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

Faculté des Sciences et de la Nature et de la Vie
Département des Sciences Alimentaires
Filière : Sciences Biologiques
Spécialité : Alimentation et nutrition
Option : Bioprocédés et technologie alimentaire

Réf :........................

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

MASTER

Thème

Optimisation d'une technique de séchage des fruits de *Myrtus comminus*

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Soutenu le : **12 Juin 2016**

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Année Universitaire: 2015/2016

Remerciements

D'abord nous tenons à remercier, le bon dieu de nous avoir donné la force et la volonté pour réaliser et accomplir ce modeste travail.

- Au terme de ce travail notre profonde gratitude et nos sincères remercîments vont à notre promotrice Mme Boulekbache. L pour ses précieuses directives, pour la qualité du suivi et au Pr Madani.K pour son accueil au sein du laboratoire BBBs.
- Nous adressons toute notre gratitude au membre du jury : M^{me} Ouchemoukh.N et M^{me} Bouchefa-Geundouze.N pour avoir accepté de présider et d'évaluer notre travail et pour toutes leurs remarques et critiques.
- Nos profonds remercîments vont à notre Co-promotrice M^{me} Bouaoudia-Madi nadia pour ses précieux conseils et ses encouragements lors de la réalisation de notre mémoire.
- Nous voudrons aussi remerciée vivement M^{me} Oukmanou sonia pour les conseils et les orientations qu'elle nous a prodigué.

Nos remercîments vont enfin à toute l'équipe du laboratoire BBBS et à toute personne ayant contribuée de près ou de loin à l'élaboration de ce travail.

MERCI

DAHIA et ASMA

Dédicaces

Je dédie ce travail :

- *En premier lieu, à la mémoire de mon père, qu'il repose en paix, que Dieu l'accueille en son vaste paradis, tu m'as laissé un immense vide que nul ne peut le remplacer.*

  Papa même si tu n'es plus là ton existence est éternelle dans mon cœur et je souhaite de te rendre fier chaque jour de ma vie.
- *A ma raison de vivre, la prunelle de mes yeux, à celle qui a guidé mes pats la source de tous mes espoirs et de mes joies, je te dis quel plaisir de rentrer chez soi chaque soir, à toi ma maman chérie je te souhaite une très longue vie auprès de nous et pleins de bonheur.*
- *A ma précieuse sœur Aldjia et son mari Hakim que j'adore.*
- *A ma mon adorable sœur Nesrine et son époux Lamine que j'aime.*
- *A mes frères tant aimés Farés et Walid, vous êtes tout pour moi merci pour votre patience, aide et amour.*
- *Aux enfants de la famille, à ceux qui rendent la vie plus belle à mes petits anges Anaïs_Titi (Le petit génie de la famille) Et Imen_Mimi (Choupinette t'es notre rayon de soleil).*
- *A tous mes Tontons et Tatas que j'estime énormément.*
- *A tous mes Cousins et Cousines que j'apprécie beaucoup.*
- *A tous mes amis en particulier Jugo, Siham et Hayat.*
- *A mon binôme que j'aime avec laquelle j'ai partagé mes meilleurs moments Dihia et sa famille.*
- *A toute la promotion Biotechnologie « 2016 ».*
- *A tous ceux qui me sont chers.*

ASMA

Dédicaces

Au nom du Dieu le tout puissant

Je dédie ce travail à :

Ceux qui m'ont tout donné sans rien en retour

- *A la prunelle de mes yeux, à celle qui a guidé mes pats la source de tous mes espoirs je te dis quel plaisir de rentrer chez soi chaque soir.*

  A toi maman chérie.

- *A mon cher père.*
- *A mon futur mari Amirouche et sa famille, tu es tout pour moi, merci pour ta patience, aide et amour.*
- *Mes très chers frères : Jugo, Kouceilla.*
- *Mes très chères sœurs bien aimées : Thiziri et thilelli et leurs maries Djamel et Waali .*
- *A l'ange et le bonheur de la famille que j'adore mimi AKSEL.*
- *A mes très chères amies, copines et sœurs et à celle que j'ai partagé mes plus bons moments de mon cursus universitaire Hayat, Kaho, Kahina, Zouzo, Luiza.*
- *A mon binôme que j'aime avec laquelle j'ai partagé mes meilleurs moments Asma et sa famille .*
- *A toute ma famille, à toute mes cousins et cousines .*
- *A mes copines de chambre : Monia, Dihia et Latifa.*
- *A toute ma promotion biotechnologie « 2016».*

DIHIA

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List of abbreviations

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ANOVA	**:**	Analysis Of Variance
CD	**:**	Conventional drying
CE	**:**	Catechin Equivalent
cy-3-gl	**:**	Cyanidin-3-glucoside
DPPH	**:**	2, 2-Diphenyl-picrylhydrazyl
DW	**:**	dry weight
GAE	**:**	Gallic Acid Equivalent
KHz	**:**	Kilohertz
MD	**:**	Microwave drying
MDA-UP	**:**	Microwave drying assisted ultrasound pretreatment
mg ER	**:**	Milligram Equivalent of Rutin
nm	**:**	nanometer
Ph	**:**	hydrogen potential
RP	**:**	Reducing Power
TPC	**:**	Total Phenolic Compounds
UA	**:**	Unit of absorbance
UAD	**:**	Ultrasound assisted drying
UP	**:**	Ultrasound pretreatment
UV	**:**	ultra-violet
v/v	**:**	volume/ volume
W	**:**	Watt

Introduction

Introduction

Phytochemicals such as phenolic compounds from plants and vegetables are known to have several health-benefitting properties, including reducing the risks of certain types of cancer, cardiovascular, heart and neurodegenerative diseases. Although there are still some unanswered questions about the effects of polyphenols on human diseases, the health-promoting potential of these foods may be attributed to the phytochemicals present in the roots, barks, stems, leaves, fruits, and flowers of some plants **(Song *et al*., 2009).**

Among the medicinal plants, *Myrtus communis* L is a powerful disinfectant for the treatment of rums, hoop net digestive and of the evils of throat **(Iserin, 2009)**. Different parts of the plant have found various uses in the food industry, such as, in the cosmetic and pharmaceutical industries (**Messaoud and Boussaid, 2011)**; and it has been also used in folk medicine because of its astringent and balsamic properties **(Flamini *et al*., 2004;Oddo *et al*, 2004).** The fruits are very astringent and it's have high amount of tannin .Its was used as a condiment as a substitute for pepper **(Aydın and Ozcan, 2007)**, and rich of anthocyanin **(Jose A-C *et al*., 2015).** The oils extracted by steam distillation of fruits are used both in flavor and fragrance industries.

Drying is one of the oldest techniques of food preservation useful for the production of special foods and food ingredients. It is the process of removing the moisture in the product up to certain threshold value by evaporation. In this way, the product can be stored for long period **(AlibasOzkan *et al*., 2007).**

Conventional drying involves exposure of food and agricultural products to high temperature and for long times, which can result in serious damage to flavor, color, rehydration capacity and nutrients of the treated material as well as long low energy efficiency **(Drouzas *et al*.,1999; Ozbek and Dadalli,2007;Sharma *et al*.,2004)**. Owing to these reason, development of new methods of drying for such perishable fruits (Myrtle) is essential for food preservation, which can save time and energy and minimize quality degradation. In two decades ago, the microwave drying has gained popularity as an alternative drying method to overcome above problems for a wide variety of food products **(Bouraoui *et al*.,1994; Tulasidas *et al*., 1995).** However, one of disadvantages of microwave drying is that excessive temperature along the corner or edges of food products results in scorching and production of off-flavors especially during final stages of drying **(Zhang *et al*., 2006).** Hence, it is necessary to combine microwave drying with an pretreatment in order to maintain product quality.

In recent years, ultrasound has been implemented as an alternative pretreatment method for drying, and the results have shown that this pretreatment can greatly reduce the overall processing time **(Duan *et al.*, 2008; Aversa *et al,*. 2011; Jangam 2011; Mothibe *et al*., 2011)** which can attribute to the following factors: Increase in the mass transfer rate (**Garcia-Perez *et al*., 2009; Carcel *et al*., 2011;Garcia-Perez *et al*., 2011**), loss of cellular adhesion, rupture of the cell walls and formation of large channels (**He *et al*., 2012).**

Therefore, the aims of this study was to evaluate the effect of ultrasound pre-treatments on pericarp drying. The influence of pre-treatments on water loss, total phenols content and their antioxidant activity were analyzed. The comparison between the microwave drying assisted by ultrasound pretreatment, conventional and microwave drying was also investigated.

Theoretical part

Chapter I

Overview of

Myrtus comminis

I. *Myrtus communis* plant

I.1. Origin and history of myrtle

Myrtus communis L is an evergreen shrub, which grows mainly in Mediterranean climates and has long been used by locals for its culinary and medicinal properties (**Ghasmi *et al.*, 2014)**. It is the only species of the genus found in the Northern Hemisphere **(Traveset *et al*., 2001)**. Myrtle is a pleasant annual shrub with dark blue ripe berries, which have a long history of application in the perfume, cosmetic, food, and pharmaceutical industries. In addition, these berries are widely used in industrial formulation of sweet liqueur **(Aidi wannes and Marzouk**, **2015).** It is an important medicinal and aromatic plant, because of the high essential oils content in its leaf, flower and fruit glands. Leaves and berries are sources of essential oils that have medicinal properties such as antimicrobial activity **(Ghasmi *et al.*, 2014).**

I.2-Geographical distribution

Distribution of myrtle is a common part of typical Mediterranean flora. The plant grows abundantly from the northwestern to the eastern Mediterranean, including bordering countries and western Asia, as well as Aegean regions (**Baytop, 1997**). Myrtle is native to southern Europe, north Africa and west Asia. It is also distributed in nouthern America, northwestern Himalaya and Australia. In Italy it grows along the coasts and on the internal hills and it is abundant especially on the islands, where it represents one of the most characteristic species **(Cannas *et al*., 2013**). In Portugal, myrtle grows wild mainly in the central and southern parts of the country. The genus *Myrtus*, in Tunisia, is represented by only one species, *Myrtus communis* L, which grows wild in the coastal areas, the internal hills, and the forest areas of northern Tunisia. Two myrtle varieties are described in old local Tunisian flora: *Myrtus communis* var. italica L. and *Myrtus. communis* var. baetica L. (**Pottier-Alapetite *et al*., 1979)**, which possesses the same vegetative characters. The morphological difference between the two varieties regards to size of fruits and leaves (**Chryssavgi *et al*., 2008; Mimica-Dukié *et al*., 2010; Berka-Zougali *et al*., 2012; Mahmoud *et al*., 2010; Jerkovicet *et al*., 2002; Gauthier *et al*., 1988).**

I.3. Morphological description and Traditional application

The morphological description of different parts of the studied plant is shown in table n°1.

	Description	Traditional application	Photographs	References
Plant	Shrub of 1 à 3m from height to sheets persistent and dense, with pennate nervation			Quizel and santa, 1963. Govaerts and Lucas, 2008.
Flowers	They are large (10-15mm), white, Hermaphrodites. Flowering this fact in summer (June at July)	Medicine –against varicose veins and for preparing capillary lotions for external use		Le Floch 1983. Gortzi et al.,2008. Messaoud et al., 2012.
Fruits	Spherical bays dark crimsons (diameter: 5mm) with many seeds, appears from November - December	Food: preparation flavoring meat and sauces; Medicine, used orally for infectious disease(diarrhea, dysentery).and externally for skin diseases and wound healing		Messaoud *et al.*, 2012. Gortzi *et al.*, 2008.
Leaves	Ovoid lanceolate, 2 to 3 times longer than broad, pennate persistent, opposed nervation, with very short petiole, coriaces and of a brilliant green	Food preparation Perfume and cosmetic; hair tonic and stimulant; orally used as antiseptic, anti-inflammatory agent, laxative, analgesic		Messaoud et al., 2012. Chalchat et al., 1998. Baytop 1999, Serce et al., 2010.

I.4. Etymology and Classification of the myrtle plant

Myrtle has closely associated names in most European and even some non-European languages; besides English myrtle, German myrte, Estonian mürt, Spanish and Italian mirto, French myrte, modern Greek mirtia [μυρτιά], Russian myrt [мырт], Armenian mrdeni [մրտենի], Farsi mourd and Turkish murt. All these names relate to the Old Greek myrtos. In Algeria, the wild plant known as Al-Rihan or el-halmouche.

Taxonomically *Myrtus* genus belong to the Myrtaceae family which includes approximately 100 genera and 3000 species growing in temperate, tropical and subtropical regions. *Myrtus communis* is the only Myrtaceae species native to Europe and it is classified according to **(Quezel and Santa, 1963).**

Sous-règne : Eucaryotes

Embranchement : Spermaphytes

Sous-embranchement : Angiospermes

Kingdom : Dicotylédones

Order : Myrtales

Family : *Myrtaceae*

Genus : *Myrtus*

Species: *Myrtus communis* L.

I.5. Chemical composition

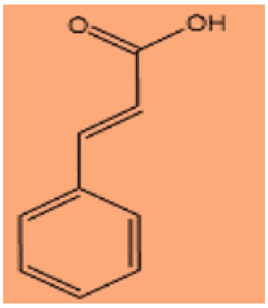
Previous studies on Myrtle, aerial parts have revealed the presence of several specific chemical compounds, for example, the essential oils, phenolic acids, flavonoids and tannins in leaf and flowers **(Messaoud *et al*., 2005; Aidi Wannes *et al*., 2010**) and anthocyanin, fatty and organic acids in berries (**Martin *et al*., 1990; Tuberoso *et al*., 2010; Messaoud *et al*., 2012, jose Antonio curel *et al*., 2015).** The fruit of myrtle plant is rich in fibers and contains considerable quantities of proteins, reducing sugars and essential oils **(Aydin and Ozcan, 2007)**. The mineral contribution is presented in table I (Annex 1).

I.5.1. Phenolic compounds

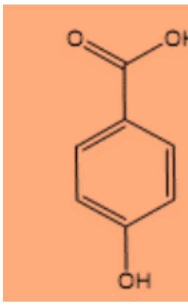
Phenolic compounds are secondary metabolites, ubiquitous widely exist in nature and food-industry by-products. They are differentiated from one another by their structure and molecular weight, and the resulting physicochemical and biological properties. Due to this enormous variety, there are reports of more than 10000 phenolic molecules and the list continues expanding **(Vázquez *et al*., 2015).** They show a large diversity of structures including simple phenols (C6); phenolic acids and related compounds (C6–C1); aceto-phenones and phenyl acetic acids (C6–C2); cinnamic acids, cinamyl aldehydes, and; flavonoids (C15); stilbenes (C6–C2–C6); and lignans, lignins, tannins, and phlobaphenes (which are dimmers, oligomers, or polymers).

I.5.1.1. Phenolic acids

The predominant phenolic acids in fruits and vegetables are acidic hydroxybenzoic and hydroxycinnamic: hydroxybenzoic acids (C1–C6) and hydroxycinnamic acids (C3–C6) (Fig. 3). Phenolic acids are commonly present under two principal forms in all plant-derived foods: a free and a bound form. The latter is found more frequently and occurs in the form of esters, glycosides and bound complexes (**Agostini-Costa *et al*., 2012).**



(a)



(b)

Figure n° 1: Structure of hydroxybenzoïc acid (a), and hydroxycinnamic acid (b)

I.5.1.2. Flavonoids

Flavonoids represent a large group of phenolic compounds found in plants that are synthesized from both the shikimate and acetate–malonate pathways involving numerous enzymatic steps. Flavonoids are thought to perform a variety of functions in plants including protection from UV radiation, defense against pathogens, pollinator attraction, pigmentation, and playing an essential role in reproduction **(Li *et al*., 1993; Vogt *et al*., 1995)**.

Flavonoids also contribute to the quality characteristics of fresh and processed food products including, texture, taste and color. Because of their biological importance, flavonoid biosynthesis-related genes have been isolated from many plant species and have been extensively investigated at the molecular level (**Hahlbrock and Scheel, 1989**; **Winkel-Shirley, 2001).**

I.6. Pharmacological activities

Many authors announced that the myrtle plant and its essential oils have a great potential like plants medicinal, with hypoglycemic **(El fellah *et al*., 2002; Appendino *et al.*, 2006),** anti-inflammatory (**Rossi *et al*., 2009; Amira *et al*., 2012**), anti-ulcerous (**Sumbul *et al*., 2010),** anti-mutagen **(Hayder *et al*., 2008; Mimica-Dukic *et al*., 2010)** and antioxidant proprieties **(Montoro *et al.*, 2006; Aidi wannes *et al.*, 2010; Tuberoso *et al.*, 2010).**

I.6.1. Antibacterial activity

The richness of myrtle in phenolic compounds (flavonoids and tannins) and essential oil is at the origin of its antibacterial activity, *Escherichia coli* and *Staphylococcus aureus* is the germs most sensitive. Myrtucommulone A and B and semimyrtucommulone are responsible for this activity compared to that of penicillin and streptomycine **(Feibt *et al*., 2005; Rotstein *et al*., 1974; Montoro *et al*., 2006; Yadegarinia *et al*., 2006).** The plant extract can inhibit the growth of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Escherichia coli* (**Mansouri and Masoudi *et al*,.2016).**

I.6.2.Antidiabitic activity

Experiment was carried out rabbit's reaches diabetes by the administration of 50 mg/kg of the extract of *Myrtus communis* each day during one week. A diminution of 51% of the concentration of glucose in blood was observed, without affecting the rate of insulin, as well as a diminution on the rate of blood triglyceride of 14%. That would be explained by the inhibiting activity of the myrtle extract of the sweats alpha glycosidase and the stimulation of the glucokinase which is a key enzyme of glycolysis **(Sepici *et al*., 2004).**

I.6.3. Anti-inflammatory activity

Myrtus (MC), semimyrtucommulone (S-MC) and nonprenylated acylphloroglucinols present in the leaves of *Myrtus communis*, potently suppress the biosynthesis of eicosanoids by direct inhibiting cyclooxygenase-1 and 5-lipoxygenase *in vitro* and *in vivo*. Their ability to suppress typical pro-inflammatory cellular responses suggests their therapeutic use for the treatment of diseases related to inflammation and allergy (**Feisst *et al*., 2005).**

I.6.4.Induction of apoptosis in cancer cells

Myrtus communis is reported to induce cell death of different cancer cell lines with characteristics of apoptosis, visualized by the activation of caspase-3, -8 and -9, cleavage of poly (ADP-ribose) polymerase (PARP), release of nucleosomes into the cytosol, and DNA fragmentation. It caused loss of the mitochondrial membrane potential in MM6 cells and evoked release of cytochrome c from mitochondria (**Tretiakova *et al.*, 2008)**.

I.6.5. Protective effect on cholesterol and human low density lipoprotein (LDL)

Myrtus communis have significant protective effect on LDL from oxidative damage, remarkable protective effect on the reduction of polyunsaturated fatty acids and cholesterol and inhibiting the increase of their oxidative products. Both the compounds have been suggested as natural dietary antioxidants with potential anti atherogenicity (**Rosa *et al.*, 2008).**

I.6.6. Antioxidant activity

Myrtus communis L. is a rich source of antioxidant compounds and possesses strong antioxidant properties **(Dairi *et al*., 2014).** The myrtle is employed like remedy to treat the diseases related to the oxydative stress for its richness in antioxidant compounds such as myrtucommulone and semimyrtucommulone which can stop the formation of the oxygenated reagents and of the peroxides which are responsible of the initiation and the maintenance of the inflammatory activity. The essential oils of this plant presents also an antioxidant character **(Feibt *et al*., 2005; Rotstein *et al*., 1974; Montoro *et al*., 2006; Yadegarinia *et al*., 2006).**

Chapter II
Drying methods

II.1. Definition

Drying is defined as being one of the methods of storage, which tends to increase the period of conservation of a food, while preserving its nutritional quality. Drying is the process of elimination of moisture in a product up to a constant value by evaporation **(Li *et al*., 2011).**

The effectiveness of the technique of drying is measured on two levels: operating costs and the quality of the finished product. In many cases, the time of drying becomes important because the speed of production. However, time is less important in the case of appearance and the biological values of a food product or medicinal is a requirement **(Hammouda and Mihoubi, 2014)**.The temperature and the times of drying are the most important devices to determine the good process **(Masson, 2014).** The aims of the drying are since to reduce the costs of conditioning, storage, handling and transport, to prolong the availability apart from the seasons and provide a range of products for the consumers **(Moses *et al.*, 2014).**

II.2. Drying Methods

II.2.1. Conventional drying

In this method, the heated air is put in contact with the wet material to facilitate heat and the massive transfer; the convection is mainly implied (**Dikbasan, 2007**). It is necessary to specify the instruction of temperature of the conventional drying, the residence time, and cuts it sample to be tested. Even if this size is not in general critical, the residence time in the conventional drying must be adapted to the report/ratio surfaces/volume (**Vasseur, 2009**).

II.2.2. Microwaves drying

Microwave is a kind of electromagnetic wave with a frequency range of 300 MHz–300 GHz, belonging to high frequency electromagnetic wave. It produces both thermal and non-thermal effects on the material being treated. Attempts have been made in the applications of microwave to inactivation of enzymes, drying, and sterilization of different kinds of food products to promote food quality **(Yaghmaee and Durance, 2005; Bondaruk *et al*., 2007; Huang *et al*., 2007; Jeni *et al*., 2010).**

Water is a bipolar molecule, in the microwave drying process, water molecules are further polarized, which change their dipole orientations rapidly in the changing electromagnetic field with the frequency of billion times by one second. Heat is produced within the treated materials due to the friction of fast moving water molecules, resulting in the temperature increase inside the treated material and the evaporation of the moistures. The quick absorption of microwave energy by water molecules causes their rapid evaporation, resulting in its unique characteristics of high heat transmission, high drying rate, high efficiency, and high quality of the treated material **(Wang, 2004; Duan and Wang, 2007; Jeni *et al*., 2010; Gulati *et al*.,2003)**

Figure n° 2: Movement of a dipole in an electric field **(Singh and Heldman, 2001).**

The major disadvantage of this type of drying is unequal drying (not uniform), production of the bad tastes, smothering of the food products and change of texture **(Gowen *et al*., 2008; Zhang, 2006**). For this reason the alternative drying methods were investigated.

II.3. Ultrasound technology

Ultrasounds can be considered as the air vibrations of a frequency from 20 kHz to 100 MHz, and also caused by the mechanical waves propagated in solids, liquids and gases other than air. Ultrasounds have been used by nature for millions of years. One of the advantages of ultrasounds, especially for analytical purposes, is their quick, precise, non-invasive action. Furthermore, they may be used in condensed and optically nontransparent systems **(McClements, 1995; Kapturowska *et al.*, 2011).** It is defined as sound waves chaving frequency that exceeds the hearing limit of the human ear (20 kHz). Ultrasound is one of the emerging technologies that were developed to minimize processing, maximize quality and ensure the safety of food products. It is applied to impart positive effects in food processing such as improvement in mass transfer, food preservation, assistance of thermal treatments and manipulation of texture and food analysis (**Knor *et al*., 2011).**

II.3. 1.Ultrasound in food processing

In recent years, ultrasound (US) in the food industry has been the subject of research and development. There is a great interest in ultrasound due to the fact that industries can be provided with practical and reliable ultrasound equipment. Nowadays, its emergence as green novel technology has also attracted the attention to its role in the environment sustainability **(Mason *et al*., 2011).**

II. 3. 2. Ultrasound assisted drying

Acoustically assisted drying has been a topic of interest for many years. Traditional methods for desiccating or dehydrating food products by a forced stream of hot air are reasonably economical, but the elimination of the interior moisture takes a relatively long time. Moreover, high temperature can damage the food, which in certain cases may change the color, the taste and the nutritional value of the hydrated product **(Fernandez and Rodriguez, 2008).** Alternative methods may eliminate these disadvantages, but some, such as freeze-drying, are expensive and others, such as spray drying, are applicable only to liquids. However, it is known supplying vibrational energy may stimulate the dehydration and avoid these disadvantages**.** Diffusion at the boundary between a suspended solid and a liquid is substantially accelerated in an ultrasonic field and heat transfer is increased by approximately 30-60% depending on the intensity of the ultrasound **(Gallego-juarez *et al*., 1998).**Heat can deteriorate the quality of the final product causing undesirable food flavor, color, vitamin degradation and loss of essential amino acids **(Mousa and Farid, 2002; Zhang *et al*., 2006).** Ultrasonic dehydration is a very promising technique since it can be utilized at low temperature, which prevents the degradation of food at high temperatures. Ultrasound power also improves heat and mass transfer phenomena in drying processes **(Gallego-juarez *et al*., 1998).** acoustic dehydration relies on cavitation **(Tarleton and Wakeman, 1998)** and also on the effects of compressions and expansions induced by sound waves passing through the food medium, which generates high forces and maintains the moisture inside the capillaries of the material thus making the moisture removal easier **(De la Fuente *et al*., 2006).**

II.3.3. Ultrasound assisted extraction

Intensification of extraction efficacy using ultrasounds has been attributed to the propagation of ultrasound pressure waves through the solvent and resulting cavitation phenomena. The controlling mechanism of UAE is generally attributed to mechanical, cavitation, and thermal effects, which can result in disruption of cell walls, particle size reduction and enhanced mass transfer across cell membranes. The implosion of cavitation bubbles generates micro-turbulence, high-velocity inter-particle collisions and perturbation on particles of the matrix which accelerates the eddy diffusion and internal diffusion.**(Shirsath, Sonawane *et al*. 2012**) .

Thus, it appears that application of ultrasounds allows target compounds to dissolve in the solvent thereby boosting yield with shorter time by disrupting the cell wall (The mechanism of cell wall disruption due to cavitation has been depicted schematically in Figures n° 3). Due to cavitation, the cracks are developed in the cell wall which increases permeability of plant tissues facilitating the entry of the solvent into the inner part of the material as well as washing out of the extracts **(Vilkhu, Mawson *et al*., 2008; Shirsath, Sonawane *et al*. 2012).**

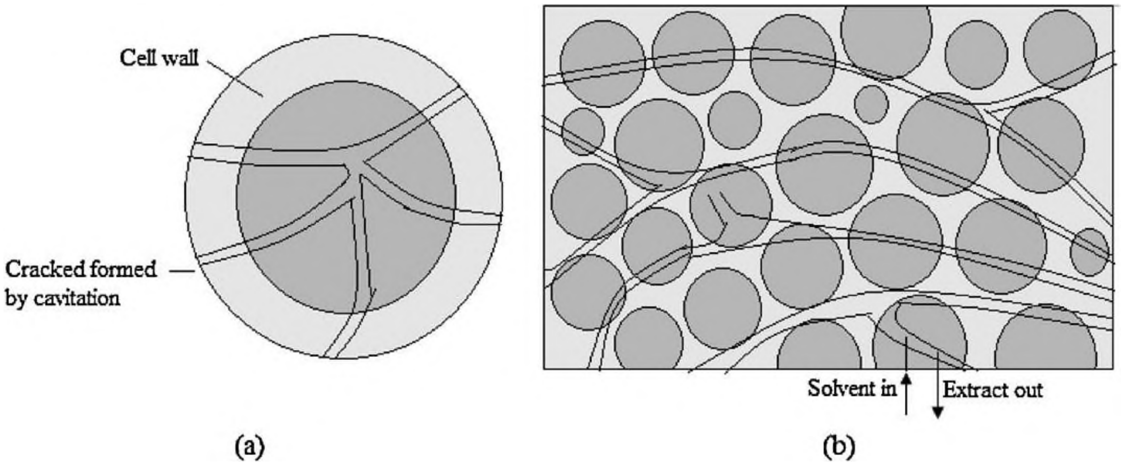


Figure n° 3: The mechanism of cell wall disruption (a) breaking of cell wall due to cavitation (b) diffusion of solvent into the cell structure **(Shirsath, Sonawane *et al*. 2012).**

Experimental part

Chapter III Materials And methods

III.1. Plant material and preparation samples

Myrtus communis plant, were collected at optimal maturity (January), from Addekar (Bejaia, North-east of Algeria). The fruits were isolated manually from the aerial parts, and were washed with a tap and distilled water to remove any adhering soil and dust. Finally, fruits were blotted with absorbing paper.

Figure n° 4: Myrtle fruits part.

III.2. Water content

To determine the water content, one tests moisture is to carry out, for the fruit of *Myrtus*, three samples of 10g are dried with 103 ± 2°C, the weight of the sample is taken each 3 hours until its stabilization. The result is average of three samples according to **(Bourkhiss *et al.*, 2009).** The water content is given according to the following equation:

$$H\% = \left(\frac{w_i - w_f}{w_i}\right) * 100$$

Where:

H%: moisture.

w_i: represent the initial weight of the sample.

w_f: represent the dry weight of sample.

III.3. Ultrasound pre-treatment

An ultrasonic bath (Ctra.NII:585 Abrera (Barcelona) Spain, Ultrasound H-D, frequencies: 20 to 60 KHZ, Power: 80 to 600 W) was used.

The samples were placed in a beaker next to each other in the bath and covered with the metal net to void flow out of the samples. After that, the distilled water was added into the ultrasonic bath. The pre-treatment was carried out at room temperature (25 C°). The ratio of raw material to water was set at 1:4, as recommended by **Fernandes and Rodrigues, 2008**. The ultrasound frequency was 25 kHz, the ultrasound energy was applied for 10, 20, 30, 45 and 90 min. After the treatment, the plant materials were blotted with absorbing paper. Before and after ultrasound treatment the mass of the samples, dry matter content and water temperature were measured. The temperatures increase during the experiments maximally by 2 to 5 C°. The experiments were conducted in triplicate for each drying process.

Figure n° 5: Ultrasound bath.

III.4. Microwave drying method (MD-AUP)

After ultrasound pretreatment, the fruits were dried in microwave by two powers (500W, 700 W). Drying treatment was performed in domestic digital microwave oven with the technical feature of 230 V, 50 Hz and 2450 W. the dimensions of microwave (Ctra.NII:585 Abrera (Barcelona) Spain, Ultrasound H-D, frequencies: 20 to 60 KHZ, Power: 80 to 600 W). The microwave oven consisted of a rotating glass plate with 300 mm diameter at the base of the microwave. The apparatus was equipped with a digital control system for irradiation time and microwave power the latter linearly adjustable from (100 to 900 W). The microwave oven was operated by a control terminal, which could control microwave power level and emission time, two different microwave power (500 700W) were used. After drying fruit samples are crushed manually and seeds are recovered. The pericarps was ground with an electrical grinder (IKA model A11 Basic, staufen, Germany), the obtained powder was passed through standard 125µm size and only the fraction with particle size < 125µm was used. The powder was stored in airtight bags until use.

III.5.Ultrasound assisted extraction (UAE)

Extraction of phenolic compounds using ultrasound has been proposed to improve the efficiency and/or speed of this step. An ultrasonic apparatus (SONICSVibra cell, VCX 75115 PB, SERIAL No. 2012010971 MODEL CV 334) was used for UAE with working frequency fixed at 20 kHz.

Figure n° 6: Ultrasound assisted extraction system.

For the extraction, one gram of the powder was placed in a 250 mL amber glass bottle containing the extraction. The suspension was exposed to acoustic waves under with a concentration of 28 ml of ethanol at 70 %, irradiation time (7min30s), and amplitude at 30 %. The temperature (27 ± 2 °C) was controlled continuously by circulating external cold water and checking the temperature using a T-type thermo couple. After the extraction, the solution was filtered through filter paper.

III.6. Analytical determinations

III.6.1. Total phenolic content (TPC)

The determination of total phenols compounds in the extracts were done according to the method of (**George and Brat, 2005)**A volume of 500 µL of diluted fruits extract with distilled water was added to 2.5 mL of 10-fold diluted Folin–Ciocalteau reagent. The solution was mixed and incubated at room temperature for 2 min. After 2 min, 2 mL of 7.5% sodium carbonate (Na_2CO_3) (v/v) were added. After incubation at 50° C for 15 min, the absorbance of the sample was measured at 760 nm against a blank (made as reported for the sample) by using a UV–VIS Spectrophotometer (SpectroScan 50, Nkesia, Cyprus). The assay was performed in triplicate. For quantification, a calibration curve was generated with the standard solution of gallic acid, (R^2= 0.998). The TPC were expressed as mg of gallic acid equivalent (GAE) per gram of powder on dry weight (AW) basis.

III.6.2. Total flavonoid content

The total flavonoid contents were estimated according to the aluminum chloride method of (**Quettier-Deleu and Gressier, 2000)** based on the formation of a complex flavonoid-aluminum **(chang and Yang, 2002)**. Briefly, 1 mL of pericarps extracts was mixed with 1 mL of 2 % AlCl3. After 15 min of incubation in the dark, the absorbance of the mixture was determined at 430 nm. Each analysis was carried out in triplicate. The total flavonoid content was calculated from a calibration curve made with rutin and expressed as milligrams of rutin equivalent per gram of powder an dry weight (AW) basis (mg RE g^{-1} DW). The calibration curve range was about10–100 mg/L (R^2= 0.9935).

III.6.3. Total monomeric Anthocyanin contents

Total monomeric anthocyanin content was determined by the pH-differential method **(Lee and Durst , 2005)**, based on the structural change of the anthocyanin chromospheres between pH1.0 and 4.5. Absorbance was measured at 520 nm and at 700 nm in buffers at pH 1.0 and 4.5. The concentration of anthocyanin was obtained using the following equation. Results are expressed on a Cyanidin-3- glycoside basis.

$$\textit{Anthocyanin pigment}\ \left(\textit{cyanidin-3-glucoside equivalents, mg/g DW}\right) = \frac{A \times PM \times FD \times 10^3}{\varepsilon \times l}$$

Where $A = \left(A_{520nm} - A_{700nm}\right)_{pH\,1.0} - \left(A_{520nm} - A_{700nm}\right)_{pH\,4.5}$

MW (molecular weight): 449.2 g/mol for cyanidin-3-glucoside (cyd-3-glu); DF: dilution factor; l: path length in cm; ε: 26 900 molar extinction coefficient, in L × mol^{-1}× cm^{-1}, for cyd-3-glu; and 10^3: factor for conversion from g to mg.

III.6.4. Total condensed tannin content

Total tannin content was determined by the HCl–Vanillin procedure according to **(Ba et *al.*, 2010).** 1 ml of the extract was mixed with 5 ml of reagent (HCl + Vanillin).The mixture is put in the dark for 20 minutes. The absorbance versus prepared blank was read at 500 nm. All analyses were performed in triplicate. Total tannins expressed as mg Catechin equivalents per gram (mg C/g) through the calibration curve with Catechin, then calibration curve range was 0.05–1 mg/ml (R^2= 0.9907). Concentrations are expressed in milligrams Catechin equivalent per gram of dry powder.

III.7. Antioxidant activities

The antioxidant activity of plants is mainly contributed by the active compounds and phenolic fraction present in them such as flavonoids **(Pietta and Simonetti, 1998)** and anthocyanin **(Montoro et *al.*, 2006)** .The antioxidant activity of pericarp was evaluated by DPPH radical scavenging assay, reducing power . The higher percentage inhibition test rate is, the greater the hydrogen donating ability, thus the higher antioxidant activities.

III.7.1. DPPH radical

The stable 1, 1-diphenyl-2-picryl hydrazyl radical (DPPH) was used for determination of free radical-scavenging activity of the extracts **(Choi et al., 2002)**. It highly colored free radical that can abstract labile hydrogen atoms from phenolic antioxidants with concomitant formation of a color-less hydrazine (DPPH-H). The free radical scavenging activity (RSA) of an extracts can be expressed as the percentage of DPPH reduced by a given amount of extract. The RSA was measured, following the method of **(Dudonné and Vitrac , 2009).** DPPH radicals have an absorption maximum at 515nm (**Choi and Kim ,2002).** which disappears with reduction by an antioxidant compound. A DPPH• solution in absolute methanol (60 µM) was prepared, and 3 mL of this solution were mixed with 1 mL of the different diluted extracts. The samples were incubated for 20 min at 37°C in the dark, then, the decrease in absorbance at 515 nm was measured. The α-tocopherol served as a positive control. All the tests were performed in triplicate, and the inhibition rate was calculated according to the following equation.

$$\%\ Scavenging = \frac{\left(A_{control} - A_{extract}\right)}{A_{control}} \times 100$$

Where $A_{control}$ is the absorbance of DPPH radical + distilled water; A_{sample} is the absorbance of DPPH radical + sample extract.

III.7.2.IRon reducing power

In this study, the yellow color of the test solution changes to green depending on the reducing power of test specimen. The presence of reductions in the solution causes the reduction of the Fe^{3+}/ferricyanide complex to the ferrous form. 1 mL of desired dilution with distilled water of fruits extracts was mixed with 2.5 mL of a 0.2 M sodium phosphate buffer (0.2 M, pH 6.6) and 2.5 mL of 1% Potassium ferricyanide ($K_3Fe(CN)_6$). The mixture was incubated in a water bath at 50°C for 20 min. Then, 2.5 mL of 10% trichloroacetic acid were added. At the end, 1mL of the obtained solution was added to 5 mL of distilled water and 1 mL of 0.1% ferric chloride ($FeCl_3$), the intensity of the blue green color was measured at 700 nm. Tests were carried out in triplicate. (**Pan *et al*, 2008).**

III.9. Statistical analysis

The analysis of variance (ANOVA) was performed using XLSTAT release 10 (Addinsoft, Paris, Framed), Tukey's multiple range test (HSD) was used to compare between TPC content and antioxidant activity as affected by microwave (MAE) or conventional drying methods (CSE).

Chapter IV Results And discussion

IV.1. Evaluation of water content

The result of the test of moisture shows that the myrtle *(Myrtus communis)* has an average water content of 56 ± 0.005%, as represented in the table II:

Table II: moisture content.

Moisture (%)	56
Dries matters (%)	44

The determination of moisture is very important to predict performance after drying. Indeed, the humidity conditions the retention settings to avoid possible economic and nutritional losses caused by microbial deterioration and enzymatic activities of preserved fruit.

IV.2. Ultrasound pretreatment

Kinetic drying of MD-AUP at 500 W and 700 W was illustrated in figure n°7 and 8.

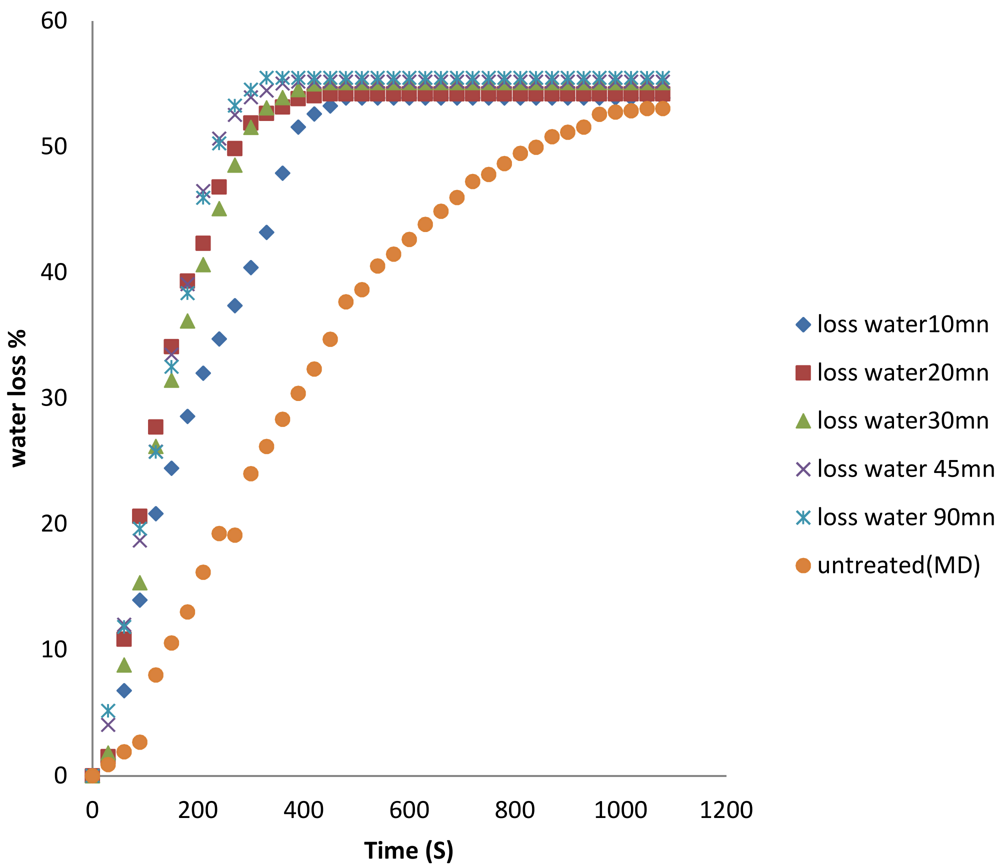


Figure n° 7: Influence of ultrasonic time on the dehydration kinetics process at 500 W of Myrtle pericarp.

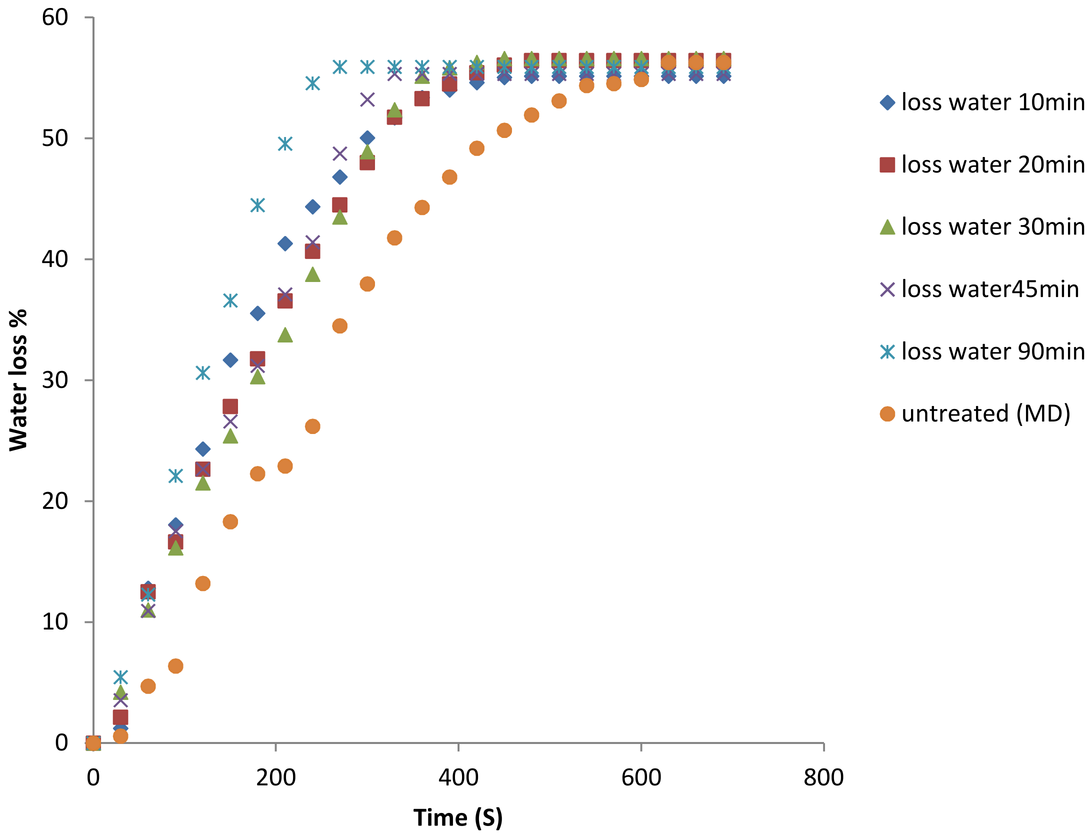


Figure n°8: Influence of ultrasonic time on the dehydration kinetics process at 700 W of Myrtle pericarp.

Drying kinetics were studied until a final moisture content of 56 ± 0.005 %.The use of ultrasound as a pre-treatment resulted in different water loss of myrtle fruits. Samples subjected to ultrasound treatment for 10, 20 and 30 min have a smallest water loss at 36.32, 38.96, 36.80% at 500 W and 38.95, 36.98, and 35.66 % at 700w respectively. probably, during the ultrasound pre-treatment, pericarp tissue apart from the effect of ultrasound causing removing water from the tissue, took place ingress of water to the inside of material, due to osmotic concentration differences. Such a process was made possible by the high porosity of pericarp tissue and could be the reason for the minimum water loss during the ultrasonic treatment. After 90 min the fruit subjected to ultrasound was the largest loss of water (35.90, 35.27%) at 500 W and 700 W respectively while at shorter ultrasound treatment time the water loss was lower **(Fernandes *et al*., 2008b).**

The results illustrate that the ultrasonic pretreatment is interesting when the quantity of water in the fruit was very high which is our case. The ultrasonic waves can cause a very fast series of compression and alternative expansions, in the manner similar to a sponge when it is tightened and released on several occasions. The forces implied in this mechanical mechanism can be much larger than those due to the surface tension, which holds moisture inside the capillaries of the fruit creating the microscopic channels which can relieve the removal of moisture **(Fernandes and Rodrigues, 2007; Fernandes *et al*., 2008, Fernandes *et al*., 2008).** This result confirms the observations of **Fuente-Blanco *et al*., (2006)**; increased water diffusivity during the microwave drying process reducing the time required for drying.

The MD-AUP effect the time duration that show the short time duration (6mn, 5mn30s at 500 W, 700 W) respectively compared with microwave drying (18mn at 500 W, 11mn at 700 W). In addition the higher temperature at the longer duration time in the microwave can be caused the phenolic compounds degradation **(Yang *et al*., 2010).**

IV.3. Analytical determination

IV.3.1. Total phenolic contents (TPC)

As one of the most important antioxidant plant components, phenolic compounds have been widely investigated in many medicinal plants **(Djeridane *et al*., 2006).** This antioxidant activity is believed to be mainly because of their redox properties **(Zheng and Wang, 2001),** which play an important role in adsorbing and neutralizing free radicals **(Laranjinha *et al*., 1995),** quenching singlet and triplet oxygen **(Hatano *et al*., 1988)**. The figure n° 13 showed the results obtained for the TPC of *Myrtus communis* fruits obtained by microwave drying at 500W, 700 W assisted by ultrasound pretreatment (Figure n° 9). The results were expressed as milligram (mg) Gallic acid equivalent (GAE) per gram of powder. (Appendix II).

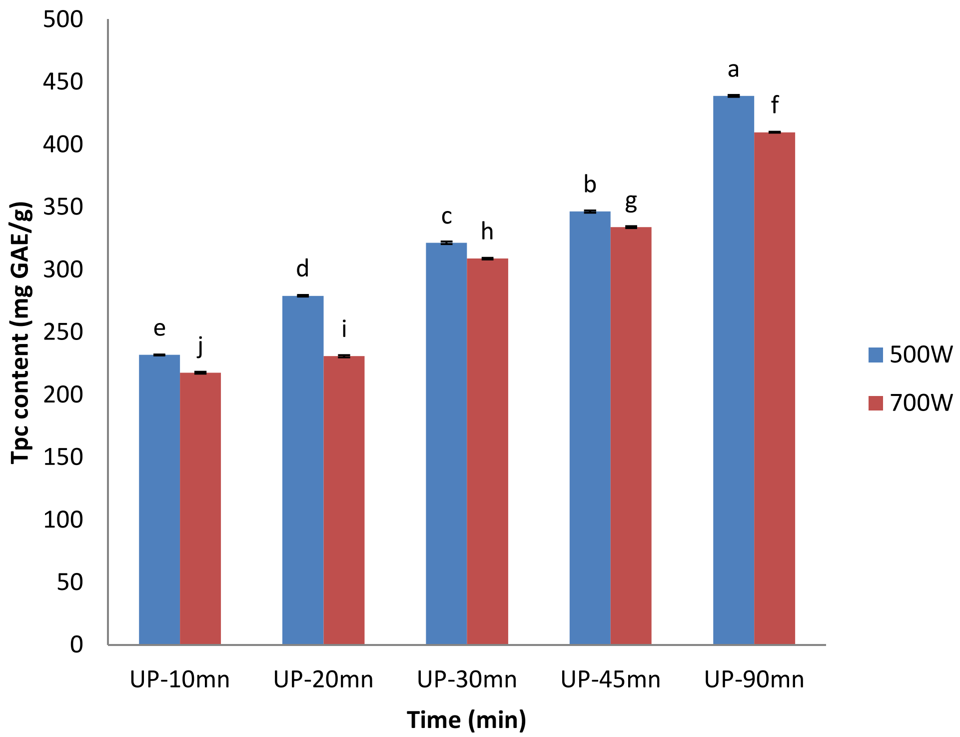


Figure n° 9: TPC content of samples obtained by MD-AUP at 500 W and 700 w.

The main significant differences were found in TPC contents among different UP time. In fact, the highest content was that at 90 min (441.43 mg GAE/ g DW) at 500 W. followed by sample pre-treated for 45 min (346.50 mg GAE/g DW), by sample pre-treated for 30 min (321.20 mg GAE/g DW), then by sample pre-treated for 20 min (282.21 mg GAE/g DW) and finely by sample pre-treated for 10 min (231.88 mg GAE/g DW).The results show that the increase ultrasound pretreatment can caused the reduction the microwave drying time according to **(Carcelet *et al.*, 2007; Gallego-Juarez *et al.*, 2007)**. However compared to that at 700 W, the TPC content was at (215.96 mg GAE/g DW). This lowest content could be due to the thermal degradation of the phytochemicals at higher microwave power. **(Shahidi and Naczk, 2004).**

The figure n°10 show the total phenolic content in myrtle fruits obtained with different drying methods.

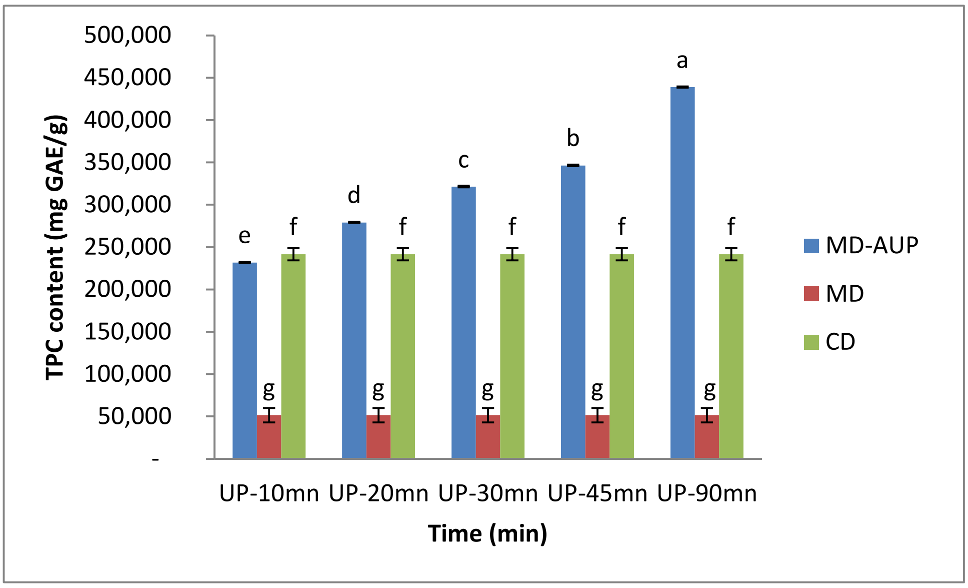


Figure n°10: Total phenolic content of Myrtle Pericarp with different drying method.

The higher TPC content was obtained with sample obtained by microwave drying at 500W assisted by ultrasound at 90min ($p< 0.05$) at (441.43mg GAE/g DW) compared with that obtained by microwave and conventional drying (51.57mg GAE/g DW, 241.60 mg GAE/g DW) respectively.

The advantage of ultrasound pretreatment was to minimize the compound degradation caused by the higher temperatures on microwave. The combination of microwave and ultrasound can be carried out at ambient temperature **(Fernandes and Rodrigues, 2007).** Our results are in agreement with **Fernandes *et al*., 2008** that ultrasound pretreatment of banana and melon before convective drying reduced drying time by 25% and in the case of pineapple by over 30%. In addition the works of **Simal *et al*., 1998** we studies the apples and the pineapples by **Fernandes *et al*., 2009**, who shows that such combination gives high speeds of water removal and solid gain even at low temperatures, thus leading to better maintenance of a natural aroma, color and nutrients content.

IV.3.2. Flavonoids content

Total flavonoids contents of Myrtle using different drying methods were represented in figure 11 and 12. The results were expressed as milligram (mg) Rutin equivalent (RE) per gram of powder (Appendix III).

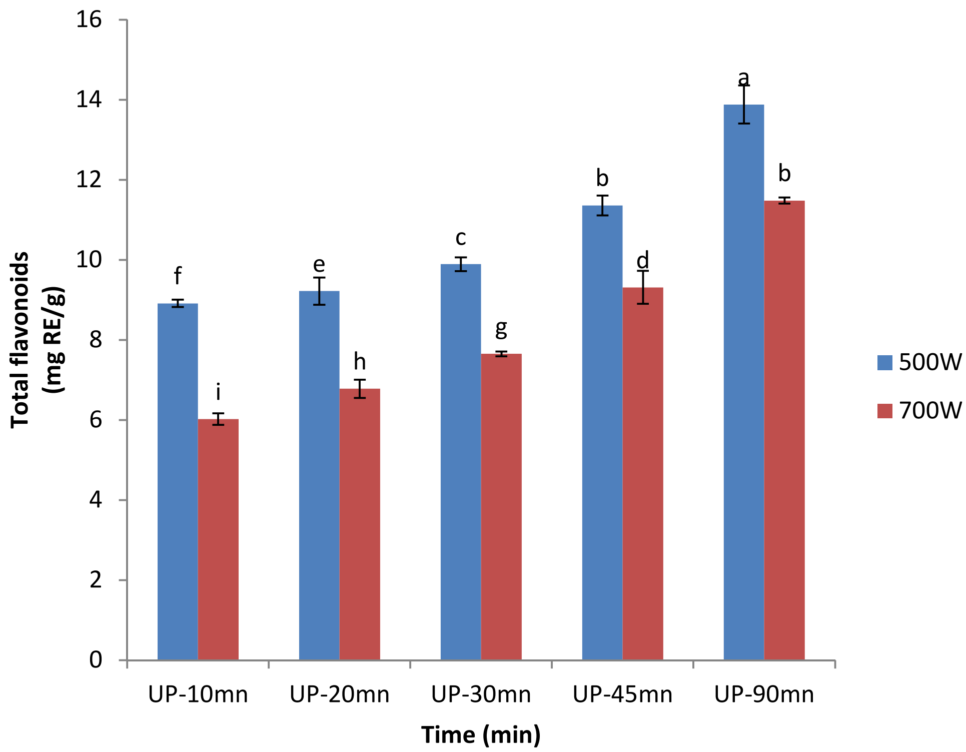


Figure n°11: Flavonoids content of samples obtained by MD-AUP at 500 w and 700 w.

As illustrated in figure n° 15, the total flavonoids content represent a significant difference (<0. 05) between all samples. The highest amount was attributed to sample pre-treated for 90 min (13. 88 mg RE/g DW), followed by sample pre-treated for 45 min (11. 36 mg RE/g DW), and the lowest content was attributed to sample pre-treated for 10 min (8.91mg RE/g DW).The ultrasound pretreatment affects the content of flavonoids. This result was in agreement with that reported by **Francisca and Oliveira, (2010)** who studied dehydration of Malay Apple using ultrasound as Pre-treatment , explained that to reduce the initial moisture content of the fruit by 90%, the total processing time can be reduced by 233 min when Malay apples are subjected to ultrasound during 60 min.

The figure n° 12 shows the flavonoids content in myrtle fruits obtained with different drying methods.

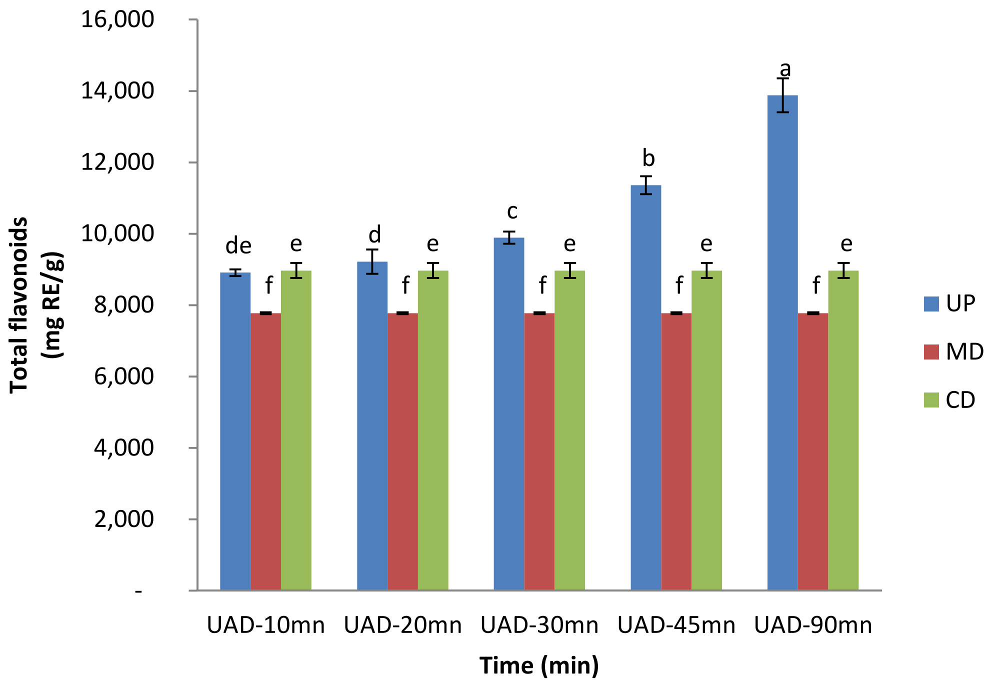


Figure n° 12: Total flavonoids content with different drying methods.

According to these results, MD-AUP gives the higher amount compared with microwave and conventional drying. The sonication caused an improvement of the resistance of the components bioactive. **(Sledz *et al.*, 2015).**

IV.3.3. Total monomeric anthocyanin contents

Anthocyanins are the largest water soluble natural pigment. They belong to a large group of flavonoids. Anthocyanins have anti-inflammatory, anticarcinogenic, Prevention of cardiovascular disease **(Basu *et al.*, 2010)**.

The results of total monomeric anthocyanin contents of Myrtle fruit using MD-AUP was represented in figure n° 13.

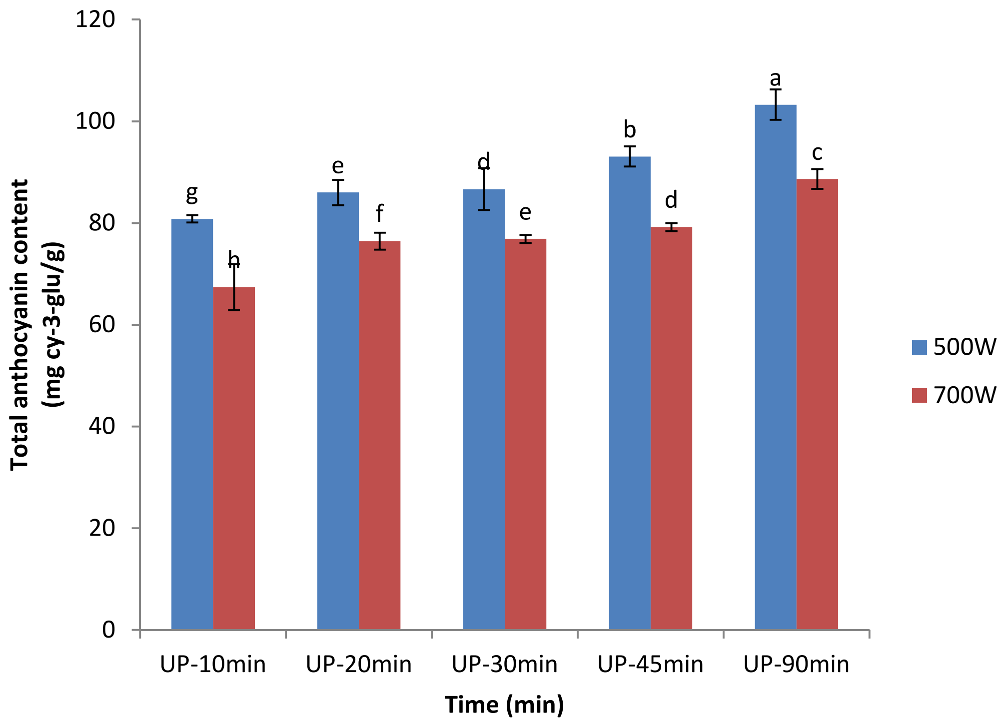


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Figure n°13: Total monomeric anthocyanin content obtained MD-AUP at 500 W and 700 W.

The result showed that the highest content total anthocyanin was observed in the samples pretreated by ultrasounds at 90 min assisted microwave drying at 500W from (103.25 mg/g E cy-3-glu/g DW), followed by sample pretreated for 45 min (93.06 mg E cy-3-glu/g DW), sample pre-treated for 30min (86.66 mg E cy-3-glu/g DW), sample pre-treated for 20 min (85.99mg E cy-3-glu/g DW) then by 10 min (80.82mg E cy-3-glu/g DW) . The results can be explained by duration time in the ultrasonic bath which can contribute to the preservation of nutritive compounds.

However the microwave drying at 700W show (88.67 mg E cy-3-glu/g); the lowest content of anthocyanin could be due to its degradation by the high temperatures and the largest duration time in microwave **(Gao *et al* ., 2007).**

The figure n° 14 show the total monomeric anthocyanin content in myrtle fruits obtained with different drying methods.

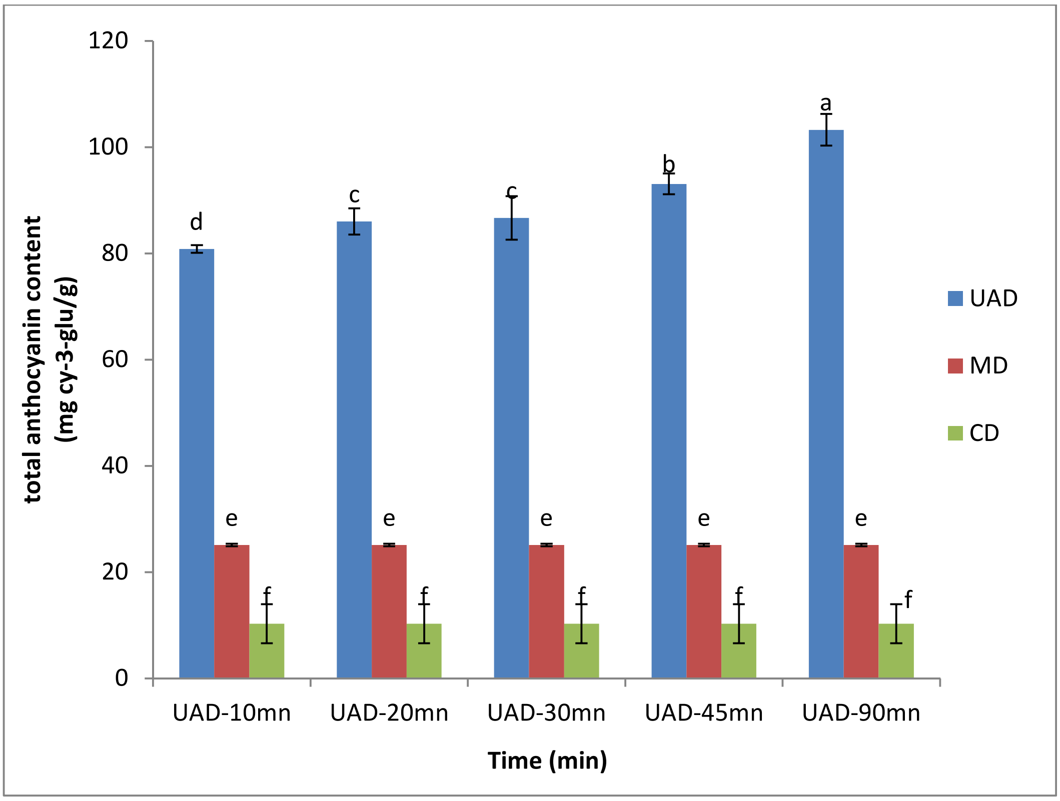

Figure n°14: Total monomeric anthocyanin content of myrtle pericarp with different drying methods.

Comparing with microwave and conventional drying, the figure n° 18 show clearly that the samples obtained by MD-AUP gives, the highest amount of anthocyanin at 90 min (103.25 mg E cy-3-glu/g DW) However, the significant difference ($p<0.05$) was observed between the samples obtained with all drying methods.

The results illustrate that anthocyanin content of myrtle fruit was depending on the method of drying (**Sen *et al.*, 2010; Chen *et a*l, 2007)**. According to the work of **Alibas and Seldz , (2014)** which illustrate that MD-AUP preserved phenolic components compared with others drying methods.

IV.3.4. condensed tannin content

The total condensed tannins for Myrtle fruit obtained by MD-AUP were showed in figure n°15. The results were expressed as milligram (mg) Catechin equivalent (CE) per gram of powder. (Appendix IV).

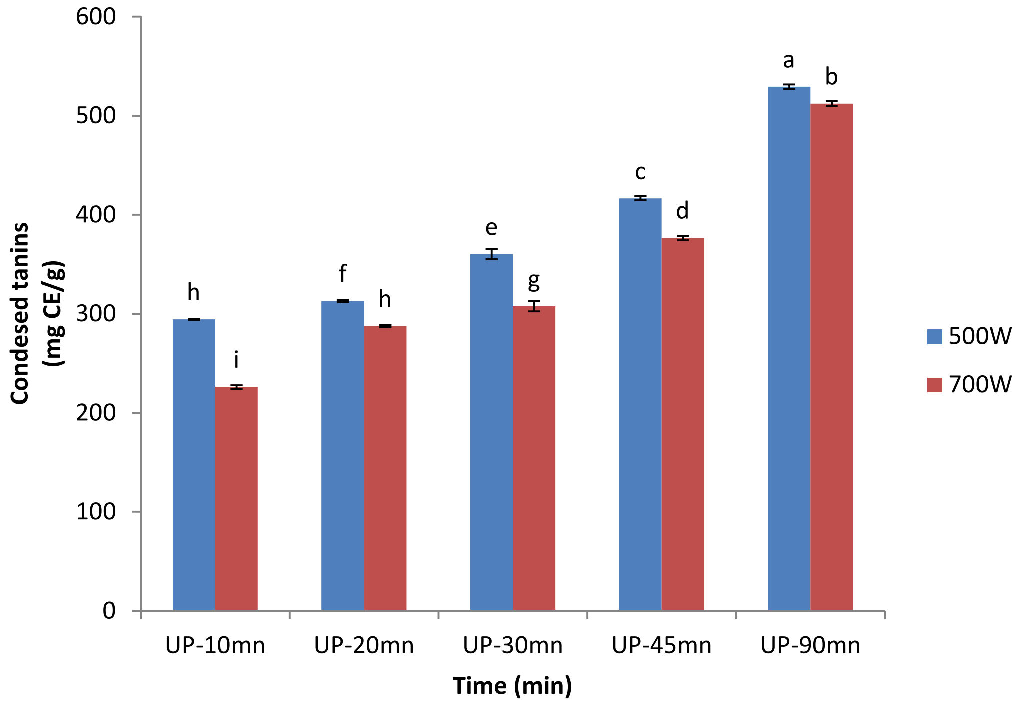

Figure n° 15: Total condensed tannins content of myrtle fruit obtained by MD-AUP at 500 W and 700 W.

The results show that the total condensed tannin in the samples obtained with microwave drying at 500W was the highest difference significative ($p<0.05$) between all samples , it is of (529.30mg CE/g DW) at 90 min , followed by sample pre-treated at 45 min, 30 min and 20 min (416.62, 360.28, 312.84 mg CE/g DW) respectively. While the lowest content of condensed tannins was attributed to the sample pre-treated for 10 min at (294.30mg CE/g DW). Furthermore, the significative difference was observed in the condensed tannins content at power of 700W (512. 25 mg CE/g). This result may be due to the degradation of these compounds under the influence of microwaves irradiation **(Zhang *et al.*, 2007).**

The figure n° 16 show the total condensed tannins content in myrtle fruits obtained with different drying methods.

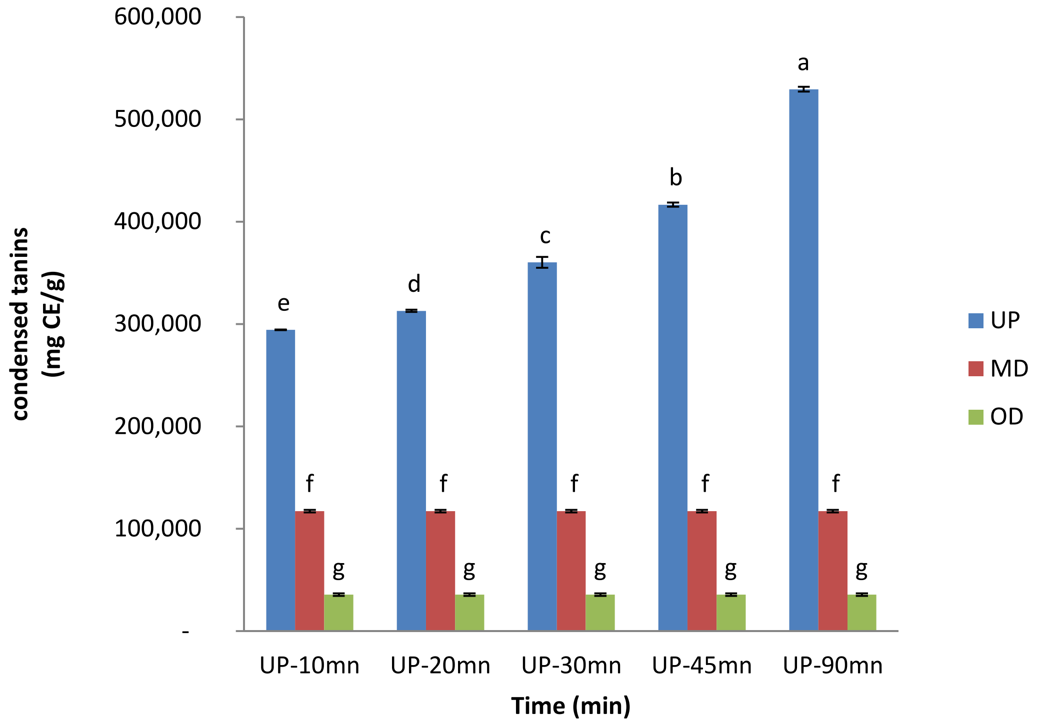

Figure n° 16: Total condensed tannin content of myrtle pericarp with deferent methods of drying.

Comparing with microwave and conventional drying, the tannins contents was lowest compared to MD-AUP. According with the work of **Alibas and Seldz**, **(2014)** which illustred that microwave drying assisted ultrasound preserved phenolic components compared with drying methods.

IV.3.5. Antioxidant activity

The antioxidant activity of plants is mainly contributed by the active compounds and phenolic fraction present in them such as flavonoids **(Pietta *et al.*, 1998**) and anthocyanin **(Montoro *et al.*, 2006)**. Their antioxidant properties are very important due to the deleterious role of free radicals in foods and biological systems (**Gülçin *et al.*, 2006)**. The antioxidant activity of, myrtle pericarp, was evaluated by DPPH radical scavenging assay and reducing power test. The higher percentage inhibition test rate is, the greater the hydrogen donating ability, thus the higher antioxidant activities.

IV.3.5.1. DPPH radical scavenging assay

The effect of antioxidant on DPPH radical scavenging was conceived to their hydrogen donating ability **(Chen *et al*., 2008).**

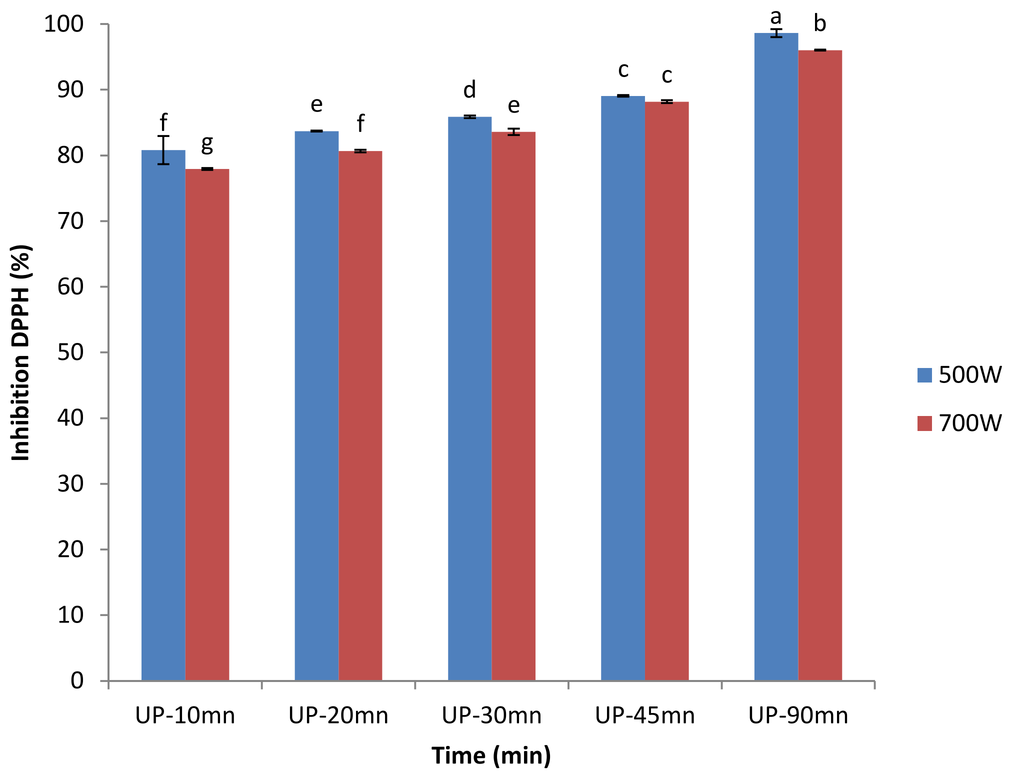

Figure n° 17: Radical DPPH inhibition of samples dried by MD-AUP at 500 and 700 W.

Concerning the extracts obtained by microwave drying at 500W assisted by ultrasound, figure n° 17 show that the inhibition effect of on DPPH radical antioxidant was most important for sample pretreatment for 90 min 98.63 % , followed by pretreatment for 45 min, and the lowest is recorded with pretreatment for 10 min (80.80 %). A positive correlation was observed between antioxidant activity and total phenolic compounds. These results were in agreement with these obtained by **Tawata, 2008; Liu *et al* 2008; Zainol and MUSE, 2003**, which proved that high total polyphenol contents increase the antioxidant activity. Effectively, the sample drying with microwave at 700W presented a low content of bioactive compounds and tannins by comparison with those of 500 W. Our results were in agreement with the results of **(Dairi *et al*., 2014; Oliveira *et al*., 2012).**

Inhibition effect of on DPPH radical antioxidant of myrtle pericarp obtained by different drying method was illusted in figure n° 18.

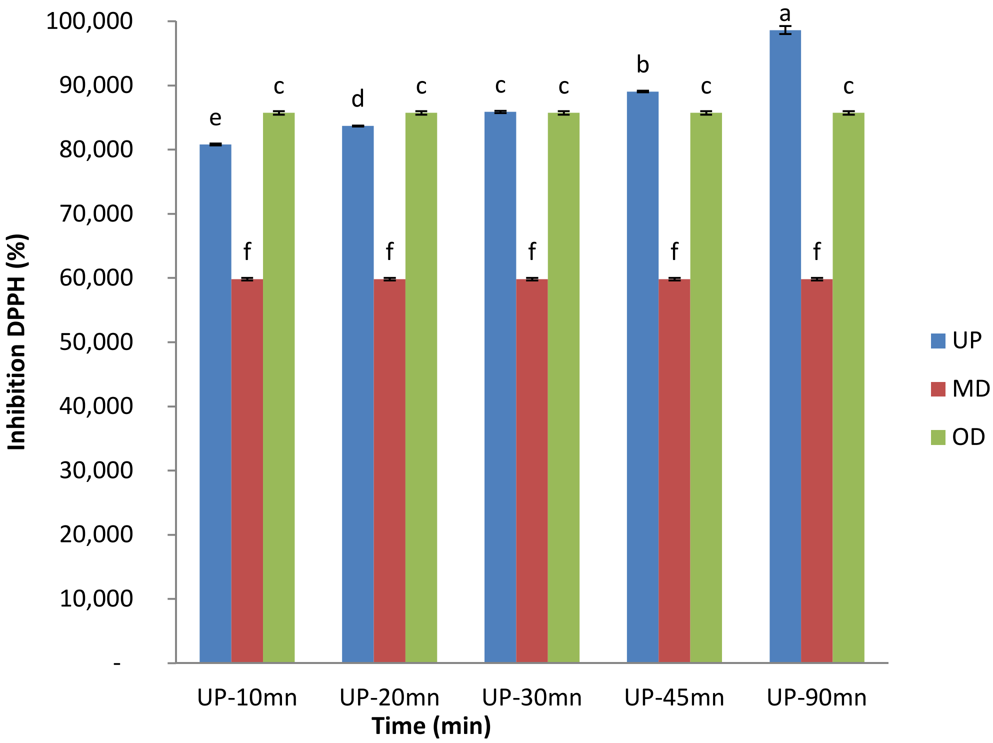

Figure n°18: Radical DPPH with deferent methods of drying.

Statistical analysis show that there is a significant difference ($p<0.05$) between the all methods of drying. The simple dried by MD-AUP have a highest capacity scavenging of DPPH.

IV.3.5.2. Iron reducing power

The reducing power was based on the capacity of the phenolic compounds to reduce the ferric iron ferrous Fe^{3+} en iron Fe^{2+}; the power of reduction is one of the antioxidant mechanisms **(Karagozler *et al*., 2008).**

The reducing power of Myrtle fruit obtained by MD-AUP at (500, 700W) was showed in figure n° 19.

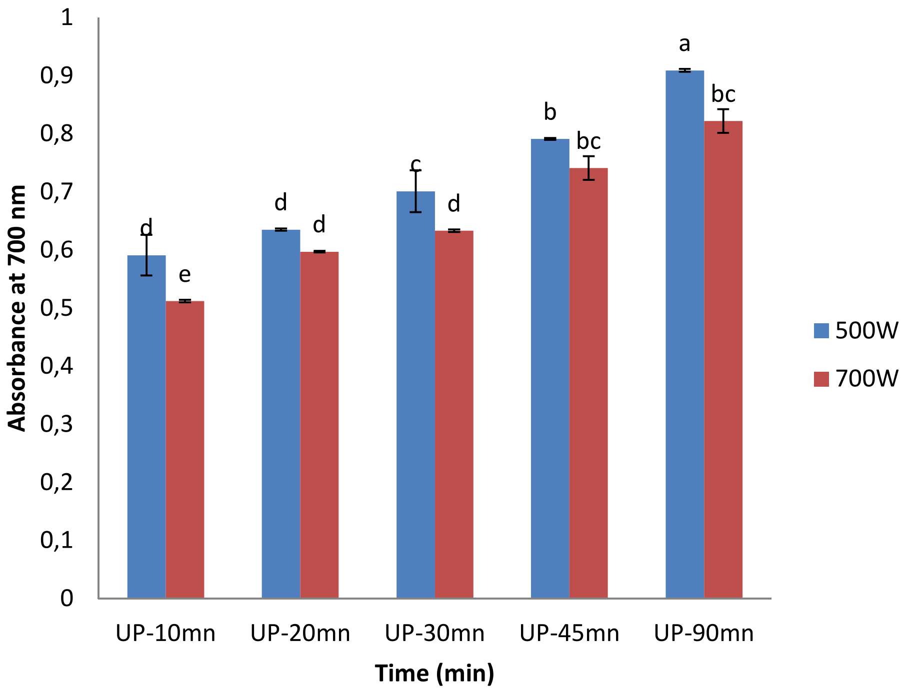

Figure n°19: reducing power of samples dried by MD-AUP at 500 and 700w.

The result show that the highest absorbance was observed to fruits pretreated at 90mnUS-500 W (0.90 UA), and the lowest was attributed to these pretreated at 10mnUP (0.59UA). The same correlation between reducing power and phenolic compounds was observed. The same correlation was observed between the research showed that there is a correlation between the activities antiradicalaire and phenolic compounds **(Bidie *et al*., 2013).**

The reducing power of Myrtle fruit dried with different methods of drying (MD-AUP, microwave and oven drying) are represented in figure n° 20.

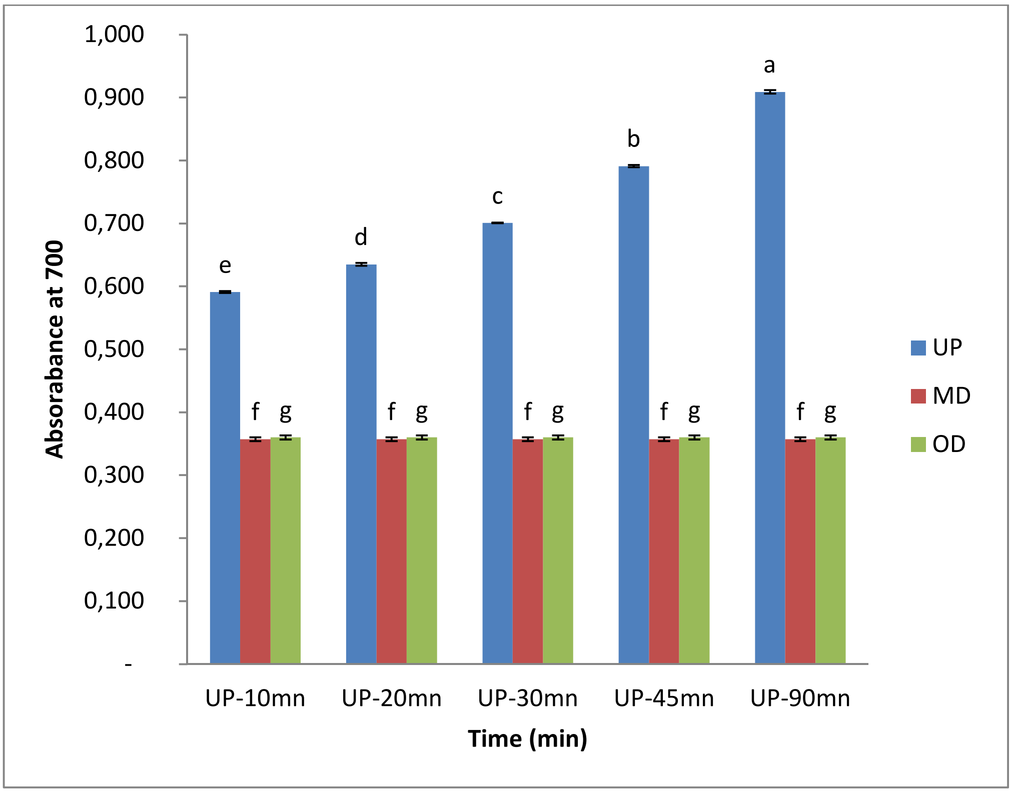

Figure n° 20: Fer reducing power with deferent drying methods.

According to the results, there was a significant difference ($p<0.05$) between different drying methods, highest content was obtained by MD-AUP.

The results suggest that phenolic compounds are the major contributors to the antioxidant activities of *Myrtus communis*, (**Amensour *et al*., 2010).**

Conclusion And perspectives

Conclusion

The aim of this study was to investigate the effect of ultrasound pretreatment on the phenolic compounds of *Myrtus communis* fruits and its antioxidant activity.

The kinetic of drying show that, with the innovative method of drying, microwave-assisted by ultrasounds, fruit of *Myrtus communis* is dehydrated more quickly compared to microwave and conventional drying techniques. For a pretreatment of 10 min, 9 min at 500 W were sufficient to stabilize the sample weight. However, more time was needed to stabilize the fruit sample when microwave (18 min at 500 W) or conventional (4320 min) drying methods were applied.

The samples obtained by **MD-AUP** (90 min), has exhibited higher TPC content (441.43 mg GAE/g of powder), flavonoids (13.88 mg RE/g of powder), anthocyanin (103.25 mg cy-3-glu/g of powder) and tannins (529.30 mg CE/g of powder). Concerning the antioxidant activity, a good correlation has been found between content of bioactive compounds and antioxidant activity. These results confirm the interesting potential of this plant as a valuable source of natural bioactive molecules in food and medical industry.

In the light of this investigation, we can confirm that **MD-AUP** is more advantageous, in term of drying time compared with MD and CD and in terms of output on the bioactive substances contents.

In conclusion, the ultrasound extracts obtained from pericarp of *Myrtus communis* could be used as natural additive to enhance functional proprieties of foods products.

However, it would be desirable to complement this work with:

- Characterization of phenolic compounds present in extracts by HPLC MS.
- Characterization the other substances (vitamins and essential oil) present in myrtle fruits.
- Utilization of other pretreatment methods such as osmotic dehydration to dry this fruit.

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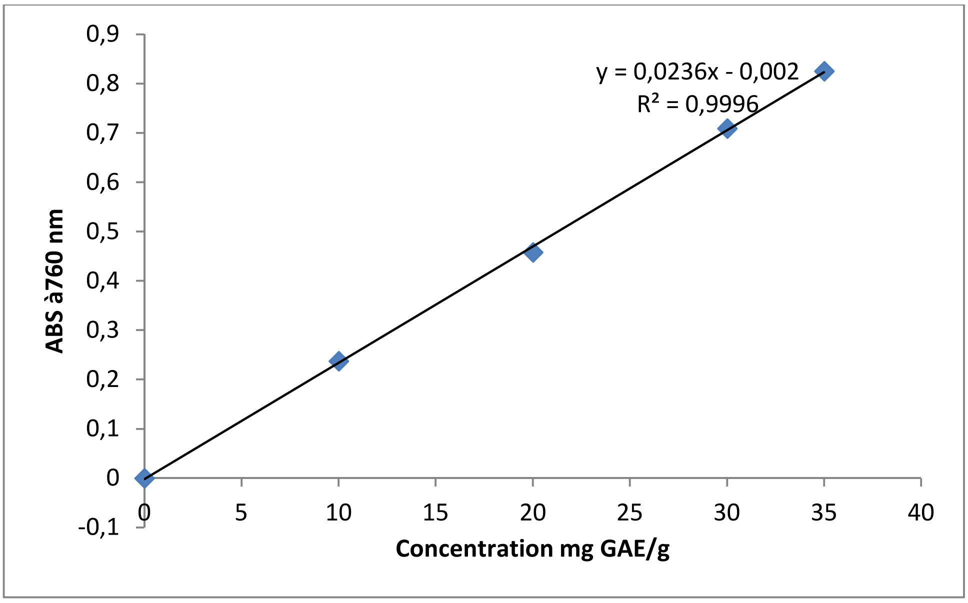
Appendix

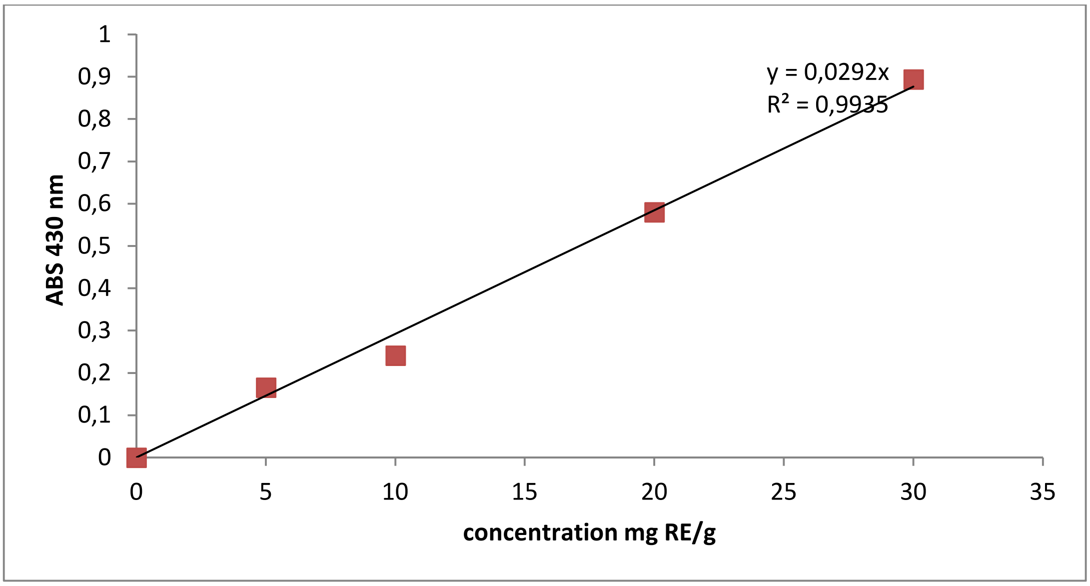
Appendix I: Mineral contribution of myrtle plant.

Minerals	**Contents**
Nitrogenize	0.310
Phosphorus	0.043
Potassium	0.750
Calcium	0.274
Magnesium	0.131
Sodium	0.192
Copper	3.5
Iron	32
manganese	9
zinc	7

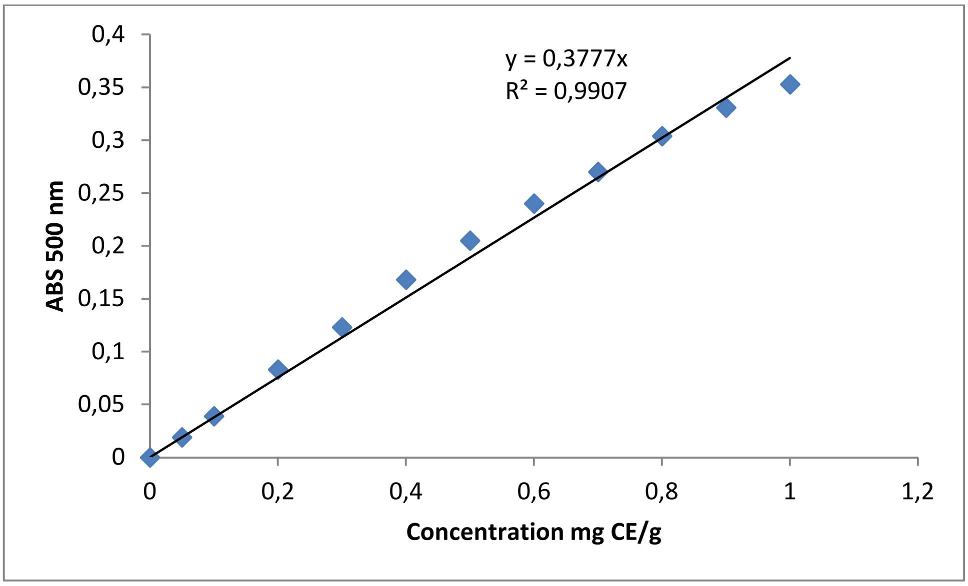
Appendix II : the calibration curve of acide gallique



Appendix III : the calibration curve of Rutin



Appendix IV: the calibration curve of Catechin



Appendix V : Matériels and méthods

1. Equipment

- Balance de précision RADWAG WAS 600/C/2
- Bain Ultrason
- Broyeur électrique (ENIEM)
- Dessiccateur RADWAG MAC 50/NP
- Etuve ventilée (Memmert)
- Microonde SAMSUNG model ME 8123ST
- Spectrophotomètre UV-Vis SRECTROSCAN50
- Vortex classic Advanced
- pH mètre EXTECH instruments (EC 500)
- Tamiseur automatique RETSH AS 200 central.

2. Chemicals Products:

- Ethanol
- Carbonate de sodium (Na2CO3) (SIGMA-ALDRICH)
- Folin-Ciocalteu (PROLABO)
- Chlorure d'aluminium (AlCl3) (SIGMA-ALDRICH)
- Méthanol (PROLABO)
- Acide chlorhydrique (HCl) (SIGMA-ALDRICH)
- Chlorure de potassium (KCl).
- Acetate de sodium (CH3CO2Na 3H2O) (BIOCHEM Chemopharma)
- Ferrycianide de potacium (K+) (SIGMA-ALDRICH)
- Chlorure de fer (Fe Cl3) (BIOCHEM Chemopharma)
- Vanilline (C_8 H_8 O_3) (BIOCHEM Chemopharma)
- DPPH (SIGMA-ALDRICH)
- TCA C2HCl3O2 (SIGMA-ALDRICH)

Abstract

Scientists and innovative food centers are looking for emerging food processing technologies to enable the introduction of new, safer, fresher and better quality of foods with longer life for local and export markets. Among emergent new technologies, ultrasonic dehydration is very promising. The present work is carried out to compare three drying methods, conventional (in oven), microwave and microwave-assisted ultrasound techniques of myrtle (*Myrtus communis L*).The fruits of myrtle were subjected to the ultrasonic waves on a water bath at a frequency of 25 KHz during 10, 20, 30, 45 and 90 min, followed by drying with microwave at 500 and 700W.The studied kinetics showed that the stability of the weight of the samples is reached more quickly with microwave (700W for 5 min), assisted with ultrasound for 90 min. The highest level of TPC is about 441.43 mg GAE/g of powder. The method of drying by microwave assisted with ultrasounds is recommended for the fast, economic and reliable preparation of the matrices containers of the substances with high benefit.

Keywords: *Myrtus communis L*, kinetics, drying, antioxidant activity, microwave, ultrasounds pretreatment, phenolic compounds.

Résumé

Les scientifiques et les centres innovateurs de nourriture recherchent des technologies naissantes de traitement des denrées alimentaires pour permettre l'introduction des nourritures, plus sûre, plus fraîche et à meilleure qualité avec la plus longue vie. Parmi les nouvelles technologies émergentes, la déshydratation ultrasonique est très prometteuse. Le présent travail consiste à comparer trois techniques de séchage, conventionnelles (étuve), micro-ondes et micro-ondes assistée par ultrasons de myrte *(Myrtus communis L*). Les fruits de myrte ont été soumis aux ondes ultrasoniques dans un bain d'eau à une fréquence de 25 kHz pendant 10, 20, 30, 45 et 90 min, suivi par un séchage aux microondes à 500 et 700W. La cinétique de séchage a été suivie selon la perte en eau du péricarpe des fruits de myrte. L'évaluation de la composition phytochimique et de l'activité antioxydante de la poudre obtenue par les trois méthodes de séchage, ont été étudiées. Les cinétiques étudiées ont montré que la stabilité du poids des échantillons est atteinte plus rapidement avec le séchage microonde assisté par les ultrasons (90 min à 700W /5 min). Le taux de PPT le plus élevé est de 441,43 mg GAE/g de poudre. La méthode de séchage microonde assistée par les ultrasons est recommandée pour la préparation rapide, économique et fiable des matrices contenant des substances à haute valeur ajoutée.

Mots-clés : *Myrtus communis L*, cinétique, séchage, activité antioxydante, micro-ondes, prétraitement à ultrasons, composés phénoliques.