Physico-Chemical Analysis and Fatty Acid Profiling of Fenugreek (Trigonella foenum graecum) Seed Oil Using Different Solvents

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Abstract: Fenugreek (Trigonella foenum-graecum) a native to Southern Europe, Mediterranean region and Western Asia has been used as a spice all over the world to increase the sensory quality to the food. It is also known for its medicinal properties such as anti-diabetic, anti-carcinogenic, hypcholesterolemic and immunological activities and can also be used as a food stabilizer and emulsifying agent. The ash, protein, moisture and fiber content of defatted fenugreek seed powder obtained were 9%, 23.04%, 3.8%, 25.47% respectively. So, this study is systematically intended to determine the fatty acid composition, to be best among the different solvents used are the ethanol, petroleum ether, acetone and hexane for the extraction of the fenugreek seed oil and to analyze its susceptibility to oxidation. This study was carried out to investigate and examine the results such as acid value, peroxide value, saponification value, iodine value and the physical properties such as the color value and the refractive index of the seed oil. The results stipulate that the oil extracted using the solvent hexane had better quality and yield. Linoleic acid (41.97%) followed by alpha-linolenic acid (29.33%) and cis-9 oleic acid (12.95%) was found as the primary fatty acids present in the oil extracted using hexane. Along with these fatty acids, the PUFA content of hexane oil (71.30%) was also observed to be in a good range. So, on comparing these results with codex standards, it revealed that it can be considered as edible oil with further purifications.

Key words: fatty acid, physicochemical properties, fenugreek seed oil, Trigonella foenum graecum, solvent extraction

1 Introduction

Fenugreek, scientifically known as Trigonella foenum graecum, which is a diploid annual legume belongs to Leguminosae family. From the age’s fenugreek seeds are used as a spice and its aerial parts are used majorly as in form of vegetable, forage and some in dried leaves form. Fenugreek is beneficial to help in digestion and also helps in altering the food. According to various past researches it has been proven that fenugreek can be included in our daily diet77. The medicinal usage of fenugreek was quite known in different forms as it is advisable to consume fenugreek seed for the treatment of kaph (phlegm) and vat (wind) which is related to digestive and respiratory problems and it is possible due to its aphrodisiac properties. But among all these parts, the fenugreek seed has the highest nutritional value like hypolipidemic effects31, antipyretic effects and anti – inflammatory32, hypoglycaemia and antioxidant properties33. Along with this fenugreek seeds are also rich in the antimicrobial, antileprotic, anticholesterolemic, antibronchitic and anthelmintic properties as depicted by21–27, 30. They are some other health benefits of fenugreek seeds like when consumed roasted or raw or soaked they can be a good remedy for hernia and pain in the groin. Fenugreek seeds are consumed as a galactagogue (milk producing agent) in case of nursing mothers28, 30. As the bitter taste of fenugreek masks it consumption less but it’s consumption in different forms as flour and other food products may provide further health benefits34. Fenugreek seed consists of endosperm, husk, and cotyledons and it depicted that endosperm contains 4.63 g/100 g saponin and 43.8 g/100 g of protein. Along with this, the husk is also rich in polyphenols content. The antioxidant activity was performed for the seed, husk and endosperm and it was observed that it contains 56%, 64% and 72% respectively32. The fenugreek seeds are also consumed as sprouts along with its medicinal properties. In the ancient time, fenugreek seeds

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were consumed for the health problem related to hay fever
tuberculosis, asthma, influenza, bronchial complaints, con-
stipation and laryngitis\textsuperscript{53}. The consumption of fenugreek
seed in various forms proves beneficial as it contains a huge
amount of antioxidants and polyphenolic compounds
such as nicotinic acid, alkaloids, salicylate and flavonoids\textsuperscript{52}.
Many different scientists have predicted approx 28 pheno-
lic compounds in fenugreek seeds which are majorly
grouped as flavonol O-diglycoside, flavones tri- and tetra o-
c-glycosides, flavones di-c-glycosides and acylatedflavone-o-
c glycosides\textsuperscript{56}. These identified flavones mainly include
querceitin, vitexin, luteolin, orientine, isovitexin and epig-
genin\textsuperscript{50}.
Along with these nutritional benefits, the fenugreek seed
oil is also a major area of concern which depicts its anti-mi-
crobial properties. Fenugreek seed oil mostly comprising
54.13% linoleic acid, 16.21% palmitic acid, 4.56% pinene,
3.87% 4-pentyl-1-(4-propyl cyclohexyl)-1-cyclohexene
and 3.19% linoleic acid methyl ester along with 18 more
chemical compounds those are comprising 99\% of total
fenugreek oil\textsuperscript{60}. Fenugreek oil is highly effective for inhibi-
tion of coronary heart diseases, inflammation and cancer.
However, the main constituents of fenugreek oil are ex-
tremely useful in reducing free radicals\textsuperscript{60}. It has been
found that fenugreek seed oil is good source of nutraceuti-
cals like; \(\alpha\)-tocopherol, ALA and sterols\textsuperscript{62} as well as also a
rich source of vitamin A\textsuperscript{44}. Due to the presence of phyto-
constituents fenugreek oil proved to have better activity on
wound healing\textsuperscript{44} and it is found best and safest treatment
for male infertility\textsuperscript{61}. Fenugreek oil found to have stimulat-
ing effects on the ovarian activity in mice\textsuperscript{55}, which showed
a promising opportunity to the use of fenugreek oil for
medical application. Research showed that due to the pres-
ence of antioxidant activity preservation of fenugreek seed
oil is much easier compare to other oils and fenugreek seed
oil showed much higher stability and lower autooxidation
\textsuperscript{50}. Use of the fenugreek seed oil in food items may
upgrade the gainfulness of seed production and processing
sectors, and chiefly might be helpful for purchasers.
Despite various studies on medicinal use and as an essen-
tial oil, the use of this as edible oil has not been explored
till date. This research work is focused on the extraction of
fenugreek seed oil of variety HS-HM 57 by different sol-
vents based on their nature. Further, the physical and
chemical characteristics of the fenugreek seed oil is also
studied in this work.

2 Experimental Procedures

2.1 Materials

\textit{Trigonella foenum-graecum} seeds were collected from
Hisar district, in Haryana, India of variety HSHM 57. The
seeds were sieved to remove the foreign matters and
sealed in an airtight plastic container and stored under
room temperature for its further use and analysis. Other
solvents used were of analytical grade and extraction was
done without going for further purifications.

2.2 Preparation of fenugreek seed oil (FGSO)

The stored seeds were oven-dried at 105 \(\pm\) 1\(^\circ\)C for 24
h\textsuperscript{44}. It was ground using a lab-scale grinder (Agrosaw
private limited, India) to powder form, which was sieved
through an 80 mesh sieve. This powder was further used
to extract oil by the traditional Soxhlet extraction apparatus
using solvents ethanol (bp 78.5\(^\circ\)C), petroleum ether (bp 30-
60\(^\circ\)C), hexane (bp 68\(^\circ\)C) and acetone (bp 56\(^\circ\)C). The
solvent was recovered back and further, the oil sample was
kept in the oven for 4 h at 45\(^\circ\)C to get a solvent-free oil and
was stored in room temperature for 1 h for further analysis
\textsuperscript{41}. A dark brownish to golden yellow color oil was ob-
tained\textsuperscript{37}. The solvents used to extract the oil were petro-
leum ether, acetone, ethanol, hexane which are represented as PE, AC, ET, HX respectively. The fenugreek
seed powder approximately 500 g was used for defatting
and oil extracted was kept in refrigerated storage at 4\(^\circ\)C
for further studies.

2.3 Proximate analysis of Fenugreek seeds

Moisture content, ash, crude protein, the crude fiber of
the samples was determined and is expressed in dry
basis\textsuperscript{50}. The total protein was calculated using the Foss Di-
gestor and was calculated by multiplying with the factor of
6.25. The crude fiber was analyzed using a semi-automatic
fiber analyzer (FOSS Technologies). Moisture content was
performed by taking the constant reading of the sample
kept in the hot air oven in 100 \(\pm\) 1\(^\circ\)C. Ash content was ana-
lyzed using the muffle furnace keeping the temperature at
550 \(\pm\) 1\(^\circ\)C for 5 h.

2.4 Color Value (CV) and Refractive Index (RI)

Determination of colour value of the FSGO was per-
formed using Lovi Bond’s Tintometer (SLIET, Punjab)\textsuperscript{38}
and the refractive index was determined using Abbe’s Re-
fractometer (SLIET, Punjab) at 20\(^\circ\)C\textsuperscript{24}.

2.5 Peroxide Value (PV)\textsuperscript{22}

5 g of sample was taken in an Erlenmeyer and dissolved
in 25 mL of solvent (chloroform and glacial acetic acid). 1
mL of saturated potassium iodide solution was added and
stopped, shaken for 1 min. 30 mL of distilled water was
added and titrated with 0.1 M sodium thiosulphate using
starch as an indicator.

2.6 Acid Value (AV)\textsuperscript{20}

10 g of each oil sample was taken in Erlenmeyer and dis-
solved in 50 mL of ethyl alcohol. Then it was titrated with
0.1 N sodium hydroxide, using phenolphthalein as the indi-
cator and shaking vigorously during titration. At the end of the titration, the color changes to pink for certain seconds.

2.7 Saponification Value (SV)\(^{20}\)

5 g of oil sample was weighed accurately in an Erlenmeyer dissolved in 25 mL of alcoholic potassium hydroxide solution. Using reflux condenser it was boiled continuously for half to one h. Further titration was carried out using 0.5 N hydrochloric acid while still hot. The blank determination was done for the same.

2.8 Iodine Value (IV)\(^{21}\)

5 g of the sample oil was taken in Erlenmeyer and dissolved in 15 mL of carbon tetrachloride and 25 mL of wiji’s reagent. The flask was stoppered and kept in the dark for 1 hour. 20 mL of potassium iodide was added and mix. 150 mL of distilled water was added titrated with 0.1 M sodium thiosulphate solution with continuous vigorous shaking until the yellow color disappears and add 2 mL of starch indicator and continue titrating until blue-black color disappears.

2.9 Fatty acid composition

Generally, for the analysis of fatty acid present in any oil, fatty acid methyl esters test (FAME) is done along with NaOH or methanol preparation method\(^{21}\). For this procedure, approx. 200 mg of oil was channelized into a ground glass stoppers test tube which contains 5 mL 0.5 mol/L of NaOH or methanol solution. The prepared sample was vortexed for about 20 s over a vortex mixer and it should be shaken once in every 5 min. The sample was left to react at 60°C for 40 min. The extraction of methyl esters was carried out using 5 mL n-hexane followed by discarding aqueous phase. Further, n-hexane extract which contains the FAMEs was removed with water and dried using anhydrous sodium sulphate and further centrifuged at 2500 g for 5 min. This is further used for analysis by GC-MS. The gas chromatography-mass spectroscopy is majorly used to study FAME, GCMS system which is equipped with a treated GCMS-TQ8040 with GC capillary column DB-23 polyethylene glycol column (60 m 0.25 mm, 0.15 μm (Supelco cat No.24056)). The separation of FAMEs was carried out for concentration by following GC oven at holding temperature i.e. 50°C (approx. 1 minute) to 100°C at hold 3°C/min. Helium was used as the carrier gas at a constant flow rate at 0.95 mL/min and split injection of 1 μL along with a split ratio of 1:20 was conducted with purge value on 2.5 min at 240°C. Further, the mass spectroscopy was operated in electron impact along with full scan monitoring mode and transferring line at 280°C and solvent delay was set to 3 min. Finally, the results were expressed in the per cent of each fatty acid along with graph generation which contains the peak area of the chromatograph.

| Solvent | Range of percentage % of FGSO recovered |
|---------|----------------------------------------|
| HX      | 4.37 – 4.75 ± 0.13\(^{\text{a}}\)          |
| AC      | 3.65 – 3.83 ± 0.06\(^{\text{b}}\)          |
| PE      | 3.97 – 4.18 ± 0.06\(^{\text{c}}\)          |
| ET      | 3.65 – 3.83 ± 0.06\(^{\text{d}}\)          |

*Each value represents the average of three replicates analyses ± S.D.

a-d, Different letters indicate significant differences \(p < 0.05\) (t-test).

3 Results and Discussion

3.1 Proximate analysis of Fenugreek seed

The confirmation of the seed cumulated of the variety HSHM-57 such as crude fiber (25.47%), crude protein (23.04%), moisture content (3.8%) and ash content (9%) was determined systematically. The oil cumulated in percentage (%) is shown in Table 1 varies from 4.37 – 4.75, 3.65 – 3.83, 3.97 – 4.18, 3.65 – 3.83 for solvents such as HX, PE, AC, ET extracted FGSO respectively.

3.2 CV and RI

The color value in Table 2 given as 360.8, 372.8, 381.6, 417.6 for solvents HX, PE, AC, ET respectively which was found yellow at room temperature and had a refractive index as given in Table 2 1.477, 1.485, 1.476, 1.478 for the different solvents used such as HX, PE, AC, ET respectively. It was found that the RI of FGSO is slightly higher than that of the value of camellia and olive oil. The higher refractive index was because of high amount of unsaturated fatty acids (UFA) which indicates that fenugreek oil has the qualities of edible oil\(^{20}\). RI is one of the important parameters in regulating the quality of oil and Codex standards permit a RI of 1.458 to 1.471. As we know higher the RI value, more is the chances of spoilage during oxidation\(^{31}\) and the FGSO has a little higher variation than the codex permitted refractive index value to the FGSO which suggests that it is prone to spoilage by oxidation.

3.3 AV and PV

These are one of the most important quality indicants of
Table 2  Physicochemical characteristics of FGSO extracted using different solvents.

| Solvents      | AV (KOH mg/g) | PV (KOH mg/g) | SV (l/g/100 g) | CV | RI | Reference |
|---------------|---------------|---------------|----------------|----|----|-----------|
| HX            | 0.3 ± 0.02a   | 19.5 ± 0.15a  | 157.9 ± 1.3a   | 122.5 ± 2.4a | 360.8| 1.477 ± 0.001a |
| PE            | 0.5 ± 0.03ab  | 16.9 ± 0.31b  | 168.0 ± 1.4b   | 119.7 ± 1.2b | 372.8| 1.485 ± 0.002ab |
| AC            | 0.7 ± 0.04bc  | 31.5 ± 0.22bc | 132.2 ± 3.5bc  | 115.0 ± 1.0bc | 381.6| 1.476 ± 0.003bc |
| ET            | 0.8 ± 0.01    | 26.4 ± 0.53bc | 127.02 ± 1.5   | 126.7 ± 1.5bc | 417.6| 1.478 ± 0.005bc |
| Olive oil     | 0.3           | 8.1           | 196.9          | 79.1 | -   | 1.4696    |
| Camellia sinensis seed oil | 0.7 ± 0.3   | 17.4 ± 9.8    | 196.2 ± 0.5    | 89.1 ± 2.8  | -   | 1.4653 ± 0.003 |
| Rapeseed oil  | 0.1           | 2.2           | 196.3          | 110.7 | -   | 1.4762    |
| Pumpkin seed oil | 1.05 ± 0.07  | 0.21 ± 0.01   | 193.8 ± 3.0    | 121.1 ± 0.2 | -   | 1.464 ± 0.002 |

*Each value represents the average of three replicates analyses ± S.D. a-c. Different letters indicate significant differences p < 0.05 (t-test).

edible oils. The AV and PV of oil samples are shown in Table 2. On further purification of the oil by deodorizing and neutralization will directly affect the AV and PV and the preservation also may cause the deterioration of these indicants of FGSO. Here, the FGSO showed a leap difference in AV and PV when extracted with different solvents. As given in Table 2 the AV for the oil extracted using HX and PE 0.3 and 0.5 respectively, 0.7 and 0.8 in AC and ET respectively which is approximate to the value of Camellia sinensis seed oil. However, according to Codex Standards the AV below 0.6 mg/g does not affect the original odour and taste of edible oils and fats. Increase in AV of the oil makes it unsuitable for edible oils and fats which can be reduced to its allowable limits by an appropriate refining process. Whereas PV calculated of the FGSO using HX, PE, AC, ET was 19.5, 16.9, 31.5, 26.4 respectively, which should be lower than that of 10. However, the values of the FGSO are higher because oxidation could not be avoided during the extraction process. The peroxide value reduces upon refining due to the absorbance of peroxides on bleaching during refining process. A low acid and peroxide value shows stability and good quality.

3.4 SV and IV

SV and IV are the important parameters of oils and fats. The SV given in Table 2 is 127.02, 132.2, 168.0, 157.9 of ET, AC, PE and HX respectively. When compared there was a difference in the values of the FGSO and other extracted seed oil. As the SV is low relatively which suggests that oils have larger molecular weight and is outside the range of 188-196, therefore it can be used for the production of soap and candles etc. Whereas, IV, as given in Table 2, is 122.5, 119.7, 115.0, 126.7 of HX, PE, AC and ET respectively which is higher than the other mentioned seed oil suggests that it cannot contribute to oxidative stability and storage. As higher the IV of the oil, it contains more unsaturated fatty acids which make it unstable and so are vulnerable to faster degradation and autoxidation or polymerization, oils having IV more than 115 is considered as dried oils. Dried oils mean getting hardened or polymerized to form a tough and solid film on exposure to air and elevated temperatures.

3.5 Fatty acid composition of FGSO

The health benefits of essential fatty acids had been recited by many scientists like linoleic acid and alpha-linolenic acid which could be beneficial in preventing many different types of diseases like diabetes, inflammation and cardiovascular ones. For the analysis of fatty acid content in FGSO, it was treated by four different solvents as AC, ET, HX and PE. The different solvents have a different effect on the composition of FGSO. The nature of solvents basically affects the oil composition as in these four solvents two are of polar nature (AC and ET) rest two are of non-polar nature (PE and HX). The difference of electronegativity of these solvents might have created the compositional difference in fatty acid profile. As from the literature survey, HX is one of the best suitable solvents for defatting and maybe it because of its non-polar nature. The best result is from HX after defatting as the fatty acid composition profile revealed good results as compared from all four solvents. The content of PUFA, MUFA and saturated fatty acid was higher in case of HX defatting for FGSO. The fatty acid analysis was performed by gas chromatography and fatty acid methyl esters (FMAE).

The gas chromatograph was generated for theFGSO by different solvents. The major content of fatty acid was depicted the analysis of C18:1n9c, C18:2n6c and C18:3n3 and minor content which is less than 20% is depicted by C16:0, C18:0, C20:0 and C22:0 in FGSO by hexane total bound fatty acids. Collectively, the SFA, MUFA, PUFA and trans fatty acid content in hexane oil was 15.75, 12.95%, 71.30% and 0.00% respectively. Similarly, the fatty acid content was checked for remaining three solvents like AC, PE and ET. In case of ethanol gas chromatograph, major fatty acid content was of C18:2n6c and C18:3n3, while
minor fatty acid content was represented by the C16:0, C18:0, C18:1n9c, C20:0 and C22:0. The major content in ET oil was presented as SFA, MUFA and PUFA was 16.07%, 15.06% and 68.87% respectively and out of the four solvents, only hexane depicted good values in respect of retention time and PUFA content.

Similarly, the different oil content was analyzed for their fatty acid profile by different scholars to depict the content of essential fatty acid. A study revealed the essential fatty acids of camellia oil on its ten different cultivars. Out of these 10 cultivars, new C. oleifera contained an almost similar amount of fatty acids composition which majorly include palmitic acid (PA), stearic acid (SA), oleic acid (OA), linolenic acid (LA), tetracosenoic acid and eicosenoic acid. While immature seeds conations OA, (75.78%-81.39%), PA (7.68%-10.01%), LA (4.85%-10.79%) and SA (1.465-2.97%) and OA had the least coefficient of variation among different new cultivars. As compared to the PUFA content of loquat seed oil (34.50%)\(^{(a)}\), the PUFA content of FGSO (71.30%) is much higher and might be considered as a better source of it.

The graph presented in Fig. 1 is reflecting the comparison of four solvents and their major fatty acid profile like PUFA, MUFA and saturated fatty acid and trans fatty acid content was nil in all the compositions. The content of PUFA, MUFA and SFA was also compared and it depicted that the PUFA content was highest in HX oil (71.30%)\(^{(a)}\), while MUFA content was highest in ET (15.06%) and SFA content was highest in AC (16.99%). This difference in values may occur due to the polarity of solvents which could react with the essential fatty acids.

The formation of the fatty acid profile is composed of a mixture of unsaturated fatty acid and saturated fatty acid. Unsaturated fatty acids (UFA) majorly classified on the basis of their FA) and polyunsaturated fatty acid (PFUA).

As in the given Table 3, there is comparison different fatty acid profile of edible oils (may differ in plant source) and FGSO HX. The relation of essential fatty acid and human health is being proved by many different scientists, and it recited the influences of fatty acid on the exposure of severe diseases and overall human health.

3.5.1 Polyunsaturated fatty acid (PUFA)

Generally, the source of PUFA is linoleic acid (C18:2, n-6) and especially docosahexaenoic acid (DHA, C22:6; n-3), is majorly occurred from marine phytoplankton and algae\(^{(5, 12-15)}\). It is also present in some terrestrial sources like vegetables, nuts and in seeds\(^{(16)}\). The location of double bonds in the carbon chain of fatty acid is the substantial reason for their difference in functioning like n-3 or n-6\(^{(17)}\). As in Table 3, there is a comparison made between the PUFA content of FGSO and other oils enlisted. The highest content of PUFA was observed in the FGSO HX (71.30%)\(^{(a)}\) followed by linseed oil (68.0%), silybummarianum (64.2%), pumpkin (54.3%), cotton seed oil (52.16%), mustard oil (27.28%), groundnut oil (26.96%), almond oil (22.8%), palmolein oil (11.5%), date seed oil (8.85%), olive oil (7.0%) and coconut oil (1.90%) in the manner of highest to lowest. The high content of PUFA reveals its good relationship with the health and in the prevention of different cardiovascular diseases. From the recent observations, it has clearly proved the relationship of PUFA and its impact on human health like in prevention of cancer, cardiovascular diseases, inflammatory, diabetes, autoimmune diseases, renal problems, rheumatoid arthritis and also in Crohn’s disease and in hypertension\(^{(16, 17)}\).

3.5.2 Monounsaturated fatty acid (MUFA)

In case of monounsaturated fatty acid, the content from the Table 3, compared and it was observed that Olive oil (78.4%), almond oil (67.9%), mustard oil (66.98%), groundnut oil (53.77%), palmolein oil (43.62%), date seed

\(\text{Fig. 1} \quad \text{Comparison of the fatty acid profile obtained of fenugreek oil using different solvents.}\)
Table 3  Representing the fatty acid profile of FGSO by different solvents along with their PUFA, MUFA and SFA contents.

| Fatty Acids (%) | AC  | ET  | HX  | PE  |
|-----------------|-----|-----|-----|-----|
| C4:0 Butyric Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C6:0 Caproic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C8:0 Caprylic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C10:0 Capric Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C11:0 Undecanoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C12:0 Lauric Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C13:0 Tridecanoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C14:0 Myristic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C14:1 Myristoleic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C15:0 Pentadecanoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C15:1 Cis-10-Penta Decanoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C16:0 Palmitic Acid | 10.48 | 10.87 | 9.89 | 9.95 |
| C16:1 Palmitoleic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C17:0 Heptadecanoic Acid | 0.29 | 0.00 | 0.00 | 0.30 |
| C17:1 Cis-10-Heptadecanoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C18:0 Stearic Acid | 4.36 | 4.15 | 4.08 | 4.02 |
| C18:1n9 Trans-9 Elaidic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C18:1n9c Cis-9-Oleic Acid | 13.73 | 15.06 | 12.95 | 12.77 |
| C18:2n6T Linolea picnic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C18:2n6c Linoleic Acid | 41.77 | 43.21 | 41.97 | 41.81 |
| C18:3n6 Gamma-Linolenic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C18:3n3 Alpha-Linolenic Acid | 27.51 | 25.66 | 29.33 | 29.47 |
| C20:0 Arachidic Acid | 1.26 | 1.05 | 1.21 | 1.16 |
| C20:1n9 cis-11-Eicosenoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C20:2 Cis-11,14 Eicosadienoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C20:3n6 Cis 8,11,14 Eicosatrienoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C20:3n Cis-11,14,17-Eicosatrienoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C20:4n6 Arachidonic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C20:5n3 EPA | 0.00 | 0.00 | 0.00 | 0.00 |
| C21:0 Henicosadienoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C22:0 Behenic Acid | 0.60 | 0.00 | 0.57 | 0.52 |
| C22:1n9 Eruic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C22:2 Cis 13,16 Docosadienoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C22:6n3 DHA | 0.00 | 0.00 | 0.00 | 0.00 |
| C23:0 Tricosanoic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C24:0 Lignoceric Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| C24:1n9 Nervonic Acid | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 |
| Saturated fatty acid | 16.99 | 16.07 | 15.75 | 15.95 |
| MUFA | 13.73 | 15.06 | 12.95 | 12.77 |
| PUFA | 69.28 | 68.87 | 71.30 | 71.28 |
| Trans fatty acid | 0.00 | 0.00 | 0.00 | 0.00 |
| Total fat% | 100.00 | 100.00 | 100.00 | 100.00 |
Fatty Acid Profiling of Fenugreek Seed Oil

Table 4  The representation of major content of fatty acid profile of some edible oils along with FGSO HX.

| Type of Oil         | PUFA  | MUFA  | SFA   | Reference |
|---------------------|-------|-------|-------|-----------|
| FGSO-HX             | 71.30 | 12.95 | 15.75 | –         |
| Linseed oil         | 68.00 | 22.1  | 9.65  | 1)        |
| Olive oil           | 7.0   | 78.4  | 14.35 | 1)        |
| Date seed oil       | 8.85  | 43.55 | 47.4  | 2)        |
| Cotton seed oil     | 52.16 | 19.66 | 28.17 | 3)        |
| Coconut oil         | 1.90  | 7.24  | 90.84 | 3)        |
| Groundnut oil       | 26.96 | 53.77 | 19.27 | 3)        |
| Mustard oil         | 27.28 | 66.98 | 5.73  | 3)        |
| Palm oil             | 11.54 | 43.62 | 44.84 | 3)        |
| Pumpkin Seed        | 54.3  | 26.1  | 19.6  | 4)        |
| Silybum Marianum    | 64.2  | 20.7  | 15.1  | 4)        |
| Almond              | 22.8  | 67.9  | 9.3   | 4)        |

oil (43.55%), pumpkin seed oil (26.1%), linseed oil (22.1%), silybummariana (20.7%), cottonseed oil (19.55%), FGSO HX (12.95%) and coconut oil (7.24%) in the manner of highest to lowest. As MUFA are easy to digest due to more compatible breakage of bonds as linked to other fatty acids. It has been depicted that, MUFA may be proved helpful in reducing the content of LDL (Low-Density Lipoprotein) cholesterol and could possibly increase HDL (High-Density Lipoprotein) cholesterol. The ratio of stearic acid to oleic acid is found as a biomarker to look into the relationship pattern of breast cancer risk and its metabolism. While in case of activation of downstream inflammatory mediators, the oleic acid has proved beneficial for an anti-inflammatory and anti-apoptotic agent via downregulation of cyclooxygenase-2 (COX-2) along with inducible nitric oxide synthase (iNOS) by activation of nuclear factor-kappa B (NF-κB).

3.5.3 Saturated fatty acid (SFA)

Generally, SAF is less than 12 carbon atoms chain known as short and medium-chain fatty acids (MCFA). As from the Table 4, the content of SFA in enlisted oils like as coconut oil (90.84%), date seed oil (47.4%), palm oil (44.84%), cottonseed oil (28.17%), pumpkin seed (19.7%), groundnut seed oil (19.27%), FGSO HX (15.75%), silybummariana (15.1%), olive oil (14.35%), linseed oil (9.65%), almond oil (9.3%) and mustard oil (5.75%) as from highest to lowest concentration. The ratio of total cholesterol to HDL is a more particular marker for coronary artery diseases as compared to LDL cholesterol. Oils which are rich in lauric acid (C12:0), is observed to decrease the ratio of total HDL cholesterol, while on the other hand palmitic acid (C16:0) and myristic acid (C14:0), affected this ratio only little but stearic acid (C18:0) slightly reduced this ration as per.

4 Conclusion

The present study was focused to analyze the oil content of fenugreek seed of variety HS-HM 57 (Hissar Sonali). The fenugreek seeds were defatted with four different solvents and the effect of different solvents was studied on their fatty acid profile. Along with the fatty acid profile, the FGSO was also analyzed for the physicochemical properties of the oil. The physicochemical properties provide a gist about the oil profile. We found that these solvents had a varying effect on the oil extracted. This study revealed maximum yield of oil collected from various solvents was observed in HX i.e. 4.37-4.75 ± 0.13% out of AC, PE, and ET. This study was also riveted on the physico chemical analysis of FGSO. The data represented in Table 2 depicted the low acid value for HX-FGSO i.e. 0.3 ± 0.02 imparts its nature for low oxidation that enhances the keeping quality
of oil as compared to other standard oil such as pumpkin seed oil i.e. 1.05±0.07. The FAME test revealed the inner profile of sample oil and the effect of solvent to analyze the different fatty acids in FGSO. The HX-FGSO out of AC, PE and ET counted for the more content of poly unsaturated fatty acid i.e. 71.30%. This predicts the HX could provide a yield and quality of FGSO. As there is quenching amount of market for the essential oil and by its further refining and processing it may a good source of edible oil and FGSO could be a better source of it when the raw material is available in profound nature. The FGSO is an essential oil and this investigation reveals that fenugreek seed oil can be used as a source of PUFA content along with its edible oil properties.

The innovation is the only way to survive and there is tremendous growth in the market of food, pharmaceutical and cosmetics industry, there are numerous options which are evolving day by day. There is a hindrance in FGSO that is causes a bitter taste after consumption and future researcher are required to bump off the bitterness causing component. There are many various reports that predict the usage of FGSO in the treatment of various metabolic diseases, hence it could be possible to deliver it in a way that eliminate its bitterness and also have the capacity to deliver the medicinal benefits. Furthermore, the researchers are required to conduct in the utilization of FGSO in food, pharmaceutical and cosmetics industry after the processing and purification to further enhance the market scope and generate new possibilities.

Conflict of Interest

None of the authors had any conflicts of interest to declare.

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