E-ISSN: 2788-9297
P-ISSN: 2788-9289
https://www.agrijournal.org
SAJAS 2024; 4(1): 42-49
Received: 04-11-2023
Accepted: 11-12-2023

Umakanthan T
Veterinary Hospital, Gokulam Annadhanam Temple Complex, Meenavilakku-Meenakshipuram, Anaikaraipatty, Bodinayakanur Taluk, Theni Dt, Tamil Nadu, India

Madhu Mathi
Veterinary Hospital, Vadakupudhu Palayam, Erode Dt, Tamil Nadu, India

Umadevi U
Assistant Professor, Department of Botany, The Standard Fireworks Rajaratnam College for Women, Sivakasi, Virudhunagar (Dt), Tamil Nadu, India

Correspondence Author:
Umakanthan T
Veterinary Hospital, Gokulam Annadhanam Temple Complex, Meenavilakku-Meenakshipuram, Anaikaraipatty, Bodinayakanur Taluk, Theni Dt, Tamil Nadu, India

Improvement of Edible oils inherent characteristics through 2-6 µm mid-infrared irradiation: A novel research

Umakanthan T, Madhu Mathi and Umadevi U

Abstract
Oils are an essential component of our diet and a calorie source. Deep-fried and shallow-fried dishes are becoming popular, and foods high in edible oil pose health hazards. As of right now, there is no technology that can lessen the amount of oil that recipes absorb while cooking. In this study, we developed a 2–6 µm mid-infrared generating atomizer (MIRGA) to irradiate edible oils. This resulted in a reduction of 13–94 percent in the amount of oil absorbed by foods, in addition to taste enhancement. This approach is affordable, secure, and low-resource. The intricacies of the expert panel's sensory analysis and the alterations in oil chemistry brought about by the mid-IR, which accentuated the inherent qualities, are presented.

Keywords: 2-6 µm mid-infrared – edible oils – cooking – less absorption – health, economy, resource – savings

Introduction
Edible oils are most important to prevent hypovitaminosis. Vit A, D, E, K are soluble in oil, hence more intestinal absorption (Singh, 2014) [1]. Edible oils have multiple use from cooking to medicine and industrial use. Increased population now made more demand on edible oil. Overusing oil in recipes and repeatedly heating cooking oil (RHCO) increases our risk of heart disease and colorectal cancer, among other health problems (Brown *et al*., 2005; Mozaffarian *et al*., 2009; Prokurat *et al*., 2013; Venkata *et al*., 2016; Sacks *et al*., 2017) [2-6]. Excess oil in recipes are inseparable except by manual pressing between paper prior to eating as done in some oil fried recipes and no other means are available. To reduce the absorption of the oil by recipes, we employed 2-6 µm mid-infrared (mid-IR) on the oil. This reduced oil absorption depending on the variety of oils trialed and simultaneously enhanced the sensory attributes of irradiated uncooked/cooked oils and the recipes. Mid-infrared generating atomizer (MIRGA) is designed to generate 2-6 µm mid-IR. The mid-IR is biologically very safe and capable to penetrate the obscurants (Xu *et al*., 2017; Datta *et al*., 2014) [7-8]. The benefits of the mid-IR irradiation on edible oils are described here.

Material and Method
MIRGA (patent no.: 401387) is a 20 ml pocket sized atomizer (Supplementary file – figure F1) containing inorganic water based solution in which approximately two sextillion cations and three sextillion anions are contained. During spraying, depending on pressure (vary with the user) applied to plunger, every spraying generates 2-6µm mid-IR. Design of the MIRGA and emission of 2-6 µm mid-IR has been presented in detail by Umakanthan *et al*., 2022a; Umakanthan *et al*., 2022b [9-10]. Every time spraying emits 0.06ml which contains approximately seven quintillion cations and eleven quintillion anions. (Details about MIRGA available in supplementary text T1).
The inorganic compounds used in the generation of MIR are a perspective for biomedical applications (Tishkevich *et al*., 2019; Dukenbayev *et al*., 2019) [11-12]. It is also a new synthesis method for preparation of functional material (2-6 µm mid-IR) (Kozlovskiy *et al*., 2021; El-Shater *et al*., 2022) [13-14]. It is well known that the combination of different compounds, which have excellent electronic properties, leads to new composite materials, which have earned great technological interest in recent years (Kozlovskiy and Zdorovets, *2021;* Almessiere *et al*., 2022) [15-16].
The spraying should be done from 0.25 to 0.50 meter towards polythene packaged/ unpackaged oil.

This distance is essential for the MIRGA sprayed solution to form ion clouds, oscillation and hence 2-6 µm mid-infrared generation (Method of MIRGA spraying in Supplementary file – video V1. The mid-IR affects the internal oil by penetrating the packing material in between. MIRGA should be applied externally to any packed or unpacked material, much like a body spray.

Service of trained experts (n: 8) from oil extraction factory and consumer panel (housewives) (n: 24) were employed. The marketed polythene packed (>51 microns) edible oils *viz*., Coconut (*Cocus nucifera*), Gingelly oil (*Sesamum indicum*), Groundnut oil (*Arachis hypogaea*), Palm (*Elaeis guineensis*), Sunflower (*Helianthus annus*) and Olive (*Olea europea*) were trialed. Though we used different brands, neither brands nor batches mixed but individually trialed. Both control and trial samples used were always from the same and single source only.

Potato chips, urad dal vada, channa dal vada, murukku and potato bajji were the five dishes prepared. For every dish, at the rate of 500ml x 3packets of same brand and batch of oil, e.g. Coconut oil purchased, the 3 packets were marked as 1, 2 and "C" (Control). The 1 and 2 marked packets were correspondingly given 1 and 2 MIRGA sprayings. The spraying was done 0.25-0.50 meter right away but towards the oil packets. The "C" marked packets received no spraying. For every dish preparation, an individual vessel (same brand and size) was used but chef remains same. For the 5 dishes prepared, each ingredient used were from the same source. Before and after spraying and cooking, the oils and dishes were subjected to the sensory attribute tests. The acceptability index used was a hedonic scale with a 9 point nominal structure: 1 - Dislike extremely, 2 - Dislike very much, 3 - Dislike moderately, 4 - Dislike slightly, 5 - Neither like nor dislike, 6 - Like slightly, 7 - Like moderately, 8 - Like very much, 9 - Like extremely (Everitt, 2009; Wichchukit *et al*., 2014) [17-18]. After preparing the dishes, the remaining oil quantity was measured. Cooked oil's regular, taste, aroma and cooking time were also recorded and compared. The control, 1 and 2 sprayed oil samples were subjected to different instrumentations and the results were compared. Same procedure was followed using the other 5 oils. One coconut oil and one gingelly oil packets were given 3 sprayings to identify the effect of extra energy (2-6 µm mid-infrared) input because in nature, extra energy should denature the target. Using palm oil, the effect of mid-IR in nutrition was also studied.

The instruments used to demonstrate these research findings are: Chemical compound transformation – Gas chromatography-mass spectrometry (GC-MS); Chemical bond changes – Fourier-transform infrared spectroscopy (FTIR); and Nuclear resonances – Proton nuclear magnetic resonance spectroscopy (1H-NMR). (Details of instruments in Supplementary file – Text T2).

Results and Discussion

Sensory evaluation result

The 1 and 2 sprayed oil samples and their dishes had acquired an enhanced taste and aroma and cooking time was 30-40% less than that of control oil (Table 1). The 3 sprayed samples has almost lost the taste and aroma.

In fact, one spraying has improved the sensory attributes in oil and dishes compared to 2 spraying and control. These sensory attribute changes were perceived in 1-5 minutes after spraying.

The consumer panel (housewives) very much liked the 1 and 2 sprayed oil and dishes prepared out of them compared to control.

From Table 2, it is found that 13-94% oil savings was achieved by using MIRGA sprayed oils than using the non-sprayed control oils for recipes preparation.

Potato chips trial with olive oil

The 6 types of cooked remnant oil was reusable for 2-4 times. And the prepared recipes' taste, aroma, texture and palatability were better than control (Table 3).

Instrumentation results (raw data of instrumentations in Supplementary file – Data D1), (detailed interpretation of instrumentations in Supplementary file – Text T3).

GC- MS

a) Coconut oil

Control sample contains many aldehyde, ketone and long chain fatty acids such as Oleic acid & their derivatives. After 1 spraying, there was great increment in peak of oleic acid (or its derivatives) while 2 spraying has specifically increased peak of 13-Octadecenal. More precisely, the long chain fatty acid (C18, 6-Octadecenoic acid) get converted to its aldehyde form during 2 spraying. In 3 spraying, there is a major peak of Cis-11-Hexadecenal, which are the by-products of spraying and transformation of oleic acid and/or Octadecenal.

b) Gingelly oil

Control shows 3 main peaks at 13.395 min, 13.804 min, and 15.892 min. In 1 sprayed, the above peaks are absent and peaks at 13.405 min and 11.712 min appeared. The peak at 13.405 min is different to the peak at 13.395 min in the control. In 2 sprayed, the above peaks are absent and peaks at 13.405 min and 11.712 min appeared. The peak at 13.405 min is different to the peak at 13.395 min in the control.

The library matches to these spectra show that the main peaks of interest mentioned above contain long chain carbon fragments. This is concordant with compounds related to long chain fatty acids such as hexadecanoic acid (palmitic acid) and octadecanoic acid (stearic acid) resulting from triglycerides in gingely oil. Though there is no major differences between the chromatograms of the 1 and 2 sprayed sample, but both sprayed samples are significantly different to the control sample showing the impact of spraying on fatty acids content in oil samples.

The control sample contains many aldehyde, ketone, heterocyclic compounds, fatty alcohol and long chain fatty acids such as Oleic acid and their derivatives. There is a great increment in the peak of oleic acid (or its derivatives). In 1 sprayed sample, additionally, 2- Ethylacridine and n-Hexadecanoic acid were found to be present which should have enhanced the inherent characters. This is the by-product occurred due to spraying i.e., transformation of oleic acid and/or Tritetracontanethe.

c) Groundnut oil

The 2 sprayed sample showed more and higher peaks than 1 sprayed sample which in turn showed more peaks than in the chromatogram of control sample. It is highly possible that the spraying applied led to the degradation of certain components in groundnut oil. The chemical compounds resulting from the degradation had an impact on the inherent characteristics of the oil, which was a favourable impact in the 1 sprayed sample due to limited degradation. It is also possible that extended spraying led to secondary degradation into chemical products that attenuated the inherent features of the oil in the 2 sprayed sample (Datta *et al*., 2014) [8].

Peak at 19.3 min has been identified by the MS library as Squalene. However, the majority of peaks have parent ion masses that range between 410 and 479 m/z. Thus, it is highly possible that most of the peaks detected in the chromatograms of sprayed samples have structures close to phytosterols and triterpen (Akhtar *et al.*, 2014) [19]. They are related to beta-Sitosterol, or its precursors such as Squalene.

d) Palm oil

Control sample contains 9-Octadecenoic acid, n-Hexadecanoic acid, cis-Vaccenic acid and other fatty acid derivatives. After 1 spraying, there was new major peak of Benzene, 1-(chloromethyl)-4-(2-propenyl and Tridecanoic acid, 2-ethyl-2-methyl-, ethyl ester. However there was reduction in peak of 9-Octadecenoic acid a typical fatty acid of Palm oil. These differences is responsible for enhancement of inherent characters in 1 sprayed sample. While 2 spraying has shown unique peak of Cinnamyl cinnamate and no peak of 9-Octadecenoic acid, a typical fatty acid of Palm oil and these attribute the reduction of inherent characters.

e) Olive oil

Control sample contains Squalene, 2, 4-Decadienal, (E, E) and other fatty acid derivatives. After 1 spraying, there was new major peak of 2-Octenal, (E) and Cinnamyl cinnamate. Additionally there was an increase in peak of Squalene. These differences is responsible for enhancement of inherent characters. On other hand, 2 sprayed sample has shown unique peak of Benzo[h]quinoline, 2, 4-dimethyl &n-Propyl 9-octadecenoate. There was reduction of Squalene peak as compared to control, hence all these attribute the reduction of inherent characters.

FTIR

a) Coconut oil

Control sample shows the important peaks due to the absorption of stretch C = O esters (CO), the flexural absorption of methylene (CH2) and methyl (CH3) groups. FTIR determined the absorption of triglyceryl due to the presence of ester molecules. In 1 sprayed, a discrete intensity increase in O-H band (3471 -3541 cm^{-1}) was observed, assigned to the formation of free fatty acids. 2 sprayed oil showed a discrete intensity increase in O-H band (3471 -3541 cm^{-1}), assigned to the formation of free fatty acids; a slight increase in the bending band CH 725 cm^{-1} (Shankar, 2017) [20]. The spectra are typical of coconut oil, samples with 1 and 2 sprayings show a slight increase of the free fatty acids and in the intermolecular arrangement in comparison with the control.

b) Gingelly oil

FTIR spectra shows typical peaks due to the absorption of stretch –O-C = O esters (CO), the flexural absorption of methylene (CH2), methyl (CH3) groups and cis -HC=CH-stretch. These absorptions are due to the presence of triglyceride. All the sprayed samples show a discrete displacement of the bands at 1658, 725 and 609 cm^{-1}, of the cis -CH = CH- functional group of the oleic acid (C18: 1 cis n-9) and linoleic acid (C18: 2cis n-6), indicating a slight intermolecular modification, compared to the control.

c) Groundnut oil

The C-H stretch indicate long chain fatty acid of groundnut oil and it was comparatively unchanged during 1 spraying, while 2 sprayed sample shows marginal increment. 2 sprayed sample also shown change for C-O bond (reduced as compared to control). The spraying has considerably changes (decreased) the labile bond of C=C suggesting the corresponding modification of inherent characters (Atkins *et al.*, 2011) [21].

d) Palm oil

One sprayed sample: Observing the FTIR spectra, no variation in the number, type, and position of bands and peaks is spotted. However, a notable increase of the transmittance is observed. This means that the concentration of the compounds giving rise to the observed peaks and bands is quite lower after 1 spraying. The explanation is that sprayed mid-IR radiation favors the evaporation of some of the components that do not contribute to the characters of the oil, causing a net augmentation in the concentration of the molecules responsible for those characters. In 2 sprayed sample: No variation in the number, type, and position of bands and peaks is spotted. Again, a notable increase of the transmittance is observed compared to the control sample. Compared to 1 sprayed sample, transmittance is slightly lower in 2 sprayed sample. This points to the fact that an excess of MIRGA irradiation lead to the loss of the molecules contributing to the inherent characters of palm oil (since many of those molecules are volatile). This could result in a small net increase in the concentration of the main components (triacylglycerides and fatty acids), that are the main contributors to the peaks and bands observed in the spectrum. For this reason, the main peaks and bands appear a little bit more intense in this sample (lower transmittance).

e) Olive oil

Control shows a band around 3032 cm^{-1} attributed to =C-H stretching. There are strong bands between 2980-2800 cm^{-1} corresponding to C-H stretching, that can be differentiated into two types: methylene (–CH_2–) C-H stretching (peak at 2930 cm^{-1}) and methyl (-CH_3) C-H stretching (peak at 2854 cm^{-1}). These groups also generate bands at 1458 and 1391 cm^{-1} (methylene and methyl, respectively), due to the bending vibrations. A very intense peak is observed around 1751cm^{-1}, attributable to the stretching of C=O bonds. Other peaks between 1500-650 cm^{-1} could be originated by deformation and bending of C-H and C-O stretching.

1 sprayed sample shows a spectrum with a significantly higher transmittance (less absorption), pointing to a decreased concentration of the compounds giving rise to the observed bands. Bands and peaks observed in this sample are quite similar in shape and position compared to the control sample.

2 sprayed sample shows a spectrum with a lower transmittance compared with the control and 1 sprayed samples. This indicates an increase in the concentration of the compounds originating the bands and peaks respect to the control and 1 sprayed samples. Bands and peaks observed in this sample are quite similar in shape and position compared to the control and 1 sprayed samples.

The number and position of the peaks and bands are almost the same. The most remarkable change is the variation in the transmittance (absorption) that is directly related to the concentration, and the appearance of a noisy region between around the peak at 1740 cm^{-1} in the 2 sprayed sample.

f) Sunflower oil

Control shows a band around 3024 cm^{-1} attributed to =C-H stretching. There are strong bands between 2980-2800 cm^{-1} corresponding to C-H stretching, that can be differentiated into two types: methylene (–CH_2–) C-H stretching (peak at 2954 cm^{-1}) and methyl (-CH_3) C-H stretching (peak at 2870 cm^{-1}). These groups also generate bands at 1442 and 1342 cm^{-1} (methylene and methyl, respectively), due to the bending vibrations. A very intense peak is observed around 1743cm^{-1}, attributable to the stretching of C=O bonds. Other peaks between 1500-650 cm^{-1} could be originated by deformation and bending of C-H and C-O stretching (intense band at 1141cm^{-1}).

1 sprayed sample shows a spectrum with a higher transmittance in the band regions (less absorption), pointing to a decreased concentration of the compounds giving rise to the observed bands. Bands and peaks observed in this sample are quite similar in shape and position compared to the control sample.

2 sprayed sample shows a spectrum with a significant lower transmittance compared with the control and 1 sprayed samples. This indicates an increase in the concentration of the compounds originating the bands and peaks respect to the control and 1 sprayed samples. Bands and peaks observed in this sample are quite similar in shape and position compared to the control and 1 sprayed samples.

Proton NMR

a) Coconut oil

Since the coconut oil is mainly made up of lauric acid C12H28O2, and there is no significant change in the chemical shift of (CH2) n (associated with saturated fats) in all samples. As can be seen in the normalized peak integral graph, with respect to the control sample, the fatty acid CH3 (associated with Oleyl and saturated chains - Linoleic chain) drops in 1 sprayed and 2 sprayed samples. But in the 3 sprayed sample this acid picks up in value. A reverse behavior is seen for the fatty acid OCO–CH2–CH2–(m) compound (associated with all acyl chains). Hence 1 and 2 sprayed samples are more favorable than the control, and 3 sprayed sample is less favorable.

b) Gingelly oil

Since the gingelly oil (sesame seed oil) is mainly made up of saturated fatty acids and oleic, and there is no significant change in the chemical shift of CH3 (associated with Oleyl and saturated chains - Linoleic chain) in all samples. As can be seen in the normalized peak integral graph, with respect to the control sample, the saturated fatty acid (CH2) n drops in the 1 sprayed and 2 sprayed samples. But in the 3 sprayed this acid picks up in value. A similar behavior is seen for the fatty acid OCO–CH2–CH2–(m) (associated with all acyl chains) and the unsaturated fatty acid CH2–CH=CH (associate with Oleic chains). All such behaviors are interpreted as to the 1 and 2 sprayed samples being more favorable than the control sample and the 3 sprayed sample being less favorable.

c) Groundnut oil

Increase in signal intensities 5.3 and 1.6 ppm, corresponding to vinyl proton HC=CH- and β-CH_2 protons of carbonyl group of CH_3O_2C-CH_2-CH_2- caused by the change of intermolecular forces close to ester group of groundnut oil.

d) Palm oil

The integral values show that variation in concentration is not very high, pointing to a small effect of the spraying on the main components of the samples.1 sprayed sample shows a general reduction of the integral values, pointing to a reduced concentration of the main components, whereas these values are partially recovered in 2 sprayed sample.

e) Olive oil

The integral values show clearly that variation in concentration is very low, pointing to a very small effect of the spraying on the main components of the samples. A slight increase in the integrals of peaks I+J could point to a higher concentration of unsaturated fatty acids.

f) Sunflower oil

The integral values show clearly that variation in concentration is very low, pointing to a very small effect of the spraying on the main components of the samples. It must be remarked here that these NMR spectra do not show signals from other minor components, which are responsible for some of the most important features of sunflower oil, such as aroma and taste which are due to the concentration of those components are too low compared with the main ones.

g) MIRGA and its action on edible oil

Invention background, definition, technique of mid-IR generation from MIRGA, toxicological study on MIRGA, safety of the MIRGA sprayed use ables and primeval and future scope of MIRGA have been described by Umakanthan *et al.*, 2022a [9] (detailed discussion on MIRGA available in supplementary text T4).

Through instrumentations, we demonstrated that the 2-6µm mid-IR coincided with the frequencies of oil and caused alterations in chemical bonds, in terms of stretching and bending to structural changes in molecular level and also evidenced the transformation of various chemical compounds (Mohan, 2004; Xu *et al.*, 2017) [22, 7]. These changes lead to oil's physicochemical changes (Yi, 2012; Atkins *et al.*, 2011) [23, 21] which enhanced the sensory attributes (Kenneth *et al.*, 2011) [24] and reduced the absorption of oil by recipes. Thus susceptibility for oil-borne diseases is averted in large. Umakanthan *et al*. (2022a) [9], Umakanthan *et al*. (2022b) [10], Umakanthan *et al*. (2023c) [25], and Umakanthan *et al*. (2023d) [26] used MIRGA spraying to obtain similar positive findings in coffee, tea, cocoa, edible salts and terminalia.

In comparison to the control, the oil that was sprayed once and heated repeatedly (four to six times) throughout recipe preparation did not become more viscous, nor did it change in colour from when it was raw. Neither did there appear to be any foaming. After spraying, the mid-IR effect on oil was observed in 1-5 minutes. Because MIRGA technology is non-ionizing, it is safe. It is also very affordable; the approximate cost to spray 500ml x 1000 packets is $1.00 USD. Spraying once is sufficient; the effects in the oil last for three to six months. Using the same technique, direct spraying on the oil surface can also be done.

Future advantages include: a) less edible oil usage, which saves money and resources; and b) less health risks.

Table 1: Sensory evaluation of edible oils based on hedonic scale

Sensory parameters	Uncooked oil			Cooked (remnant oil)			Cooked dish made of		
Coconut oil									
	Control	No. of spraying 1	No. of spraying 2	Control	No. of spraying 1	No. of spraying 2	Control oil	Oils given no. of spraying 1	Oils given no. of spraying 2
Taste	5	7	7	4	6	6	5	7	7
Aroma	5	6	7	5	6	7	5	7	8
Texture	-	-	-	-	-	-	5	7	7
Gingelly oil									
	Control	No. of spraying 1	No. of spraying 2	Control	No. of spraying 1	No. of spraying 2	Control oil	Oils given no. of spraying 1	Oils given no. of spraying 2
Taste	5	7	6	5	5	6	5	7	9
Aroma	5	6	6	4	5	7	5	8	8
Texture	-	-	-	-	-	-	5	8	8
Groundnut oil									
	Uncooked oil			Cooked (remnant oil)			Cooked dish		
	Control	No. of spraying 1	No. of spraying 2	Control	No. of spraying 1	No. of spraying 2	Control oil	Oils given no. of spraying 1	Oils given no. of spraying 2
Taste	5	6	6	5	5	6	5	8	7
Aroma	5	7	7	5	6	6	5	6	6
Texture	-	-	-	-	-	-	5	7	6
Palm oil									
	Uncooked oil			cooked (remnant oil)			Cooked dish made of		
	Control	No. of spraying 1	No. of spraying 2	Control	No. of spraying 1	No. of spraying 2	Control oil	Oils given no. of spraying 1	Oils given no. of spraying 2
Taste	5	6	7	4	6	6	5	7	9
Aroma	5	7	6	3	5	7	5	5	6
Texture	-	-	-	-	-	-	5	7	8
Sunflower oil									
	Uncooked oil			Cooked (remnant oil)			Cooked dish made of		
	Control	No. of spraying 1	No. of spraying 2	Control	No. of spraying 1	No. of spraying 2	Control oil	Oils given no. of spraying 1	Oils given no. of spraying 2
Taste	5	6	7	5	7	8	5	8	8
Aroma	5	7	7	5	6	7	5	7	7
Texture	-	-	-	-	-	-	5	9	9
Olive oil									
	Uncooked oil			Cooked (remnant oil)			Cooked dish made of		
	Control	No. of spraying 1	No. of spraying 2	Control	No. of spraying 1	No. of spraying 2	Control oil	Oils given no. of spraying 1	Oils given no. of spraying 2
Taste	5	5	6	5	6	7	5	7	7
Aroma	5	7	7	4	5	5	5	7	8
Texture	-	-	-	-	-	-	5	8	8

Table 2: Recipe preparation trial with edible oils

Sl. No.	Recipe prepared	Initial quantity used (ml)	Quantity of oil remained after cooking (ml): Control (Non-sprayed)	1 sprayed	2 sprayed	Oil saved % (1 and 2 sprayed)
Coconut oil						
1.	Potato chips	500	340	460	478	83 and 87%
2.	Urad dal vada	500	352	455	466	70 and 87%
3.	Dal vada	500	269	465	439	74 and 85%
4.	Murukku	500	345	478	462	76 and 86%
5.	Potato bajji	500	236	392	406	60 and 65%
Gingelly oil						
1.	Potato chips	500	242	400	420	62 and 69%
2.	Urad dal vada	500	345	451	478	69 and 86%
3.	Dal vada	500	296	450	462	76 and 82%
4.	Murukku	500	249	461	463	85 and 86%
5.	Potato bajji	500	260	432	465	72 and 86%
Groundnut oil						
1.	Potato chips	500	336	458	475	75 and 85%
2.	Urdal vada	500	325	457	489	86 and 94%
3.	Dal vada	500	258	432	435	72 and 74%

4.	Murukku	500	233	382	399	56 and 63%
5.	Potato bajji	500	242	404	409	63 and 65%
Palm oil						
1.	Potato chips	500	325	469	472	83 and 84%
2.	Urad dal vada	500	342	468	485	80 and 81%
3.	Dal vada	500	245	405	416	63 and 67%
4.	Murukku	500	267	402	427	58 and 69%
5.	Potato bajji	500	254	417	429	67 and 72%
Sunflower oil						
1.	Potato chips	500	364	454	471	67 and 81%
2.	Urad dal vada	500	346	470	488	81 and 93%
3.	Dal vada	500	321	465	475	81 and 87%
4.	Murukku	500	367	468	469	76 and 77%
5.	Potato bajji	500	377	450	475	60 and 80%
Olive oil						
1.	Potato chips	500	363	403	430	30 and 49%
2.	Urad dal vada	500	232	290	296	22 and 24%
3.	Dal vada	500	260	305	326	19 and 28%
4.	Murukku	500	433	473	470	60 and 64%
5.	Potato bajji	500	236	313	323	68 and 71%

Table 3: Trial with olive oil

Trial details	Initial oil weight (in gm)	Final oil weight after frying (in gm)	Color of potato chips	Taste and aroma (oil/ chips)	Frying time (in min)	Texture (chips)
Control (non-sprayed)	100	65	Dark brown	Regular	20	Hard
1 sprayed	100	83	Golden brown	Increased	10	Smooth and crispy
2 sprayed	100	96	Golden brown	Increased	10	Smooth and crispy

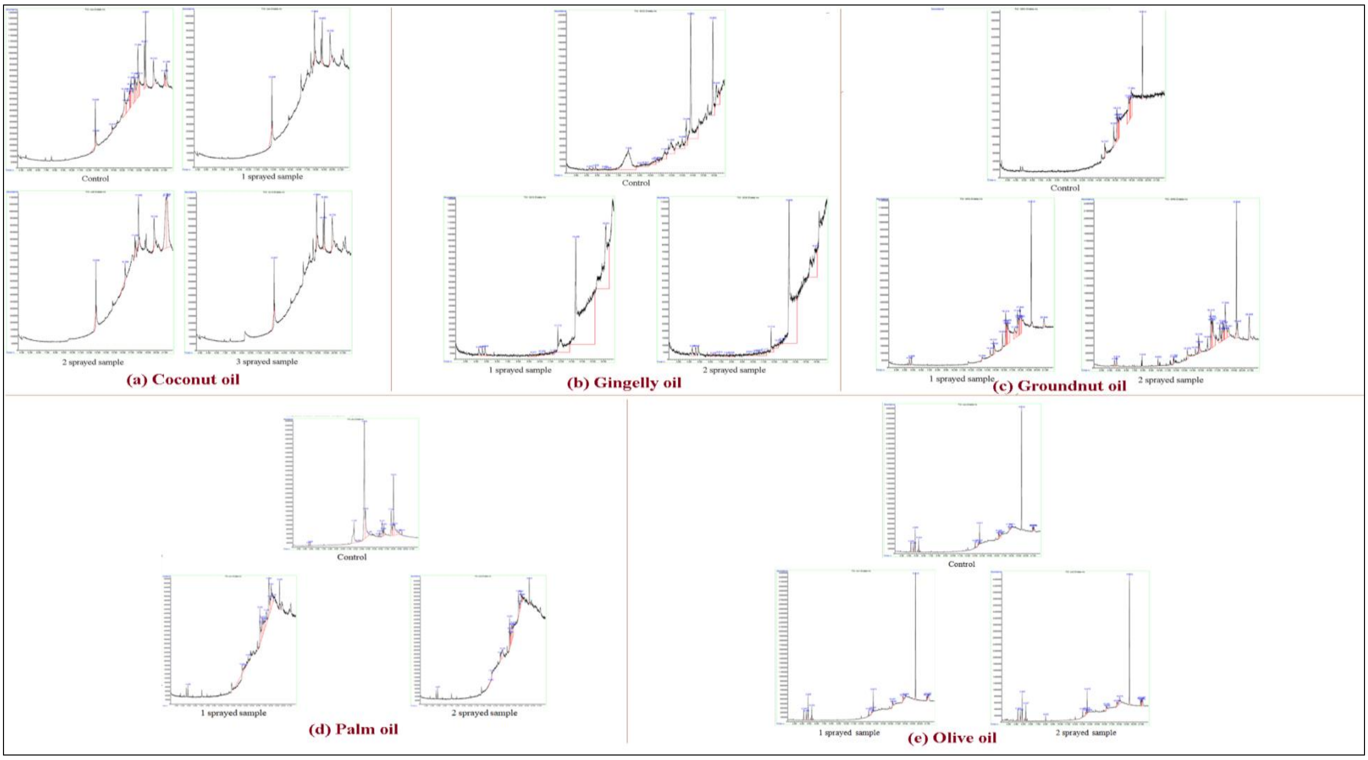

Fig 1: GC-MS of edible oils (a) Coconut oil, (b) Gingelly oil, (c) Groundnut oil, (d) Palm oil, (e) Olive oil

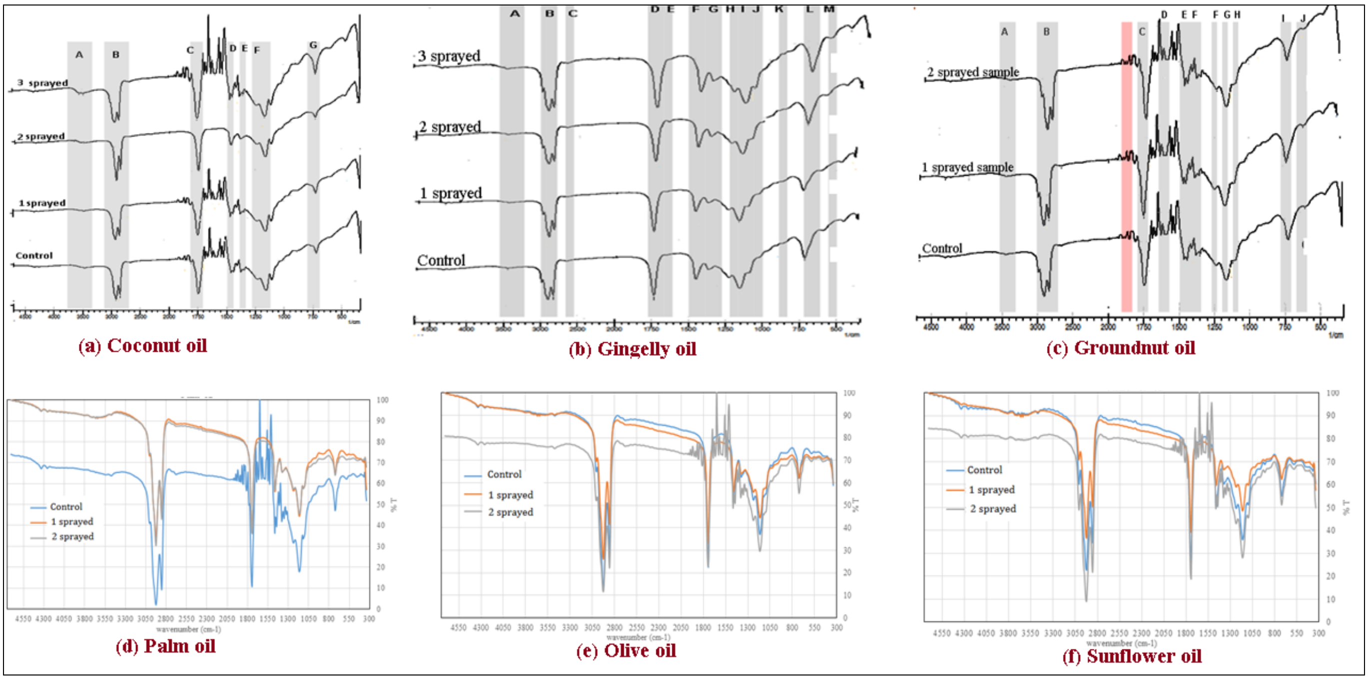

Fig 2: FTIR of edible oils (a) Coconut oil, (b) Gingelly oil, (c) Groundnut oil, (d) Palm oil, (e) Olive oil, (f) Sunflower oil

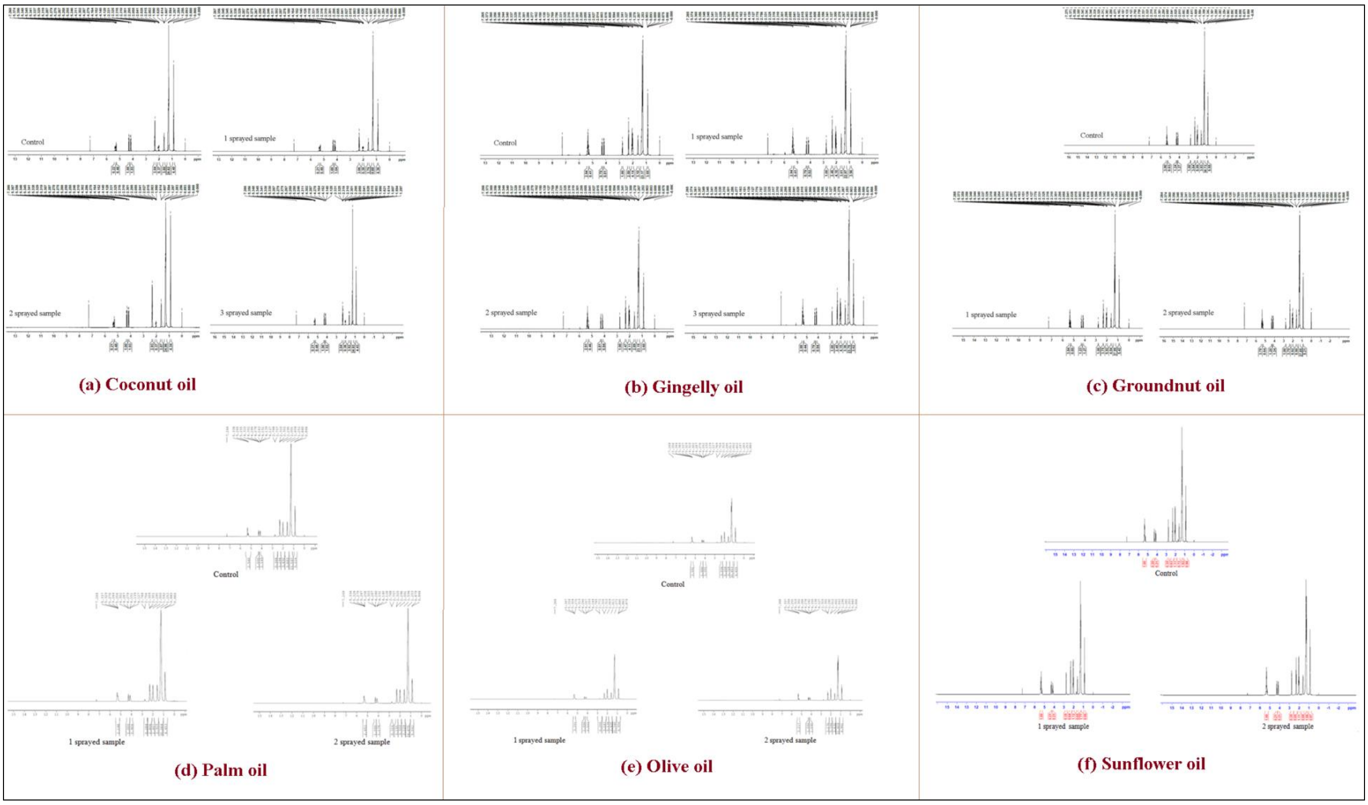

Fig 3: NMR of edible oils Coconut oil, (b) Gingelly oil, (c) Groundnut oil, (d) Palm oil, (e) Olive oil, (f) Sunflower oil

Conclusion

The six edible oils that were tested had changes in chemistry and several parameters as a result of 2–6 µm mid-infrared irradiation. As a result, resources are conserved, health risks are decreased, and recipes and oil quality are improved via frequent heating and use. Prospective investigations could open doors for the development of nutritious recipes and breakthroughs in the food, health, and oil industries. Applying mid-IR to oil seeds or plants will prevent genetic engineering from producing new oil, preserving the gene's natural state.

Author contribution

Umakanthan
Conceptualization, Methodology, Supervision, Validation.

Madhu Mathi
Data curation, Investigation, Visualization, Writing - Original draft preparation.

Umadevi
Project administration, Resources

Umakanthan, Madhu Mathi
Writing- Reviewing and Editing.

Competing interest
In accordance with the journal's policy and our ethical obligation as researchers, we submit that the authors Dr. Umakanthan and Dr. Madhu Mathi are the inventors and patentee of Indian patent for MIRGA (under-patent no.: 401387) which is a major material employed in this study.

Supplementary File
https://drive.google.com/drive/folders/1VrQZvnUcQTxS7Bc8sZZ6-U8x4QFee8Kw?usp=drive_link
All data is available in the manuscript and supplementary materials.

Funding
The authors received no specific funding for this research.

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