DOI: 10.21088/rfpjbb.2582-3558.11126.3

Journal of Biochemistry and Biophysics
Volume 11 Number 1, January - June 2026

Review Article

Silent Carcinogens at Home: Understanding Cancer Risks in Indian Kitchens

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How to cite this article:

Sachin C Narwadiya, Neha Suthar. Silent Carcinogens at Home: Understanding Cancer Risks in Indian Kitchens. RFP Jour. of Bio. and Biophy. 2026; 11(1): 21–25.

ABSTRACT

There is a growing concern that latent exposure to carcinogens in the home kitchen may lead to an increase in cancer risk. In the Indian context, the interaction of traditional and modern cooking methods adds complexity to the issue. While there are many ways to prepare food, this paper reviews only certain cooking methods such as deep frying, grilling, roasting, and the repeated use of cooking oils, and points out that during those methods of preparation, harmful molecules or compounds i.e., nitrosamines (NOC) / polycyclic aromatic hydrocarbons (PAHs) and numerous other forms of carcinogens are produced. In addition, other risk factors such as using biomass fuels for cooking, cooking in poorly ventilated homes, and the increasing dependency on processed, high-temperature food products compound household exposure to carcinogens. Over time, these factors may contribute to the cumulative carcinogenic burden of the person/citizen and the prevalence of diet-related cancers.

The second aim of the article is to examine the possible protective role of millets in the diet in relation to the risk factors previously described. Millets such as ragi, bajra, jowar, and other varieties of millet contain excessive amounts of dietary fibre, polyphenols, and antioxidants, as well as essential nutrients that have the potential to provide protection against cancer via their anti-carcinogenic, anti-inflammatory, and detoxification properties. Thus, consuming millets may facilitate reducing oxidative stress and lessening the impacts of food-related carcinogens. The review indicates the need for additional awareness and dietary diversity, as well as public health efforts, to reduce the hidden carcinogenic exposures in Indian homes.

KEYWORDS

• Carcinogens • Nitrosamines • Nitrosamines (NOC) • Polycyclic Aromatic Hydrocarbons (PAHs)

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➢ **Received:** 15-04-2026 ➢ **Accepted:** 20-05-2026

INTRODUCTION

The rise of non-communicable diseases (NCDs) has coincided with an increasing epidemic of cancer in both urban and rural populations. There has also been an increase in cancer deaths in both rural and urban populations. This massive increase in cancer death rates in India has been attributed to changes in sedentary lifestyles, diets, exposure to environmental factors, and occupational exposure. More than ever, the kitchen once considered a safe haven for families has become a potential source of long-term, daily exposure to carcinogenic materials due to the introduction of modern cooking methods and changes in the way people eat.

Once predominantly based on plant foods (whole grains, pulses, seasonal vegetables, and naturally harvesting food), Indian traditional dietary patterns were thought to have protective properties against chronic disease. However, in the last thirty years, globalization, urbanization, and changing socio-economic conditions have greatly altered the food environment of India. There has also been a significant and rapid shift from traditional foods to the heavily processed, energy-dense, and convenience foods of the modern Indian diet. Fats, refined sugars, and animal products have also become increasingly popular in modern Indian food consumption. Additionally, there has been a shift from traditional cooking styles (long, slow cooking at low heat) to higher-temperature, shorter cooking styles, including deep-frying, grilling, roasting, and microwaving food item, which are responsible for harmful chemical release.

There is a lot of scientific evidence that shows that multiple carcinogens are created during common cooking processes including cooking oils (polycyclic aromatic hydrocarbons), cooking methods at high temperatures (heterocyclic amines), food storage and plastic cooking containers (endocrine-disrupting chemicals like BPA) and many other cooking processes put you at risk of colorectal and gastrointestinal cancers.

Many households in India (especially in semi-urban and rural areas) have poor ventilation in their kitchens due to their dependence on biomass fuels, which adds to the indoor air pollution that is caused by cooking oil fumes, smoke, and particulate matter - creating a significant risk of respiratory disease and lung cancer among women whose primary role is cooking. In addition, the improper storage of food in warm and humid environments presents a significant risk of fungal contamination of foods, which can expose an individual to aflatoxins a known cause of liver cancer in India.

The interplay between these risk factors is amplified by the decrease in the consumption of traditional antioxidant-rich foods, the increase in sedentary lifestyle-related obesity, and these factors have all been identified as contributing to cancer risk. Additionally, India presents a unique blend of these factors by virtue of some people utilizing traditional methods for food preparation while others have modern food and cooking habits; therefore, understanding the carcinogenic exposures within the kitchen environment is very complex.

Based on this background, an urgent need exists to comprehensively study the different types of carcinogenic risks associated with the cooking practices of Indian households, their epidemiological relevance, and the changes in how food is prepared and consumed over time. Such studies will enable us to identify and understand; risk factors in regard to cancer, and the basis upon which to develop focused public health interventions, education programs, and policy initiatives directed at alleviating the risks of developing cancer due to unsafe cooking practices within Indian homes.

REVIEW OF LITERATURES

Repeated heating and reuse of cooking oils in the kitchen can generate harmful compounds such as Trans-fats, aldehydes, and Polycyclic Aromatic Hydrocarbons, all of which are associated with increased cancer risk, particularly in the digestive system.[1] Similarly, the accumulation of black, burnt residues on utensils indicates incomplete combustion and the formation of toxic substances like Heterocyclic Amines and PAHs, which are known carcinogens.[2] Cooking practices that lead to overcooked or charred food, especially meats further intensify the production of these compounds.[3] High-temperature cooking of starchy foods such as potatoes can produce Acrylamide, a chemical linked to potential cancer risk.[4] The use of low-quality or overheated non-stick cookware may release hazardous chemicals

like Perfluorooctanoic acid, raising long-term health concerns.[5] In addition, preserved and processed foods commonly stored in kitchens may contain Nitrosamines, which are associated with gastrointestinal cancers.[6] Exposure to kitchen smoke, particularly in poorly ventilated spaces, introduces PAHs and fine particulate matter into the air, increasing the risk of respiratory diseases and lung cancer.[7] Heating food in plastic containers can release endocrine-disrupting chemicals such as Bisphenol A, which may contribute to carcinogenic processes.[8] Improper storage of grains, nuts, and spices can lead to fungal contamination and the production of Aflatoxin, a potent liver carcinogen.[9] Lastly, excessive use of aluminum utensils, particularly for cooking acidic foods, may result in metal leaching, which has been debated for its potential long-term health effects, including possible links to toxicity and disease.[10]

Table 1: Carcinogenic Risks, Epidemiology, and Changing Indian Kitchen Practices (1990–2025)

Risk Factor / Exposure	Carcinogenic Agents	Associated Cancers	Epidemiological Evidence (India)	Change in Cooking/ Food Habits	Reference
Reuse of cooking oils	PAHs, aldehydes, trans fats	GI, colorectal	Increasing NCD burden linked to oil reuse	Rise in deep frying, street food	Rastogi *et al.*, 2004
Cooking oil fumes	PAHs, particulate matter	Lung cancer	DNA damage reported in exposed individuals	Indoor cooking with poor ventilation	Balakrishnan *et al.*, 2013
Charred foods	HCAs, PAHs	Colorectal, pancreatic	Linked with high-temp cooking	More grilled/fried foods	Sinha *et al.*, 1999
Starchy foods at high heat	Acrylamide	Colon, kidney	Processed food rise increases exposure	Growth of packaged snacks	Tareke *et al.*, 2002
Processed foods	Nitrosamines	Gastric, colorectal	Urban cancer rise linked to diet	Shift to ready-to-eat foods	Dhillon *et al.*, 2018
Plastic heating	BPA	Breast, prostate	Endocrine disorders rising	More plastic & microwave use	Rochester, 2013
Fungal contamination	Aflatoxin	Liver	Still prevalent in food chain	Storage issues persist	Wild & Gong, 2010
High fat intake	Oxidation products	Breast, colon	Obesity-cancer link rising	More oil/fat consumption	Ferrucci *et al.*, 2010
Loss of traditional diet	Low antioxidants	Multiple	Protective diet declining	Shift to refined foods	Rastogi *et al.*, 2004
Poor ventilation	Smoke toxins	Lung	Indoor pollution risk persists	Closed kitchens common	Balakrishnan *et al.*, 2013

ROLE OF MILLETS IN CANCER MITIGATION

The factors generating carcinogens in kitchen need to be minimize and millets need to be adopted in diet to mitigate the cancer. Due to their bioactive compound content, millets such as finger millet, sorghum and pearl millet have been recognized as cancer-preventative foods in India. These whole grains are high in polyphenols, lignans, antioxidants, dietary fibre and flavonoids all of which help to reduce oxidative stress and chronic inflammation; two factors involved in the development of cancer. Dietary data show that regular consumption of millet also improves gut health due to the modulation of the gut microbiome, leading to improved short-chain fatty acid production, which may reduce the risk of colorectal cancer.[19,20] The low glycaemic index of millets helps to control blood glucose and insulin levels, which decreases the likelihood of developing conditions such as obesity or diabetes, both associated with an increased risk for cancer.[21] In India specifically, where domestic shifts in food sourcing and preparation away from traditional grains toward more refined cereals and highly processed foods have led to increased non-communicable disease incidence, the re-introduction of millet into the diet is consistent with national guidelines on nutrition policy and the prevention of cancer.[22]

There are many types of phytochemicals within these millets (examples include ferulic acid, catechins, and tannins) that are believed to help with cancer prevention and slowing down the growth rate of tumors.[23] To further illustrate this point, phenolic extracts from sorghum have been found to inhibit cancer cell lines in vitro, while finger millet, due to high amounts of calcium and polyphenol, is known to assist

with cell's ability to repair themselves as well as to regulate the process of apoptosis.[24,25] The Indian Council of Agricultural Research has promoted the use of millets through various initiatives, including designating 2023 as an International Year of Millets. This highlights the significance of millets for the public's health. Incorporating millets regularly into the diets of rural and semi-urban groups may be used as a sustainable, culturally appropriate, and cost-effective method for reducing the burden of cancer and improving overall nutritional security.[26]

CONCLUSION

Undetected carcinogens in Indian kitchens are an underappreciated yet serious public health problem fueled by changing cooking habits, types of fuel used and changing diets. Long-term exposure to harmful compounds such as polycyclic aromatic hydrocarbons (PAHs), heterocyclic amines (HCAs), acrylamide, and aldehydes produced from high-heat cooking methods such as frying, grilling, and repeated use of cooking oils can cumulatively lead to an increased risk of cancer through regular use. Contributing to this risk are high use of biomass fuels in Indian kitchens, limited ventilation in Indian kitchens and an increase in the consumption of ultra-processed and fried foods. Addressing these factors requires both improved education and interventions through better cooking techniques, cleaner fuels (i.e. LPG), improved oil management techniques and including antioxidant-rich foods in everyday diets.

Millets offer a positive intervention to reduce cancer risk from these exposures. Millets, including finger millet (ragi), pearl millet (bajra), and sorghum (jowar) are high in fiber, polyphenols, flavonoids, and essential micronutrients. These bioactive compounds possess strong antioxidant, anti-inflammatory and anti-proliferative properties and therefore neutralize free radicals, decrease oxidative stress, and modulate detoxification pathways in the body in order to combat the effects of both dietary and environmental carcinogens.

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