Saffron and Various Fraud Manners in its Production and Trades

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Keywords: adulteration, *Crocus sativus*, falsification, fraud, trade

Abstract

While the world's total annual saffron production is estimated in 300 t per year, Iran produces 76 percent (230 t) of this total. Khorasan province alone accounts for 44895 ha and 172.6 t of the above mentioned totals. Saffron is produced from dried stigmas of *Crocus sativus*, and is considerate to be the highest priced spice in the world. It is used as spice and food colorant and, less extensively, as a textile dye or perfume and due to its analgesic and sedative properties folk herbal medicines have used saffron for the treatment of numerous illnesses for centuries. The recently advances in the elucidation of the biosynthesis of saffron carotenoids using molecular biology tools, the advances in genomic and molecular genetic analysis, and the botanic and physiological are studied in saffron and allies with the application in vitro technologies for both Micro propagation and genetic improvement of this crop. Nowadays saffron consumption is rising but not as fast as production rate. Therefore due to restriction of its production and also its high price, some efforts have been done for its artificial production and in some cases adversely, frauds has been done grown. In this article we try to survey the various fraud manners in saffron production and trades are being done in the world.

INTRODUCTION

The dried stigma of *Crocus sativus*, which is used for production of saffron, is considerate to be the highest priced spice in the world. The history of saffron cultivation reaches back more than 3,000 years. Ancient Persians cultivated Persian saffron (*Crocus sativus 'Hausknechtii*) in Isfahan, and Khorasan by the 10th century BC. At such sites, saffron threads were woven into textiles, ritually offered to divinities, and used in dyes, perfumes, medicines, and body washes. In Europe, saffron cultivation declined steeply following the Roman Empire's fall. Europeans brought saffron to the Americas when immigrated there.

Scientific classification of saffron is as follows: Kingdom: *Plantae*, Division: *Magnoliophyta*, Class: *Liliopsida*, Order: *Asparagales*, Family: *Iridaceae*, Genus: *Crocus*, Species: *C. sativus* L. (Khatib et al., 2005). The wild precursor of domesticated saffron *crocus* was *Crocus cartwrightianus* and human cultivators bred wild specimens by selecting for unusually long stigmas. Thus, a sterile mutant form of *C. cartwrightianus*, *C. sativus*, emerged in late Bronze Age Crete. Nowadays, most saffron is grown in a belt of land ranging from the Mediterranean in the west to Kashmir in the east. Annually, around 300 t of saffron are produced worldwide. Iran, Spain, India, Greece, Azerbaijan, Morocco, and Italy are the major producers of saffron (Wikipedia, 2006).

Iran produces about 76 % (230 t) of the entire world production of saffron and 75.1 % of Iran's saffron is produced mainly in the Khorassan region. Iran's climate is
suitable for growing the spice and it has had a long tradition of cultivating saffron. Due to the long experience of Iran in cultivation, and the transfer of methods of growing and harvesting from person to person, or generation to generation, Iranian saffron has managed to keep its distinctive qualities in comparison with those produced in other regions of the world with exceptional recognition for its fragrance, flavor and color at international markets (saffron gold, 2006). Saffron is the most expensive spice in the world and its high price is due to the much direct labor required for its cultivation, harvesting, and handling. Also this restriction of production has been exposed to its high demand of consumption. One stigma of saffron weights about 2 mg, each flower has three stigmata, and 150,000 flowers must be carefully picked one by one in order to produce 1 kg spice. So, its high value has made saffron the object of frequent adulteration, and also being the object of intense chemical and biotechnological research (Fernández, 2004). In the middle Ages, there were saffron inspectors in Nuremberg, Germany, with authority to burn or bury alive those who adulterated saffron. International standards are available, detailing tests that can be carried out to determine saffron quality.

True Saffron is made up of the red stigmas which have been cut and separated prior to drying. Stigmas cut this way provide maximum flavor, aroma and natural dye in cooking and baking. The stigmas are attached to a slender white style, which, when dried, turns pale yellow. The style of the saffron plant has no culinary value that means no, flavor or color. If is left attached to the red stigmas, it adds 30 % to 50 % dead weight to the saffron, and you pay for it. Note it’s as long as 1 ¾ inches. When dry, it curls and you can hardly see it. Saffron and various fraud manners in its production and trades is a permanent problem for consumers in the world. The differences in quality between saffron with different origins and the subsequent fluctuation of prices have confused them. Therefore the quality of saffron is certified in the international trade market following the ISO 3632 Normative since 1993. Saffron types are graded by quality according to laboratory analysis to determine the quantity of crocin (yellow dye), picrocrocin (flavor expressed as bitterness) and safranal (aroma) present in commercial saffron. Other characteristics of saffron distinguished in mentioned standard by related grades are Moisture and volatile matter, Total ash on dry basis, Acid-insoluble ash, Solubility in cold water, Total nitrogen and Crude fiber. This regulation is currently under revising, because it does not prevent fraud due to unsuccessful control of organoleptic properties of saffron. Despite these attempts at quality control and standardization, there is a rich history of saffron adulteration.

**ADULTERANT**

Under the prevention of Food Adulterant Act, an adulterant is any material which is employed for the purposes of adulteration, so any article of food is adulterated if: any inferior or cheaper substance has been substituted wholly or in part, any constituent of the article has been wholly or in part abstracted, the article has been prepared, packed or kept under unsanitary conditions, the article consists in part filthy, rotten, decomposed or diseased animal or vegetable or is infested with insects, the article contains any poisonous ingredient, the article hasn't prescribed coloring substance or the coloring substance is in excess of the prescribed limits, the article contains any prohibited or excessive preservatives, the quality nor purity of the article falls below prescribed standard (Hint for detection of food adulteration, 2006).

**VARIOUS TYPES OF ADULTERATION**

1. Traditional Manners
- Mixing of extraneous materials such as beet, pomegranate fibers, red-dyed silk fibers are used for decreasing the saffron price.
- In order to increase the saffron mass the tasteless and odorless yellow stamens of saffron were/are mixed with the saffron threads or powder.
- Immersing saffron fibers with viscid materials such as honey, vegetable oil or glycerin were/are another ways for falsification.
- Sometimes the flowers of other plants, particularly *Carthamus tinctorius*, or safflower, *Calendula officinalis*, or marigold, arnica and tinted grasses are fraudulently mixed with the genuine stigmas. A specimen of this adulteration was at one time introduced into the American market, by the name of African Saffron (Remington et al., 1918).
- An adulteration which has been largely practiced appears to consist of yellow-colored chalk or barium sulphate, made into a thin paste, probably with honey, and attached to the stigmas. (Remington et al., 1918).
- A record Read at the Pharmaceutical Meeting November/19/1889, Botanical Medicine Monographs and Sundry, Note On Adulterated Spanish Saffron, adulterated saffron was loaded with a calcium sulphate artificially colored, and attached there to with some saccharine substance, most likely glucose which yielded on incineration 40 % of ash (Beringer, 1889).
- In various European markets there has been offered saffron largely adulterated with borates, chlorides, carbonate, sulphate and other salts of sodium and potassium, or other various mineral substances (Remington et al., 1918).
- Cape saffron, which has a remarkable resemblance to genuine saffron, having a similar odor, and yielding a similar color to water, though the flowers themselves are differently colored. It is the flower of a small plant very abundant at the Cape, belonging to the family of Scrophulariaceae, and is said by Pappe of Cape Town, to possess medicinal virtues closely resembling those of true saffron (Remington et al., 1918).

2. Current Adulteration Manners

Powdered saffron is far more susceptible to adulteration, however. Turmeric, paprika, and other substances were and still are often combined with saffron powder.

The illegal mixing of relatively lower grades (cheaper) with premium categories of saffron is more likely to be adulterated (Wikipedia, 2006). The common mislabeling of turmeric (*Curcuma longa*) as "Indian saffron", "American saffron" or "Mexican saffron", also borders fraud, so be wary of packets listing above because neither of them are from *crocus sativus* (Mangalaseril, 2006).

Addition of artificial colorants is a most common way of adulteration with the aim of misleading of the consumer for improving the appearance of the dried stigmas or even other extraneous materials to give rise to the coloring strength of the aqueous extract.

Sometimes saffron is used as a therapeutically plant. For this reason, adulterations make it completely useless or even harmful.

DETECTING ADULTERATION

In spite of, available international standards, with detailing tests for determining of saffron quality, there are many other methods used to detect adulteration of saffron. One of the least costly is to throw saffron in water. It immediately expands into a characteristic form that is easily distinguishable from Crocus stamens or florets of safflower, marigold or arnica. Also genuine saffron
dissolves easily in water giving the aroma of saffron. If the water extract is dried and 
a rod dipped in sulphuric acid is drawn across the surface, a blue color which 
immediately turns purple and then reddish-brown indicates pure saffron (Hint for 
detection of food adulteration, 2006). Other detection methods include color 
reactions, microscopic study, thin layer chromatography (TLC) and high performance 
liquid chromatography (HPLC). HPLC is considered the most effective (frontier coop, 
2006).

A rapid procedure for the evaluation of saffron coloring strength using 
Tristimulus Colorimetry was studied by Cuko et al in 2003. And hunter color 
parameters (L*, a*, b*) measured by a portable tristimulus colorimeter, were used to 
develop a rapid procedure to evaluate saffron coloring strength in situ. Such a 
procedure is expected to strengthen the quality control of saffron under the conditions 
it is traded by the Saffron Cooperative. Correlations were sought among colorimetric, 
spectrometric (E1 % 440) and HPLC data (crocin content). The effect of parameters 
such as sample type (filament or powder) and moisture content on the method 
robustness was discussed.

Due to adverse effect of synthetic dyes, all countries have made strict 
regulations about the permitted colors to be used as food additives. Most of the 
countries have prohibited the use of several synthetic dyes as food coloring agents and 
permitted a limited number of synthetic colors under specified maximum limits. So 
screening method for the detection of artificial colors (naphthol yellow, tartrazine, 
quining yellow, Sunset yellow, Allura red, amaranth, azorubine, Ponceau 4R and 
Red 2G) in saffron using derivative UV-Vis spectrometry after precipitation of 
crocetin was investigated by Zalacain et al. (2005). The lowest detectable amount for 
each color was strongly dependent on chemical structure. This procedure can replace 
the current ISO TLC method (2003) and be used alternatively or in combination with 
HPLC procedures adopted in the same standard.

Identification and isotopic analysis of safranal from supercritical fluid 
extraction and alcoholic extracts of saffron was investigated by Semiond et al in 1996. 
Safanal from five saffron samples from different countries have been analyzed by 
methanol or by Supercritical Fluid Extraction (SFE). The results indicate that there is 
a significant difference between the synthetic safranal and the natural one. On the 
contrary, it is difficult to conclude on the difference between the various geographical 
origins, as the isotopic variations are small. Moreover, it has been found that 
Supercritical Fluid Extraction allowed the selective extraction of volatile compounds 
from saffron under optimized conditions. It is a cleaner and faster method of 
extraction compared to the extraction using organic solvent. Nevertheless, an isotopic 
fractionation occurs in relation to the extraction yield of safranal.

Authentic identification of stigma Crocus sativus from its adulterant via 
molecular genetic analysis was investigated by Ma et al in 2000. By using molecular 
genetic method, the spacer domains of 5s-RNA were cloned from the genomic DNAs 
that were isolated from C.sativus, C. tinctorius, H.fulva and H.citrina. The cDNAs 
encoding the spacer domains, about 300 to 500 bp. were sequenced. The nucleotide 
sequence of these four species showed great diversity. It could serve as markers for 
authentic identification of stigma Croci to distinguish from its substitution and 
counterfeit.

Adulterations with inorganic salts can be detected by the amount of ash left on 
burning, genuine saffron leaving from five to seven per cent. The borated saffron also 
yielded immediately to water an orange-yellow color. Further, some of it at least was
hygroscopic, so that when rubbed up between the fingers into a ball it retained that form instead of being elastic as is true saffron (Hughes, 2002).

Method to determine the authenticity of aroma of saffron (*Crocus sativus* L.) was reported by Alonso et al. (1998). They applied a thermal desorption-gas chromatography-mass spectrometry technique to 252 different Spanish saffron samples (from La Mancha and Teruel). The average safranal content made up of 60% of the volatile fraction of the saffron. All the chromatograms obtained showed an interval between 8 and 18 min (retention time of safranal +/- 5 min) in which the silhouette of the chromatographic peaks was similar in all the samples. Therefore this interval can be used as a "fingerprint" to detect adulteration (Alonso et al., 1998).

**PREVENTING OF SAFFRON ADULTERATION**

More recently, the certification of the origin and quality of food is another area where the use of molecular techniques is getting increased. Measures of molecular and morphological genetic variation are often used to set conservation priorities and design management strategies for plant taxa. Random Amplified Polymorphic DNAs (RAPDs) is a DNA polymorphism assay based on the amplification of random DNA segments with single primers of arbitrary nucleotide sequence been widely utilized in plant genomic studies (Pardo et al., 2003).

Low yield is mainly due to primitive agronomic practices but also partly due to non-availability of high yielding strains which totally they are adulteration exciter. All allies of genus Crocus are diploid but *C. sativus* is triploid in genetic makeup (2n=3x=24). Due to triploidy, meiosis in *C. sativus* is highly erratic and genetically unbalanced gametes are formed, which lead to formation of sterile gametes and ultimately no sexuality is involved that is essential phenomenon for seed formation. Due to absence of sexuality in the existing strains, a non-conventional breeding program at Govt. Fruit Research Centre Pithoragarh, was carried out by irradiating *C. sativus* corms to develop putative mutants of economical use. Corms were subjected to different does of Co60 to induce variability. Six sets of saffron consisting of 100 uniform corms of 4-5 cm in diameter were irradiated with 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 krad doses of gamma rays. A set of 100 corms was planted as control. Variability with respect to sprouting time, plant height, and induction of flowering, number of petals and shape of petals was noted. Corms of identified mutants were harvested separately and these mutant lines were advanced to next generations to bring them true to type. Delayed sprouting and slow growth in higher doses (2.0, 2.5, and 3.0 krad) increase of plant height in lower doses (0.5 and 1.0 krad), and induction of flowering in middle doses (1.0, 1.5, and 2.0 krad) was noted. On evaluating the variants, serrated petal mutants were found to be superior than parental strain and other mutants with respect to days of flowering (68 days), size of flower (4.87 cm), length of stigma (2.91 cm) and weight of 100 fresh stigmas (0.608 g). Delayed sprouting, slow growth in higher doses, increase and decrease of plant height in lower and higher doses respectively is due to the amount of auxin synthesized during the course of sprouting. Development of serrated petal is the result of a somatic gene mutation, whereas fused petal is the result of inhibition of apical cell division of petal at initial stage of flower development, caused by irradiation (Khan, 2003).

Determining of chemical composition of Saffron (*Crocus sativus* L.) is another effort for preventing of saffron adulteration (Caballero-Ortega et al., 2003). Comparative analytical and semi-preparative High Performance Liquid Chromatography (HPLC) studies using photodiode array analyses were performed on a Waters HPLC system for the separation of several ingredients from alcoholic
extracts of four different saffron types. Ten saffron peaks were identified by comparison of their retention times with those of known reference compounds and quantified from samples of Azerbaijani, Spanish, Indian and Iranian saffron. It was found that the total content of carotenoids in Azerbaijani and Iranian saffron samples was higher in comparison to other samples. These HPLC analytical procedures are sensitive, reproducible and allow for higher scaling of the instrumental conditions for obtaining sufficient amounts (mg) of the different saffron components for further cytotoxic assessments. Spanish saffron metabolites were collected and tested for their cytotoxicity against human tumor cells. Their results confirm that glycosidic carotenoid-type metabolites are responsible for the antitumor effects demonstrated by saffron (Caballero-Ortega, 2003).

Zalacaín et al. (2003) used fourier transform near infrared spectroscopy analysis (FT-NIR) of saffron for the first time in saffron. Its principal advantage was speed analysis, and it didn't require sample treatment either. Using Principal Component Analysis (PCA), saffron samples from Spain, Iran and China were clearly differentiated. Other parts of the flower, as the styles, were also analyzed being possible its differentiation among the saffron stigmas. The sensitivity for each sample in its own family group, and its specificity, was in both cases 100 % (Zalacaín et al., 2003).

CONCLUSION

Dried stigmas of *Crocus sativus*, is the highest priced plant substance in the world and its high price and increasing demand for buying it, incites fraud, which is achieved mainly by inclusion of other cheaper substances colored with additives that in many cases are not authorized by health organizations. Apart from the serious health risk posed by such additives, the fraud is causing an important socio-economic problem affecting many world enterprises. The use of these substances is hardly detectable by the equipment commonly used by companies. This adulteration can vary between 5 and 8 % of the total production of saffron. As a result of this fraud, some companies sell big quantities of reduced-price adulterated saffron while indicating on the label that it is a pure product (Anonymous, 2003). Therefore, the modern consumer protection movement confirms fraud is on the rise. The increases have generally been attributed to criminogenic market structures and inadequate regulation, as well as a number of other situational and structural factors. Ultimately, research endeavors should be directed toward the creation of theoretically informed, consumer fraud prevention policies. Such efforts will assist in detecting and preventing frauds (Holtfreter et al., 2005).

Literature Cited


