PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA

MINISTRY OF HIGHER EDUCATION

AND SCIENTIFIC RESEARCH

UNIVERSITY OF ABOU BAKR BELKAID-TLEMCEN

FACULTY OF NATURAL AND LIFE SCIENCES, EARTH SCIENCES AND THE UNIVERSE

DEPARTMENT OF BIOLOGY

MEMORY

Presented by

BOUDGHENE STAMBOULI MOHAMMED

To obtain the Master's degree in Biological Sciences

Specialty: microbiology and Quality control

Theme

Valorisation des fleurs du safran (*Crocus sativus*)

Defended on: 03/07/2022

Before the following jury:

President	Ms. Loukidi Bouchra	Pr.	University of Tlemcen
Examiner	Mr. Belyagoubi Larbi	MCA	University of Tlemcen
Supervisor	Ms. Belyagouibi-Benhammou Nabila	Pr.	University of Tlemcen

College year: 2021/2022

THANKS

Before presenting the content of my work, I would like to thank the only true God, creator of heaven and earth who by his grace led me peacefully throughout the development of this work. I would like to express my gratitude and appreciation to my Professor **Mrs. BELYAGOUBI BENHAMMOU Nabila,** at the University of Tlemcen, Faculty of SNV- STU, Department of Biology, for having supervised and directed this work with great scientific rigor, His availability, his advice and his confidence. His support has been invaluable throughout the year.

I would also like to thank the members of the jury:
Mr. BELYAGOUBI Larbi, Class A lecturer at the University of Tlemcen, Faculty of SNV-STU, Department of Biology, for agreeing to be a reviewer of this work. I would like to express my sincere gratitude and my deepest respect to you.

Mrs. LOUKIDI BOUCHRA, Professor at the University of Tlemcen, Faculty of SNV- STU, Department of Biology, for agreeing to chair the jury for this work.

A big thank you also to all the teachers of the Biology department

I would like to express my gratitude to my parents. Thanks to them, I have succeeded in all stages of my life. I would also like to thank my brothers and my sister for their constant support.

DEDICATIONS

I dedicate this work: To my dear parents for their love, their support and their sacrifice, in testimony of my great esteem and my love for them.

To my sister **Sara** and her husband **Sidi Mohammed** and their children **Chihab, Feriel, Baraa .** To my dear brothers: **Zakaria** and **Hichem** thank you very much for your more than precious support, my life would not be so magical without your presence and your love**.**

To all my friends

To everyone I love

To all who love me.

Abstract

Saffron "*C. sativus*" is a plant of iridaceae's family.Its therapeutic virtues have been known since antiquity, it is used in traditional medicine and in the various culinary preparations, it is also known for its use in cosmetic, because it has various types of beneficial pharmacological activities for human skin. In particular, saffron petals are the main by-product of saffron processing,it contains several bioactive compounds such as mineral agents, anthocyanins, monoterpenoids carotenoids, flavonoids and flavonols (kaempferol).The purpose of this review is to describe the different properties of *C. sativus* petals .It has been found that saffron petals are components that have pharmacological activity such as antibacterial ,antispasmodic, immunomodulatory,antitussive,antidepressant,antinociceptive,hepatoprotective,renoprotective ,antihypertensive, antidiabetic and antioxidant activity. According to these properties, saffron petal can be used as addictive in pharmacy and cosmetics.

Keywords: Phytochemical characterization, Biological activities, Chemical components, Valorization of by-products, active ingredient, *Crocus sativus.*

Résumé

Le safran « *Crocus sativus* » est une plante de la famille des iridacées. Ses vertus thérapeutiques sont connues depuis l'antiquité, il est utilisé en médicine traditionnelle et dans les différentes préparations culinaires il est également connu pour son utilisation en tant que cosmétique, car il possède divers types d'activités pharmacologiques bénéfiques pour la peau humaine. Notamment, les pétales de safran sont le principal sous-produit de la transformation du safran, il contient plusieurs composés bioactifs tels que des agents minéraux, des anthocyanes, Monoterpénoïdes, caroténoides ,flavonoïdes et flavonol du (kaempférol). Le but de cette étude était d'évaluer les différentes propriétés de pétales de *C. sativus*. Il a été constaté que les pétales du safran sont des composants qui ont une activité pharmacologiques tel que l'activité antibactérienne, antispasmodique, immunmodulatrice, antitussive, antidépressive, antinociceptive, hépatoprotectrice, rénoprotectrice, anti hypertensive, antidiabétique et antioxydante . Selon ces propriétés, le pétale de safran peut être utilisé comme additifs dans la pharmacie et la cosmétique.

Mots clés : Caractérisation phytochimique, Activités biologique, Composants chimique, Valorisation des sous-produits, Ingrédient actif, *Crocus sativus.*

ملخص

الزعفران "Crocus sativus" هو نبات من عائلة السوسنيات. وقد عُرفت مزاياه العلاجية منذ العصور القديمة ، وهي تُستخدم في الطب التقليدي وفي مستحضرات الطهي المختلفة ، كما يشتهر باستخدامه كمستحضر تجميلي ، نظرًا لأن له أنواعًا مختلفة من الأنشطة الدوائية المفيدة لبشرة الإنسان. تعتبر بتلات الزعفران المنتج الثانوي الرئيسي لمعالجة الزعفران ، فهو يحتوي على العديد من المركبات النشطة بيولوجيًا مثل العوامل المعدنية ، والأنثوسيانين ، ومونوتربينويدات , الكاروتينات الفلافونويد, الفلافونول ، والكايمبفيرول. كان الغرض من هذه الدراسة هو تقييم الخصائص المختلفة لبتلات Crocus Sativus. لقد وجد أن بتلات الزعفران هي مكونات لها نشاط دوائي مثل النشاط المضاد للبكتيريا ، ومضاد التشنج ، والمناعة ، ومضاد للسعال ، ومضاد الاكتئاب ، ومضاد للالتهاب ، ومضاد للالتهاب ، ومضاد للضغط ، ومضاد للسكري ، ومضاد للأكسدة. وفقًا لهذه الخصائص، يمكن استخدام بتلات الزعفران كمضافات في الصيدلة ومستحضرات التجميل.

الكلمات المفتاحية: التوصيف الكيميائي النباتي، الأنشطة البيولوجية، المكونات الكيميائية ، تثمين المنتجات الثانوية، العنصر النشط، Crocus sativus

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Abbreviations list

C3GE : milligram of cyanidin 3-glucoside equivalents

MIC : Minimum Inhibitory Concentrations

MBC : Minimum Bactericidal Concentrations

FRAP : Ferric Reducing Antioxidant Power

KE : Kaempferol-3-glucoside Equivalent

DPPH : 2.2 Diphenyl 1 picryl hydrazyl

IC50 : Inhibitory concentration 50%

GAE : gallic acid equivalents.

GAE : Gallic Acid Equivalent

SPF : Sun Protection Factor

QE : quercetin equivalents

CE : catechin equivalents.

TP : Total polyphenols

TF : Total flavonoids

Mg : Milligram

Ms : Dry Matter

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1. Introduction

Red gold is not copper but saffron is considered the most precious spice in the world. This name of red gold comes from the color of the product which varies from bright orange to intense purple. It is sometimes also called yellow gold, because it colors culinary preparations (rice in paella, fish in bouillabaisse, etc.) in golden yellow **(Régis et al., 2021).** Saffron (*Crocus sativus*) is a perennial herbaceous plant of the Iridaceae family, the Liliaceae lineage, nowadays saffron is produced mainly in Iran, Spain, India, Greece and Morocco which are the main producers while Algeria and Turkey are very small producers **(Tantry et al., 2017).** the flowers of *C. sativus* are made up of 6 purple tepals 3 yellow stamens and a white threadlike style ending in a stigma made up of 3 filaments.

Nevertheless, a huge amount of saffron by-products (leaves, flowers, stamens and styles) with little or no commercial value is wasted during stigma processing. **(Jadouali et al., 2019).**

To harvest 1 kg of stigmas, about 350 kg of petals, 1500 kg of leaves, and the bulbs are not used and discarded **(Jadouali et al., 2018).** However, this biomass can be used as a potentially important source of biologically active secondary metabolites. The exploitation of these by-products can significantly increase the profitability and sustainability of saffron production and the creation of employment opportunities through new recycling companies (**Khoulati et al., 2020).** The valorization of saffron by-products is essential and necessary thanks to several bioactive compounds such as polyphenols, hydroxycinnamic acids, flavonoids, flavonols, carotenoids, terpenoids and anthocyanins.

Serrano-Diaz et al., (2013) showed that the different parts of the saffron flower have interesting contents in proteins, ashes, fibers, Ca, K, Mg, P and Fe. Serrano-Diaz suggested the use of some of the flowers of *C. Sativus* at the end of spice production.

These by-products can be used in the food, pharmaceutical and cosmetics industries for their antioxidant properties. antibacterial and antifungal. Thus as a food supplement and fresh or dry decoration **(Bergoin; 2005).**

2.Botanical descriptions of saffron flower

The *C. sativus* is a pretty bulbous plant from which we get the famous yellow spice, saffron. Not to spoil anything, it is also very aesthetic and will delight your eyes in the fall. The flower of saffron is a bulbous plant which has the advantage of flowering in autumn. Corms (bulbs) usually produce one to two large goblet-like flowers. The petals are mauve in color, veined with a darker purple. the golden yellow heart is embellished with red stigmas, these long filaments that are harvested to create saffron. **(USDA.2009).** *C.sativus* represented in **figure 1,** belongs to the family of iridae (synonym: irideae, iridaceae, iridaceae) and to the tribe of croceaes.The taxonomic classification of this plant is given by Wintherhalter , **(Winterhalter and Straubinger.,2000).**

- Division: *Spermatophyte*
- Subdivision: *Angiosperms*
- Class: *Monocotyledons*
- Subclass: *Liliidae*
- Order: *Liliales*
- Family: *Iridaceae*
- Genre : *crocus*
- Species: *Crocus sativus*

Figure 1. General appearance of *C. sativus* **(Jan et al.,2014).**

3.Main phytochemicals of petal saffron

In vitro scientific studies have established that the chemical composition of saffron flower has potent antioxidant, antiviral, antimicrobial properties, and potential use in pharmacology treatment **(Chiang et al., 2005).** These activities are due to the different chemical families such as proteins, sugars, flavonoids, polyphenols, anthocyanin and terpenoids etc. This unique chemical composition of Crocus contributes to the network of chemical signals that play a role in plant growth, development and environmental adaptation. **(Jadouali et al.,2018).** The Saffron petals could be a great by-product of agriculture and a good source of natural dyes in food products, adding to its other medicinal/industrial applications.

4.Levels of biological active compounds in *C. sativus* from saffron by-products

Table 1. shows the results of the chemical composition regarding these primary metabolites of the different saffron by-products

4.1. Energetic value, macronutrient composition

The petals are the parts of the flower that have the highest moisture content with 92 ± 1.1% compared to the other by-products, the extract of C. sativus stamen *had* a higher concentration of crude fiber with 13 ,3± 0.7% and high ash content with 13.4±1.06% styles, petals, per **(Lewis et al., 1981, Serrano-Diaz et al., 2013)** The protein contents obtained in the different parts of the plant of *C. sativus* are indicated in descending order in this sense, the petals of 6.35 %, the styles with 6.11%, the stamens with 5.97%, the whole flowers with 4.3% No significant difference was observed between the lipids contained in the petals, the stamens, the whole flower and style, while petals, stamens, and whole flowers had the lowest levels of lipids and total carbohydrates. A study by **Khoshbakht et al. (2005)** showed that Iranian saffron petals contained crude fat (5.3%) and protein (10.2%). They also contained ash (7.00%) and crude fibers (8.8%). The ash content of saffron petals in this study was 7%. Variations in the chemical composition of saffron by-products reflect differences in environmental conditions during plant maturation, age and vigor **(Cocan et al., 2005; Hamamoto et al., 2006) (Table 1).**

4.2. mineral elements

The Na content 54.1±2.40% higher in the style compared to those of the other parts of the flower (**Table 1**). The Ca content is significantly higher in the style with 42.9±2.26% and the petals with 39.25±1.06% compared to to those of other parts of the plant, Then The content of N and Fe 1.01±0.08% and 149.50±6.2% is significantly higher in the petals than in the other floral parts. The whole flower has a high Fe content compared to those of the floral parts of *C.*

sativus . For the Zn content no significant difference between the different parts of the flower. The same results were found in saffron flower **(Serrano-Diaz et al., 2013) (Table 1).**

4.3. Fatty acid content

The petals of the *C. sativus flower* are the richest in linolenic fatty acids with 25.09% and 16.63%. The main fatty acids found in the petals in relatively high concentrations are palmitic acid, linoleic acid and linolenic acid, with respective average values of 11.64%; 22.60% and 16.63%. The lowest fatty acid content was found in whole flowers. The results obtained by **Faizy and Rayhani (2016)** the results obtained by these authors showed that the petals contained palmitic acid (16.21%); linoleic acid (28.48%) and linolenic acid (21.06%).

Table 1. Energetic value, macronutrient and mineral composition in the different parts of *C. sativus* **(Jadouali et al., 2018).**

	Petals	**Stamens**	**Styles**	**Flowers whole**
Humidity %	92 ±1.11	89.5±1.5	91±1.3	87.3±1.02
Crude fiber %	11.2±0.97	13.3± 0.7	7.93±0.54	10.4±0.66
Ash %	7.30±0.3	13.4±1.06	7.86±0.5	10.9±0.95
% protein	6.35±0.07	5.97± 0.09	6.11±0.42	4.3±0.14
% fat	0.03± 0	0.03± 0	0.01±0	0.035±0
T. carbs %	0.071±0.014	0.062±0.07	0.069±0.007	0.067±0.01
CV kcal/g	310±1.6	272±2.1	303±1	285±1.54
Na (mg/kg)	45.85±5.44	53.35±4.59	54.1±2.40	45.85±5.44
K (mg/kg)	23.75±2.75	26.35±1.34	23.65±0.91	23.75±2.75
Ca (mg/kg)	39.25±1.06	14.8±1.13	42.9±2.26	39.3±0.98
N %	1.01±0.08	0.952±0.012	0.38±0.014	0.7±0.02
Fe (mg/kg)	149.50±6.2	94.76±4.13	-	727.95±6.4
Zn (mg/kg)	47.23±5.04	49.96±4.3	-	42.68±4.4

CV kcal/g= Caloric Value; GT %= Total Carbohydrates in %

5. Polyphenolic compounds

5.1.Polyphenolic contents

The petals have a very high content of total phenolic compounds and total flavonoids the content of total phenols recorded at petals 65.34 ±1.74% is much higher than the others **(Table 2).**

5.2. Hydrolysable and condensed tannin compounds

So far, some research does not show that the aerial part of the *C. sativus flower* is rich in a high percentage of flavonols , apart from a recent study by Belyagoubi et al, (2019) which revealed a percentage of 5.452 ± 0.226 (mg QE/g DM). flavonols. The latter found that the content of hydrolysable tannins in the flowers (277.304 ± 6.756 mg GAE/g DM), and a content of condensed tannins in the flower with (48.854 ± 5.927 mg CE/g DM) **(Table 2).**

Table 2. Main phenolic content identified in the species *C. sativus*.

Classes	Raw material	Reference
total phenolics	Whole flowers 54.59 ± 0.6% Petals 3.42 ± 0.2 mg GAE/g DM Petals 66.41 ± 0.60 mg GAE/g DM Petals 65.34 ±1.74%	**Jadouali et al. (2018)** **Termentzi and Kokkalou . (2008)** **Karabagias et al. (2017)** **Jadouali et al. (2018)**
Total favonoids	Petals 60.64 ±2.71% Whole flowers 34.23 ± 1.26%	**Jadouali et al. (2018)**
Favonols totals	Petals 84.0% Whole flowers 5.452 ± 0.226 (mg QE/g DM)	**Goupy et al. (2013)** **Belyagoubi et al. (2019)**
Anthocyanins	Petals 136.96±5.7 (mg C3GE/g DM) Petals 1712.19 ± 60 (mg C3GE/g DM) Whole flowers 11.526±0.118(mg QE/g DM)	**Auzkan et al. (2007)** **Mahdavee et al. (2015)** **Belyagoubi et al. (2019)**
Hydrolyzable tannins	Whole flowers 277.304±6.756 (mg GAE/g DM)	**Belyagoubi et al. (2019)**
Condensed tannins	Whole flowers 48.854 ± 5.927 (mg EC/ gDM)	**Belyagoubi et al. (2019)**

5.3. Flavonoids

According to the results reported in **Table 2**, the petals of *C. sativus* have a flavonoid content of 60.64 ± 2.71%**.** This value remains higher compared to flowers 34.23 ± 1.26%.

Flavonoids were isolated and identified in the petals of *C. sativus*. These compounds were mainly represented by glycosylated compounds and methoxylated derivatives of kaempferol, quercetin, isorhamnetin and tamarixetin **(Montero et al., 2012)** and glycosides in the form of mono-, di- or tri-glycosides **(Goupy et al., 2013).** The glycosides of kaempferol were the main flavonols (84.0% of total flavonol content) with kaempferol 3-O-so phoroside as the main compound **(Table 2).**

Falvonoids are organic compounds with antioxidant properties that have beneficial effects on human health. Indeed, they are of interest for the prevention and treatment of certain diseases or even certain cancers, inflammatory and cardiovascular diseases **(Cushnie and Lamb, 2005; Mercader et al., 2008; Sharma et al., 2008).**

It should be noted that the phenolic compounds, flavonoids and carotenoids help prevent oxidative damage to plants **(Dai and Mumper , 2010; Agati et al., 2012; Ramel et al., 2013)** while apocarotenoids provide a resistance against biotic stress **(Bouvier et al.,2005).**

5.4. Anthocyanins

Anthocyanins are major compounds of the petal part of saffron is the components delphinidin has a high 1712.19 ± 60 C3GE/g DMcompared to that of Whole Flowers which contains a rate of 11.526 ± 0.118(mg QE/g DM) **(Table 2).** (J´essica Serrano -D et al.,2012) showed that tepals were present in greater proportion (84.1 g tepals/100 g) compared to whole flowers (78.4 g tepals/100 g). The purple color of saffron petal is due to anthocyanin, while the main anthocyanidin aglycones are delphinidin and petunidin (Garrido et al., 1987) . Anthocyanins from saffron petals have been studied for possible antioxidant activity, and antitumor can be used as a potential resource of natural anthocyanin dyes for food and pharmaceuticals **(Table 3)**.

6. Terpenoids

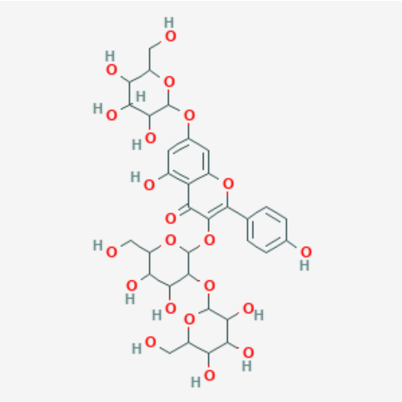
The petal terpenoids contained in essential oils are strong-smelling compounds that protect plants by repelling potential predators. They are mainly selected for their interest in cosmetics, pharmaceutical industries and biotechnology **(Sparg Light and van Staden, 2004).**

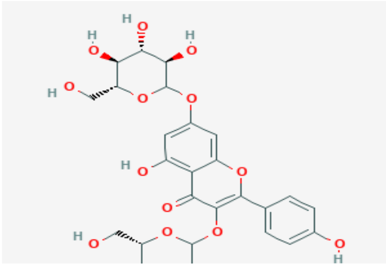
7. Monoterpenoids

(Montoro et al., 2012) identified the compounds picrocrocin 19 and a derivative of sinapic acid in the petals of *C. sativus* . The crocusatins C 32, D 33, E 34, I 38, J 39, K 40, L41 have been detected in the petals of *C. sativus* (**Li et al., 2004),** produced from oxidation products of carotenoids and responsible for its taste, its bitter and antifungal aroma , **(Tarantilis and Polissiou , 1997) (Table 3).**

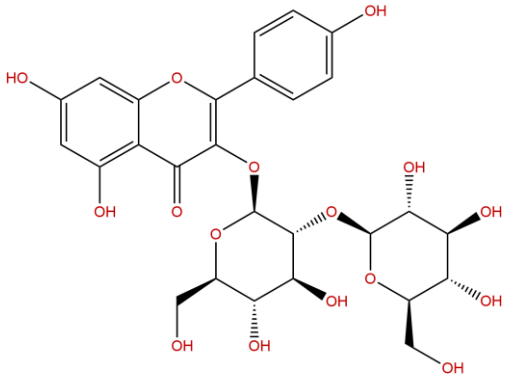
8. Carotenoids

carotenoids (mainly crocin at 0.6% content and crocetin) **(Azar et al., 2018)** exhibits antiseptic activity are among the most important plant sources with antioxidant activity in the human diet **(Moure et al., 2001).**



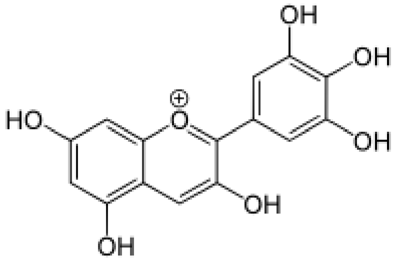


Kaempferol 3,7-di-O glucoside

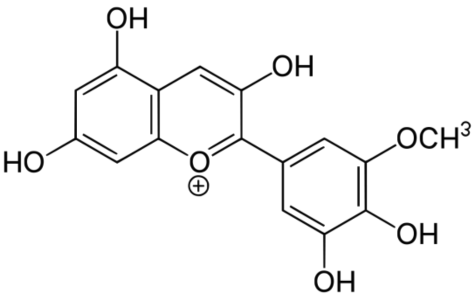


Kaempferol 7- O glucoside -3- O-sophoroside

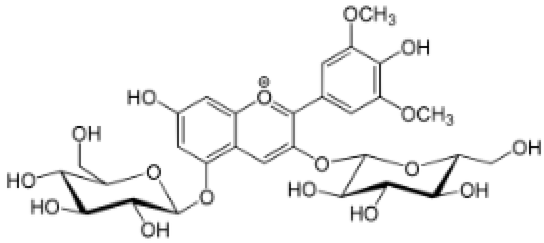
kaempferol 3-o-sophoroside



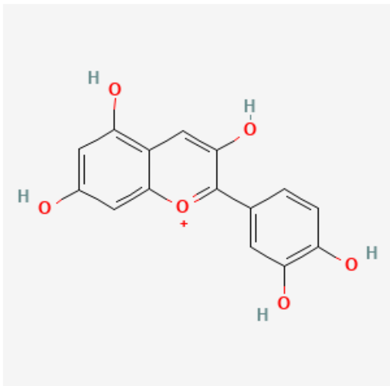
delphinidin



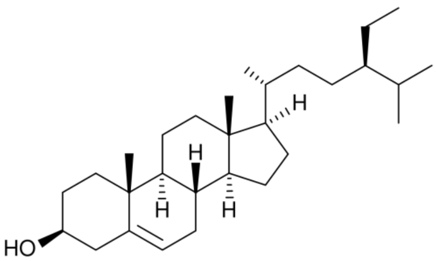
Petunidin



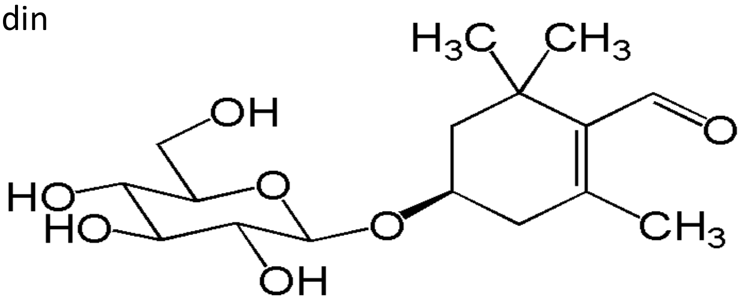
malvidin 3,5 -diglucoside



cyanidin



sitosetrol



Picrocrocin

Figure2. Main flavonols and anthocyanidins **(Grestaet al.,2008)**

Various analytical studies have been conducted to characterize a large number of biologically active compounds found in the petal:

Table 3. Composition of petals and flower of saffron **(Mykhailenko et al., 2019).**

Active substances	Compounds	References	Biological activities
Flavonoids	Kaempferol 3-O-sophoroside 7-O-glucoside	**Serrano- Díaz et al. (2014) ; Goupy et al. (2013)**	Diuretic hypotensive Anti-inflammatory Anti-carcinogenic Hypo-allergenic Antimicrobial Antioxidant Antitumor Antiviral Antiulcer inhibitor
	Kaempferol 3,7-di-O-glucoside		
	kaempferol 3-O-sophoroside	**Serrano- Díaz et al. (2014)**	
	kaempferol 3-O-rutinoside	**Goupy et al. (2013)**	
	Kaempferol-3-O-sophoroside-7-O-glycoside		
	Kaempferol 3-O-(6-acetyl-glycoside) 7-O-glycoside	**Goupy and Caris (2013)**	
	Kaempferol 3-O-(6-acetyl-glycoside) 7-O-glycoside	**Goupy et al. (2013)**	
	Kaempferol 3-O-sophoroside 7-O-rhamnoside		
	Isorhamnetin 3-O-sophoroside		

	Astragalin Narinrenin7-O-hexoside Taxifolin	**Montero et al. (2008)**	Anti-inflammatory anti-coronavirus Anti-oxidant Hypotensive
	Populin	**Straubinger et al. (1997). Montoro et al. (2008)**	Anti-inflammatory
	Vanillic acid	**(Li et al., 2004)**	Anti-microbial
Monoterpenoids	Picrocrocin Safrnal	**Rios et al. (1996); Montoro et al. (2012)**	Anti-infective antibacterial antifungal antiviral
	Crocusatin C Crocusatin D Crocusatin I Crocusatin J Crocusatin K Crocusatin L	**Li et al. (2004)**	
	Petunidin / delphinidin , malvidin3,5-diO-glucoside	**Serrano- Díaz et al. (2014)**	
	delphinidin 3-O glucoside petunidin 3-O-glucoside	**Goupy et al. (2013).,(Serrano-Díaz et al.(2014)**	

Anthocyanins	Delphinidin-3-O-β-rutinoside	**(Bergoin , 2005)**	
	Delphinidine3,7-O-diglucoside	**Goupy et al. (2013)**	Antioxidant antimicrobial antitumor sickle cell and thermodegradation
	Cyanidin	**Belyagoubi et al. (2019)**	
Diterpenes	Trans- /cis- crocetin ester	**Rychener et al. (1984)**	Antiviral
Phytosterols	Sitosterol Stigmasterol Fagastero	**(Feizy and Reyhani , 2016); Zheng et al. (2011)**	-
Nitrogen compounds	Tribulusterine Adenosine Nicotinamide	**Li et al. (2004); Termentzi and Kokkalou , (2008)**	-
Vitamins	Vitamin (tocopherol)	**Zheng et al. (2011)**	-

9. Biological activities

The pharmacological importance of Crocus has been appreciated both by the (**Canon et al., 2018)** of Avicenna's traditional medicine and by modern scientific reports. Evidence indicates that saffron flower has antioxidant properties against a broad spectrum of tumors, such as leukemia, ovarian carcinoma, colon adenocarcinoma, etc. **(Abdullaev and Espinosa-Aguirre, 2004; Zhang et al., 2013).** Others biological activities were listed in literature (**Figure 3**).

9.1. Antioxidant activity

Biological antioxidants have been defined as compounds that protect biological systems from the potentially harmful effects of processes or reactions that can cause excessive oxidation. **(Reiter and Robinson; 1995).** The anti-radical activity by **DPPH test** of the crude extracts of different polarities such as water, 80% methanol and 80% ethanol obtained from the different parts of the *C. sativus plant* were established by **(Hossain et al., 2014).** The study showed that the methanolic extracts of the whole flowers,stamens and ethanolic extracts of the styles have a fairly significant antioxidant power. This power is confirmed by low IC50 values with 164.76±8.3μg ml 235.5±10.4 μg ml, 190.26±19.98 μg ml .The most potent fractions appear to be the whole flower in the methanolic extract with IC50 values of 164.76 ± 8.31 μg ml .The IC50 values for the methanolic extracts of the whole flower, stamen, petals, and style were 164.76±8.3 μg ml, 235.5±10.4 μg ml, 268.02±5.6 μg ml and 342.7±14.6 μg ml respectively, compared to ascorbic acid (2.5±0.34 μg ml) used as positive control and α - tocopherol with 182.02±2.09 μg ml **(Jadouali et al., 2018). The FRAP** reducing power of petal, stamen and style extracts was negligible compared to ascorbic acid and α-tocopherol. According to **(Sedoud 2018),** the reducing power of the petals is 2.01 mg/ml and which remains low compared to other samples **(Jadouali et al et al., 2018).**

9.2. Antimicrobial activity

methanolic extracts of different concentrations (4500 μg /well, 9000 μg /well and 13500 μg /well) revealed that only the leaf extract of *C. sativus* represents a source of substances with antimicrobial activity against the bacteria studied, in particular against *Listeria* spp. **(Tagg and Given, 1971).**

The methanolic extracts of whole saffron flowers inhibited the growth of six bacteria such as *Escherichia coli* Cip54127, *Escherichia coli* Tg1, *Bacillus sp, Citrobacter freundii* and *Staphylococcus aureus*, with zones of inhibition 19; 16; 14; 10; 9.5 and 9mm respectively. While petal extracts show antibacterial activity against *Escherichia coli* Cip54127 and *Escherichia coli* Tg1 with respective zones of inhibition of 14.5 and 8mm **(Jadouali et al., 2018).** *C.sativus* whole flower extract exhibits the maximum antimicrobial effects against *Escherichia coli Tg1, Escherichia coliCip54127, Staphylococcus aureus* and *Cryptococcus respectively neoformans* Cip960 with MIC values equal to 0.78 µg/µl, 1.56 µg/µl, 12.5 µg/µl. The petal extracts had the maximum antibacterial effect against *Cryptococcus neoformans* , *Entercoccus faecalis Atcc19433, Bacillus sp* and *Candida albicans* with the lowest MIC values of 6.25; 50; 50; 50 µg/µl, respectively. According to **(Asgarpanah et al., 2013),** the inhibitory effect of petal extract against *Staphylococcus aureus* ATCC 25923 with an MIC value of 31.2 mg/ml.

However the CMB therefore makes it possible to affirm that the extract of the whole flowers showed a strong bactericidal power against *Staphylococcus aureus* and *Esherichia coli Dg5alfa* with a CMB of 3.125µg/µl. Regarding the extract of the petals show a strong CMB against *Aspergillud niger* with 6.25 µg/µl, and for the other microorganisms the CMB varies between 12.5 and 100 µg/µl. a study made by **(Asgarpanah et al., 2013)** showed that the methanol extract of *C. sativus petals* exhibited the bactericidal effects against *S. aureus* with the lowest CMB of 125 mg/ml. And that the petal extract has a CMB of 250 mg/ml against *Bacillus cereus* PTCC 1247.

9.3. Anti-inflammatory activity

Recent studies that different models of inflammation have also confirmed the anti-inflammatory properties of saffron and crocin **(El-Mas et al., 1998; Hosseinzadeh et al., 2002).** These two compounds have powerful antioxidants demonstrated by their inhibition of the production of pro-inflammatory cytokines **(Pradère et al., 2016) (Table 4).**

9.4. Antispasmodic activity

Saffron petals are used on smooth muscle tone. Petal extracts reduced electric field stimulation (EFS)-induced contraction in isolated rat vas deferens. Petal extracts reduced responses to epinephrine. However, **Fatehi et al. (2013)** showed that petal extract antagonized adrenergic receptors **(Table 4).**

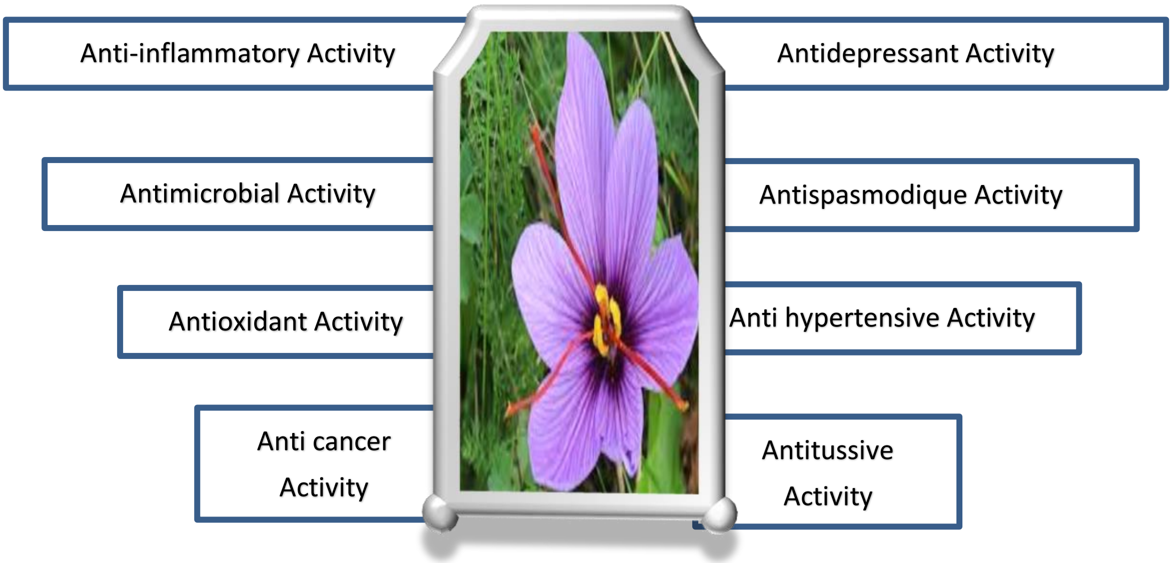


Figure 3. Flower of *C. sativus* and different biological activities **(Gasparetto et al., 2012).**

Table 4. Pharmacological effects of *C. sativus* petal in in vitro, in vivo studies **(Hosseini et al., 2018).**

Effect	**study design**	**Results**	**Ref.**
Anti-inflammatory	*In-vivo*	Petal extracts anti-nociceptive effects against pain by chemicals	**Hosseinzadeh et al. (2002)**
Antibacterial	*In vitro*	Methanol, ethyl acetate and extracts aqueous inhibited the growth of bacteria with different potencies. The effect is related to the presence of phenolic compounds and antioxidant activity	**Asgarpanah et al. (2013)**
Antispasmodics	*In vitro*	Petal extracts reduced responses to epinephrine	**Fateh et al. (2003)**
Antitussive	*In-vivo*	Aqueous extracts of petal and crocin did not improve cough	**Hosseinzadeh et al. (2006)**
Antidepressant	Human	Saffron petal, kaempferol , can be a valuable agent in the treatment of depression.	**Hosseinzadeh et al. (2007)**
Antiobesity and antidyslipidemia	*In-vivo*	Extracts lowered total cholesterol, triglycerides and LDL, while HDL levels increased. In addition, the extracts reduced the atherosclerosis index (LDL/HDL	**Hoshyar et al. (2016)**
Antihypertensive	*In-vivo*	Reduction of blood pressure may be related to the effect of *C. sativus* on cardiac resistance or device.	**Fatehi M et al. (2003)**

10. Cosmetology and perfumery uses of saffron petal

Nowadays, the saffron petals have been investigated in several studies to be rich in crocin and kaempferol, thus representing an important source of bioactive compounds for potential cosmetic formulations **(Ahrazem et al., 2018)**. In addition to its antioxidant properties, saffron flower has many interests for cosmetic applications. The most promising activities are listed below.

10.1. UV protection agent

The petal is known to have sunscreen effects that can protect the skin from harmful UV rays. The petals contain major compounds such as crocin, safranal and crocetin which have various activities due to its activity as an antioxidant which can counteract free radicals from ultraviolet (UV) rays) **(Mirhadi et al., 2019)**. Based on these compounds, commonly made sun cream is included in photoprotection, which can prevent and even damage the skin by UV radiation **(Marianne et al., 2019).**

10.2. Ace toner

According to a **2021** study by **Salvi and Prima**, pistil saffron (*C. sativus*) can be used as a facial tonic because it contains vitamin C, flavonoids and zinc, and is traditionally used to treat facial skin. The vitamin C contained in saffron pistil is 1.41%. Flavonoids act on depigmentation or are often called lightening agents to inhibit tyrosinase activity when the process of melanogenesis occurs **(Salvi et al., 2021).** The facial toner can work as a cleanser and remove excess sebum on the facial skin so that this facial toner has anti-sebum activity **(Timudom et al., 2019; Pongsakornpaisan et al., 2020).** In addition, the petals are containing the terpenoids such as crocusatins with antityrosinase activity (**Li et al., 2004**).

10.3. Anti-wrinkle

Saffron petals have antioxidant effects derived from the compounds of kaempferol, crocin, crocetin, and safranal, while these compounds eliminate wrinkles due to age and stress **(Kerscher et al., 2011; Bernad et al., 2020).**

10.4. Anti-stain

Saffron flower is known to reduce melamine in which brown spots appear **(Moshiri et al., 2015).** The flower of saffron contains crocin compounds that can inhibit the activity of the enzyme tyrosinase by damaging the hydrogen bonds in the tyrosinase, which causes rearrangement and conformational changes in the enzyme **(Pinon et al., 2011).**

10.5. Coloring pigments in cosmetics

These colors result from crocetin and crocin compounds of saffron, which have the carotenoid glycoside structure **(Javadi et al., 2013).**

10.6. Scent

In ancient Greek times, saffron was often used as a perfume. The flower of saffron contains more than 150 volatile and aromatic compounds. Safranal is one of the main components of saffron essential oil. It is formed by hydrolysis of picrocrocin during its drying and storage **(Kosar et al., 2018).**

Conclusion

The present study proved that the saffron petal is composed of different active principles such as anthocyanins, flavonols (kaempferol), new monoterpenoids including picrocrocin, crocusatine -J, Safrnal. Saffron petal is very rich in anthocyanins and can be used as a potential substitute of natural color resources of anthocyanins for food and pharmaceutical industries. These components have also possessed interesting biological properties such as antibacterial, hepatoprotective, anti-inflammatory, antidepressant and antioxidant activities which prevent the enzymatic peroxidation of fatty acids and which scavenge free radicals. Today, saffron petals are making their advantageous entry into the cosmetics field through their impact in several products, in order to protect the skin against aging and the sun's rays.

In terms of perspectives, it would be interesting to study the other biological effects demonstrated *in vitro* and *in vivo*.

On the other hand, additional efforts are needed to deepen this research in order to take advantage of the benefits of these biological and pharmacological activities.

It is also necessary to devote research on the natural compounds which act in synergy with the compounds of saffron (crocins, picrocrocin, safranal) or phenolic compounds of leaves, tepals, bulbs of Crocus to treat cancer or nerve diseases of the system.

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Abstract

Saffron "*C. sativus*" is a plant of iridaceae's family. Its therapeutic virtues have been known since antiquity, it is used in traditional medicine and in the various culinary preparations, it is also known for its use in cosmetic, because it has various types of beneficial pharmacological activities for human skin. In particular, saffron petals are the main by-product of saffron processing,it contains several bioactive compounds such as mineral agents, anthocyanins, monoterpenoids carotenoids,flavonoids and flavonols (kaempferol).The purpose of this review is to describe.the different properties of *C.sativus* petals it has been found that saffron petals are components that have pharmacological avtivity such as antibacterial, antispasmodic, immunomodulatory ,antitussive, antidepressant ,antinociceptive , hepatoprotective , renoprotective , antihypertensive , antidiabetic and antioxidant activity . According to these properties, saffron petal can be used as addictive in pharmacy and cosmetics.

Keywords: Phytochemical characterization, Biological activities, Chemical components, Valorization of by-products, active ingredient, *Crocus sativus*,

Résumé

Le safran « *Crocus sativus* » est une plante de la famille des iridacées. Ses vertus thérapeutiques sont connues depuis l'antiquité, il est utilisé en médicine traditionnelle et dans les différentes préparations culinaires il est également connu pour son utilisation en tant que cosmétique, car il possède divers types d'activités pharmacologiques bénéfiques pour la peau humaine. Notamment, les pétales de safran sont le principal sous-produit de la transformation du safran, il contient plusieurs composés bioactifs tels que des agents minéraux, des anthocyanes, Monoterpénoïdes, caroténoides, flavonoïdes et flavonol du (kaempférol). Le but de cette étude était d'évaluer les différentes propriétés de pétales de *C. sativus*. Il a été constaté que les pétales du safran sont des composants qui ont une activité pharmacologiques tel que l'activité antibactérienne, antispasmodique, immunmodulatrice, antitussive, antidépressive, antinociceptive, hépatoprotectrice, rénoprotectrice, anti hypertensive, antidiabétique et antioxydante. Selon ces propriétés, le pétale de safran peut être utilisé comme additifs dans la pharmacie et la cosmétique.

Mots clés : Caractérisation phytochimique, Activités biologique, Composants chimique, Valorisation des sous-produits, Ingrédient actif, *Crocus sativus*

ملخص

الزعفران "Crocus sativus" هو نبات من عائلة السوسنيات. وقد عُرفت مزاياه العلاجية منذ العصور القديمة ، وهي تُستخدم في الطب التقليدي وفي مستحضرات الطهي المختلفة ، كما يشتهر باستخدامه كمستحضر تجميلي ، نظرًا لأن له أنواعًا مختلفة من الأنشطة الدوائية المفيدة لبشرة الإنسان. تعتبر بتلات الزعفران المنتج الثانوي الرئيسي لمعالجة الزعفران ، فهو يحتوي على العديد من المركبات النشطة بيولوجيًا مثل العوامل المعدنية ، والأنثوسيانين ، ومونوتربينويدات , الكاروتينات الفلافونويد, الفلافونول ، والكايمبفيرول. كان الغرض من هذه الدراسة هو تقييم الخصائص المختلفة لبتلات Crocus Sativus. لقد وجد أن بتلات الزعفران هي مكونات لها نشاط دوائي مثل النشاط المضاد للبكتيريا ، ومضاد التشنج ، والمناعة ، ومضاد للسعال ، ومضاد الاكتئاب ، ومضاد للالتهاب ، ومضاد للالتهاب ، ومضاد للضغط ، ومضاد للسكري ، ومضاد للأكسدة. وفقًا لهذه الخصائص، يمكن استخدام بتلات الزعفران