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THE IMPORTANCE OF SAFFLOWER (*CARTHAMUS TINCTORIUS L., ASTERACEAE FAM.*)

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Abstract: Safflower is one of the oldest species used by human beings. It is cultivated in many countries of the world due to its variety of uses, the main one being the extraction of an oil with special properties from the seeds. The traditional uses of the plant refer to those of the flowers (petals) for colouring food and textiles, as well as their use in folk medicine. Due to its characteristics, safflower possesses significant potential for current fields of interest: healthy food, animal feed, organic farming, pharmacology, biorefinery, floriculture, cosmetic industry, etc. The species is resistant to drought, exploiting even lands with low fertility, representing an opportune substitute for classic oilseed crops, in areas affected by drought induced by climate change. The paper presents a brief synthesis of the important uses of safflower, able to highlight the commercial capacity of this plant, insufficiently cultivated and exploited, at present.
Keywords: safflower, seeds, oil, petals, biofuel

1. INTRODUCTION

Safflower (*Carthamus tinctorius L., Asteraceae fam.*) is a species with oleaginous seeds, similar to thistle, which usually grows favourably in areas with an arid climate. It has been cultivated since ancient times in China, India, South Asia, where it originated, Iran, the Mediterranean Basin, along the Nile valley, reaching Ethiopia.

There is evidence that proves that BC, in Egypt, flower stems were used in religious ceremonies, and the extract from flower petals, due to its properties, was used in the mummification process *(Delshad E. et al. 2018, Menegaes J. F. and Nunes U. R. 2020, Hashemi S. et al. 2020, Gomashe S. et al. 2021)*.

In some of the Western countries (Italy, France, Spain) and the United States, safflower was introduced into culture between the 5th and 14th centuries. Because the species shows high tolerance to drought, floods, strong winds, soils with a pH of 5–8, today it is cultivated in different regions of the globe, in more than 60 countries.

Thus, safflower is best adapted to three general types of climate zones:

- areas such as South Central India, where the crop is sown in autumn in October or November in heavy soils wet from summer rains or irrigation, and harvested in the dry spring;
- areas with a Mediterranean climate such as Australia, Mexico, Spain, Middle Eastern countries, California in the US, where winters are usually wet and summers are dry;
- areas that have a climate similar to the prairies of the US and Canada, where safflower is sown in the spring and harvested in the dry fall months of September and October *(Delshad E. et al. 2018, Menegaes J. F. and Nunes U. R. 2020, Akgun M. and Soylemez E. 2022).*

Worldwide, the demand for organic oilseeds is constantly growing, as they represent an important element in the manufacture of organic food products, intended for human or animal consumption. Due to its biology, which is fully compatible with the conditions of the arid climate, safflower is one of the promising oleaginous crops that can successfully replace the sunflower crop, even more so, the one produced in an ecological system. *(Ivan Gh. and Tudora C. 2015, Nasiyev B. et al. 2022)*.

In the middle of the 19th century, the discovery of mauveine, a cheap synthetic dye based on aniline, determined the strong limitation of the use of natural dyes extracted from safflower petals, for colouring food or textiles. Thus, the species was cultivated mainly for the oil extracted from the seeds, rich in bioactive compounds and highly polyunsaturated fatty acids *(Steberl K. et al. 2020, Mani V. et al.2020)*.

Synthetic food dyes can have allergic or carcinogenic effects, which has led to increased interest in natural, biodegradable ones. In accordance with EU directives, since 2013, the profile industry has reconsidered the natural food colours extracted from safflower as the appropriate alternative to replace the synthetic ones, often used: Tartrazine (E102) and Quinoline Yellow (E104) *(Steberl K. et al. 2020)*

The use of safflower *(Carthamus tinctorius* L., *Asteraceae family)* as a raw material in the food industry instead of saffron *(Crocus sativus L., Iridaceae family)*, the most expensive spice, is determined by the price difference, depending on the yield of each crop *(Adamska I. and Biernacka P. 2021)*.

Minor or niche crops, such as medicinal and aromatic plants, can play an important role in strategic priorities for rural development, according to the basic principles of multifunctionality, sustainability and diversification. *(Stan Tudora C. and al. 2022)*.

Safflower has been treated as a minor crop for a long time, not being paid due attention to the research and development of its various aspects, despite its adaptability with high yield, to varied cultivation conditions, as well as diversified use *(Gomashe S. et al. 2021)*.

The context of climate change and the increase in the consumption of healthy foods have determined the return of interest in the safflower culture, in this paper a brief review of the various approaches to this culture is presented, involving new uses along with economic and even industrial aspects.

2. MATERIALS AND METHODS

Safflower (*Carthamus tinctorius* L.) is an annual herbaceous plant of the *Asteraceae* family, which grows bushy, reaching a height of 1.0–1.3 m, and even 2.1 m. The plant forms large, lanceolate leaves with jagged edges. Safflower flowers are radial and tubular, forming large inflorescences (flower heads). Based on the different varieties, the flowers appear differently coloured (fig.1): yellow, orange, red and white. Each plant can contain between 20–250 flowers *(Mani V. et al.2020, Adamska I. and Biernacka P. 2021)*.

Figure 1 – Differential flowering phenotypes (Mani V. et al.2020)

There are safflower varieties/cultivars, which have thorns and others, which do not have thorns (fig.2). To obtain a high crop yield, the choice of the variety and the cultivation technology are essential, being carried out according to the destination and subsequent uses of the plant. Thus, the colour of the flower, as well as the number of heads and branches are primarily influenced by the variety and its origin. Sowing density and row spacing together with environmental conditions influence the number of heads and branches, and colour also depends on the time of flower/petal collection *(Steberl K. et. al. 2020)*. To these, add the influence of the intensity of sunlight and the period of exposure of plants to it on the content of compounds (e.g. the content of flavonoids) *(Adamska I. and Biernacka P. 2021)*.

(a) (b)

Figure 2 – Two cultivars of Carthamus tinctorius L. (Steberl K. et. al. 2020): (a) German, spiny cultivar; (b) Chinese, thornless cultivar

The harvesting/collection of the plant is done according to the uses. The seeds are harvested with the wheat harvester, adjusted appropriately *(Pari L. et al. 2020)*. Harvesting of safflower petals is done manually in most cases, the equipment used in some places for this operation being in the experimental model or prototype phase *(Muscalu A. et al. 2023*). Every part of the safflower plant has utility either as a food, as a phytomedicine, or in other related fields (*Gomashe S. et al. 2021).*

3. RESULTS

Safflower plant: medicinal – In Asian countries the whole safflower plant (root, leaves, inflorescences, seeds) is used in traditional medicine in the form of: decoction, tea, dye, ointments, encapsulated oil, etc. Also, the plant has a high potential for modern medicine. Safflower flower and seed extracts, oils and chemical components are important for the development of medicines characterized by different pharmacological activities. In Canada, plants are used as a substrate for the production of high–quality insulin at a low cost (*Menegaes J. F. and Nunes U. R. 2020, Mani V. et al., 2020, Gomashe S. et al., 2021).*

Safflower flowers have an interesting and rich chemical composition, consisting of approx. 200 substances identified so far. Flower petals contain 1.82% protein, 4.8% lipids, 11.6% crude fibre, and 10.8% ash, (for 4.7% moisture content). They also contain, among others, alkaloids, flavonoids, lignanoids, organic acids and polyacetylenes, alkanediols, riboflavin, steroids, and quinochalcone C–glycosides. The pigments in flower petals are mostly flavonoids, the best–known being carthamidin (water soluble yellow coloured dye) and carthamin (water–insoluble red dye), having solubility in alkali. Carthamidin (the yellow pigment) accounts for 24–30% of the compounds found in safflower flowers, while carthamin (the red pigment) typically accounts for 3–6% of the petal composition, in some flower parts the content is below 1%. The compounds extracted from the petals are used for colouring textiles (linen, cotton, silk and wool in different shades), food, cosmetics, medicine and painting. The water–soluble components of safflower are important for intravenous administration. The plant is mainly attributed with special properties: analgesic, anti–inflammatory, anti–aging, etc. also being used in cardiovascular disease, fertility problems, pain and swelling associated with trauma, etc. To maintain their medicinal properties, safflower flowers must be collected, selected and stored in the absence of light (*Menegaes J. F. and Nunes U. R. 2020, Gomashe S. et al., 2021, Adamska I. and Biernacka P. 2021).*

Also, recent studies have shown that safflower petal extract produces anxiolytic and antidepressant effects, similar to those of standard drugs (diazepam and nortriptyline), used to treat patients with anxiety disorders and depression. Thus, the plant can be used as a therapeutic alternative during the treatment of patients with such conditions *(Albaiz A. S. 2022).*

Safflower seeds, composed of 33–60% shell and 40–67% kernel, are used as animal feed and for the extraction of an oil used in food, cosmetic and pharmaceutical products *(Emongor V. and Oagile O. 2017)*.

This oil contains a higher amount of linoleic acid (71–76%) as well as oleic acid (12–15%), compared to that extracted from other oilseed crops, having an effect on reducing blood cholesterol levels. Also, the presence of phenolic compounds, in addition to the antioxidant activity, gives the oil stability and high nutritional value. In addition, it is used in a variety of products, including alkyd resins, paints, varnishes, linoleum, medicines and diet foods. Clinically, safflower oil is used in the treatment of conditions such as essential fatty acid deficiency and the control of high blood pressure. Being non–allergenic and having a consistency that does not change at low temperatures, safflower oil is ideal for cosmetic products. It is usually used as an emollient in hair oil, skin moisturizers, tanning lotions, bath products,

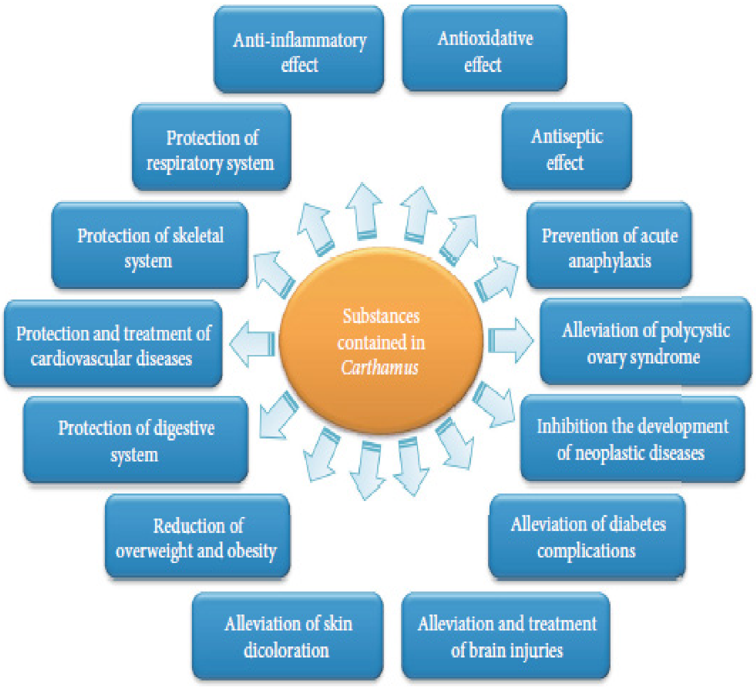

Figure 3 – Bioactive effect of the safflower substances (Adamska I. and Biernacka P. 2021)

etc. *(Ruyvaran M.et al., 2021, Hingnekar P. and Karikar M. 2022)*. The medicinal uses of substances isolated from safflower are summarized in figure 3.

In some countries, such as India, safflower is cultivated as a leafy vegetable due to its high content of carotene, riboflavin and vitamin C. To preserve these substances, prolonged treatments at high temperatures of the leaves are not recommended, but use in fresh salads or cold soups (*Adamska I. and Biernacka P. 2021*). The synthesis of safflower uses in the food industry is presented in figure 4.

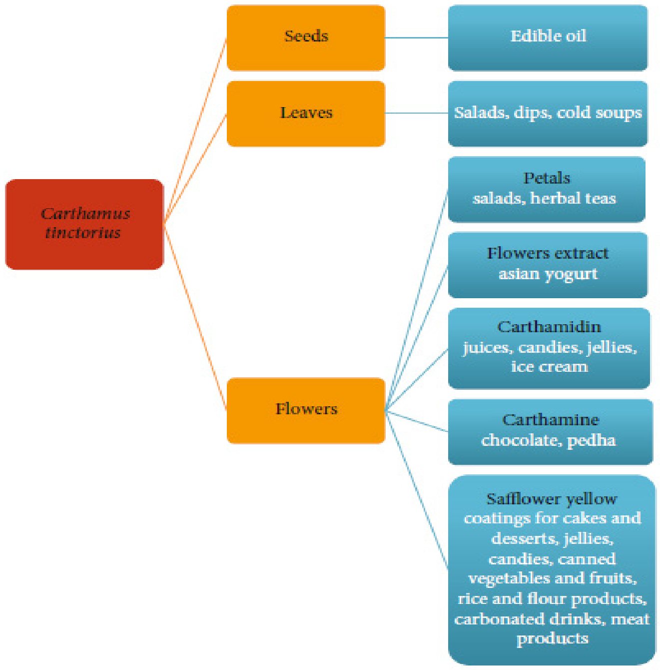

Figure 4 –The use of safflower in food production. (Adamska I. and Biernacka P. 2021)

Safflower in the pre–flowering stage can be used as grazing fodder for sheep. They, like goats, are able to use safflower fodder (the plant cut 30 cm from the ground) better than cattle, choosing and consuming only leaves and buds. Thornless varieties of safflower can be used as fodder for cattle. The safflower seeds, the flour obtained from them and the seed cakes, left over from the oil extraction, can be used as protein and energy supplements for animal nutrition. In fact, whole safflower seeds are too expensive to use as a feed ingredient for farm animals, so they are mostly used for pet food (birds and rodents). *(Peiretti P.G. 2017, Menegaes J. F. and Nunes U. R. 2020).*

Safflower can be used as a phyto–improver, to clean contaminated soils of heavy metals, this role being very important along with resistance and high productivity in drought conditions. In addition, used as green manure, it improves soil fertility, as well as its texture, being a species capable of reducing its density *(Nasiyev B. et al. 2022)*.

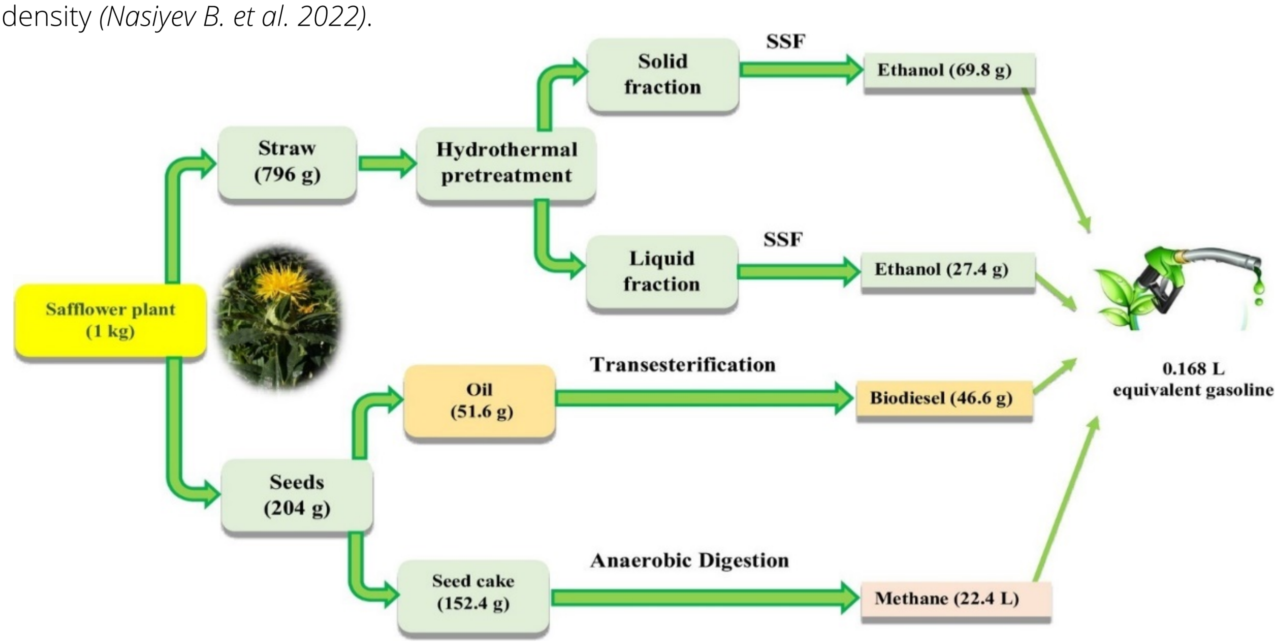

Figure 5 – The use of safflower for development a biorefinery through the multi–biofuel production
(SSF–Simultaneous saccharification and fermentation) (Hashemi S.S. et al., 2020)

Also, some of the characteristics of safflower (good yield, oleaginous seeds and lignocellulosic stems) recommend it as a suitable substrate for multi–biofuel production in a biorefinery approach. Thus, the safflower plant, of whose mass the seeds represent 20.6%, the rest (79.4%) being represented by strow, was used for the production of bioethanol, biogas and biodiesel. The oil extracted from the seeds was subjected to a methanolic transesterification process for the production of biodiesel. The remaining

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

seed cake was converted into biogas through the anaerobic digestion process. Ethanol production from strow was not satisfactory, requiring their hydrothermal pretreatment at a temperature of 120–180°C for 1–5 h to maximize production. The highest yield for ethanol production (60.3%) was obtained by pretreatment at 180°C for 5 hours. Biodiesel and methane production from oilseeds and seed cakes were 90.3% and 185.8 ml/g volatile solids, respectively. Overall, each kilogram of safflower plant produced 97.2 g of ethanol, 22.4 l of methane and 46.6 g of biodiesel, which is a total equivalent of 0.168 l of gasoline, in this biorefinery concept. The previously described results are presented in figure 5 and they demonstrate that the safflower plant can constitute an attractive raw material for the development of multi–biofuel biorefineries, economically and ecologically viable. To obtain biofuels, safflower can be grown on marginal land, avoiding competition with food crops, regarding land and water *(Hashemi S.S. et al. 2020).*

As with clothing, also in floriculture there is a "fashion" of consumer preferences for certain flowers and ornamental plants. Safflower flower stems were widely marketed between the 1980s and 2000s in Europe as dried flowers. In Japan and America, the inflorescences are appreciated in fresh form for the composition of floral arrangements. In Asia, the consumption of safflower flower stalks is relatively constant, being used mainly in religious cults *(Menegaes J. F. and Nunes U. R. 2020).*

4. CONCLUSIONS

The safflower crop can provide raw material for several sectors of the economy, due to its pharmacological, industrial and culinary properties. Although it has important uses, the harvest has remained minor. It is necessary to be aware of the usefulness of safflower, as well as of its commercial value, representing an alternative cultivation, due to the pedoclimatic adaptations.

Future multidisciplinary studies and research should be directed to increase safflower production by addressing disease and pest issues, agronomic traits, development patterns, etc. Also, safflower oil should be promoted much more to create demand. In addition, the efficiency of safflower is related to the application of modern culture technologies, as well as to the involvement of entrepreneurs in the development of processing industries.

Acknowledgement

This paper was supported: by Ministry of Research, Innovation and Digitalization one funding source the NUCLEU Programme, Project PN 9N/01.01.2023; PN 23 04 02 05 "Innovative technology for the superior use of inflorescences and seeds of medicinal plants" and through Programme 1–Development of the national research–development system, Subprogramme 1.2.–Institutional performance–Projects for financing excellence in RDI, Contract no. 1PFE/30.12.2021.

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Note: This paper was presented at ISB–INMA TEH' 2023 – International Symposium on Technologies and Technical Systems in Agriculture, Food Industry and Environment, organized by University "POLITEHNICA" of Bucuresti, Faculty of Biotechnical Systems Engineering, National Institute for Research–Development of Machines and Installations designed for Agriculture and Food Industry (INMA Bucuresti), National Research & Development Institute for Food Bioresources (IBA Bucuresti), University of Agronomic Sciences and Veterinary Medicine of Bucuresti (UASVMB), Research–Development Institute for Plant Protection – (ICDPP Bucuresti), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and Romanian Agricultural Mechanical Engineers Society (SIMAR), in Bucuresti, ROMANIA, in 5–6 October, 2023.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

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