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# *Saffron (Crocus sativus L.) : Quality Assessment in Morocco*

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*Workshop on  
Saffron:  
Production Progress & Market Promise  
Friday, March 15, 2019  
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# Saffron uses



**SAFFRON** as a dye  
(carpet-Taznakht-Morocco)



**SAFFRON PLANT**  
*Crocus sativus L.*

Family : Iradaceae, Genus. *Crocus* ( ab. 80 species distributed primarily in the Mediterranean and south-western Asia.

<https://www.persavita.com/>



**SAFFRON** as medication



**SAFFRON** in food



**SAFFRON** in perfume and cosmetics

<https://www.robertharding.com/index.php?lang=en&page=search&s=saffron%2Brobe&smode=0&zoom=1&display=5&sortby=1&bgcolour=white>

[https://express.google.com/u/0/product/9709518533217544308\\_6947756572781394422\\_5459102?utm\\_source=google\\_shopping&utm\\_medium=tu\\_cu&utm\\_content=eid-lsjeuxoetq&tim=CL5fkPWcy6-hIAEQ2NkC7\\_79lJAhGIDgkgIA1VTRCjgwLDk8TcemcOC&utm\\_campaign=5459102&gclid=Cj0KCCjwsZ3kBRcNARisAluAV\\_TznzYoXhyHueOoQkAscIjZxZb5xZgx6SQn0A-qgavVwz5E8Ioj8aAl96EALw\\_wcb](https://express.google.com/u/0/product/9709518533217544308_6947756572781394422_5459102?utm_source=google_shopping&utm_medium=tu_cu&utm_content=eid-lsjeuxoetq&tim=CL5fkPWcy6-hIAEQ2NkC7_79lJAhGIDgkgIA1VTRCjgwLDk8TcemcOC&utm_campaign=5459102&gclid=Cj0KCCjwsZ3kBRcNARisAluAV_TznzYoXhyHueOoQkAscIjZxZb5xZgx6SQn0A-qgavVwz5E8Ioj8aAl96EALw_wcb)

# What is saffron



SAFFRON SPICE

SAFFRON' style-stigmas, dried, are the source of the saffron spice and accumulate the apocarotenoids crocetin, crocins, picrocrocin, and safranal, responsible for its color, taste, and aroma power. It represents the most interesting and attractive specie.



Ancient mother corm bearing new cormels



SAFFRON Corms

It is a geophyte herbaceous, **sterile** plant known only as a **cultivated species**; it propagates solely vegetatively by means of corms, vegetative underground stems acting as storage and reproduction structures.

# What is saffron



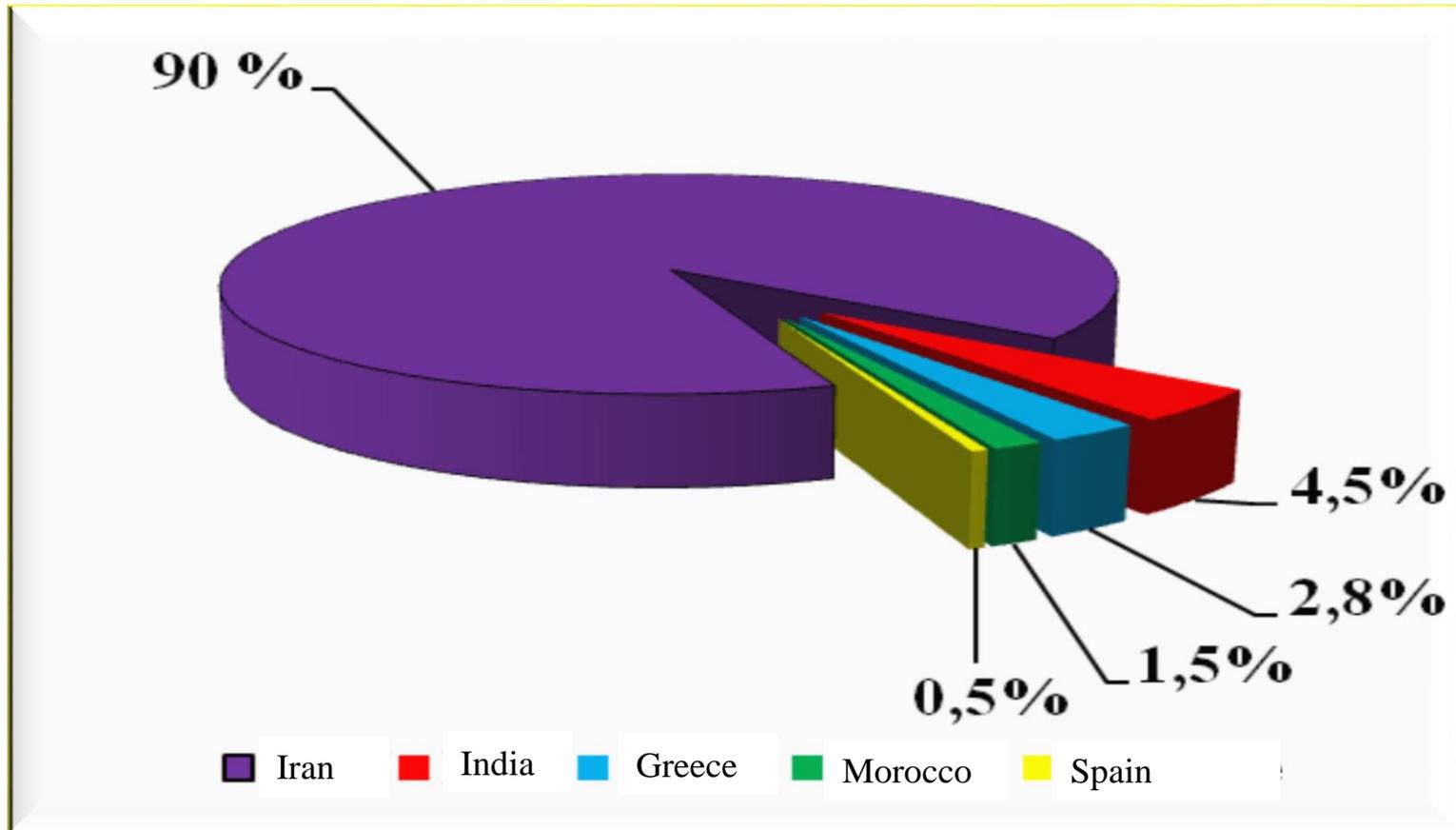
Saffron crop is a plastic plant, cultivated in a **wide range of environments** with mild to dry climates.

It has been neglected by researchers and farmers since it was considered a minor crop. It is actually gaining a more interesting role in low-input agricultural systems and as an alternative crop and as a medicinal plant.

It is a very attractive crop for organic agriculture as no irrigation, chemical fertilization or chemical weed control are needed.

The main management techniques (corm planting, flower harvest, stigma separation and corm lifting) are carried out manually and this contributes to its high price.

# Worldwide saffron production



**The world production of saffron is up to 330 tones  
World trade of saffron worth one billion dollars which accounts  
for 5 percent of the total spices sold internationally.**

# Saffron quality

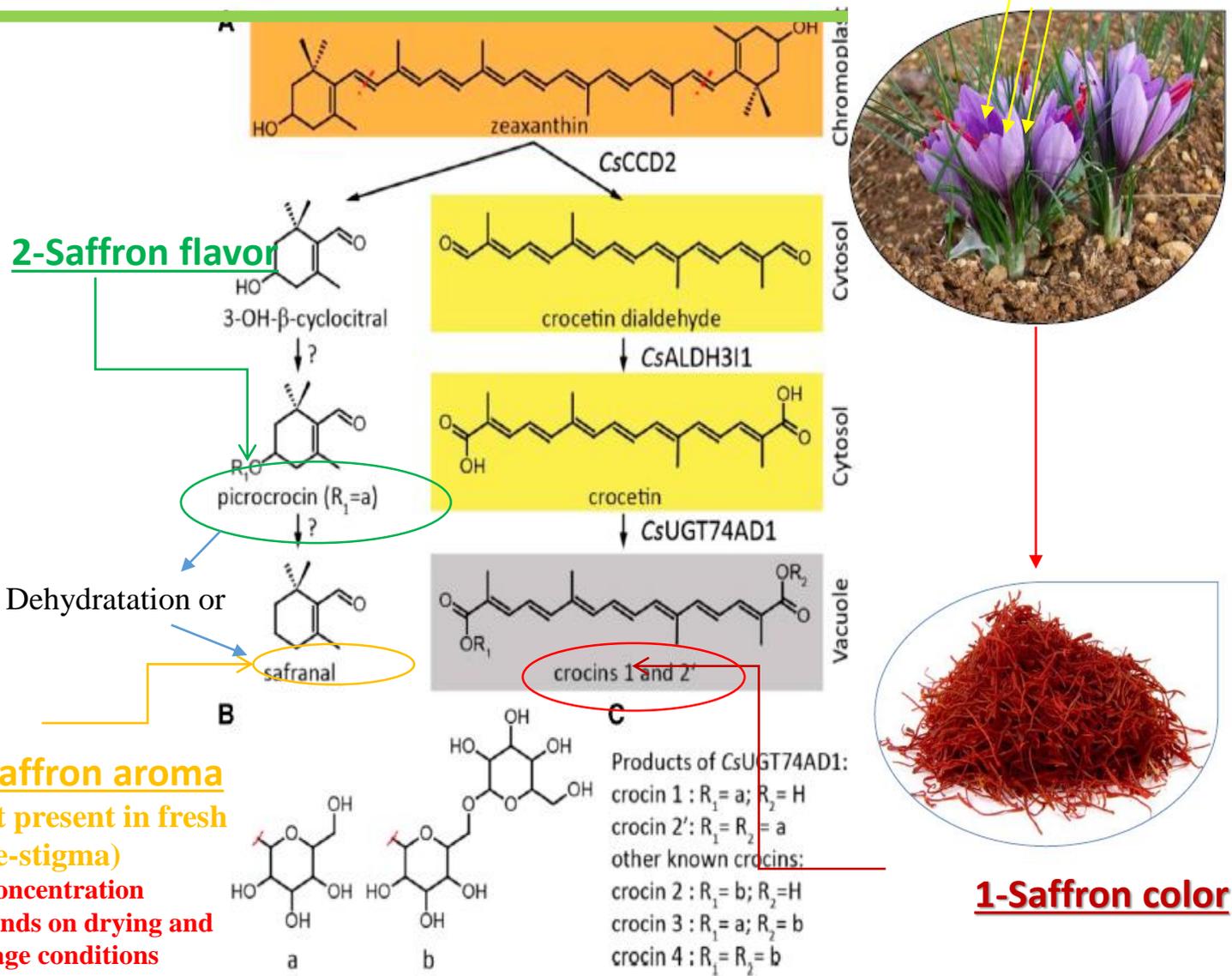


Figure 1. Crocin biosynthesis in *C. sativus* stigmas. A, Biosynthesis scheme adapted from Demurtas et al. (2018), indicating the localization of the metabolite. B, Sugar moieties of crocins and picrocrocin. C, Naming convention of crocins.

# Analytical methods for the certification of saffron quality and authenticity

UV-VIS Spectrometer	Mainly used, in the international trade, by specification recommended by the ISO 3632 (2011). It classifies saffron into three categories based on their physical and chemical characteristics. The three parameters used to define the saffron quality are color, taste and aroma, This determination is actually debated.
Near Infrared spectroscopy(NIRS)	with chemometric techniques is the fastest and safest method for food certification
High-Performance Liquid Chromatography-Photodiode Array Spectroscopy (HPLC-PDA)	detect, tentatively identify and quantify any non-volatile compound and, combined with derivatization, several volatile aldehydes.
HPLC-Fluorescence spectroscopy (HPLC-FS),	exhibits very high sensitivity (parts per billion) and is the method of choice for mycotoxin identification.
Liquid Chromatography-Mass Spectrometry (LC-MS),	It can detect and identify almost any non-volatile compound down to parts per trillion
Gas Chromatography-Mass Spectrometry (GC-MS)	detects volatile molecules (eg HTCC, safranal). Compound identification in GC-MS is straightforward, thanks to the available databases of mass spectra.
Direct Infusion MS (DiMS))	the mixture is directly infused into the mass spectrometer, eliminating the use of costly and toxic chemicals, and detecting hundreds (vs. thousands in LC-MS) compounds in a complex mixture. Several thousands of samples (vs. hundreds in LC-MS) can be fingerprinted in a working day
Inductively Coupled Plasma Mass Spectrometry (ICP-MS)	allows the simultaneous quantitation of trace metals and several non-metals, exhibits very high sensitivity (down to parts per quadrillion), processivity and high mass resolution. It has been used successfully to determine geographic origin of several food products, such as honey (Chudzinska, & Baralkiewicz, 2010) and saffron (D'Archivio et al, 2014).
Fourier Transform Infrared Spectroscopy (FTIR)	Eliminates sample preparation. IR spectroscopy allows both structural elucidation and quantitative determination of compounds in mixtures. <b>With chemometrics, it</b> has been used for the authentication of the geographical origin (Anastasaki et al., 2010a) or to detect adulteration (Karimi et al., 2016; Petrakis & Polissiou, 2017).
RAMAN spectroscopy	It has been used for the quantitative determination of crocins and colouring strength in saffron (Anastasaki et al., 2010b).
FT-IR and Raman spectroscopies	are very promising techniques for routine basis of saffron quality control and they can be used also for the differentiation of authentic saffron samples from the adulterated.

# Saffron adulteration issues

**Fraud** in food industry has a long history and it dates back to thousands of years ago AND it is believed that nothing is adulterated as much as saffron due to its high price **SPECIALLY powdered** saffron;

Adulteration is a process which normally begins in **the market chain** and not by farmers;

Adulteration may be by:

- Mixture of many saffron (new and older) and from many countries (Most common, cheap, bad quality...),
- Various parts of the saffron plant (stamens, perigone),
- Substances that increase weight (Humidity percentage increase, soaking in syrup, honey, glycerin or olive oil ),
- Animal substances (salted and dried meat fiber)
- Artificial substance (colored gelatin fibers)
- Organic dye substances (Martins yellow, Erythrocin, orange yellow...)
- Potentially toxic colorants (amaranth, azorubine, orange II, Ponceau 4R, quinoline yellow, sunset yellow S, tartrazine, yellow 2G, rocelline, Sudan I-IV) (ISO 3632, 2011; Petrakis et al, 2017).

- Herbaceous plants cut in pieces and colored like:



Gardenia (*Gardenia jasminoides*)



Turmeric (*Curcuma longa*)

*Pure saffron is adulterated (20%) with Turmeric, or Stamens or Safflower or Gardenia*



Safflower (*Carthamus tinctorius*)

# Saffron in Morocco- General considerations

- Small total economic value in commercial production and trade, comparing to the staple crops and agricultural commodities

- Scarce attention by national agricultural and biodiversity conservation

**Underutilized**



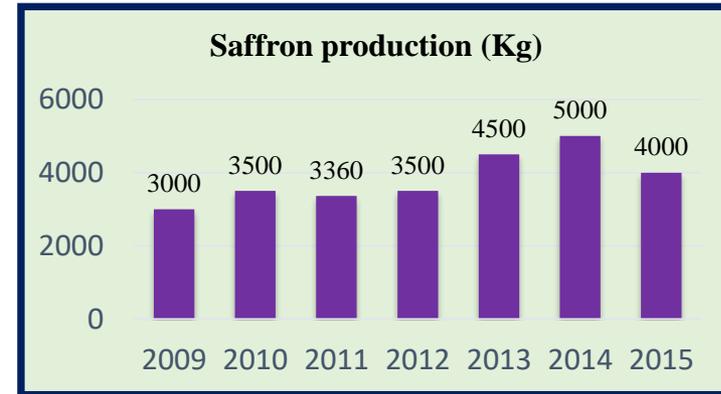
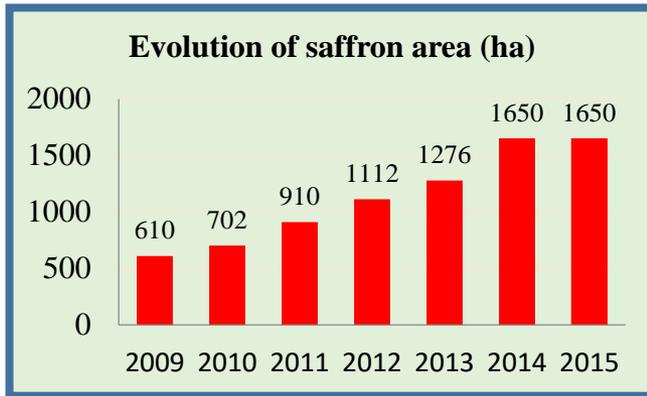
**Neglected**



- Reducing rural poverty
- Higher water use efficiency
- Higher economic return per unit area compared to traditional crops
- Applications in internal industries
- Economic role because of good international market for export
- Potential role in public health

# Saffron in Morocco

- Taliouine, the heart of Morocco's saffron producing region, has been cultivated by saffron for many centuries (The 10<sup>th</sup> Century). In 2016, the Area of saffron is 1630 ha (5.8 t) (Mean annual Temp= 63 F, 300 mm rain). The region's highest altitude (2400 m).

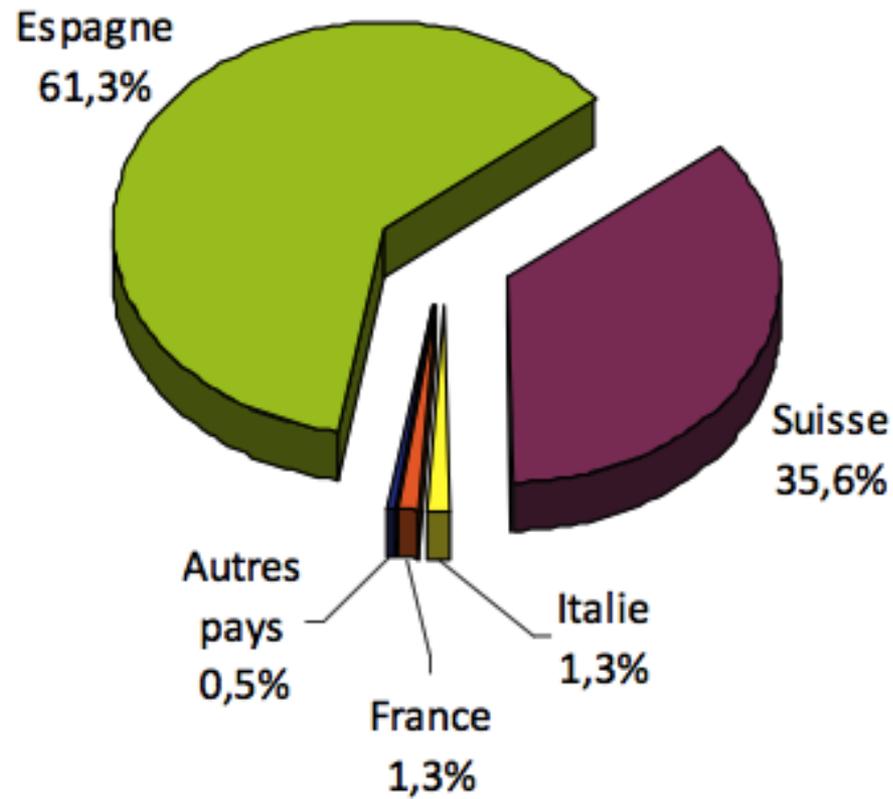


1Ha =2.47 acres , 1 Kg=2.20 pounds



ii (<https://www.journeybeyondtravel.com/blog/taliouine-morocco-saffron.html>)

## Saffron in Morocco- General considerations



Moroccan saffron exportation  
(1998-2009)  
(% of total value)

*Source: office des changes*

# Saffron in Morocco

- The region' relationship with saffron is built on a reliance and esteem for the fortune it brings. Guesthouses and restaurants are all named after the crocus and it is reflected in the local cuisine and traditional medicines. The name in Amazigh given to saffron is 'Asafar' which means medication.



(<https://www.journeybeyondtravel.com/blog/taliouine-morocco-saffron.html>)

# Saffron in Morocco

- About 1500 to 2000 saffron producers are located in Taliouin region which is the only one in the MENA region and Africa that produces saffron



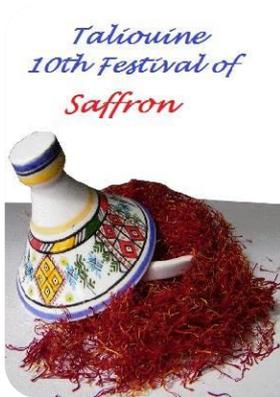
- Morocco **saffron house** of Taliouin: plays a role of integrator of the producers for the valorization and the marketing of the saffron.



(<https://www.journeybeyondtravel.com/blog/taliouine-morocco-saffron.html>)

# Saffron in Morocco

- Every first week of November, a saffron festival is held at harvest time for 3 days. Men and women alike, with their wonderful local costumes gathered in the evening to enjoy the vibrant rhythms of local music and dance. People also from around Morocco come to celebrate, buy saffron from local producers and many traders take contacts. In addition many cultural conferences, skill building workshops, sport activities and entertaining activities for children were planned to take place in Dar Zaafran (the house of saffron) during the three days of the festival.

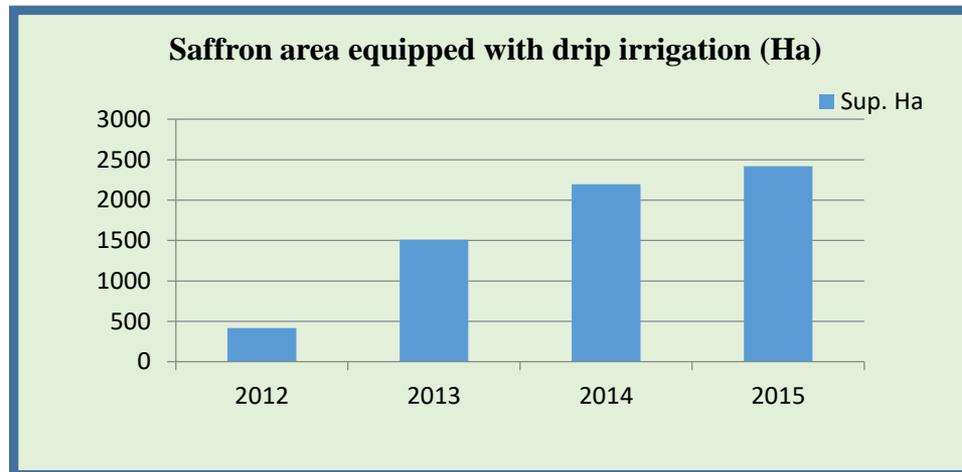


[https://www.google.com/search?q=festival+safran+talioquin&source=lnms&tbn=isch&sa=X&ved=0ahUKEwilgpmqzNvgAhUSWhoKHfjBCKkQ\\_AUIDigB&biw=2133&bih=946#imgsrc=OLrYDclnY2tA-M:](https://www.google.com/search?q=festival+safran+talioquin&source=lnms&tbn=isch&sa=X&ved=0ahUKEwilgpmqzNvgAhUSWhoKHfjBCKkQ_AUIDigB&biw=2133&bih=946#imgsrc=OLrYDclnY2tA-M:)

<https://www.journeybeyondtravel.com/blog/talioquine-morocco-saffron.html>

# Saffron Area and Production Evolution in Taliouin Region

Moroccan Government invests of 80 MDH (8.5Million US\$) and 20 MDH(2.1MUS\$) from the region for the improvement of saffron quality, adding-value, marketing, organization and area increase



1Ha =2.47 acres  
1 Kg=2.20 pounds

# Moroccan Saffron conduct to achieve good quality

- Saffron is expensive, not because it is rare but because it requires many hours of work and because all labor is manual.

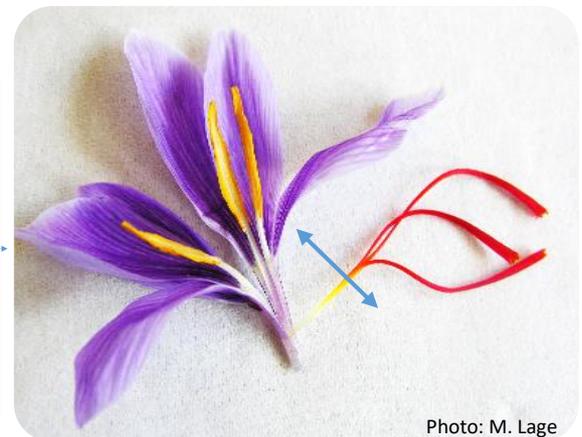


- For 1 gr of dried saffron more than 235 flowers must be picked up and extracted which takes a **skillful woman** approximately **65 minutes/g dried saffron**.



# Moroccan Saffron conduct to achieve good quality

- Harvesting saffron' flowers **before dawn** when flowers are still closed and the style-stigmas are protected from the sun, they are **pruned the same day of harvest** to not lose their quality over time.
- Pruning is done on a **clean surface** in the houses of the villagers respecting hygiene conditions. This step is particularly delicate because the style-stigma part should be cut just below the point of attachment of the 3 filaments.



# Moroccan Saffron conduct to achieve good quality

- Style-stigma are dehydrated as quickly as possible in order to conserve the saffron's quality. Saffron lose more than 80% of its fresh weight and the dried product contains only 10 to 12% of water.



Red Orange

During drying the color changes.



claret-red.

- If properly dried and stored in good conditions (ex: opaque glass jars or stainless steel boxes, in a dry place away from light), saffron can be kept for a long time. Indeed, humidity exceeding the limits (12% as specified in ISO 3632-1, 2011) could lead to the growth of yeasts and bacteria. According to farmers, drying done in the open air, promotes a high crocins concentration.

# Moroccan Saffron quality

## Insurance

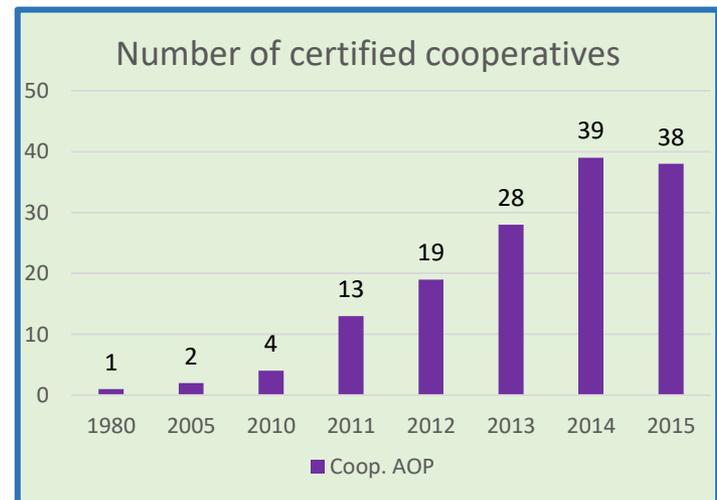
Like olive oil, Argan oil, Majhoul dates and others local products, saffron has features that are tied up to its 'terroir' (soil, climate, very old corms, the know-how of farmers).

To protect the specific features of the Taliouine saffron, it has received the Protected Designation of Origin ('AOP') of Morocco.



Saffron is the most adulterated spice in the world. But this 'AOP' allows to guarantee a good traceability of the products (town, village, cooperative and producer) .

<http://www.darazaafarane-gie.com/en/safran>

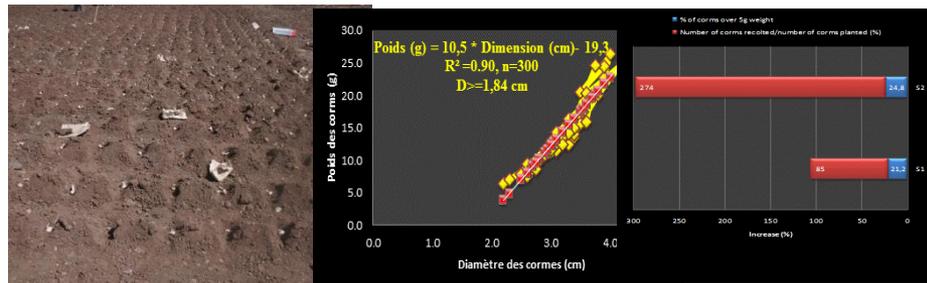


# Research on saffron conducted by INRA-

## Experimental Trials

Actually many universities including medicine and pharmacy are interested to work on saffron

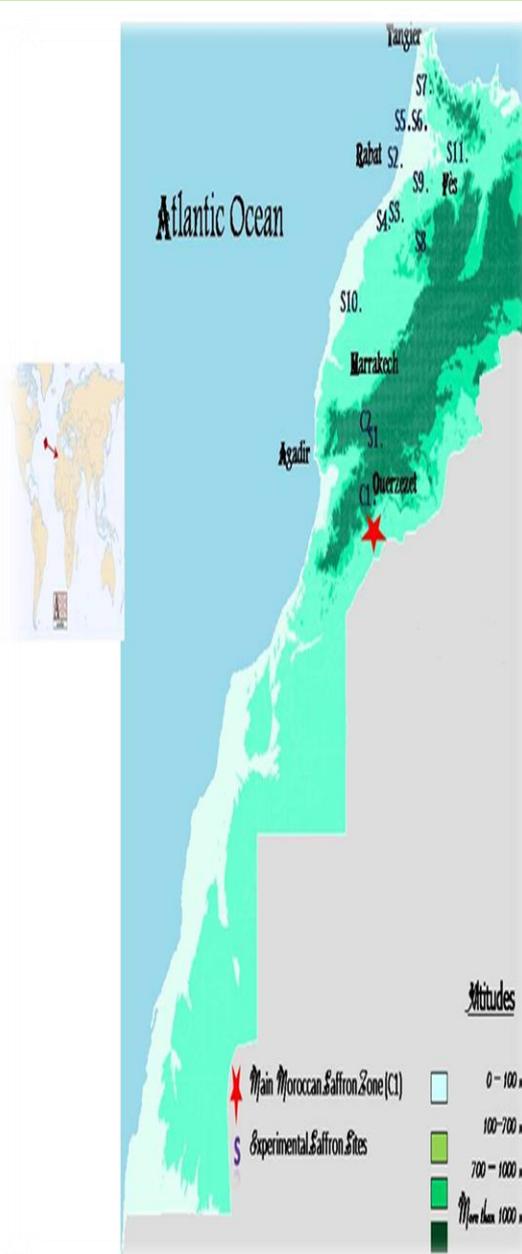
- **Adaptation to news zones** → Identification of the new saffron zones based on saffron quality
- **Agronomic trials** → Agronomic technics (Corms size, density, mode of sowing ....)  
Saffron quality analysis-  
Phytopathological studies-
- **Genetic variability and corms production** → Selection of the best corms for enhancing saffron corm production and saffron quality
- **Biotechnological studies** → Production of saffron cormels via CIV  
Genetic characterisation of moroccan saffron



# Saffron quality –Environment- Research Work-INRA

The main goal to propose a **sustainable substitute crop** with **high added value** in some Moroccan agricultural areas with **low and erratic rainfalls** for poor farmers,

The quality of saffron spice crop produced under different environments, KT and genetic variability were studied prior to recommendation for new farmers. For this purpose, saffron was grown in different experimental zones with a **disparity of altitudes, soils and climates**.



Saffron @ Altitude 50 m



Saffron @ Altitude 1300 m



Saffron @ Altitude 2500 m

# Moroccan Saffron quality analysis under different environments

## HPLC ANALYSIS

Determination of saffron constituents (% dry weight) under different environment in comparison to two commercials control (C1 and C2) using HPLC method: Crocins and safranal values are average of 3 years of experimentation (2005, 2006 and 2007), picrocrocin are values obtained during harvest 2006. (Sites are classified from the lowest to the highest altitude).

Site number	Site name	Sites altitude	Crocins (%)	Safranal (%)	Picrocrocin (%)
S5	Larache	46.7	17.90	0.21	11.92
S2	Rabat	75.3	25.84	0.11	14.25
S4	Koudia	200	25.14	0.18	6.75
S10	Settat	397	26.70	0.04	15.75
S3	Merchouch	398	24.46	0.19	10.67
S11	Taounate	509	24.00	0.48	-
S7	Chaouen	600	31.17	0.19	17.84
S6	Ouezzen	614	29.63	0.10	4.23
S9	Meknes	714	25.13	0.28	10.01
C2	"Safranier d'Ourika"	1100	37.23	0.24	28.78
S8	Oulmes	1135	31.88	0.27	9.11
S1	Marrakech	1300	34.25	0.35	14.69
C1	Taliouin	1630	36.27	0.17	24.52

Means with different letters in a column show differences at a significance level of 5% according to DMRT.

## Uv/Vis Spectro (ISO/TS 3632, 2003).

Comparison of  $E_{2\%}^{1\text{cm}}$  values of Picrocrocin, safranal and crocins obtained in different experimental sites with ISO procedure. Crocins and safranal values are average of 2 years of experimentation (2006 and 2007), picrocrocin are values obtained during harvest 2006. (Sites are classified from the lowest to the highest altitude).

Sites number	UV-visible <sup>a</sup>	
	$E_{330}^{2\%}$	$E_{440}^{2\%}$
S5	50 ± 1	128 ± 1.1
S2	48 ± 0.2	254 ± 0.3
S4	38 ± 0.3	243 ± 0.4
S10	48 ± 0.3	231 ± 0.7
S3	46 ± 0.3	139 ± 0.4
S11	47 ± 0.3	117 ± 0.3
S7	50 ± 0.7	268 ± 0.1
S6	43 ± 0.01	275 ± 0.2
S9	47 ± 0.7	202 ± 0.4
C2	40 ± 2	350 ± 1.6
S8	50 ± 0.6	256 ± 1.9
S1	36 ± 0.7	287 ± 0.5
C1	38 ± 0.01	276 ± 0.7

<sup>a</sup> Extraction according to ISO 3632 method with distilled water as the reference liquid.

# Moroccan Saffron quality analysis under different environments

The yield and quality based on crocins are **inversely proportional**;

Based on crocins content, 2 groups were identified:

**Group 1**, which has an altitude over 1000 m showed higher crocins than **Group 2** which has an altitude lower Than 1000 m

- **Crocins** are **stable** under each specific environment tested ( $p > 5\%$ ) over **3 years of study**.
- Meanwhile, there was a **large variability in safranal** content for the same period ( $p < 0.05$ ) . And statistic analysis do not show an impact of the altitude on safranal.

## HPLC ANALYSIS

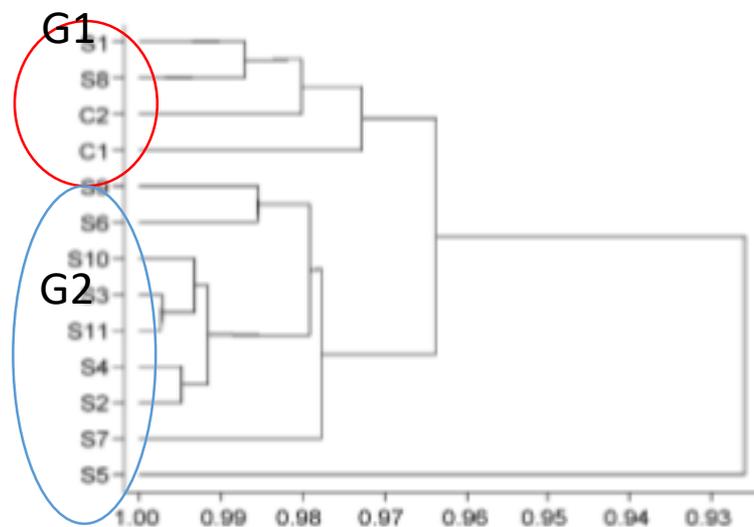


Fig. 6. Dendrogram of saffron sites gathered on altitude and crocins basis.

# Moroccan Saffron quality analysis –impact of drying and conservation modes

**Samples:** 23 samples collected from different environments and years,

**Analytical method :** Thermal desorption-gas chromatography–mass spectrometry.

## Results:

-Drying method have a significant effects ( $p<0.05$ ) on crocins, safranal and picrocrocin

-Samples dried in the oven had the highest coloring strength, aroma and bitterness values as well as the highest values of kaempferol, one of the compounds responsible for the antioxidant capacity of saffron, than samples dried by a traditional method.

-Using electric Oven reduces drying time and danger of contamination by dust and insect

**Conclusion :** Saffron dried by oven (40°C) with a drying time which varies from 30 to 60 minutes (12% of RH) and conserved in the refrigerator in a sealed box at 8°C provided satisfactory results.

Serial numbers	Moisture & volatile matter (%)	Harvest	Storage conditions	E1% 1cm 440 nm	E1% 1cm 339 nm	E1% 1cm 257 nm
E1	12	2011	S.G	206	40	83
E2	12	2011	S.G	253	33	101
E3	13	2011	S.G	199	39	103
E4	11	2011	S.G	260	40	109
E5	10	2011	S.G	232	34	94
E6	11	2011	S.G	212	43	96
E7	13	2011	S.G	254	39	104
E8	11	2011	S.G	229	38	98
E9	13	2011	S.G	194	38	87
E10	11	2011	S.G	186	42	88
E11	7	2012	W.B	204	42	100
E14	12	2012	8°C/G.B	168	47	95
E15	12	2012	8°C/G.B	242	38	105
E16	10	2012	8°C/G.B	212	38	100
E17	11	2012	8°C/G.B	204	36	84
E18	12	2012	8°C/G.B	253	42	111
E19	13	2012	8°C/G.B	234	39	102
E20	11	2012	8°C/G.B	277	32	110
E21	11	2012	8°C/G.B	205	39	95
E22	10	2012	8°C/G.B	227	41	115
E23	10	2011	S.G	210	37	88

S.G: smoked glass      W.B: wood box, G.B: glass box

# Moroccan Saffron quality analysis –volatile composition

**Samples:** 19 three replicate saffron samples collected from under different environment and with 3 main drying modes (natural under shade, natural under sun and oven 80 deg. 30 mn)

**Analytical Method:** SPME-GC-MS

## Results:

This study highlights the impact of the environment on saffron volatiles composition

- When samples are dried by oven, we can't identify saffron origin. But when it is performed naturally, a difference between samples aroma from different environment is obvious.
- The cluster analysis based on Jaccard similarity and complete link method has identified five groups, at 75% of similarity.

Table 1: Samples origin and site identification

Serial Numbers	Site Origin	Lat./Long.	Altitude (m)	Soil Ph (Water)	Organic Matter (%)	Clay (%)	Drying Mode
S1	Taliouin	30.53 /-7.9	1404	8.11	0.05	20.00	Natural/Sun
S2	Taliouin	30.53 /-7.9	1393	8.19	0.39	20.00	Natural/Shade
S3	Taliouin	30.53 /-7.9	1477	7.93	0.81	35.00	Natural/Sun
S4	Taliouin	30.53 /-7.9	1764	8.08	1.03	15.00	Natural/Shade
S5	Taliouin	30.53 /-7.9	1783	8.25	1.15	10.00	Natural/Shade
S6	Taliouin	30.53 /-7.9	1715	7.90	1.18	10.00	Natural/Shade
S7	Taliouin	30.53 /-7.9	1733	7.80	3.29	10.00	Natural/Shade
S8	Taliouin	30.53 /-7.9	1792	7.48	5.18	5.00	Natural/Shade
S9	Taznakht	30.57/-7.20	1500	8.61	1.26	NI	Natural/Shade
S10	Taznakht	30.57/-7.20	1604	8.45	0.59	NI	Natural/Shade
S11	Taznakht	30.57/-7.20	2100	7.90	2.40	NI	Natural/Shade
S12	Marrakech	31.63/-8	1100	8.28	3.9	NI	Oven
S13	Errachidia	31.93/-4.42	1500	8.48	0.14	NI	Natural/Shade
S14	Taznakht	30.57/-7.20	1590	7.80	1.80	NI	Natural/Shade
S15	Errachidia	31.93/-4.42	1906	8.31	3.90	NI	Oven
S16	Tetuan	35.57/-5.36	100	8.11	0.05	22.5	Natural/Shade
S17	Kosovo	42.60/20.90	NI	8.19	0.39	> 35%	Oven
S18	PDO (Cooperative)	NI	NI	7.93	0.81	NI	Oven
S19	Saffron Market	NI	NI	8.08	1.03	NI	Natural/Shade

NI: Not identified, Lat./Long. : Latitude and Longitude

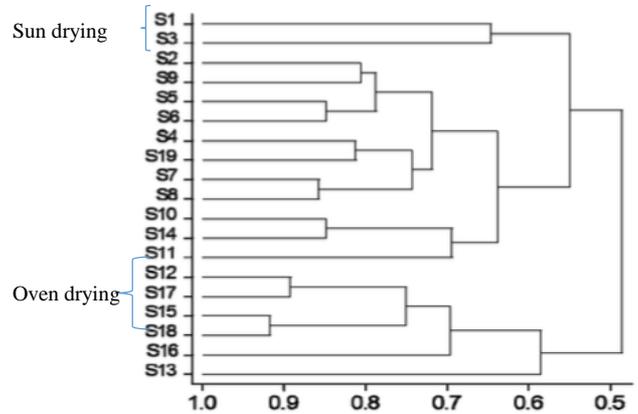


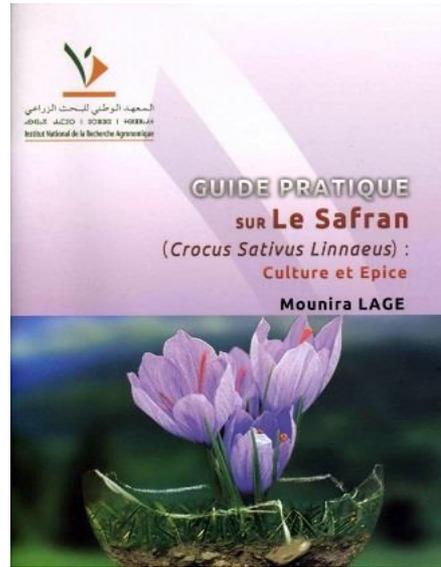
Table 4: Grouping (G) at 75% of similarity

G1	G2	G3	G4	G5
S2, S9	S4, S19	S7 S8	S10 S14	S12 S17
S5 S6				S15 S18

G1,G2,G3 and G4 : natural/shade drying, G5: Oven drying

# Research on saffron conducted by INRA- Research and Development

## 1- Technical guide on saffron conduct



## 2- Conducting experimentations at farms level



# Research on saffron conducted by INRA-Research and Development

## 3- Monitoring and farmer supervision-Technology transfer



1- Corms collect-and sowing



2-Visiting exp. trials with farmers



3- Having lunch with farmers and discussion on saffron conduct and quality assessment

# Valorization and dissemination of research results



Organizing International Saffron Symposium And workshops

<http://www.ishs.org/symposium/459>

**Thanks FOR YOUR ATTENTION**