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# New formulation of frying oil based on sesame oil

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**ABSTRACT**

Since sesame oil has higher oxidation stability than other vegetable oils, in this research, sesame oil was added to sunflower and corn frying oils to determine the effect of adding sesame oil on preventing the production of trans fatty acids during the frequency of frying. Epidemiological evidence and case-control studies show the relationship between the intake of trans fatty acids and the risk of various diseases. In this research, in addition to investigating the effect of adding sesame oil on preventing the production of trans fatty acids, the peroxide value test was performed. For this purpose, three oil treatments were prepared from sesame, corn, and sunflower oils. The first treatment contained 33% sunflower, 33% corn, and 33% sesame; the second treatment contained 25% sunflower, 50% corn, and 25% sesame; and the third treatment contained 50% sunflower, 25% corn, and 25% sesame. The measurement of trans fatty acids and peroxide values was done according to the national standard of Iran.The results showed that the amount of trans fatty acids decreased with increasing the number of times of frying. The amount of trans fatty acids after 21 times of frying was 1.243% in the first treatment, 1.184% in the second treatment, and 1.022% in the third treatment. As a result, the third treatment was the most resistant oil mixture against the formation of trans fatty acids. In the peroxide test, the amount of peroxide value increased with increasing the number of frying times (more than 5). The best oil mixture against oxidative spoilage was the first treatment and then the second treatment.

## 1-Introduction

Heating, frying, and reusing edible oils and fats cause an isomerization reaction in the oil, during which the trans fatty acid isomer is produced from cis-unsaturated linkages [1].Trans fatty acids are unsaturated fatty acids containing a non-conjugated carbon-carbon double bond in the trans configuration. **[2]**.

Epidemiological studies[1]It has been shown that excessive consumption of trans fatty acids increases cholesterol levels.LDL [2]and lipoproteinAand reduces the concentration levelHDL[3]They get into the blood **[**2 and 3**]**.Kamro et al. (2004) have shown that consumption of trans fats prevents the metabolic conversion of linoleic acid to arachidonic acid and other polyunsaturated fatty acids.(PUFAs[4])Prevents, which is a risk factor for developing coronary heart disease**[4]**It is reported that the consumption increase is 2%.TFA[5]Increases the risk of cardiovascular disease by 23%.**[5]**.Due to the adverse effects of excessive consumptionTFAsOn health, some countries, with the aim of informing consumers, place contentTFAsThey suggested processed foods on the label.**[6]**.A systematic review from 1980 to 2012 showed that mandatory food labeling laws indicating the amount of trans fatty acids in a food and limitingTFAIn food, it can cause a decreaseTFAsReal and reported in food, it also reduces the availability of food sources and seems to encourage food manufacturers to reformulate their products. **[7]**.

Formation rateTFAs When frying, it depends on the frying temperature, the number of times you fry, and whether or not you add fresh oil. Increasing the temperature and frying time increases the formation ofTFAs Therefore, in some European countries it is recommended that frying temperatures, whether on an industrial or small scale, do not exceed 180 degrees Celsius. [1]. AlsoTFAsThey are found naturally in many foods, such as meat and dairy, at low levels. AlthoughTFAsThey cannot be completely eliminated from food sources, but their levels can be reduced.TFAsreduced industrial. Worldwide, guidelines indicate that consumptionTFAshould be limited to less than 1% to 2% of total dietary energy [8 and 9].Given the formation of trans fatty acids due to heating oil at high temperatures and the harmful effects of consuming trans fatty acids on human health, it is necessary to reduce the production of trans fatty acids in oil at high temperatures.

Sesame seed oil has a higher oxidation stability than other vegetable oils, which is not only related to the antioxidant activities of its intrinsic lignans and tocopherols, but also attributed to the products produced by the browning reaction during sesame seed roasting. Lignans in sesame seed oil can be divided into two categories, namely intrinsic lignans, which include sesamin, sesamolin, and lignans that are mainly formed during the oil production process, which include sesamol, sesaminol, etc. The most abundant tocopherol in sesame seed oil is gamma-tocopherol. Due to the presence of these phenolic compounds in sesame seed oil, this oil acts in a way that prevents oxidation. [10].A study showed that sesamol (found in sesame oil) and resveratrol, an exogenous antioxidant, had a specific inhibitory effect on the formation of isomerization products in peanut oil heated to 180°C. [11].The purpose of this study is to investigate the effect of adding sesame oil to frying oils to prevent the formation of trans isomers during the frying process. In this study, in addition to the aforementioned study, we investigated the

1- Epidemiological

2- Low - density lipoprotein

3-High - density lipoprotein

4- Polyunsaturated fatty acids

5- Trans Fatty Acids, TFAs

effect of adding sesame oil to frying oils on peroxide value.

## 2- Materials and methods

### 2-1- Methods

#### 2-1-1- Formulation of frying oils

Initially, sesame, corn and sunflower oils were purchased from the market, then 3 oil treatments were prepared using different amounts of sesame, corn and sunflower oils. According to Table 1, the research treatments were obtained for all three independent variables (in values of 0 to 100%). Each treatment was fried for three days without adding fresh oil. The frying process was performed seven times per day. In fact, in each frying process, 100 grams of frozen half-fried potatoes were fried in it (7 series per day). The time interval between each frying process was 00:45 minutes. In total, the frying process took 5:30 hours per day. Frying each oil at a temperature of 5±180 degrees Celsius; at the end of each day, the oil remaining in the fryer was filtered by sieve, then sampled for tests related to determining the trans fatty acid profile and the test Peroxide number should be done on them.

**Table 1. Research treatments**

| Run | Sesame | Corn | Sunflower |
|---|---|---|---|
| 1 | %33.33 | %33.33 | %33.33 |
| 2 | %25.0 | %50.0 | %25.0 |
| 3 | %25.0 | %25.0 | %50.0 |

#### 2-1-2 - Measurement of trans fatty acids in frying oils

MeasurementTFAsIn frying oils, according to the Iranian National Standard No. 13126-2 and 13126-4, gas chromatography was performed [12 and 13]. Tests related to determining the trans fatty acid profile were performed at the end of the first day, at the end of the second day, and at the end of the third day after frying on the treatments. All measurementsTFAIn frying oils by machineGC[6]It was carried out at Pars Minoo Industrial Company.

#### 2-1-3-Measuring peroxide value in frying oils

Peroxide value measurement in frying oils was carried out according to Iranian National Standard No. 4179. [14]**.** Peroxide value test was performed on the treatments at the end of the first day, at the end of the second day, and at the end of the third day after frying.

#### 2-1-4- Determining the characteristics of primary oils

In order to compare the behavior of the raw oils with the treatments, all raw oils were initially sampled. Then, all raw oils, like the treatments, were fried seven times per day for three days. At the end of each day, samples were also taken from them. Finally, fatty acid profile and peroxide value tests were performed on all samples.

### 2-2- Materials

The consumables in this experiment are presented in Table 2 and the non-consumables in this experiment are presented in Table 3.

6-GC, Gas Chromatography

**Table 2, consumables**

| Manufacturer company-Country | Type of consumable |
|---|---|
| Saman/ Iran | **Pure sesame oil** |
| Zar-oil/ Iran | **Pure corn oil** |
| Varamin/ Iran | **Pure sunflower oil** |
| Dr. Mojallali/ Iran | **Glacial Acetic acid** |
| Dr. Mojallali/ Iran | **N-Hexane** |
| Dr. Mojallali/ Iran | **Potassium Iodide** |
| Dr. Mojallali/ Iran | **Sodium thiosulfate pentahydrate** |
| Merck/ Germany | **starch solution** |
| AskingIndividual quick frozen French fries/ Iran | **Individual Quick Frozen French Fries** |

**Table 3, non-consumable materials**

| Model/company/country | Device name |
|---|---|
| Gas Chromatography Younglin ACME 6100/ South Korea | **Gas chromatography device** |

## 3- Data from the research

### 3-1- Data from Trans Fatty Acid Measurements

Measurement dataTFAIn the first, second and third treatments, after 7 frying times, after 14 frying times and after 21 frying times, it is presented in graphs 1, 2 and 3.

Figure 1 shows the data from the measurement of trans fatty acids in the first treatment, after 7 frying times, after 14 frying times, and after 21 frying times.

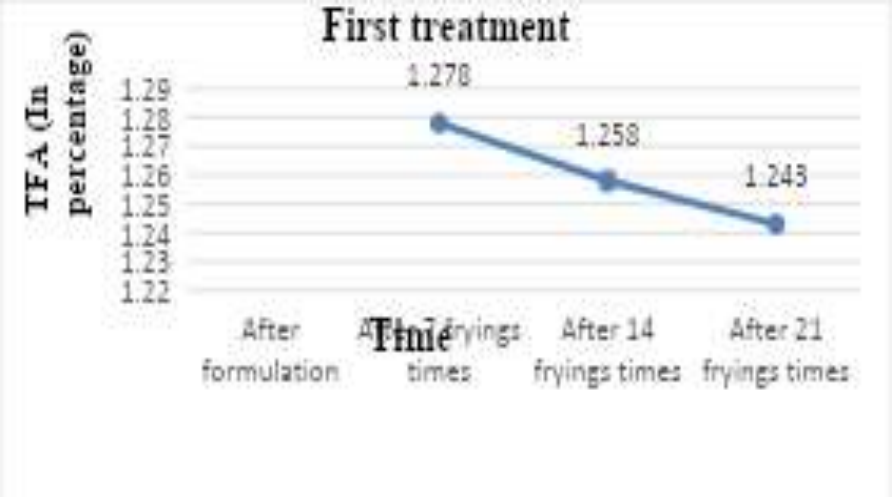


**Chart 1. Graph of the amount of trans fatty acids in the first treatment**

**First treatment: (mixed frying oil: 33% sunflower, 33% corn, 33% sesame)**

Chart 2The data from the measurement of trans fatty acids in the second treatment show that at the end of the first day, the end of the second day, and the end of the third day after frying.

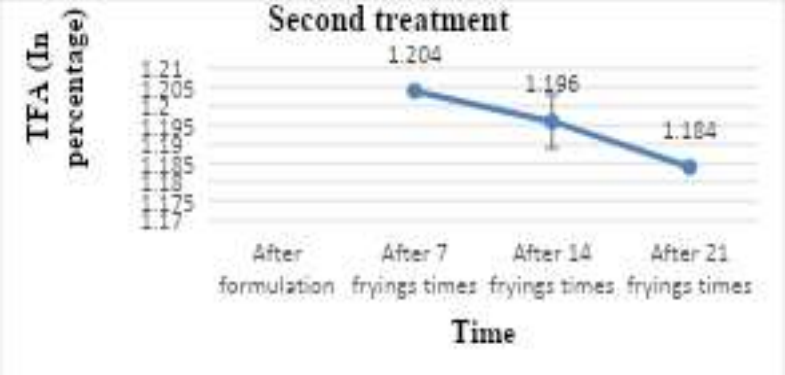


**Chart 2. Graph of the amount of trans fatty acids in the second treatment**

**Second treatment: (mixed frying oil: 25% sunflower, 50% corn, 25% sesame)**

Chart 3The data from the measurement of trans fatty acids in the third treatment shows the levels at the end of the first day, the end of the second day, and the end of the third day after frying.

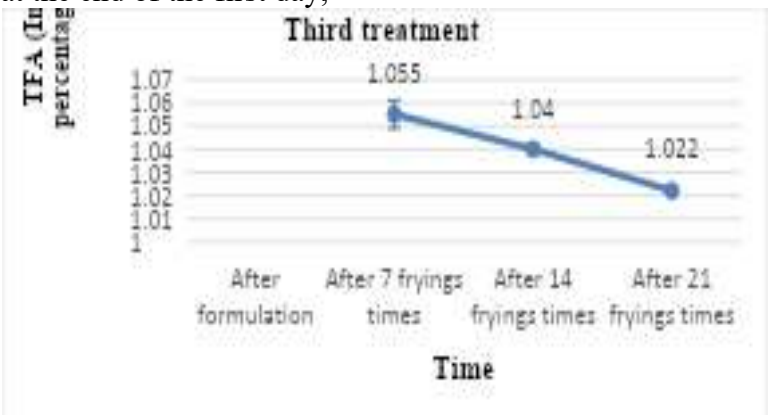


**Chart 3. Graph of trans fatty acids in the third treatment**

**Third treatment: (mixed frying oil: 50% sunflower, 25% corn, 25% sesame)**

### 3-1-4The overall results obtained from examining the amount ofTFA In the first, second and third treatments

As shown in graphs (1, 2 and 3), the amount of trans fatty acids decreases with increasing number of frying cycles. That is, the amount of trans fatty acids in the oil after 21 frying cycles is lower than the amount in the oil after 7 frying cycles. The highest amount of trans fatty acids was related to the first treatment (1.243%), and the lowest was related to the second treatment (1.184%) and the third treatment (1.022%). From these results, it can be concluded that the second treatment, which contains 25% sunflower, 50% corn and 25% sesame, and the third treatment, which contains 50% sunflower, 25% corn and 25% sesame, show greater resistance to the formation of trans fatty acids than the first treatment. The data obtained from the measurement of trans fatty acids in pure sesame, corn and sunflower oils, for crude oils, on the first and third day after frying, are presented in Figures 4, 5 and 6 (for brevity, the figures are omitted).GCWe have avoided.

Chart4 shows the data obtained from the measurement of trans fatty acids (in percent) in sunflower oil, in the crude oil, at the end of the first day and at the end of the third day after frying.

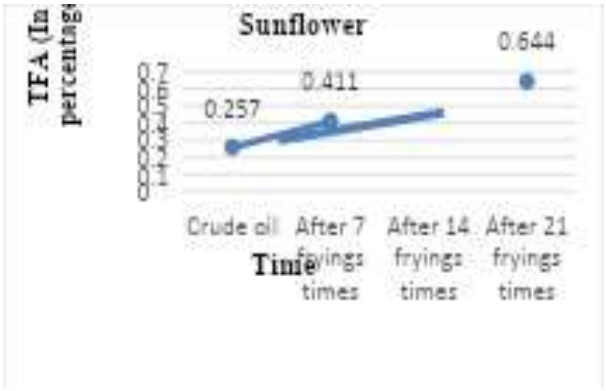


**Chart 4. Graph of the amount of trans fatty acids in sunflower oil**

Chart 5Data from the measurement of trans fatty acids in corn oil, in crude oil, at the end of the first day and at the end of the third day after frying.

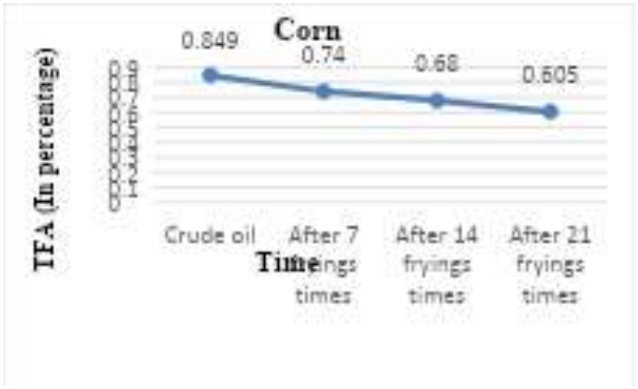


**Chart 5. Graph of trans fatty acids in corn oil**

Chart6 shows the data from the measurement of trans fatty acids in sesame oil, in the crude oil, at the end of the first day and at the end of the third day after frying.

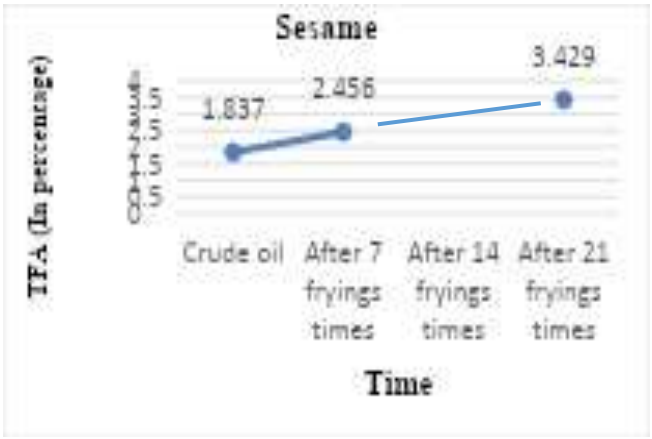


**Chart 6. Graph of the amount of trans fatty acids in sesame oil**

### 3-1-8 - General conclusion from the study of the amount of trans fatty acids in primary oils

As shown in graphs (4, 5, and 6), the amount of trans fatty acids in sunflower and sesame oil increases with increasing number of frying times (21 times), but the amount of trans fatty acids in corn oil decreases with increasing number of frying times. The amount of trans fatty acids in corn oil after 21 frying times is 0.605%, while this amount is 0.644% in sunflower oil and 3.429% in sesame oil. The decreasing trend in the formation of trans fatty acids in corn oil indicates that corn oil is more resistant to the formation of trans fatty acids than sunflower and sesame oils. After corn oil, sunflower oil,The oil is resistant to the formation of trans fatty acids.

## 3-2- Results from the peroxide test

### 3-2-1- Results of the peroxide test in treatments

The data from the peroxide test in the first, second, and third treatments, after formulation, at the end of the first day, the end of the second day, and the end of the third day after frying, are presented in Figure (7).

Graphs from the peroxide test in the first, second, and third treatments:

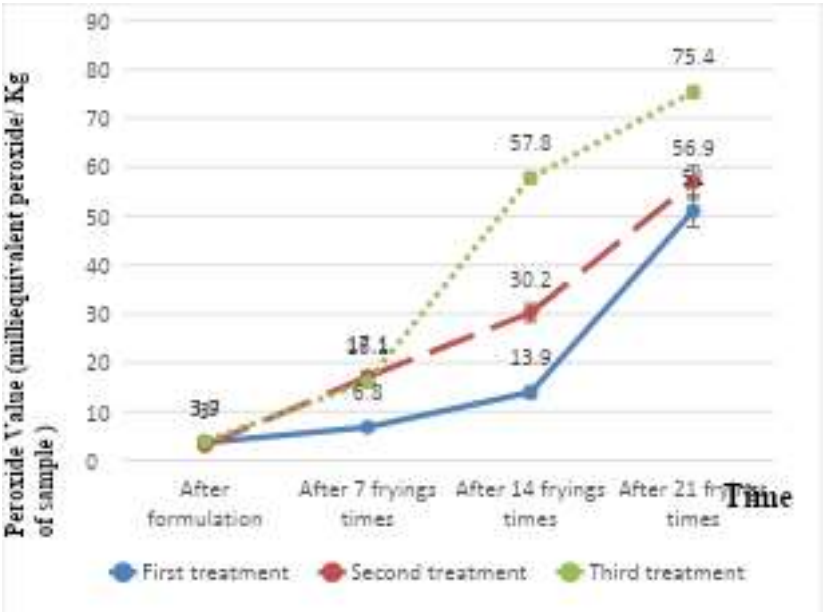


**Chart 7. Peroxide value graph in the first, second and third treatments**

**First treatment: (mixed frying oil: 33% sunflower, 33% corn, 33% sesame)**

**Second treatment: (mixed frying oil: 25% sunflower, 50% corn, 25% sesame)**

**Third treatment: (mixed frying oil: 50% sunflower, 25% corn, 25% sesame)**

As shown in the graphs above, the peroxide value increases with the number of frying cycles. After 21 frying cycles, the peroxide value was 51 in the first treatment, 56.9 in the second treatment, and 75.4 milliequivalents of active oxygen per gram of sample in the third treatment.

Overall, the results showed that the first treatment, which contained 33.33%

sunflower, 33.33% corn, and 33.33% sesame, and the second treatment, which contained 25% sunflower, 50% corn, and 25% sesame, showed greater resistance to oxidative spoilage than the third treatment.

### 3-2-2- Results from peroxide test in primary oils

The data from the peroxide test in pure sunflower, corn and sesame oils, for crude oil, after 7 frying times, after 14 frying times and after 21 frying times, are presented in Figure (8).

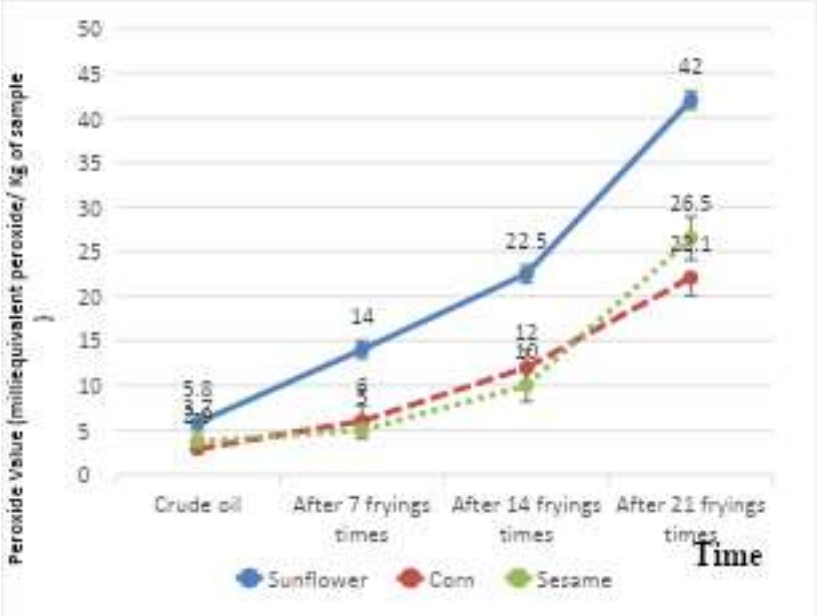


**Chart 8. Peroxide value in graph sunflower, corn and sesame oil**

As shown in the graphs above, the peroxide value increases with the number of frying cycles. After 21 frying cycles, the peroxide value was 42 in sunflower oil, 22.1 in corn oil, and 26.5 in sesame oil. Overall, the results showed that corn and sesame oils were more resistant to oxidative deterioration than sunflower oil.

## 4- Discussion and conclusion

### 4-1- Discussion

The amount of trans fatty acids at the end of the first day in the first treatment was 1.278%, in the second treatment was 1.204%, and in the third treatment was 1.055%. After 21 frying times, the amount of trans fatty acids at the end of the third day in the first treatment was 1.243%, in the second treatment was 1.184%, and in the third treatment was 1.022%. The findings obtained from the measurement of trans fatty acids in the treatments showed that the amount of trans fatty acids decreases with increasing number of frying times. That is, the amount of trans fatty acids in the oil after 21 frying times is less than its amount in the oil after 7 frying times. As mentioned in the introduction, heating, frying, and reusing edible oils and fats causes an isomerization reaction in the oil, during which the trans fatty acid isomer is produced from cis-unsaturated bonds. [1]. Therefore, it was expected that the amount of trans fatty acids in the food would increase with increasing frying times, but the decreasing trend in the amount of trans fatty acid formation in the treatments raised a debate as to whether the high number of frying times causes the breakdown of trans fatty acids? Or, is the trans fatty acid absorbed into the food (potato with starchy structure) during the high number of frying times?

To answer this question, pure sesame, corn, and sunflower oils were fried without potatoes for three days (21 times), and samples were taken from the crude oils at the end of the first and third days, and their trans fatty acid levels were measured by the device.GCwas investigated. The results of measuring trans fatty acids in pure sesame, corn and sunflower oils, in crude oils and on the third day after frying were as follows; The levels of trans fatty acids in pure sunflower, corn and sesame oils in crude oil were 0.257%, 0.849% and 1.837%, respectively. At the end of the third day after frying, the levels of trans fatty acids in pure sunflower, corn and sesame oils were 0.644%, 0.605% and 3.429%, respectively.

In this experiment, the amount of trans fatty acids in sunflower and sesame oils increased with increasing frying times, but the amount of trans fatty acids in corn oil decreased with increasing frying times. The decreasing trend in the rate of trans fatty acid formation in corn oil indicates that this oil is more resistant to trans fatty acid formation than sunflower and sesame oils.

The increasing trend of trans fatty acid formation in sunflower and sesame oil indicates that trans fatty acid is absorbed into the food (potato with starchy structure) during high frying times. As a result, trans fatty acid is not broken down during high frying times.

Numerous studies have been conducted by researchers regarding the formation of trans fatty acids during frying.took place, for example:In the year (2023) Manzooret al. investigated the effect of food type, oil type (soybean oil and mustard oil), and frying frequency on the formation of trans fatty acids in frying oils and in fried foods. When fish fillets were fried in soybean oil, the amount ofTFAThe first and third times after frying were 2.56% and 3.29%, respectively, and when the fish fillet was fried in mustard oil, the amountTFAThe first and third times after frying were 2.38% and 3.15%, respectively. The results showed that the amountTFAIn fish fillets, the number of frying times increases, as does the amount ofTFAAfter frying in soybean oil, it is higher than in mustard oil. Therefore, the composition of a food and the fatty acid composition of an oil play a key role in the formationTFAduring deep frying [17].

In the present study, the amount of trans fatty acids in pure oils increased with increasing number of frying times. Also, in the studyManzooret al. stated that the fatty acid composition of an oil plays a key role in the formation of trans fatty acids. This point is consistent with the present study, because in the present study, the amount ofTFAAfter 21 frying cycles, it increased in two pure oils: sunflower and sesame, but it decreased in corn oil.

In the year (2024)Addoet al. conducted a case study on green banana chips sold within the Accra metropolitan area to investigate the factors affecting the occurrence of trans fatty acids in fried foods. Banana chips are produced using the deep frying method. In this study, 120 banana chips samples were statistically obtained from manufacturers and vendors in the Accra metropolitan area and the total fat concentration and the amount of trans fat were determined.TFAIn addition, a comprehensive survey of 30 people who produced commercial banana chips was conducted through interviews. The fat content of banana chips ranged from 26gUp to 30gIn 100gand concentrationTFABetween 1.41gUp to 2.88gIn 100gFat and 0.41gUp to 0.78gIn 100gFood items varied. Approximately 97% of commercial banana chip producers admitted to using an oil 4 or more times before discarding it. The results showed that oil reuse was a factor in the occurrence ofTFAIt is between meals [18].

ResearchAddoet al. is consistent with the present study. Reuse of edible oils as an effective factor in the occurrence ofTFAIt is.

of theYear (2024)Largeet al. investigated the thermal stability of vegetable oils enriched with omega fatty acids during frying. The aim of this study was to evaluate changes in fatty acid composition and the formation of harmful compounds, such as:$TFA_s$In this study, various commercially available vegetable oils containing omega-3, omega-6 and omega-9 fatty acids, such as high oleic sunflower oil, rapeseed oil and formulated oils containing two oils (high oleic sunflower and rapeseed) in different proportions, were investigated during different frying cycles at temperatures between 180 and 230°C. The data from the study showed a significant degradation of polyunsaturated fatty acids.($PUFA_S$)and an increase in saturated fatty acids($SFA_S$) It also showed that the higher the number of frying times, the higher theTFAThe findings of the study indicated that different oils had different thermal stability. For example, high oleic sunflower oil and formulated oils (a blend of sunflower oil and rapeseed oil) showed higher thermal stability than regular sunflower oil [19].

ResearchLargeet al. is consistent with the present study. In the present study, increasing the number of frying times increased the amount ofTFAIn addition, the findings from the researchLargeet al., stated that different oils had different thermal stability, in the present study also different oils had different thermal stability. For example: corn oil compared to sesame and sunflower oil.

In the year (2023)Thatet al. studied the effect of resveratrol on inhibiting the production of heat-induced trans fatty acids in peanut oil. The results showed that the amount of resveratrol decreased with increasing temperature and excessive temperature caused its complete destruction. Resveratrol significantly inhibited the formation of$TFA_S$It is in peanut oil and the total inhibition rate$TFA_S$It decreased with increasing temperature [20].

Considering that consuming trans fatty acids is harmful to health, their formation should be prevented, researchThatet al. present a suitable method for inhibiting the production of trans fatty acids.

In the year (2022)Bhatet al. conducted a systematic review to investigate the effect of heat on the formation of trans fatty acids in edible oils during cooking. The results showed that heating the oils at normal cooking temperatures ($\geq$200°C) has the least effect on productionTFAhas, while a further increase in the amountTFAThe whole was observed with prolonged heating at 200 to 240 degrees Celsius.[21]. In the present study, the rate of trans fatty acid formation increased with increasing number of frying times in pure oils without potatoes.

## 4-2- Conclusion

In the study of the formation of trans fatty acids during frying, the third and second treatments showed greater resistance to trans fatty acid formation than the first treatment. The level of trans fatty acids at the end of the third day after frying was 1.243% in the first treatment, 1.184% in the second treatment, and 1.022% in the third treatment. Overall, the results showed that the best oil mixture in terms of resistance to trans fatty acid formation was the third treatment, which contained 50% sunflower, 25% corn, and 25% sesame. After the third treatment, the second treatment oil was resistant to trans fatty acid formation. The second treatment contained 25% sunflower, 50% corn, and 25% sesame.

In the peroxide test, the best mixture against oxidative spoilage was the first treatment, followed by the second treatment. The first treatment contained 33% sunflower, 33% corn, and 33% sesame. The trans fatty acid content in the pure sunflower, corn, and sesame oils, which were in raw form, was

0.257%, 0.849%, and 1.837%, respectively.The amount of trans fatty acids in corn oil after 21 frying times is 0.605%, while this amount is 0.644% in sunflower oil and 3.429% in sesame oil.The decreasing trend in the rate of trans fatty acid formation in corn oil indicates that this oil is more resistant to trans fatty acid formation than sunflower and sesame oils.Of course, considering that the amount of trans fatty acids in sunflower oil after frying 21 times is 0.644% and this amount in sesame oil is 3.429%, it can be said that sunflower oil shows greater resistance to the formation of trans fatty acids than sesame oil. In oxidation index tests,Corn oil is more resistant than other primary oils.

## 5-Resources


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مقاله علمی_پژوهشی

# فرمولاسیون جدید روغن سرخ کردنی بر پایه‌ی روغن کنجد

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**چکیده**

از آن جا که روغن کنجد پایداری اکسیداسیون بالاتری نسبت به سایر روغن‌های گیاهی دارد، در این تحقیق روغن کنجد به روغن‌های سرخ کردنی آفتابگردان و ذرت افزوده شد تا تاثیر افزودن روغن کنجد را بر جلوگیری از تولید اسید چرب ترانس در طی تعداد دفعات بالای سرخ کردن، مورد بررسی قرار گرفته شود. شواهد همه‌گیری شناسی و مطالعات مورد شاهدی ارتباط بین میزان دریافت اسیدهای چرب ترانس و خطر بیماری‌های مختلف را نشان می‌دهد. در این تحقیق، علاوه بر بررسی تاثیر افزودن روغن کنجد بر جلوگیری از تولید اسید چرب ترانس، آزمون عدد پراکسید انجام شد. بدین منظور، تعداد ۳ تیمار روغن، از روغن‌های کنجد، ذرت و آفتابگردان تهیه شد. تیمار اول حاوی ۳۳٪ آفتابگردان، ۳۳٪ ذرت و ۳۳٪ کنجد، تیمار دوم حاوی ۲۵٪ آفتاب‌گردان، ۵۰٪ ذرت و ۲۵٪ کنجد و تیمار سوم حاوی ۵۰٪ آفتابگردان، ۲۵٪ ذرت و ۲۵٪ کنجد بود. اندازه گیری اسیدهای چرب ترانس و عدد پراکسید طبق استاندارد ملی ایران، انجام شد. نتایج نشان داد میزان اسیدهای چرب ترانس با افزایش تعداد دفعات سرخ کردن کاهش می‌یابد، میزان اسیدچرب ترانس پس از ۲۱ بار سرخ کردن در تیمار اول ۱.۲۴۳٪، در تیمار دوم ۱.۱۸۴٪ و در تیمار سوم ۱.۰۲۲٪ بود. در نتیجه تیمار سوم مقاوم ترین مخلوط روغن در برابر تشکیل اسید چرب ترانس بود. در آزمون پراکسید میزان عدد پراکسید با افزایش تعداد دفعات سرخ کردن، افزایش یافت (بیشتر از عدد ۵)، بهترین مخلوط روغن در برابر فساد اکسیداتیو تیمار اول و سپس تیمار دوم بود.