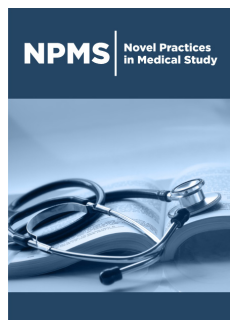


Biological Potential of *Carthamus Tinctorius L.* as a Food and Medicinal Culture

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Abstract

A new oilseed crop of safflower (*Carthamus tinctorius L.*) has been introduced in Russian Central Nonchernozem Belt. Of particular relevance is the study of the oil content of safflower seeds, which is determined by the agrometeorological conditions of the growing season, seed reproduction, heat and moisture availability of various regions and ranges from 14.5 to 31.2%, which allows you to grow this crop in the Central region - the Moscow region, in order to obtain oil. The oil yield was 240kg/ha. It should be noted that the safflower culture in the Central region of the Russian Federation accumulates oil in seeds as much as at home in India. Under atypical excessively humid conditions in 2013 in the Moscow and Saratov regions, the accumulation of oil amounted to 6.4 and 8.6%. The fatty acid composition of the Krasa Stupinskaya grade oil is characterized by a high content of oleic and linoleic acid, which is of particular value for use for food purposes. For food purposes, it is recommended to use the Stupinskaya Krasa variety, which has a high oil content and fatty acid composition.

Keywords: Safflower; Introduction; Oil content; Fatty acid composition; Linoleic; Oleic; Linolenic; Food purposes

Introduction

N.I. Vavilov attached special importance to the issue of new cultures, fuller use of the world's wild flora both within in our country and abroad. Following his ideas, scientists learn and introduce in the production cultures, previously unknown in our agricultural science and practice. The problem of the new crop's introduction is becoming increasingly important due to the fact that the provision of Russia by vegetable oils and biologically active substances is carried out mainly by imports. To such new cultures applies safflower [1]. The Safflower (*Carthamus tinctorius L.*) belongs to the family Asteraceae. Homeland is Egypt, India. The innovative direction of using safflower in the world (China, India, USA) is flower petals. Safflower used to be more familiar as a natural source of healing plant oil, but the petals of this plant have been added to tea for a long time. They make the taste of tea pleasant and unusual. It has been recommended for centuries as a sedative and as a cure for intestinal diseases [2-4]. Flowers contain nutrients and are used in the treatment of many diseases, including menstrual pain, cardiovascular disorders and as a tonic tea. In this context, safflower is cultivated in India more for flower collection than for seed production, which is more economical. In addition, safflower prevents proliferation (cell death), which can make an extract from it useful in the treatment of psoriasis and mutagenic diseases [3,5]. It was recommended as treatment for rheumatism and paralysis, vitiligo and black spots, psoriasis, mouth ulcers, phlegm humor, poisoning, numb limbs, melancholy humor and the like. According to the modern pharmacological and clinical examinations, safflower provides promising opportunities for the amelioration of myocardial ischemia, coagulation, thrombosis, inflammation, toxicity, cancer and so forth [6].

The plant contains 4-hydroxy-benzaldehyde, E-1-4'-hydroxyphenyl-butenone, 3-formylindole, 2-acetyl-5-hydroxymethylfuran, p-hydroxycinnamic acid, 4-hydroxyacetophenone, 5-hydroxymethyl-2-furaldehyde, 4-hydroxybenzoic acid, stigmasterol-3-O-be-

ta-Dglucopyranoside, daucosterol, beta-sitosterol [7,8]. Safflower flowers contain the bitter coloring substance kartamine, palmitic, coumarinic acids, kaempferol, apigenin, daukosterol [9], triterpene saponins [10], spermidines-safo-spermidines A and B [11], acetyl glycosides-cartamosides [12], flavonol glycosides [13]. The flowers also contain quinochalcons-saffloquinosides A and B [14], cartormin, safflomin [15], quinochalcone C-glycosides-cartorquinosides A and B [16,17], scutellarin, kaempferol-3-O- β -rutinoside, hydroxysafflor yellow A, rutin, cumalic acid, adenosine, syringoside, (3E)-4-(4'-hydroxyphenyl)-3-butene-2-one, (8Z)-decaene-4, 6-diene-1-O- β -D-glucopyranoside, 4-hydroxybenzaldehyde, (2E, 8E)-tetradecadiene-4, 6-diene-1, 12, 14-triol-1-O- β -D-glucopyranoside, kaempferol-3-O- β -sophorose, uridine, roseoside, cinnamic acid, kaempferol [18]. Roseoside, D-glucopyranoside, glucopyranosyloxybenzoic and hydroxybenzoic acids have also been determined (Jiang 2008). Safflower flowers contain aromatic glycosides [12].

The use of safflower oil and petals in medicine is relevant because safflower is one of the 50 fundamental medicinal plants used in Chinese herbal medicine. For medicinal purposes, flowers, seeds and seed oil of this plant are used. Safflower grows widely in many areas of China and is one of the traditional Chinese medicinal herbs used in the treatment of the heart and coronary vessels diseases [14,19,20]. As an important traditional Chinese medicine, were investigated the pharmacological effects and molecular mechanisms of this plant based on modern realization of diseases' pathophysiology. Over 104 compounds from this plant have been isolated and identified, and quinochalcons and flavonoids are considered as the characteristic and active constituents of safflower. Safflower with its active compounds possesses wide-reaching biological activities, including dilating coronary artery, improving myocardial ischemia, modulating immune system, anticoagulation and antithrombosis, antioxidation, antiaging, antihypoxia, antifatigue, antiinflammation, anti-hepatic fibrosis, antitumor, analgesia [21].

Scientific studies have revealed antioxidant, anti-inflammatory, cardioprotective, hepatoprotective, neuroprotective properties of plant extracts [22,23]. Experimental studies have revealed the antiallergic properties of hydroxy safflower yellow [24]. CF substance with pronounced local anesthetic properties was isolated from the seeds of the plant [25]. Sedative and antidepressant properties of safflower flower extracts were revealed [26]. Safflower polyphenols have immune-stimulating properties [27,28]. Experimental studies have shown that safflower extract has a therapeutic effect in postoperative fatigue syndrome [29]. Safflower oil has one of the highest values of linoleic acid content (75-80%) and is used in lipo-chemistry, human nutrition and dietetics [30]. Many clinical and laboratory studies confirm the use of safflower medications for gynecological, cardiovascular diseases and general pain and swelling associated with trauma [31].

American cardiologists' recent studies have proved that this product can be used as a means of preventing cardiovascular diseases. This is due to the fact that safflower oil contains linolenic acid, which is rich in polyunsaturated acids that contribute to

the prevention of heart disease. Safflower oil is said by scientists to normalize cholesterol levels, improve insulin sensitivity and lessen inflammatory processes when consumed regularly in diet. The oil is also highly effective as a weight-normalizing agent. It reduces the amount of abdominal fat, while increasing muscle tissue [32]. The most famous dye isolated from flower petals is Hydroxysafflor A (HSYA), which has antibacterial, anti-inflammatory, and antioxidant properties. However, positive impact of yellow Carthamine (CY), Safflor A (SA), Safflower Yellow (SY), Hydroxysafflor B (HSYB), Hydroxysafflor C (HSYC), and selected water-soluble polysaccharides on human health has been also demonstrated [33]. Hydrosafflor yellow improves microcirculation in ischemia, preventing the development of complications [34,35]. Safflower compound- hydroxysafflor yellow - reduces myocardial damage in ischemia [36-41]. Alcohol extract of safflower flowers prevents the development of atherosclerosis under the influence of lipopolysaccharides [42].

Scientists from Ohio State University (USA) tested the effectiveness of the product on a group of volunteers who took a teaspoon of oil daily for 4 months. At the end of this period, all participants in the experiment had an increase in the concentration of the hormone adiponectin, which regulates the level of sugar and fat in the body. Cardiologists believe that the inclusion of 2/3 teaspoons of safflower oil in the diet per day will reduce the risk of cardiovascular diseases and prevent menopause-related weight gain in women with type 2 diabetes. Safflower oil has a hypocholesterolemic effect, reducing the number of low-density lipoproteins, improves appetite, and has positive effects in some types of tumors [32]. Modern pharmacological studies have shown that safflower also has antioxidant properties [43]. In the folk medicine of India, a mixture is made with safflower oil to strengthen the hair [44]. In the pharmaceutical industry, safflower flowers are used as carriers of vitamin E and A [32]. All parts of the plant have antioxidant properties [45]. The aim of our study was the introduction of safflower in the Central region of Russia, creation of adaptive varieties for using in agricultural production and food processing.

Materials and Methods

The research was carried out at the Center for Gene Pool and Plant Bioresources of the Federal Horticultural Center for Breeding, Agrotechnology and Nursery, Mikhnevo village, Stupinsky district. in 2008-2015, in 2015-2023 - in the All-Russian Research Institute of Phytopathology, Bolshiye Vyazemy village, Odintsovo district, Moscow region, and Central Tajikistan-2005-2015, in 2012-2015 in FGBNU the All-Russian Research Institute of grain crops, Zernograd, Rostov Region. The object of research was the variety of safflower Krasa Stupinskaya and some collection samples of reproduction from Tajikistan. The harvest from 2008 to 2023 is taken into account annually, and research continues. Determination of oil content in the seeds was conducted in accordance with GOST 10857 «Oilseeds». Determination of oil content, the fatty acid composition of the oil was made in accordance with GOST 30623-98 «Vegetable oils and margarine. Detection method of falsification».

Results and Discussion

A comparative analysis of the seeds oil content of safflower Krasa Stupinskaya for three years, grown in Moscow and Rostov regions showed that the content of the seeds mass fraction of fat in Rostov region (2013) was 19.02%, which is 4.42% higher than in 2012, in 2014-23.7%, which is 9.2% higher than the seeds oil content in 2012. The oil content in the seeds grown in the Moscow region in 2012, showed - 22.92%, which is 8.42% higher than in the Rostov region. In atypical weather conditions in 2013 seeds oil content of safflower grown in the Rostov region was 12.66%

higher than that in safflower grown in the Moscow region - 6.4%. In 2014, safflower seed oil content in the Moscow region amounted to 30.2%, which is 6.5% higher than in safflower from the Rostov region (23.7%) (Table 1). We marked that the accumulation of oil content depends not only on the quantity of precipitation, but also by the temperature factor. Moderate rainfall and temperatures above 18 °C (phase of flowering and ripening) have a positive effect on the formation of oil content. It should be noted that a direct correlation depending on the proportion of fat mass accumulation in safflower seed culture on the amount of precipitation during the growing season and temperature regime.

Table 1: Comparative characteristics of safflower oil percentage, 2012-2014.

Indicator Name	Sample					
	Krasa Stupinskaya, Rostov region, 2012	Krasa Stupinskaya, Rostov region, 2013	Krasa Stupinskaya, Rostov region, 2014	Krasa Stupinskaya, Moscow region, 2012	Krasa Stupinskaya, Moscow region, 2013	Krasa Stupinskaya, Moscow region, 2014
Oil content (fat mass fraction), %	14,50	19,02	23,7	22,92	6,4	30,2

It should be noted that there is a direct correlation between the fat content in the seeds of safflower and the amount of precipitation during the growing season and temperature. Noted the influence of agro-biological factors on the oil content of seeds safflower cultivation in contrasting years. Analysis of the seed oil content at 5 reproductions 2010-2015 years safflower cultivar Krasa Stupinskaya grown in the Moscow region, Table 2. In 2010, the acutely arid, characterized by high air temperature-18.8 °C (long-term average-15,1 °C) and low precipitation-154.4mm during the growing season, the accumulation of a mass fraction of fat in the seeds was-31.2% and in a more humid 2011-285.5mm rainfall during the growing season, temperature 17.8 °C in 2012 (optimal warmth, less humid)-245.8mm during the growing season, temperature 17.8 °C was respectively 29.0 and 22.3 %. In 2013, when the rainfall during the growing season fell to 335.8mm (at a rate of 264mm) and a temperature of 18.4 °C, the mass fraction of fat was only 6.4% in 2014 precipitation during the growing season

was 184.1mm, average temperature-16,4 °C, oil content was 30.2% in grade Krasa Stupinskaya. In 2015, oil content of seeds varieties Krasa Stupinskaya was 34.3% in the Central Tajikistan and in the Central region of the Russian Federation-30.9%. We conducted a comparative analysis of the oil content determination in the safflower seeds (Krasa Stupinskaya) for three years, obtained from the Rostov region. Mass fraction of fat in the seeds was 19.02 % in 2013, which is 4.52 % higher than in 2012, while the fat content in seeds was 23.7% in 2014g. In the Moscow region safflower seed oil yield in 2012 was 8.42% higher than in the Rostov region. In 2013 safflower seed oil content in safflower grown in the Moscow region was 12.66% higher than in the Rostov region. In 2014 safflower seed oil grown in the Moscow region accounted for 30.2%, 2.0% lower than in safflower from the Rostov region (28.0%). These results show the dependence of the mass fraction of fat accumulation in the safflower seeds under weather conditions, (Tables 2&3).

Table 2: The influence of agro-biological factors on seed's oil in contrasting years, 2010-2014.

№	Sample	Oil Content (Fat Mass Fraction), %	Precipitation, mm		Temperature, t° C	
			Average during several years	Average during the growing season	Average during several years	Average during the growing season
1	Krasa Stupinskaya Moscow region, 2010 r.	31,2	264	154,4	15,1	18,8
2	Krasa Stupinskaya Moscow region, 2011	29,0	264	285,5	15,1	17,8
3	Krasa Stupinskaya Moscow region, 2012	22,3	264	245,8	15,1	17,8
4	Krasa Stupinskaya Moscow region, 2013	6,4	264	335,8	15,1	18,4
5	Krasa Stupinskaya Moscow region, 2014	30,2	264	184,1	15,1	16,4
6	Krasa Stupinskaya Central Tajikistan, 2015	34,3	510	306,8	16,8	20,5

Table 3: Fatty acid composition of safflower oil in 2013.

Fatty Acids	Mass Fraction of Fatty Acids, % to Total Content of Fatty Acids			
	Mahalli 260 (Tajikistan), 2013	Krasa Stupinskaya, 2013	Krasa Stupinskaya, 2014	Norms in accordance with GOST 30623-98
C14:0 (myristic)	0,1	0,1	0,1	<1,0
C16:0 (palmitic)	7,6	7,7	9,94	2,0-10,0
C16:1 (palmitoleic)	0,2	0,1	0,55	<0,5
C18:0 (stearic)	2,6	2,0	2,48	1,0-10,0
C18:1(oleic)	13,2	13,6	16,89	7,0-42,0
C18:2 (linoleic)	75,6	75,7	65,88	55,0-81,0
C18:3 (linolenic)	0,2	0,1	-	<1,0
C20:0 (arachidic)	0,3	0,4	-	<0,5
C20:1 (gondoinovaya)	0,2	0,3	-	<0,5

It has been determined the influence of agro-biological factors on seed oil in contrasting years. Analysis of seed's oil content in five safflower reproductions 2010-2015 grown in the Moscow region (Table 2) shown that in conditions of 2010 year, characterized by increased air temperature-18,8 °C long-term (average-15,1 °C) and low rainfall-154.4mm during the growing season, the accumulation of fat in seeds was-31.2%. At the same time in 2011 (285.5mm of rainfall during the growing season, temperature 17,8 °C) oil content was 29.0%, and in 2012 (optimal heat-17,8 °C, less humid-245.8mm)-22.3%. In 2013 characterized with high precipitation (near 335.8mm, t-18,4 °C) fat mass fraction was only 6.4%. In 2014 precipitation during the growing season was 184.1mm, average temperature - 16,4 °C, Krasa Stupinskaya oil content was 30.2%. In the Central Tajikistan (2015) oil content was 34.3%. In samples Moldir-24.0 %, Moldir 2008-22.2% and VIR 2933-21.7%, respectively. It is important the creation of breeding varieties with different fatty acids ratio in the oil, Table 3. According to the content of linoleic acid, that is not synthesized in the human body, this variety (Krasa Stupinskaya) is not inferior to the southern variety Mahalli 260. According to the content of oleic acid-16.89%, responsible for preserving the freshness of the oil over a long period, it exceeded other varieties.

The higher content of saturated fatty acids, particularly palmitic characterized sort Krasa Stupinskaya. Krasa Stupinskaya has an oil yield near 240kg/ha (at plant density of 250-300 thousand/ha and seed yield - 0.8t/ha). In Central Tajikistan oil output amounted near 940kg per hectare (at plant density of 160 thousand plants per hectare and crop seeds 1.7t/ha). At the moment seeds oil content increasing selection have become a major asset of our agricultural production, such as the property becomes a breeding for oil quality change. It has been shown that each variety and even the shape of the population are composed of a larger or smaller number of biotypes differing by number of features, including the concentration of the fatty acid oil [46]. The basis in the selection of the quality of oil for technical and food use is the knowledge of genotypic variability of the fatty acids composition in the range of cultivated species and wild relatives. N.I. Vavilov attached great importance to the study of differentiation within the species for chemical signs of quality grades [47] repeatedly emphasizing need

to identify genetic differences that can be seen in the study in the same conditions of different varieties in different geographical locations.

It was observed that linoleic acid in sunflower oil contains nearly 67% and in safflower oil-80% under the experimental conditions of VIR Kuban station. Qualitative differences are determined by genetic characteristics of oil varieties and forms. Oils quality features can be enhanced by content increasing of main fatty acids (oleic and linoleic). Large variability in the content of linoleic acid in the various years of cultivation, probably due to a stretched period of flowering and late maturing of certain cultures. Fluctuations in temperature cause changes in the partial pressure of oxygen in the cells, which affects the processes of oxidative hydrogenation. It has been determined the influence of environmental on the unsaturated fatty acids accumulation rate-oleic and linoleic. In all sunflower varieties intensive accumulation of linoleic acid observed in more northern growing areas compared with the southern zone (71.7-72.0 and 53.7-59.0%, respectively). Thus, high linoleic acid content combined with a low concentration of oleic (16,9-17.9 and 29.0-36.0%, respectively).

The oils of different crops include fatty acids, mainly with C16 to C22 chains, saturated or unsaturated with double bonds (one, two, three). Within various crop species, individual grades and within individual varieties biotypes differ by increased or reduced content of typical fatty acids. These biotypes features caused by various factors (mutation, etc.) are also inherited. Individual variability (for plants) is the basis of selection to increasing of concentrations and a decrease in some - other fatty acids, functionally related to each other. Our variety of safflower Krasa Stupinskaya is distinguished by a high content of oleic (13.6-16.8%) and linoleic (65.8-75.7%) acids, the yield is from 0.6 to 1.5t/ha on average for 2008-2023. Created safflower cultivar Krasa Stupinskaya quickly adapt to contrasting soil and climatic conditions of the regions. It should be noted that in India, which in the first position on safflower in the world, special attention is not on the collection of seeds per hectare, and the collection of safflower flowers. Collection of flowers is a cost-effective, profitable for farmers, as they are traditionally used in India not only for dyeing, but also as a food dye [48]. Recently it became known about the use of colors safflower in China and

Kazakhstan as an herbal medicine for the treatment of several chronic diseases, such as hypertension, coronary heart disease and stroke. Therefore, honey and flowers of safflower culture are of special value for human health [49].

Conclusion

The oil content and fatty acid composition of the introduced new culture of safflower dye in the Central region of the Russian Federation were studied for the first time. The variety Krasa Stupinskaya has been created [50,51]. The oil content of raw seeds

in the mentioned regions varied from 14.5 to 31.2%; and in the year 2013 that was excessively humid, it comprised 6.4% in the Moscow region and 8.6% - in the Rostov region. In the fatty acid composition of the Krasa Stupinsky safflower variety, oleic acid content varied between 13.6 and 6.8% and linoleic acid content between 68.5 and 75.7%. Its oil field in the Moscow region was 240 kg/ha. The yield of the variety on average for 2008-2023 ranged from 0.6 to 1.5.t/ha. The variety is recommended for use with medicine and food purposes, Figure 1.



Figure 1: Flowers and seeds of the Krasa Stupinskaya variety.

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