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Resurgence of Safflower (*Carthamus tinctorius* L.) Utilization: A Global View

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Abstract: The growing demand for vegetable fats as food purposes has entailed a considerable expansion of oilseed crops all over the world. Although safflower ranks last in oilseed crops, it includes some valuable characteristics that have made the species famous throughout the centuries, in particular as a multi-purpose oilseed, medicinal plant and a source of carthamin, a dye. For human nutrition, safflower oil has a nutritional value that similar to olive oil; moreover, the high oleic type is very suitable for hypo-cholesterol diets, for frying and in the preparation of frozen food. The high linoleic type may also used for industrial purposes such as preparation of varnishes, the production of biodiesel and alcohols to use in producing surfactants. Safflower is also a source of important chemicals like α -tocopherol and carthamin. In this review, after illustrating the uses of safflower as a oil and medicinal plant and the major characteristics of the oil, seed and flower, a brief analysis of world-wide current situation and future prospects of safflower utilization are presented.

Key words: Safflower utilization, product, marketing, processing

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is a member of the family Compositae or Asteraceae and mainly cultivated as an oilseed, birdseed or for its flowers, used as dye sources and for medicinal purposes. Safflower is a branching, thistle-like herbaceous annual or winter annual plant, with numerous spines on leaves and bracts. The stems elongate quickly and branch extensively. Each stem ends in a globular flower capitulum, enclosed by clasping bracts, which are typically spiny. Developed capitula contain 15-30 or more achenes. The typically white achenes, averaging from 0.030 to 0.045 g, are smooth and four-sided, with a thick pericarp. A mature achene of common varieties is made up of 33-60% hull and 40-67% kernel. Oil content ranges from 20 to 45% or more of the whole seed^[1].

Safflower is a very ancient crop which originated in the Middle East^[2]. Compared to other oilseed crops it is a worldwide minor crop. According the FAO data, safflower is grown in large areas in India (350000 ha), Mexico (85000 ha), Ethiopia (72000 ha) and USA (54000 ha). Other producer countries, in decreasing order, are Kazakhstan (63000 ha), Australia (35000 ha), Argentina (30000 ha), Uzbekistan (13000 ha) and China (12000 ha). However, Russian Federation, Pakistan, Spain, Turkey and Israel have relatively minor acreages. In addition Canada, Portugal, Syria, Iran, Czech Republic, Cyprus, Romania and Italy are known for their safflower research and development^[3]. India and Ethiopia are the countries

with the longest tradition of safflower growing as an oil plant. In the India, the leading producer country, safflower is mainly produced for the domestic vegetable oil market. In addition, safflower florets are also harvested for use in traditional medicines in the China and the crop is not reported internationally. As from the beginning of this century, safflower has become an oil crop used both for food and industrial purposes in many other countries as well^[4,5].

HISTORY OF SAFFLOWER USES

Despite its relatively minor importance in world agriculture, safflower has been known for thousands of years and has been used for many purposes. Safflower was cultivated in Egypt, Morocco, China and India for carthamin, a yellow or red colored dye material in ancient times, as early as 4500 BC.^[1,6] Safflower was indigenous to Egypt and was known as an herb. In Egypt, dye from safflower was used for coloring cotton and silk as well as ceremonial ointment in religious ceremonies and to anoint mummies. Safflower seeds packets and garlands of florets have been found with 4000 year old mummies and it is mentioned by Pliny in his Natural History^[6]. The oil was used as an unguent and for lightening as well. By the 18th century, Egyptian safflower dye was used in Italy, France and Britain to color cheese and flavor sausage^[1]. In China and many other countries, the yellow type dye has been increasingly used for coloring food, beverages and clothes. Carthamin, the red pigment, is mostly used in

cosmetics^[6,7]. In addition, safflower was also used for treatment as a medicinal plant in China^[8,9]. Safflower dyes were particularly important to the carpet-weaving industries of Eastern Europe, the Middle East, Indian and Turkey. Before cheaper aniline dyes became available, Carthamin dye was used extensively to coloring cloth until the 19th century. At present, the safflower corolla pigment, greatly appreciated in Japan, is used for dye cloth^[10]. The florets are sometimes sold as saffron to unsuspecting tourists in the Eastern Mediterranean. Safflower has a long history of cultivation although its main use has been the extracted dye from its florets for coloring food and textile in Iran. Its importance as an oilseed crop has only been realized since 1970^[11].

THE CURRENT SITUATION OF SAFFLOWER USE

Safflower is a kind of special industrial crop which sum up all of medicine, dye, oil and its floret, seed, stem, leaf and stalk can be utilized. All the plant's organ was found useful in the herbal sector application. In the present, it is grown mostly as a medicinal plant particularly in China^[12]. Spineless varieties have been used as cut flowers in Western Europe, Japan and Latin America^[2]. The seedlings are delicious vegetables^[1]. Young leaves and thinning are eaten as a boiled vegetable side dish with curry or rice in India, Pakistan and Burma^[1,13]. Tea from safflower foliage is used to prevent cardiac and cerebral vascular diseases in China^[14]. Safflower stems and leaves are also good forage for animals. The forage is palatable and its feed value and yields are similar or better than oats and alfalfa^[1]. Safflower can be grazed or stored as hay or silage. Safflower meal serves as animal forage and poultry^[15]. Because of the high contents of amino acids and minerals, safflower meal and cake are hopeful to be a better diet for animals, even for human beings in the future^[12,15]. The safflower florets contain two kinds of pigments. The commercial carthamin is a mixture of carthamin with a certain resin that maintains the color of the red pigments, which is used to cosmetics and fiber dyes in Japan and China^[16]. The yellow type has been increasingly use in China. It is used as yellow colored dye in food, beverage and additives in pharmacy^[4,8,12]. In addition, safflower crop is also useful as organic manure and serves as a natural fence against trespass^[13].

Safflower flowers and its products use: Safflower flowers produce red and yellow pigments and mainly used material of dye^[17]. Safflower petal contains about 30% of yellow pigment^[18] and 0.83% red pigment^[19,20].

Coloring food and cosmetics: Safflower yellow and red pigment is a nice and safe natural pigment, which can be used as coloring agent for food and cosmetics^[17,21]. Addition of safflower florets to foods is a widespread and ancient tradition. Rice, soup, sauces, bread and pickles take on a yellow to bright orange color from the florets^[1]. Safflower floret pigments are good replacements for synthetic food colors. Today, red safflower pigment is widely used as a food colorant. The main component of the red pigment is called carthamin and due to its low solubility in water, the red pigment is mainly used in colored chocolate in Japan. The yellow safflower pigment (carthamidine), on the other hand, has been used as a natural food colorant for a long time, mainly in colored juice, jelly and candy because of its water solubility^[22]. These pigments are also used as food additive by improvement of Chinese government^[10] and because of these dyes are natural, they widely used in food and beverage coloring, such as in fruit syrup, fruit juice, soda water, fruit powder, wine, candy, pastry, refreshments, tinned food, condiment, as well as flour soybean and meat products^[18,20,21]. Health concerns regarding synthetic food colorings may increase demand for safflower-derived food coloring in the world. In the future, natural food dyes will continue to be widely acceptable in food products due to their non-allergic and non-carcinogenic properties^[18].

Cosmetics always require strict safety. Safflower yellow pigment is very safe for cosmetics, such as hair-cream, shampoo, face cream and perfume^[23]. The carthamin is also mainly used for making high quality cosmetics such as lipstick, rouge, bath soap, as well as high quality egg cake^[21,24]. Cosmetics rouge can be made from carthamin dye mixed with French talk and the Japanese cosmetic and lipsticks include safflower coloring^[1,6]. The safflower oil contains some essential fatty acids such as linoleic and linoleum acids and lack of these fatty acids for human body caused drought of skin and plump scales^[7,16]. The linoleic acid can keep cell membranes with soft and strengthen elasticity and vitality. By using safflower oil, it has developed the natural skin toning cream^[16,21]. At present, the safflower oil has been determined as available oil in the cosmetics proportioning dictionary in the cosmetic trades of the United States, Japan etc.^[16].

Dyes: Until this century, after cheaper aniline dyes became available, safflower was mainly grown as far north and southern Germany and Alsace in France for dye^[1,6]. Today, carthamidin (the water-soluble yellow dye) and carthamin (red dye soluble in alkali) is still used to dye cloth, which is greatly appreciated in Japan, India and Bangladesh^[6,10,13,19]. It is also used to dye the furniture^[21].

Dye from safflower is used to color cotton, silk and the carpet-weaving colorings in Turkey. Dye manufacturing has virtually ceased in Asia, but dye is still prepared on a small scale for traditional and religious occasions^[1].

Medicinal use: Safflower petals have been shown to have a lot of medicinal and therapeutic values^[25]. Safflower is grown almost exclusively for its flowers, which are used for medicine in China and it is regarded as the most important medicine for invigorating the circulation of blood and reducing stasis and its applying has long history. Chinese experts think highly of the future of safflower industry, some curative medicines have been developed, such as safflower injection, safflower powder injection, etc.; health care medicine, such as safflower oral solution, safflower emulsion, safflower tea, safflower cola; health care food, such as safflower capsule, safflower health care oil, health oil, mixed oil, etc.^[21]. Safflower medicine products are mainly developed from dry florets and seed oil in China. The main active ingredient in safflower medicines is water-soluble yellow pigment, but alcohol extracts are also used in some preparations. Many clinical and laboratory studies support the use of safflower medicines^[8,9]. Up to date, together with other Chinese medical herbs, safflower is widely used in Japan, Korea and other Asian nations and became fashionable all over the world^[26]. In recent years, the dry florets of safflower are mainly used for cure of woman diseases, injures from falls, cardiac and cerebral vascular diseases, high blood pressure, diabetes and other illnesses related to blood stasis and microcirculatory disturbances^[21,23,26]. Safflower is also used for health care for middle and old-aged people^[8]. The Chinese safflower preparation and products spread out of the world and make contribution to the health of mankind^[21]. Additionally, some Indian pharmaceutical companies are showed private interest to utilize safflower petal products^[27].

Safflower tea has worth popularization because of its beautiful color and rich nutrients. A pleasant-tasting herbal tea is prepared from safflower blossoms^[14]. It was developed by Beijing Botanical Garden and became very popular as a new kind of health care beverage. People liked the distinctive taste, color and aroma of the herbal tea and its popularity among the people is gradually increasing due to its therapeutic effects, body invigoration and good health^[19]. The regular users of this herbal health tea have reported its usefulness in curing diseases like hypertension, angina, arthritis, swelling of joints, constipation and menstrual disorders and in reducing cholesterol level^[8]. Some experts suggested that safflower should be developed as a health beverage for middle and old ages^[14]. Safflower used as a beverage, will be beneficial to the health of people.

Safflower seed oil and its products use: Around the world, safflower is mainly grown for its edible oil for cooking, salad oil and margarine. In affluent countries, the research linking health and diet has increased for demand of oil, which as the highest polyunsaturated / saturated rations of any oil available^[1]. There is a considerable health food market for safflower oil, especially in North America, Italy, Germany^[28] and Japan^[29]. In the India, the high-income group also prefers sunflower and safflower oil primarily due to their health consciousness and aggressive marketing by certain branded oils, while poor income groups do not prefer safflower due to its relative high cost^[27].

The seeds contain 35-50% oil, 15-20% protein and 35-45% hull fraction^[30]. The seed oil has gained importance in recent years because of utilization for human nutrition; safflower oil has a nutritional value that is similar to that of olive oil. The high oleic type is very suitable for hypo-cholesterol diets, for frying and in the preparation of frozen food. Safflower oil is very stable at high temperatures and does not produce any smoke or bad smell during frying. Its consistency also does not change at low temperatures, making it particularly suitable for use in chilled foods. Safflower oil salad dressings have remained stable and satisfactory to -12°C. It is better suited to hydrogenation for margarine than soy or canola oils, which are unstable in this process^[1]. Standard safflower oil, variability for fatty acid composition in seed oil, contains about 6 to 8% palmitic acid, 2 to 3% stearic acid, 16 to 20% oleic acid and 71 to 75% linoleic acid^[27]. The content of linoleic acid ranks first in all kinds of vegetable oils and it is the best edible oil in the world^[1]. Safflower oil, with high linoleic acid content, especially is blended with other vegetable oils to nutritionally upgrade them. Corleto^[31] reported that part of the seed produced will be submitted to cold extraction in an oil firm that will also provide the separate bottling of the two oil types (high oleic and high linoleic, respectively) and the estimated total production is 20,000 oil bottles (dark glass bottles of 50 cl) in Italy. The high linoleic acid types have also a large industrial potential to be used in manufacturing of varnishes, alcohols, surfactants and as oleic acid rich types for biofuel and biolubricants^[1]. However, Bergman and Flynn^[32] reported that high oleic safflower oil has promise as a pollutant-reducing diesel fuel additive to reduce smoke and particulate emissions. Because safflower oil is virtually free of sulfur, biodegradable and totally lacks fossil carbon dioxide, it would also reduce acid rain, the greenhouse effect and surface pollution. In addition, safflower oil contains predominantly α -tocopherols, which exhibits the highest vitamin E activity^[33]. Safflower oil is sprayed on various edible products to prevent losing water and thus extend

their shelf life. An oleic oil derivative, methyl-oleate, sprayed on grapes on the vine to accelerate drying reduced the risk of rain and cost of producing sun-dried raisins^[28]. The commercialization of safflower was driven by the paint and varnish industry in the 1950s. The oil's properties (it has no linolenic acid, high linoleic acid and low color values, no wax, low free fatty acids and low unsaponifiables) are contribute to unsurpassed quality in paints, alkyd resins and coatings. However, market forces have still limited for this use^[1].

Safflower use for animal feed: Safflower is an excellent forage plant, which is palatable and its feeding value (crude value and total digestible nutrients) and yields are similar to or better than cereal or alfalfa. Safflower stubble is highly desired by cattle, sheep and goat^[15,28]. It is good for grazing during the early stages and shows a fast regrowth. On the Great Plains of North America, the crop remains green after other crops have matured^[1].

Safflower seeds are commonly used as birdseed, especially for members of the parrot family and pigeons (Canada, USA, France, Egypt and Japan)^[1]. Corleto^[31] reported that safflower seeds are an excellent food (chicken feed) for poultry and there is a good market in Italy with a price around 40 euros per 100 kg of imported seed.

After oil extraction, the residual fat varies from under 2 to 15%, the residual meal may be used for animal feeding^[13,15]. Although the cattle apparently find safflower meal palatable, it has a bitter taste which makes it unacceptable to humans. But protein isolates prepared from debittered meal can be used to fortify bread, pasta and nutritional drinks^[34].

CONCLUSIONS

Safflower oils for both edible and industrial purposes will be increasingly important. In recent years, results of nutritional studies with high linoleic and oleic oils have been promising. Safflower oil, with high linoleic acid content, can be blended with other vegetable oils to nutritionally upgrade them. In a different system of utilization, the high percentage of linoleic acid in safflower oil may be exploited for lipochemical applications. Therefore, safflower oils and meals will be offered versatile products that will find many applications in livestock nutrition, human nutrition and in technical industries.

Industrial uses of safflower oil can be expanded due to environmental concerns raised by exclusive use of fossil fuels. Biodiesel and fuel additives, as well as uses such as chainsaw-bar oil, may reduce pollutant effects of exhaust gases. Research in Montana, USA is continuing

to make high oleic safflower oil more economical use a biofuel by adding value to safflower meal through genetic breeding and improvement^[32].

Safflower flowers are also an excellent material for extracting the yellow and red pigments, which have multiple uses. The yellow pigment can be especially utilized in the textile industry, while the red pigment can be used for coloring and flavoring food. Thus, the culture of safflower can be profitable. Safflower petals have tremendous potential for value addition, as it an excellent source of different medicines and also food dyes. Health problems, particularly cancer associated with synthetic azodyes, may have further stimulated the utilization of natural chemicals such as the safflower dyes. Besides, development of safflower industry exist large market in China, it will bring with the glad tidings for 200 million of patients suffered heart and brain vascular disease, it is also good news for the middle-aged and the old.

Nowadays, the safflower products shows great potential in the market of the world with its important contribution of edible oil or industrial oil as well as its highly nutritious by-products for animal feed and its petals as coloring for food and textile. Therefore, technologies such as medicine, tea, food colors and textile colors need to be developed in the international research system and the crop can be promoted through to be increased market opportunities in the world.

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