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Sumit Kumar
(1) Department of Food Safety and Quality Testing, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National Importance; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India
(2) Center of Excellence in Non-Thermal Processing, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National Importance; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India

S Vignesh
Department of Food Engineering, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National Importance; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur. Tamil Nadu, India

Sunil CK
Department of Academics and Human Resource Development, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India

N Venkatachalapathy
Department of Academics and Human Resource Development, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India

Ashish Rawson
(1) Department of Food Safety and Quality Testing, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National Importance; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India
(2) Center of Excellence in Non-Thermal Processing, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National Importance; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India

Corresponding Author:
Ashish Rawson
Ashish Rawson
(1) Department of Food Safety and Quality Testing, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National Importance; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India
(2) Center of Excellence in Non-Thermal Processing, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), An Institute of National Importance; Formerly Indian Institute of Food Processing Technology-IIFPT, Thanjavur, Tamil Nadu, India

Blending of tomato seed oil and sunflower oil: Its characteristics and quality evaluation

Sumit Kumar, S Vignesh, Sunil CK, N Venkatachalapathy and Ashish Rawson

Abstract
Tomato waste (seed) is generated in large amounts from the tomato processing industries which constitutes a good quantity and quality oil. The present study aimed to blend the tomato seed oil with the sunflower oil in order to stabilize it and use it for edible purposes. Preliminarily various ratios (1:4, 2:3, 3:2 and 4:1) of tomato seed oil and sunflower oil blend was evaluated for peroxide value (PV), antioxidant activity and colour value. The optimized blending ratio (2:3) of tomato seed oil and sunflower oil was selected due to improved antioxidant activity and peroxide value. The optimized blended oil was evaluated for its quality which includes p-anisidine value, peroxide value, colour change, FTIR spectrum, antioxidant activity and specific gravity. These quality parameters of the blended oil were compared with the raw tomato seed oil and sunflower oil. The blended oil of tomato seed oil and sunflower oil was observed to have higher antioxidant activity and good resistance to secondary oxidation which makes the blended oil a good candidate for consumption purposes.

Keywords: Blending, tomato seed oil, antioxidant activity, functional potential, oxidation

1. Introduction
The industrial tomato (*Solanum lycopersicum*) processing waste is generated worldwide in large quantities. The tomato waste generated from the industries constitutes a good amount of the compounds such as phytochemicals, bioactive compounds and oil etc [1, 2, 3]. Tomato is one of the most consumed vegetables in the world in the processed as well as raw form, the processing of the tomato leads to the generation of the waste which is known as pomace. The composition of the pomace of tomato includes skin (peel), seed and liquid. To date, several studies have been conducted on the waste generated from the tomato processing industries which includes adsorption [3], antioxidants [4] and extraction [5, 6, 7]. The oil extracted from tomato seeds has been reported to have a high amount of unsaturated fatty acids which makes it a good candidate for consumption purposes. However, several studies have been reported on the extraction of oil from tomato seeds [8, 9, 10]. Though the worldwide consumption of vegetable oils has been reported to be increased day by day from 75 to 175 million metric tons which include palm oil and soybean oil etc [15].
The seeds which have been generated from the food processing industries are evaluated for several important components which include the protein and oil content [3, 4]. The short life of vegetables is one of the factors which results in the less use of these oils across the globe [11, 12]. Further, the vegetable oils oxidative rancidity is one of the limiting factors which affects the storage period and packaging of vegetable oils [13, 14]. This oxidation not only affects the storage capacity of oils but also affects the products developed in the food industries. The unsaturated fatty acids present in the vegetable oils are prone to oxidation compared to the oils which have less unsaturated fatty acids and higher saturated fatty acids [16, 17, 18]. Furthermore, the blending of oils has become a well-known procedure to develop a new oil product. The blending of the oil results in the changing of levels of lipids, natural antioxidants and fatty acid profile which leads to a better quality of oil as well as improved nutritional and oxidative stability [16, 17]. The improved quality of oil leads to valuable industrial applications with improved health benefits for humans. To date, several studies has been conducted on the extraction of tomato seed oil and the effect of the processing technologies on the quality of the oil. The studies have shown that tomato seed oil is a good candidate which constitutes a sufficient amount of unsaturated fatty acids in order to use as edible oil. Owing to the fact, the objective of the present study was framed to blend the tomato seed oil with the sunflower oil and measure the quality characteristics.

2. Material and Methods

The tomato seeds (*Solanum lycopersicum*) were collected from the tomato paste processing plant located in Erode, Tamil Nadu, India. The seeds were dried (moisture content 6.5±0.5) and powdered with particle size having a uniform matrix of ≤ 600 microns by passing through the sieve. The seed powder was packaged in the zip lock HDPE (high-density polyethylene) and placed in refrigerated conditions until further use.

2.1 Extraction

The tomato seed oil was extracted using the conventional Soxhlet extraction technology. The tomato seed quantity was poured into the thimbles of the Soxhlet extraction unit. The parameters for the Soxhlet extraction of tomato seed oil were fixed to the boiling of the solvent for 30 mins. Further, the total extraction time at a temperature of 180 °C was fixed to 1 hr. The solvent n-hexane was used in the present study.

2.2 Oil yield

Oil recovery from the oil and solvent mixture was done using the methodology described [13]. Tomato seed oil recovery yield was calculated using the formula Eqn. 1:

$$Oil\ yield\ (\%) = \frac{W_0}{W_s} \times 100 \qquad \ldots 1$$

Where W_o denotes the weight of extracted oil from tomato seed and W_s sample weight used for the extraction of oil.

2.3 Blending

The tomato seed oil and sunflower oil in an optimized ratio (2:3) was blended using magnetic stirring at an rpm of 1000. After blending the samples were kept in refrigerated conditions and the quality characteristics of sunflower oil, tomato seed oil and blended oil were evaluated.

2.3 Quality characteristics of extracted tomato seed oil

2.3.1 Measurement of antioxidant activity (DPPH)

The antioxidant activity DPPH of tomato seed oil extracted using the Soxhlet apparatus was measured based on 2, 2-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging as described [6]. The hydrophilic and lipophilic assessment of the compound's scavenging activity (radicle) can be done using the DPPH method. The DPPH method is a stable radicle that may have the maximum absorbance at 517 nm wavelength and also results in the decrease of the antioxidant molecule. Briefly, 0.8±0.001 g of Soxhlet apparatus extracted oil was poured into a 20 ml tube then the 2-diphenyl-2-picrylhydrazyl solution was added to the tube. Then the solution was incubated and shaken for 15 min at the ambient conditions (30±2 °C) in a dark environment. The UV-vis spectrophotometer blank as ethyl acetate (0.840 mL) was used to measure the absorbance at 517 nm wavelength.

2.3.2 Specific gravity and Density

A specific gravity bottle (100 mL) was used to determination of the specific gravity and relative density of the oil extracted using different emerging technologies using the methods given [7]. The commercial value of the extracted oil can be well defined by measuring the specific gravity, which is considered the qualitative parameter of oils and fats. To see the crude oil quality, the low value of specific gravity is considered as good which possesses lighter fractions etc. The extracted oil from the tomato seed can be classified as heavy, medium, or light.

2.3.3 Colour value

The colour plays an important role in the world whereas synthetic colour change actions and causes reactions. It can irritate or soothe eyes, raise blood pressure or suppress appetite. The colour is one of the good forms of communication and also an irreplaceable parameter. Due to its versatile properties, it plays a crucial role in the oil extracted from tomato seed powder. A Hunter Lab colorimeter provides a less expensive and more versatile way to determine colour parameters of food products than traditional colour measuring equipment. Good colour of the sample depends upon the intensity of light, and it depends on the distance between the sample [13]. Hunter Lab colorimeter (Model: Color Flex EZ, USA) was used to measure the colour of the extracted oil samples. The colour difference (ΔE*) was determined as the method given by [13, 1] Eqn. 2.

$$\Delta E^* = \sqrt{(a - a^*)^2 + (L - L^*)^2 + (b - b^*)^2} \qquad \ldots 2$$

where b, a and L and are the colour parameters of sunflower oil, tomato seed oil and blended oil samples.

2.3.4 Peroxide value (PV)

The PV of the Soxhlet apparatus extracted tomato seed oil was determined using the AOCS method (Cd 8-53). Briefly, a tomato seed oil sample of 5±0.01 g with chloroform and acetic acid (2:3) was added to the 250 mL conical flask. Further, potassium iodide (0.5 mL), double distilled water (30 mL) and starch indicator (0.5 mL) were added to the conical flask. The solution was kept in the darkness for 1 min and mixed until colour appears yellow. Then, the 0.5 M sodium thiosulfate was used for the titration of the solution until the removal of the blue colour from the mixture. The PV (meq/kg) of the tomato oil samples for different pre-treatment techniques was calculated using Eqn. 3. [11]

$$\text{Peroxide value (PV)} = \frac{\text{V}\times\text{M}}{\text{W}} \times 100 \qquad \ldots 3$$

Where M represents the molarity, V denotes the volume (mL) and W represents the weight (g).

2.3.5 p-Anisidine value (AV)

The AOCS method (Cd 18-90) method was used to determine the p-anisidine value (AV) of the Soxhlet extracted tomato seed oil. The non-volatile aldehyde content (majorly 2-alchenals) of extracted tomato seed oil was calculated using the method [11].

2.3.6 Fourier-transform infrared (FTIR) spectroscopy

FTIR analysis of tomato seed oil and blended oil samples was done using Perkin Elmer (US; Model: Spectrum Two), having a wavelength of 400 - 4000 cm^{-1} range for characterization [22]. Surface functional group determination was done using Spectrum Two, 99065 $NIOS_2$ software at room temperature.

2.4 Statistical analysis

The experiments were conducted in triplicate and the mean and standard deviation (SD) values are given in Table 1. The experimental data were processed in the Minitab software for one-way ANOVA.

3. Results and Discussion

3.1 Extraction

The oil extracted using the Soxhlet extraction method was observed to have a maximum extraction yield of 20.11% whereas the oil extracted using the cold press was found to have an extraction yield of 7.56%. The Soxhlet extracted oil was used in the present study in order to the blending of the sunflower oil with the tomato seed oil.

3.2 FTIR analysis

The FTIR spectrum for fats and oils are triglycerides and hence composition of the fats and oils is dominant in the spectrum. The identity of Soxhlet apparatus extracted oil and its structural characteristics can be demonstrated using the FTIR spectrum Fig. 1. The FTIR spectrum demonstrated that there was a change in the peaks of raw tomato seed oil and the blended oil by the sunflower oil. However, a notable change in the peak was found in the range of 1000-1200, 1450, 1650-1750 and 2850-2900 cm^{-1} wavenumber. The frequency range around 3400-3500 cm^{-1} in the FTIR adsorption was found to be maximum and the adsorption spectrum corresponds to hydroxyl groups (hydroperoxides and water). Further, the raw tomato seed oil and blended oil samples can be considered clean, dry and unoxidized since there were minor changes in the peaks were observed. The spectrum ranges between 3015 cm^{-1}, 2920 cm^{-1} and 2850 cm^{-1} denoting the asymmetrical stretching, methylene ($-CH_2$) symmetrical stretching vibration, and *cis* double-bond stretching. At the wavenumber range, 1750-1650 cm^{-1} fatty acid and glycerol linkages form a strong bond due to ester linkages which lead to the formation of triglycerides. The peak frequency range 1700 cm^{-1} for the blended oil depicted the adsorption band of the carboxyl groups of fatty acid. Furthermore, the wavenumber range 1498-850 cm^{-1} denotes the fingerprint range of the lipids which shows functional groups of the fatty acid and uses them to identify the substances [13]. The wavenumber region also provides information such as the absence/presence of *trans*-triglycerides and triglycerides configuration. The peak bands in the range of 1450 cm^{-1} wavenumber correspond to asymmetric C-H vibration which demonstrates the methyl esters presence. The adsorption peak at 1050 cm^{-1} and 1198 cm^{-1} wavenumber depicts the vibration of C-O which depicts the region of the ester group. Furthermore, the adsorption peaks present at the 722 cm^{-1} wavenumbers depicts the long-chain alkanes having the C-H bond.

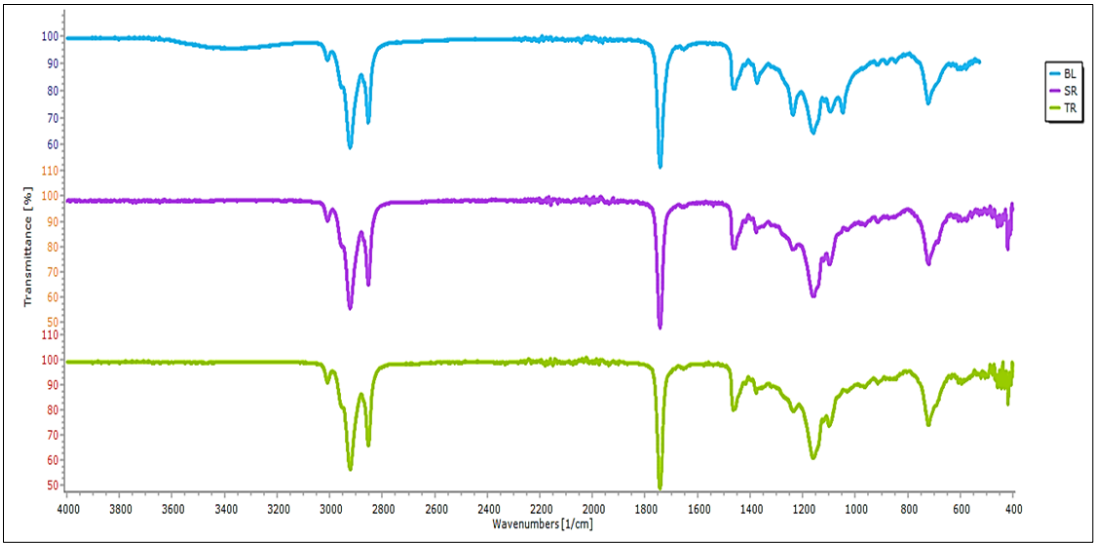

Fig 1: The identity of Soxhlet apparatus extracted oil and its structural characteristics can be demonstrated using the FTIR spectrum

3.3 Colour change

The extracted oil samples were placed in the colorimeter uniformly to the surface. The Hunter lab colorimeter captured the image of the sunflower oil, tomato seed oil and blended oil samples. The L* coordinate denotes the colour whiteness of oil samples which range from black (0) to white (100). The positive value a* denotes red and negative shows the green value of the oil samples and the positive value of b* denotes the yellow colour of the oil samples whereas the blue colour denotes the negative value. [12] The Eqn. (4, 5, 6) can be used for the calculation of the coordinates b*, a*, and L* (Eqn. 4). The measurement of change in colour (ΔE^*) of the extracted oil samples can be calculated as follows:

$$L^* = \frac{Lightness}{255} \times 100 \quad \ldots 4$$

$$b^* = \frac{240 \times b}{255} - 120 \quad \ldots 5$$

$$a^* = \frac{240 \times a}{255} - 120 \quad \ldots 6$$

The ΔE value will always be positive but the coordinates values can be negative or positive. The coordinates values (L^*, b^* and a^*) for the oil samples were 2.96, 0.07 and 0.11 for the blended oil samples whereas the coordinate values for the tomato samples were observed to be 7.62, 0.12 and -0.13. The coordinate a^* values denote that the raw tomato seed oil samples possess the greenish colour whereas the blended colour shows the retention of the colour yellowish which is the conventional oil colour for the better use of the consumers.

3.4 p-Anisidine value (AV)

The secondary products of oxidation like unsaturated aldehydes which are responsible for the unpleasant taste and odor can be described using the AV value. The AV value is one of the important good indicators in order to determine the quality of edible oils which assesses the secondary product levels which leads to oxidation of oil and fats oxidation. The oxidized oils could be having oxidation products due to complex composition and also many causes for oxidation

such as conjugated diene hydrogen peroxide, ketones, lipid radicals, aldehydes, hydroperoxides etc. However, an ultra-fast liquid chromatography-diode array detector-electrospray ionization mass spectrometry method has been developed for the detection of the oxidation compounds in the various decontaminated oil and fats. The AV value determines and gives relative information about the status of the deterioration of oils and fats. Recent studies have reported the presence of malonaldehyde (MDA) and 4-HNE concentrations in consumable oils and fats. However, several attempts for the quantitative and qualitative analysis of the secondary oils and fats oxidation are important in order to develop some other robust methods for secondary lipid oxidation. Though, some attempts have been made in order to the analysis and detection of secondary oxidation of oils and fats having lower toxicity like saturated aliphatic aldehyde, saturated aldehydes and glyoxal. The vegetable oil and fats can be considered good which has a maximum limit of p-anisidine value of 10. The AV values of Soxhlet extracted tomato seed oil (TR), sunflower oil (SR) and blended oil (BL) are given in the Table. 1 The AV values for the TR, SR and BL are 6.27, 5.47 and 4.14 respectively. The minimum AV value was found to be of blended oil which shows less secondary oxidation of the oil. The results depicted the potential resistance of BL oil for the formation of secondary aldehydes which makes BL a good oil for edible purposes.

Table 1: Oil quality characteristics for raw tomato, sunflower and blended oil

Sample	Color difference (ΔE)	Antioxidant capacity (% DPPH)	p-anisidine value	Peroxide value (meq/kg)	Density (g/ml)	Specific gravity
TR	6.16±0.10^{e}	25.08±0.02^{a}	6.27±0.07^{e}	5.49±0.08^{a}	0.79^{e}	0.791^{d}
SR	7.12±0.08^{e}	24.77±0.09^{a}	5.47±0.11^{e}	6.16±0.42^{c}	0.78^{e}	0.804^{c}
BL	5.58±0.21^{d}	28.76±0.08^{a}	4.14±0.13^{c}	8.14±0.07^{d}	0.77^{e}	0.787^{d}

Means that do not share a letter are significantly different

3.5 Specific gravity and Density

The fatty acid groups, antioxidant components, fatty acid chain length and temperature are several constituents that influence the density of the oil and fats (Senrayan & Venkatachalam, 2020). The average molecular weight present in the vegetable oil fatty acids contributes to the SG (specific gravity) of oil and fats [18, 19, 20]. The density and specific gravity of the tomato seed oil and blended oil were found to be in the range of 0.77-0.79 g/ml and 0.787-0.804 respectively Table. 1. As per the guidelines of FAO/WHO the vegetable oil specific gravity can maximum be around 0.90-0.92 [17]. The results found in the present study showed that tomato seed oil, sunflower oil and blended oil had specific gravity in range as per the guidelines. Further, the density values of oil were lesser than that of the water and hence it can be used in the cosmetic industries in order to the production of cream based products. [19] The specific gravity and density values of tomato seed oil and blended oil were found to be in range of standard limits which revealed that there is less effect on the changes in fatty acid composition after blending.

3.6 Antioxidant activity

The enzymatic oxidation and autoxidation of lipids during processing and storage is one of the major reactions in fat-containing foods, oils and fats which leads to the decontamination of the food quality. The oxidation of the foods affects the texture, flavor, color, and also nutritional composition of the food products. The antioxidants present in the plant based products can prevent oxidation (radical chain reactions) by removing the propagation step and initiation stages, which directly results in the termination of the reaction and also delay in the degradation reactions. Humans have always demanded natural antioxidants for the oil's stabilization and edible fats against oxidative rancidity. [20] Tomato seed oil, sunflower oil and blended oil were observed to have good antioxidant activity. Out of these oils, blended oil was found to have the highest antioxidant activity whereas sunflower oil was observed to have the least antioxidant activity.

3.7 Peroxide value

The formation of the hydroperoxides results in the oil or fat oxidation as the primary oxidation which may divide into various volatile and nonvolatile secondary products. The hydroperoxides development rate increases the decomposition at the initial stages of the oxidation which reverses at the last stage [21]. Therefore, PV is one of the important indicators of stability at the first stages of oxidation. PV measured for pure oils, stripped oils and oil blends were shown in Table. 1. Results indicated that pure oils showed very lower PV compared with stripped ones which assessed the antioxidative effect of the minor polar components (including phenolic compounds, sterols and tocopherols and carotenoids) which were removed in the stripping process. The peroxide value was found to be lowest for the raw tomato seed oil whereas the maximum peroxide value of 8.14 was found to be the blended oil of tomato seed oil and sunflower oil. Among the tomato seed oil, sunflower oil and blended oil, blended oil was observed to retain the natural antioxidants and hence found to have minimum peroxide value.

4. Conclusion

The blending can be affected by several parameters which include temperature, rpm and ratio of the different oil varieties. The blending of tomato seed oil was observed to have great potential for consumption by human beings. The study has the scope to use the tomato agro-industrial byproducts/waste for value addition and is also reported as a good candidate for the circular economy concept. The better colour retention of the blended oil was observed which increases the consumer acceptability for edible use.

5. Conflict of Interest

The authors declare no conflict of interests.

6. References

1. Kumar S, Rajan A, Sunil CK, Radhakrishnan M, Rawson A. Recent advances in the utilization of industrial byproduct and wastes generated at different stages of tomato Processing: Status Report. Journal of Food Processing and Preservation, e17063.
2. Kumar S, Thirunavookarasu NS, Rawson A. Development of Power Ultrasound Modified Industrial Tomato Processing Waste as Efficient Biosorbent: Its Characterization, Application on synthetic Dyes, and

Optimization by Artificial Neural Networks. Journal of Food Processing and Preservation, e17041.
3. Thirunavookarasu N, Kumar S, Rawson A. Effect of ultrasonication on the protein–polysaccharide complexes: a review. Journal of Food Measurement and Characterization. c2022. p. 1-20.
4. Mathews A, Tangirala AS, Thirunavookarasu N, Kumar S, Rawson A. Protein extraction from sesame meal and its quality measurements; c2022.
5. Kumar S, Manokar SN, Thirunavookarasu N, Nivethitha V, Nidhusri TN, Niranjana T, e al. Characterization of Power Ultrasound Modified *Kappaphycus alvarezii* Biosorbent and its Modeling by Artificial Neural Networks. Water, Air, & Soil Pollution. 2022;233(7):1-20.
6. Bakhshabadi H, Mirzaei H, Ghodsvali A, Jafari SM, Ziaiifar AM, Farzaneh V. The effect of microwave pretreatment on some physico-chemical properties and bioactivity of Black cumin seeds' oil. Industrial Crops and Products. 2017;97:1-9.
7. Bhutada PR, Jadhav AJ, Pinjari DV, Nemade PR, Jain RD. Solvent assisted extraction of oil from Moringa oleifera Lam. seeds. Industrial Crops and Products. 2016;82:74-80.
8. Casal S, Malheiro R, Sendas A, Oliveira BPP, Pereira JA. Olive oil stability under deep-frying conditions. Food and Chemical Toxicology. 2010;48:2972-2979.
9. Gavahian M, Chu YH, Sastry S. Extraction from Food and Natural Products by Moderate Electric Field: Mechanisms, Benefits, and Potential Industrial Applications. Comprehensive Reviews in Food Science and Food Safety. 2018;17:1040-1052.
10. Giuffrè AM, Capocasale M, Zappia C. Tomato seed oil for edible use: Cold break, hot break, and harvest year effects. Journal of Food Processing and Preservation. 2017;41:1-11.
11. Hernández-Santos B, Rodríguez-Miranda J, Herman-Lara E, Torruco-Uco JG, Carmona-García R, Juárez-Barrientos JM, *et al*. Effect of oil extraction assisted by ultrasound on the physicochemical properties and fatty acid profile of pumpkin seed oil (*Cucurbita pepo*). Ultrasonics Sonochemistry. 2016;31:429-436.
12. Kumar S, Chand K, Lohani UC, Singh A. Process Optimization of Hand Operated Machine for Coating of Apples using Carboxymethyl Cellulose. 2021;10:71-82.
13. Naik M, Natarajan V, Rawson A, Rangarajan J, Manickam L. Extraction kinetics and quality evaluation of oil extracted from bitter gourd (*Momardica charantia* L.) seeds using emergent technologies. Lwt. 2021;140:110714.
14. SNT, Kumar S, Kalakandan SK. Effect of ultrasound treatment on soy protein : Rice starch interaction. The Pharma Innovation Journal. 2021;10:1516-1522.
15. Tripathi A. Effect of Ultrasonication Process on the Physical Properties of Three Different Honey Varieties. Indian Journal of Pure & Applied Biosciences. 2020;8:667-674.
16. Vearasilp S, Thobunluepop P, Thanapornpoonpong S, Pawelzik E, Hörsten D Von. Radio Frequency Heating on Lipid Peroxidation, Decreasing Oxidative Stress and Aflatoxin B1 Reduction in *Perilla frutescens* L. Highland Oil Seed. Agriculture and Agricultural Science Procedia. 2015;5:177-183.
17. Lesten ECC, Hankie U, Kingsley M. Comparison of oil quality extracted from selected conventional and non conventional sources of vegetable oil from Malawi. African Journal of Biotechnology. 2019;18:171-180.
18. Neagu A-A, Niţa I, Botez E, Geaca S. A physico-chemical study for some edible oils properties. Analele Universitatii Ovidius Constanta - Seria Chimie. 2014;24:121-126.
19. Senrayan J, Venkatachalam S. Ultrasonic acoustic-cavitation as a novel and emerging energy efficient technique for oil extraction from kapok seeds. Innovative Food Science and Emerging Technologies. 2020;62:102347.
20. Shao Y, Hu Z, Yu Y, Mou R, Zhu Z, Beta T. Phenolic acids, anthocyanins, proanthocyanidins, antioxidant activity, minerals and their correlations in non-pigmented, red, and black rice. Food Chemistry. 2018;239:733-741.
21. Shahidi F, Zhong Y. Lipid oxidation: measurement methods. Bailey's industrial oil and fat products; c2005.
22. Van de Voort FR, Ghetler A, García-González DL, Li YD. Perspectives on quantitative mid-FTIR spectroscopy in relation to edible oil and lubricant analysis: evolution and integration of analytical methodologies. Food Analytical Methods. 2008;1(3):153-163.