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A Short Review on the Seed Oil and Nutritional Potential of *Kusumbha* – The Lost Crop of India

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Abstract

Kusumbha or safflower (*Carthamus tinctorius* L.) is one of the earliest domesticated oilseed crops of the Old World, traditionally valued for its oil fit for human consumption, medicinal purposes, and herbal dyes. Despite its ancient significance, safflower cultivation has declined significantly over a long time due to opposition from high-yielding oilseed plants, restrained marketplace help, and decreased research attention. In the prevailing context of climate change, declining soil fertility, and increasing call for healthful, safe-to-eat oils, *Kusumbha* has re-emerged as an underutilised crop with huge capability for sustainable and climate-resilient agriculture. The goal of this evaluation is to critically synthesise available medical literature, with a unique emphasis on the starting place, botanical capabilities, agro-climatic adaptability, oilseed characteristics, nutritional value, medicinal and industrial uses, and destiny possibilities of *Kusumbha*. This evaluation is primarily based on an intensive review of peer-reviewed articles, reviews, and study findings usually posted after 2020. The overview highlights that safflower possesses several suited tendencies, including tolerance to drought, salinity, and nutrient stress, excessive water-use performance, and compatibility with low-input and organic farming systems. Its oil is rich in unsaturated fatty acids, especially linoleic and oleic acids, and consists of bioactive compounds useful for cardiovascular and metabolic fitness. However, predominant constraints consisting of declining cultivation region, lack of improved sorts, susceptible policy help, and negative marketplace integration continue to restrict its adoption. The novelty of this evaluation lies in integrating ancient know-how with current clinical evidence to reposition *Kusumbha* as a multipurpose oilseed crop, thereby strengthening its significance in both sustainable agriculture and healthcare.

Major Findings: *Kusumbha* are well-suited to rainfed and marginal conditions with minimal inputs, making it a climate-resilient crop. With better research, policy support, and market focus, it can be revived as a valuable and sustainable oilseed.

Keywords: Adaptability, Climate-resilience, Nutraceuticals, Sustainability, Underutilised

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1. Introduction

Kusumbha, an ancient oilseed crop, has recently gained renewed attention from researchers due to its nutritional value, ability to adapt to harsh growing conditions, and potential role in sustainable agricultural production[1]. The term "oilseed" refers to crops that are cultivated primarily for their seeds, which contain significant amounts of oil that can be extracted and used for edible, industrial, or medicinal purposes; *Kusumbha* is categorised as an oilseed crop because its seeds yield oil rich in unsaturated fatty acids. Over the last decade, its cultivation declined from earlier high levels to very limited production; however, it is now being reconsidered as a "forgotten" crop with the potential to contribute significantly to edible oil production and climate-resilient agriculture[2]. As an ancient component of Indian agri-horti systems, *Kusumbha* belongs to the group of plants referred to as chasmophytes and was mainly cultivated for its edible and medicinal oil, while its flowers were traditionally used for textile dyeing[3]. Ethnobotanical and pharmacological studies indicate that safflower has been used for generations as part of a healthy diet and as a therapeutic agent in traditional healing systems, particularly across South Asia[4]. Owing to its tolerance to drought and low soil fertility, safflower became suitable for regions facing irregular rainfall, salinity, water scarcity, and semi-arid or acidic soils, where high-input oilseed crops often fail to perform well[5].

Despite these advantages, the popularity of *Kusumbha* has declined due to the expansion of high-yielding oilseed crops such as soybean and mustard, along with shifts in dietary preferences and market systems[6]. As it is cultivated on limited land and has received comparatively less research attention than major oilseeds, safflower is often regarded as a neglected crop[7]. However, this neglect overlooks its significant agronomic and nutritional potential. Recent studies report that safflower oil is rich in polyunsaturated fatty acids, particularly linoleic acid, as well as bioactive compounds such as flavonoids and phenolic acids, which are beneficial for cardiovascular and metabolic health[8]. The crop also aligns well with low-input farming practices and current strategies for sustainable and climate-resilient agriculture[9]. This review aims to compile recent scientific evidence on *Kusumbha*, focusing on its historical importance, oilseed characteristics, nutritional composition, and future prospects[10]. Based on available pre- and post-2020 literature, we propose to reposition *Kusumbha* as a neglected oilseed crop with potential benefits in managing chronic diseases, including thyroid-related disorders and risk factors (TYRF)[11].

2. Botanical Description and Taxonomy

Safflower, also known as *Kusumbha,* is a member of the family Asteraceae and the only cultivated species in *Carthamus.* The systematic position and the taxonomical classification from kingdom to species are shown in Table 1.

Botanically, safflower is an annual erect herbaceous plant with a deep tap root system conferring resistance

Table 1. Taxonomic classification of *Kusumbha*

Taxonomic Rank	Classification
Kingdom	*Plantae*
Clade	*Angiosperms*
Clade	*Eudicots*
Order	*Asterales*
Family	*Asteraceae*
Genus	*Carthamus*
Species	*Carthamus tinctorius* L.
Common Name	*Kusumbha* / Safflower

Table 2. Botanical description and morphological characteristics of *Kusumbha*

Plant Part	Description
Growth habit	Erect, annual, herbaceous plant
Root system	Deep taproot system with lateral branches
Stem	Erect, branched, globularto slightly spiny.
Leaves	Simple, sessile, alternate; margins serrated or spiny.
Inflorescence	Terminal capitulum
Flowers	Tubular florets, yellow to orange/red
Flowering	60–90 days after sowing
Fruit	Achene
Seed colour	White to cream
Oil content	~30–45%
Crop duration	120–150 days

to moisture stress. The stems are erect and branching, the leaves simple, sessile and alternate, usually with serrate or spinose margins. The inflorescence consistsof a terminal capitulum with tubular florets, followed by the formation of achenes rich in oil. The morphological and growth parameters of *Kusumbha* are summarised in Table 2.

3. Origin, History and Traditional Importance

Safflower (*Carthamus tinctorius* L.), part of the Asteraceae family, is thought to be one of the first oilseed crops grown in the Old World[12]. In the Indian subcontinent, it's called *Kusumbha*[13]. The Fertile Crescent and nearby areas in West Asia are believed to be where safflower was first domesticated, from which it gradually spread to the Mediterranean[14]. Later domestication and selection resulted in landraces adapted to semi-arid and rainfed areas[15]. *Kusumbha*, which comes from the Indian subcontinent, has been grown since ancient times and is mentioned in old Sanskrit writings and *Ayurveda* texts as a fine oilseed and medicinal plant[16]. Studies after 2020 support the traditional uses of *Kusumbha* for cooking oil, medicinal preparations, and natural dyes from its flowers[17]. The oil was commonly used for cooking, lamps, and medicine, while the flower pigments carthamin and carthamidin were used in textiles[18]. Before synthetic dyes were discovered, safflower was used to dye fabrics[19].

Kusumbha also held special importance in *Ayurveda* medicinal practices of India and other Asian nations as a cure for circulatory problems, healing of injuries, menstrual disorders, and inflammation[20]. Currently, more studies have supported these medicinal uses by extracting effective components such as flavonoids and phenolic acids that possess anti-oxidative and anti-inflammatory properties[21]. *Kusumbha* also held special regional importance and was often cultivated in low-productive zones to ensure the adequate supply of food in arid regions[22]. Though safflower is a traditional crop of immense cultural and historic importance, its importance has steadily declined due to advancements in agricultural practices[23]. More productive oilseed crops replaced their cultivation, and the demand for natural dyes reduced[24]. Currently, researchers have also emphasised the rich historical background of *Kusumbha*, its adaptability, and its multiple uses, thereby advising to reconsider a crop that is already somewhat forgotten[25].

4. Agro-climatic Requirements and Cultivation Practices

Kusumbhaisi is known for its adaptability to various agro-climatic situations, particularly under arid and semi-arid conditions[26]. The crop thrives well under cool and dry conditions during vegetative growth, warm and dry conditions of leaf maturity[27]. It has been reported that safflower can sustain temperatures between 10 and 35 °C and may be suitable for a wide range of thermal regimes[28]. The crop is extremely susceptible to moisture and extended rain during flowering, leading to poor seed set and oil quality[29]. *Kusumbha* is well-adapted to grow on many soils, from sandy loam to clay loam types that are well drained[30]. A good moisture-holding capacity of soil is needed as the plant develops long taproots[31]. It has a moderate tolerance to soil salinity and alkalinity, which extends its use for marginal lands[32]. The requirements of safflower concerning soil and climate are presented, in general terms, in Table 3.

Being a kharif crop of India, it is planted in June and July, and the harvesting continues from September to October[33,34]. Due to its long root system and the effective water-use physiology, safflower is more drought-resistant than many other conventional oil crops[35]. Recent studies related to physiology have also unveiled that safflower can maintain its photosynthesis along with biomass accumulation even when low irrigation is provided to it, which proves its low-input character and drought-resistant nature[36]. Historically,

Table 3. Agro-climatic and soil requirements of safflower

Parameter	Requirement
Temperature	10–35 °C
Rainfall	300–600 mm
Climate	Cool and dry during growth
Soil type	Sandy loam to clay loam
Soil pH	6.0–8.0
Drainage	Well drained
Season	Rabi

safflower has been grown in low-input systems with reliance on residual soil moisture and landrace[37]. However, in the last few years, its area of cultivation is threatened by the presence of high-yielding oilseeds that are more preferred and less preferred in the market[38]. The current study aims at the amalgamation of elite genotypes, and nutrient management is dependent on attributes and more machinery activities aiming at enhanced productivity in the low-input mode[39]. The conceptual model of safflower adaptability, along with traditional and new modes of cultivation, is shown in Figure 1.

5. Oilseed Characteristics of *Kusumbha*

Kusumbha is an important oilseed crop largely cultivated for its seeds,whichpossess significantnutritional and industrial value[40]. The Seeds consist primarily of lipids, proteins, and carbohydrates, but they also contain other constituents, including minerals and phenolics[41]. Recent compositional studies revealed that the oilseed of safflower has 30–45% oil and 15–20% protein, which are competitive with many conventional oilseeds[42]. The oil derived from *Kusumbha* seed is clear and pale in colour, with a good degree of oxidative stability and has much variation by both varieties and growing cases[43]. Breeding efforts have resulted in two main types of oil: linoleic acid–rich and oleic acid–rich lines[44]. Linoleic-type safflower oil is especially valuable in the human diet as an ingredient with elevated polyunsaturated fatty acid composition, whereas oleic-type oil has superior thermal and oxidative stability for commercial and cooking applications[45]. Fatty acid analysis of safflower oil shows that linoleic acids present vary from 70 to 80% in old climatic genotypes and enhanced oleic (more than 70%) available[46]. Saturated fatty acids like palmitic and stearic acid are present in low quantities, making the oil more acceptable for health[47]. The provision of significantly ($P < 0.01$) higher content of linoleic acid than mustard and groundnut, safflower oil also had a similar unsaturated fatty acid profile with sunflower oil to those in other major oilseed crops[48]. These features made *Kusumbha* an important speciality oilseed crop for nutritional, pharmaceutical and industrial uses[49]. Its oil quality characteristics with adaptability to marginal environments also strengthen the importance of diversified and sustainable oilseed

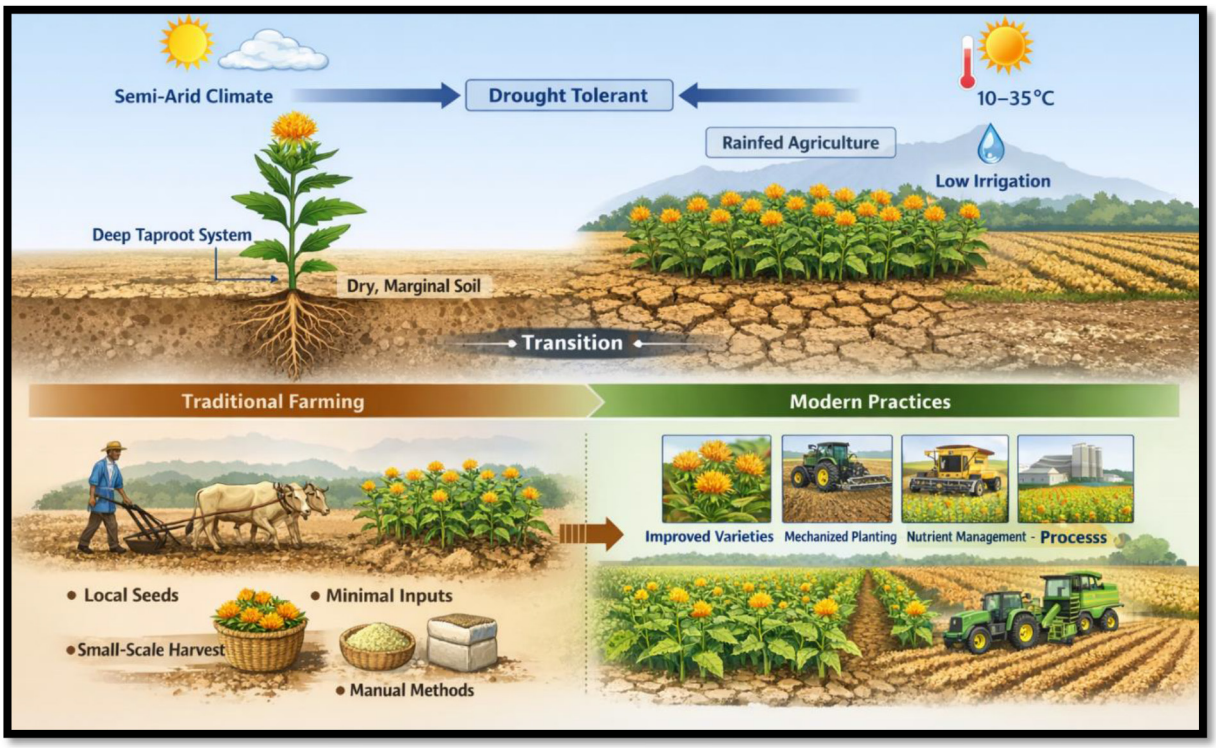


Figure 1. Cultivation practices in traditional and modern systems of safflower.

Table 4. Comparative seed composition and oil characteristics of *Kusumbha* and major oilseed crops

Parameter	*Kusumbha* (Safflower)	Mustard	Groundnut	Sunflower	Linseed	Soybean	Sesame	Cottonseed
Oil content (%)	30–45	35–40	45–50	38–45	35–42	18–22	45–50	30–35
Protein (%)	15–20	20–25	25–30	18–22	20–25	35–40	18–25	20–25
Major fatty acid(s)	Linoleic / Oleic	Erucic / Oleic	Oleic	Linoleic	Linolenic	Linoleic	Oleic / Linoleic	Linoleic
Linoleic acid (%)	70–80	15–25	30–35	60–70	15–20	50–55	35–45	50–55
Oleic acid (%)	10–75*	20–60	45–55	20–30	18–22	20–25	35–45	15–20
Linolenic acid (%)	<1	<1	<1	<1	50–55	7–10	<1	<1
Saturated fatty acids (%)	8–10	10–12	15–18	10–12	9–10	14–16	14–16	22–26
Oil quality characteristics	Light oil, rich in PUFA	Moderate stability	Oxidatively stable	High PUFA content	Omega-3 rich, low oxidative stability	Moderate stability	Antioxidant-rich	Industrial and edible uses

*Varies with cultivar type

production systems[50]. A comparative overview of seed composition and oil characteristics of safflower and other oilseed crops is presented in Table 4.

6. Nutritional Potential of *Kusumbha*

Kusumbha seeds have high nutritional value because they possess a mix of fatty acids, proteins, and essential minerals. Recent studies demonstrated that oil content in safflower seeds contributed about 30–45%, while 15–20% of protein, along with carbohydrates, fibres, and trace amounts of minerals like Ca, Mg, P, and Fe[51]. Another oil extracted from this plant's seeds, known as 'Safflower oil,' has gained remarkable significance due to its high content of 'unsaturated fatty acids'. 'Safflower oil' rich in 'Linoleic acid' possesses essential fatty acids with applications in maintaining 'cellular membrane integrity' and'lipid metabolism regulation'. Oleic acid-rich varieties showed higher 'thermal stability', 'cuisine stability', due to which their'adoption in diets' has significantly progressed[52]. Moreover, 'Safflower oil' rich in 'Tocopherols and phenolic compounds' proved to be rich in 'bioactivity' due to its 'anticancer', 'hypolipidemic' effects exhibited by 'heart health benefits'. At nutritional levels, high-consumption Safflower oil showed positive 'lipid profile effects' and'low-density lipoprotein'. Extensively having 'low saturated and healthy fatty acids content', 'Safflower oil' has marked its presence in the 'heart-healthy edible vegetable oils' category[53]. This detailed observation emphasises 'Nutritional viability', 'feasibility' of '*Kusumbha*' oilseed crops, portraying hope to augment 'diets and nutritional security'.

7. Medicinal and Industrial Uses of *Kusumbha*

7.1 Traditional Medicinal Uses

Kusumbha crop has a long history of traditional use as a Medicine in the ancient civilisations of the world, especially the South Asian, East Asian, and Middle Eastern regions of the world. The use of the flowers and seeds of *Kusumbha* to increase the circulation of blood, relieve pain, and heal injuries quickly was documented in the traditional use of this herb as a Medicine in the remote areas of the world[54]. The medicinal uses of *Kusumbha* are mainly associated with its phytochemical constitution, particularly the presence of flavonoids, phenolic acids, and unsaturated fatty acids[55]. Recent research studies have supported the fact that extracts of safflower possess remarkable antioxidant and anti-inflammatory properties, which are useful in combating oxidative stress and inflammation at the cellular level[56]. These qualities have been associated with its traditional use in treating chronic diseases

like arthritis, cardiovascular diseases, and circulatory problems[57]. The seeds have also been employed as a mild laxative and tonic, thereby establishing their effectiveness as a medicinal herb.

7.2 Use in *Ayurveda*

Kusumbha is classified as a crop which possesses the characteristics of *anushna* as well as *rakta-shodhaka*. This plant is utilised in the treatment of disorders associated with the imbalance of "*vata*" and "*kapha*," thus enhancing blood flow, metabolism, and strengthening the body. Historical uses of safflower oil as well as flowers have been recorded in the treatment of various disorders such as irregular menstrual cycles, arthritis, skin diseases, and heart disorders[58]. The safflower oil (*Kusumbhataila*) is applied both externally and internally. The internal use of the oil is in smaller quantities to gain the effects of lipid metabolism and the digestive processes. The externally applied usage of the oil includes massage therapies in the treatment of rigidity, rheumatic pains, and swelling of the joints. These have shown scientific importance in lipid-lowering effects, vasodilation, cardio protection, thus establishing their importance in *Ayurveda*[59]. *Kusumbha* oil is also used concomitantly with herb extracts such as turmeric or *ashwagandha* by *Ayurveda* practitioners themselves to enhance medicinal purposes, particularly in detoxification treatments or *Ayurveda* restoring or rejuvenating treatments called *Panchakarma*. The result is that there is still a special place occupied by *Kusumbha* oil within the arena of *Ayurveda* Medicine that encompasses nutritional well-being, plus pharmacological healing, as shown in Figure 2.

7.3 Use in Folk Medicine

As far as conventional *Ayurveda* medicine is concerned, *Kusumbha*has been a major part of folk remedies in India, China, and the Middle East. Folk medicinal practitioners have employed safflower preparations such as decoctions, powders, and flower infusions for the purpose of taking care of cardiovascular health, inducing menstrual discharge, and recovery from childbirth[60]. In traditional remedies, safflower is prescribed in order to "invigorate blood" and relieve blood stasis, which is responsible for preventing circulatory and cardiac problems.

Modern pharmacological studies have revealed hydroxysafflor yellow A as one of the major active substances in *Kusumbha*, accounting for most of its medicinal properties. Hydroxysafflor yellow A has been shown to possess neuronal protective, anti-ischemic,

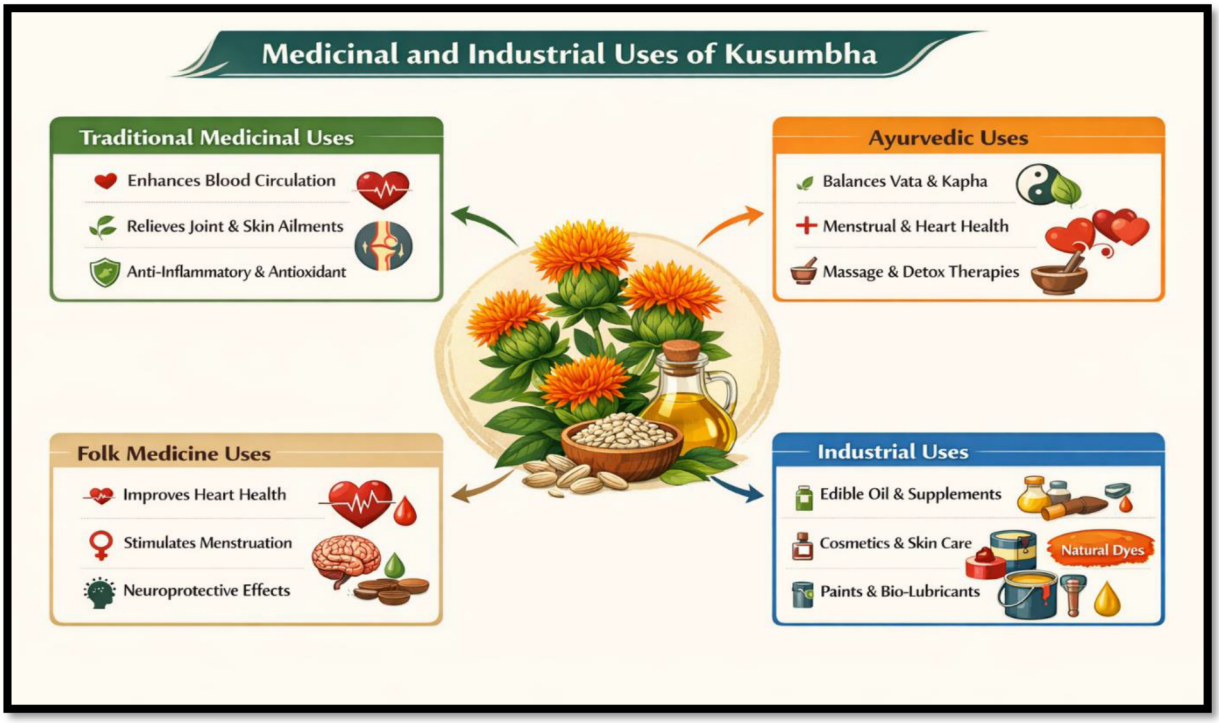


Figure 2. Overview of traditional medicinal, *Ayurveda,* folk and industrial uses of *Kusumbha.*

and cardio-protective activities in animal studies[61]. Such discoveries not only prove modern uses for this herb but also confirm ancient wisdom through its applications in contemporary medical research.

7.4 Industrial Uses

Beyond its medicinal and cultural importance, *Kusumbha* is of great industrial importance. Safflower oil is considered to be a good edible oil due to its favourable fatty acid profile of high unsaturation and low saturation of fatty acids. The oil has wide applications in nutraceutical and pharmaceutical products, especially in various dietary supplements or functional foods designed to manage cardiovascular and metabolic disorders[62].

7.5 Cosmetic and Personal Care Applications

In the cosmetic industry, safflower oil is cherished for its moisturising, anti-ageing, and skin conditioning properties. It is rich in oleic acid and Vitamin E. This makes safflower oil a favourite amongst natural skin creams, lotions, soaps, and hair products[63]. It has skin-smoothing properties and can prevent skin drying. This is why safflower oil is one of the favourite components in organic and herbal cosmetics.

7.6 Natural Dye and Sustainable Uses

Conventional applications of safflower flowers included their use as natural sources of red and yellow dyes, named carthamin and carthamidin. Before the advent of industrialisation, these natural dyes were in high demand as textile dyes, in the manufacture of cosmetics, and in food processing. But because of the emergence of artificial dyes as a result of industrialisation, the use of safflower dyes has become common in modern industry because of the preference for eco-friendly products[64].

7.7 Other Industrial Applications

Safflower oil also holds other uses other than the food industry. With its excellent drying attributes and oxidation resistance, it finds applications in the production of paints, alkyd resins, surface coatings, bio-lubricants, and even biodiesel, amongst others[65]. Such attributes make *Kusumbha* more than a medicinal herb; it also represents a sustainable resource for industry.

8. Role in Sustainable and Climate-resilient Agriculture

*Kusumbha*or safflower is progressively being considered not only as an adaptation-friendly oilseed but also because of its ability to withstand and adapt to extreme and rainfed areas. This plant can grow in semi-arid conditions and is able to sustain equal yields even in low-quality soil, making the growth of major oilseed

Table 5. Role of *Kusumbha* in sustainable and climate-resilient agriculture

	Role of *Kusumbha*	Contribution to Sustainability
Suitability for rainfed areas	Performs well under semi-arid and rainfed conditions	Ensures stable yield under erratic rainfall
Performance on marginal lands	Thrives in low-fertility and degraded soils	Enables productive use of marginal lands
Root system	Deep taproot system	Enhances drought tolerance and moisture extraction
Water requirement	Low water demand with high water-use efficiency	Reduces dependence on irrigation
Nutrient requirement	Efficient utilisation of residual soil nutrients	Minimises chemical fertilizer use
Input intensity	Low-input crop	Lowers cultivation cost and environmental impact
Compatibility with organic farming	Responds well to FYM, compost, and bio fertilisers	Supports organic and natural farming systems
Pest and disease pressure	Relatively less susceptible	Reduces need for pesticides
Role in crop diversification	Suitable for inclusion in rotations	Breaks pest and disease cycles
Soil health improvement	Deep rooting improves soil structure and aeration	Enhances long-term soil fertility
Ecosystem services	Flowers attract pollinators	Supports biodiversity and agro-ecosystem balance
Climate resilience	Tolerates drought and abiotic stress	Strengthens adaptive capacity under climate change

crops impossible. This plant also possesses an efficient tap root, which allows the plant to derive its sustenance from deeper soil and survive even in conditions of drought, making the plant an adaptation-friendly species for irrigation and growth in drought-prone areas[66]. The factor that proves the sustainability of the plant, the characteristic of which is being progressively recognised, is the plant's drought-tolerance and its ability not to require much water. Studies have shown that the safflower is highly efficient and able to sustain itself even in low irrigation conditions, reducing the need for external sources of water[67]. Apart from using water effectively, the other benefit of safflower is that it requires a lower amount of nutrients to grow compared to other oil crops. Safflower is capable of utilising the leftover nutrients found in the soil, and hence, requires fewer uses of fertilisers. This not only makes the growing of the crop less expensive but also ensures the environmental impact created by fertilisers used by other crops is less by the safflower crop[68]. Another significant inherent advantage that exists in the use of *Kusumbha* is its adaptability to organic and natural farming systems. The reason behind this is that the crop has inherent tolerance to different abiotic stress factors, such as drought and salinity stress, along with reduced vulnerability to biotic forces like biotic pests and diseases. The results of the research analysis that have been carried out to test the adaptability of the organic farming method prove that the adaptability and performance advantage of safflower to the raw materials used in organic farming, like farmyard manure, compost, and organic fertilisers, do not compromise the yield potential of the safflower oil and seeds to a greater extent[69].

Furthermore, *Kusumbha* is a critical element for improving agricultural diversity, as well as enhancing soil quality. Crop rotation techniques utilising safflower plants can be an effective mechanism in breaking the pest and disease cycles, which may grow with the continuous growth of a single species/produce. Safflower plants tend to possess extensive root systems through which soil aeration, as well as turnover, enhances soil quality. Crop diversity strategies utilising safflower plants can provide insurance strategies to farmers in terms of climate variability, as well as encouraging overall productivity in the ecosystem[70]. Safflower mixed cropping systems have several advantages, including the prevention of soil erosion and an increase in soil organic carbon content, as well as the stimulation of diversity, especially flower diversity with flowers of orange-yellow colouration, signalling their ability to attract useful bugs. All these factors contribute to the execution of efficient agricultural practices and, therefore, an improvement in agricultural resilience to environmental changes in our current climatic conditions. In this regard, taking into consideration the fact that this crop is able to grow with lower input levels and can be used in organic farming, it's apparent that *Kusumbha* has a significant role to play in ensuring sustainability in oilseed crop development programs. Redevelopment of this crop in the latest agricultural technologies will help in ensuring diversified earning sources in addition to climate-resilient agriculture programs. The role of *Kusumbha* in sustainable and climate-resilient agriculture is shown in Table 5.

9. Constraints for Decline of *Kusumbha*

9.1 Declining Cultivation Area

In spite of the malleability and diversity of uses of *Kusumbha*, the area under cultivation of the plant has progressively been declining over the past decades. Data obtained from the main cultivation sites of the plant, especially from India, has shown a decline in the area under cultivation as a result of the changes in the patterns and the selection of more profitable crops by the farmers. In rain-fed ecosystems, the use of safflower has declined in favour of crops believed to be more reliable or less risky, including cereal crops/Oilseed crops[71].

9.2 Competition with Major Oilseed Crops

One of the major reasons for the decline could be that it has stiff competition from other crops such as soybean, mustard, sunflower, and groundnut, which offer a higher yield. These crops offer better varieties, stronger procurement, and assured market access. This could be a possible reason that safflower crops are not performing well due to less development work on variety and lower yielding capacity[72].

9.3 Lack of Awareness and Market Support

However, there is a lack of awareness about the nutritional and industrial uses of safflower among

farmers. The reason for this may largely be attributed to a lack of proper markets, support price, and chain of value-added products, which deters their large-scale usage. Additionally, the presence of less demand for safflower oil, which is a nourishing fatty acid, has also impeded the growing demand of the market.

9.4 Research and Policy Gaps

Kusumbha continues to receive minimal research and policy attention compared to other oilseed crops. Investment in breeding programs, agronomic optimisation, and post-harvest processing remains inadequate. Likewise, minor oilseeds like safflower are often excluded from government support schemes and institutional frameworks. Without targeted interventions and improved research funding, reviving *Kusumbha* cultivation will remain a challenge[73,74]. Overall, the decline of *Kusumbha* is driven by interrelated agricultural, economic, and institutional factors. Addressing these challenges through research, policy support, and market development is essential to re-establish safflower's role in sustainable oilseed production systems.

10. Future Prospects and Revival Strategies

10.1 Scope for Revival as a Niche Oilseed Crop

Kusumbha has a bright revival prospect as a niche oilseed crop highly suitable for dryland and low-input farming systems. The resilience to drought and adaptability of this crop in semi-arid conditions, together with high-quality oil rich in unsaturated fatty acids, place it in a privileged competitive position in the emerging health-oriented edible oil market. Increasing consumer demand for natural, heart-friendly, and sustainable oils is now offering new opportunities for the repositioning of safflower as a value-added product in both national and international markets.

10.2 Research and Breeding Needs

One major approach for revival would be to enhance research and varietal development. Development of high-yielding, short-duration, and disease and drought-resistant varieties would enhance the variability andsustainability of rainfed farming. Oil of diverse qualities, for example, linoleic and oleic acid species, can be used for various purposes infood, pharmaceuticals, and industry. Joint efforts of ICAR institutes, Agricultural Universities, and other private seed corporations would help in the development offocused agronomic practices for large-scale adoption ofsafflower cultivation.

10.3 Policy and Farmer-level Interventions

Policy reforms can significantly accelerate safflower's revival. Ensuring minimum support prices, providing crop insurance, and including safflower under the national oilseed missions would build farmer confidence. Training and capacity-building programs focused on sustainable cultivation, organic production, and post-harvest management can improve productivity and profitability. Establishing producer cooperatives and connecting them with local processing and marketing networks can further strengthen the value chain and rural livelihoods.

10.4 Market and Value-addition Potential

Expanding safflower's use beyond edible oil is vital for long-term sustainability. Promoting safflower-based nutraceuticals, cosmetics, bio-lubricants, and natural dyes can diversify income sources. Branding *Kusumbha* as a climate-resilient and health-benefiting crop under initiatives like "One District One Product" can attract investment and consumer awareness. With coordinated strategies across research, policy, and markets, safflower can re-emerge as a profitable and sustainable crop for future agriculture.

11. Conclusion

Kusumbha (*Carthamus tinctorius* L.), also known as safflower, is considered to be one of the oldest domesticated oilseed crops due to its high content of valuable lipids. *Kusumbha* has always occupied an important position in the past due to its nutritional value and its use in the preparation of medicines and various other products. However, the development of high-yielding oilseed crops has led to the decline in the cultivation of *Kusumbha* over the years, which has been further worsened due to a lack of attention and less emphasis on its cultivation in the present era. Despite the decline in the cultivation of *Kusumbha*, the crop has many positive attributes

from an agricultural point of view. It is well adapted to low-input cultivation and requires less water than the other crops, which makes its cultivation suitable in regions with varying types of soil. Moreover, the crop has a strong root system, which helps in its cultivation in rain-fed areas and also provides resistance to frost. Additionally, the crop can produce high-quality oil, which further adds to its economic importance. Considering the present environmental conditions, the cultivation of *Kusumbha* is worthy of consideration and deserves to be explored in detail in the present era, as the promotion of this crop may not only help in the development of the environment but also the people living in the rural areas.

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13. References

1. Abd El-Baset WS, Almoselhy RIM, Abd-Elmageed SMM. Physicochemical characteristics and nutritional value of safflower oil as a potential sustainable crop. North Afr J Food Nutr Res. 2024; 8(18):1–12. https://doi.org/10.51745/najfnr.8.18.140-153
2. FAO. The state of the world's biodiversity for food and agriculture. Rome: Food and Agriculture Organization of the United Nations; 2021.
3. Meena P, Lakpale R. Nutrient management strategies in safflower (*Carthamus tinctorius* L.) under diversified cropping systems. Agron J. 2024; 116(2):845–856. https://doi.org/10.1002/agj2.21478
4. Patel DK, Kumar R, Laloo D. Ethnopharmacological and therapeutic potential of *Carthamus tinctorius* L.: A review. J Ethnopharmacol. 2021; 268:113578. https://doi.org/10.1016/j.jep.2020.113578 PMid:33189840.
5. Rathore SS, Shekhawat K, Premi OP, Kandpal BK. Oilseed crops for climate-resilient agriculture in arid and semi-arid regions of India. Agronomy. 2022; 12(4):921. https://doi.org/10.3390/agronomy12040921
6. Ren F, Zhang H, Wang Y. Nutritional and pharmacological properties of safflower flavonoids: recent advances. Front Nutr. 2023; 10:1189456. https://doi.org/10.3389/fnut.2023.1189456.
7. Sharma P, Singh R, Yadav RK. Constraints and opportunities in minor oilseed crop production in India. Indian J Agric Sci. 2021; 91(9):1321–1327.
8. Singh R, Kachroo D, Thakur NP. Status and future prospects of safflower cultivation in India. Indian J Agron. 2021; 66(4):512–519.
9. Singh V, Verma RK. Underutilised oilseed crops for sustainable agriculture. Sustainability. 2020; 12(21):8924. https://doi.org/10.3390/su12218924
10. Singh V, Nimbkar N, Kumar S. Safflower breeding and production: progress and challenges. Plants. 2023; 12(3):564. https://doi.org/10.3390/plants12030564 PMid: 36771648 PMCid: PMC9920470.
11. Rathod PS, Patil SB. Nutritional profiling of safflower oil and its health implications. J Food Compos Anal. 2022; 108:104432. https://doi.org/10.1016/j.jfca.2022.104432.
12. Kumar S, Meena S, Yadav A. Potential of neglected oilseed crops in improving edible oil security. J Clean Prod. 2020; 276:124194. https://doi.org/10.1016/j.jclepro.2020.124194
13. Cheng H, Zhang Y, Liu J, Wang X. Genetic diversity, phytochemical composition and pharmacological potential of *Carthamus tinctorius* L. Front Pharmacol. 2024; 15:1298456. https://doi.org/10.3389/fphar.2024.1374680 PMid: 38799156 PMCid: PMC11127628.
14. Dong Y, Liu M, Zhao J, *et al*. Genome insights into domestication and evolution of safflower (*Carthamus tinctorius* L.). Front Plant Sci. 2024; 15:1362148. https://doi.org/10.3389/fpls.2024.1362148
15. Erbaş S, Mutlu H, Akın A. Flower yield, pigment content and quality traits of different safflower genotypes. Agronomy. 2023; 13(4):956. https://doi.org/10.3390/agronomy13040956
16. Muscalu AM. Importance, uses and future prospects of safflower (*Carthamus tinctorius* L.). CAB Rev. 2023; 18(021):1–12. https://doi.org/10.1079/PAVSNNR202318021
17. Xian B. Historical uses and phytochemistry of safflower pigments. Phytochem Rev. 2022; 21(4):987–1003. https://doi.org/10.1007/s11101-022-09792-5
18. Ahmad S, Khan M, Iqbal J. Temperature stress tolerance in safflower under semi-arid conditions. J Agron Crop Sci. 2023; 209(4):512–523. https://doi.org/10.1111/jac.12592
19. Ali M, Hussain S, Farooq M. Physiological responses of safflower to water-limited environments. Plants. 2023; 12(9):1846. https://doi.org/10.3390/plants12091846 PMid: 37176904 PMCid: PMC10180817.
20. El-Sabagh A, Hossain A, Barutçular C. Oilseed crop performance under drought stress conditions. Agronomy. 2022; 12(6):1342. https://doi.org/10.3390/agronomy12061342
21. Hosseini SM, Mohammadi R, Karimi M. Soil salinity tolerance and yield stability in safflower. Land Degrad Dev. 2024; 35(2):678–689. https://doi.org/10.1002/ldr.4692
22. Kumar R, Singh A, Yadav R. Effect of climatic variability on flowering and yield of safflower. Indian J Agric Sci. 2022; 92(7):891–897.

23. Nair R, Thomas G, Menon S. Declining trends and challenges of minor oilseed crops in India. Agric Econ Res Rev. 2021; 34(1):55–63.
24. Patil SB, Rathod PS, Kulkarni GN. Crop geometry and water use efficiency in safflower. J Oilseed Res. 2020; 37(2):101–108.
25. Reddy MP, Rao SS, Kumar V. Agro-climatic suitability of safflower in dryland farming systems. J Agrometeorol. 2021; 23(3):261–268.
26. Rehman A, Shahzad M, Bilal M. Drought adaptation mechanisms in oilseed crops with special reference to safflower. Front Plant Sci. 2024; 15:1289014. https://doi.org/10.3389/fpls.2024.1289014
27. Singh P, Mishra A, Tripathi RS. Improved cultivation practices for enhancing safflower productivity. Indian J Agron. 2022; 67(4):489–496.
28. Yadav S, Meena K. Low-input oilseed crops for sustainable agriculture in semi-arid regions. Sustainability. 2023; 15(18):13421. https://doi.org/10.3390/su151813421
29. Zhang L, Chen H, Liu Y. Soil adaptability and yield response of safflower under marginal land conditions. Agriculture. 2021; 11(10):1015. https://doi.org/10.3390/agriculture11101015
30. Demir B, Arslan Y, Gül MK. Fatty acid composition and quality traits of safflower oil under different environments. J Food Compos Anal. 2021; 96:103715. https://doi.org/10.1016/j.jfca.2020.103715
31. Hassan MA, El-Sayed AA, Abdelrahman HA. Quality assessment of oleic and linoleic safflower oil cultivars. Foods. 2023; 12(7):1486. https://doi.org/10.3390/foods12071486 PMid: 37048307 PMCid: PMC10094669.
32. Kaya MD, Atak M, Çiftçi CY. Oil quality and fatty acid composition of safflower cultivars. Ind Crops Prod. 2020; 148:112285. https://doi.org/10.1016/j.indcrop.2020.112285
33. Özcan MM, Aljuhaimi F, Ghafoor K. Comparative evaluation of physicochemical properties of edible vegetable oils. J Food Process Preserv. 2022; 46(3):e16321. https://doi.org/10.1111/jfpp.16321
34. Rahimi A, Mohammadi R, Karimi M. Seed composition and oil quality of safflower grown under dryland conditions. Agriculture. 2021; 11(9):835. https://doi.org/10.3390/agriculture11090835
35. El-Banna AN, Zayed BA. Functional properties and health-promoting components of safflower oil. Food Chem Adv. 2022; 1:100012. https://doi.org/10.1016/j.focha.2022.100012
36. Kumar V, Meena SK, Yadav RS. Potential of alternative oilseed crops for nutritional security in India. J Oilseed Res. 2024; 41(1):1–9.
37. Gharby S, Harhar H, Bouzoubaa Z. Physicochemical characterization and oxidative stability of vegetable oils under different storage conditions. OCL. 2021; 28:36. https://doi.org/10.1051/ocl/2021025
38. Ali S, Ahmad M, Khan MA. Application of plant-based oils in cosmetic and personal care formulations: recent advances and future prospects. Cosmetics. 2022; 9(4):92. https://doi.org/10.3390/cosmetics9040092
39. Chen L, Zhao Y, Xu J. Cardioprotective and vasodilatory effects of *Carthamus tinctorius* extracts: mechanisms and therapeutic implications. J Ethnopharmacol. 2021; 276:114169. https://doi.org/10.1016/j.jep.2021.114169 PMid:33932513.
40. Erbaş S, Mutlu H, Akın A. Natural dye potential, pigment composition and industrial applications of safflower (*Carthamus tinctorius* L.) florets. Ind Crops Prod. 2023; 193:116201. https://doi.org/10.1016/j.indcrop.2022.116201
41. Kumar A, Sharma R, Singh P. Medicinal plants in *Ayurveda*: traditional knowledge, therapeutic relevance and modern validation. J Ayurveda Integr Med. 2020; 11(4):589–598. https://doi.org/10.1016/j.jaim.2020.06.002 PMid: 33288353 PMCid: PMC8185966.
42. Liu X, Sun Y, Wang H. Phytochemical composition, antioxidant and anti-inflammatory activities of safflower (*Carthamus tinctorius* L.). Phytother Res. 2021; 35(6):3321–3330. https://doi.org/10.1002/ptr.7051 PMid: 33570219.
43. Patel DK, Rao RV. Traditional medicinal uses and pharmacological significance of safflower (*Carthamus tinctorius* L.). J Herb Med. 2021; 28:100443. https://doi.org/10.1016/j.hermed.2021.100443
44. Delshad E, Yousefi M, Sasani S. Advances in phytochemical profiling and therapeutic applications of *Carthamus tinctorius* L. Phytomed Plus. 2023; 3(2):100445. https://doi.org/10.1016/j.phyplu.2023.100445
45. Sharma S, Meena R, Yadav K. Ethnomedicinal importance of oilseed crops in India with special reference to safflower. Indian J Tradit Knowl. 2022; 21(3):512–520.
46. Singh V, Meena SK, Yadav RS. Industrial applications of vegetable oils in sustainable manufacturing systems. Renew Agric Food Syst. 2024; 39:e12. https://doi.org/10.1017/S1742170523000187
47. Wang Y, Liu J, Chen X. Neuroprotective and anti-ischemic effects of hydroxysafflor yellow A: Pharmacological mechanisms and clinical potential. Front Pharmacol. 2023; 14:1214567. https://doi.org/10.3389/fphar.2023.1214567
48. Zhang L, Chen H, Liu Y. Traditional uses and modern pharmacology of safflower in Chinese medicine. Chin J Integr Med. 2022; 28(9):814–822. https://doi.org/10.1007/s11655-022-3448-6
49. Bhaduri D, Rao AS. Low-input oilseed crops for sustainable production systems under climate stress. Sustainability. 2023; 15(6):5124. https://doi.org/10.3390/su15065124
50. Das S, Mukherjee D, Banerjee H. Performance of safflower under organic nutrient management in dryland conditions. Org Agric. 2021; 11(4):623–632. https://doi.org/10.1007/s13165-021-00363-4

51. Kaur R, Singh J, Dhaliwal SS. Rainfed oilseed crops as climate-resilient options for semi-arid regions. J Agrometeorol. 2021; 23(4):418–426.
52. Lal B, Gautam P, Tripathi RS. Crop diversification as a strategy for climate-resilient agriculture in South Asia. Agric Syst. 2023; 206:103617. https://doi.org/10.1016/j.agsy.2023.103617
53. Moradi R, Kashani A, Nezami A. Water use efficiency and drought tolerance mechanisms in safflower (*Carthamus tinctorius* L.). Agric Water Manag. 2022; 264:107496. https://doi.org/10.1016/j.agwat.2022.107496
54. Rathore SS, Shekhawat K, Premi OP. Trends and constraints in safflower cultivation under rainfed systems. Indian J Agron. 2021; 66(2):210–216.
55. Sharma P, Singh R. Competitiveness of minor oilseed crops in changing agricultural systems. Indian J Agric Sci. 2022; 92(10):1205–1211.
56. Yadav S, Meena K, Lal B. Policy gaps and research needs for underutilised oilseed crops. Sustainability. 2023; 15(14):10982. https://doi.org/10.3390/su151410982
57. FAO. Oilcrops and oilseed products: Market and policy developments. Rome: Food and Agriculture Organization of the United Nations; 2022.
58. Jha GK, Pal S. Growth and instability in oilseed production in India: trends and policy implications. Agric Econ Res Rev. 2022; 35(2):147–158.
59. Dhyani A, Chopra R, Garg M. Utilization of plant-derived oils in cosmetic formulations: emerging trends. J Cosmet Dermatol. 2023; 22(5):1342–1350.
60. Li D, Wang P, Luo Y. Natural pigments from safflower: extraction, stability and industrial applications. Food Biosci. 2023; 52:102424. https://doi.org/10.1016/j.fbio.2023.102424
61. FAO. Climate change and food security: Risks and responses. Rome: FAO; 2019.
62. Reddy AA, Bantilan MCS. Competitiveness and sustainability of oilseed crops in India. Indian J Agric Econ. 2021; 76(3):378–392.
63. Choudhary R, Jat RS. Resource conservation strategies in oilseed-based cropping systems. Agric Rev. 2022;43(4):415–423. https://doi.org/10.18805/ag.R-2268
64. Vermaak I, Viljoen A. Vegetable oils in dermatology and skin care: a review. Int J Mol Sci. 2021; 22(8):4234.
65. Kumar D, Singh B, Meena RK. Emerging industrial applications of non-traditional vegetable oils. Ind Crops Prod. 2023; 193:116094. https://doi.org/10.1016/j.indcrop.2023.116094
66. Patel SR, Patel RB. Climate-resilient rainfed oilseed cropping systems in semi-arid regions. J Agrometeorol. 2022; 24(3):299–307.
67. Golkar P, Arzani A. Drought tolerance mechanisms in safflower genotypes. *Euphytica*. 2021; 217:112.
68. Chauhan BS, Mahajan G. Climate-resilient oilseed production systems in semi-arid regions. Agric Syst. 2022; 198:103381.
69. Tiwari R, Meena NL. Organic nutrient management in safflower under dryland ecosystems. J Oilseed Res. 2022; 39(1):45–52.
70. Pathak H, Aggarwal PK. Crop diversification strategies for climate-resilient agriculture. Agric Syst. 2021; 190:103094.
71. Jadhav RR, Patil VD. Constraints in safflower production under rainfed farming. Indian J Agron. 2022; 67(3):342–348.
72. Singh P, Yadav RS. Market competitiveness of underutilized oilseed crops in India. Indian J Agric Mark. 2023; 37(1):56–64.
73. FAOSTAT. Crops and livestock products database. Rome: Food and Agriculture Organization; 2023.
74. Meena K, Yadav S, Lal B. Research priorities for neglected and underutilized oilseed crops. Sustainability. 2024; 16(3):1458.

Author Contribution

A.K., B.D., and M.N. contributed to the conceptualisation of the review. M.N. supervised the study and prepared the original draft of the manuscript. A.K., B.D., J., and B.B.D. performed the literature search and data curation. J. and D.P. contributed to data analysis and interpretation of the reviewed studies. P.B. and A.P. assisted in manuscript writing and formatting. V.K.P. supervised and critically revised the manuscript for important intellectual content. All authors have read and agreed to the published version of the manuscript.