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Adulteration in Saffron: A Demographic Study

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Abstract

One of the costliest spices used worldwide is saffron, also known as kesar, Because of its various benefits, it is also used in herbalism and traditional medicine. Due to its widespread usage in medicine, its popularity has made it a target for adulteration and counterfeiting. It is produced from dried flower stigmas *(Crocus sativus)*. Considering how rare and limited this plant is, saffron fakes can be found in local stores. To investigate fast authenticity testing of real saffron, a study on forensically identifying saffron using chemical techniques, microscopic analysis was conducted on saffron samples. There was total six brands each 2-gram and total sample was of twelve grams. Possible adulterants were food colour, paper, coloured Konj.

Keywords: Saffron (Kesar); Adulteration, Toxicity, Forensic, Adulterants

Introduction

Saffron is a strong and potent spice, Saffron is obtained from the flower of the Crocus sativus plant, which is also known as the "saffron crocus". The bold red stigma and styles of saffron, sometimes called threads, are gathered and dried for use. Because of its high cost, saffron is one of the most frequently adulterated commodities. Put another way, saffron has a long history of adulteration that stretches back roughly 600 years, and it has always been vulnerable to fraud owing to financial motivations [1]. Studies show that dietary adulterants are so hazardous that they can cause renal problems, liver problems, heart failure, and many other conditions. Saffron is also valued for its medicinal properties and has been historically used in traditional medicine. Due to its labour-intensive harvesting process, one of the priciest spices available is saffron. Experts evaluate the saffron and its components through forensic investigation to ensure quality and identify fraud. The dried, sterile disgrace of the triplet flower Crocus sativus is known as saffron [2].

The problem statement for adulteration in saffron revolves around the widespread occurrence of counterfeit saffron products in the market, posing health risks and compromising the integrity of the saffron industry. It is essential to develop reliable detection methods, ensure consumer safety, and safeguard the economic interests of genuine saffron producers, in context of adulteration in saffron within forensic science encompasses the rising frequency of fraudulent practices, such as the addition of foreign substances to saffron samples, impacting the accuracy of forensic analysis [3]. Saffron is one of the many food and nutritional goods that are easily adulterated; it has a high market value and is ranked highest on the list. Dried stigmas from the Crocus sativus flower are known as saffron. Botanically, C. sativus is a member of the Iridaceae family, which comprises roughly 1500 species and 60 genera [4]. The main producers of saffron are Turkey, Greece, Spain, Iran, India, and a few other European nations. Saffron is grown in Jammu and Kashmir's Pampore region and Kashmir valley in India. C. sativus is a male-sterile geophyte that blossoms in late fall and spreads vegetatively by corms. Saffron, in its full stigma or in powdered form, has been adultered due to its extremely high market value and rising demand [5]. Various substances, such as chemicals or plant parts, or alternative techniques have been employed for adulteration. Adulteration utilizing elements other than the saffron stigma, pieces of other plants/spices that resemble saffron stigmas in color or morphology, chemical and natural colours, and mineral compounds have all been employed as bulking agents to enhance the volume or weight of the commercial product. For example, the stamen portion of saffron is dyed and utilized as saffron in marked items or to increase the weight and value of genuine saffron, which causes adulteration in the saffron as a whole [6].

In the Kashmir Mongra, Lacha, and Guchi are the three different types of saffron that are sold. The real source of saffron is the stigma of a saffron flower, which is the plant's carpel at its distal end. The primary distinction between these three types is the duration of the Style's attachment to its Stigma. The saffron flower has three dark red stigmas, or filaments, in the centre that are each 2 to 3 centimeters long. Pale filaments known as styles further connected to the deep red stigmas to the bloom.

Types of Saffron

Negin Saffron

This particular kind of saffron smells wonderful and has lovely color and form. Three seamless, interconnected strands of stigmas make up this type of saffron (as opposed to Sargol saffron, which has fractured stigmas). this variety of saffron costs more than Sargol saffron and has a nicer appearance [5]. Sargol saffron, which is less expensive than Negin saffron and has the same and scent, is preferred by most consumers [7]. It is more common for foreign consumers to purchase pricey saffron. Super-Negin and Semi-Negin are the two varieties of Negin saffron.

Sargol Saffron

Consumers are more familiar with the most common and extensively used type of saffron, which is for human use. Sargol saffron comes in various grades; AII-Red is one of them. The cream or white portion of pure Sargol saffron is completely removed, leaving only the red portion [5]. It is dubbed "all red" for this reason. The stigmas of sargol saffron are categorized and valued differently according to their thickness, fineness or brokenness [7].

Determining the type of saffron Sargol is a challenging task. Saffron is graded from 1 to 3 based on two factors: "stigma length" and "the presence or absence of white pieces of the root that have turned red and are mixed in with the load."

Figure 1: NeginSaffron from local market of Kashmir

Figure 2: Sargol Saffron from Kashmir

Konj Saffron

There aren't many different varieties of Konj, or white saffron. The root, or white component, is taken after the head and stalk have been separated. This portion is referred to as "white saffron" in Europe.[5] While most people believe that the root of the saffron is the most fragrant component, testing and scientific investigations reveal that the red section of the plant has more beneficial compounds. Crocin is among these substances. It travels from the white root portion of the saffron plant to the crimson stigma portion. The saffron root has a richer scent since its cream portion contains more water. Saffron root has the same properties as red saffron, but it lacks crocin, which is what gives saffron its color [7].

Figure 3: konj Saffron (https://www.indiamart.com/proddetail/natural-konj-saffron-2849769147130.html)

Bunch Saffron

Figure 4: Bunch Saffron from a local brand

A single strand of saffron contains both the red and yellow portions of the plant. Thirty percent is yellow and seventy percent is red. The saffron is entire in this categorization type, and the stigmas of the three saffron branches are joined to the white portion of the saffron (also known to be the saffron cream)[7] in both one-way and two-way fashions. The stigmas and creams are layered on top of one another in the one-way configuration. However, in the two-way set up, the creams are placed in the centre and the stigmas are placed on both sides.

Materials and Methodology

Sample

Twelve grams of the actual saffron were used and about twenty grams of saffron from different brands were purchased.

Chemicals

Methanol, benzene, Xylene, ether, chloroform, Sulphuric acid and nitric acid [16].

Instruments

Compound microscope and stereo-microscope

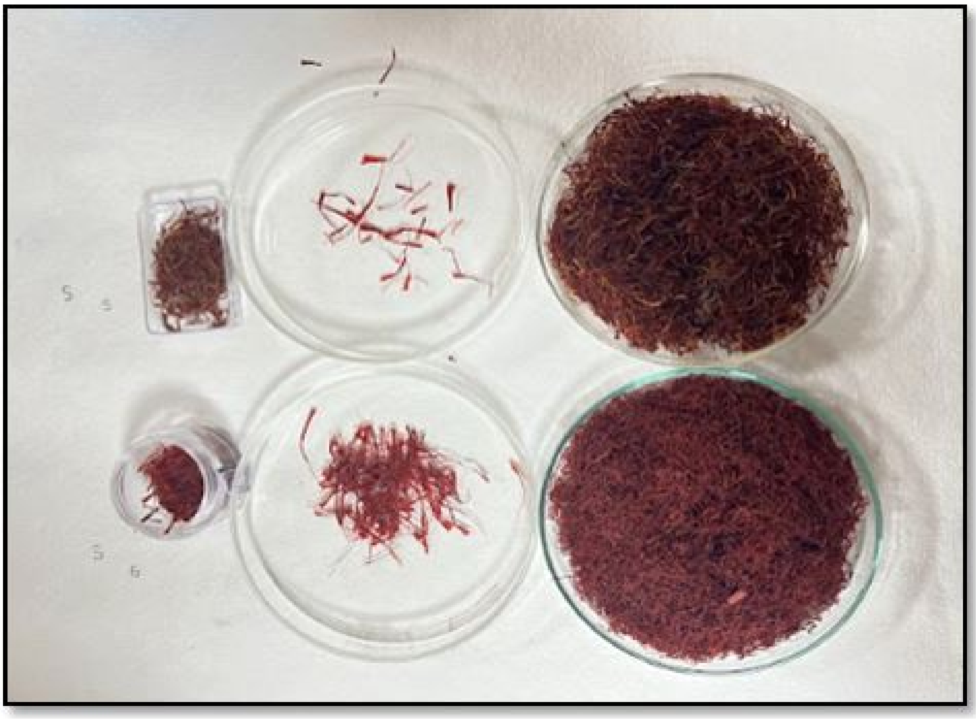


Figure 5: Saffron Samples

Sample 1 Sample 2 Sample 4 Sample 5

9748462728003Figure 6: From Sample 1 to sample 6 each were of 2 grams

Chemical Analysis

Sulfuric Acid Test

A blue tint that gradually turns violet and red is produced by the carotenoid pigments, such as crocin, crocetin, and picrocrocin, reacting with sulfuric acid due to the hydrolysis of the carotenoid esters [16]. The maximum level of uniqueness in saffron is determined by the sulphuric acid chemical test. The real thing instantly becomes blue when sulfuric acid reacts with it, but false saffron turns yellow [17].

Figure 7: Results of Saffron with sulphuric acid

Figure 8: *Results of Sulphuric Acid with Saffron*

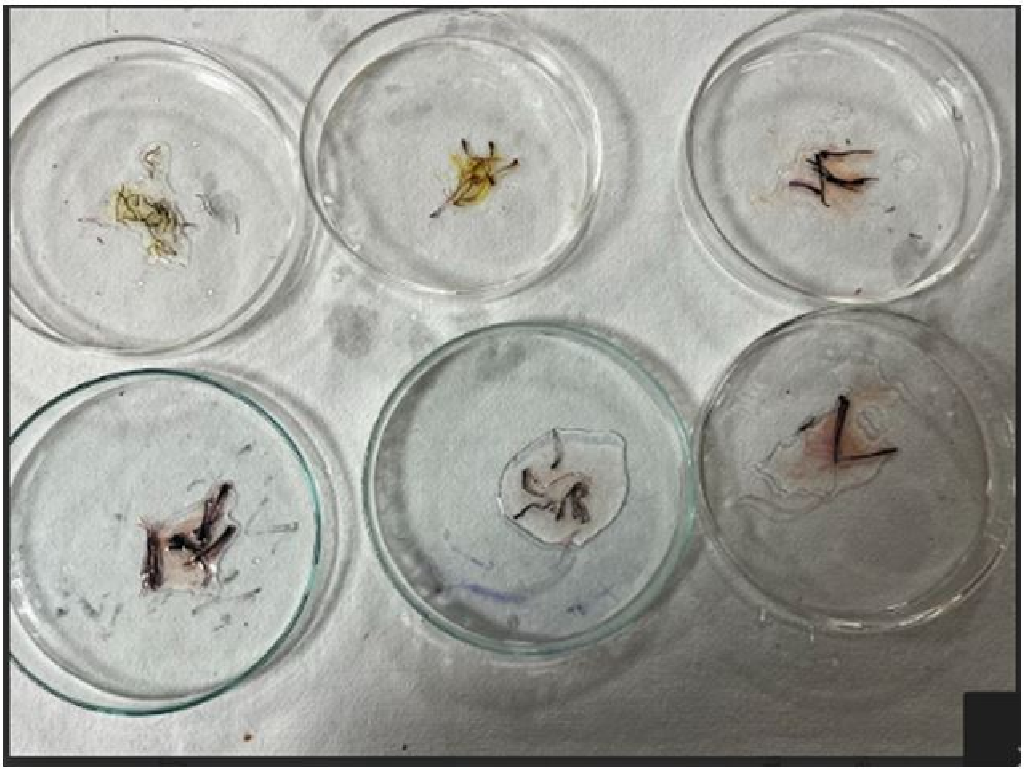


Figure 9: Results of Saffron from Sulphuric acids

Figure 10: Results of Saffron from Nitric acids

Figure 11: True result of Saffron from Nitric acid

Nitric Acid Test

When true saffron pigment reacts with nitric acid, it produces a light blue color [17].

Ammonia Test

Real saffron pigments give off a yellow-orange colour when combined with ammonia, whilst fake saffron pigments give off a light brown color.

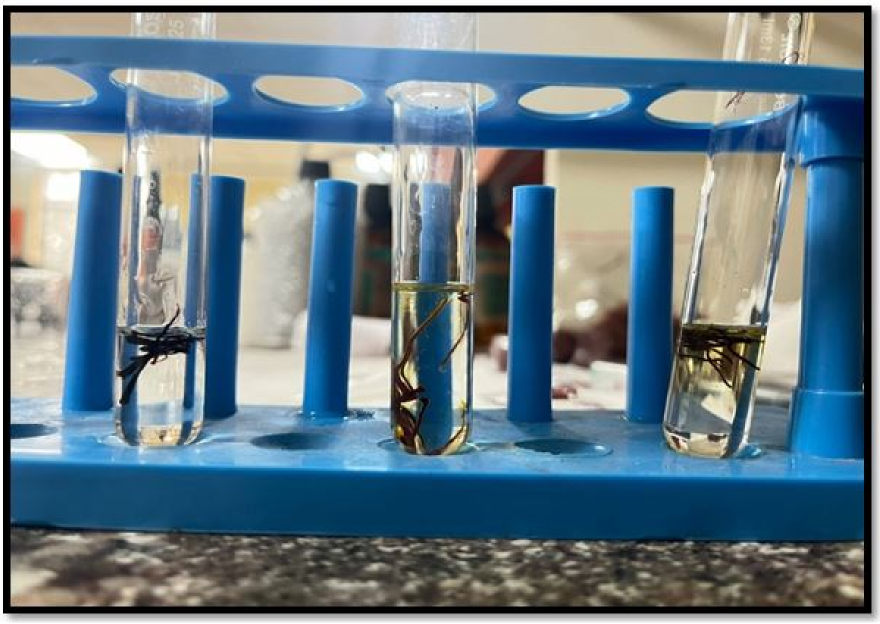
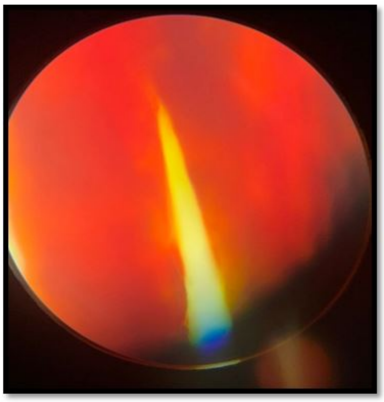


Figure 12: Result of Saffron with Ammonia

Figure 13: Result of Saffron with Ammonia

Microscopic Test

Samples examined using a compound microscope



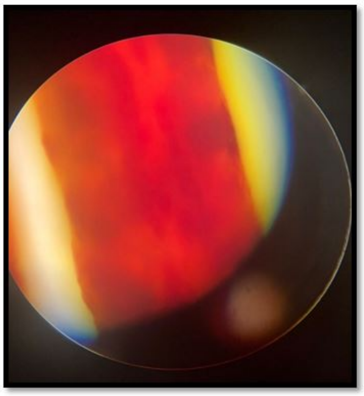


Figure 14 and Figure 15: specimen seen under a compound microscope

"Showing the structure of control sample and how stigmas are connected Showing the result of sample which seems genuine because of its structure and color".

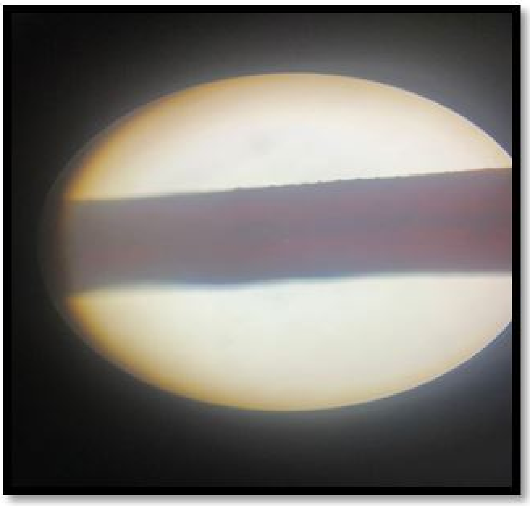


Figure 16: Sample under compound Microscope

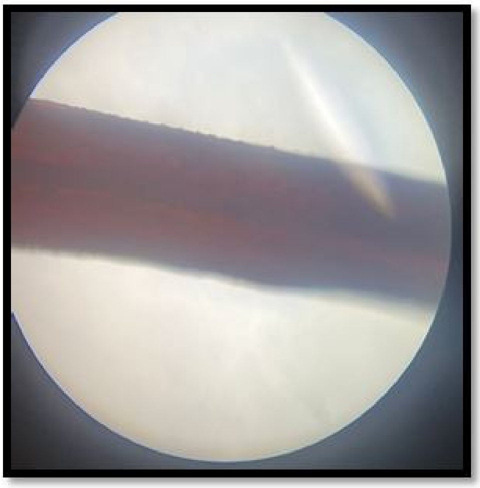


Figure 17: Sample under compound Microscope

Structure is different, hard and straight Sample result is false

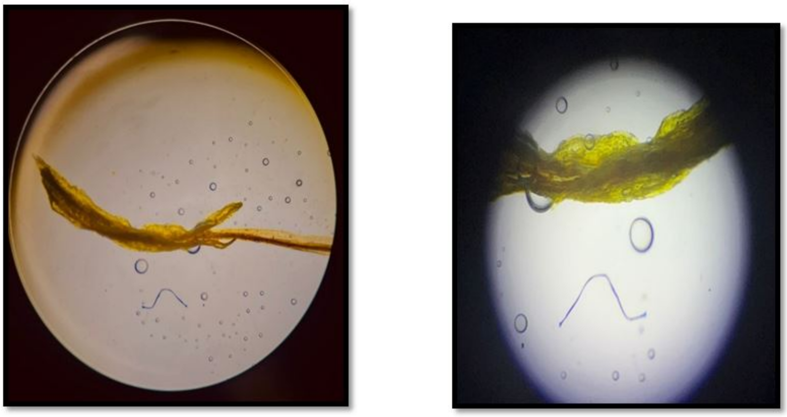


Figure 18 and 19: specimen seen under a compound microscope shows the stamen of crocus sativus which is later dyed and also sold as stigmas of saffron

Samples Under Stereomicroscope

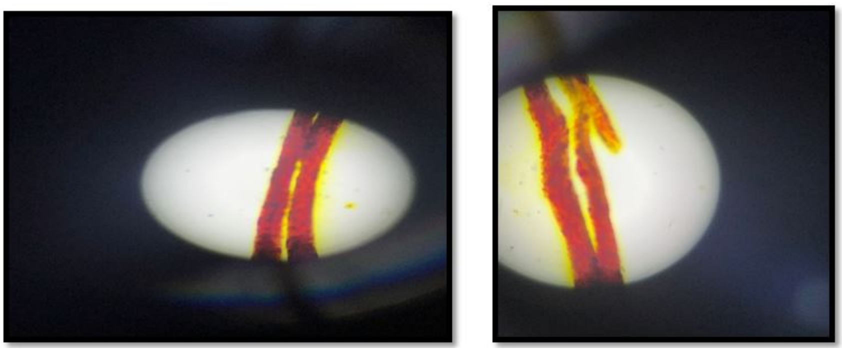


Figure 20: Sample under stereomicroscope

Showing the structure of sample, how one of the 3 interconnected stigmas is cut/broken

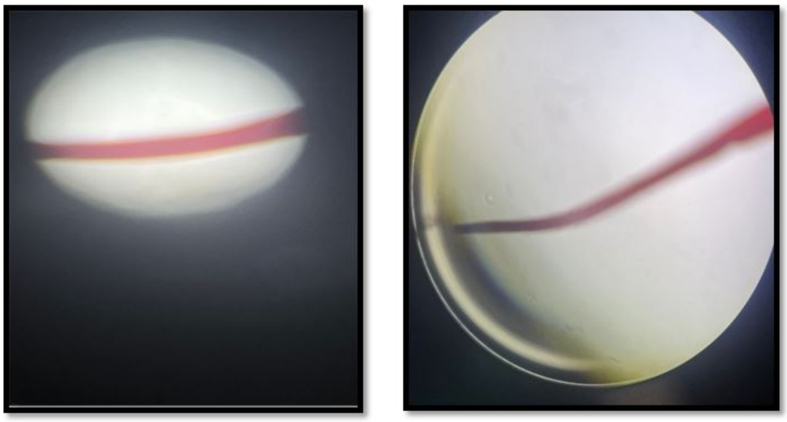


Figure 21: Sample under stereomicroscope

Sample images show straight hard thread like structure

Graph

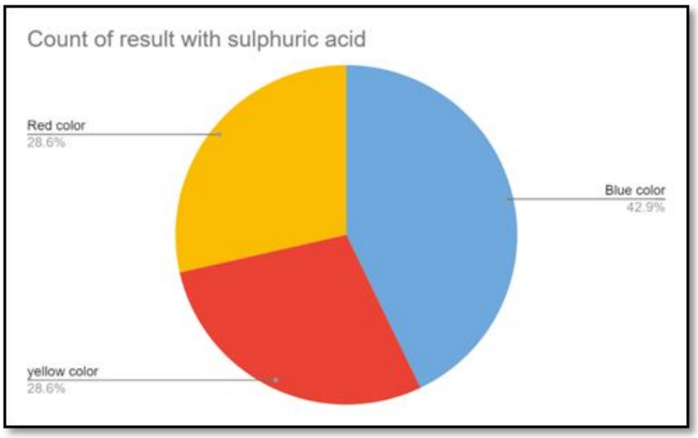


Figure 22: Result of Reaction with Sulphuric Acid

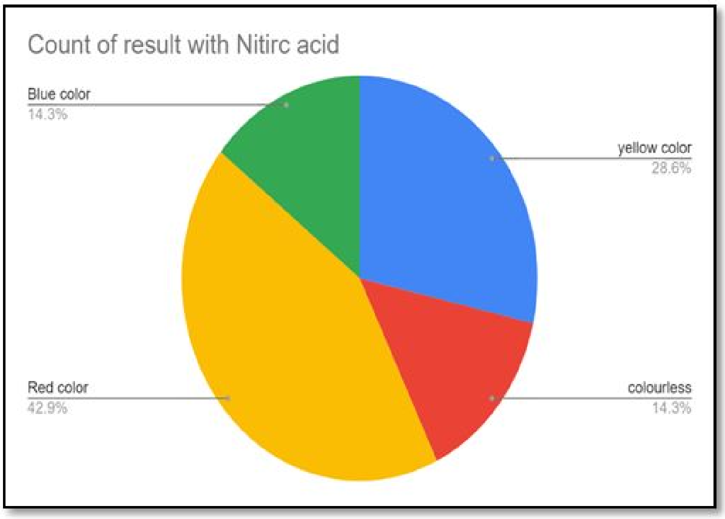


Figure 23: Result of Reaction with Nitric Acid

Result

These saffron samples were gathered from the market under various labels, inspected, and control samples were taken from Pampore, Jammu and Kashmir. The samples underwent chemical and instrumental analysis in order to differentiate real saffron from false. Indigo blue color is produced when sulphuric and nitric acids react with crocin, crocetin, and picrocrocin—components of saffron—forming a quick primary authenticity test. In nitric acid chemical test samples gave misleading results. A positive outcome results in light blue coloration right away, but fake saffron causes yellow, red, or brown coloration. Red colour result can be due to artificial dye. Blue colour is produced due to the presence of crocin. Yellow colour result can be the colour which saffron produces but sometimes it can be indication of Konj saffron. Colour less result shows fake saffron which can be made of paper or plastic.

Discussion

Our study took a comprehensive approach by collecting saffron samples from various market sources, alongside control specimens directly obtained from Pampore, Jammu and Kashmir, a region esteemed for its saffron production. This diverse sample pool allowed us to assess the integrity of saffron available to consumers across different geographical locations, chemical tests involving sulphuric and nitric acids were utilized to assess saffron authenticity. While our research found discrepancies in the results of these tests for few samples, the other study [1] also emphasized the formation of indigo blue colour as a rapid primary authenticity test, with our research samples 5 and 6 were identified as genuine. microscopic examination provided crucial insights into the features of saffron in studies, aiding in the differentiation between genuine and fake samples[5]. By comparing the methodologies and findings of studies, we can gain a comprehensive understanding of saffron authentication methods and the prevalence of adulteration, thus informing future research and quality control measures in the saffron industry [5]. The samples to a chemical reaction with sulphuric and nitric acids, targeting the crucial components of saffron: crocin, crocetin, and picrocrocin. The expected outcome of this reaction is the production of an indigo blue colour, serving as a rapid authenticity test. However, our findings revealed a troubling trend during chemical test. Samples exhibited misleading results, contrary to the expected light blue coloration indicative of authentic saffron. Instead, these samples displayed hues of yellow, red, or brown, suggesting the presence of adulterants. This discrepancy underscores the prevalence of adulteration practices within the saffron industry and emphasizes the urgency of addressing this issue to safeguard consumer trust and uphold the reputation of authentic saffron. Our research highlights the critical need for enhanced quality control measures and standardized testing protocols within the saffron supply chain. By implementing robust authentication methods, such as those employed in our study, stakeholders can mitigate the risks associated with adulterated saffron and ensure consumers have access to genuine, high--quality products [17]. There is a critical need for enhanced quality control measures and standardized testing protocols within the saffron supply chain. By implementing robust authentication methods, such as those employed in our study, stakeholders can mitigate the risks associated with adulterated saffron and ensure consumers have access to genuine, high-quality products. Raising awareness about the indicators of adulteration and promoting transparency in sourcing and production processes are essential steps towards preserving the integrity of saffron and maintaining consumer confidence in its purity and authenticity [18].

Conclusion and Future Scope

Our study has revealed the alarming prevalence of saffron adulteration within the market, as evidenced by the misleading results obtained from chemical tests on select samples. This underscores the urgent need for enhanced quality control measures and standardized testing protocols to safeguard consumer interests and uphold the integrity of authentic saffron. Addressing this issue requires collaboration among industry stakeholders, regulatory bodies, and researchers to implement robust authentication methods and raise awareness about the indicators of adulteration.

Future Scope

Future research endeavors could be explored to enhance the detection and characterization of adulterants in saffron using advanced analytical techniques, such as isotopic analysis and other scientific methods. The development of portable, user-friendly, and cost-effective testing devices, which are currently not such available in the market, could be a key focus area. These devices could utilize technologies like near-infrared spectroscopy, machine learning, or smartphone-based sensors to enable consumers and regulatory agencies to conduct on-the-spot authenticity checks. This would strengthen the enforcement of quality standards throughout the supply chain.

Furthermore, interdisciplinary collaborations involving experts in chemistry, botany, and food science could provide valuable insights into the botanical origins and chemical profiles of saffron, facilitating the development of reliable markers for authentication purposes. By pursuing these opportunities for innovation and collaboration, researchers can contribute to a more transparent and sustainable saffron industry, where consumers can confidently access genuine, high-quality products, and producers are incentivized to uphold ethical and responsible practices.

Limitations

1. Difficulty in sourcing genuine saffron: Authentic saffron may be challenging to procure, leading to

reliance on potentially adulterated or lower quality substitutes.

2. Lack of standardized testing methods: The absence of universally accepted testing protocols for saffron authenticity can make it difficult to accurately detect adulteration.

3. Variability in adulteration techniques: Adulterants used in saffron may vary widely, making it challenging to identify adulteration consistently across different samples.

4. Limited transparency in the supply chain: Lack of transparency in the saffron supply chain may obscure the origin and processing methods of the saffron, increasing the risk of adulteration.

5. Seasonal and regional factors: Saffron production is influenced by seasonal and regional factors, which can affect availability and quality, potentially leading to increased susceptibility to adulteration during certain times or in specific regions.

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