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Fatty acid profile and quality assessment of safflower (*Carthamus tinctorius)* oil

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Abstract
The present investigation was undertaken with the objective to study the different physico-chemical properties, fatty acid profile by GC and total tocopherol by HPLC of the safflower oil. The different physical properties as density, specific gravity, refractive index and viscosity whilst, chemical properties iodine value, peroxide value, saponification value and acid value were determined. Color by Hunter Color Flex meter showed the highest reading for the lightness L* (45.24). The fatty acid profile of safflower oil showed 14 fatty acid with variation of fatty acid concentration. In unsaturated fatty acids the PUFA was found to be dominant with highest concentration of linoleic acid (76.22%) followed by oleic acid (13.75%). Whereas, palmitic acid showed the highest concentration 6.02% among all the saturated fatty acids. The ratio of PUFA/ TSFA and TSFA/TUFA was obtained to be 7.93 and 0.10 resp. Finally, Total tocopherol content was 513.8mg/kg of safflower oil.

Keywords: Density, Safflower, fatty acid, tocopherol, percent etc.

Introduction
Safflower (*Carthamus tinctorius*) is an oilseed is a member of the family *Compositae* or *Asteraceae*, which, for a long time, has been developed on a generally little scale in parts of North Africa and Middle East. Safflower was initially developed for the blossoms that were utilized as a part of making red and yellow colors for apparel and sustenance planning (Purdy *et al*., 1959) [14].

Safflower is drought and salt tolerant plant, it is preferred in poor and dry lands as a suitable alternative crop. Whole safflower seeds include 38–48% oil, 15–22% protein and 11–22% fiber. The hull makes up 18–59% of the seed weight (Aydeniz *et al.*, 2014) [5].

Significant consideration has been created in the utilization and improvement of safflower seed oil as a superb medicinal services item and medical advantages got from it incorporate anticipation and treatment of hyperlipaemia, arteriosclerosis, coronary illness. Likewise the safflower oil is the bearer of fat-dissolvable vitamins retinol, calciferol, tocopherol and phylloquinone and gives fundamental unsaturated fats linoleic acid. Moreover, high oleic safflower oils are very stable on heating, and do not give off smoker smell during frying (Han *et al*., 2009) [10].

Safflower is well known, that aids in lowering the cholesterol level in the blood which are in charge of development and can't be synthesized in the body, protect body tissues and protect interior organ (Fasina *et al*., 2006) [9].

India ranks first in the production of safflower oil along with the other minor oilseeds like sesame.Safflower oil has been characterized in different regions of the world and several experiences have demonstrated a variability of composition functions of varieties, soil and climate conditions. So the introduction of a new crop to a regional cropping system requires information concerning its performance under local environmental conditions (Camas *et al*., 2007) [7].

A health conscious population has made the most critical market, for safflower oil as serving of mixed greens oil, margarine and cooking oil used to fry such substances as French fries, chips and other nibble things, So that the safflower oil has various utilizations both in individual and business applications.However there is a lake in the information about safflower cultivars in local market and its oil characteristics thus, the objective of this work is to obtain information about the safflower oil fatty acid profile and different physicochemical characteristics.

Materials and methods
Safflower seeds oil was obtained from local market of Parbhani city, Marathwada region were used in the current investigation.

Physico-chemical characteristics

Density, Specific gravity and Refractive index were determined as per the methods given by the standard method described in AOCS, (2009) [3]. A Brookfield Viscometer Model DV-E was used to measure the viscosity of safflower oil. The chemical properties such as the iodine value, acid value, Peroxide value, and saponification value of the extracted oils were analyzed according to AOAC, (2005) [2].

Color characteristics

The Colour (L*, a*, b* values) of the safflower oil was determined by using Hunter Colour Flex Meter. L* is known as the lightness and extends from 0 (black) to 100 (white). The other two coordinates a* and b* represent redness (+a) to greenness (-a) and yellowness (+b) to blueness (-b), respectively were recorded. (Park and Lin, 2005).

Fatty acid composition

Fatty acid composition of the different vegetable oils and blended oils will be determined using Gas chromatography of FAMES (Fatty Acid Methyl Esters) with Flame Ionization Detector by (AOCS, 2009) [3] O. The oil (20-25 mg) was treated with 0.55 sodium methoxide solution (5ml) in a glass stopper flask. The content was heated to 50°c for 10-15 min and 0.1ml glacial acetic acid was added followed by water 5-10 ml. the organic phase was extracted with hexane15-20ml and washed with water till neutral pH. The hexane extract was dried over anhydrous sodium sulphate and concentrated under reduced pressure to get methyl esters. An Aligent GC fitted with a DB225 polar column (30m, 0.322mm, 0.25µ) and FID was used. The temperature of the oven, injectors, detector blocks were maintained at 210, 230, 250°c respectively. Nitrogen gas was used as the carrier gas. Peaks were identified by comparison with relative retention times of the standard FAMEs. Concentration of each fatty acid was recorded by normalization of peak area using GC post run analysis software, manual integration and reported as percent of the particular fatty acid.

Total tocopherol

Tocopherol composition of the oil samples was analyzed using an Agilent HPLC series 1200 (Agilent, Waldbronn, Germany) with Chem Station software. The separation was with a ACE 5 SIL normal phase column (150 mm, 4.6 mm i.d., particle size 5 lm), and quantification was with tocopherol standards (Merck, Darmstadt, Germany) as method described by Panfili *et al.* (2003) [12].

Results and Discussion

The different physical, chemical, fatty acid composition and total tocopherol content of safflower oil were determined and the obtained results are presented and discussed under suitable headings.

Physical properties of safflower oil

The different physical properties such as density, refractive index, specific gravity, and viscosity were determined. The results obtained are depicted in Table 1.

Table 1: Physical properties of safflower oil

Physical Properties		
Sr. No.	**Properties**	**Results**
1	Density (g/ml)	0.940
2	Specific gravity	0.917
3	Refractive index	1.469
4	Viscosity (cP)	45.6
5	Color	
	L*	45.24
	a*	-2.87
	b*	21.04

*Each value is a mean of three determinations.

From the table 1 it is revealed that the density is nothing but the ratio of mass per unit volume. The density of the safflower oil was found to be 0.940. Generally, specific gravity of oils increases with unsaturation levels. The different proportion of C18 polyunsaturated fatty acids could be a major factor for the increase in the specific gravity of the oil, and it is temperature-dependent and decreases when the temperature increases. The specific gravity of safflower oil was noted 0.917.

Specific gravity and refractive index measurements rarely provide sufficient information to quantitatively identify a pure analyte, but are highly useful to check oil contamination/adulteration (Bhavsar *et al.*, 2017) [6]. Refractive index is used mainly to measure the change in unsaturation as the fat or oil is hydrogenated. The refractive index for the safflower oil is 1.469. It shows that the viscosity value for safflower oil was 45.6cP.

The color of the oils has been associated with better quality oils, especially for salad oils and shortenings. Colour is also one of physical property which determines the adulteration of oil or fat. The physical properties of safflower oil has colour values such as L* value (45.24), a* value (-2.87) and b* value (21.04).The results noted are in comparable with the results noted by Al Surmi *et al*., (2015) [1].

Chemical properties of safflower oil

The chemical properties such as acid value, iodine value, peroxide value and saponification value were analyzed and the results determined are presented in table 2.

Table 2: Chemical properties of safflower oil

Chemical Properties		
Sr. No.	**Properties**	**Results**
1	Acid Value (mg KOH/g)	0.22
2	Iodine Value (g of I_2/100g)	142.3
3	Peroxide Value (meq/kg)	2.81
4	Saponification Value (mg KOH/g)	162.69

*Each value is a mean of three determinations.

The Acid value is a measure of the free fatty acids in oil. The higher the acid value found, the higher the level of free fatty acids which translates into decreased oil quality. It is observed from Table 2 that the results indicate that the acid value which is an index of free fatty acid content due to enzymatic activity in the oils and safflower oil showed the 0.22 mg KOH/g acid value. Further, it was found that the iodine value was 142.3 g of I_2/100g which shows that it has lower degree of saturation. Higher iodine value indicates lower degree of saturation and vice versa. This value could be used to quantify the amount of double bonds present in the oil, which signifies the susceptibility of oil to oxidation (Dim, 2013) [8].

The results indicate that the peroxide value (PV) of safflower oil was found to be 2.81 meqO_2/kg oil. Peroxide value is a measure of oxidation during storage and the freshness of lipid matrix. High peroxide value is an indicator of oxidation level and the greater the peroxide value, the more oxidized the oil is (Atinafu and Bedemo, 2011) [4]. However the results reported in table 3 revealed that the saponification number 162.69 mgKOH/g. Saponification value indicates high proportion of lower fatty acids since saponification value is inversely proportional to the average molecular weight or chain length of the fatty acids (Muhammad *et al.*, 2011) [11].

The findings of the current research are in comparable with the results reported by the (Rafiquzzaman *et al.*, 2006) [15].

Fatty acid profile and total tocopherol content of safflower oil

The safflower oil was subjected to gas chromatography by preparing the fatty acids methyl esters to determine the fatty acid profile and the total tocopherol content was estimated by using HPLC. The data pertaining to fatty acid profile and tocopherol content of safflower oil is presented graphically in Figure 1 and Figure 2 resp. and Table 3.

Table 3: Fatty acid profile and total tocopherol content of safflower oil

Fatty acid profile		
Name of fatty acids	**Chemical configuration**	**Area (%)**
Saturated fatty acids		
a. Lauric acid	C_{12}:0	0.07
b. Myristic acid	C_{14}:0	0.11
c. Palmitic acid	C_{16}:0	6.02
d. Heptadecanoic acid	C_{17}:0	0.04
e. Stearic acid	C_{18}:0	2.37
f. Arachidic acid	C_{20}:0	0.37
g. Behenic acid	C_{22}:0	0.23
h. Lignoceric acid	C_{24}:0	0.12
Unsaturated fatty acids		
I. Monounsaturated fatty acids		
a. Palmitoleic acid	C_{16}:1	0.06
b. Oleic acid	C_{18}:1n9	13.75
c. Eicosenoic acid	C_{20}:1	0.08
II. Polyunsaturated fatty acids		
a. Linoleic acid	C_{18}:2**n6**	76.22
b. Gamma linolenic acid	C_{18}:3**n6**	ND
c. Alpha linolenic acid	C_{18}:3**n3**	0.04
Tocopherol (mg/kg safflower oil)		513.8

*Each value is an average of three determinations (ND = Not Detected)

It is observed from present finding that among the saturated fatty acids the C16:0 i.e. palmitic acid (6.02 percent) concentration was found to be highest as compared to the other saturated fatty acid followed by the C18:0 i.e. stearic acid (2.37 percent). Further, it was also noted that the other saturated fatty acids such as Lauric acid (C12:0), Myristic acid (C14:0), Heptadeconoic acid(C17:0), Arachidic acid (C20:0), Behenic acid (C22:0) and Lignoceric acid (C24:0) were observed as 0.07, 0.11, 0.04, 0.37, 0.23 and 0.12 percent respectively.

It is clearly notedfrom the table 3 that unsaturated fatty acids was predominance as compared to saturated fatty acids.In unsaturated fatty acids the mono-unsaturated fatty acids, Oleic acid (C18:1) concentration was found to be highest (13.75 percent). The palmitoleic acid (C16:1) and Eicosenoic acid (C20:1) was found to be 0.06 percent and 0.08 percent respectively. However, in view of polyunsaturated fatty acids linoleic acid (C18:2n6) was predominant in case of safflower oil. The concentration of linoleic acid (C18:2n6) was found highest i.e 76.22 percent followed Alpha linolenic acid (C18:3n3) 0.04 percent and Gamma linolenic acid (C18:3n6) was not detected. Finally, it was noted from the table 3 that the total tocopherol content of safflower oil was 513.8mg/Kg. The present findings are in comparable with the results noted by Yeilaghi *et al.*, (2012) [16].

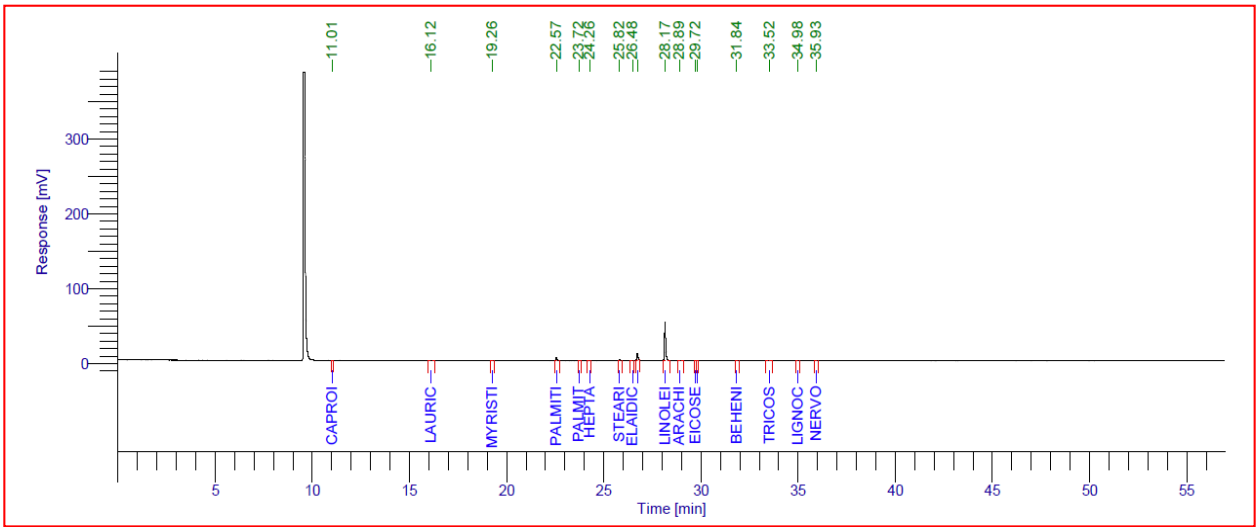

Fig 1: Fatty acids chromatogram Safflower oil

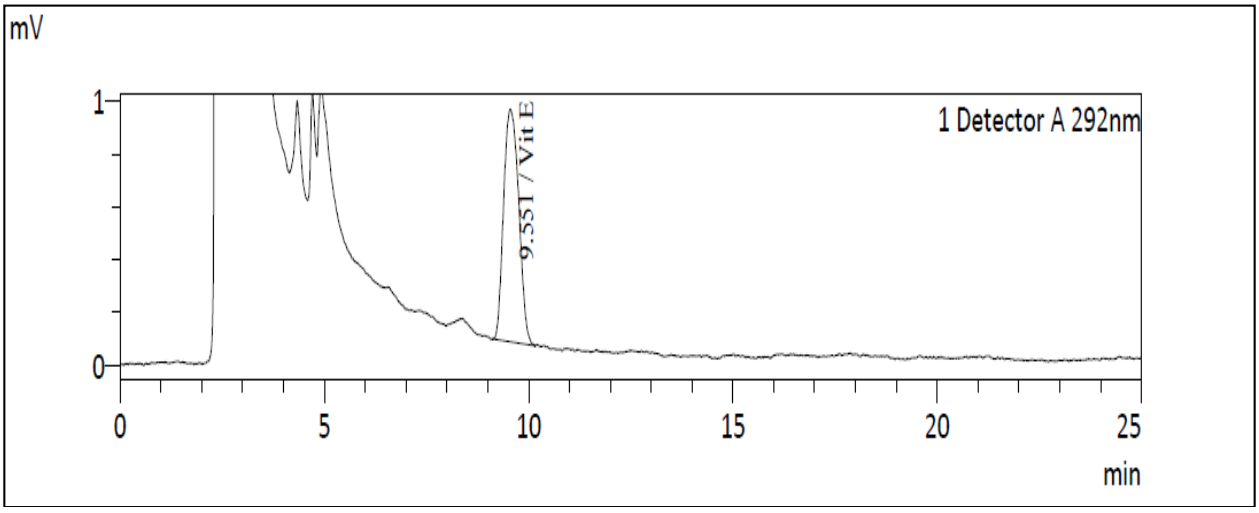

Fig 2: Chromatogram of tocopherol content of Safflower oil

Overview of fatty acid profile of safflower oil

Different amounts of the saturated fatty acids, unsaturated fatty acids, polyunsaturated fatty acids, n-3, n-6 were determined and their relation are summarized in the following Table 4.

Table 4: Overview of fatty acid profile of safflower oil

Overview of fatty acid composition	
Fatty acids	**Contribution (%)**
Total Saturated Fatty Acids (TSFA)	9.61
Total Unsaturated Fatty Acids (TUFA)	90.33
Monounsaturated Fatty Acids (MUFA)	14.07
Polyunsaturated Fatty Acids (PUFA)	76.26
PUFA/TSFA	7.93
n-6	76.22
n-3	0.04
TSFA/TUFA	0.10

The overview of fatty acid composition of safflower oil contained 9.61% of Total Saturated Fatty Acids (TSFA) and 90.33% of Total Unsaturated Fatty Acids (TUFA). The unsaturated fatty acids contain 14.07% of Monounsaturated Fatty Acids (MUFA) and 76.26% of Polyunsaturated Fatty Acids (PUFA). The ratio of PUFA/ TSFA and TSFA/TUFA was found to be 7.93 and 0.10 respectively. However, the concentration of n-6 and n-3 fatty acids was found to be 0.04% and 76.22% respectively.

Conclusion

Finally, it could be concluded that the due to lower peroxide value and higher total tocopherol content, polyunsaturated fatty acid, omega 6 acids content and lower saturated fatty acids, it showed that safflower oil had high stability and superior quality for the edible purpose and commercial applications.

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