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Using Magnetic Levitation to Identify Types of Iranian Cooking Oils Based on Density

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ABSTRACT

Public health is significantly affected by the consumption of impure edible oils and the repeated reuse of cooking oils. Although traditional analytical techniques, such as gas chromatography and high-performance liquid chromatography, offer high precision, their reliance on complex and costly instrumentation limits their application outside laboratory settings. This study introduces an accessible and cost-effective analytical approach based on magnetic levitation (Maglev) for evaluating oil quality and detecting impurity in Iranian edible oils, including Kermanshahi animal fat and olive oil. The technique exploits density variations among oil samples to establish their levitation equilibrium in a paramagnetic fluid, enabling simple visual differentiation. To validate the performance of the Maglev method, controlled adulteration of Kermanshahi animal fat was carried out using graded concentrations of bovine fat, industrial hard fats, and semi-solid oils. In addition, the capability of the system to distinguish pure olive oil from industrial liquid oils was investigated. The experimental results demonstrate that the Maglev technique reliably detects impurities and provides semi-quantitative estimates of oil purity. The system is characterized by its simplicity and portability, requires no electrical power, and uses minimal components—specifically two permanent magnets and a paramagnetic solution. These features make Maglev a promising tool for on-site quality control, food safety monitoring, rapid contamination screening, and prevention of adulteration in regions with limited technical infrastructure.

1- INTRODUCTION

Traditional edible oils, particularly Kermanshahi animal fat and homemade olive oil, are among the most widely consumed and nutritionally valuable foods in the Iranian diet [1]. These oils are important not only for nutrition but also culturally and economically. Due to their popularity, limited production capacity, and high market value, they are vulnerable to adulteration, contamination, and counterfeit products. Common practices include blending with lower-cost oils, adding synthetic flavoring agents, or mislabeling refined oils as virgin or traditional varieties [2]. Reliable analytical methods are therefore essential to verify authenticity, detect fraud, protect public health, and support legitimate producers.

Currently, techniques such as gas chromatography (GC), gas chromatography–mass spectrometry (GC-MS), high-performance liquid chromatography (HPLC), and nuclear magnetic resonance (NMR) spectroscopy are standard tools for oil quality control and authenticity assessment [3–14]. Although highly accurate and reliable, these methods are often impractical for field use due to operational complexity, high equipment costs, lengthy procedures, and the need for trained personnel.

Given the widespread nature of oil adulteration and the importance of consumer health, simple, rapid, low-cost, and portable methods are needed for on-site detection. Magnetic levitation (Maglev) is an innovative approach that determines density by measuring the equilibrium position of diamagnetic objects in a paramagnetic medium [15,16]. Its low cost, ease of use, portability, and visually interpretable results have made it a powerful tool in areas such as separation, self-assembly, forensics, quality control, food safety, and biosensing [17]. Recently, Maglev has been applied in nondestructive quality control of polymeric materials and in evaluating the nutritional characteristics of food products [18,19].

Unlike previous studies that applied MagLev for general food analysis [4,5], this study specifically targets Iranian edible oils, including Kermanshahi animal fat and homemade olive oil, and provides detailed calibration curves for impurity quantification. This adaptation enables a simple, rapid, and reliable method suitable for on-site applications in environments with limited technical infrastructure. Since density is a key physical property distinguishing pure from impure oils, MagLev can detect even minor changes in sample density, allowing authenticity and purity assessment without sophisticated instruments or large sample volumes [20,21]. Therefore, this method can serve as a complementary, rapid preliminary screening tool alongside conventional techniques such as chromatography and spectroscopy, especially in field or low-resource settings [22].

2- Materials and Methods

2.1. Materials

Two neodymium magnets (NdFeB) with N42 grade, magnetic field strength of 0.3 Tesla and dimensions of 25×50×50 mm were purchased from Caspian Magnet Engineering Company (Iran) (Figure 1). Manganese(II) chloride tetrahydrate ($MnCl_2 \cdot 4H_2O$) and methanol were purchased from Merck. Pure animal fat oil

(Kermanshahi oil) was extracted from animal butter. Various edible oils, including solid and semi-solid oils from Oila, Highly, and Khazar brands, as well as solid and liquid oils from Ladan Company, were used. In addition, two types of olive oil (industrial and homemade, both pure) were prepared. Animal fat was also extracted from bovine tallow. A water bath was used to heat the solutions and oils. This step continued until the oil within the solution remained as a liquid droplet. As the experiment was conducted during the cold season, the water bath was maintained until the temperature reached 25°C. This process took approximately 5 minutes. To measure the levitating height of the oil droplet, a single drop of the oil sample was added to the optimized solution, and the container was placed between the two magnets of the MagLev device. Using a ruler mounted vertically on the device, the floating height of the droplet was measured and photographed.

2.2. Devices

The experimental setup comprised two identical NdFeB magnets positioned with like poles facing each other, and a transparent container filled with a paramagnetic solution (Figure 1). A vessel filled with a paramagnetic solution of manganese(II) chloride tetrahydrate ($MnCl_2 \cdot 4H_2O$) is placed between two neodymium (NdFeB) magnets with dimensions of 25×50×50 mm. The magnets are vertically aligned with like poles facing each other and mounted at a distance of 45 mm apart. The phenomenon of magnetic levitation of a drop of cooking oil, suspended in the solution, is a result of the balance between gravitational and magnetic forces. The magnetic force (Fm) generated by the magnetic field and the gravitational force (Fg) acting on the diamagnetic sample are described as follows. The sample reaches its equilibrium position when the net force acting upon it is zero, i.e.:

$$\vec{F}m = ((Xs - Xm)/\mu_0)V(\vec{B} \times \vec{\nabla})\vec{\beta} \quad (1)$$

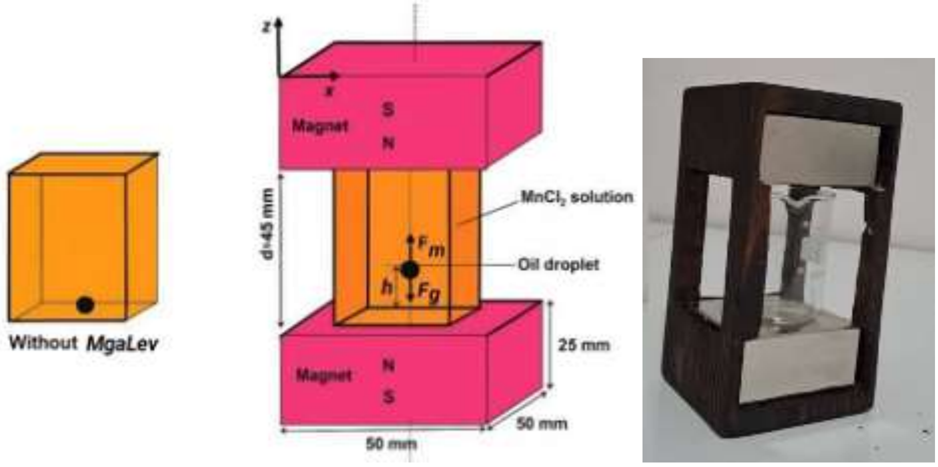
$$\vec{F}g = (\rho_s - \rho_m)\ V\vec{g} \quad (2)$$

$$\vec{F}m + \vec{F}g = (\rho_s - \rho_m)\ V\vec{g} + \left(\frac{Xs - Xm}{\mu_0}\right)V\left(\vec{B} \times \vec{\nabla}\right)\vec{\beta} = 0 \quad (3)$$

Where X_s and X_m are the magnetic susceptibilities of the diamagnetic sample and the paramagnetic solution, respectively; μ_0 is the magnetic permeability of free space; V is the volume of the sample; $\vec{B}$ is the magnetic flux density; ρ_s and ρ_m are the densities of the diamagnetic sample and the paramagnetic solution, respectively; and $\vec{g}$ is the gravitational vector [4, 23]. These two forces only balance each other along the central axis. From Equation (3), it can be inferred that the levitation height of the sample is linearly correlated with its density.

$$h=\frac{(\rho_s-\rho_m)\ \vec{g}\mu_0 d}{(Xs-Xm)4{\beta_0}^2}+\frac{d}{2} \quad (4)$$

This relationship is described by Equation (4), where B_0 denotes the maximum magnetic flux density along the central axis of the device, and d represents the distance between the two magnets.



a b

Fig. 1: ***(a)*** *Schematic of the magnetic levitation (MagLev) system and* ***(b)*** *a sample of Maglev fabricated in our laboratory*

3- Results and Discussion

3.1. Detection method

Since the test sample in this experiment is a droplet of oil, the paramagnetic solution must be chemically inert and must not dissolve the oil. For this purpose, the paramagnetic solution was prepared by dissolving manganese(II) chloride tetrahydrate ($MnCl_2 \cdot 4H_2O$) in a mixture of water and methanol, and the oil droplet was added to observe its levitation. To determine the optimal composition, experiments were conducted with different concentrations of $MnCl_2 \cdot 4H_2O$. Three concentrations were tested: 1 M, 0.4 M, and 0.2 M. In the 1 M solution, the oil droplet levitated at the highest position, approximately 41 mm from the bottom of the container. In the 0.4 M solution, the levitation height decreased to 35 mm. In the 0.2 M solution, the oil droplet also remained suspended, but at a lower height. Figure 2 shows the relationship between $MnCl_2 \cdot 4H_2O$ concentration and the levitation height of the oil droplet. As illustrated in the graph, the equilibrium height of the oil droplet increases approximately linearly with the concentration of the paramagnetic solution. The fitted line ($y = 1.0962x + 2.9154$) and the high R^2 value (0.9918) confirm a strong correlation between solution concentration and levitation height. After analysing the results, the concentrations were optimized to ensure that all oil samples could be levitated. Ultimately, the 0.2 M concentration was selected as the lowest concentration that still maintained the ability to fully levitate oil droplets.

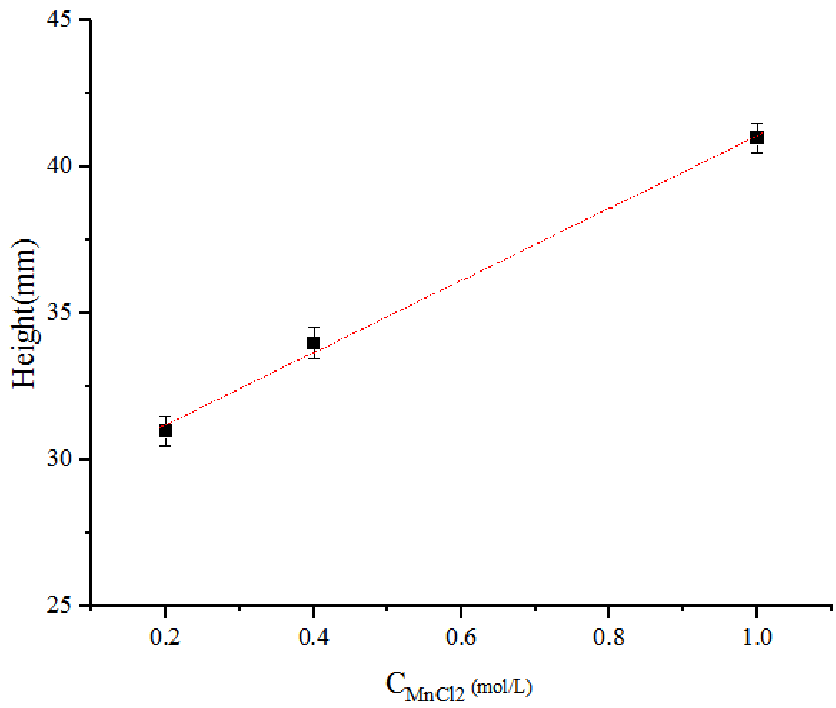


Fig. 2: The relationship between the concentration of manganese(II) chloride tetrahydrate ($MnCl_2·4H_2O$) and the levitation height of the oil droplet in the paramagnetic medium.

3.2. Determination of the percentage of methanol in a paramagnetic solution

To determine the optimal percentage of methanol in the paramagnetic solution, different methanol–water mixtures were prepared and tested. The aim of this step was to adjust the solution's density so that it could levitate all oil droplets. The experimental results are as follows:

- In solutions with more than 80% methanol, the oil droplet remained on the surface of the solution. This behaviour indicates that the density of the oil droplet was less than that of the solution.
- In solutions with more than 80% methanol, the oil droplet stayed on the surface, indicating that its density was lower than the solution density.
- In solutions with 70–80% methanol, some droplets levitated while others settled.
- In the 65% methanol solution, the droplet settled at the bottom, indicating that its density was greater than that of the solution.

Based on these observations, the optimal composition was found to be 70% methanol and 30% distilled water with 0.2 M $MnCl_2·4H_2O$, which enabled all droplets to levitate.

3.3. Detection of uncleanness in animal fat using the MagLev device

To identify and differentiate the original animal fat from the mixed samples, a MagLev (magnetic float) device was used.

Three types of samples were used in this experiment: semi-solid Oila oil (a cheap industrial vegetable oil), beef tallow (animal fat), and pure traditional animal fat (animal oil). Given the lower cost of semi-solid oils compared to original animal fat, the possibility of mixing is high. The aim of this experiment was to identify and differentiate the samples based on the difference in their density. Equal amounts of all three oils were taken and heated using the bain-marie method to ensure complete melting and mixing. Since these oils are semi-solid or solid at room temperature, they tend to re-solidify after entering the paramagnetic solution, which complicates the separation process. To overcome this problem, the solution inside the MagLev device was kept at 25°C to prevent re-solidification. Then, a relatively large drop of the oil mixture was introduced into the heated solution using the tip of a spatula. To ensure full dispersion of the oil in the solution, a capillary tube was used to thoroughly stir the mixture, allowing the oil to break down into very fine particles. To eliminate the air bubbles formed in the solution, the container was tapped several times against the magnetic plate to release the trapped bubbles. The oil particles were given time to undergo density-based separation and reach equilibrium and stable positions (Fig 3). After the droplets were fixed in position, their levitation height was measured using the device's ruler. Subsequently, each pure component (beef tallow, pure animal fat, and vegetable oil) was analyzed separately and the levitation height of each was recorded. For more precise identification, Fourier-transform infrared (FT-IR) spectroscopy was employed to compare the spectral profiles of the samples. Figure 4 presents the FT-IR spectra of various pure and separated samples. To enhance comparison, the spectra were plotted in both transmission and absorption modes and examined in pairs. Attention was paid to characteristic vibrational bands, and analysis of the fine spectral structure showed the close similarity between separated droplets and their original samples. These results demonstrate that the system effectively separates mixed edible oils.

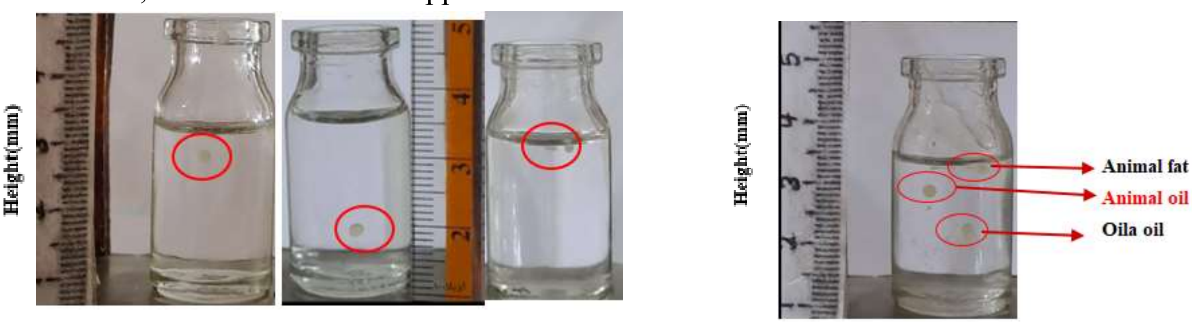


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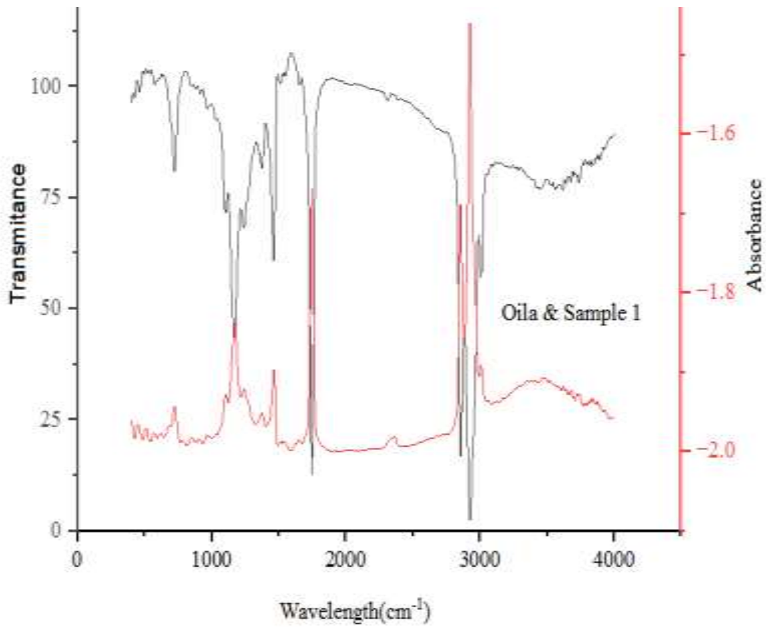
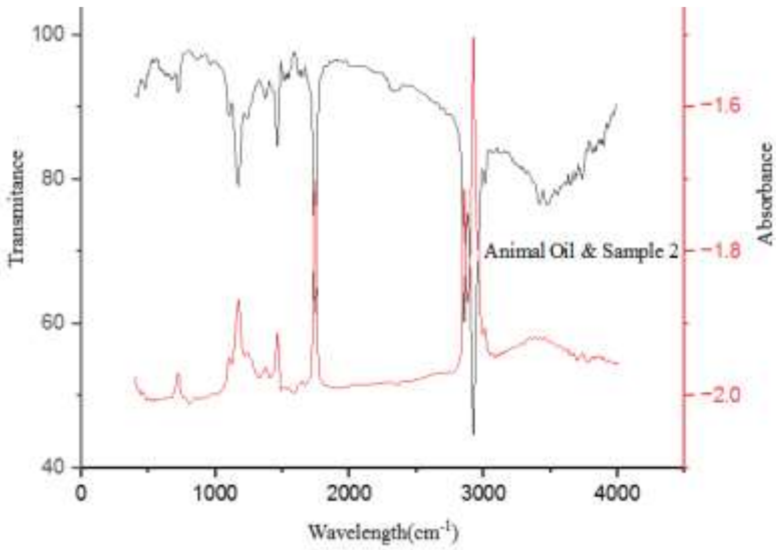
*Fig. 3: **(a)** Images of three types of oils levitating in a 0.2 M $MnCl_2$ paramagnetic solution in the MagLev system: from left, container 1, animal oil (in the middle); container 2, Oila solid oil (near the bottom); container 3, animal fat (near the surface). **(b)** Separation and identification of three types of oils in a mixed sample. Each oil is fixed at a specific height in the solution depth.*


Transmitance
Absorbance
Oila & Sample 1
Wavelength(cm^{-1})
0
25
50
75
100
0
1000
2000
3000
4000
-1.6
-1.8
-2.0


Transmitance
Absorbance
Animal Oil & Sample 2
Wavelength(cm^{-1})
40
60
80
100
0
1000
2000
3000
4000
-1.6
-1.8
-2.0

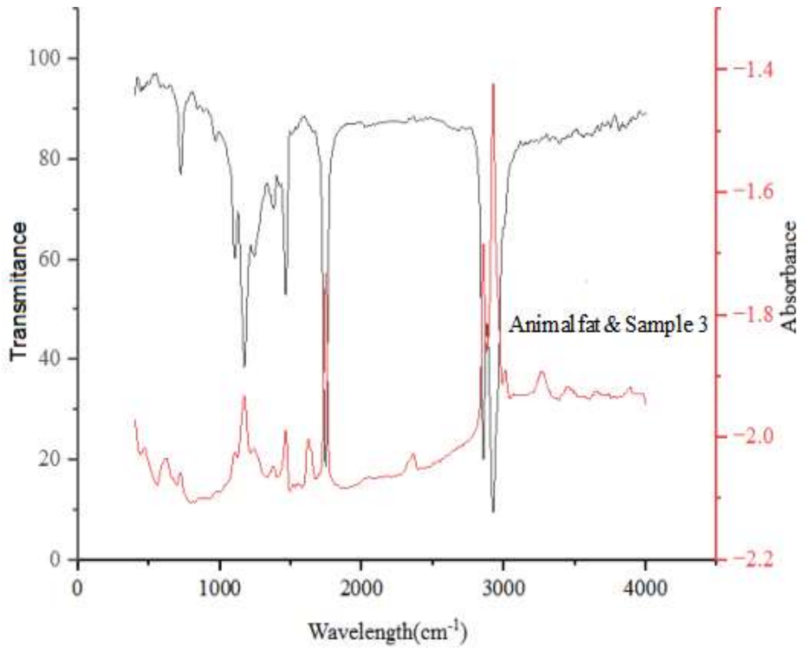


Fig. 4: *FT-IR spectroscopy for comparison between original and separated samples: (upper) comparison between Oila solid vegetable oil and the droplet separated from the mixture, sample 1; (middle) comparison between animal oil and the separated droplet, sample 2; (lower) comparison between animal fat and the separated droplet, sample 3.*

Our observations showed that the droplet at ~20 mm was semi-solid Oila oil (highest density), the droplet at ~30 mm was pure animal oil, and the droplet near the surface was beef tallow (lowest density). These findings indicate that the higher the density of the oil, the lower its levitation height in the MagLev system. Oila is denser than pure animal oil, and pure animal oil is denser than beef tallow. Therefore, the droplet height in the MagLev solution is inversely related to the density of the oil. Furthermore, the results confirmed that droplet levitation height is strongly affected by the concentration of the manganese chloride ($MnCl_2$) solution. This parameter must be carefully controlled to ensure consistent and accurate separation.

3.4. Separation of animal fat from solid vegetable oil (Ladan)

The next experiment was to study the mixture of animal fat (known as Kermanshahi oil) with hydrogenated vegetable oil, ladan. First, equal amounts of the two oils were taken and heated using the bain-marie method to obtain a uniform mixture. The paramagnetic solution was heated to ~25°C to prevent the oil droplet from freezing. Then, a drop of the warm oil mixture was added to the paramagnetic solution using the tip of a capillary tube and immediately stirred thoroughly with the same tube to disperse the oil into very fine particles. Next, the container with the solution and oil was placed in the MagLev device. To remove air bubbles formed in the solution, the container was tapped several times on the magnetic platform to release the bubbles. Then, the oil particles were allowed to reach equilibrium in the magnetic field and stabilize separately at different heights based on the difference in density and magnetic properties. After the positions were stabilized, the height of each separated droplet or particle was measured using a ruler. The final position of the particles was photographed (Fig. 5). The difference in levitation height is due to variations in their density and magnetic susceptibility. This image clearly demonstrates the ability of the MagLev technique to detect and separate different oils based on their density and magnetic properties, even when they are presented as mixtures or impure samples. The separated samples were collected, and their FT-IR spectra were recorded for further analysis, as shown in Figure 6. Comparison of the spectra of the original sample with those of the separated fractions revealed a close match in the regions corresponding to the main vibrational bands. This strong spectral agreement between the components isolated by the MagLev device and the original samples demonstrates the effectiveness of the separation method in extracting animal fat (Kermanshahi oil) from the mixture. Correlation coefficients were calculated to quantify the spectral similarity across all compared FT-IR spectra, yielding values in the range of 0.98–0.99. These results indicate excellent agreement between the separated droplets and their original counterparts. This quantitative analysis further validates the reliability of the MagLev system for the separation and identification of different types of oils.

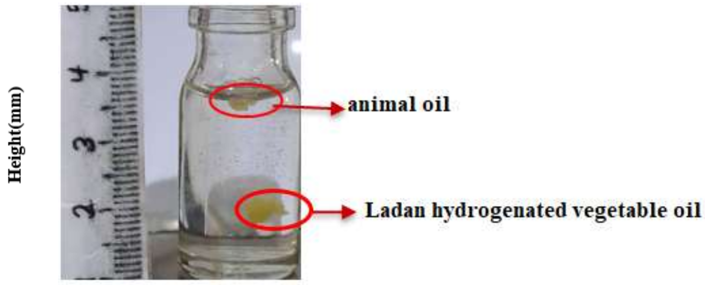
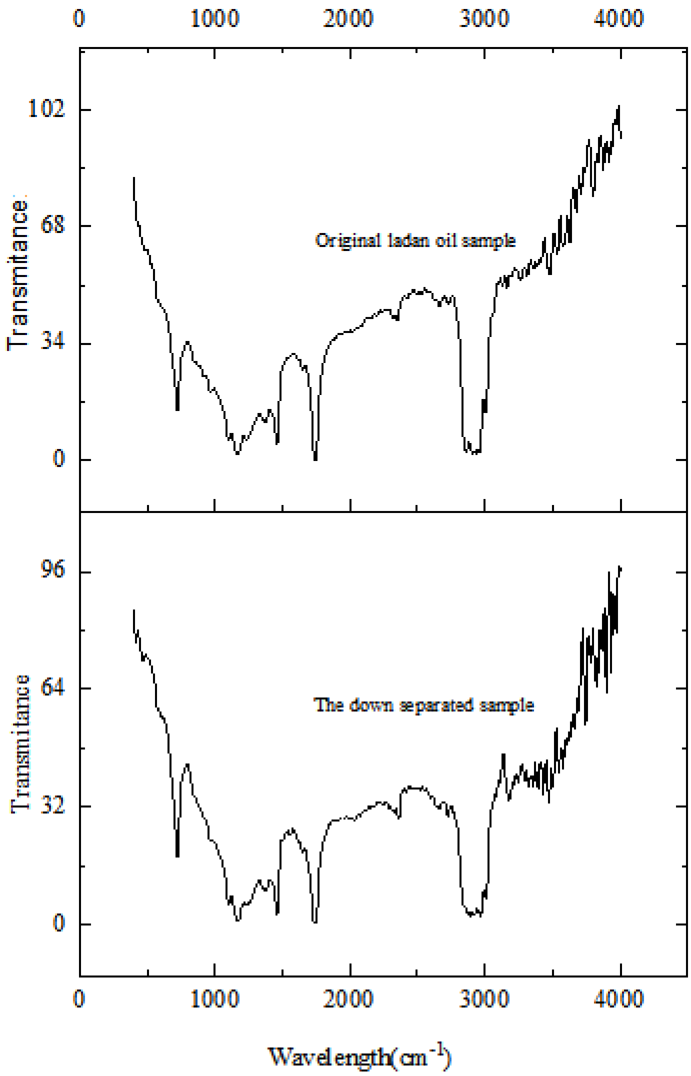


Fig. 5: *This image shows the simultaneous levitation of two different types of oil in a magnetic solution (MagLev system). The upper droplet corresponds to animal fat, while the lower droplet represents Ladan solid vegetable oil.*


0
1000
2000
3000
4000
102
68
34
0
Transmitance
Original ladan oil sample
96
64
32
0
Transmitance
The down separated sample
0
1000
2000
3000
4000
Wavelength(cm-1)

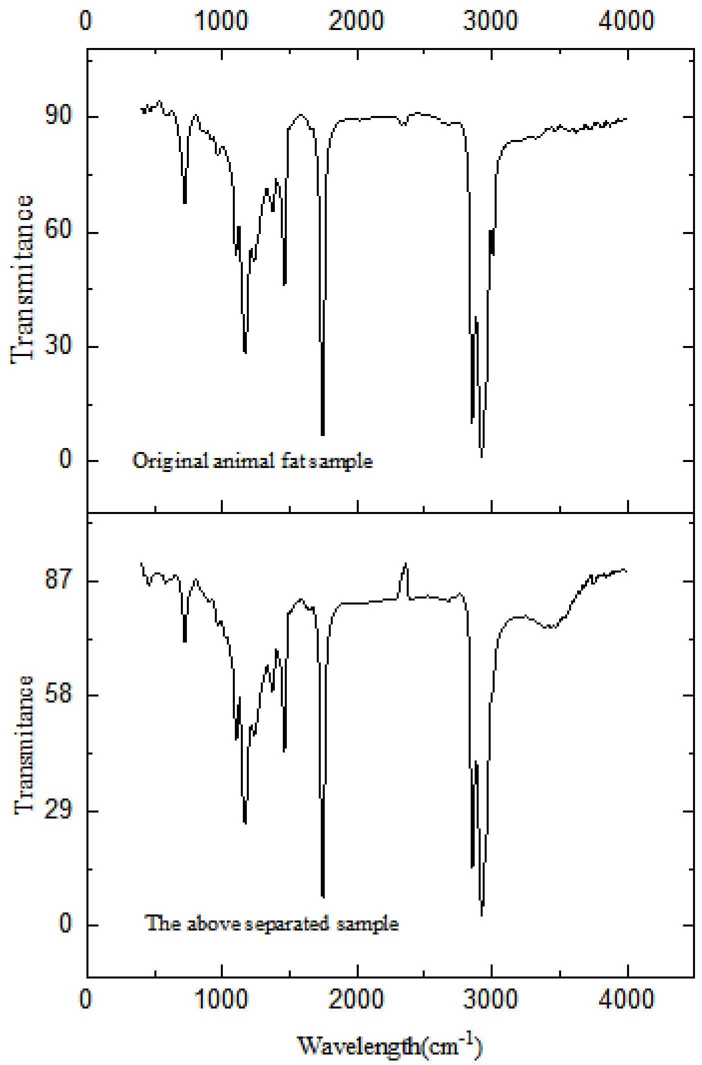


Fig. 6: *(upper): FT-IR spectroscopy for comparison of the spectrum of the original Ladan oil sample with the corresponding separated sample; (lower): comparison of the spectrum of the original animal fat sample (Kermanshahi oil) with the corresponding separated sample.*

3.5. Separation of homemade Olive oil from Ladan liquid edible oil

Olive oil is one of the most widely used and expensive oils in society. As a result, some profiteers mix it with cheaper oils such as liquid edible oils and sell the mixture as pure olive oil to increase their profit. One method for detecting adulteration in olive oil is to compare its density with that of liquid oil. For this experiment, equal amounts of homemade olive oil and Ladan liquid oil were mixed together. Since both oils are liquid at room temperature, there was no need to heat either the mixture or the paramagnetic solution. The mixture was thoroughly stirred to ensure uniformity. Then, using a capillary tube, a droplet of the oil mixture was introduced into the paramagnetic test solution, which was also gently stirred. To eliminate any air bubbles formed in the solution, the container was gently tapped several times on the magnetic platform. After approximately 5 to 10 minutes, the oil droplets separated and reached stable positions (Fig. 7). Extending the time beyond this can cause droplets to stick to the vessel walls or re-aggregate, reducing separation accuracy. At this stage, the levitation height of each droplet was recorded. The droplet at the higher position corresponds to the olive oil, while the lower one belongs to the Ladan liquid oil. This difference in levitation height originates from the density contrast between the two oils and clearly enables their separation. The distinct spatial positioning of the droplets achieved without the need for complex instrumentation confirms the effectiveness of the MagLev-based separation method relying on magnetic force and density differences.

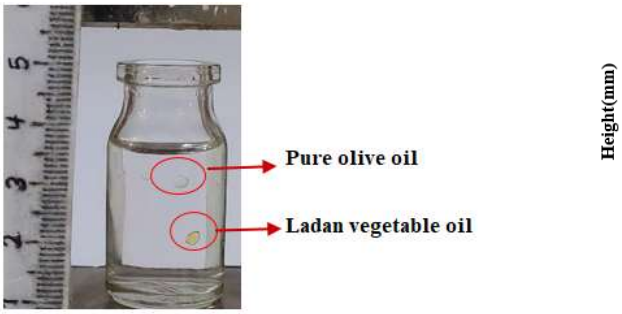


Fig. 7: Separation of Olive oil and Ladan liquid oil.

To validate the results, each oil (olive oil and Ladan liquid oil) was tested separately under the same conditions, and their levitation heights were recorded (Fig. 8). This figure shows the equilibrium positions of the two pure oil samples separately within the paramagnetic medium. In the left image, the droplet of Ladan liquid oil is located near the bottom of the solution, indicating a higher density relative to the surrounding medium. In the right image, the olive oil droplet is levitated at a higher position, reflecting its lower density compared to the solution. This difference in levitation height allows for the identification and separation of these two oils in a magnetic field environment. Therefore, this method can be effectively used to detect uncleanness in olive oil.

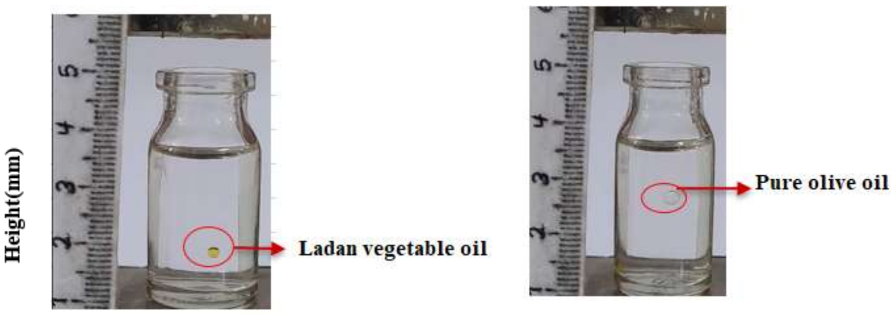


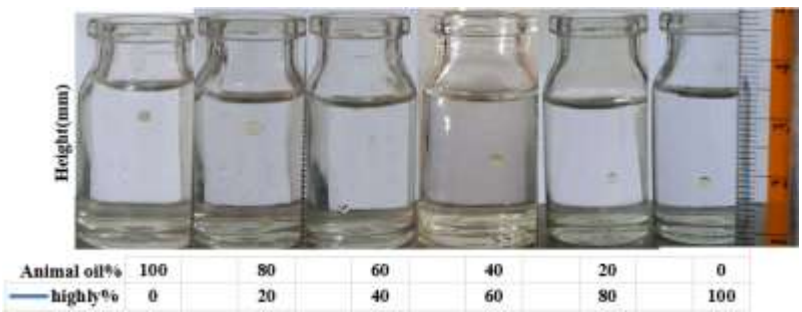
Fig. 8: Levitation positions of pure Olive oil and Ladan liquid oil in the paramagnetic solution.

3.6. Determination of purity of animal fat oil

To evaluate the purity of animal fat oil, mixtures containing various proportions of animal fat and other oils were prepared. Different percentages of animal fat (0%, 20%, 40%, 60%, 80%, 100%) were combined with complementary percentages of semi-solid oils (Oila, Highly, and Khazar). The mixtures were thoroughly homogenized using indirect heat (bain-marie). From each mixture, a small droplet was separately added to the paramagnetic solution containing manganese(II) chloride ($MnCl_2$) using the tip of a capillary tube. The solution was not stirred at any point, and the droplets were not allowed to break into smaller particles, in order to preserve clear observation of their floating behaviour. The container was then softly tapped to eliminate any air bubbles that might interfere with the droplet's levitation. Once the droplet reached a stable position, its levitation height was measured and photographed. This procedure was repeated for all mixture ratios. By recording the floating height of the droplets for various concentrations of animal fat, a calibration curve of droplet height versus animal fat percentage was plotted. This curve served as a reference to determine the purity of unknown samples, allowing impurity detection based on droplet equilibrium in the magnetic solution.

The calibration curve of mixed samples of animal fat oil and Highly cooking oil with different ratios is shown in Figure 9. As observed in Fig. 9(a) increasing the percentage of animal fat oil results in a higher floating position of the droplet in the solution. The curve, Fig. 9(b), exhibits a linear relationship: $y = -0.0127x + 2.9633$ with a determination coefficient of $R^2 = 0.9929$, indicating a strong correlation between the droplet's levitation height and the oil composition percentage. These results confirm that the MagLev magnetic levitation technique can serve as a simple, rapid, and reliable method for estimating the purity of animal fat oil.

a)



b)

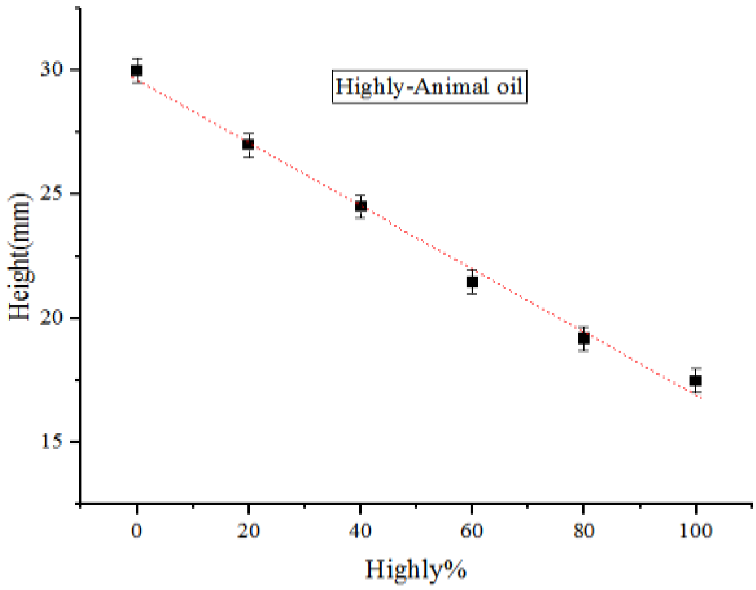
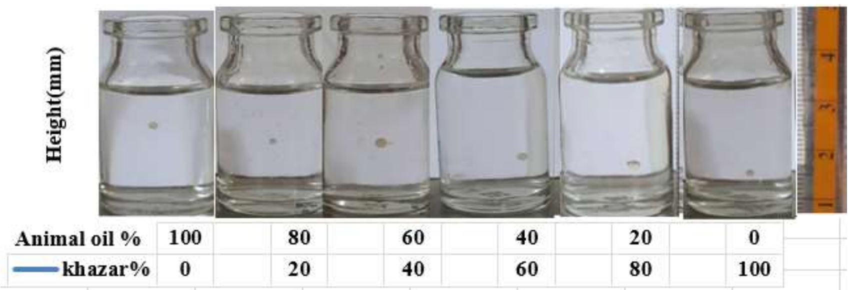


Fig. 9: (a), *Pictures of samples of animal fat oil and Highly cooking oil mixtures in different proportions.* ***(b),*** *presents the calibration curve plotted between the percentage of Highly oil and the levitation height of the droplet in the paramagnetic solution.*

Our next study was on mixed samples containing different proportions of animal fat oil and Khazar cooking oil. As observed in Figure 10(a), the levitation height of the droplet increases with higher percentages of animal fat oil in the mixture. Figure 10(b) shows an almost linear relationship between Khazar oil percentage and droplet levitation height: y = -0.0139x + 2.9429, with R^2 = 0.992, indicating a strong correlation.

a)



b)

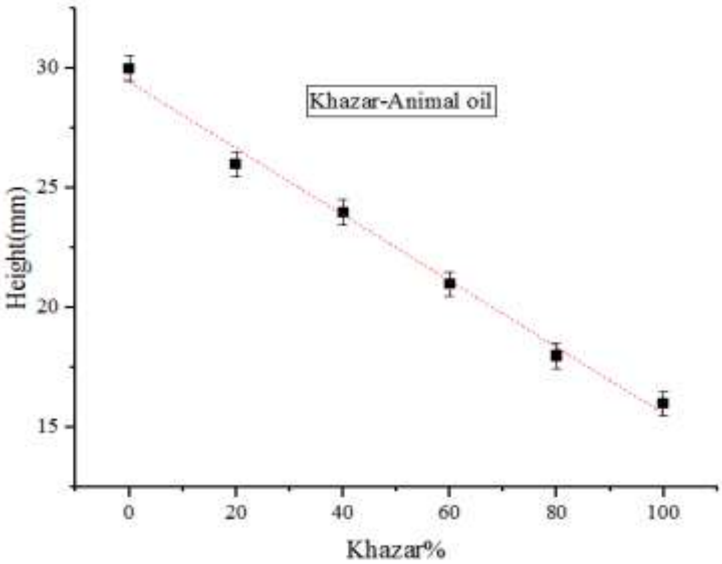
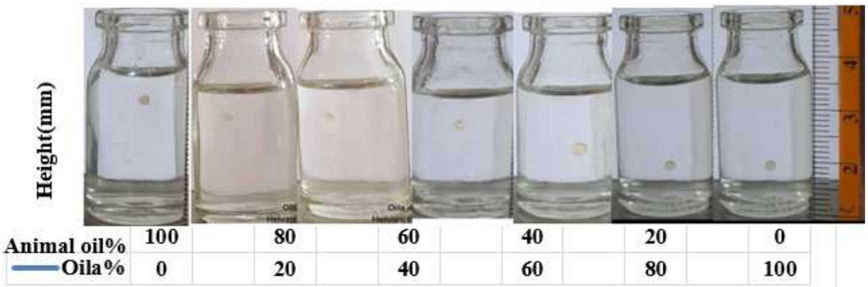


Fig. 10: ***(a),*** *Images of mixed samples containing various proportions of animal fat oil and Khazar cooking oil.* ***(b),*** *It shows a linear relationship between the percentage of Khazar cooking oil and the droplet's levitation height.*

Another study was on mixed samples containing different proportions of animal fat oil and Olia oil. As can be seen in Figure 11(a), the droplet levitation height increases with higher percentages of animal fat oil. Figure 11(b) shows an almost linear relationship between Olia oil percentage and droplet levitation height: $y = -0.0076x + 2.9905$, with $R^2 = 0.9923$, indicating a strong correlation. As the proportion of Olia oil increases, the levitation height decreases by the same proportion.

a)



b)

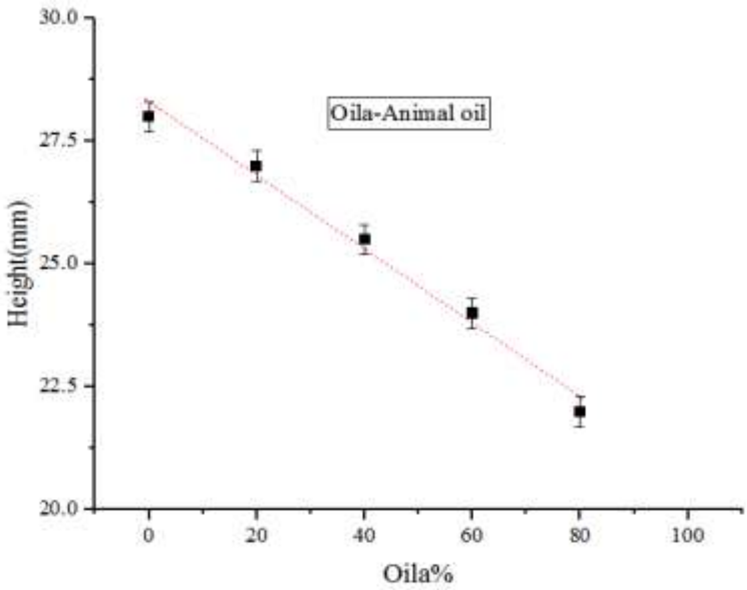


Fig. 11: (a), *Images of mixed samples containing different proportions of animal fat oil and Oila cooking oil.* ***(b),*** *The graph shows an approximately linear relationship between the percentage of Oila cooking oil and the levitation height of the droplet.*

Table 1. Levitation heights of pure oils and their mixtures with animal oils in an aqueous $MnCl_2$ paramagnetic solution. All measurements were performed in triplicate (n = 3)

Ratio (oil %)	Levitation Height (mm) (Oila oil)	Levitation Height (mm) (Khazar oil)	Levitation Height (mm) (Highly oil)
100	22.0±0.5	16.0±0.5	17.5±0.5
80	24.0±0.5	18.0±0.5	19.2±0.5
60	25.5±0.5	21.0±0.5	21.5±0.5
40	27.0±0.5	24.0±0.5	24.5±0.5
20	28.0±0.5	26.0±0.5	27.0±0.5
0	30.0±0.5	30.0±0.5	30.0±0.5

Table 1 shows the levitation heights of pure oils and their combinations in an aqueous $MnCl_2$ paramagnetic solution, as illustrated in the preceding graphs. To ensure reproducibility, each sample should be measured in at least three independent replicates. Mixtures containing varying proportions of animal fat and industrial oils were analyzed to establish the relationship between animal fat content and levitation height (calibration curve). The results indicate that increasing the proportion of animal fat in the mixture decreases the droplet density and, consequently, increases the levitation height. This approach therefore provides a rapid and reliable method for evaluating the purity of animal fat oils.

3.7. Evaluation of the proposed method with other methods

The comparison between MagLev and conventional analytical techniques was performed using only the references already cited in this manuscript (Table 2). Previous studies have shown that MagLev is a simple, low-cost and portable density-based approach, capable of producing results within a few minutes. In contrast, GC and HPLC methods, although highly accurate, require complex instrumentation, higher operational costs, and typically 1–2 hours of analysis [2-4, 12, 15-18].

Table 2. A comparison between the MagLev method and standard GC and HPLC techniques

Item No	Analytical method	Accuracy	Analysis time (minute)	Equipment requirement	Portability	Approx. cost
١	MagLev	medium to high	few minutes	Minimal setup (two magnets and an aqueous $MnCl_2$ solution)	very high	low
٢	GC	very high	60-120	complex instruments	low	high
٣	HPLC	very high	60-120	complex instruments	low	high

4- Conclusion

This research presents a straightforward, economical, and transportable approach for identifying impurity in edible oils by exploiting density variations through a magnetic levitation (MagLev) platform. Experimental findings confirmed the system's effectiveness in detecting contaminants in animal fat–based oils, facilitating their separation and enabling quantification of impurity levels by correlating levitation height within a magnetic field. The vertical position of oil droplets suspended in a manganese(II) chloride ($MnCl_2$) paramagnetic solution thus serves as a reliable metric for assessing uncleanness in animal-derived oils. Calibration plots derived from levitation data allow estimation of the true concentration of animal fat in unknown mixtures. Analytical observations indicated that higher impurity levels correlate with increased sample density, thereby permitting differentiation among constituents such as pure animal fat, hydrogenated fats, and semi-solid industrial cooking oils. Droplets exhibiting greater levitation heights typically correspond to less dense fats (e.g., bovine-derived lipids), whereas reduced heights suggest the presence of denser industrial oil fractions. Additionally, it was determined that the density of commercial liquid cooking oils surpasses that of unadulterated olive oil, extending the applicability of this technique to other organic oils including sesame, canola, and sunflower oils. Evaluation of composite samples demonstrated the MagLev system's precision in quantifying impurity proportions within animal fat oil blends. Key advantages of this method are simplicity, rapid analysis, no need for electricity, portability, low cost, and good analytical accuracy. The experimental setup comprises merely two permanent magnets and a vessel containing the paramagnetic solution, rendering it practical for deployment in environments such as food retail outlets, dining establishments, regulatory bodies, and quality assurance laboratories.

Despite these advantages, the Maglev technique is inherently semi-quantitative and requires calibration for different oil matrices. Therefore, it is best suited as a rapid screening and complementary tool rather than a replacement for high-resolution analytical methods**.** In summary, the MagLev method provides a reliable, portable, and cost-effective tool for detecting impure animal fat and olive oil and determining their impurity levels. Owing to its high sensitivity and ease of use, this technique can be extended to broader quality control applications, including the detection of burnt or spoiled oils in food preparation facilities and fast-food establishments. This is currently being investigated as a follow-up to this research. in which the effects of interferences such as colour, viscosity, or the presence of particles in the oil will be examined.

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استفاده از شناوری مغناطیسی برای تشخیص انواع روغن های پخت و پز ایرانی بر اساس چگالی

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چکیده

سلامت عمومی به طور قابل توجهی با مصرف روغن‌های خوراکی ناخالص و استفاده مجدد مکرر از روغن‌های پخت و پز به خطر می‌افتد. اگرچه تکنیک‌های تحلیلی سنتی یعنی کروماتوگرافی گازی و کروماتوگرافی مایع با کارایی بالا دقت بالایی دارند، اما اتکای آنها به ابزارهای پیچیده و پرهزینه، کاربرد عملی آنها را در خارج از محیط‌های آزمایشگاهی محدود می‌کند. این تحقیق یک رویکرد تحلیلی در دسترس و مقرون به صرفه مبتنی بر شناوری مغناطیسی (MagLev) را برای ارزیابی کیفیت روغن و شناسایی آلاینده‌ها معرفی می‌کند. این تکنیک از تغییرات چگالی در نمونه‌های روغن برای ایجاد تعادل شناوری آنها در یک سیال پارامغناطیسی استفاده می‌کند و تمایز دیداری را تسهیل می‌کند. برای اعتبارسنجی اثربخشی روش MagLev، وجود ناخالصی کنترل‌شده چربی حیوانی کرمانشاهی با استفاده از غلظت‌های درجه‌بندی‌شده چربی گاوی، چربی‌های سخت صنعتی و روغن‌های نیمه جامد انجام شد. علاوه بر این، توانایی سیستم در تشخیص روغن زیتون خالص از روغن‌های مایع درجه صنعتی بررسی شد. نتایج تجربی نشان می‌دهد که تکنیک MagLev به طور قابل اعتمادی ناخالصی‌ها را تشخیص می‌دهد و تخمین‌های نیمه کمی از خلوص را ارائه می‌دهد. این سیستم به دلیل سادگی و قابلیت حمل، عملکرد بدون ورودی الکتریکی و استفاده از حداقل اجزا، به ویژه دو آهنربای دائمی و یک محلول پارامغناطیس، قابل توجه است. این ویژگی‌ها، MagLev را به ابزاری جذاب برای استقرار در محل در تضمین کیفیت، نظارت بر ایمنی مواد غذایی، غربالگری سریع آلودگی و جلوگیری از سودجویی غیرقانونی در محیط‌هایی با زیرساخت فنی محدود تبدیل می‌کند.