LPS-induced inflammatory responses in RAW 264.7 cell and zebrafish. Journal of agricultural and food chemistry 63:2098-2105.

Ragazzi E., Veronese G., Guiotto A. (1973) Demethyloleoeuropeine, new glucoside isolated from ripe olives. Annali di chimica 63:13-20.

Romani A., Mulinacci N., Pinelli P., Vincieri F.F., Cimato A. (1999) Polyphenolic content in five tuscany cultivars of Olea europaea L. Journal of Agricultural and Food Chemistry 47:964-967.

Rovellini P., Cortesi N., Fedeli E. (1997) Analysis of flavonoids from Olea europaea by HPLC-UV and HPLC-electrospray-MS. Rivista Italiana Delle Sostanze Grasse 74:273-279.

Re R., Pellegrini N., Proteggente A., Pannala A., Yang M., Rice-Evans C. (1999)

Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free

radical biology and medicine 26:1231-1237.

Rice-Evans C.A., Packer L. (2003) Flavonoids in health and disease CRC Press.

Sanchez A., García P., Rejano P. (2006) Trends in table olive production. Elaboration of table olives. Grasas Aceites 57:86-94.

Sakouhi F., Harrabi S., Absalon C., Sbei K., Boukhchina S., Kallel H. (2008) α-Tocopherol and fatty acids contents of some Tunisian table olives (Olea europea L.): Changes in their composition during ripening and processing. Food Chemistry 108:833-839.

Scoditti E., Calabriso N., Massaro M., Pellegrino M., Storelli C., Martines G., De Caterina R., Carluccio M.A. (2012) Mediterranean diet polyphenols reduce inflammatory angiogenesis through MMP-9 and COX-2 inhibition in human vascular endothelial cells: a

potentially protective mechanism in atherosclerotic vascular disease and cancer. Archives of biochemistry and biophysics 527:81-89.

Scoditti E., Nestola A., Massaro M., Calabriso N., Storelli C., De Caterina R., Carluccio M.A. (2014) Hydroxytyrosol suppresses MMP-9 and COX-2 activity and expression in activated human monocytes via PKCα and PKCβ1 inhibition. Atherosclerosis 232:17-24.

Sousa A., Ferreira I.C., Barros L., Bento A., Pereira J.A. (2008) Effect of solvent and extraction temperatures on the antioxidant potential of traditional stoned table olives "alcaparras". LWT-Food Science and Technology 41:739-745.

Sabatini N., Marsilio V. (2008) Volatile compounds in table olives (Olea Europaea L., Nocellara del Belice cultivar). Food chemistry 107:1522-1528.

Şahin S., Bilgin M. (2018) Olive tree (Olea europaea L.) leaf as a waste by-product of table olive and olive oil industry: a review. Journal of the Science of Food and Agriculture 98:1271-1279.

Sakouhi F., Harrabi S., Absalon C., Sbei K., Boukhchina S., Kallel H. (2008) α-Tocopherol and fatty acids contents of some Tunisian table olives (Olea europea L.): Changes in their composition during ripening and processing. Food Chemistry 108:833-839.

Singleton V.L., Orthofer R., Lamuela-Raventós R.M. (1999) Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent, Methods in enzymology, Elsevier. pp. 152-178.

Soler-Rivas C., Espín J.C., Wichers H.J. (2000) Oleuropein and related compounds. Journal of the Science of Food and Agriculture 80:1013-1023.

Soufi O., Romero C., Louaileche H. (2014) Ortho-diphenol profile and antioxidant activity of Algerian black olive cultivars: Effect of dry salting process. Food chemistry 157:504-510.

Soufi O., Romero C., Motilva M.-J., Gaya X.B., Louaileche H. (2016) Effect of dry salting on flavonoid profile and antioxidant capacity of Algerian olive cultivars. Grasas y Aceites 67:e132-e132.

Sousa A., Ferreira I.C., Barros L., Bento A., Pereira J.A. (2008) Effect of solvent and extraction temperatures on the antioxidant potential of traditional stoned table olives "alcaparras". LWT-Food Science and Technology 41:739-745.

Terzuoli E., Donnini S., Giachetti A., Iñiguez M.A., Fresno M., Melillo G., Ziche M. (2010) Inhibition of Hypoxia Inducible Factor-1α by Dihydroxyphenylethanol, a Product from Olive Oil, Blocks Microsomal Prostaglandin-E Synthase-1/Vascular Endothelial Growth Factor Expression and Reduces Tumor AngiogenesisDPE Inhibits Tumor Angiogenesis. Clinical Cancer Research 16:4207-4216.

Terzuoli E., Giachetti A., Ziche M., Donnini S. (2016) Hydroxytyrosol, a product from olive oil, reduces colon cancer growth by enhancing epidermal growth factor receptor degradation. Molecular nutrition & food research 60:519-529.

Therios I. (2009) CROP PRODUCTION SCIENCE IN HORTICULTURE 18, OLIVES, CABI.

Tomas-Barberan F.A., Gil M.I. (2008) Improving the health-promoting properties of fruit and vegetable products Elsevier.

Uylaser V., Tamer C.E., İncedayı B., Vural H., Çopur Ö.U. (2008) The quantitative analysis of some quality criteria of Gemlik variety olives. J Food, Agric Environ 6:26-30.

Uylaşer V., Yildiz G. (2014) The historical development and nutritional importance of olive and olive oil constituted an important part of the Mediterranean diet. Critical Reviews in Food Science and Nutrition 54:1092-1101.

Ünal K., Nergiz C. (2003) The effect of table olive preparing methods and storage on the composıtıon and nutrıtıve value of olives. Grasas y Aceites 54:71-76.

USANMAZ S., ÖZTÜRKLER F., HELVACI M., Turgut A., KAHRAMANOĞLU İ., AŞKIN M.A. (2018) EFFECTS OF PERIODS AND ALTITUDES ON THE PHENOLIC COMPOUNDS AND OIL CONTENTS OF OLIVES, cv. AYVALIK. International Journal of Agriculture Forestry and Life Sciences 2:32-39.

Uylaser V., Tamer C.E., İncedayı B., Vural H., Çopur Ö.U. (2008) The quantitative analysis of some quality criteria of Gemlik variety olives. J Food, Agric Environ 6:26-30.

Vinha A.F., Ferreres F., Silva B.M., Valentao P., Gonçalves A., Pereira J.A., Oliveira M.B., Seabra R.M., Andrade P.B. (2005) Phenolic profiles of Portuguese olive fruits (Olea europaea L.): Influences of cultivar and geographical origin. Food chemistry 89:561-568.

Vlahov G. (1992) Flavonoids in three olive (Olea europaea) fruit varieties during maturation. Journal of the Science of Food and Agriculture 58:157-159.

Vossen P. (2007) Olive oil: history, production, and characteristics of the world's classic oils. HortScience 42:1093-1100.

Vilaplana-Pérez C., Auñón D., García-Flores L.A., Gil-Izquierdo A. (2014) Hydroxytyrosol and potential uses in cardiovascular diseases, cancer, and AIDS. Frontiers in nutrition 1:18.

Vinha A.F., Ferreres F., Silva B.M., Valentao P., Gonçalves A., Pereira J.A., Oliveira M.B., Seabra R.M., Andrade P.B. (2005) Phenolic profiles of Portuguese olive fruits (Olea europaea L.): Influences of cultivar and geographical origin. Food chemistry 89:561-568.

Zhang X., Cao J., Zhong L. (2009) Hydroxytyrosol inhibits pro-inflammatory cytokines, iNOS, and COX-2 expression in human monocytic cells. Naunyn-Schmiedeberg's archives of pharmacology 379:581-586.

Zhu L., Liu Z., Feng Z., Hao J., Shen W., Li X., Sun L., Sharman E., Wang Y., Wertz K. (2010) Hydroxytyrosol protects against oxidative damage by simultaneous activation of mitochondrial biogenesis and phase II detoxifying enzyme systems in retinal pigment epithelial cells. The Journal of nutritional biochemistry 21:1089-1098.

Zou X., Feng Z., Li Y., Wang Y., Wertz K., Weber P., Fu Y., Liu J. (2012) Stimulation of GSH synthesis to prevent oxidative stress-induced apoptosis by hydroxytyrosol in human retinal pigment epithelial cells: activation of Nrf2 and JNK-p62/SQSTM1 pathways. The Journal of nutritional biochemistry 23:994-1006.

Ziogas V., Tanou G., Molassiotis A., Diamantidis G., Vasilakakis M. (2010) Antioxidant and free radical-scavenging activities of phenolic extracts of olive fruits. Food chemistry 120:1097-1103.

Annex

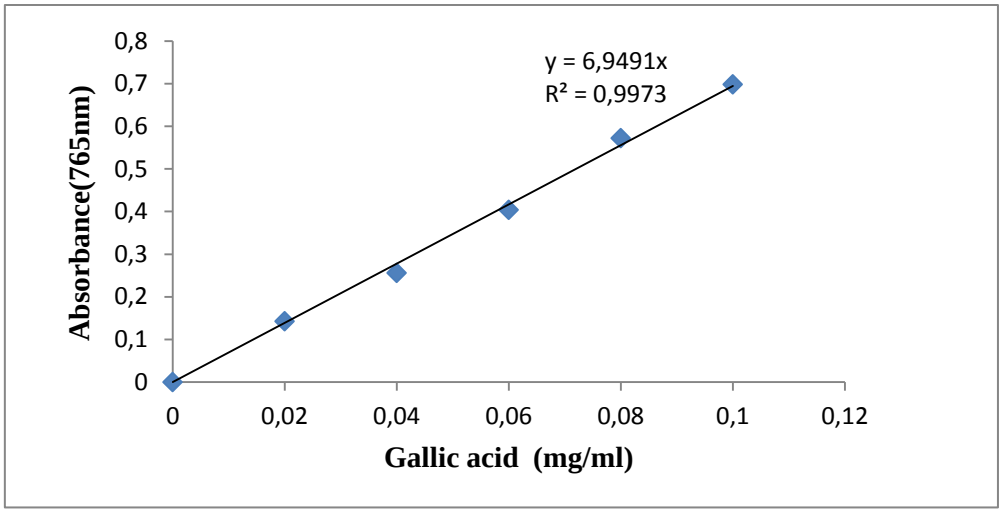

Figure 1: Total Polyphenols calibration curve

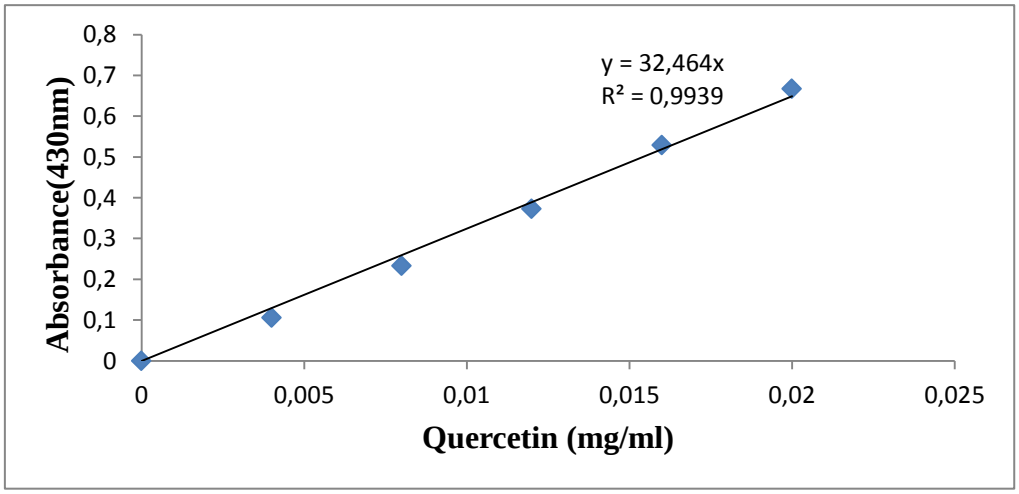

Figure 2: Total Flavonoid calibration curve

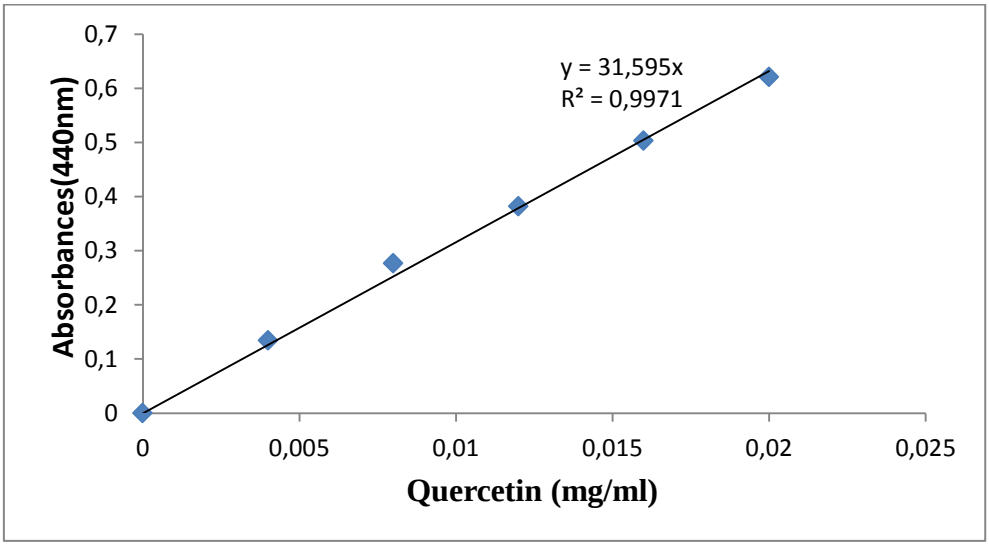

Figure 3: Flavonols calibration curve

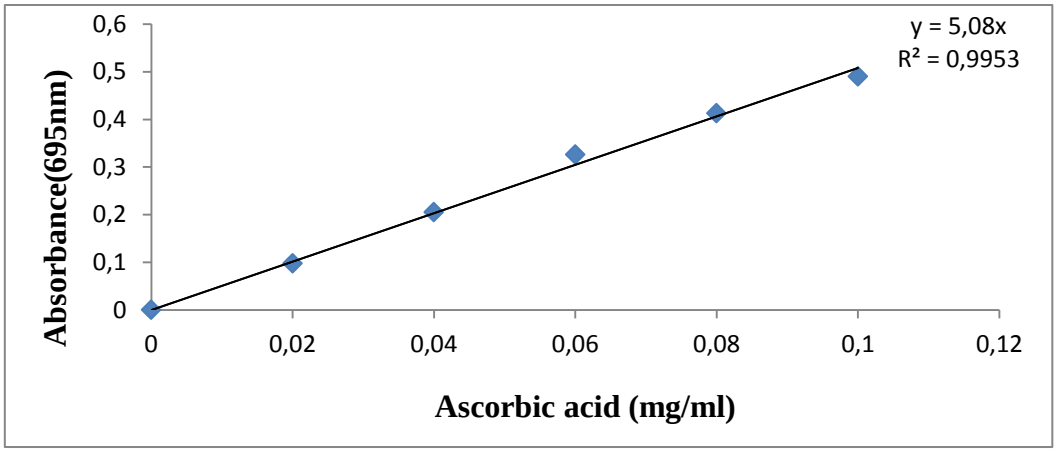

Figure 4: Total antioxidant activity calibration curve

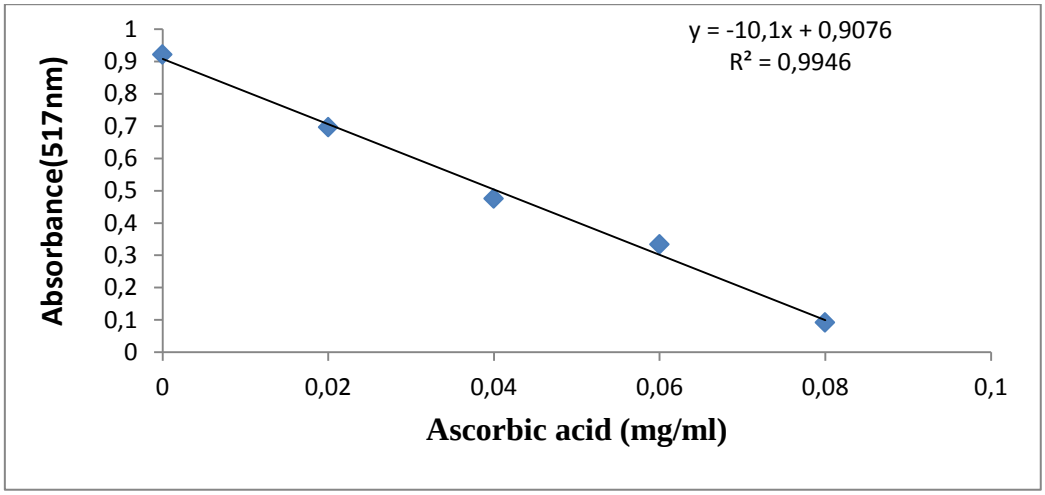

Figure 5: DPPH-RSA activity calibration curve

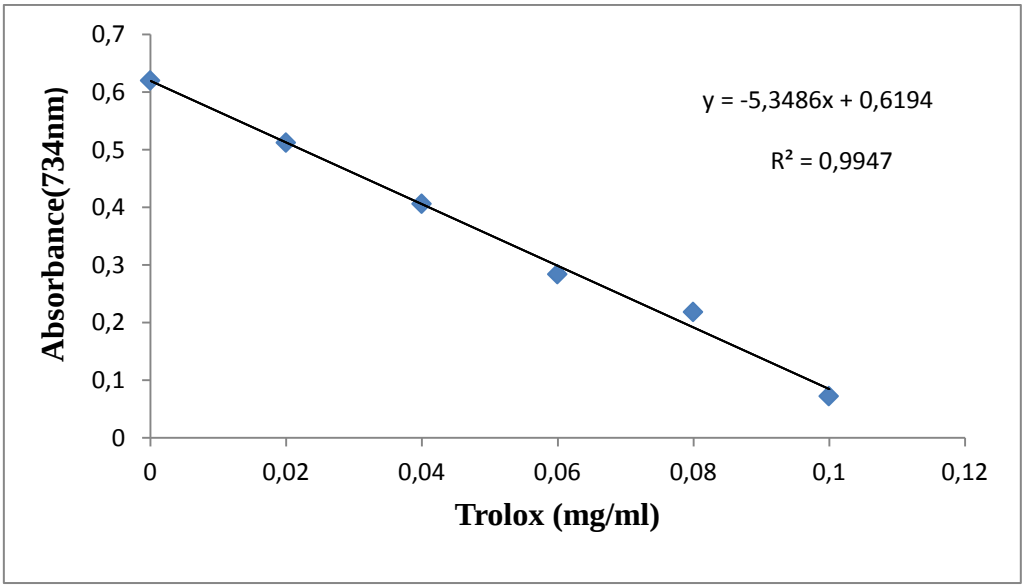

Figure 6: ABTS-RSA activity calibration curve

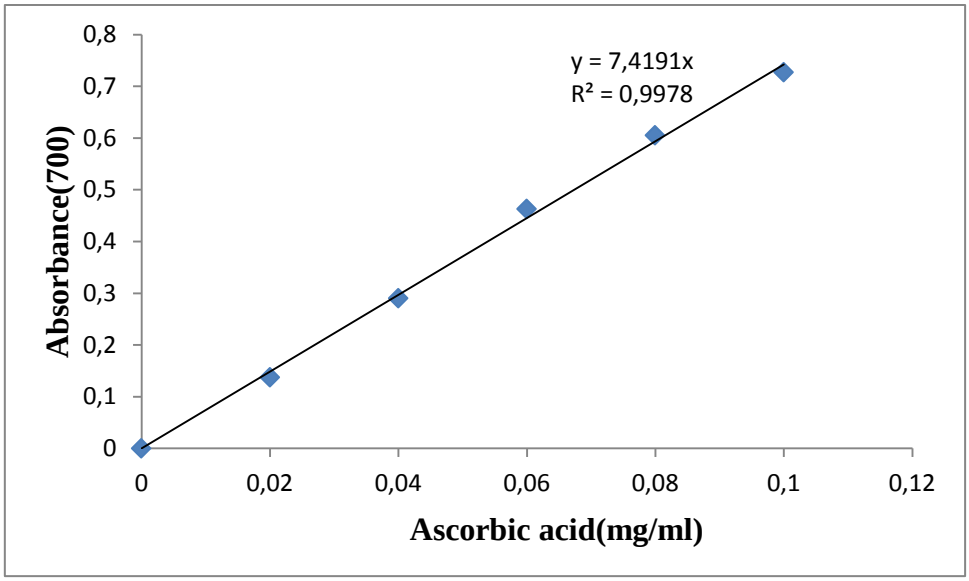

Figure 7: FRP activity calibration curve

Abstract: This study aims to investigate the effects of solvent extraction and dry salting on the phenolic contents (total phenolic content; TPC, total flavonoid content; TFC, total flavonol content; TFLC and total anthocyanin content; TAC) and the antioxidant activities (total antioxidant activity; TAA, DPPH radical-scavenging activity; DPPH-RSA, ABTS radical-scavenging activity; ABTS-RSA, ferric reducing power; FRP and iron chelating activity; ICA) of three fresh black Algerian olives cultivars (Aharoune, Bouchouk and Sigoise) cultivated in the region of Bejaia. Results showed that variety and solvent extraction affected significantly the TPC, TFC, TFLC, TAC and the antioxidant activities (TAA, DPPH-RSA, ABTS-RSA, FRP and ICA). 60% acetone was the best solvent for extracting phenolic compounds from fresh black olives, followed by 60% ethanol and water. Results showed also that dry salting of black olives induces decreases, increases or had no effect on the phenolic compound contents and on the antioxidant activities of black olives depending on the variety and the solvent extraction used. Pearson correlation analysis showed good linear positive correlations between phenolic compounds and the antioxidant activities, suggesting that black olives phenolic compounds are the main contributors to their antioxidant potential. Finally, we can conclude that black olives (fresh and salted) are a good source of phenolic compounds displaying high antioxidant activities (antiradical scavenger activity, ferric reducing power and iron chelating activity) and therefore, fresh black olives extracts could be used as potential functional ingredients or additives in food industry, cosmetics and medicine. Additionally, the consumption of black salted olives must be encouraged.

Keywords: black olives, variety, phenolic compounds, antioxidant activity, dry salting, solvent, increase, decrease.

Abstract: This study aims to investigate the effects of solvent extraction and dry salting on the phenolic contents (total phenolic content; TPC, total flavonoid content; TFC, total flavonol content; TFLC and total anthocyanin content; TAC) and the antioxidant activities (total antioxidant activity; TAA, DPPH radical-scavenging activity; DPPH-RSA, ABTS radical-scavenging activity; ABTS-RSA, ferric reducing power; FRP and iron chelating activity; ICA) of three fresh black Algerian olives cultivars (Aharoune, Bouchouk and Sigoise) cultivated in the region of Bejaia. Results showed that variety and solvent extraction affected significantly the TPC, TFC, TFLC, TAC and the antioxidant activities (TAA, DPPH-RSA, ABTS-RSA, FRP and ICA). 60% acetone was the best solvent for extracting phenolic compounds from fresh black olives, followed by 60% ethanol and water. Results showed also that dry salting of black olives induces decreases, increases or had no effect on the phenolic compound contents and on the antioxidant activities of black olives depending on the variety and the solvent extraction used. Pearson correlation analysis showed good linear positive correlations between phenolic compounds and the antioxidant activities, suggesting that black olives phenolic compounds are the main contributors to their antioxidant potential. Finally, we can conclude that black olives (fresh and salted) are a good source of phenolic compounds displaying high antioxidant activities (antiradical scavenger activity, ferric reducing power and iron chelating activity) and therefore, fresh black olives extracts could be used as potential functional ingredients or additives in food industry, cosmetics and medicine. Additionally, the consumption of black salted olives must be encouraged.
Keywords: black olives, variety, phenolic compounds, antioxidant activity, dry salting, solvent, increase, decrease.

Résumé: Cette étude vise à étudier les effets du solvant d'extraction et du salage à sec sur les teneurs en composés phénoliques (polyphenols totaux ; PT, flavonoïdes totaux; FT, flavonols totaux; FLT et en anthocyanines totales; AT) et sur les activités antioxydantes (activité antioxydante totale ; AAT, activité anti-radicalaire; DPPH-RSA, activité anti-radicalaire; ABTS-RSA, pouvoir réducteur; PR et activité chélatrice du fer ; ACF) de trois variétés d'olives noires algériennes fraîches (Aharoune, Bouchouk et Sigoise) cultivées dans la région de Béjaïa. Les résultats ont montré que la variété et le solvant d'extraction affectaient significativement les les PT, FT, FLT, AT et les activités antioxydantes (AAT, DPPH-RSA, ABTS-RSA, PR et ACF). L'acétone 60% était le meilleur solvant pour extraire les composés phénoliques des olives noires fraîches, suivi de l'éthanol 60% et l'eau. Les résultats ont également montré que le salage à sec des olives noires induit des diminutions, des augmentations ou n'avait aucun effet sur les teneurs en composés phénoliques et sur les activités antioxydantes des olives noires selon la variété et le solvant d'extraction utilisé. L'analyse Pearson des corrélations a montré de bonnes corrélations positives linéaires entre les composés phénoliques et les activités antioxydantes, suggérant que les composés phénoliques des olives noires sont les principaux contributeurs à leur potentiel antioxydant. Enfin, nous pouvons conclure que les olives noires (fraîches et salées) sont une bonne source de composés phénoliques présentant des activités antioxydantes élevées (activité antiradicalaire, pouvoir réducteur et activité chélatrice du fer) et par conséquent, les extraits d'olives noires fraîches pourraient être utilisés comme ingrédients fonctionnel ou additifs dans l'industrie alimentaire, cosmétique et médicale. De plus, la consommation d'olives noires salées doit être encouragée.
Mots clés : olives noires, variété, composés phénoliques, activité antioxydante, salage à sec, solvant, augmentation, diminution.