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**ORIGINAL ARTICLE**

# Saffron: A Concise Review of Researches

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Shahram Sharafzadeh; Saffron: A Concise Review of Researches

**ABSTRACT**

Saffron (*Crocus sativus* L.), a member of Iridaceae family is a perennial spice species. stigmas of saffron flowers are the most expensive spice. This review focuses on botany, propagation, uses and production of saffron. Saffron is sterile and has fleshy corms. The origin of saffron by allopolyploidy seems more probable considering the recent data on its karyotype and molecular biology but many authors have hypothesized the origin of saffron by autotriploid. Conventional propagation methods are very slow and propagation by tissue culture represents an important potential to effectively propagate it. Compounds considered pharmacologically active and important are volatile agents (e.g. safranal), bitter principles (e.g. picrocrocin) and dye materials (e.g. crocetin and its glycosidic, crocin). It is highly priced due to high demand and low supply.

***Key words***: *Crocus sativus*, corm, sterile, crocine, crocetin, micropropagation.

## Introduction

Saffron, *Crocus sativus* L., is an important crop cultivated as the source of its spice for at least 3,500 years. Saffron is a perennial spice species of Iridaceae Family and has been spread out in Mediterranean and west of Asia from 10 west to 80 east degrees of geographical longitude, as well as from 30 to 50 north degrees of geographical latitude and up to 1000 meters from sea level [27]. Dried stigmas of saffron flowers compose the most expensive spice which has been valuable since ancient times for its odoriferous, coloring, and medicinal properties [38].

It has been propagated and still continues to be propagated vegetatively. There is a supposition that saffron as a clone can be scarcely changed genetically and its improvement is hardly possible through clonal selection [9,37].

The name saffron is commonly used to refer both to the spice and the plant itself. Some archaeological and historical studies indicate that domestication of saffron dates back to 2,000-1,500 years BC [19]. Saffron is currently being cultivated more or less intensively in Iran, India, Greece, Spain, Italy, Turkey, France, Switzerland, Israel, Pakistan, Azerbaijan, China, Egypt, United Arab Emirates, Japan, Afghanistan, Iraq and recently Australia (Tasmania) [35]. The name 'saffron' is derived from Arabic *zá-faran* which means 'be yellow' [44].

Saffron leaves (with producing about 1.5 t dry matter each year) can provide forage for about 160000 heads of cattle. Saffron petal is one of the by-products of fields that the amount of this by-product is more than 10000 t each year. Nowadays, the only usage of saffron petals is dye extraction, which is not flourished yet [14].

This review focuses on botany, propagation, uses and production of saffron.

*Taxonomy and Morphology:*

Saffron is classified into Magnoliophyta division, class Liliopsida and order Asparagales. It is a member of the Iridaceae family and the *Crocus* L. genus. Iridaceae family includes about 60 genera and 1,500 species. The plants in this family are herbs

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with rhizomes, corms or bulbs. The *Crocus* genus includes approximately 80 species worlwide. Among these, the cultivated species saffron is well known with its high economic value [16]. At present about 8 taxa are recognized in Iran [18].

Saffron is produced from the dried styles of *Crocus sativus* L. (Iridaceae) which is unknown as a wild plant, representing a sterile triploid derived from the naturally occurring diploid *C. cartwrightianus* Herbert. These belong to subgenus *Crocus* series *Crocus* which constitutes 9 species: *C. cartwrightianus* and its derivative *Crocus sativus, C. moabiticus, C. oreocreticus, C. pallasii, C. thomasii, C. hadriaticus., C. asumaniae* and *C. mathewii.* The taxonomy of these species and their infraspecific taxa is presented, together with their distribution, ecology and phenology; full descriptions and chromosome counts are provided and there is a key to their identification. The genus *Crocus,* a member of the large family Iridaceae, comprises some 85 species having an Old World distribution, primarily in Mediterranean Europe and western Asia. Phytogeographically, the majority of species occur within the Mediterranean floristic region, extending eastwards into the Irano- Turanian region; both of these areas are characterized by cool to cold winters with autumn-winterspring precipitation and warm summers with very little rainfall; the latter region experiences much colder winters and generally less rainfall. The genus *Crocus* is well adapted to such conditions, the plants being in active growth from autumn to late spring and surviving the summer drought below ground by means of a compact corm. Many species commence their above-ground growth at the onset of autumn rains and flower almost immediately; some of these produce their leaves and flowers concurrently, or nearly so, while others bloom without leaves and delay their leaf production until the onset of warmer weather, usually in spring. These physiological characteristics, together with cytological information and morphological features of the corm tunics, bracts, bracteols, leaves, flowers and seed, have been used to divide the genus into a hierarchy of subgenera, sections and series, and to define the species within those infrageneric groupings [31].

Saffron is sterile and has fleshy corms. The corms covered by tunics and consist of nodes and are internally made up of starch-containing parenchyma cells. A corm survives for only one season, reproducing via division into "cormlets" that eventually give rise to new plants. Each corm produces six to nine leaves. The photosynthetic activity of the leaves during the early winter and the early spring months contributes to the formation of the replacement corms at the base of the shoots. Leaves are grass-like. The plant shows no aboveground organs or roots during late spring and most of summer.

Flowers autumnal, fragrant, 1–4, deep lilac-purple with darker veins and a darker violet stain in the throat; throat white or lilac, pubescent. Prophyll present. Bract and bracteole present, very unequal, white, membranous with long tapering, rather flaccid tips. Perianth tube 4–5(–8) cm long; segments subequal, 3.5–5 cm long, 1– 2 cm wide, oblanceolate or obovate, obtuse. Filaments 7–11 mm long, purplish, glabrous; anthers 15–20 mm long, yellow. Style divided into 3 deep red clavate branches, each branch 25–32 mm long, much exceeding the anthers and at least half the length of the perianth segments, arising at a point well below the base of the anthers in the throat of the flower. Capsules and seeds rarely produced (a triploid of low fertility). 3n=24 [31].

Saffron corms produce both fibrous roots and contractile roots. The fibrous roots emerge from a single ring at the base of the corms. These roots are straight and thin (about 1mm in diameter). The contractile root has the appearance of a tuber organ, very large and whitish. This type of roots enable corms to dig into the ground, so corms rest in optimum depth and position in the soil [6].

*Propagation:*

Grilli Caiola and Canini [20] study on saffron, *Crocus sativus* and the diploid species *C. cartwrightianus*, *C. thomasii*, *C. hadriaticus*. When saffron originated is still open to dispute. It has been widely known since the pre-Hellenic and Hellenic periods, but it is impossible to detect if was *C. sativus* or other *Crocus* species such as *C. cartwrightianus.* Concerning the site origin the research indicates two possible sites: one in Greece in the Mediterranean area, the other at East in Turkey-Iran-India. In both areas, records and place names connected with various species of *Crocus* constitute an important information source for the presence of saffron. Cytological, DNA, and reproductive studies on the allied species of *C. sativus* such as *C. cartwrightianus*, *C. thomasii*, *C. hadriaticus*, indicate a more likely parent of saffron may be *C. cartwrightianus* or *C. thomasii*. Both these species are diploid with a karyotype similar to saffron. In addition, their pollen can fertilize the egg cell of saffron, giving rise to seeds which are viable, germinate and form new corms. Thus saffron can originate through fertilization of a normal reduced egg cell with an unreduced male gamete of the same *Crocus* species or by crossing between an egg cell and the male unreduced gamete of another species.

The saffron is a sterile geophyte that produces annual renewal corms and is propagated only by them [32]. The physical properties of saffron corms are prerequisite to designing and developing harvesting, handling, sizing and sowing equipments of corms.[21].

Cytological studies indicate that saffron is a sterile triploid (2n=3x=24) plant [4,32]. The origin of saffron by allopolyploidy seems more probable considering the recent data on its karyotype and molecular biology [20]. Many authors have hypothesized the origin of saffron by autotriploid [4,17,33].

On the basis of overall length and centromeric position, the somatic chromosomes could be assembled in seven triplets, one pair and one single chromosome. The karyotype consists of a series of chromosome triplets with the exception of one group of three chromosomes of which one is different from the others. Because of this unique chromosome in saffron genotype, selfing can be excluded [5]. Since *Crocus sativus* is sterile, the presence of this chromosome may be explained by the existence of chromosomal polymorphism at diploid level in the progenitors, most probably *C. thomasii* or *C. cartwrightianus* [4,19,31].

Conventional propagation methods are very slow and propagation by tissue culture represents an important potential to effectively propagate it. Ding *et al*. [10,11] successfully regenerated callus and intact plantlets from corm explants. Homes *et al*. [23] produced microcorms on corm explants. Sharafzadeh and Khosh Khui [42] produced microcorms on corm explants and leaves were regenerated by subculturing of microcorms. Ovary wall explants gave the best response, with stigma and style-type structures regenerating from the explants [7]. Corms of *C. sativus* were induced on shoot explants and from callus [34]. Style and perianth explants produced stigma-like structures [12]. Embryogenic callus of *C. sativus* was initiated from shoot meristems by Karamian and Ebrahimzadeh [28]. Non-embryogenic and embryogenic callus were produced by Darvishi *et al*. [8].

### *Uses of Saffron:*

Saffron is commonly used in medicine, as well as dye and spice in food industry. Saffron has been also used as a drug to treat various human health conditions [3].

Compounds considered pharmacologically active and important are volatile agents (e.g. safranal), bitter principles (e.g. picrocrocin) and dye materials (e.g. crocetin and its glycosidic, crocin) [41].

The chemical components of saffron include the coloured carotenoids, crocin, crocetin and monoterpene aldehytes, picrocrocin and saffranol [1,13,30,43].

In medicine, it is used as an antispasmodic, eupeptic, gingival sedative, anticatarrhal, nerve sedative, carminative, diaphoteric, expectorant, stimulant, stomachic, aphrodisiac and emmenagogue [41]. Besides, it has anticonvulsant [25], antidepressant [24], anti-inflammatory [26] and antitumour [13] effects.

Reserchers showed that saffron has a protective effect on chromosomal damage [39,40]. It is an antioxidant and detoxifying spice [39]. Crocetin and crocin, active constituents of saffron, help memory recovery [45]. Crocin is also an antioxidant help overcoming oxidative stress in neurons [36]. An antidepressant effect of saffron petal and stigma in mice was showed [29].

### *Production of Saffron:*

The world's total production of dried saffron is estimated around 300 tons per year [15]. Iran produces more than 90 percent of the world's total production of saffron. More than 92 percent of Iranian saffron is cultivated in Khorasan province with about 210 Tons Annual Production. The Kashmir region in India produces between 8 to 10 tons mostly dedicated to India’s self-consumption. Greek production is 4 to 6 tons per year. Morocco produces between 0.8 and 1 ton. Saffron production has decreased rapidly in many traditionally producing countries, and is abandoned in others such as England and Germany. Spain was used to be the traditional world leader and most reputed saffron producer for centuries in areas of La Mancha and Teruel. Nowadays, the production is only about 0.3-0.5 tons. Productions of Italy (Sardinia, Aquila, Cascia) 100kg; Turkey (Safranbolu) 10kg; France (Gatinais, Quercy) 4-5kg; and Switzerland (Mund) 1kg are nearly insignificant. All saffron producers in the European Union, as well as in Turkey, suffer from increasing labour costs [16].

Despite wide use of this unique spice, it is highly priced due to high demand and low supply. Saffron prices at wholesale and retail rates range from US$1100– US$11,000 per kilogram. In Western countries, the average retail price is US$2200 per kilogram [22]. It is considered to be the highest priced spice in the world [44]. The main reason for its great cost is that saffron is still propagated by human help. The cultivation processes, such as planting, flower harvesting and separation of the stigmas are carried out manually. Each saffron flower has three stigmata and one stigma weights about 2mg. It takes 150,000-200,000 flowers and over 400 h of hand labor to produce 1kg saffron stigma [38]. 75,000 blossoms or 225,000 hand-picked stigmas are required to make a single pound of saffron, which explains why it is the world’s most expensive spice [2].

It has been shown that some practices such as mycorrhiza and biohumus were effective for improved saffron cultivation [2].

That is why there are some differences in quality between saffron of different origins and the subsequent fluctuation of prices. Its high value makes saffron the object of adulteration. The addition of artificial colorants is one of the most common means of deception. Such a practice is expected to improve the appearance of the dried stigmas or even to give rise to the coloring strength of the aqueous extract.

Other methods include mixing in extraneous substances like beet, pomegranate fibers, red-dyed silk fibers, or the saffron's tasteless and odorless yellow stamens, and submerging saffron fibers with viscid substances like honey or vegetable oil. Saffron consumption is rising but production is not enough to meet this demand. In order to ensure the future of saffron crop, it is necessary to improve cultivation techniques. The production should be increased due to rising in utilization of saffron as natural product through worldwide.

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