Review

Toxic wrapper of bidi: The unobserved part of a handmade cigarette

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ABSTRACT

Bidis are small handmade cigarettes, mainly manufactured in India. They are made by rolling crude tobacco in *Diospyros melanoxylon* Roxb. leaf wrapper. The wrapper makes about half of the total bidi weight. Research studies published in relation with bidi smoke toxicities are mostly done with its tobacco part and report the toxicities attributed to the tobacco. During the long course of toxicological observations the wrapper remained unnoticed even when contributing to more than half of the bidi weight. In India bidi is the most popular form of tobacco consumption, constituting around 53% of total tobacco consumption. Toxicological studies with the bidi wrapper may provide a deeper insight into the health effects of bidi smoke.

Key words: Bidi smoking, bidi wrapper, *Diospyros melanoxylon*, toxicity.

INTRODUCTION

Smoking is associated with high mortality rate in human beings (Ray and Gupta, 2009). Smoking is associated with the most of the lung cancer cases and cessation of smoking is the most effective strategy to avoid lung carcinogenesis (WHO Tobacco Free Initiative, 2006). Cigarette remains the most popular form of smoking in United States (Backinger *et al.,* 2008) and other countries. However there are many alternatives to the cigarettes such as cigar, bidi, hookah (water pipe) and kreteks (Soldz and Dorsey, 2005). Smoke released from these smoking devices contains tar, carbon monoxide, HCN, phenols, formaldehyde and several other toxicants (Adams *et al.*, 1984; *Lu et al.,* 2003; Pakhale *et al.,* 1990). Bidi is the most popular form of smoking in India (50%) (Food and Agricultural Organization, 2003).

Bidis are made by rolling crude tobacco in tendu or tamburni leaf (*Diospiros melanoxylon* L.) and tied with a coloured cotton thread. It is mainly manufactured in India. Other producers include Bangladesh, Pakistan, Nepal and Sri Lanka.

In India bidis constitute over 50 % of the total tobacco consumption (Jha *et al.,* 2008; Panchamukhi *et al.,* 2008). During the past three decades bidi has gained popularity among the young population of many developed countries (CDC 1999; Richter *et al.*, 2002). The reason of its popularity is its more natural appearance, low price, availability in many flavours like chocolate, vanilla, mango, cherry etc. (Fischer, 2000; Yen *et al.*, 2000). There is a misconception among youth that bidis are safer than conventional cigarettes. A survey conducted in India found that 12.5 % of school students were bidi smokers (Sinha and Dikshit, 2008). Another survey in United States reported that 4.8 % students were current bidi users (CDC, 2004).

Bidi smoking is a major health concern. Bidis release greater amount of tar, nicotine and carbon monoxide than western branded cigarettes (Malson *et al.*, 2001; Watson *et al.*, 2003). Bidis are reported as a major cause of death in Indian men mainly with respiratory and vascular diseases (Gajalakshmi, 2003; Gupta PC, Mehta, 2000). Studies from India show an association between bidi and cancers of lung, oral, stomach and oesophagus. It is also involved in the development of chronic bronchitis, coronary heart disease and myocardial infarction (Pais *et al.*, 1996; Rahman and Fukui, 2000; Sankaranarayanan *et al.*, 1991).

Inhalation route is the most important when considered with both survival and exposure to toxicant. In the present environment the presence of toxic inhalants, which are released from chimneys, automobile exhausts, cigarettes, forest fires etc., is unavoidable. Survival without oxygen cannot be imagined even for minutes. This makes the inhalation process an essential natural phenomenon for the continuity of life. Exposure through inhalation route is more important in terms of interactions with the environment. The lungs work as an interface between body and the environment, however, skin also fulfil the same purpose, but the anatomical and physiological natures of these organs are different. Lungs provide much larger surface area (~70 m^2), for the exposure to external environment, than skin (1.73 m^2, in average adult human).

Brief introduction to airway anatomy

The respiratory system, located in the thoracic cavity, makes an interface between the circulatory system and the external environment, and it is responsible for gaseous exchange. Upper airways are involved in inhalation of air via the nasal cavity, pharynx and larynx through the lower airways (trachea, primary bronchi and bronchial tree) and small bronchioles and alveoli within the lung tissue.

The nasopharyngeal region includes nares, nasal turbinates, glottis, epiglottis, pharynx and larynx. This region functions in removing the larger inhaled particles through filtration by nasal hair and impaction in the turbinates. It also conditions the inhaled air by increasing the humidity and moderating the temperature. Physiological responses of the nasopharyngeal region can be altered in response to inhaled toxicants.

Conducting airways or the tracheobronchial region is responsible for maintaining the supply of inspired air to the alveolar region of the lung. Trachea and bronchus are the major components of this region; it ends at the terminal bronchioles. These airways are covered with a layer of goblet cells that secrete mucus, and ciliated columner cells that, in combination with mucus, form a protective mucociliary coating. This region function in further conditioning of the inspired air and clearance of the inhaled particulate matter, by ciliary movement, that is trapped on the protective mucociliary layer.

Gaseous exchange occurs in the pulmonary region, which comprise approximately 80–90% of the total lung parenchyma. The region is an arrangement of bronchioles, alveolar ducts and alveoli. Capillaries, blood plasma, and other blood components are separated from the air space by means of a thin layer of tissue formed by epithelium, interstitial part, and endothelium.

As a whole lungs are divided into lobes. In humans lungs contain five lobes, two left and three right. The left lung is composed of the upper lobe, the lower lobe, the right lung is composed of upper, middle and lower lobes. Both right and left parts of the lungs are separated from each other by contents of the mediastinum and the heart. In rats and mice (Rodents) lungs contain five lobes, one left and four rights.

The ever increasing hazards

The number and concentration of air pollutants is rapidly increasing in the present environment. Most of them are causing damages to the lung. A minor imbalance in atmospheric composition can disturb the physiology of the lung. Airborne toxicants are a matter of major concern regarding human health. They get direct entry into the lungs with the inhaled air during the normal process of breathing. Major inhalant toxicants include automobile exhausts, chimney exhausts, suspended particulate matter (SPM), certain gases, fumes, cigarette smoke, smoke generated from forest fires etc. Automobile exhaust, cigarette smoke and SPM are causing more debilitating effects as people are exposed to these agents on a regular basis. These exposures are more common throughout the world.

Why do lungs are susceptible to toxicities?

Lungs are more susceptible to damage when exposed to toxicant via inhalation. Rich vasculature, large surface area and thin epithelium contribute to lung's high sensitivity towards various kind of air borne toxicants. The most important effect of many toxic inhalants is to place an undue oxidative burden on the lungs. Studies on humans and animals provide strong evidences that the consequences of oxidative stress may be instrumental in initiating and propagating ailments such as chronic bronchitis, emphysema, fibrosis, and cancers (Crapo *et al.*, 1992; Pastorino, 1997; Witschi, 1997).

Alterations in lung epithelial cells may cause architectural and functional disruptions in the lung (Aoshiba and Nagai, 2003). Bidi wrapper generates a copious amount of smoke which probably contains a large number of toxic products after combustion process. These toxicants pose a significant concern in views of susceptibilities of the lung. The wrapper also generates a substantial amount of carbon monoxide and poses a toxic threat to cardiovascular system as well.

Role of inflammation and oxidative stress

The conditions like inflammation and oxidative stress are responsible for various kinds of damages to the lung epithelium. Inflammation, itself, exaggerates oxidative stress by recruiting inflammatory cells, which in turn produces reactive oxygen species (ROS). Inflammation is also associated with generation of nitric oxide (NO), a free radical gas, which participate in worsening the oxidant burden within the tissue when over produced. These oxidants induce cellular injuries in lung epithelium and may lead to permanent alterations in lung architecture and function. Repeated exposure of cigarette smoke can tilt the acute inflammatory responses towards chronic one. These chronic inflammatory conditions may have any of the diseases form that is known to have lethal effects on the patients. These include chronic obstructive pulmonary disease (COPD), emphysema, bronchitis, bronchiolitis, pulmonary fibrosis etc. Cancer is also a chronic disorder that is associated with genetic alterations in oncogenes and tumor suppressor genes. Although inflammation is a protective response of the body but a close relation has been found between chronic inflammation and cancer development (Mantovani, 2008). Lungs are very much sensitive towards damages and show quick inflammatory responses and most of the lethal lung ailments are inflammatory. Bidis generate greater amount of tar as compared with cigarettes (Richter and Watson, 2008), which is mainly due to combustion of wrapper leaf. The dense smoke released from bidis can induce significant inflammation in the lung and wrapper should not be ignored in this respect. A different pattern of morbidities caused by bidis, as compared with those by cigarettes, also indicates towards the involvement of wrapper smoke in the toxic manifestations. The relation between cancer and inflammation may be a potent reason why lung cancer deaths outnumber the deaths caused by any other cancer.

Inflammation is body's protective response to cellular or tissue injuries. The function of this process is to eradicate and remove the pathogens, noxious agents and injured tissues, thereby promoting tissue repair. When this important and normally protective response occurs in an uncontrolled manner, it results in excessive cellular and tissue injuries that may lead to chronic inflammation and destruction of normal tissue. In case of lung ailments, inflammation plays a central role as most of the lethal lung diseases are inflammatory in nature. Inflammatory lung diseases are characterized by chronic inflammation (McNee, 2000) associated with oxidative stress. Oxidative stress conditions are proposed to be involved in tissue damage associated with chronic lung inflammation and consequent diseases (Rahman and McNee, 1999; Morcillo, 1999).

Bidi as a health problem

Various epidemiological studies have reported the debilitating effects of bidis on human health (Rahman M and Fukui, 2000). Most of the toxic effects of bidis are thought to be due to its tobacco part (Mokdad *et al.*, 2004). Reports suggest the role of wrapper leaf in the generation of high amount of tar and carbon monoxide; the leaf does not contain nicotine. It is reported that wrapper can determine the physicochemical nature of the smoke (Hoffmann D and Hoffmann, 1997).

Most of the incapacitating activities of bidis are attributed to the tobacco filler (Bagwe *et al.*, 1994; Shah *et al.*, 2001). However, the wrapper leaves, that constitute over half of the bidi, generate larger amount of smoke, but remained unnoticed toxicologically. The toxic potential of *Diospyros melanoxylon* leaf smoke on biological system is indirectly indicated by its effects which are somewhat different from those of the conventional cigarettes.

In India bidis constitute over 50 % of the total tobacco consumption (Jha *et al.*, 2008; Panchmukhi *et al.*, 2008). During the past three decades bidi has gained popularity among the young population of many developed countries (CDC, 1999; Richter and Watson, 2008). The reason of its popularity is its more natural appearance, low price, availability in many flavours like chocolate, vanilla, mango, cherry etc. (Fisher, 2000; Yen *et al.*, 2000).

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Bidi smoking is a major health concern. They release greater amount of tar, nicotine and carbon monoxide than western branded cigarettes (Malson *et al.*, 2001; Watson *et al.*, 2003). Bidis are reported as a major cause of death in Indian men mainly with respiratory and vascular diseases (Gajalakshmi *et al.*, 2003; Gupta and Mehta, 2000). Studies from India show an association between bidi and cancers of lung, oral, stomach and oesophagus. It is also involved in the development of chronic bronchitis, coronary heart disease and myocardial infarction (Pais *et al.*, 1996; Rahman and Fukui, 2000; Sankaranarayanan, 1991). "Herbal bidi" is an alternative form of bidi in which some herbs and non-tobacco contents such as ginseng, catnip and jasmine are wrapped in the same tendu leaf (*D. melanoxylon*). Herbal bidis are considered safer than tobacco filled bidis. Although both the types of bidis are considered harmful for the health but a few studies have been conducted on their toxicological aspects.

Bidi wrapper smoke toxicity

The major constituents of *Diospyros* species are naphthoquinones, pentacyclic triterpenes and coumarins (Mallavadhani *et al.*, 1998; Mallavadhani *et al.*, 2001; Richter and Watson, 2008). These compounds are known to exert toxic burden on kidneys, lung and liver in mice (Shimkin, 1941; IARC, 2000; Venkatakrishnan, 2009). Toxic compounds such as nitrosamines and polycyclicaromatic hydrocarbons (PAHs) etc. are found in tobacco. Thus toxicity of bidi smoke, as a whole, should be a combined effect of smoke from both wrapper leaf and tobacco.

Studies suggest that increased oxidative burden in bidi smokers may lead to various inflammatory reactions and damages in lungs (Buhl *et al.*, 1996). This is probably due to accumulation of hydrogen peroxide which can diminish the activities of catalase and glutathione peroxidase (Pigeolet *et al.*, 1990) further leading to generation of hydroxyl radicals, DNA damage and cell death.

Plants are the producer of a great variety of phenols, which along with other toxic compounds may be responsible for the toxic effects of the wrapper leaf smoke. Further probability of formation of toxic pyrolysis products (Czégénya, 2009) during combustion of leaf cannot be ignored. The very same observations can be applied to tobacco free, herbal bidis.

The published reports are not sufficient enough to conclude about what chemicals in wrapper leaf are responsible for its toxic effects, only we can have a hypothesis at this moment. In most of the studies, enhanced toxicity of bidi smoke as compared with cigarettes, is suggested due to low porosity and low combustibility of wrapper leaf that contribute to longer and deeper puffs during bidi smoking (Richter and Watson, 2008). But these considerations did not suggest anything about the chemical properties of the wrapper and its smoke. Toxicological studies are needed to evaluate the ultimate health effects of the bidi wrapper smoke and its role in toxicities caused by tobacco smoke and consequent diseases.

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Conflict of interest

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