

Detailed Analysis of Synthetic Fat in Synthetic Milk with Conductivity and pH

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Received: 5th Feb, 2026; Revised: 6th March, 2026; Accepted: 26th March, 2026; Available Online: 8th April, 2026

ABSTRACT

Milk adulteration has become an increasingly widespread issue, largely driven by the pursuit of higher profits. Like many food products, the problem escalates when demand surpasses supply. A significant and growing concern is the production of synthetic milk, particularly through the incorporation of synthetic fats. This study explores the formulation of synthetic fat using various ingredient combinations and ratios. It further reveals the limitations of conventional detection methods, such as the Gerber test and lactometer readings, in identifying this type of adulteration. Alternatively, the research demonstrates that pH and electrical conductivity serve as more reliable indicators for detecting the presence of synthetic fat in milk.

Keywords: Synthetic milk, Milk adulteration, Conductivity, pH

How to cite this article: Dave JB, Bhatt CB, Khediya MD, Gadhiya RB. Detailed Analysis of Synthetic Fat in Synthetic Milk with Conductivity and pH. *Int J Drug Deliv Technol.* 2026;16(22s): 63-67. DOI:

10.25258/ijddt.16.22s.6

Source of support: Nil.

Conflict of interest: None

Food adulteration has become a growing concern across the globe. There are three primary reasons behind this issue. First, the imbalance between the demand and supply of food, largely due to limited natural resources, leads to a consistent shortage of certain food items. Second, the lack of simple, accessible household methods to detect adulteration makes it difficult for consumers to identify tampered food. Third, the motive to gain extra profit drives many to deliberately adulterate food, making it a common practice in many of the items we consume daily.

To address this, the book "Quick Test for Some Adulterants in Food" (1), published by the Food Safety and Standards Authority of India (FSSAI) in 2012, outlines numerous methods for detecting food adulteration. However, most of these methods are chemical-based, require specific skills to perform, and involve complex apparatus that demand trained personnel. As a result, these tests are often inaccessible to the average consumer.

Milk, being a vital part of our daily diet, is frequently subjected to adulteration. One of the simplest and oldest techniques used to adulterate milk is the addition of water to increase its volume. To detect such adulteration, modern methods like the GERBER method (2) which calculates the percentage of fat, or the use of a lactometer to measure the specific gravity of milk, are commonly employed. However, both of this method can be fooled with different types of the adulterant. This paper enlightens how the both conventional methods can be misled using the synthetic fat.

TD-NMR spectroscopy (3) has been effectively applied to detect synthetic adulterants in milk, including synthetic fat. Studies showed that as the percentage of synthetic components increases, relaxation time constants rise, enabling clear identification of adulteration levels. Using various chemical methods (4), different components of synthetic milk such as urea, sugar, and neutralizers were successfully detected. These methods provide a

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direct approach for identifying chemical adulterants in milk. Using the conduction method (5), synthetic fat adulteration in milk was examined by preparing samples with concentrations ranging from 0% to 100%. It was observed that as the proportion of synthetic fat increased, the conductance of milk consistently decreased. Other adulterants such as water (6) (7) (8) (9) (10) (11), urea (11) (12) (13), detergents (14) (15) (16), melamine (17) (18) (19), starch (13) (20), formalin (21) (16), sodium carbonate/bicarbonate (16) (22) (23) (24), etc., have been extensively studied, and a considerable body of research is available on their detection methods. In contrast, the detection of synthetic fat adulteration requires more focused investigation. Synthetic fat adulteration is particularly challenging because it is rarely introduced in isolation. It is usually accompanied by multiple additional adulterants, which makes its identification more complicated. Furthermore, a systematic study is needed to understand how variations in the ratio of oil to emulsifier influence the overall detection outcomes. In India the price of milk is generally been decided based on the %fat in the milk. As the %fat of milk value goes up, the price of that milk is more. Hence to earn more money, it is been practice to add the extra synthetic fat in the milk sample. The synthetic fat can be made using any type of vegetable oil and emulsifier (generally shampoo). The detailed process to make synthetic milk was discussed (4) (22). Synthetic milk closely resembles natural milk in appearance and texture. Vegetable oil is used to replicate milk fat, urea substitutes for the nitrogen content, and detergents are added to produce froth.

Experimental setup:

To explore the best counterfeit for natural milk fat, initially using different type of vegetable oils and emulsifier combination the synthetic fat was generated. The quantities of sugar, urea, water chestnut flour, and water were kept constant throughout the experiment. Only the proportion of synthetic fat was varied to prepare the synthetic milk. However, the type of synthetic fat and the amount of the synthetic fat were changed throughout the experiment. The table.1 displays the type of oil and Table.2 displays the emulsifier that are used.

Table 1 Types of vegetable oils

Vegetable oil
Cottonseed oil
Groundnut oil
Sunflower oil
Palm oil

Table 2 Types of Emulsifiers

Emulsifier
Branded chemical-based shampoo
Ayurvedic shampoo
Branded Detergent

Different combination of vegetable oil and emulsifier with constant ratio

Primarily the ratio of oil to emulsifier was kept constant to make the synthetic fat for synthetic milk. The ratio was kept 100 ml oil 10 ml emulsifier, resulting ratio of 10:1. Total 12 combinations were made. However, from the texture of the synthetic fat and to better match the milk properties, the Ayurvedic shampoo provides better counterfeit. With the synthetic fat other adulterant like water, urea, starch, sweetener and neutralizers were used. The lactometer reading and the Gerber method reading were taken for all 12 samples. Table.3 shows the outcome of the Gerber method value, and lactometer reading. Along this the as non-conventional method Electrical conductivity and pH was measured, to see whether these two methods can detect the synthetic milk adulteration. For both parameter handheld devices of HM digital company were used. For electrical conductivity measurement "COM-100" and for pH measurement "pH-80" model were used.

Variation of ratio between vegetable oil and emulsifier for one combination

Among the various types of oils examined, palm oil emerged as the most economical, making it the preferred choice for those aiming to maximize profit. Based on this insight, a more detailed set of experiments was conducted using palm oil and Ayurvedic shampoo. Different ratios of these two components were mixed to create synthetic fat, to which a fixed amount of water and other adulterants were added, forming synthetic milk. The resulting samples were then analyzed using the Gerber method, lactometer readings, electrical conductivity, and pH. The outcome of the experiments including %fat (from Gerber method), lactometer values, electrical conductivity, and pH for 10 different samples are summarized in Table 4.

Table 3. Fat Analysis of counterfeit Milk Fat made using various proportion of vegetable oil and emulsifier

S r N o.	Veget able oil type	Emul sifier type	Ger ber met hod rea	Lacto meter readi ng	Electri cal Condu ctivity (mS)	P H

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			ding			
1	Cottonseed oil	Branded chemical-based shampoo	6.5	36	2.24	7.8
2	Groundnut oil	Branded chemical-based shampoo	6.3	34	2.40	7.7
3	Sunflower oil	Branded chemical-based shampoo	6.7	37	2.16	7.8
4	Palm oil	Branded chemical-based shampoo	6.5	35	2.21	7.8
5	Cottonseed oil	Ayurvedic shampoo	6.8	38	2.09	7.6
6	Groundnut oil	Ayurvedic shampoo	6.5	36	2.16	7.6
7	Sunflower oil	Ayurvedic shampoo	6.8	38	2.14	7.5
8	Palm oil	Ayurvedic shampoo	6.7	37	2.18	7.6
9	Cottonseed oil	Branded Detergent liquid	6.2	40	2.41	7.9

10	Groundnut oil	Branded Detergent liquid	6.1	37	2.45	7.9
11	Sunflower oil	Branded Detergent liquid	6.6	38	2.36	7.9
12	Palm oil	Branded Detergent liquid	6.4	39	2.40	8

Table 4. Fat Analysis of counterfeit Milk Fat made using various proportion of vegetable oil and Ayurvedic Shampoo

Sr No.	Ratio of Palm Oil: Ayurvedic Shampoo	Gerber method reading	Lactometer reading	Electrical Conductivity (mS)	pH
1	20:1	8.2	48	1.60	6.5
2	18:1	8.0	45	1.74	6.8
3	16:1	7.8	43	1.85	6.9
4	14:1	7.5	41	1.92	7.1
5	12:1	7.1	39	2.01	7.4
6	10:1	6.7	37	2.18	7.6
7	8:1	6.2	36	2.90	7.9
8	6:1	6.0	34	3.42	8.1
9	4:1	4.7	30	3.97	8.5
10	2:1	2.4	28	4.63	8.8

Result and Discussion

It was observed that both the Gerber method and lactometer readings completely failed to detect the presence of synthetic milk. The first four synthetic milk

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combinations appeared pale yellow in color. Interestingly, the sample prepared using Ayurvedic shampoo closely resembled real milk, making it difficult to distinguish visually. In contrast, the last four samples exhibited a bluish-white hue, which can be attributed to the coloration of the detergent liquid used. All samples showed electrical conductivity values ranging from 2 to 2.5 mS, which fall within the normal range for genuine milk. However, their pH levels were significantly elevated, between 7.5 and 8.0, primarily due to the emulsifiers present in synthetic milk. These values that are unusually high for any pure milk sample.

It was observed that the oil component plays a major role in the fat percentage detected by the Gerber method. As the proportion of palm oil decreases, the measured fat percentage also declines accordingly. Additionally, it was noted that lactometer readings are influenced not only by the quantity of vegetable oil but also by the amount of emulsifier present in the synthetic milk. Although the readings generally decrease with a reduction in vegetable oil content, the emulsifier level significantly affects the density and thus the lactometer values.

In the case of electrical conductivity, the readings appear to be more strongly affected by the amount of emulsifier rather than the oil content. As the quantity of emulsifier increases, the electrical conductivity rises rapidly. However, in all cases, it remained within the typical range observed for pure milk. Among all the parameters, pH proved to be the most reliable indicator for detecting synthetic milk. In 8 out of 10 samples, the pH value remained above 6.8, which is unusually high for natural milk. That said, it is important to note that pH can potentially be manipulated using neutralizers, which could make detection more difficult.

Conclusion.

In summary, the findings demonstrate that pH is the most promising indicator for detecting synthetic milk prepared using vegetable oil and emulsifier, offering greater reliability than traditional methods, though its effectiveness may be limited by the presence of neutralizing agents. It was also observed that an increase in oil content leads to higher Gerber method values and lactometer readings, while an increase in emulsifier content results in a rise in lactometer readings. Furthermore, Conductivity values increase as the ratio of oil to detergent comes closer to one. The rise is sharper when the amount of oil decreases and the emulsifier content increases. This highlights the importance of developing complementary or advanced detection techniques to ensure the authenticity and

safety of milk in the face of increasingly sophisticated adulteration practices.

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