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

MASTER

Thème

Elaboration d'un yaourt enrichi en polyphénol et en fibre des gousses de la fève

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Dedication

I dedicate it modest work:

In both beings which are me the dearest to the world my father and my mother to whom I owe what I am and what today that I would be tomorrow and I would always make, which were always present by my side by their love, support and encouragements. That god their gets good health and long life.

My very dear brothers

My very dear sisters,

My nephews and my nieces

To my dear momoh fiancé and my beautiful family

To my colleague Drifa, her family and her beautiful family

To all my close friends and my friends his exception.

In everything the special offer "**industrie laitiere**" 2016-2017

And at the end in all those who contributed to the realization of this report.

Ounissa

Dedications

I dedicate it modest work in:

My very dear parents who supported me during all my studies, who shared my enjoyments and my punishments, who made of me what I am aujourdh' ui I. there would eternally be grateful

To the memory of my dear brother ghiles

May Dear brother salim and miccipssa

Me adorable sister

My dear husband who my given boucou of courage and patience

My grandparents

My parents step- parents, beautiful brothers, beautiful sisters and their family

My cousins and cousins, uncles and aunts

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Drifa

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LIST OF ABBREVIATION

°C: Degree cercus

°D: Degree dornic

µl: Microliter

µm: Micromètre

ABS: Absorbance

AlCl3: aluminum Chloride

AW: Water activity

BM: Brewed mixt

BS: Brewed standard

BWF: Brewed with fiber

BWP: Brewed with polyphenols

C: Carbon

CM: Centimeter

CP: Centi Poise

DM: Dry Matter

DPPH^{0}: 2, 2-diphényl-1-pecrylhydrazyle.

DW: Dry weight

E.G: For example

FAO: Food and Agriculture Organization of the United Nations

FIG: Figure

G: Gram

GHz: Gigahertz

H: Hour

H2O: Water developed formula, two molecules of hydrogen and one molecule of oxygen

HCL: Hydrogen chloride

IC: Equivalent catechin

KSW: Konfrontacja Sztuk Walki

LMWC: Low molecular weight carbohydrates

M: Meter

M17: M17 agar

MC: Moisture contents

Mg: Milligram

MHz: Megahertz

MIN: Minute

MRS: Rogoza and Sharpe agar

Na2CO3: Carbonate de sodium

NaOH: Sodium hydroxide

NM: Nanometer

ORC: Oil retention capacity

PH: Potential hydrogen

RPM: Equivalent of revolutions by minute

S: Second

SC: Swelling capacity

SD: Standard deviation

TFC: content total flavonoids

TPC: total phenolic contents

USA: United States of America

V: vicia

VRBL: Violet Red Bile Agar

W/V: Weight/Volume

W: Watt

WHC: Water-holding capacity

WRC: Water retention capacity

YGC: Yeast extract glucose chloramphenicol agar

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INTRODUCTION

Introduction

Today the consumer demands in the field of food production has changed considerably, these products are not intended to only satisfy hunger and to provide necessary nutrients for humans but also to prevent nutrition-related diseases and improve physical and mental well-being of the consumers, who more and more believe that foods contribute directly to their health.

Most legumes are consumed after a simple industrial process in which the pod is removed and the seed is prepared as fresh or frozen food. Broad bean are widely consumed and are grown all over the world **(Mateos-Aparicio and al., 2012)**, according to the United Nations Food and Agriculture Organization (FAO), world production is around 3.6 million tons, of which 70 % are by-products **(Abu-Reidah and al., 2017)**. Thus, the harvesting of this legume would generate around 2.4 millions of tons of broad bean by-product. This by-product from agro industries could be an important source of functional ingredients **(Mateos-Aparicio et al., 2012)**. In a context of resource preservation, the determination of bioactive compounds from by-products together with their re-valorization in the food, cosmetic or pharmaceutical industry give rise to an increasing social, economic and scientific interest.

In order to contribute to the valorization of this cultivation and to overcome the lack of knowledge about all aspects concerning its by-product in Algeria, current study has been designed firstly to investigate the drying of broad bean pods (local variety). Drying is regarded not only as a preservation process, but also as a method of increasing added value of foods. Among foodstuffs, particular attention has been given to drying of fruits and vegetables so that diversified products can be obtained to include in breakfast cereals, soup and dairy products **(Ramos and al., 2003)**.

The fermented dairy products already have a positive image for the health because of the beneficial action of its viable bacteria **(Sendra and al., 2010)**. The yoghurt appears a food of choice within the framework of a balanced diet. Indeed, it is rich in proteins and assures a contribution of vitamins and trace elements, particularly the calcium, while having a moderate energy contribution **(Yahia, 2012).** However, the presence of antioxidants in this fermented milk is weak and can contain artificial additives.

In the view of the health promoting properties and high nutritional benefits of broad bean pods, the present study was carried out on the one hand to compare the effect of drying

drying on their bioactive components and their antioxidant activities, using three methods free air, oven and microwave. On the other hand, to manufacture stirred yoghurts, at laboratory scale, with dried powder of broad bean pod. After physico-chemicals and microbiological analysis, of yoghurts, antioxidant capacity and total phenolic compounds were determined.

This by-product can constitute an interesting matrix, to enrich this food in active substances namely polyphenols and fiber.

BIBLIOGRAPHY SYNTHESIS

I. Overview of broad bean pod

Broad bean (*Vicia faba L.*), is a species of bean family; Fabaceae (*Leguminosae*), an ancient crop species that originated in the Near East1, is mainly grown in Europe, the Middle East and North Africa. It is an important leguminous crop worldwide because of its nutrient-rich seeds. It is extensively used as a legume, a vegetable, and as fodder **(Li and Yang, 2014)**. According to FAO estimates, world production of broad beans was estimated to be around 4 million tons. Curiously, harvesting this vegetable would yield around 2.8 million tons of broad bean by-products (~70% of the total production) **(Abu-Reidah and al., 2017)**.

I.1. Morphological description

V. faba is an annual herb with coarse and upright stems, unbranched 0.3 to 2 m tall, with 1 or hollowed stems from the base. The leaves are alternate, pinnate and consist of 2 to 6 leaflets each up to 8 cm long. The plant flowers profusely but only a small proportion of the flowers produce pods. Flowers are large, white with dark purple markings; 1-4 pods develop from each flower cluster **(Singh and al., 2013)**.

Pods are fruits fleshy which can be from 10 to 20 cms long according to the varieties and can contain a variable number of seeds (4 - 9). In the young state, pods are of green color then darken in the maturity **(Fig.1)**. The inside of pods is papered with a whitish downy coat, there are about 15 pods per stalk **(Chaux and Foury, 1994)**.

Figure 1: Morphology of broad bean pod

I.2. Chemical composition

Broad bean pod is a prized diet component since it contains considerable amounts of valuable nutrients: fiber, minerals **(Tab.I)**, and secondary metabolites namely phenolic compounds **(Abu-Reidah and al., 2017)** Broad bean pod generated from the agro-industrial practices are considered a key source of bioactive and functional components that can be used for their nutritional and added value properties **(Singh and al., 2013).**

Table I: Composition of broad bean pod: low molecular weight carbohydrates (LMWC) and minerals (g/100 g dry matter) **(Mateos-Aparicio (A) and *al*., 2010)**.

Element	Content	Element	Content
Protein	13.6 ± 0.2		
Fat	1.3± 0.5	Potassium	2.29 ±0.3
LMWC	26.6± 0.5	Sodium	0.09 ±0.0
Sucrose	6.1± 0.2	Calcium	0.34 ±0.0
Glucose	13.3±0.5	Magnesium	0.12 ±0.0
Arabinose	1.3± 0.1		
Fructose	4.1± 0.3	Iron	0.65 ±0.1
Starch	11.7± 0.2	Cupper	0.05 ±0.0
Dietary fibre	40.1±1.0	Manganese	0.13 ±0.0
Insoluble DF	30.8 ±1.2	Zinc	0.14 ±0.0
Soluble DF	9.3± 0.6		
Ash	6.3±0.1		

I.3. Phenolic composition

Phenolic compounds include a wide range of chemicals comprising at least one aromatic ring and one or more hydroxyl groups, in addition to other constituents **(Hagerman and al., 1998)**. Natural polyphenols range from simple molecules to highly polymerized compounds, the most important are: phenolic acids, flavonoids and tannins **(Hmid., 2013)**.

- Flavonoids

Flavonoids have the C6–C3–C6 general structural backbone in which the two C6 units (Ring A and Ring B) are of phenolic nature. Due to the hydroxylation pattern and variations in the chromane ring (Ring C), flavonoids can be further divided into different sub-groups such as flavones, flavonols and anthocyanins **(Tsao., 2010).**

- Phenolic acids

There are two main classes of phenolic acid; the derivatives of benzoic acid (C1-C6) and derivatives of cinnamic acid (C3-C6, **(Tsao., 2010)**. The concentration of the hydroxybenzoic acid is generally very low in edible vegetable. These derivatives are quite rare in the human diet by those against hydroxycinnamic acids which are very present **(Marcheix and al., 2005).**

- Tannins

Tannins are complex phenolic compounds obtained from the condensation of simple phenols. They are divided into two groups: hydrolysable tannins (carbohydrate ester and phenolic acids) and condensed tannins (dimers, oligomers and/or polymers of flavannes-3-ols or flavannes -3, 4-diols) (**Fig.2)** (**Macheix and al., 2005; Makkar, 2003).**

Broad bean pod showed to contain polyphenols such as phenolic acids, flavonoids and tannins **(Mateos-Aparicio and al., 2010).**

- The structure of some characterized bioactive compounds in broad bean pod, are illustrated in figure 2.

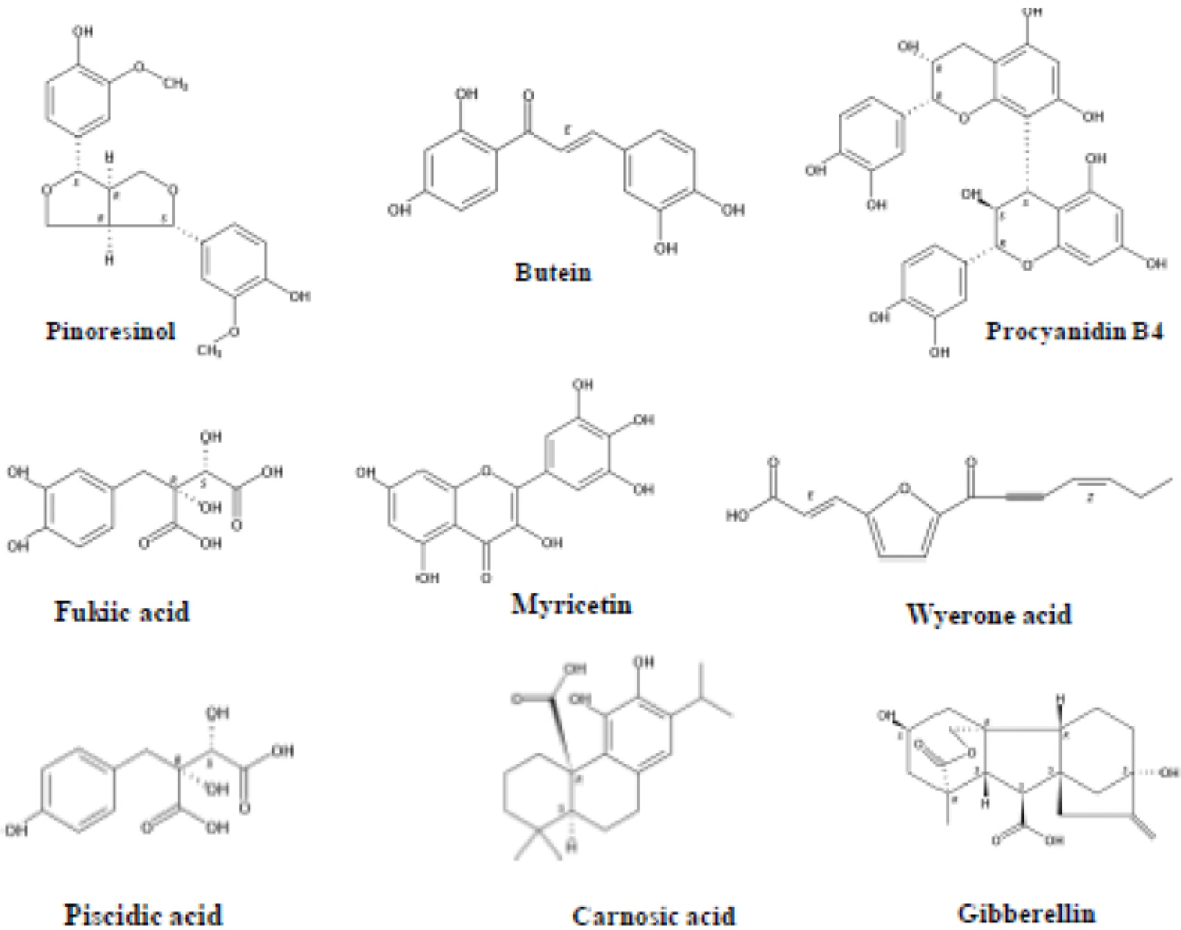


Figure 2: Structure of some phytochemicals characterized in broad bean pods **(Abu-Reidah and al., 2017)**

I.4. Drying process

Drying is one of the oldest and the most commonly used methods of preservation of fruits, vegetables **(Huang and al., 2016)**. It is the process of removing the moisture in product up to certain threshold value by evaporation. In this way, the product can be stored for a long period **(Alibas., 2007)**.

Drying fruits and vegetables is a process where water removal halts the growth of spoilage microorganisms, as well as the occurrence of enzymatic or nonenzymatic browning reaction in the material matrix preserving thus the structure, sensorial characteristics and nutritional value of the starting material. Also they are dried for storage stability, minimize packaging requirements and reduce transport weight o they are dried for storage stability, minimize packaging requirements and reduce transport weight **(Karam and al., 2016)**. Thus, drying is used to achieve the desired characteristics of a food product **(Chiewchan and al., 2010)**.

I.4.1. Drying techniques

There exists a great number of processing choices for the dehydration of bio-materials and foods **(Orsat and al., 2007)**, from the most basic technique such as air drying to more expensive methods microwave drying **(Bonazzi and Bimbenet, 2008)**.

a- Conventional Drying

Conventional drying remains the most adopted technique in the food industries drying used operations for food dehydration **(Tsami and al., 1998)**. In air drying, the heated air (of low relative humidity) meets the surface of the wet material that transfers heat into the solid primarily by conduction. The liquid migrates then onto the material surface and is transported away by air convection. Transport of moisture within the solid food occurs by liquid or vapor diffusion, surface diffusion, hydrostatic pressure differences and combinations of these internal mass transfer-types drying, with moisture diffusion as the controlling step **(Karam and al., 2016)**.

b- Microwave drying

Microwave drying is among the alternative drying methods gaining popularity in recent years, and offering great compromises between energy consumption and product quality **(Karam and al., 2016).**

Microwave drying uses electromagnetic energy in the frequency range of 300 MHz to 300 GHz **(Orsat and al., 2007)**, this electromagnetic energy was being directly absorbed by water-containing in food that is the primary component responsible for dielectric heating. Due to their dipolar nature, water molecules attempt to follow the electric field which alternates its direction at very high frequencies. Such rotations of the water molecules generate heat **(Huang and al., 2016)**.

I.5. Yoghurt

I.5.1. Definition

A wide range of fermented milks are manufactured throughout the world, Around 400 generic names are applied to traditional and industrialized products. Many of these products are known locally by different names but, in essence, a more accurate list may include far fewer variations. Yogurt or yoghurt is one of the most popular fermented dairy products worldwide which has great consumer acceptability due to its health benefits other than its basic nutrition **(Law., 2012)**.

In legislation, the name «yoghurt" is obtained by the lactic development of the only bacteria *Lactobacillus delbrueckii* and *Streptococcus thermophilus*, which must be simultaneously sowed and found alive in the product at the rate of at least 10^7 bactéries.g-^{1}. The addition of additives (agent of texture, etc.) in yoghurt is authorized by the regulations of the majority of the European countries **(Enkelejda-PACI., 2004).**

I.5.2. Production diagram

Industrially, yoghurts can be largely divided into two types. A set-style yogurt is made in retail containers giving a continuous undisturbed gel structure in the final product. On the other hand, stirred yogurt has a delicate protein gel structure that develops during fermentation .In stirred yogurt manufacture, the gel is disrupted by stirring before mixing with fruit and then it is packaged. Stirred yogurts should have a smooth and viscous texture. In terms of rheology, stirred yogurt is a viscoelastic and pseudoplastic product. Yoghurts come in a variety of textures (e.g. liquid, set, and smooth), fat contents (e.g. luxury, low-liquid, virtually fat-free) and flavors (e.g. natural, fruit, cereal), can be consumed as a snack or part of a meal, as a sweet or savory food, and are available all year round. This versatility, together with their acceptance as a healthy and nutritious food, has led to their widespread popularity across all population subgroups **(Khraisheh and al., 1997).**

The production steps in the manufacture of stirred and adjusted yogurt are illustrated in the following figure 3. The type of milk to be used depends on the variety or type of yoghurt to be prepared **(Weerathilake and al., 2014).**

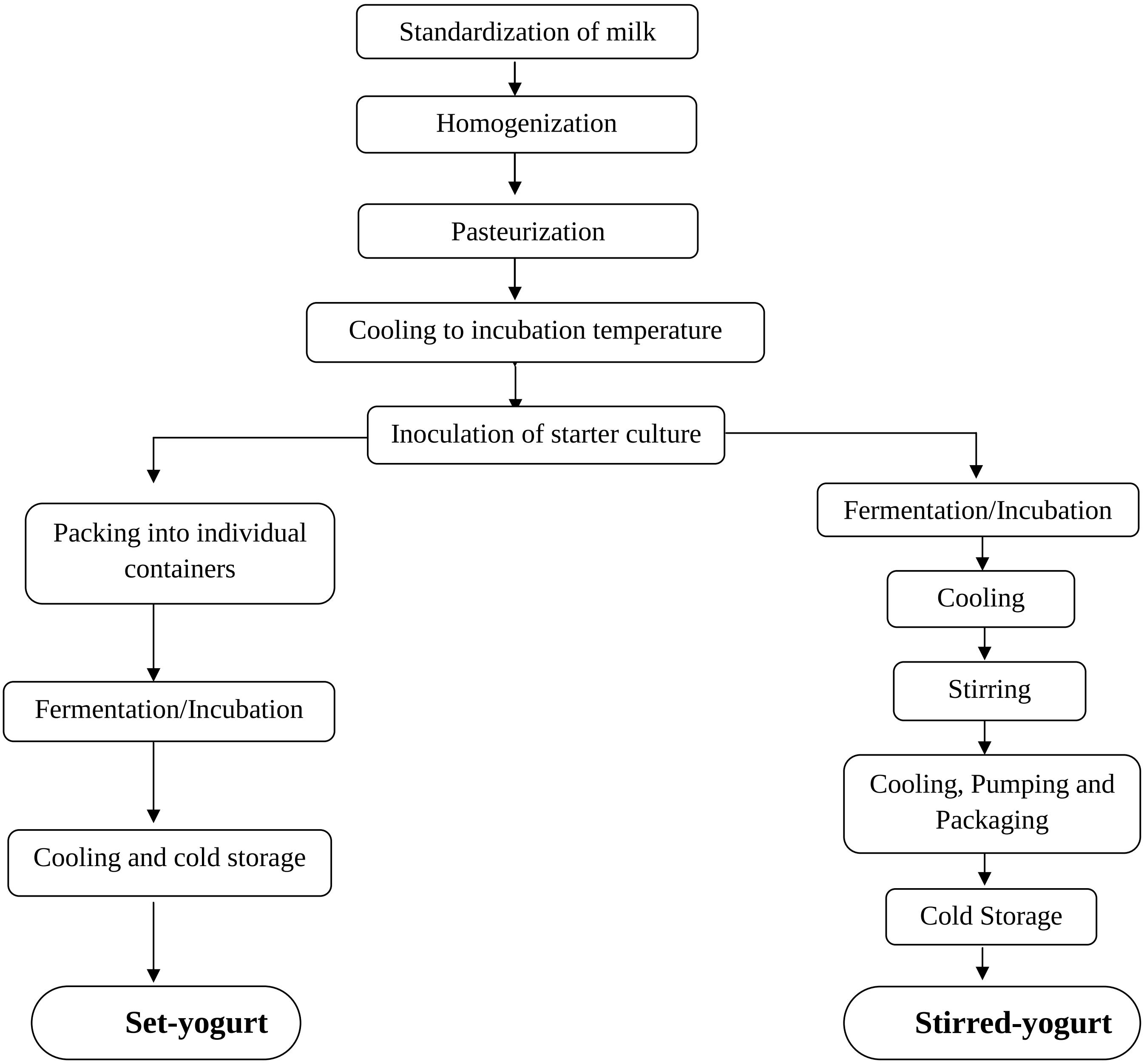


Figure 3: Manufacturing process of set- and stirred-yogurt

I.5.3. Health Benefits

There is a wealth of evidence about the relationship between dairy foods and health. Several studies now show that yoghurt consumption in particular is associated with benefits relating to bone health, cardiovascular health, diabetes and obesity **(Ruxton., 2015):**

- Bone health

Yoghurt provides many of the nutrients needed for optimal bone health such as calcium, protein, magnesium, zinc and phosphorus. The calcium presents in yoghurt is bioavailable as the low pH ionizes calcium, facilitating intestinal calcium uptake **(Williams and al., 2015).**

- Cardiovascular

Studies and meta-analyses have reported beneficial associations between yoghurt intake and cardiovascular disease risk factors. A high yoghurt intake was thought to support blood pressure control and may even help prevent hypertension **(Ralston and al., 2012)**.

- Lactose intolerance

Yoghurt naturally contains less lactose than milk (typically 3.4% compared with 6.0%), suggesting that it may be better tolerated than milk in people with lactose intolerance. An opinion by the European Food Safety Authority confirmed that live yoghurt can be included in the diets of people with lactose mal digestion because, within the gut, the cultures in live yoghurt improve the digestion of lactose **(Ruxton., 2015)**.

- Improvement of the digestibility of proteins

Bacterium lactic produces enzymes which hydrolyze partially proteins of the milk. Therefore, yoghurt contains more peptides and free amino acids than the milk. It is generally admitted that the prehydrolysis of casein improves the digestibility of proteins of the yoghurt **(Scientifique de Syndifrais, 1997)**.

I.5.4. Yogurt and bioactive compounds

Due to a growing demand for functional fermented dairy foods with improved nutritional qualities, the food processing industry has prompted to cut down on ingredients such as fat, sugar and additives, thereby necessitating some important changes in sensory qualities that influence consumer acceptance of fermented dairy products (**Stijepić and al., 2012)**

- Polyphenols are chemical compounds that act as antioxidants, are known for their potential beneficial effects on health. Although some bioactive substances have been added to yogurt in order to enhance the health outcomes of conventional yoghurt (**Georgakouli and al., 2016)**.

- Dietary fibers have beneficial effects for human health. The recommended daily intake of fiber is about 38 g for men and 25 g for women. Dairy product as yoghurt can provide major opportunities for the development of fiber enriched foods. Their acceptability by the consumers is mainly based on satisfactory textural and sensory attributes **(Sendra., et al 2010)**.

EXPERIMENTAL WORK

MATERIALS AND METHODS

Most legumes, broad bean are consumed after a simple industrial process, in which a fibre-rich residue and polyphenols of the legume by-products, broad bean pod is removed who proof that this money by-product is not industrially valued. However in the current tendency, broad bean pod arouse an interest more and more growing as well at the consumer's as at the dietitians and the nutritionists. Therefore, the by-products of these legumes could be added to different foods to provide these beneficial properties **(Mateos-Aparicio and al 2010).**

The yoghurt appears a food of choice within the framework of a balanced diet. Indeed, he is rich in proteins and assures a contribution of vitamins and trace elements, particularly the calcium, while having a moderate energy contribution **(Yahia., 2012).** However, the presence of antioxidants in this fermented milk, small rest and he can contain artificial additives. The powder of the broad ben pod can possibly constitute an interesting matrix, to enrich this food in active substances. That is why the incorporation of this powder in yoghurt, turns out an interesting and promising alternative in the industrial ladder.

What is the technique of drying which guards these nutritional values? What is this denier? How to make a success of a formulation of yoghurt enriched by these broad bean pods?

The answer to these questions will be thus the subject experimental study development.

II. Material and methods

II.1. Plant materials

Fresh broad bean was purchased from local market, Bejaia city (Algeria) in March 2017, then washed by distilled water. The removal of broad bean seed from its pod was made manually. The whole pods were dried by different methods.

II.2. Evaluation of moisture content

Thermal drying method was used in the determination of moisture content of the sample **(AOAC, 1990)**. Broad bean pod was cut into squares (≈ 1 cm and 0.3 mm of thickness) **(Fig.4)** 5g of samples were placed in an oven (ECOCELL) at 105 °C, until constant weight. The moisture content (MC) was calculated by expressing the weight loss upon drying as a fraction of the initial weight of sample used:

$$MC\ (\%) = \left(\frac{w_i - w_f}{w_i}\right).100$$

- W_i: initial weight of sample (g)
- W_f : final weight after drying (g)

Figure 4: Photograph of broad bean

II.3. Drying process

Three methods for drying broad bean pod were investigated, open air drying, oven drying and microwave drying

II.3.1. Oven drying

The broad bean pod were cut **(Fig.5)** then dried in a ventilated oven (MEMMERT, UFB400) **(Fig.6)**, at different temperatures (40, 60, 80, 100 and 120 °C), until constant weight.

II.3.2. Microwave drying

Microwave drying experiments were performed in a domestic microwave oven (Maxipower. Germany) The apparatus was equipped with a digital control system for irradiation time and microwave power (the latter linearly adjustable from 100 to1000 W). Different microwave power (100, 300, 500, 700 and 900W), were used in the drying of broad bean pod, until constant weight **(Fig.7)**

Figure 6: Photograph of oven drying

Figure 5: Photograph of broad bean pod slices

Figure 7: Photograph of microwave drying

II.3.3. Open-Air drying

Open-air drying experiments were conducted by placing broad bean pod, on wire mesh racks placed on a table and set out in the open outdoors away from any structures that would disrupt the natural air flow patterns. Air temperatures were taken using a digital thermometer and the mass was periodically measured up to a constant value.

II.4. Grinding, sieving and water activity

The dried pods were ground using an electric coffee mill (KSW445 CB) **(Fig.8)**and sieved to granulometry < 500 µm and < 250µm prior to extraction **(Fig.9)**. The water activity (aw) of powders was determined by HygroPalm AW. The fine powders were stored in air tight containers until use.

Figure 8: Photograph of electrical grinder

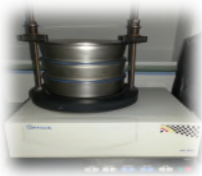


Figure 9: Photograph of sifter

II.4. Color measurement

Color of the samples was measured using a color reader (Minolta, CR10, Osaka, Japan) under white light at 90° angle. The colorimetric coordinates of the powders of broad bean pod peel, were computed in the CIELAB scale. In this scale, each color is numerically specified by a unique set of three cylindrical coordinates ($L^*a^*b^*$): L^* indicates the luminance and changes from 0 for black to 100 for white, a^* changes from - 60 for green to + 60 for red, b^*changes from - 60 for blue to + 60 for yellow. Data were the average of three measurements **(Achat and al., 2012)**.

II.5. Functional properties

Functional properties measured included swelling, water retention capacity and fat adsorption capacity based on the methods described by **(Femenia and al., 1997):**

II.5.1. Swelling capacity (SC)

The sample (100 mg) was hydrated in a measuring cylinder with 10 ml distilled water at room temperature. After 18 h, the volume (ml) occupied was recorded, and SC was expressed as volume (ml)/g of original sample.

II.5.2. Water retention capacity (WRC)

The sample (500 mg) was hydrated in 30 ml distilled water in a centrifuge tube at room temperature. After 24 h, samples were centrifuged (5000g; 30 min). The supernatant was decanted and residue fresh weight was recorded. WRC was calculated as the amount of water retained by the pellet (g water/g sample dry weight).

II.5.3. Oil retention capacity (ORC)

The same protocol as above was followed, substituting extra virgin olive oil (acidity 0.7°) for distilled water. ORC was expressed as g oil/g sample dry weight.

II.6. Determination of crude fiber

The method is based on the solubilization of non-cellulosic compounds by sulfuric acid and sodium hydroxide solutions, according to the method of **(Weende., 1985) (Fig.10)**

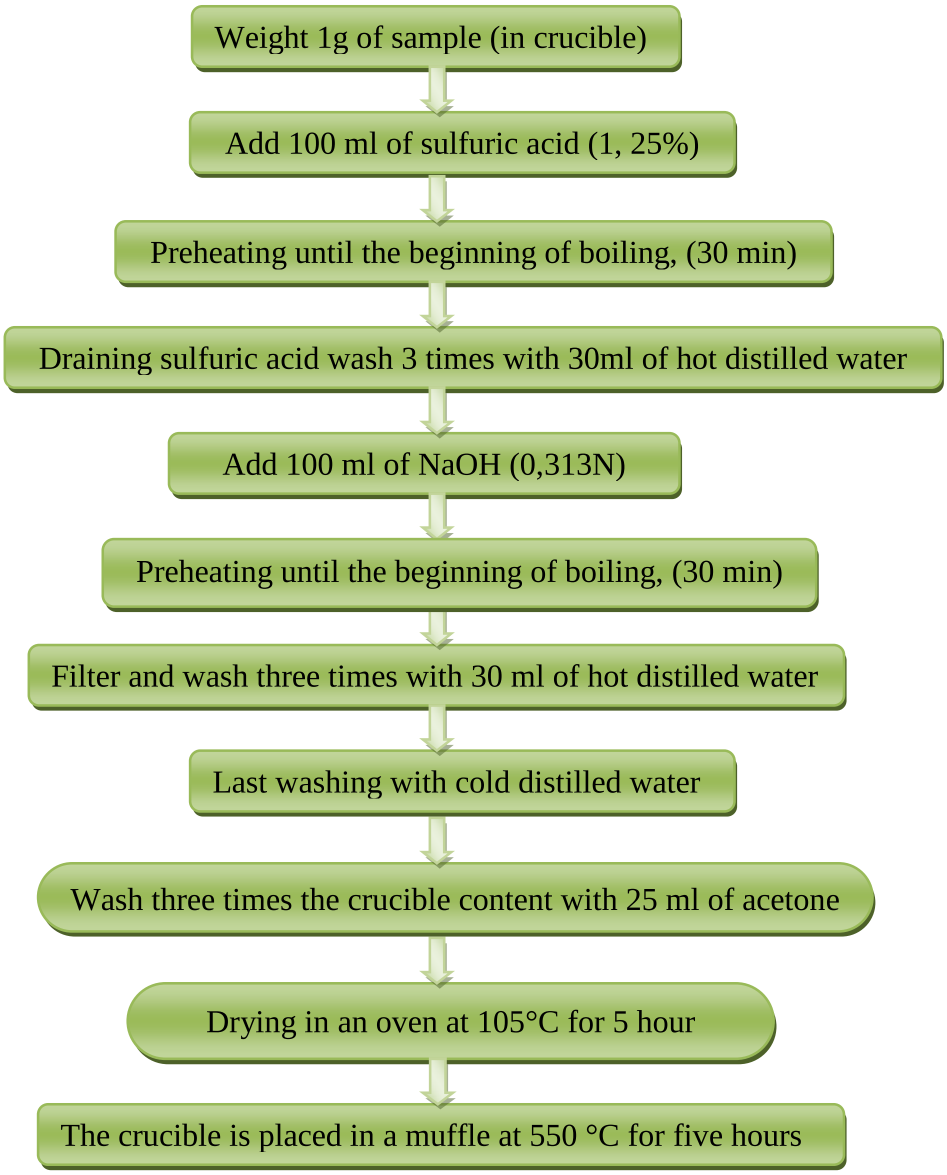


Figure 10: Protocol of determination of crude fiber (**Weende., 1985)**

- **Expression of the results**

Remove the crucibles of the oven and determine the dry weight. Let cool in a desiccator. This weight represents the crude fiber plus ash content in comparison to initial weight.

The mineral represent the part of a plant product which stays, when the organic matter was totally extracted

Reweighed the sample, after cooling in a desiccator. The difference in weight in comparison to preceding weight represents the crude fiber content without ash.

II.6.1. Determination of rate of ashes

The mineral (M) represent the part of a plant product which stays when the organic matter was totally extracted. It is determined by calcination of the sample **(Standard 1981) (Fig.11)**.

Set 1g of powder in porcelain melting pots

↓

Incretion in an oven with mitten in 550°C during 5 hours

↓

Cool in a desiccator and weigh the set

Figure 11: Protocol of determination of rate of ashes **(Norme 1981)**.

- Expression of the results

We to determine the percentage in mineral according to the Protocol describe by **(Standard 1981)** according to the following formula:

$$\%M = 100 \times ((M1 - MMP) / (M0\text{-}MMP))$$

Where:

M: mineral

M1: mass of the sample after the incineration

MMP: mass of the melting pots

M0: mass of the sample before the incineration

II.7. Determination of active ingredients

Broad bean pod can be used as a source of natural functional components, Such as the phenolic compounds, the flavonoids and the tannins **(Abu-Reidah and al., 2017),** before the quantification of these substances it is necessary to extract them at first.

II.7.1. Ultrasonic assisted extraction

Extractions were performed using an ultrasonic processor (Sonics VCX 500, Connecticut, USA) according to the protocol proposed by **(Dahmoune and al., 2013)**. Briefly, 1 g of powder of broad bean pod was extracted with 40 mL of ethanol 64 % during 15 min of holding time and 78 % for amplitude. The extracts were filtered through Whatman N°3 paper and the recovered and transferred to 100 mL volumetric flask.

II.7.2. Determination of total phenolic contents

The polyphenol content (TPC) of the broad bean pod extract, was quantified using the Folin-Ciocalteu reagent **(Fig.12).**

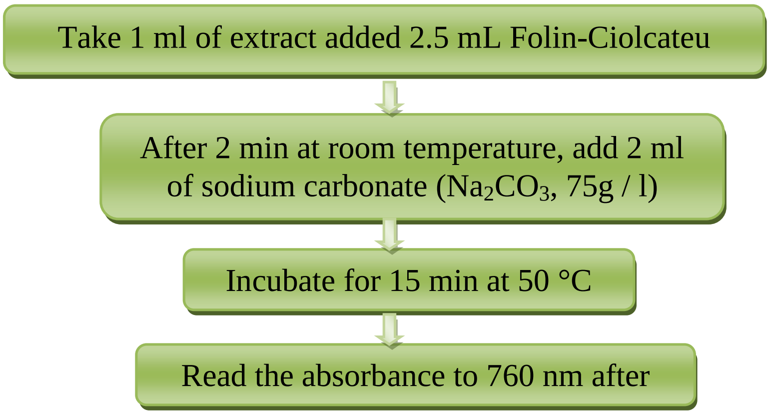


Figure 12: Protocol of Determination of Total Polyphenols **(George and al., 2005)**.

- TPC concentration was calculated from a calibration curve, using gallic acid as a standard and the results were expressed as mg gallic acid equivalents per 100 g of dry matter (mg GAE/ 100 g). All determinations were carried out in triplicate.

III.7.3. Flavonoid content

The content of total flavonoids (TFC) was estimated by the aluminum chloride method **(Fig.13).**

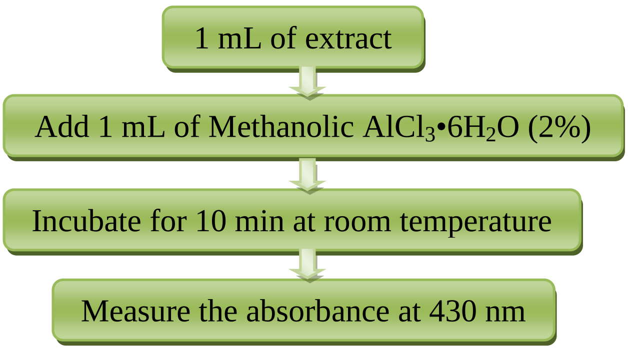


Figure 13: Determination of TFC **(Quettier-Deleu and al., 2000).**

- The results were expressed in mg quercetin equivalents/g dry weight of fine powder (mg QE/ g DW) of broad bean pod.

II.7.4. Condensed tannins

The condensed tannins are determined by the Vanillin in an acid medium **(Fig.14)**. This method is based on the ability of vanillin to react with condensed tannin units in the presence of acid to produce a colored complex measured at 500 nm **(Price and al., 1978)**.

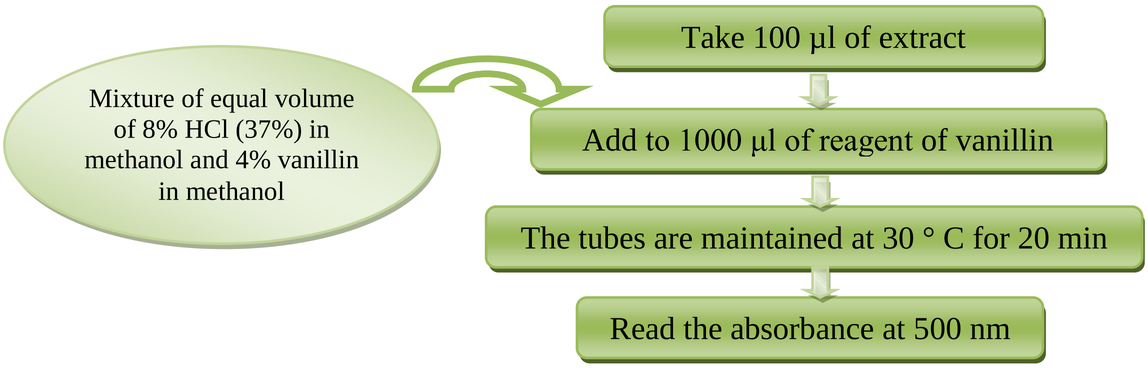


Figure 14: protocol of determination of condensed tannins **(Price and al., 1978).**

- Catechin is used as a standard and results are expressed in mg of catechin equivalent per 100 mg of flour dry matter (mg CE/ 100 mg DM).

II.8. Antioxidant activities

II.8.1. Reducing power assay

The reducing power was determined according to the method of (**Oyaizu., 1986**), as shown in figure15

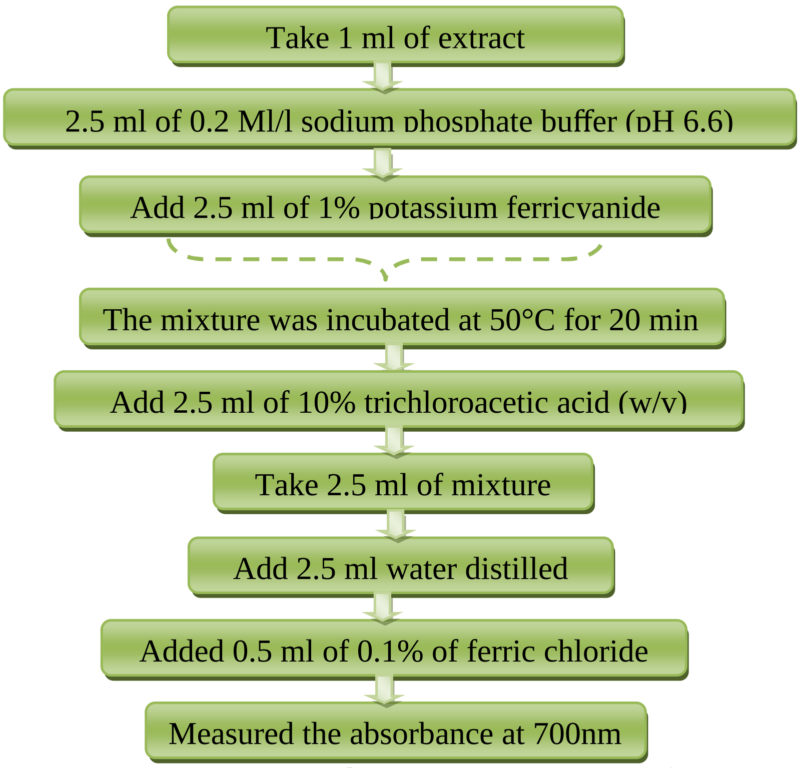


Figure 15: Determination reducing power assay (**Oyaizu., 1986**)

- Higher absorbance indicates higher reducing power.

II.8.2. DPPH° assay

The electron donation ability of the extracts **(Fig.16),** was measured by bleaching of the purple-colored solution of 1,1diphenyl-2-picrylhydrazyl radical (DPPH°), according to the method of **(Brand-Williams and al., 1995).**

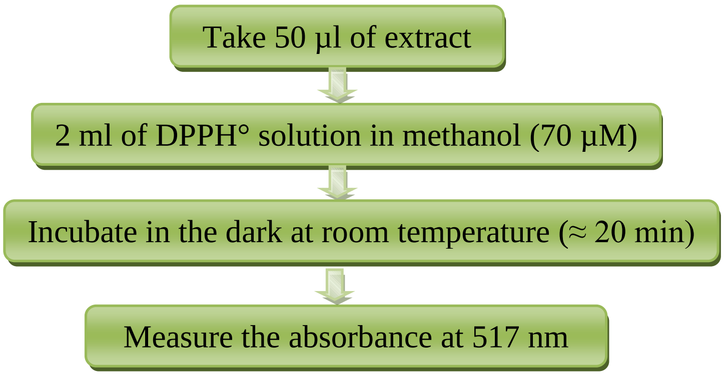


Figure 16: DPPH° assay **(Brand-Williams and al., 1995).**

- The antioxidant capacity of the extract was expressed as a percentage of inhibition of DPPH radical (% inhibition of DPPH radical), calculated according to the following equation:

$$\% \text{ DPPH inhibition} = (\text{Abs Control} - \text{Abs sample}) / \text{Abs Control} \times 100$$

Where: $Abs_{Control}$: absorbance of DPPH° solution;

Abs_{sample}: absorbance of DPPH after reaction with the extract

The quantity (lg) of dry extract per mL of reaction medium necessary to decrease the initial DPPH radical concentration by 50% (IC50) was determined using an exponential curve.

From data elaboration (% inhibition plotted versus total phenols concentration), the concentration of TPC required to reach 50% radical inhibition (IC sample 50) was calculated **(Achat and al., 2012)**

II.9. Formulation of fruity stirred yoghurt at laboratory scale

II.9.1. Manufacture of yoghurts

The preparation of yoghurt was made in the laboratory of the dairy industry "DANONE DJURDJURA". The recipe was applied as shown in table 02. Thus milk was homogenized and heated to 95 °C for 5 min then cooled to 40 °C. After then, traditional starter culture was added and the mixture was incubated until the gel structure was formed. The gel was stirred and stored at refrigerator

(6 ± 2°C), in this case a standard stirred yoghurt was obtained. The same experiment was done with the other yoghurts except that whereas dried broad bean pod were added.

Table 02: Recipe of stirred yoghurts with the broad bean pod (polyphénols and fiber).

Recipe	Milk (L)	Sugar (g)	Pods (%)	Lactic Ferment (%)
Standard yoghurt	1	80-100	0	0.02
Stirred yoghurt (polyphenols)	1	80-100	(--)	0.02
Stirred yoghurt (Fiber)	1	80-100	(--)	0.02
Stirred yoghurt (polyphenols + fiber)	1	80-100	0	0

II.9.2. Physico-chemical properties of yoghurt

Physico-chemical properties of the manufactured yoghurts (standard yoghurt, yoghurt enriched with polyphenol and fiber) were determined namely, pH, dornic acidity, viscosity, the dry extract and fat contents **(Tab.03)**. These tests were carried out at the laboratory of the dairy industry "DANONE DJURDJURA".

Table 03: Physico-chemical properties of prepared yoghurts

Measure	Method
pH	The pH value of yoghurt was measured at fixed temperature (9.5- 10.5°C) with a calibrated pH electrode (HANNA HI 2210).
Viscosity (g)	Apparent viscosity of yoghurt was expressed using a viscometer "TAXT EXPRESS" during 45 S.
Dornic acidity (°D)	10 g of sample (adjusted with distilled water up to 60 g), was put in acidometer apparatus then the result was directly displayed
Brix degree	The soluble solids content of the filtered yoghurt (whey) and was assessed by the refractometer, where sugar content value was given
Total dry extract (%) Protein content (%) Fat contents (%)	50 g of yoghurt was placed in "Food scan" apparatus which give the values of total dry extract, protein and fat contents.

II.9.3. Microbiological analysis

Microbiological quality of prepared yoghurt was evaluated by enumerating total viable organisms. The organisms enumerated include total flora, yeast, moulds, total coliforms and specific bacteria of yoghurt **(Tab.04)**.

Table 04: Microbiological analysis of manufactured yoghourts

Micro-organisms	Selective mediums	Incubation temperature	Incubation time	Method
Yeasts, moulds	VRBL	30°C	24h	3g of the Yoghurt samples was spread plated in triplicates into prepared and dried petri-plates of suitable media for the enumeration of different organisms
Total Flora	PCA	30°C	72 h	
Total Coliforms	YGC	25°C	5 days	
Streptococcus thermophilus	M17	37°C	48h	
Lactobacillus bulgaricus	MRS	37°C	72h	

VRBL: Violet Red Bile Agar
YGC: Yeast extract glucose chloramphenicol agar
M17: M17 agar
MRS: Rogoza and Sharpe agar

II.9.4. Antioxidant activity

The Radical scavenging capacity was measured in manufactured yogurts by the DPPH$^•$ assay (Section II.8.2). The TPC content in fermented milk products were also determined by using colorimetric methods (Section II.7.2).

- Sample preparation

- *Yogurt water extract*

Yogurt sample (10g) was mixed with 2.5ml distilled water and the yogurt pH was adjusted to 4.0 using 1M HCl. The yogurt was then incubated at 45 ^oC for 10 minutes, followed by centrifugation (10000 rpm, 20 minutes, 4 ^oC). The supernatant was harvested and the pH was adjusted to 7.0 using NaOH. The neutralized supernatant was recentrifuged (10000 rpm, 20 minutes, 4^oC) and the supernatant was used in analysis **(Zainoldin and al., 2009).**

II.10. Statistical analysis

All experiments were conducted in triplicate and results are expressed as mean ± standard deviation (SD). Data were treated for multiple comparisons by analysis of variance (ANOVA) in the software JMP7 (Trial Version 7.0.3, Stat Ease Inc., Minneapolis, MN, USA), Evaluations were based on the $p < 0.05$ significance level.

RESULTS AND DISCUSSIONS

III. Results and discussions

III.1. Moisture contents and water activity

Drying is the process of removing the moisture in the product up to certain thershold value by evaporation. In this way, the product can be stored for a long period, inactivate enzymes, deteriorative microorganisms and reduce water activity **(Maskan and al., 2001).** The drying efficiency was evaluated in terms of water loss; moisture and water activity for the various powders obtained (after drying and grinding) in the various conditions applied **(Fig.17).** The water content of freshly broad bean pod was 89 ± 1.12 %. This result is in accordance of humidity rate of vegetable and fruits 80-90% **(Mirabella., 2013)**

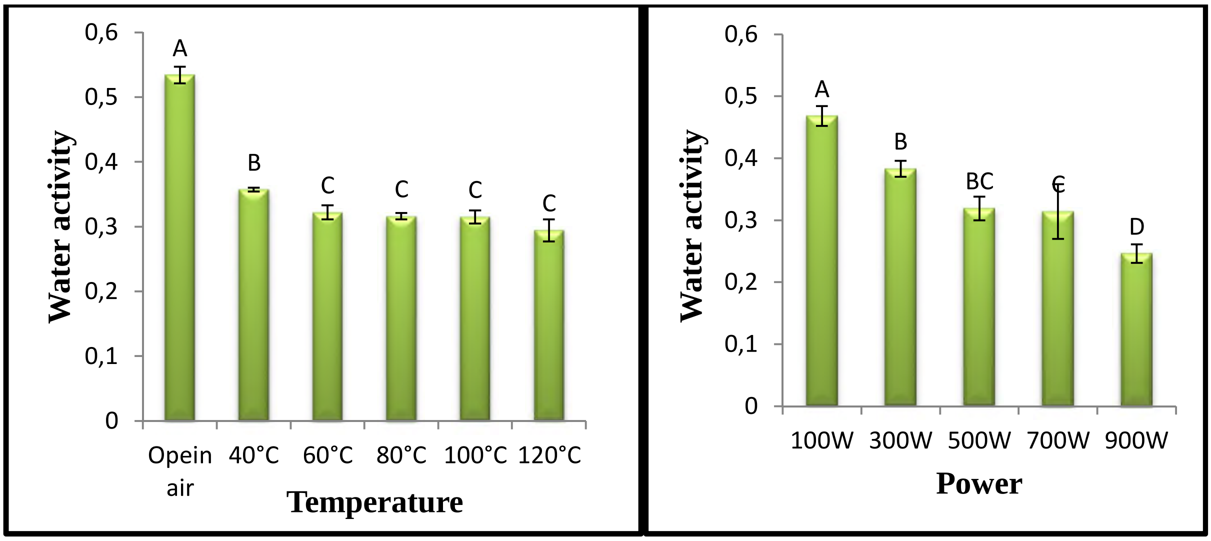


Figure 17: Water activity of broad bean pod powder dried by oven, open-air (at left) and microwave (at right).

High water activity indicates more water available for biochemical reactions and hence, shorter shelf life. Generally food with $a_w < 0.6$ is considered as microbiologically stable and if there is any spoilage occurs, it is induced by chemical reactions rather than by micro-organism **(Chiewchan and al., 2010)**. From the results, the water activities of the broad bean pod powders were in the range of 0.28 – 0.52. This means that the pea pod powders were relatively stable microbiologically. However, the storage conditions also played an important role in this matter.

The results of the water activity show that there is significant difference ($p \leq 0.05$), between open-air, microwave and oven drying methods. On the other hand, the water activity of the open-air drying method is higher compared to the two other methods. This confirms the microbiological efficiency of drying by microwave and oven.

III.2. Color

Color is one of the more important quality parameters in dehydrated fruits and vegetables **(Femenia and al., 2003).** The results of the total color difference ΔE between fresh broad bean pod samples and those after drying were illustrated in the figure 18.

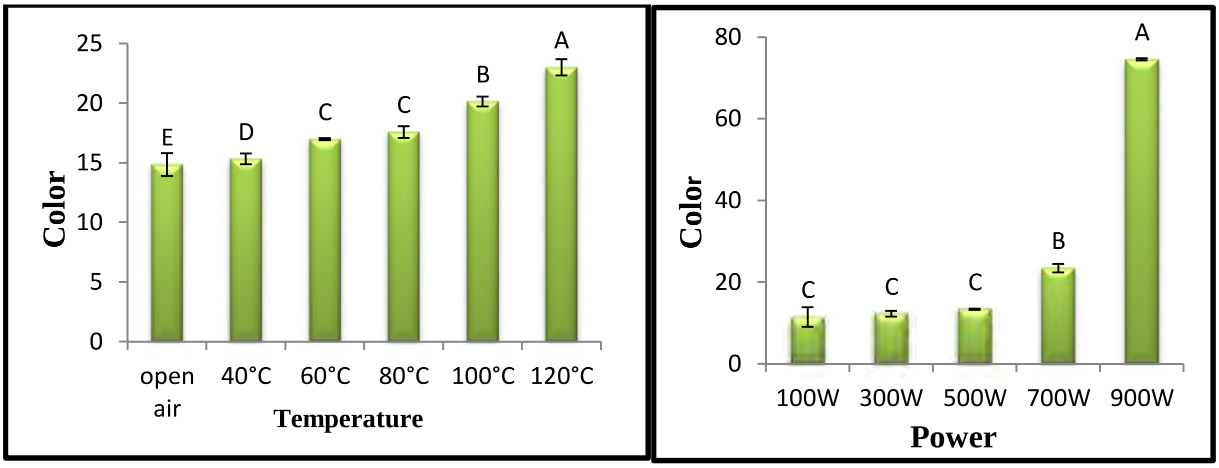


Figure 18: Color of broad bean pod powders dried by Oven, Open-air (at left) and by microwave (at right).

The color of powder obtained by oven drying, increase with the increasing of the temperature, the same observation for microwave ($p \leq 0.05$). The last one, of drying method, often yields better color **(Orsat and al., 2007**), confirmed by the results obtained using different power. The lowest ΔE value was obtained at the lower microwave power level 100w (11.454 ± 2.353), which is close to the color of sample fresh. However the highest ΔE value was attributed for 900 w (74.529±0.270). This increase can be associated with production of brown pigments with low and high molecular weights by Maillard reaction, often occurs when foods are heat-treated **(Jogihalli and al., 2017**; **Femenia et d'autres., 2003).** Indeed parameters affecting the Maillard and non-enzymic reactions are primarily temperature and the duration of the heat treatment **(Femenia and al., 2003).**

Reactions can affect the color during the thermal process of vegetables, the most known are: the degradation of pigments, specially carotenoids and chlorophyll, reactions of tanning (reaction of Maillard), and the oxidation of the ascorbic acid **(Barreiro and al., 1997; Lee and Coates, 1999)**.

III.3. Drying

III.3.1. Speed of drying

In the aim of estimating the efficiency of the drying, the drying time and the speed f drying were determined for various powders obtained in the various applied conditions. The results were presented in the table VI.

Table V: Time and speed of drying of pods with different powers and temperatures.

Temperature (°C)	Time of drying **s**	Speed of drying **s**	Power (W)	Time of drying **s**	Speed of drying **s**
Open-air 24°C	1814400	$4,4091.10^{-5}$	100	57600	$1,388.10^{-2}$
40	64800	$1,1695.10^{-3}$	300	7800	$1,0125.10^{-2}$
60	25200	$3,1746.10^{-3}$	500	3900	$2,05125.10^{-2}$
80	21600	$3,7037.10^{-3}$	700	2880	$1,4305.10^{-2}$
100	14400	$5,555.10^{-3}$	900	995	$8,0402.10^{-2}$
120	7200	$1,111.10^{-2}$	/	/	/

The results show that temperatures affect the drying time of bean pod. There is an inverse relationship between temperature and drying time; an increase in temperature resulted in a decrease in the drying time. Indeed, at high temperatures (100 to 120 °C), the drying time is much faster. As represented in table IV, samples set 2 hours to dry at 120 °C, while 17 hours at 40 °C. These results are similar to those reported in the literature **(Bonazzi and Bimbenet, 2003; Vasseur, 2009)**, which revealed that the drying time is inversely proportional to the temperature applied.

It can be observed that increasing microwave output power substantially increases the drying rate and thus decreasing drying time. This indicates that mass transfer within the sample was more rapid during higher microwave power heating, because more heat was generated within the sample creating a large vapor pressure difference between the center and the surface of the product due to characteristic microwave volumetric heating **(Wang et al., 2000).** Microwave drying is not only faster but also requires less energy consumption than conventional drying **(Adiletta and al., 2016)**.

III.4. Functional properties

The important properties of dietary fiber of bean pod including water retention capacity (WRC), oil- retention capacity (OHC) and swelling capacity (SC) are suggestive of the possibilities of using fibers as ingredients in food products.

III.4.1. Swelling capacity

SC of pea pod dried with different methods drying was measured. The corresponding results are shown in figure 19

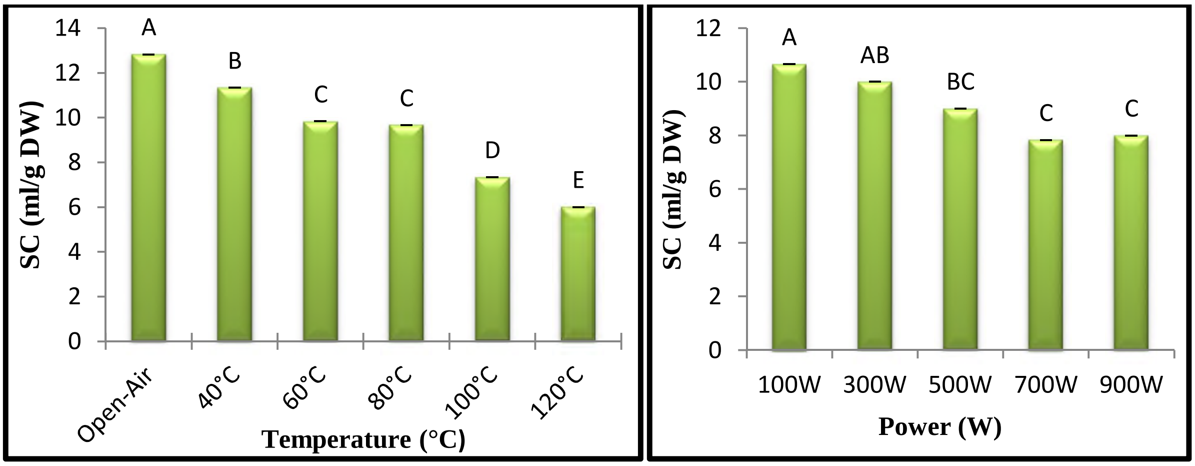


Figure 19: Swelling capacity of broad bean pod dried by Oven, Open-air (at left) and by microwave (at right).

In the reflection of this figure, we note that the SC of the powder decreases with the increase of the temperature and the power, with significant difference (P <0.005). Drying at open-air and 40°C give the greatest SC (12,83 ± 0,28; 11,33 ± 0,57 ml/ g DW, respectively). Whereas, the lowest SC is obtained at 120°C (6 ± 0,00 ml/ g DW), that can be explained by decline in the water absorbance capacity.

The value of SC obtained by the temperature of 60°C (9,83 ± 0,28 ml/ g DW) is in accordance with SC found by **Mateos-Aparicio and al (2010)**: 9.96 ml/ g DW, after the freeze-dried process of broad bean pod.

The Dried products are characterized by the low porosity **(Wu and al., 2007)** and the rehydration ratio decreased as the drying temperature was increased **(Singh and al., 2007)**

In microwave drying, the highest SC is attributed to the power of 100 W (10,66 ± 0,57 ml/ g DW), furthermore 900 W recorded the lowest one (8±0,57 ml/ g DW). The microwave drying offers higher drying fails and shorter drying time, more porous to higher rehydration compared to ratio convective drying **(Aydogdu and al., 2015).**

III.4.2. Water retention capacity

WRC provides more information about the type of fiber, in particular about the pore size of the substrate, and so might explain behavior in food as well as during intestinal transit. **(Mateos-Aparicio and al. 201)** WRC results of bean pod, dried at different drying microwave power levels and temperatures were illustrated in figure20.

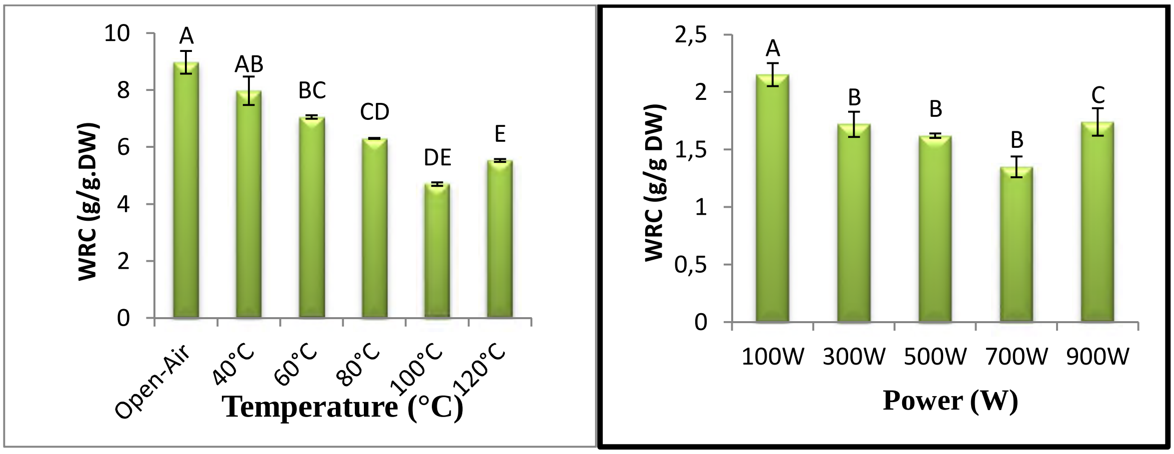


Figure 20: Water-retention capacity of broad ben pod powders dried by Oven, Open-air drying (at left) and by microwave (at right)

These results show that there is a significant difference ($p<0.05$), between the open air (8.97±0.4 g/g DM) and other applied temperatures. On the other hand there is no significant difference between 60°C (9.83±0.28 g/g DM) and 80°C (9.66±0.57 g/g DM).

For drying with microwave, the powder dried at 100W presents the highest WRC ($p<0.05$). We also notice that there is no significant difference of WRC results, obtained at 300W, 500 W and 700W.

Every time the temperature increases the WRC decreases, which can be explained by the low porosity characteristic of the dried products **(Wu and al., 2007).** The other reason might be also the porous nature of the cell which drink and hold some water through capillary action **(Jogihalli and al., 2017).** The dried products are characterized by the low porosity

(Wu and al., 2007) and the rehydration ratio decreased as the drying temperature was increased **(Singh and al., 2007).**

The WRC value obtained by drying open-air (8,97 ± 0,40 g/ g DM) is in a good agreement to WRC that found by **Mateos-Aparicio and al. (2010),** after a freeze-drying process.

III.4.3. Oil retention capacity

ORC depends on surface properties, overall charge density, thickness and the hydrophobic nature of the fiber particle **(Mateos-Aparicio and al 2010).** The mean values of ORC, recorded for the dried bean pod using open air, oven and microwave drying were shown in figure21.

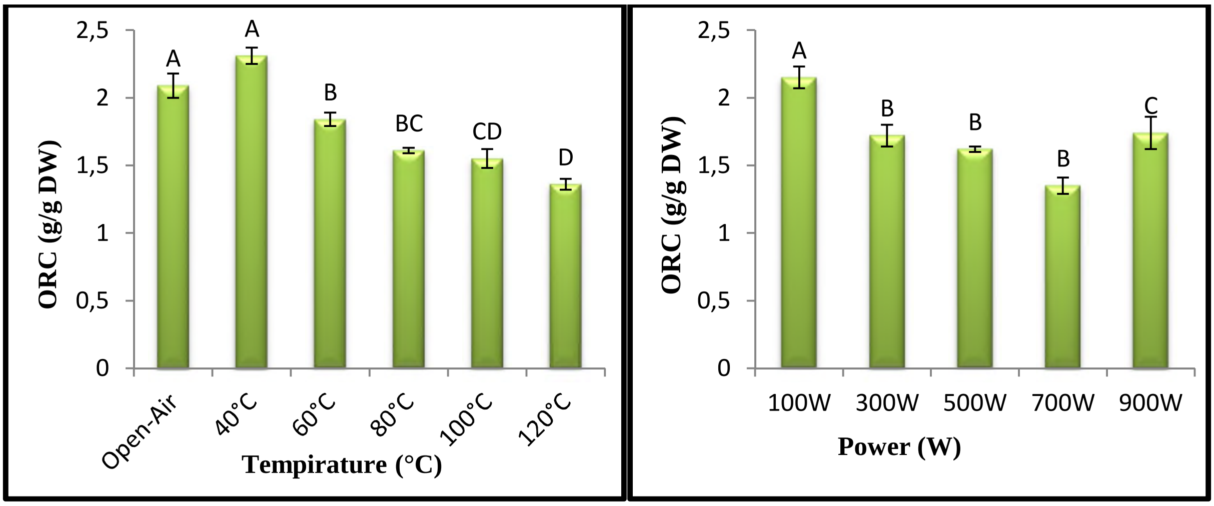


Figure 21: Oil retention capacity of broad bean pod powders dried by Oven, Open-Air drying (at left) and by microwave (at right)

As it can be seen, that oven drying decreases the WRC of bean pod and 40 °C possessed the highest WRC (p<0.05), compared to other applied temperatures. The microwave drying, recorded a greater WRC at 100 W, but with a less WRC at 900 W. The statistical study showed that there is no significant difference (p<0.05), between powers (300 to 700 W).

The reason of decrease of ORC can be linked to the porous nature of the sample which drink and hold some water through capillary action, The g/g of the Oil and drying processes reduced considerably the ORC of 2,31 ± 0,26 in 40 °C until 1,36 ± 0,04 in 120 °C. The same trend was obtained in microwave, that can be attributed to the denaturation and the dissociation of the constituent protein **(Jogihalli and al., 2017).**

III.5. Crude fiber

Fiber broad bean pod are studied because of their importance in the functionality and nutritional quality of food fibers **(Fendri and al., 2016).** The results obtained during the determination of the crud fibers content (CFC) of the dried pea pods using open air, oven and microwave methods are shown in figure 22.

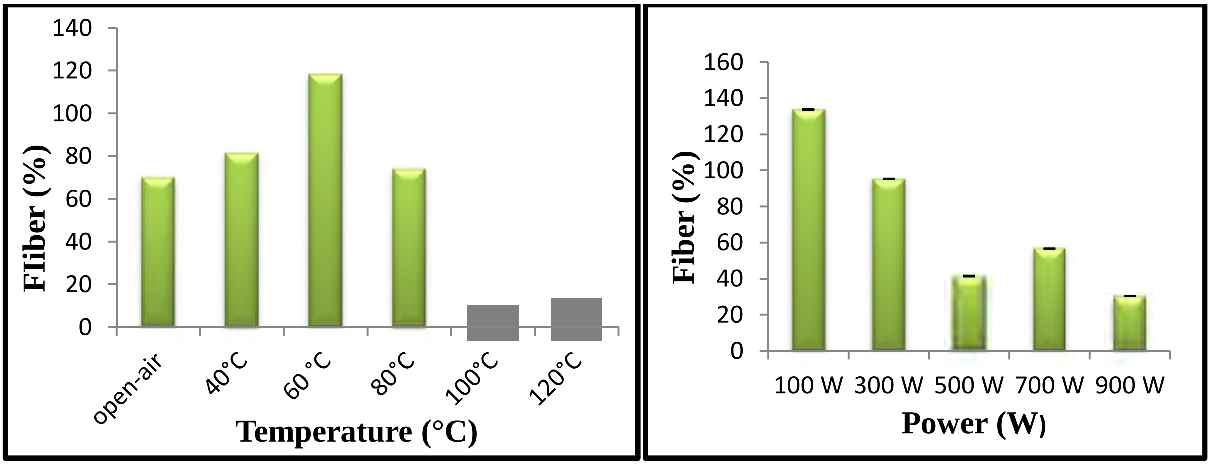


Figure 22: Crude fiber of broad bean pod powder dried by Oven, Open-Air drying (at left) and by microwave (at right)

In the reflection of this figure, we note that the contents in fiber of bean pod powders depend on drying methods. The temperature of 60°C recorded the highest content in fiber (118.35 %), followed by a reduction at 80 °C and 100 °C, to reach a minimal value at 120 °C (11,4 %).

The results show that the content in fiber of pods dried in the microwaves, is inversely proportional to the applied power. The highest content was attributed to the power 200 W (53,5 %) and the lowest one at 900 W (33,25 %). This decrease can be explained by the degradation of fibers by the strong powers generator of waves.

Products with content in fibers superior to 50 % can be considered a source of food fibers **(Larrauri 1999).** Consequently the presence of this great amount of dietary fiber provides an important added value broad bean pod and could be considered as a good a source of fiber.

III.5.1.Total ash content

Ash is an incombustible residue obtained after incineration **(J.O.R.A., 2016).** The ash contents of different powders obtained after drying with the three methods are illustrated in figure23

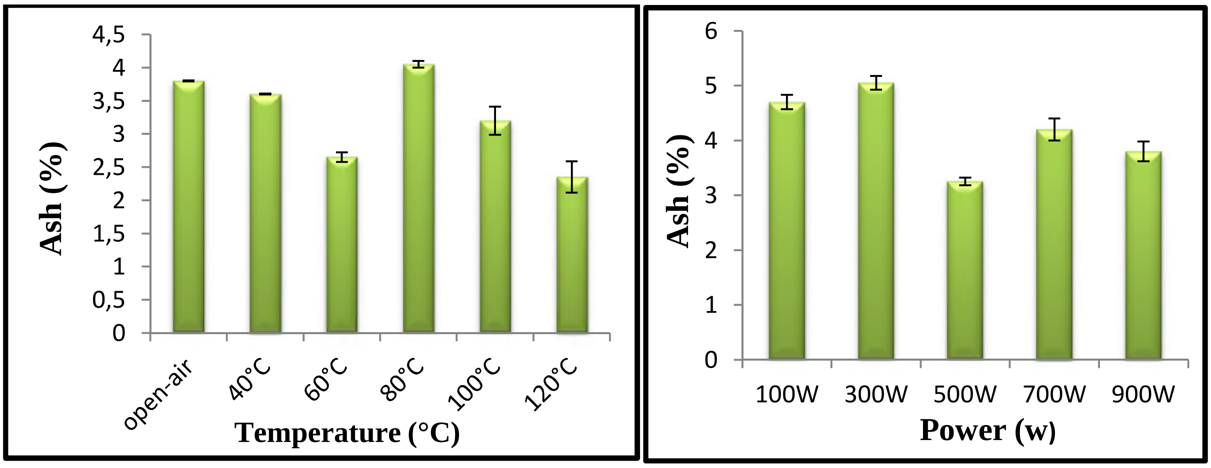


Figure 23: Ash contents of bean pod dried in the open-air, oven and in microwave

According to the results, the total ash content of the dried bean pod with oven ranged from 2.35 to 4.05 %, which represent the highest percentage (4.05±0.05 %), at 80°C ($p<0.05$). For Microwave treatment, the maximal ash content was attributed to 300 W (5.05±0.125 %), the lowest content was obtained with 500 W (3.2±0.2 %)

These data are close compared to the results obtained by **Mateos-Aparicio and al., (2012).** For the same matrix

III.6. Determination of polyphenols

III.6.1. Total phenolic content

Figure 24 depicted the amount of TPC of broad pea pod, using different drying methods. The results obtained were statistically different ($p < 0.05$).

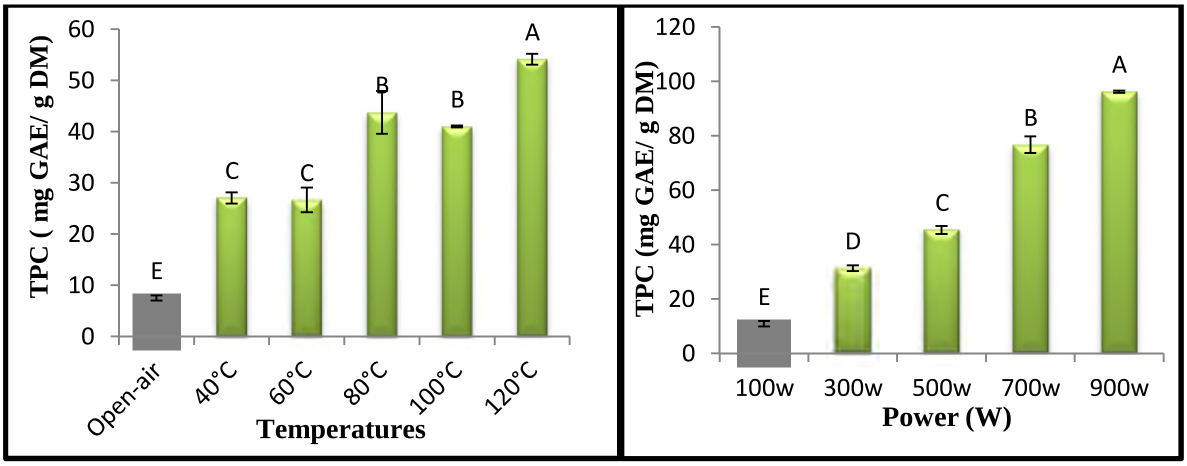


Figure 24: Total phenolic compounds of broad bean pod in different types of drying

Among results obtained pods dried at 900 W and 120 °C were the richest in phenolic compounds (14.253± 1.588; 13.298 ± 2.396 mg GAE/g DW) respectively. Whereas the by-product dried usijng open air and at 100 W resulted in the weakest concentration of TPC (3.961 ± 0.562; 4.975 ± 0.99 mg GAE / g DW respectively).

The increase of TPC could be due to the destruction of the cellular walls and the compartments under cellular during the drying, which leads the phenolic liberation of compounds **(Boukanouf and al., 2015).** According to **Jogihalli and al. (2017)** the time and the heat are both factor which leads the increase of total phenolic contents.

It is noted that the total phenolic compounds in pea pods are not in agreement with to those found by **Mateos-Aparicio Cediel (2012):** 30.8 ± 2.3 g kg^{-1}. This difference is probably due to the extraction method and drying process (freeze dried) **.**

III.6.2. Flavonoïd content

The results of the determination of total flavonoïds content for the various powders obtained after drying with the three methods are illustrated in figure 25

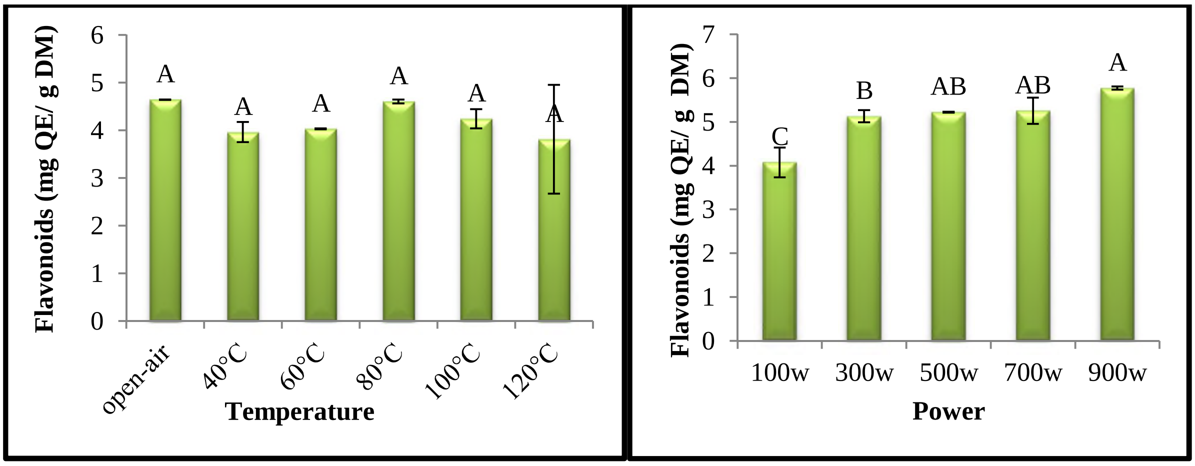


Figure 25: Flavonoïds contents of pods dried by Oven, Open-air drying and by microwave

Microwave drying at 900 W exhibited the highest flavonoid content (5,77 ± 0,038 mg QE / g DW), and the lowest yields were obtained at 100 W and at 40°C (4,075 ± 0,341; 4,026 ± 0.01 mg QE / g DW respectively) at $p<0.05$. Oven drying show less yield of flavonoïd and whatever the used temperature for drying pods, there is no significant difference ($p>0.05$).

III.6.3. Condensed tannins

The results of the determination of condensed tannins content for the various powders obtained after drying with the three methods are summarized in figure 26

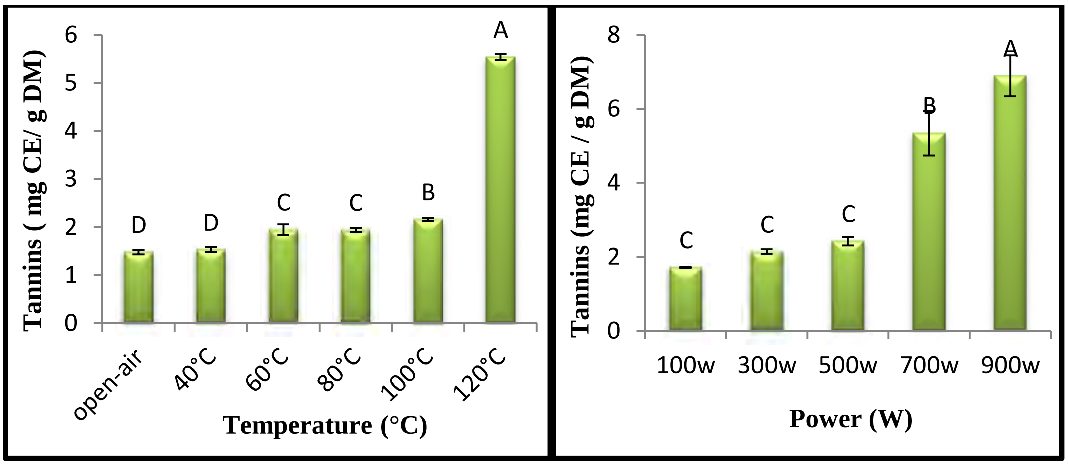


Figure 26: Condensed tannins of broad bean pod extracts

The highest level of total tannins of the dried powder extracts, has been detected in microwave at 900 W (6.86 ± 0.55 mg CE/g DM), followed by oven drying at 120 °C (5.54± 0.6 mg CE / g DW). However the lowest content, was recorded in open-air drying (1.48 ± 0.048 mg CE/g DM).

There are many factors that affect the tannin content, such as harvest time and temperature. **(Elsheikh and al., 1997)**

III.7. Antioxidant assays

III.7.1. Reducing power

Fe(III) reduction is often used as an indicator of electron-donating activity, which is an important mechanism of antioxidant action, and can be strongly correlated with other antioxidant properties **(Dorman and al., 2003)**. In this work, all samples **(Fig.27),** showed their abilities to reduce Fe^{3+} to Fe^{2+}. The increase in the absorbance at 700 nm of the reaction mixture caused by the tested extracts is indicative of their increased reducing power.

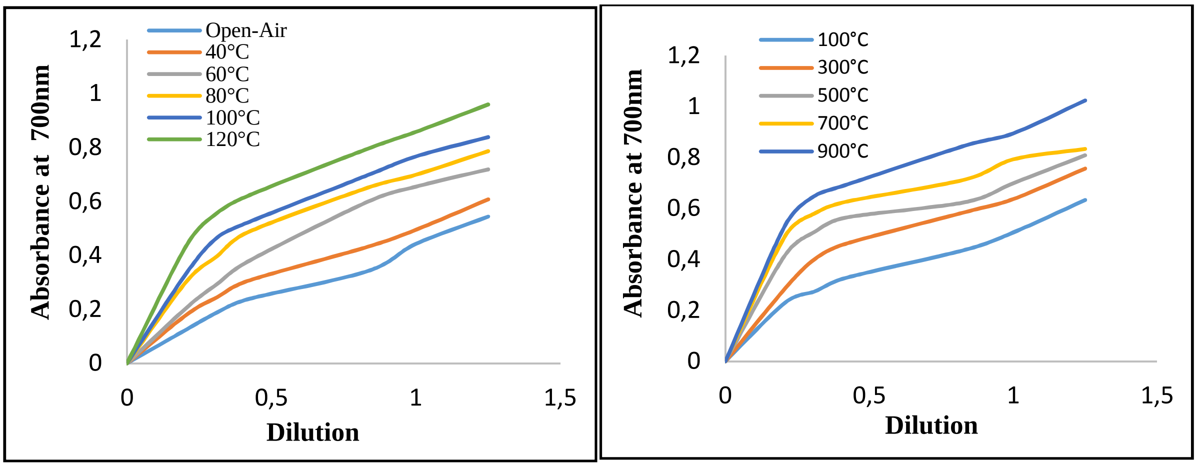


Figure 27: Reducing power of the broad bean pod dried in oven, open-air and microwave.

The reducing power of pods dried in oven exhibit the high absorbance at 120 °C extract , followed by the treatment at 100 °C and 80°C (A= 0.883; 0.794) respectively. At 40 °C and 24 °C, weaker absorbances were recorded (0.492 and 0.529 respectively).

In the case of dried microwave samples, reducing power of broad bean pod showed the same order of the ability of sample to act as the donor of hydrogen atoms or electron: 900 W > 700 W > 500 W > 300 W > 100 W (0.919; 0.879; 0.793; 0.688; 0.627 respectively)

When all these data were taken into consideration, it can be suggested that all phenolic do not have the same antioxidant activity; some are potent while some have moderate antioxidant activity and others have weak antioxidant activity**. (Odabasoglu and al., 2004)**

III.7.2. Radical-scavenging

The DPPH radical is usually used as a substrate to evaluate the antioxidative action of antioxidants by determining the free radical-scavenging ability of various samples **(Achat and al., 2012*)***. Figure28 shows the DPPH° radical scavenging activity of different extract of dried pea pod, and the results are significantly different.

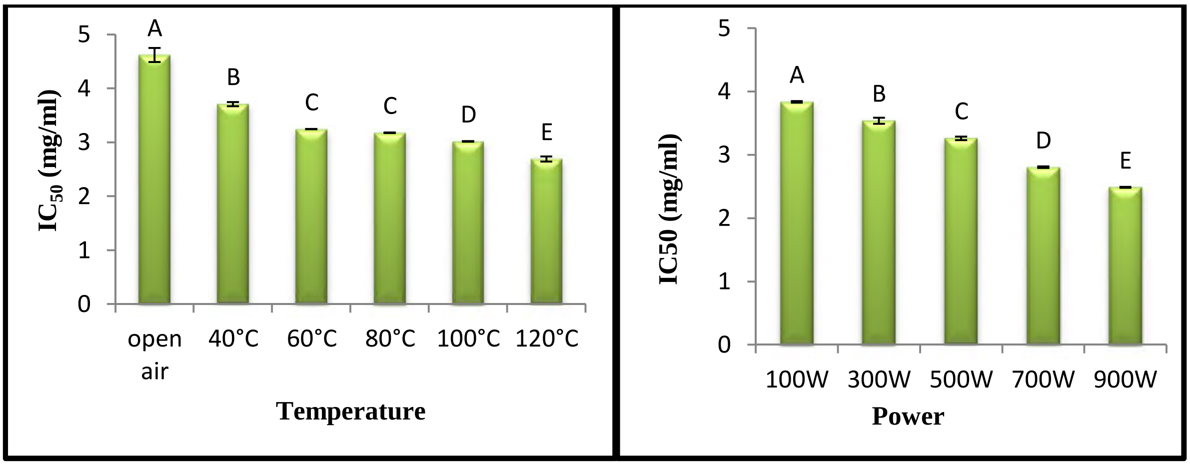


Figure 28: Antiradical activity (IC_{50}) of pods, dried in open-air, oven and microwave.

The IC_{50} values (the concentration reducing 50% of DPPH) obtained for scavenging activities on DPPH° radical, were evaluated. The lower the IC_{50} value the greater the free radical-scavenging activity. Thus, the strongest activities ($p < 0.05$) were obtained in the case of drying method of microwave at 1000 W (3.014$\pm$0.05 mg/ml), followed by oven drying at 120°C (2.69$\pm$0.04 mg/ml). However the sample of 40°C, 24°C and 100W possessed weaker antioxidant effects ($P < 0.05$): 3.938 ± 0.042; 0.753 ± 0.145 and 2.876 ± 0.109 mg/ml respectively.

Consequently, the activity of the strongest reduction could be attributed to the wealth of extracts in phenolic **(Boukhanouf and al 2015)** due to their properties of the redox which make them act as reducing agents, donors of the hydrogen, and that bids of the only oxygen **(yahia and al., 2013)**. Authors showed also that the content raised in total phenol increases the capacity antioxidant total **(Boukhanouf and al 2015)**

The IC50 obtained in this study was very higher than those obtained by **Mateos-Aparicio., 2012,** for the same matrix (0.43 mg mL^{-1}). This difference can be explained by the difference of the drying technique (freeze), extraction method and climatic conditions of broad bean pod.

III.8. Characterization of prepared yoghurt

III.8.1. Physico-chemical analysis

Physico-chemical properties of the manufactured stirred yoghurts (standard Brewed. Brewed with broad bean pod), were shown in table V

Table VI: Physicochemical analysis of stirred prepared yoghurts.

	pH	Viscosity (m pas)	Total dry extract (%)	Fat content (%)	Protein content (%)
Standard yoghurt	4.45	24.6	23.6	2.75	2.62
Brewed t with fiber	4.57	23.82	29.7	4.73	6.90
Brewed with polyphenol	4.40	25,6	25.2	2,73	2.71
Brewed t mixed with TPC and fiber	4.43	26.68	24,44	2.84	2.79
Norms	4.4-5.7		23.9- 25.15	2.75-3.15	2.85-3.15

- Results revealed that pH, dry extract, viscosity, fat and protein content determinations were conform to norms. However an increase in total dry extract, fat and protein content were observed after addition of fiber of broad bean pod to standard yoghurt. On the one hand this may be related to chemical composition of pods (protein: 13.6g; fat: 1.3 g and fiber: 40g) **(Mateos-Aparicio and *al*., 2010)**., on the other hand to its impact on the aggregation of casein network in yoghurts via electrostatic interaction. and on the resistance for the yoghurt matrix to flow. Indeed the addition of plant extracts generally decreased the consistency of the products owning to reduced water-binding capacity of proteins **(El-Said et al. 2014)**

III.8.2. Microbiological analysis

Microbial quality of the manufactured stirred yoghurts was given in table X.

Table VII: The results of the microbiological analyses of yoghurt prepared.

	Total coliforms at 37°C	Moulds And Yeasts	Lactic flora
Standard Brewed	<1ufc/g	absence	>10e7
Brewed with fiber	<1ufc/g	absence	>10e7
Brewed with TPC	<1ufc/g	absence	>10e7
Brewed with TPC and fiber	<1ufc/g	absence	>10e7
Norms	ISO 4832	ISO 6611	MFE 004

- Moulds, yeast and coliforms are the primary contaminants in yoghurt (**Amakoromo and al., 2012**) were not detected in yoghurt samples (polyphenols, fiber and standard). This illustrates the adequate heating treatment of milk under strict aseptic conditions during processing and manufacturing of the different stirred yoghurts.

- Yoghurt enriched with pods did not influence the viability of lactic acid bacteria flora (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) when compared with control yoghurt, which could be related with the composition of proliferation media (sugar and lipid) of samples after addition of pods. The total viable numbers of lactic flora is an important parameter which contributes in the shelf life of yoghurt. (**Georgakouli and al., 2016)**

III.8.3. Antioxidant activity and TPC content

III.8.3.1. Polyphenol content

Total phenolic compounds of different manufactured yoghurts, are given in figure29. The results suggested that the addition of pods in yoghurt, influence statistically ($p < 0.05$) the amount of polyphenols.

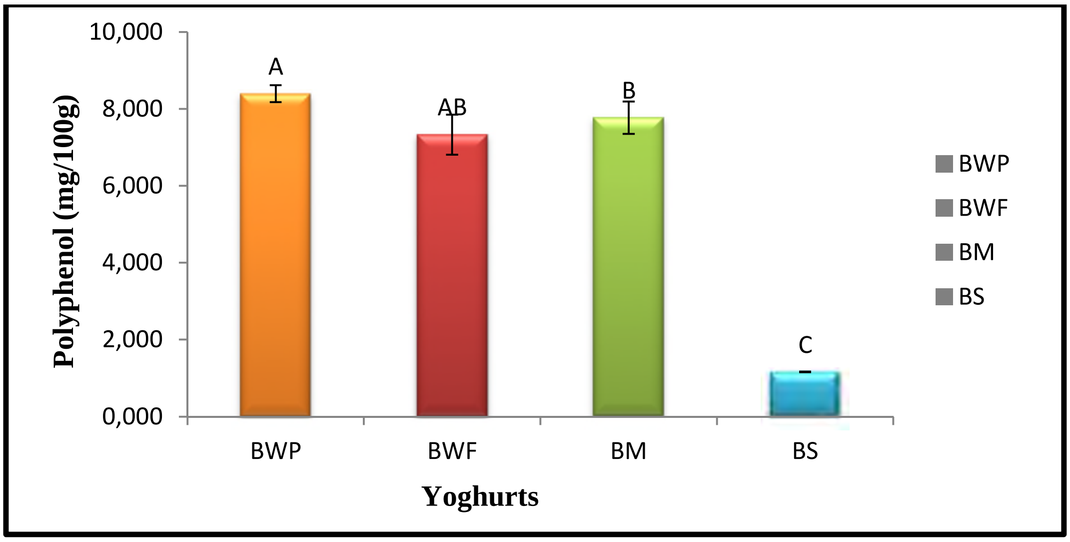


Figure 29: Polyphenol content in prepared yoghurts

The highest level of TPC has been detected in yoghurt with polyphenols, followed by yoghurt with fiber and yoghurt with TPC and fiber (30.09 ± 0.07 and 19.87 ± 0.02 mg GAE / g DM. respectively). Whereas the lowest amount of TPC was attributed to standard yoghurt. These data provide a confirmation of supplementation yoghurts with bioactive components of broad bean pod.

III.8.3.2. Radical scavenging activity

Antioxidant activity of different stirred yoghurts is depicted in figure 30

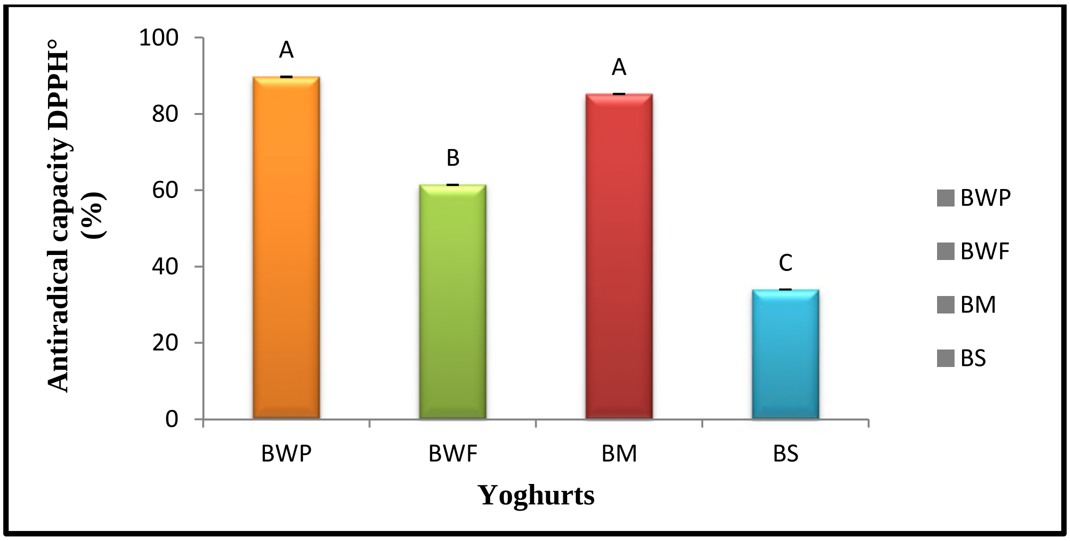


Figure 30: Radical scavenging activity (DPPH°) of prepared yoghurts

It was noticed from this figure that antioxidant activity of different stirred yoghurts measured by RSA, revealed that the addition of pods, increased significantly the inhibitory activity against DPPH° radical compared with standard yoghurt, being pronounced in yoghurt with polyphenols (80.78 ± 0.51 %).

- Broad bean pod is characterized by substantial amounts of phenolic compounds **(**13.298 ± 2.396 mg GAE/g DW**).** Therefore polyphenols were well correlated and dominantly responsible for the antioxidant activity. The studied pods possess proton donating ability and in association with a number of hydroxyl groups in the polyphenols structures to stabilize free radicals it could due to their ability to quench hydroxyl radicals by transferring hydrogen atom to free radical. **(El-Said and al., 2014)**. It is clear that addition of this vegetable gave the highest value, difference was statistically significant when p <0.05, in the antiradical capacity providing additional evidence of its antioxidant activity.

These results are in accordance with those recently reported, where it is found that the increase of antioxidant activity of yoghurt enriched with polyphenol, is related directly to the phenolic content **(Georgakouli and al., 2016)**

CONCLUSION

Conclusion

Among legumes, an increasing interest is dedicated to broad bean for his positive nutritional contribution Properties the popular food bases itself on the boucoup seed more the immature seed. The recent studies is interested in the study of broad been pod which presents an excellent source of food fibers, A significant correlation between the phenolic contents and the properties anti oxidizing were found.

The present study got down on the drying of the broad bean pod by two method microwave and conventional, then physic-chemical investigation of broad bean pod powder of beans and finally enrichment of yoghurt brewed in active substances and minerals.

The evaluation of the parameter physics-chemical of broad bean pod powder indicate the evaluation of the activity of water according to temperature the biggest activity of which is outdoors (0.534 ± 0.17) and (0.468 ± 0.01) which decrease according to time. For inhibited the change of microorganisms, color which increases with the increase of temperature the most higher of which are in 900W (74.529 ±0.02) and 120°C (23.011 ± 0.06) who allows the apparition of reaction of the Maillard.

The evaluation of the functional property of the powder dried expresses himself by the inflation which is reduced in temperature raised the biggest is marked in open air (12.83 ± 0.28) and in 100W (10.66 ± 0.57) who expresses himself by the reduction of pores with the increase of the temperature.

The water retention which decreases with the increase of temperature of which the open air (8.97 ± 0.40) 100W (8.01 ± 1.84) Present the highest value, which has a relation in the detection of type of fiber, the retention of oil which also decreases with the increase of the temperature which is translated by the constituent denaturation of proteins, fiber dietetics which presents a big source of fiber, She ' influences by the temperature. she decreases with the increase of the temperatures, contained total in ash expresses himself by the wealth minerals, the powder the richest in ash is the one of 80°C (4.05±0.05) and 300W (5.05±0.125).

The evaluation of contained main thing activates who expresses himself by phenolic compound which increases with the increase of the temperatures the most higher of which are in 900W (96,22 ± 0.40) and 120°C (54,11 ± 1.0) who expresses himself by the phenolic liberation of compounds, flavonoids that is presented by the value the most higher in 900W (5.77 ± 0.038) that is characterized by the liberation of flavonoids, the condensation of tannins the highest is at the level of 900W (6.86 ± 0.55) which reach the maximum of condensation of the tannin.

The evaluation of antioxidants by reducing power that is the present the biggest value at the level of the powder 900W which is understandable by the reduction of Fe^{+3} in Fe^{+2}. Then the DPPH which has the big value in 100W (83.81 ± 0.24) which expresses the necessary value for inhibited 50 %.

The addition of broad bean pod powder in in the yoghurt has allows us to obtain a yoghurt enriched in fiber and in polyphenol, The results of the physico-chemical and microbiological analyses made within the brewed body DANNONE Djurdjura of yoghurts show clearly their perfect conformity with the standards.

Concerning the activity antioxidant, the elaborate yoghurt marks a remarkable increase of the activity antioxidant.

BIBLIOGRAPHICAL REFERENCES

A

Abu-Reidah, I. M., D. Arráez-Román, et al. (2017). "UHPLC/MS 2-based approach for the comprehensive metabolite profiling of bean (Vicia faba L.) by-products: A promising source of bioactive constituents." Food Research International 93: 87-96.

Achat, S., V. Tomao, et al. (2012). "Direct enrichment of olive oil in oleuropein by ultrasound-assisted maceration at laboratory and pilot plant scale." Ultrasonics sonochemistry 19(4): 777-786.

Adiletta, G., P. Russo, et al. (2016). "Drying characteristics and quality of grape under physical pretreatment." Journal of food engineering 172: 9-18.

Alibas, I. (2007). "Energy consumption and colour characteristics of nettle leaves during microwave, vacuum and convective drying." Biosystems Engineering 96(4): 495-502.

Allaf, K., S. Mounir, et al. (2012). "Swell-drying: séchage et texturation par DIC des végétaux." Techniques de l'Ingénieur. La Rochelle, France

Amakoromo, E., H. Innocent-Adiele, et al. (2012). "Shelf-life study of a yoghurt-like prod Antioxidant activities and physical properties of stirred yoghurt fortified with pomegranate.

AOAC (1990). Official methods of analysis of the Association of Analytical Chemist. No. 934.06. Arlington, VA.aqueous extracts from selected Lamiaceae herbs." Food chemistry 83(2): 255-262. collaborative study." Journal of AOAC international 88(5): 1269-1278.

Aydogdu, A., G. Sumnu, et al. (2015). "Effects of microwave-infrared combination drying on quality of eggplants." Food and Bioprocess Technology 8(6): 1198-1210.

B

Barreiro, J., M. Milano, et al. (1997). "Kinetics of colour change of double concentrated

Bonazzi, C. and J.-J. Bimbenet (2008). "Séchage des produits alimentaires: Appareils et applications." Techniques de l'ingénieur. Agroalimentaire 2(F3002).

Boukhanouf, S., H. Louaileche, et al. (2016). "Phytochemical content and in vitro antioxidant activity of faba bean (Vicia faba L.) as affected by maturity stage and cooking practice." International Food Research Journal 23(3)

Boulekbache-Makhlouf, L., L. Medouni, et al. (2013). "Effect of solvents extraction on phenolic content and antioxidant activity of the byproduct of eggplant." Industrial Crops and Products 49: 668-674.

Brand-Williams, W., M.-E. Cuvelier, et al. (1995). "Use of a free radical method to evaluate antioxidant activity." LWT-Food Science and Technology 28(1): 25-30.

C

Chaux, C. and C. Foury (1994). "Introduction à la notion de légumes et typologie des productions légumières." Productions légumières Tome 1: 3-9.

Chiewchan, N., C. Praphraiphetch, et al. (2010). "Effect of pretreatment on surface topographical features of vegetables during drying." Journal of food engineering 101(1): 41-48.

D

Dahmoune, F., L. Boulekbache, et al. (2013). "Valorization of Citrus limon residues for the recovery of antioxidants: evaluation and optimization of microwave and ultrasound application to solvent extraction." Industrial Crops and Products 50: 77-87.

Dorman, H., A. Peltoketo, et al. (2003). "Characterisation of the antioxidant properties of deodourised aqueous extracts from selected Lamiaceae herbs." Food chemistry 83(2): 255-262.

E

El-Said, M. M., Haggag, H. F., El-Din, H. M. F., Gad, A. S., & Farahat, A. M. (2014).

Elsheikh, E. A. and A. A. Elzidany (1997). "Effect of Rhizobium inoculation, organic and chemical fertilizers on proximate composition, in vitro protein digestibility, tannin and sulphur content of faba beans." Food chemistry **59**(1): 41-45.

Enkelejda-paci K., 2004. Interaction physico-chimiques et sensorielles dans le yaourt brassé aromatisé : quels impacts respectifs sur la perception de la texture et de la flaveur,unité mixte de recherche Génie et microbiologie des procédés Alimentaire (Inra-Ina PG).Institus national agronomique Paris-grignon. Ecole doctorale ABIES. thèse de doctorat.

F

Femenia, A., A. C. LEFEBVRE, et al. (1997). "Physical and sensory properties of model foods supplemented with cauliflower fiber." Journal of food science 62(4): 635-639.

Fendri, L. B., F. Chaari, et al. (2016). "Wheat bread enrichment by pea and broad bean pods fibers: Effect on dough rheology and bread quality." LWT-Food Science and Technology 73: 584-591.from African Yam bean." Nature Sci 10(5): 6-9.

G

Georgakouli, K., A. Mpesios, et al. (2016). "The Effects of an Olive Fruit Polyphenol-Enriched Yogurt on Body Composition, Blood Redox Status, Physiological and Metabolic Parameters and Yogurt Microflora." Nutrients 8(6): 344.

Georgé, S., P. Brat, et al. (2005). "Rapid determination of polyphenols and vitamin C in plant-derived products." Journal of agricultural and food chemistry 53(5): 1370-1373.

Gouw, V. P., J. Jung, et al. (2017). "Functional properties, bioactive compounds, and in vitro gastrointestinal digestion study of dried fruit pomace powders as functional food ingredients." LWT-Food Science and Technology 80: 136-144.

H

Hagerman, A. E., K. M. Riedl, et al. (1998). "High molecular weight plant polyphenolics (tannins) as biological antioxidants." Journal of agricultural and food chemistry 46(5): 1887-1892.

Hmid, I. (2013). Contribution a la valorisation alimentaire de la grenade marocaine (punica granatum l.): caracterisation physicochimique, biochimique et stabilite de leur jus frais, Université d'Angers.

Huang, J., M. Zhang, et al. (2016). "Effect of microwave air spouted drying arranged in two and three-stages on the drying uniformity and quality of dehydrated carrot cubes." Journal of food engineering 177: 80-89.

J

J.O.R.A, 2015. Convection et accords internationaux-lois et décrets arrétes, décisions, avis, communication et annonces. Journal official N52

Jogihalli, P., L. Singh, et al. (2017). "Effect of microwave roasting parameters on functional and antioxidant properties of chickpea (Cicer arietinum)." LWT-Food Science and Technology 79: 223-233.

K

Karam, M. C., J. Petit, et al. (2016). "Effects of drying and grinding in production of fruit and vegetable powders: A review." Journal of food engineering 188: 32-49.

Khraisheh, M., T. Cooper, et al. (1997). "Microwave and air drying I. Fundamental considerations and assumptions for the simplified thermal calculations of volumetric power absorption." Journal of food engineering 33(1-2): 207-219.

L

Law, B. A. (2012). Microbiology and biochemistry of cheese and fermented milk, Springer Science & Business Media.

Lee, J., R. W. Durst, et al. (2005). "Determination of total monomeric anthocyanin pigment

Li, X. and Y. Yang (2014). "A novel perspective on seed yield of broad bean (Vicia faba L.): differences resulting from pod characteristics." Scientific reports **4**.

M

Makkar, H. P. (2003). Quantification of tannins in tree and shrub foliage: a laboratory manual, Springer Science & Business Media.

Marcheix, J., A. Fleuriet, et al. (2005). "Les composés phénoliques des végétaux."

Mateos-Aparicio, I., A. Redondo-Cuenca, et al. (2010). "Isolation and characterisation of cell wall polysaccharides from legume by-products: Okara (soymilk residue), pea pod and broad bean pod." Food chemistry 122(1): 339-345.

Mateos-Aparicio, I., A. Redondo-Cuenca, et al. (2010). "Pea pod, broad bean pod and okara, potential sources of functional compounds." LWT-Food Science and Technology 43(9): 1467-1470. (A)

Mateos-Aparicio, I., A. Redondo-Cuenca, et al. (2012). "Broad bean and pea by-products as sources of fibre-rich ingredients: potential antioxidant activity measured in vitro." Journal of the Science of Food and Agriculture 92(3): 697-703.

Mateos-Aparicio, I., C. Mateos-Peinado, et al. (2010). "High hydrostatic pressure improves the functionality of dietary fibre in okara by-product from soybean." Innovative Food Science & Emerging Technologies 11(3): 445-450

Mateos-Aparicio, I., C. Mateos-Peinado, et al. (2010). "Multifunctional antioxidant activity of polysaccharide fractions from the soybean byproduct okara." Carbohydrate Polymers 82(2): 245-250

Mateos-Aparicio, I., C. Mateos-Peinado, et al. (2010). "Multifunctional antioxidant activity of polysaccharide fractions from the soybean byproduct okara." Carbohydrate Polymers 82(2): 245-250.

Mirabella, N., V. Castellani, et al. (2014). "Current options for the valorization of food manufacturing waste: a review." Journal of Cleaner Production 65: 28-41.

N

Norme, A. (1981). Détermination des cendres, méthode par incinération à 550 C, NF.

O

Odabasoglu, F., A. Aslan, et al. (2004). "Comparison of antioxidant activity and phenolic content of three lichen species." Phytotherapy Research 18(11): 938-941.

Orsat, V., W. Yang, et al. (2007). "Microwave-assisted drying of biomaterials." Food and Bioproducts Processing 85(3): 255-263

Oyaizu, M. (1986). "Studies on products of browning reaction." The Japanese Journal of Nutrition and Dietetics 44(6): 307-315.

P

Perez-Lopez, E., I. Mateos-Aparicio, et al. (2016). "Okara treated with high hydrostatic pressure assisted by Ultraflo® L: effect on solubility of dietary fibre." Innovative Food Science & Emerging Technologies 33: 32-37.

Pietta, P.-G. (2000). "Flavonoids as antioxidants." Journal of natural products 63(7): 1035-1042.

Price, M. L., S. Van Scoyoc, et al. (1978). "A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain." Journal of agricultural and food chemistry 26(5): 1214-1218.

Puig, A., I. Perez-Munuera, et al. (2012). "Moisture loss kinetics and microstructural changes in eggplant (Solanum melongena L.) during conventional and ultrasonically assisted convective drying." Food and Bioproducts Processing 90(4): 624-632.

Q

Quettier-Deleu, C., B. Gressier, et al. (2000). "Phenolic compounds and antioxidant activities of buckwheat (Fagopyrum esculentum Moench) hulls and flour." Journal of ethnopharmacology 72(1): 35-42.

R

Ralston, R., J. Lee, et al. (2012). "A systematic review and meta-analysis of elevated blood pressure and consumption of dairy foods." Journal of human hypertension **26**(1): 3-13.

Renting, H., T. K. Marsden, et al. (2003). "Understanding alternative food networks: exploring the role of short food supply chains in rural development." Environment and planning A 35(3): 393-411.

Robu, S., A. Aprotosoaie, et al. (2012). "In vitro antioxidant activity of ethanolic extracts from some Lavandula species cultivated in Romania." cell 60: 3.

Ruxton, C. (2015). "NUtritioNAl BeNefitS of yoGhUrt." energy 1: 1.1. - Issue 103.

S

Scientifique de Syndifrais, M. (1997). "Yaourts, laits fermentés." Le Lait 77(3): 321-358.

Sendra, E., V. Kuri, et al. (2010). "Viscoelastic properties of orange fiber enriched yogurt as a function of fiber dose, size and thermal treatment." LWT-Food Science and Technology 43(4): 708-714.

Singh, A. K., R. Bharati, et al. (2013). "An assessment of faba bean (Vicia faba L.) current status and future prospect." African Journal of Agricultural Research 8(50): 6634-6641.

Singh, G. D., R. Sharma, et al. (2008). "Drying and rehydration characteristics of water chestnut (Trapa natans) as a function of drying air temperature." Journal of food engineering 87(2): 213-221.

Stijepić, M., D. Đurđević-Milošević, et al. (2012). "Production of low fat yoghurt enriched with different functional ingredients." Quality of Life 5(1-2).

T

Tomas-Barberan, F. A., M. M. Garcia-Grau, et al. (1991). "Flavonoid concentration changes in maturing broad bean pods." Journal of agricultural and food chemistry 39(2): 255-258.

Tsami, E., M. Krokida, et al. (1998). "Effect of drying method on the sorption characteristics of model fruit powders." Journal of food engineering 38(4): 381-392.

Tsao, R. (2010). "Chemistry and biochemistry of dietary polyphenols." Nutrients 2(12): 1231-1246.Université d'Angers.

W

Weende, P. (1985), NF V03-400, in Recueil des Normes Françaises-AFNOR.

Weerathilake, W., D. Rasika, et al. (2014). "The evolution, processing, varieties and health benefits of yogurt." International Journal of Scientific and Research Publications 4(4): 1-10.

Williams, E., B. Hooper, et al. (2015). "The contribution of yogurt to nutrient intakes across the life course." Nutrition Bulletin **40**(1): 9-32

Wu, L., Y. Ogawa, et al. (2008). "Electrical impedance spectroscopy analysis of eggplant pulp and effects of drying and freezing–thawing treatments on its impedance characteristics." Journal of food engineering 87(2): 274-280.

Y

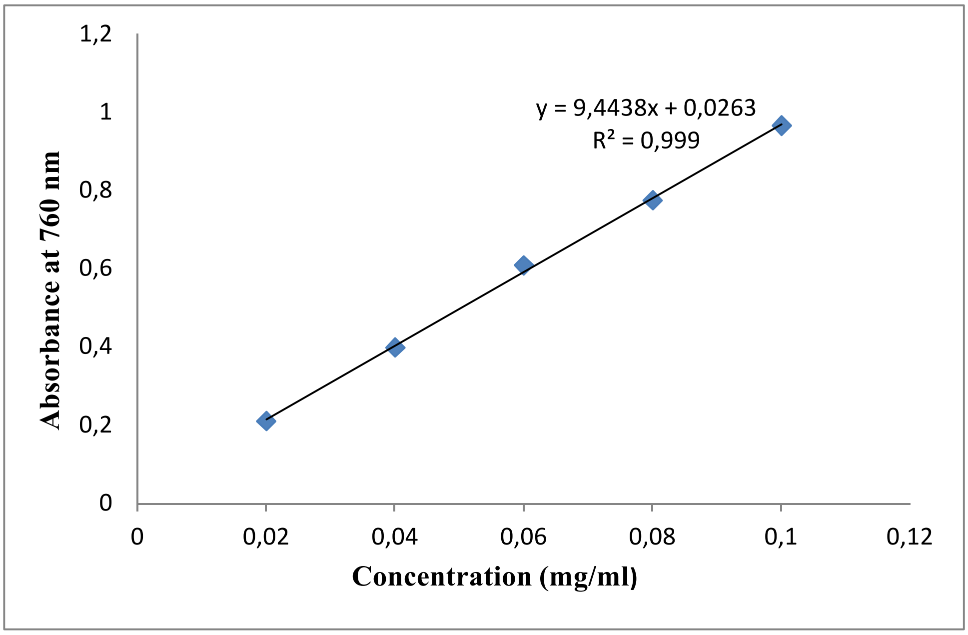
Yahia, L. B. (2012). Étude du dialogue hôte/bactéries lactiques du yaourt chez des rats gnotobiotiques, AgroParisTech

Yahia, Y., W. Elfalleh, et al. (2013). "PHYTOCHEMICAL CONTENTS AND ANTIOXIDANT ACTIVITIES OF SOME TUNISIAN FABA BEAN POPULATIONS." Romanian Agricultural Research 30: 65-74.

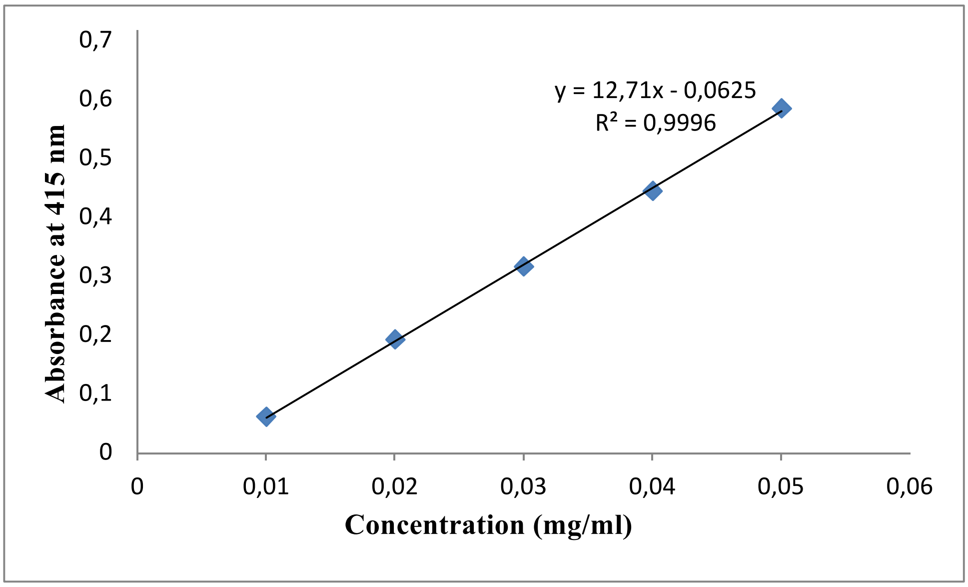
Z

Zainoldin, K. and A. Baba (2009). "The Effect of Hylocereus polyrhizus and Hylocereus undatus on physicochemical, proteolysis, and antioxidant activity in yogurt." World Academy of Science, Engineering and Technology 60: 361-366.

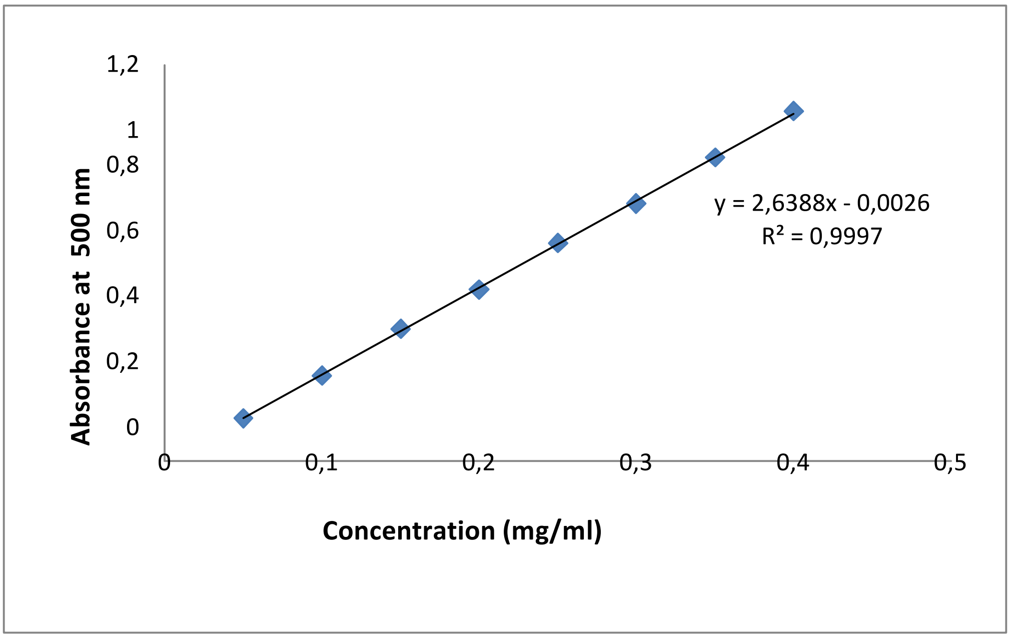
APPANDIX



Appendix 01 : Calibration courbe of gallic acid



Appendix 02 : Calibration courbe of quercitine



Appendix 03 : Calibration courbe of catéchi

Résumé

Les effets thérapeutiques de la gosse des fèves suscitent des intérêts importants et très attractifs pour le développement d'aliments fonctionnels. Quelques étude ont été effectué telle que l'évaluation de la composition physico-chimique et l'activité antioxydant de la poudre obtenue par deux méthode de séchage. L'élaboration du yaourt brassé avec des poudres séchées de la gosse de fèves en utilisant la poudre 100W et 900w celles qui ont donné des teneurs élevé en fibre et polyphénol, les produit finaux ont été soumis à des analyses physico-chimique et microbiologique révèle plus de protéines et minéraux avec des meilleures propriétés antioxydant.le séchage par microonde à donner des teneurs en polyphénol et en fibre avec une valeur de 96,22 ± 0,40 mg GAE / g DM de poudre, correspond à 900W et de 83.81 ± 0.24 pour 100W respectivement.

Mots clés : Gosse des fèves (*vicia faba. L*), séchage, yaourt, polyphénols, fibre, activité antioxydante.

Abstract

The therapeutic effects broad bean pods arouse important and very attractive interests for the development of functional food. Some studies were made such as the evaluation of the physic-chemical composition and the antioxidant activity of the powder obtained by two method of drying the elaboration of the yoghurt brewed with powders dried of kid of beans by using the powder 100W and 900w those who gave contents raise in fiber and polyphenol, Product final were subjected to physic-chemical and microbiological analyses reveal more proteins and minerals with better properties antioxidant. The drying by microwave to give contents in polyphenol and in fiber With a value of 96.22 ± 0.40 mg EC/g of powder, corresponds in 900W and of 83.81 ± 0.24 for 100W respectively **.**

Keywords: Broad been pod (*vicia faba. L*), drying, yogurt, polyphenol, fiber, antioxidant activity.