International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

# Carcinogenic Potential of Repeatedly Heated Vegetable Oils: Mechanisms, Evidence, and Future Directions

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**Abstract**

This paper evaluates the carcinogenic potential of repeatedly heated vegetable oils (RHVOs). Animal based studies have shown that consumption of RHVO induces oxidative stress, early tumor development and cellular damage in hepatic and intestinal tissues; increased lipid peroxidation, histopathological abnormalities and altered antioxidant enzyme profiles has been observed in animals fed on RHVO [5]. Critical reviews highlight the generation of polycyclic aromatic hydrocarbons (PAHs), and other genotoxic agents in overheated oils and their fumes which further links the RHVO exposure to higher risks of lung, prostrate, colorectal and breast cancer [3][8]. Meta-analysis of general vegetable oil consumption has not shown any significant link with the breast cancer risk, this emphasis the distinction between unheated and thermally degraded oils [7]. This study underscores the need for public awareness around oil reuse practices in commercial and domestic cooking, to mitigate potential carcinogenic risks.

## 1. Introduction

There is global rise in cancer incidences which has prompted growing concern over lifestyle and dietary factors contributing to carcinogenesis. The habitual consumption of deep fried foods prepared in repeatedly heated vegetable oils (RHVOs) has emerged as a potential yet under-recognized risk factor. Vegetable oils are generally assumed to be healthier than animal fats, which may be due to their unsaturated fatty acid content, but the fact that their stability declines significantly when exposed repeatedly to high temperatures for prolonged durations while cooking contradicts this preconceived notion [2]. Repeated heating of vegetable oils is a very common practice in both domestic as well as commercial kitchens, especially in low income countries and regions like Kashmir which rely heavily on non-vegetarian food that needs greater amount of oil to cook.

When vegetable oils are reheated, or heated for prolonged duration, they undergo complex physiochemical transformations such as oxidation, hydrolysis & polymerization, which results in the formation of degradation products like polycyclic aromatic hydrocarbons (PAHs), aldehydes, & lipid peroxides which possess genotoxic, mutagenic, and carcinogenic properties [3][6][8]. These changes make the food fried in such oils as potential vector for chronic health conditions, including cancer.

A study by Perumall Venkata and Subramanyam (2016) [5] showed that rats fed with RHVOs exhibited elevated levels of oxidative stress, along with histological damage to the liver and intestines, including

adenoma formation in the colon. These alterations have been associated with increased peroxide value in the oils, confirming the generation of toxic oxidative compounds following repeated heating.

Literature Review and Evidence Synthesis

The possible carcinogenic potential of repeatedly heated vegetable oils (RHVOs) has drawn attention of scientific community; Aldehydes, polycyclic aromatic hydrocarbons (PAHs), & other oxidative degradation products are among the main causes of concern, as they are known to impair cellular processes [2][3]. These compounds are formed when oils are heated for an extended period of time, particularly while deep-frying [6].

According to a study by Venkata and Subramanyam (2016) [5], rats given heated oils three times displayed notable biochemical and histological changes, including elevated antioxidant activity, a higher level of lipid peroxidation (malondialdehyde), and obvious damage to the intestinal and liver tissues, including thickening of the mucosa and adenomatous changes. These results show that cellular inflammation and oxidative stress are caused by long-term consumption of degraded oils.

The study also found elevated levels of serum glucose, creatinine, and cholesterol; all of these indicate metabolic disruption (when elevated above normal levels) a known risk factor for the development of cancer. It was discovered that when oils were heated repeatedly, their peroxide value increased significantly. The toxic effects on organ tissues were noticeable, particularly at higher doses for longer periods of time, even though haematological parameters stayed largely unchanged [5].

Ganesan et al. (2019) [3] studied the toxicological implications of RHVOs by analyzing many studies connected with the inhalation and consumption of degraded oil vapors and the included risk of a number of cancers, including breast, prostate, colorectal, and lung cancers. The study made it clear that exposure to RHVOs may not just take place through ingestion, but airborne particulates and fumes from heated oils also contain potent carcinogens, particularly volatile aldehydes and PAHs [3][8]. Insufficient ventilation during cooking can thus compound the risk, particularly in women who spend more time in the kitchen.

Despite all the evidences mentioned so far, not all findings directly associate vegetable oil consumption with cancer. The meta-analysis conducted by Xin et al, (2015) [7] analyzed data from 16 studies and found no significant relationship between overall vegetable oil intake and breast cancer risk. Surprisingly, olive oil was found to reduce the risk, may be due to its high content of monounsaturated fats and anti-oxidants. However, the analysis did not account for oil reuse and heating practices, given that carcinogenic compounds are formed primarily during thermal breakdown.

This gap in evidence, a common oversight in dietary studies is concerning; the form in which food is consumed matters as much as the quantity. While fresh vegetable oils may be benign or even beneficial [1], it appears repeated heating of oils makes them potent carcinogens, and other associated toxicological effects [3][5][6]. Together these findings suggest that it is repeated heating which transforms vegetable oils into a potential carcinogen, therefore there is a need of revised food safety guidelines and awareness campaigns.

## 2. Conclusion and Recommendations

The significant carcinogenic risks associated with the consumption of repeatedly heated vegetable oils were revived in this paper; chemical transformations during repeated heating while cooking results in the formation of harmful by-products such as PAHs, aldehydes and reactive oxygen species [3][6][8]. These compounds have been linked to DNA damage, oxidative stress and carcinogenesis in experimental models [4][5]. The added risk is posed by the fact that exposure is not limited to ingestion only; inhalation of fumes from overheated oils also carry a significant amount of risk especially in poorly ventilated rooms [3][8].

Although there is no evidence of a direct association between overall vegetable oil consumption and breast cancer in meta-analytical studies, this may be due the limitations in research design rather than a true absence of risk [7].

To reduce these risk factors, focus should be on awareness and behavioral change in public health campaigns; highlighting the dangers of oil reuse should be integrated into cancer prevention programs. Further research is needed to measure the exact amount of RHVO exposure in humans which is associated with long term cancer risks, and explore the safer alternatives.

In conclusion, the carcinogenic potential of repeatedly heated vegetable oils is not a speculative concern now, but a substantiated public health issue. A combined effort of scientific community, regulatory authorities, and community education is required to prevent the chronic exposure to degraded oils which in turn could reduce the global burden of non-communicable diseases, including cancer.

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