
SAFFRON: AN ALTERNATIVE CROP FOR SUSTAINABLE AGRICULTURE SYSTEM

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ABSTRACT

The costliest spice in the world, saffron (*Crocus sativus* L.), is valued for its vivid color, distinctive scent, and characteristic bitterness. It is a member of the Iridaceae family. Saffron is grown only by vegetative propagation and grows well in a variety of temperatures, especially in southwestern Asia and the Mediterranean. Historically employed in industrial, medical, and culinary settings, its stigmas are now mostly prized as food coloring and flavoring agents. Iran produces 88% of the world's supply of saffron, which is grown in a few countries and needs labour-intensive harvesting. India, Spain, Greece, Afghanistan, Morocco, and Italy are other important producers. Limited production areas and rising global demand are the main drivers of the spice's high market value. Crocins, picrocrocins, and safranal are important chemicals found in saffron that contribute to its unique qualities. According to recent studies, it is a sterile triploid that originated from *Crocus Cartwrightianus*. The spice has a long history, dating back to ancient Mesopotamian rituals and its use in European trade. The quality and traits of saffron varieties vary depending on the region's cultivation methods. Initiatives to produce fragrant crops and their cultivation in areas like Jammu and Kashmir highlight its cultural and economic importance.

Keywords: Saffron Cultivation, Picrocrocin, Safranal, Saffron Production.

I. INTRODUCTION

Saffron (*Crocus sativus* L.) belongs to the large family of Iridaceae and to the genus *Crocus*, which includes about 80 species distributed primarily in the Mediterranean and south-western Asia. Among these, saffron, recognised as the most expensive spice in the world (Winterhalter and Straubinger, 2000; Fernandez, 2004), certainly represents the most interesting and attractive species, for the colouring, bitterness and aromatic power of its dried stigmas. Saffron is a spice derived from the flower of *Crocus sativus*, commonly known as the "saffron crocus". The vivid crimson stigma and styles, called threads, are collected and dried for use mainly as a seasoning and colouring agent in food. The saffron crocus was slowly propagated throughout much of Eurasia and was later brought to parts of North Africa, North America, and Oceania. Saffron is a geophyte herbaceous plant, whose stigmas have been used from ancient times as a spice in food, as a dye, in perfumes and cosmetics preparation and for medicinal purposes. Nowadays, it is almost exclusively used for food colouring and flavouring, even though recent studies are boosting interest in its medical properties. Saffron is known only as a cultivated species; it propagates solely vegetatively by means of corms, underground stems acting as storage and reproduction structures, and does not produce seeds or exist as a spontaneous plant.

Saffron is cultivated in a wide range of environments with lid to dry climates. For a long time, saffron has been neglected by researchers and farmers since it was considered a minor crop used only for agricultural diversification. However, in the last few years it is gaining a more interesting role in low-input agricultural systems and as an alternative crop. Moreover, saffron is a very attractive crop for organic and low input agriculture considering that no irrigation, chemical fertilisation or chemical weed treatments are applied in some environments in which it is cultivated. Saffron's colour, bitter taste and aroma are its three main and particular characteristics, which are associated with three different molecular features: crocins, picrocrocins and safranal, respectively. These and other characteristics make saffron one of the most interesting alternative rediscovered crops, especially for the Mediterranean environment, where the hot, dry summer climate inhibits the spread of pathogenic disease. Saffron has gained a high market value and its price has been consistently growing with the ever-increasing demand because of its beneficial properties, restricted production area and labour-intensive procedures. The global commerce in saffron is approximately one billion dollars. The principal

countries that produce saffron are Iran, India, Afghanistan, Greece, Morocco, Spain, and Italy with a worldwide average yield of 418 tonnes per year.

Origin

The history of saffron dates back thousands of years, with its origins rooted in ancient civilizations. The use of saffron can be traced back to ancient Mesopotamia, where it was highly valued for its medicinal properties and was used in religious ceremonies. Saffron was also highly prized in ancient Egypt, where it was used in perfumes, as a dye, and as an ingredient in culinary preparations. The Egyptians believed that saffron had aphrodisiac properties and used it in their love potions. During the reign of the Minoan civilization in ancient Greece, saffron was a symbol of luxury and wealth. It was used in religious rituals and as a colouring agent for fabrics. The Greeks also believed that saffron had medicinal properties and used it to treat a variety of ailments. In the Middle Ages, saffron gained popularity in Europe and became an important commodity in trade. It was highly valued for its intense flavour and vibrant colour, and was used in various dishes, including soups, sauces, and desserts. Saffron also had medicinal uses and was believed to have properties that could improve mood and digestion. Saffron-based pigments have been found in the prehistoric paints used to illustrate beasts in 50,000-year-old cave art found in modern-day Iraq, which was even then northwest of the Persian Empire. The Sumerians used saffron as an ingredient in their remedies and magical potions. Sumerians did not cultivate saffron. They gathered their stores from wild flowers, believing that divine intervention alone enables saffron's medicinal properties.

History

Human cultivation and use of saffron spans more than 3,500 years and extends across cultures, continents, and civilizations. Saffron, a spice derived from the dried stigmas of the saffron crocus (*Crocus sativus*), has through history remained among the world's most costly substances. With its bitter taste, hay-like fragrance, and slight metallic notes, the apocarotenoid -rich saffron has been used as a seasoning, fragrance, dye, and medicine. A study reported in 2019 that the authors considered that a cross between two cytotypes of *Crocus cartwrightianus* was responsible for the emergence of *Crocus sativus*. This was probably a unique or very rare event as there is no genetic diversity in commercial saffron today. Another study in 2019 showed that a population of *Crocus cartwrightianus* near Athens in Attica was the closest match to the theoretical ancestors of *Crocus sativus*. The saffron crocus is now a triploid that is "self-incompatible" and male sterile; it undergoes aberrant meiosis and is hence incapable of independent sexual reproduction—all propagation is by vegetative multiplication via manual "divide-and-set" of a starter clone or by interspecific hybridisation. If *C. sativus* is a mutant form of *C. cartwrightianus*, then it may have emerged via plant breeding, which would have selected for elongated stigmas, in late Bronze age Crete.

Distribution

Saffron is a legendary crop of Jammu and Kashmir produced on well drained karewa soils of Kashmir and Kishtwar where ideal climatic conditions are available for good growth and flower production. It grows at an elevation of 1500-2000 m amsl. Photoperiod and temperature exert a profound influence on the flowering of saffron. Total world production of saffron is around 300 tons per year. Iran, India, Spain and Greece are the major saffron producing countries with Iran occupying the maximum area and contributing about 88% of world's saffron production. Though, India occupies the 2nd largest area but produces approximately 7 per cent of the total world production. Jammu and Kashmir is the only state in India where saffron is produced. Spain with 600 ha of land is the 3rd largest producer with an average productivity of 8.33 kg/ha which is highest in the world. The leading saffron growing countries like Iran, Spain and Greece with intensive production technologies are able to achieve higher production and productivity than our productivity and posing great threat to our saffron industry as imports are increasing every year. CSIR-IIIM has been actively involved in the production and processing of high value aromatic crops in the different regions of the country. Lavender being a signature crop of the Institute is extensively extended for commercial production of Lavender oil in different under-utilized areas of the temperate Kashmir. Owing to the higher marketability, demand for lavender essential oil in aroma industry CSIR-IIIM has successfully introduced the crop and installed distillation facilities in hilly under-utilized areas of frontier district of Kupwara, Sonamarg, Ganderbal and other areas of Kashmir in 2020.

Saffron Production Top 7 Countries

The costliest spice in the world, saffron, is mostly grown in areas with certain soil and climate conditions. The top 7 saffron-producing nations are as follows:

- 1. Iran-** Iran is the undisputed leader in saffron production, accounting for about 88% of the global output. Iran produced 430 tons of saffron in 2019, mainly in the provinces of Khorasan, Fars and Isfahan. Iran exports saffron to more than 50 countries, including Spain, India, China, UAE and Germany. Iran's saffron is known for its high quality and purity, as well as its diverse varieties and grades.
- 2. India-** India is the second largest producer of saffron in the world, with an annual output of 22 tons in 2019. India grows saffron mainly in the state of Jammu and Kashmir, where it has been cultivated for centuries. India's saffron is famous for its aroma, flavour and colour, and is used in various cuisines, desserts, beverages and religious rituals. India exports saffron to countries like Saudi Arabia, UAE, USA and UK.
- 3. Spain-** Spain is the third largest producer of saffron in the world, with a production of 18 tons in 2019. Spain grows saffron mainly in the regions of Castilla-La Mancha, Aragon and Andalusia, where it has a long history and tradition. Spain's saffron is renowned for its quality and certification, and is used in dishes like paella, risotto and bouillabaisse. Spain exports saffron to countries like France, Italy, Germany and USA.
- 4. Greece-** Greece is the fourth largest producer of saffron in the world, with a production of 12 tons in 2019. Greece grows saffron mainly in the northern region of Macedonia, where it has been cultivated since ancient times. Greece's saffron is recognized for its organic cultivation and distinctive flavor, and is used in recipes like rice pudding, chicken soup and tea. Greece exports saffron to countries like Germany, France, UK and USA.
- 5. Afghanistan-** Afghanistan is the fifth largest producer of saffron in the world, with a production of 10 tons in 2019. Afghanistan grows saffron mainly in the provinces of Herat, Balkh and Kunduz, where it has been introduced as an alternative crop to opium poppy. Afghanistan's saffron is appreciated for its high quality and social impact, as it provides income and employment opportunities for farmers, especially women. Afghanistan exports saffron to countries like India, China, UAE and Turkey.
- 6. Morocco-** Morocco is the sixth largest producer of saffron in the world, with a production of 6 tons in 2019. Morocco grows saffron mainly in the regions of Taliouine and Taznakht, where it has been cultivated for centuries. Morocco's saffron is valued for its authenticity and flavor, and is used in dishes like couscous, tagine and harira. Morocco exports saffron to countries like France, Italy, Spain and USA.
- 7. Italy-** Italy is the seventh largest producer of saffron in the world, with a production of 4 tons in 2019. Italy grows saffron mainly in the regions of Abruzzo, Sardinia and Tuscany, where it has a rich cultural heritage and gastronomy. Italy's saffron is prized for its quality and variety, and is used in dishes like risotto all milanese, zafferano di Navelli and zafferano di San Gimignano. Italy exports saffron to countries like Germany, France, Switzerland and UK.

Varieties of Saffron

Saffron, also referred to as the "red gold," is valued for its unique taste, vivid hue, and medicinal properties. Harvesting practices, cultivation region, and variety all have a significant impact on saffron quality. Here are the top 11 saffron kinds that are well-known throughout the world- Super Negin, Negin, Sargol, Poushal, Bunch, Konj, Kashmiri, Greek, Moroccan, Spanish and Italian

Super Negin

Considered the highest quality type of saffron, The Super Negin is one of the most expensive and rarest of its kind. Super Negin has red threads about 0.5 in long.

Other Names- Premium Negin, All-red, Pure saffron

Place of origin- Iran

Average length- Approx.0.5-0.7 inches (1.5-2.0 cm)

Common grade- Class I or Grade I

This very same part of saffron filaments also contains the most amount of the main three compounds which give this red-gold spice its value—crocin, picrocrocin, and safranal. But I'll talk more about them after I finish

describing all the recognized saffron types there are. In other words, the Persian Super Negin is among the—if not the—cream of the crop when it comes to saffron not just in Iran but all over the world.

Negin

Similar to the Super Negin, the Persian Negin saffron is a high-quality spice consisting of only red threads. Each Negin thread is about 0.7 inc.

Other names- Negin Cut

Place of Origin- Iran

Average length- Approx 0.7-0.9 inches (2-2.5 cm)

Common grade- Class I or Grade I

Just like the first type of Persian saffron, Negin also doesn't have any yellow or white parts in its thread. When cut from the whole filament, with all 3 stigmas still intact, the Negin saffron only retains the primarily red portion as well as a tiny red-orange part.

So, in comparison, the Negin is a bit longer than the Super Negin saffron—but not by a whole lot. At most, a Negin thread will be twice the length of one Super Negin thread. However, when you put them up against each other in terms of quality, the Negin still loses against Super Negin. But in terms of colour, taste, and smell, they're quite comparable. Because of this, Negin is generally produced for export.

Sargol

The shortest of all red-threaded Persian saffron, Sargol only measures approximately 0.1 in. It is obtained from the very thick tips of saffron stigmas in Iran.

Other names- All-red, Pure Saffron

Place of Origin- Iran

Average length- Approx 0.1-0.3 inches (0.5-1.0 cm)

Common grade- Class I-II or Grade 1-2

Poushal

Poushal, another Persian-saffron, is among the longer types with lower grades. Measuring more or less 0.9 inches, its threads contain yellow parts of the style.

Other names- Poshal, Pooshal. Pushal, Pushali

Place of origin- Iran

Average length- Approx. 0.9 -1.1 inches (2.5-3.0 cm)

Common Grade- Class I-III or Grade 1-3

Again, the Poushal is not that different from the previous types of saffron threads produced in Iran. It is still considered to have a generally moderate to high quality. Similar to previous saffron types originating from Iran, Poushal threads are quite straight and fine. From time to time though, you're likely to spot some wavy and curly threads here and there. When put beside the Negin, only 2 differences will be picked up by your naked eye. First, the Poushal is longer. Second, 1–5 mm of its threads is yellow.

Bunch

The Bunch is the longest at about 1.1 in. Besides the yellow part of the strand, it also has more or less 3-5mm of the cream or white portion.

Other names- Dasteh, Dastehi, Dokhtar-Pich, Khooshe

Place of origin- Iran

Average length- Approx. 1.1-1.3 inches (2.5-3.5 cm)

Common grade- Class II-IV or Grade 2-4

As its name suggests, Persian Bunch saffron threads are traditionally sold in bundles resembling sheaves of wheat, tied using a thin piece of string. Being the longest of the Persian bunch, Dastehi saffron contains a lot less of the dark red stigma per ounce than mostly and all-red varieties. Ordinarily, about 70–90% of each thread is made up of stigma. In effect, it also scores lower on overall colouring power, bitterness, and fragrance. This, in turn, earns it a lower grade and cheaper price as a direct result.

Konj

Primarily made up of style, Konj saffron threads are short, thin and pale. It has 0.1-inch-long filaments that are cream coloured.

Other names- Konge, Konche, Sefid, Style, Saffron Root, White Saffron

Place of Origin- Iran

Average length- Approx. 0.1-0.5 inches (0.5-1.5 cm)

Common Grade- N/A

Even though it's quite comparable in size to Sargol, the Konj can't put up a good fight in terms of overall quality and value. Physically, it's quite similar to regular Persian saffron besides the obvious lack of colour. In the rare case that a thread does have a bit of red left on it, it's still not enough to boost the grade of the so-called "White" saffron. So even if it contains some of its characteristic oils and compounds, it can't be put under Class IV. This, however, doesn't mean that the Konj has no value at all. Of course, due to its lack of stigma, it has little to no dyeing power. Still, it does have some of that distinctly saffron taste and smell since it also has more moisture.

Kashmiri

India's thick Kashmiri saffron threads are about 0.6 inch long and purple-maroon-coloured, which may have some of the styles on them. They are rich in aromatic compounds but also contain quite a bit of ash.

Other names- Kesar, Kong Posh, Kungumapoo, Urdu, Kashmir saffron

Place of Origin- India

Average length- Approx. 0.6-0.9 inches (1.7-1.25 cm)

Common grade- Class or Grade I-IV

For a country known for having dishes rich in spices, it's not surprising that India is also one of the top producers of saffron in the international trade for the highly sought-after spice. Despite its name, however, it isn't cultivated in the Jammu and Kashmir region. This Indian saffron is also grown in Karnataka and Himachal Pradesh, both of which have ideal growing conditions for the variety. Kashmiri saffron is broadly divided into 2 sub-types-

1. Mongra- Stigma without style
2. Lacha- Stigma with some of the style

Mongra saffron is comparable to the Negin, whereas the Lacha is like the Poushal. Despite their physical similarities though, Kashmiri saffron generally grades lower than Persian ones. However, with improved harvesting, handling, and drying practices, Kashmir saffron can be on par with Super Negin in terms of quality and grading. In effect, its price can also be raised.

Greek

Krokos, The Greek saffron, has relatively long red-orange threads, averaging around 1.2 inches in length. This is because a portion of the style is commonly retained

Other names- Krokos, Krokos Kozanis, Krocus, Red saffron

Place of origin- Greece

Average length- Approx. 1.2 inches (3.3 cm)

Unlike Indian and Persian saffron, the Greek variety doesn't have its very own classification system. As such, the product you'll get from the country can vary greatly. In a 2000 study, Greek saffron was shown to contain only half the average amount of essential oils found in Indian saffron and some Spanish ones. Moreover, Persian saffron had thrice of these aromatic compounds. For the most part, they keep a part of the style on each Krokos thread. Hence, it's common to see Greek saffron thread having more or less 80% stigma and 20% style.

The Greeks have a long history of cultivating saffron for domestic use and consumption. They have been farming and enjoying the fruits—or should I say, spice—of their labour for over 300 years.

Moroccan

About 1-inch in length, red Moroccan saffron threads generally have a bit of the red-orange and yellow style portion on them. Those cultivated at higher altitudes are of great quality, normally classed under Grade 1 or 2.

Other names- Zaafran, Taliouine Saffron

Place of Origin- Morocco

Average length- Approx 1.0 inches (2.7 cm)

Common grade- Class I-IV or Grade 1-4

Just like the Greek type, Moroccan saffron does not have specific subcategories. All saffron farmed in Morocco is generally referred to as Moroccan. In spite of having a lighter red colour and each thread containing about 40% of orange to yellow styles, Moroccan saffron still contains moderate to high amounts of aromatic. Most likely, this is due to the typical location of small family farms in Moroccan—highlands. Saffron cultivated in such areas seems to retain a lot of its essential oils. Several recent studies seem to confirm this relationship between potency and altitude. If you want to get the most bang out of your buck, look for Taliouine saffron with a PDO label. Like Greece, the country has a long history of saffron production—since the 10th century.

Spanish

Spanish saffron threads are generally bright red and around 0.9-in long. This type has its own 5-level classification system and is rarely subjected to grading international standards. Its quality and class can vary greatly depending on where its sourced.

Other names- Azafran, Spanish superior, Crème

Place of Origin- Spain

Average length- Approx. 0.9-1.7 inches (2.5-4.5 cm)

Common grade- Class I-IV or Grade 1-4

When made to image Spanish saffron, most people tend to think of short and slightly curled threads that are brighter in colour compared to other varieties. Most are familiar with Spanish saffron being mostly red-orange but still having a considerable portion of the yellow style. The highest Spanish saffron grade has stigma-only threads. It's called the Coupe, often compared to Negin, Super Negin, and Sargol.

Italian

The threads of Italian saffron are commonly short, at about 0.5 in, and mostly red in colour. However, some do retain small portions of the orange and yellow style.

Other names- Zaffarano, Aquila Saffron

Place of Origin- Italy

Average length- Approx. 0.5-0.6 inches (1.5-1.6 cm)

Common grade- Class I-IV or Grade 1-4

Physically, the average Italian saffron thread is similar to Spain's Mancha and Rio—which makes sense since it was likely brought by the Spaniards during the inquisition. Italian saffron is predominantly red but deeper in shade and with a bit of the yellow-orange style at times. We could also find some Italian saffron that resembles the Persian Negin. These are mostly categorized under Grade 1. However, this is true even for threads with some style on them. The rest normally fall under 2 and 3, with few in 4—but adulteration of Italian saffron exists too. The cultivation of Italian saffron is quite restricted because of its overall climate. Most farms are located in Navelli Valley and Sardinia. Although it contains a lot of the aromatic compounds that saffron is known for, the high humidity and year-round rainfall have remained to be a recurrent problem. These issues have consistently lowered Italy's already low saffron harvest.

Season For Saffron Farming

- Saffron Corms are grown in India between the months of June and July, as well as August and September in some areas
- In October, it begins to flower
- In the summer, it requires intense heat and dryness, while in the winter, it requires extreme cold
- Winters in areas of Karnataka provides the best conditions for development

Soil For Saffron Farming

One of the most important aspects of saffron growing is the soil. It thrives on loamy, sandy, and calcareous soils. A gravelly soil is also excellent for saffron farming; however, a heavy, clayey soil is not. Saffron grows best on acidic soil. It thrives well when pH of soil is around 5.5 to 8.5.

Water Requirement

Saffron requires less water than other spices. The soil should be slightly damp but not completely dry. Irrigation is done on a weekly basis and 283 m cubic per acre of water must be delivered during the cultivation period.

Land Preparation for Saffron Cultivation In India

Make the soil brittle before ploughing or planting saffron seeds by ploughing the land thoroughly. Put 20 tonnes of cow dung, 90 kg of nitrogen, 60 kg of phosphorus, and 60 kg of potassium per hectare on your field before final ploughing, and plough it thoroughly. Your soil will remain fertile and rugged as a result, and your saffron crop will be excellent.

Planting of Saffron Plant

- Pits of 12-15 cm depth are dug, with an inter-plant interval of roughly 10 cm
- Saffron corms are planted straight into the dug trenches for cultivation
- The soil is applied loosely on the surface
- If you don't pack compactly, air circulation may be restricted
- Irrigation is not required after sowing the corms; however irrigation may be required if there has been a protracted dry spell or extended drought throughout the hot season.

Times Of Planting of Saffron Crop

Any crop must be planted at a specific time. We don't receive the expected yield since we don't plant seeds at the proper time. As a result, make sure to plant the seeds on the fields at the appointed time.

- The greatest months to harvest saffron are July and August, with mid-July being the best.
- When applying the saffron corms, make a 6-7 centimetre pit for the corms to go into, and leave about 10 cm between the two corms. The corms will flourish as a result, and plenty of pollen will be produced.

Irrigation for Saffron Crop

There is no need to water the land if there is light rain a few days after planting the crop. If there isn't any rain, we'll have to irrigate twice or three times during the course of 15 days. It is important to remember that there should be no water deposits in the field during irrigation, and that if water deposits do form, drainage should be arranged as quickly as possible. Crops will be harmed if they are not properly organized.

Saffron Harvesting and Drying

- If the harvest process that makes saffron a costly price
- It starts flowering within three to four months of planting
- If planted in June, ideally, they would start flowering by October
- Harvesting of flowers must be done at the first appearance of light in the sky before sunrise, it is said that the flowers must be lucked between sunrise and 10 AM.
- The stigma strands are dried under the sun for five to six days and then it is packed in air-tight containers
- In case of solar driers, it needs 7-8 hours of drying

Production Of Saffron in India

In India, the annual demand for saffron spice is 100 tons per year but its average production is about 6-7 tons per year. Hence a large amount of Saffron is being imported. NAIP Production system ensures average productivity of 6.37 kg/ha (1- 2 kg/ha in the first year to 10 12 kg/ha in the fourth year of planting cycle) as compared to 2.5 kg/ha achieved under traditional practices (0.300 -0.500kg/ha in the first year to 4.5-5.0 kg/ha in the 4th year). NAIP production system ensures a benefit of ` 9.26 lakh/ha/year with a B:C ratio of 3.99:1 as compared to 3.24 lakh/ha/year achieved under traditional system with a B:C ratio of 2.47:1. Saffron growers after investing ` 9,28,560 over 4 years on different in put variables like corms (` 5,40,000), energy (`

25,000), Nutrients/ Protectants (` 1,71,560) and labour(` 1,92,000) achieve returns to the tune of ` 46,35000 on account of sale of 25.5 kg of saffron over 4 years (` 38,25000) and sale of 60 quintals of saffron corms in the fourth year (` 810,000). Whereas under traditional system after investing ` 5,25,000 on saffron farming system the farmers attain returns to the tune of ` 18,24,000 on account of sale of 10 kg saffron amounting to ` 15,00000 and 24 quintals of graded saffron corms for ` 3,24,000. Estimated sale price of saffron and corms is presumed to be ` 1.50 lakhs/kg for saffron and ` 13,500/quintal for corms.

II. CONCLUSION

The costliest spice in the world, saffron has important cultural, historical, and economic significance. Originating from the desiccated stigmas of *Crocus sativus*, this unusual plant flourishes in a variety of climate-suitable locations, including Spain, India, and Iran, which lead the world in production. For culinary, pharmaceutical, and industrial uses, saffron is still a sought-after commodity because to its vivid colour, unique flavour, and therapeutic qualities. The demand for saffron is still growing because of its many uses and well-known advantages, even in the face of obstacles like labour-intensive harvesting and restricted geographic cultivation. Saffron is a crop that shows promise as interest in low-input and sustainable agriculture rises, especially in areas like Kashmir and the Mediterranean where favourable conditions support environmentally friendly growing methods. Saffron's long history as a symbol of wealth, health, and culinary skill is highlighted by the widespread respect for its quality and cultural heritage.

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