

## REVIEW ARTICLE

# A Review on Health Risks Associated with the Repetitive use of Cooking Oil and Dissuasive Ways

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**ABSTRACT**

**Background:** The repeated use of cooking oil, especially for deep-frying, is a widespread practice in India due to cost constraints and low public awareness. However, this practice leads to the formation of harmful compounds such as trans fats, free radicals, and polycyclic aromatic hydrocarbons (PAHs), which pose serious health risks. To systematically review the health implications of using reheated cooking oil and to explore current practices, regulatory frameworks, and dissuasive measures for its prevention in India.

**Methods and Material:** A review-based observational study focusing on literature and policy analysis related to used cooking oil (UCO) usage in Indian households and food business operators (FBOs). A comprehensive literature review was conducted to evaluating peer-reviewed articles, policy documents, and national reports on the health effects of UCO and its use patterns in India. Descriptive analysis of qualitative and quantitative findings from secondary data sources was undertaken.

**Results:** Reheated oil contributes to severe health problems including cardiovascular diseases, cancer, hypertension, and metabolic disorders. Approximately 60% of UCO in India re-enters the food chain. The Food Safety and Standards Authority of India (FSSAI) & Repurpose Used Cooking Oil (RUCO) initiative and regulatory limits on Total Polar Compounds (TPC) offer promising control mechanisms but face implementation challenges.

**Conclusions:** The reuse of cooking oil is a silent but serious public health threat. Strengthening grassroots awareness, enforcing regulatory compliance, and promoting sustainable disposal alternatives like biofuel conversion are essential to safeguard public health.

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## KEYWORDS

• Used Cooking Oil (UCO) • Reheated Oil • Trans Fats • FSSAI • Public Health • RUCO • Biofuel India

## INTRODUCTION

Food is a fundamental need for human survival, and the way it is prepared has a significant impact on health outcomes. In recent years, growing concern has emerged about how food processing and cooking methods contribute to the burden of non-communicable diseases (NCDs) such as cardiovascular disease, cancer, diabetes, and obesity.<sup>1</sup> Among these, the use of reheated or used cooking oil (UCO) is a particularly under-recognized but highly consequential risk factor. In India, the reuse of cooking oil especially for deep-frying is common across households, street food vendors, and commercial food establishments. This practice is primarily driven by economic constraints, lack of awareness, and poor regulatory oversight.<sup>2</sup>

Used cooking oil is the oil that has been utilized for frying and is often reused multiple times for economic reasons. Each cycle of heating degrades the oil's chemical composition, leading to the formation of toxic compounds such as trans fatty acids (TFAs), free radicals, aldehydes, and polycyclic aromatic hydrocarbons (PAHs).<sup>2</sup> These substances are known to cause oxidative stress, inflammation, and Deoxyribonucleic acid (DNA) damage conditions that can initiate or accelerate chronic diseases including heart disease, atherosclerosis, hypertension, and cancer.<sup>3</sup>

India's dependency on edible oil imports and rising food prices further exacerbate the problem. According to the Food Safety and Standards Authority of India (FSSAI), nearly 60% of UCO generated in the country finds its way back into the food chain either through domestic reuse or in food service operations.<sup>4</sup> Inadequate public knowledge, absence of infrastructure for proper disposal, and a lack of strict enforcement mechanisms contribute to the widespread unsafe use of reheated oil.<sup>5</sup>

Scientific evidence indicates that heating oil beyond its smoke point alters its molecular structure, reducing its nutritional value and producing harmful chemicals.<sup>6</sup> Deep frying,

a preferred cooking method in Indian cuisine, typically exceeds 170°C, a temperature sufficient to break down unsaturated fats into potentially carcinogenic compounds.<sup>7</sup> Studies show that oils high in polyunsaturated fatty acids (PUFAs) such as sunflower, soybean, and safflower oil are particularly vulnerable to oxidative damage during repeated heating.<sup>8</sup>

The health implications of consuming food prepared with UCO are alarming. Trans fats formed during oil degradation increase low-density lipoprotein (LDL) cholesterol and reduce high-density lipoprotein (HDL) cholesterol, heightening the risk of coronary artery disease. Additionally, PAHs generated from degraded oil have been classified as carcinogens by the International Agency for Research on Cancer (IARC). The persistent use of such oils also contributes to gastrointestinal disturbances such as acidity, heartburn, and indigestion.<sup>9</sup>

Given the serious health risks and the widespread nature of this practice, urgent public health interventions are necessary.<sup>10</sup> While FSSAI has launched initiatives such as Repurpose Used Cooking Oil (RUCO) to promote the collection and conversion of UCO into biodiesel, the effectiveness of these measures remains limited by poor implementation, especially at the grassroots level. Moreover, there is a pressing need to increase awareness among both consumers and food business operators about the dangers of UCO, and to promote safe alternatives such as regulated oil usage, use of thermostats for frying, and responsible disposal methods.

This review aims to explore the extent of UCO usage in India, assess the associated health risks, evaluate existing policies, and recommend practical dissuasive strategies to prevent UCO from re-entering the food chain.

## METHODS AND MATERIAL

**Study Design:** A descriptive and narrative review design was adopted to explore existing scientific literature, policy documents, and governmental initiatives concerning the

use and reuse of cooking oil. The primary focus was on understanding the prevalence, chemical risks, public health implications, and regulatory frameworks associated with UCO in India.

**Data Sources and Search Strategy**

Multiple electronic databases were searched, including: PubMed, Google Scholar, ScienceDirect, National Center for Biotechnology Information (NCBI), World Health Organization (WHO) databases, Food Safety and Standards Authority of India (FSSAI) reports and press releases. Keywords used for the search included: *used cooking oil, reheated oil, trans fats, polycyclic aromatic hydrocarbons, RUCO initiative, FSSAI, health risks of UCO, and oil reuse in India*. Boolean operators (AND, OR) were applied to refine the search.

**Inclusion Criteria:** Articles published in English, Studies conducted on humans or human-related data, Studies and reports published between 2000 and 2022, Peer-reviewed journal articles, government reports, and policy briefs, Literature focusing on Indian or South Asian populations, or global studies with applicable findings

**Exclusion Criteria:** Non-English language articles, Animal-only studies without relevance to human health, Editorials, opinions, or unverified online sources, Duplicated studies or studies with incomplete data, Data Extraction and Synthesis.

**Data Analysis:** Relevant data were extracted using a data abstraction form that included the following elements: Author and year of publication, Study type and population, cooking oil type and method of reuse, Health outcomes observed (e.g., cardiovascular, carcinogenic, metabolic effects), Regulatory or public health interventions, Recommendations or conclusions drawn. The data were categorized into themes: chemical risks, health impacts, consumer and vendor behaviors, and policy-level responses. Findings were analyzed qualitatively and summarized narratively to highlight patterns, common findings, and discrepancies across studies.

**RESULTS & DISCUSSION**

A total of 28 peer-reviewed articles and official reports published between 2000 and 2022 were included in the final synthesis after screening for eligibility and relevance.

**Table 1:** PRISMA Flow Diagram

| Section                                                                                                       | Description                      |
|---------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>Identification</b>                                                                                         |                                  |
| Records identified through database searching (PubMed, Google Scholar, ScienceDirect, NCBI, WHO, FSSAI, etc.) | 164                              |
| Additional records identified through other sources (e.g., manual search, grey literature, reports)           | 28                               |
| <b>Total Records Identified</b>                                                                               | <b>192</b>                       |
| <b>Screening</b>                                                                                              |                                  |
| Records after duplicates removed                                                                              | 170                              |
| Records screened (titles and abstracts)                                                                       | 170                              |
| Records excluded (irrelevant titles, non-English, animal-only studies, editorials)                            | 110                              |
| <b>Eligibility</b>                                                                                            |                                  |
| Full-text articles assessed for eligibility                                                                   | 60                               |
| Full-text articles excluded (not meeting inclusion criteria, incomplete data)                                 | 32                               |
| <b>Included</b>                                                                                               |                                  |
| Studies included in qualitative synthesis                                                                     | <b>28</b> (as listed in Table 2) |

Analysis of the included literature revealed that the reuse of cooking oil is a deeply entrenched practice in both domestic and commercial food settings across India. Factors such as economic constraints, poor regulatory

enforcement, and lack of awareness have contributed to a widespread disregard for the health implications of reheated oil.<sup>11</sup> The selected studies consistently reported that repeated heating of edible oils especially

those rich in PUFAs such as sunflower and soybean oils leads to the generation of toxic compounds like TFAs aldehydes, (PAHs). These compounds are linked to oxidative stress, lipid peroxidation, and DNA damage.<sup>12</sup>

In terms of health outcomes, the literature strongly supports a causal association between UCO consumption and elevated risk of cardiovascular diseases, including atherosclerosis and hypertension.<sup>13</sup> Several studies also highlight an increased likelihood of carcinogenesis, particularly gastrointestinal and liver cancers, due to the ingestion of PAHs and other degradation products formed during repeated heating. Additionally, gastrointestinal symptoms such as hyperacidity, heartburn, and indigestion were frequently reported

among populations with habitual consumption of reheated oil-based foods.<sup>14</sup>

The regulatory response in India, particularly through the FSSAI, has included initiatives like the RUCO program. While this scheme seeks to divert UCO from the food chain and convert it into biodiesel, implementation remains fragmented, and compliance among small-scale FBOs is limited. The data revealed that in urban centers such as Delhi, Mumbai, Kolkata, and Chennai, many vendors either fail to dispose of UCO appropriately or intentionally mix fresh oil with previously used oil to minimize costs.<sup>13,15</sup>

The table 2 below summarizes the key studies included in the review that examined the chemical and health impacts of UCO, as well as interventions to mitigate its use:

**Table 2:** Summary of Included Studies and Reports on the Health Risks and Policy Aspects of UCO

| Author(s)/Source                  | Year    | Study Focus                                                     | Key Findings                                                |
|-----------------------------------|---------|-----------------------------------------------------------------|-------------------------------------------------------------|
| Gupta <i>et al.</i>               | 2015    | Reheating and PAHs in sunflower oil <sup>3</sup>                | Multiple reheating cycles produce carcinogenic PAHs         |
| Sharma & Bhatia                   | 2018    | TFA content in Indian fried foods <sup>4</sup>                  | High TFA levels in re-used oil samples                      |
| Kumar <i>et al.</i>               | 2017    | Oxidative stress and reheated oils <sup>5</sup>                 | Markers of oxidative stress increase with UCO consumption   |
| National Library of Medicine      | Various | Systematic health effects of heated vegetable oils <sup>6</sup> | Links to carcinogenic PAH formation and inflammation        |
| FSSAI                             | 2022    | RUCO program documentation <sup>7</sup>                         | RUCO targets 220 crore liters UCO for biodiesel conversion  |
| ORF-Cone Advisory Group           | 2021    | UCO usage in 4 Indian metros <sup>8</sup>                       | 60% of small eateries re-use UCO; awareness decreases reuse |
| WHO Technical Report              | 2019    | Trans fats and noncommunicable diseases <sup>9</sup>            | Industrial TFAs increase cardiovascular risk                |
| Singh <i>et al.</i>               | 2014    | Lipid oxidation in reused oils <sup>10</sup>                    | Reused oils show higher MDA and TPC levels                  |
| Bajaj & Patel                     | 2020    | Gastrointestinal effects of rancid oil <sup>11</sup>            | Linked to acidity, indigestion, and GERD                    |
| FAO-India                         | 2018    | Edible oil demand and price fluctuation <sup>12</sup>           | Rising oil prices contribute to unsafe reuse                |
| Goyal <i>et al.</i>               | 2016    | Chemical composition of cooking oils <sup>13</sup>              | PUFA-rich oils degrade faster under heat                    |
| IARC Monograph                    | 2010    | Carcinogenicity of PAHs <sup>14</sup>                           | PAHs from reheated oils confirmed carcinogens               |
| WHO/FSSAI                         | 2020    | Policy guidance on oil safety <sup>15</sup>                     | Advocates <25% TPC use limit                                |
| Mishra & Sen                      | 2013    | Deep-frying behavior in Indian households <sup>16</sup>         | Over 70% households reuse oil $\geq 2$ times                |
| Tamil Nadu Consumer Rights Survey | 2022    | Vendor practices across 13 districts <sup>17</sup>              | 10% vendors reuse oil fully; 20% mix UCO with fresh oil     |
| Srivastava <i>et al.</i>          | 2011    | Cardiovascular risk and TFA <sup>18</sup>                       | TFAs increase LDL/HDL ratio and promote atherosclerosis     |
| Nagarajan <i>et al.</i>           | 2017    | Fatty acid transformation during heating <sup>19</sup>          | Shift from cis to trans configuration                       |
| Bajpai <i>et al.</i>              | 2019    | Awareness campaign impact on oil reuse <sup>20</sup>            | Training programs cut UCO use by 40%                        |

*table cont....*

| Author(s)/Source                        | Year | Study Focus                                            | Key Findings                                                     |
|-----------------------------------------|------|--------------------------------------------------------|------------------------------------------------------------------|
| Indian Journal of Nutrition             | 2021 | Cooking practices and health literacy <sup>21</sup>    | Low knowledge among rural women on oil safety                    |
| WHO-South Asia                          | 2016 | NCD control in relation to diet <sup>22</sup>          | Recommends limiting reheated fats and oils                       |
| McDonald's India Case Report            | 2021 | Corporate biodiesel initiative <sup>23</sup>           | Recycles UCO into biodiesel at 100+ locations                    |
| Bajaj Oils White Paper                  | 2022 | Shelf-life and heating tolerance of oils <sup>24</sup> | Mustard oil more stable than refined blends                      |
| Rao <i>et al.</i>                       | 2009 | Cancer incidence and deep-fried diets <sup>25</sup>    | High fried food intake linked with GI and colorectal cancers     |
| Thakur <i>et al.</i>                    | 2020 | Food vendor licensing in Delhi <sup>26</sup>           | 55% operate without FSSAI registration                           |
| Jain & Rathi                            | 2022 | Health effects of aldehyde consumption <sup>27</sup>   | Aldehydes from reheated oil damage liver enzymes                 |
| Dey <i>et al.</i>                       | 2018 | Thrombogenic index in heated oils <sup>28</sup>        | Reuse increases thrombogenicity and cardiovascular load          |
| Indian Institute of Chemical Technology | 2015 | UCO to biodiesel potential <sup>29</sup>               | India can generate 220 crore liters UCO/year                     |
| FSSAI (Microsite Reports)               | 2022 | Tracking UCO collection and conversion <sup>230</sup>  | Initiatives tracked online; collection network still in progress |

The present review underscores a grave and often underestimated threat to public health in India the repeated use of cooking oil, particularly for deep frying. Drawing on a range of empirical studies, national surveys, and policy assessments, the findings paint a compelling picture of how economic constraints, poor regulatory oversight, and limited public awareness converge to perpetuate the unsafe use of UCO.<sup>17</sup>

### Health Implications of UCO Reuse

A dominant theme across the reviewed literature is the chemical transformation of oils upon repeated heating. Oils rich in PUFAs such as sunflower, soybean, and safflower are particularly vulnerable. Degradation leads to the formation of harmful substances including TFAs, polycyclic aromatic hydrocarbons (PAHs), aldehydes, and other oxidative products, all of which have been linked with serious health outcomes. Studies such as those by Gupta *et al.* (2015) and Sharma & Bhatia (2018) confirm the presence of carcinogenic PAHs and excessive TFAs in reheated oil samples.<sup>3,4</sup>

Importantly, these chemical alterations are not just laboratory curiosities they translate into tangible health risks. Recurrent consumption of food prepared in UCO is associated with increased oxidative stress, lipid peroxidation, and inflammation, which are key biological pathways in the development of cardiovascular disease, gastrointestinal cancers, and metabolic

disorders. The IARC monograph (2010) further classifies PAHs derived from overheated oils as definite carcinogens,<sup>14</sup> while findings by Srivastava *et al.* (2011) and Singh *et al.* (2014) point to atherosclerosis, hypertension, and endothelial dysfunction due to elevated TFAs and MDA levels.<sup>10,18</sup>

Gastrointestinal symptoms, including acidity, heartburn, and indigestion, have also been frequently reported, especially among populations with routine exposure to foods fried in reused oil (e.g., Bajaj & Patel, 2020).<sup>11</sup> These findings reinforce the biological plausibility of the observed epidemiological associations and validate public health concerns.

### Behavioral and Socioeconomic Drivers

Despite well-documented health risks, reuse of cooking oil remains a widely accepted practice. According to Mishra & Sen (2013), over 70% of Indian households reuse oil more than twice. The Tamil Nadu Consumer Rights Survey (2022) revealed that in many districts, 10–20% of vendors either fully reuse or mix UCO with fresh oil driven by cost-saving motives.<sup>16</sup>

Such behaviors are further reinforced by a low level of health literacy, particularly among women in rural households (Indian Journal of Nutrition, 2021). Moreover, urban street vendors, who serve a significant portion of the population daily, often operate without FSSAI licensing or inspections (Thakur *et al.*, 2020),

creating a regulatory blind spot that enables unsafe practices.<sup>26</sup>

### Policy and Regulatory Response

The RUCO initiative by FSSAI represents a critical step in mitigating the issue by redirecting UCO from the food chain to biofuel production. The program has set ambitious targets, including converting 220 crore liters of UCO annually into biodiesel. However, its impact remains uneven and limited, particularly at the grassroots level. Data suggest that only a small fraction of UCO is currently being collected and repurposed, primarily in large urban centers or through organized food chains such as McDonald's India.<sup>6</sup>

Challenges include poor vendor compliance, lack of awareness among small-scale FBOs, and inadequate infrastructure for UCO collection and monitoring. Although RUCO has made progress, a robust and enforceable regulatory framework complete with licensing, inspections, and penalties is necessary for meaningful change. As noted by WHO and FSSAI (2020), keeping Total Polar Compounds (TPC) under 25% should be a mandatory practice, not a voluntary guideline.<sup>30</sup>

### Opportunities and Recommendations

Several studies in the review also provide a hopeful direction. Bajpai *et al.* (2019) demonstrated that educational programs and vendor training can lead to a 40% reduction in UCO use. This suggests that community-level interventions, public awareness campaigns, and inclusion of oil safety in food hygiene curricula could significantly curb hazardous practices.<sup>20</sup>

Alternative cooking practices, such as using thermostats to regulate frying temperatures and choosing oils with higher oxidative stability (e.g., mustard oil as per Bajaj Oils, 2022), should be actively promoted. In addition, there is immense potential in public-private partnerships for UCO collection and conversion into biofuels, offering a dual benefit of environmental sustainability and public health protection.<sup>20,11</sup>

### CONCLUSION

The repeated use of cooking oil poses a significant yet often overlooked public health risk in India. This review highlights the strong

association between used cooking oil and serious health issues such as cardiovascular disease, cancer, and gastrointestinal problems. Despite existing regulations and initiatives like RUCO, widespread reuse continues due to low awareness, economic pressures, and weak enforcement. Addressing this issue requires a combined approach strengthening policy implementation, raising community awareness, and promoting safe disposal practices. Protecting public health demands urgent action to eliminate unsafe oil reuse from both household kitchens and commercial food outlets.

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