Assessing the Nicotine Content of Smoked and Smokeless Forms of Tobacco Available in Bhopal

Abstract

**Context:** Abuse of tobacco, such as drug and alcohol abuse, is a worldwide public health problem. Once a person is addicted to nicotine, quitting smoking is difficult. A measure of the addictive potential of tobacco products is the amount of nicotine available from them. The present study is an attempt to assess the nicotine content of tobacco products available in Bhopal. **Aims:** This study aims to assess the nicotine content of some popular brands of smoked (cigarettes and bidis) and chewed forms (pan masalas containing tobacco) of tobacco available in Bhopal. **Settings and Design:** This was an in vitro cross-sectional study. **Subjects and Methods:** Six brands of cigarettes (filtered), six brands of bidis, and six brands of chewed tobacco (pan masalas) were used for the study. The methodology published by Association of Official Analytical Chemists was followed, and reagents conforming to American Chemical Society specifications were used. **Statistical Analysis Used:** One-way ANOVA, Bonferroni post hoc test. **Results:** The mean nicotine levels for cigarettes, bidis, and chewed tobacco were 7.84 ± 5.10, 16.86 ± 5.66, and 16.30 ± 3.33, respectively. The differences in the mean scores were compared using one-way ANOVA and were found to be statistically significant with F = 6.636 and P = 0.009. Bonferroni post hoc test assessed the difference in mean nicotine content among the groups indicating that the difference between cigarettes versus bidis and cigarette versus chewed tobacco was significant with P = 0.016 and 0.024, respectively. **Conclusions:** Bidis had the highest content of nicotine, followed by chewed tobacco (pan masalas) and cigarettes.

**Keywords:** Bidis, chewed tobacco, cigarettes, nicotine content, titration

Introduction

Tobacco has been smoked for at least the last 3000 years. Nicotine (3-[1methyl2-pyrrolidinyl] pyridine) is the most abundant of the volatile alkaloids in the tobacco leaf. The primary commercial source of nicotine is by extraction from the plant *Nicotiana tabacum* and *Nicotiana rustica*. Nicotine acts on nicotinic cholinergic receptors, affecting most organ systems in the body and is a highly addictive drug.[1]

Nicotine normally makes up about 5% of a tobacco plant, by weight. Cigarettes contain 8–20 mg of nicotine (depending on the brand), but only approximately 1 mg is actually absorbed in the human body. Approximately, 70% of smokers who want to quit smoking cannot and about 83% of smokers smoke every day.[2]

The recent decades have seen a massive global increase in tobacco use; the consumption of cigarettes alone having risen from 300 million/year in 1920 to 5.5 trillion in 2000.[3] The Indian scenario as far as tobacco consumption is concerned is far worse because of the prevalence of the tobacco-chewing habit, which covers a wide spectrum of socioeconomic and ethnic groups and is spread over urbanized areas as well as remote villages. This is in addition to the widespread prevalence of smoking, with both cigarettes and bidis being smoked in large numbers. Tobacco use has been associated with the development of oropharyngeal and upper respiratory tract cancers and is a risk factor for cardiovascular disease and adverse reproductive outcomes. Cigarettes and other forms of tobacco are addictive, and nicotine is the substance in tobacco that causes addiction.[4]

Abuse of tobacco, such as drug and alcohol abuse, is a worldwide public health problem. In India, it is estimated that 57% of the population aged 15 years and above (i.e., >500 million) use tobacco.
in one form or the other. Of this group, 72% smoke bidis, 12% smoke cigarettes, and 16% use tobacco in the smokeless form.\(^5\)

Once a person is addicted to nicotine, quitting smoking is difficult, and more than 90% of the smokers who try to quit each year fail. The epidemic of addiction to nicotine among young people has enormous implications on public health.\(^6\)

Self-report measures among tobacco users are highly imprecise owing to individual differences in how cigarettes are smoked such as number of puffs, intensive puffing, occlusion of ventilation holes in the filter, length of breath holding, and unsmoked butt length, to obtain the desired dose of nicotine. Typically, a cigarette delivers about 1 mg of nicotine to the circulation of the smoker, with an absolute bioavailability of about 12%. It is estimated that 5 mg of nicotine per day is a threshold level that can readily establish and sustain addiction.\(^7,8\) In contrast, among chewing tobacco users, nicotine absorption is primarily determined by the product itself, the pH, and size of tobacco cuttings. A measure of the addictive potential of tobacco products is the amount of nicotine available from them. The difference in the nicotine concentration between various tobacco products is perhaps due to plant variety, cultivation, curing methods, and the design of the smoking product. The U.S. and Canadian Governments have sponsored regular assays of the tar and nicotine yield of cigarettes since 1967.\(^9\)

The existing policies in our country do not mandate companies to display the nicotine content on the manufactured tobacco products. Knowledge about this may help the user to be more conscious while using any of the tobacco products, be it smoked or chewed. There are various methods of assessment of nicotine content of tobacco products mentioned in literature. The present study is an attempt to assess the nicotine content of tobacco products available in Bhopal by a simple titration method.

Aim

The aim was to assess the nicotine content in Indian tobacco products, including some popular brands of smoked (cigarettes and bidis) and chewed forms (pan masalas containing tobacco) available in Bhopal.

Objectives

1. To assess the nicotine content of various smoked and smokeless forms of tobacco available in Bhopal
2. To compare the nicotine content of smoked and smokeless forms of tobacco.

Subjects and Methods

This was an in vitro cross-sectional study, which assessed the nicotine content in commonly available tobacco products of Bhopal, Madhya Pradesh, India. The laboratory procedures of the study were carried out in the School of Pharmacy of the University. The study was conducted in the months of August and September of 2015. A synopsis of the study was presented before the Institutional Ethical Committee of the college and approval was obtained (PCDS/ACAD/8/2015/32). After obtaining the approval, data on commonly available brands of cigarettes, bidis, and chewed tobacco (pan masalas) in Bhopal were collected.

Required number of tobacco samples was obtained from local retail outlets for the study in August 2015. Six brands of cigarettes (filtered), six brands of bidis, and six brands of chewed tobacco (pan masalas) were used for the study. Nicotine contents in the products were assessed by extracting similar quantity of all the products. Each of the product was analyzed separately.

The methodology published by Association of Official Analytical Chemists (AOAC) was followed and reagents conforming to American Chemical Society specifications were used.\(^9\)

- Each sample was suspended in 15 mL of 5% acetic acid briefly
- Followed by addition of 100 mL of toluene-chloroform (1:1 v/v), and then 10 mL of 36% sodium hydroxide
- This solution was mixed for 20 min using a mechanical wrist action shaker
- Now, the toluene-chloroform layer was filtered twice through Whatman no. 2 paper
- Two drops of crystal violet indicator was added to 25 mL aliquots of the filtered toluene-chloroform solution and titrated to a green endpoint using a perchloric acid solution
- Standardization of the perchloric acid to 0.02453 normal was done using potassium phthalate as a primary standard.

The percentage of total alkaloids as nicotine was then calculated as follows:

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\text{Nicotine content (\%) = \frac{(volume of titrant) (0.02453 \times 32.45)}{weight of sample}}
\]

- The percentage values were also converted into mg/g, as many of the studies have mentioned in this unit as well
- To establish the accuracy of the extraction, the same procedure was performed on 15 and 30 mg samples of purified nicotine obtained from Oxford Laboratory Chemicals Ltd. (ISO-9001-2008 Certified chemical company), Vasai (District: Thane), Maharashtra, India, used as a standard.

Concentrations of nicotine were compared between cigarettes, bidis, and chewed tobacco (pan masalas). Difference in the nicotine concentrations between the groups was assessed using one-way ANOVA and Bonferroni post hoc tests.
Results

All the samples were coded alphabetically A-F for cigarettes, G-L for bidis, and M-R for chewed tobacco (pan masalas). Percentage of nicotine found in various products in all the three groups has been summarized in Table 1. Highest level of nicotine was found in bidis, followed by chewed tobacco and cigarette. One of the brands of bidi contained 21.79% of nicotine, which was the highest level among all the three groups. Highest level of nicotine among chewed tobacco was 21.70%, and that for cigarettes was 17.67%. The mean nicotine levels for cigarettes, bidis, and chewed tobacco were 7.84 ± 5.10, 16.86 ± 5.66, and 16.30 ± 3.33, respectively. The data reveal that bidis and chewed tobacco (pan masalas) contained higher levels of nicotine compared to cigarettes.

The differences in the mean scores were compared using one-way ANOVA as seen in Table 2 and were found to be statistically significant with $F = 6.636$ and $P = 0.009$. Further Bonferroni post hoc test was applied on the data [Table 3] to check for the significance of difference between groups. The difference in the mean nicotine content among the groups revealed that the difference between cigarettes versus bidis and cigarette versus chewed tobacco was significant with $P = 0.016$ and 0.024, respectively. The comparison of bidis and chewed tobacco did not yield a significant result.

Discussion

Use of tobacco, such as drug and alcohol abuse, is a worldwide public health problem. In India, it is estimated that 57% of the population aged 15 years and above (i.e., >500 million) use tobacco in one form or the other.[7] Of the 250 million kilograms of tobacco cleared for domestic consumption in India, 86% is used in the smoking form and 14% in the smokeless form.[5] Of the millions of people in this country who use chewing tobacco, as many as 1 in 4 is under the age of 19 years.[10]

Cigarette is commonly referred to a small roll of finely cut tobacco leaves wrapped in a cylinder of thin paper for smoking.[11] Cigarettes, cigars, and spit and pipe tobacco are made from dried tobacco leaves, as well as ingredients added for flavor and other properties. According to American Cancer Society, more than 4000 individual chemicals have been identified in tobacco and tobacco smoke. Among these are more than 60 chemicals that are known carcinogens.[12]

According to the society for neuroscience, in tobacco smoke, nicotine – rides on small particles of tar. The smoke carries this nicotine/tar mixture to lungs where nicotine is absorbed. Nicotine reaches brain about 8 s after the smoke is inhaled. Much of the nicotine is burned off, and a smoker gets about 9% (1 mg of nicotine out of 11 mg) of nicotine in every cigarette.[13]

| Sample | Concentration of nicotine (%) |
|--------|------------------------------|
| Cigarettes |                               |
| Sample A | 17.67                        |
| Sample B | 4.34                         |
| Sample C | 8.66                         |
| Sample D | 4.40                         |
| Sample E | 4.98                         |
| Sample F | 7.02                         |
| Mean±SD  | 7.84±5.10                    |
| Bidis    |                              |
| Sample G | 21.79                        |
| Sample H | 17.62                        |
| Sample I | 24.33                        |
| Sample J | 16.27                        |
| Sample K | 10.07                        |
| Sample L | 11.09                        |
| Mean±SD  | 16.86±5.66                   |
| Chewed tobacco |                          |
| Sample M | 14.10                        |
| Sample N | 14.91                        |
| Sample O | 12.40                        |
| Sample P | 18.35                        |
| Sample Q | 21.70                        |
| Sample R | 16.33                        |
| Mean±SD  | 16.30±3.33                   |

SD=Standard deviation

Table 2: Comparison of the mean nicotine levels among cigarettes, bidis, and chewed tobacco with one-way ANOVA

| Sum of squares | df | Mean square | $F$ | Significant |
|---------------|----|-------------|-----|-------------|
| Between groups | 306.153 | 2 | 153.076 | 6.636 | 0.009* |
| Within groups  | 346.011 | 15 | 23.067 |       |        |
| Total          | 652.164 | 17 |       |       |        |

*The mean difference is significant at the 0.05 level.

Table 3: Comparison of the mean nicotine levels using Bonferroni post hoc test

| Comparison of samples | Significant | $95\%$ CI | Likely bound | Upper bound |
|-----------------------|-------------|-----------|--------------|-------------|
| Cigarettes            |             |           |              |             |
| Bidis                 | 0.016*      | −16.4862  | −1.5471      |
| Chewed tobacco        | 0.024*      | −15.9229  | −0.9838      |
| Bidis                 |             |           |              |             |
| Cigarettes            | 0.016*      | 1.5471    | 16.4862      |
| Chewed tobacco        | 1.000       | −6.9062   | 8.0329       |
| Bidis                 |             |           |              |             |
| Chewed tobacco        | 0.024*      | 0.9838    | 15.9229      |
| Bidis                 | 1.000*      | −8.0329   | 6.9062       |

*The mean difference is significant at the 0.05 level.

CI = Confidence interval

Pan masala containing tobacco was introduced in the Indian market during the 1970s. It is a mixture of areca nut, lime,
catechu, and sweetening, coloring, and flavoring agents, with or without tobacco.[7] Tobacco-containing brands are preferred by many due to their intoxicating effect and also the added flavor and taste due to the tobacco in the mix.

Long-term exposure to tobacco and nicotine results in addiction and dependence as well as increases the chances of cancer. Nicotine is one of the most addictive substances known and quitting it is very difficult.[14]

The nicotine content of a cigarette is an important element in its design. Nicotine content is the amount of nicotine contained in the tobacco before it is burned and inhaled.

A smoker extracts the nicotine contained within the tobacco by inhaling nicotine, which is released into the smoke when the tobacco is burned. A cigarette with higher nicotine content has a greater amount of nicotine, which may potentially be extracted by the smoker and inhaled during smoking. Consumers may believe that “light” and “ultra-light” cigarettes contain less nicotine than full flavor cigarettes. However, such classifications do not reflect the amount of nicotine in the cigarette; they are based solely on Federal Trade Commission ratings of nicotine yield, which are based on the amount of nicotine – inhaled by a smoking machine.[15]

Once the nicotine is determined gravimetrically, it may be reported as:
1. Content (mg) per cigarette
2. Nicotine concentration per gram of tobacco, or
3. Percent nicotine.

Various assessment procedures have been devised to determine the nicotine content of tobacco products. Methods such as gas chromatography, high-performance liquid chromatography (HPLC), and spectrometry have been used. The major problems in the usage of sophisticated techniques include requirement for expensive instrumentation and high-level trained personnel among other associated with high contending issues of stable electricity supply in most developing countries.[16] In view of these issues, a methodology which is less expensive, technically less sensitive, and less laborious may offer a practical solution. Keeping these points in mind, a simple titration method has been used in the present study for assessment of nicotine content of tobacco products.

The results of the present study reveal that bidis and chewed tobacco (pan masalas) contained higher levels of nicotine as compared to cigarettes. In India, it is estimated that 57% of the population aged 15 years and above (i.e., >500 million) use tobacco in one form or the other. Of this group, 72% smoke bidis, 12% smoke cigarettes, and 16% use tobacco in the smokeless form.[17] It is alarming to note that the usage of bidis is high in our country, especially among the rural population. Moreover, about 70% of Indian population is from rural areas.

The highest level of nicotine was found in one of the brands of bidi with 21.79% of nicotine, which was the highest level among all the samples compared in the present study. The highest level of nicotine among chewed tobacco was 21.70%, and that for cigarettes was 17.67%. The mean nicotine levels for cigarettes, bidis, and chewed tobacco were 7.84 ± 5.10, 16.86 ± 5.66, and 16.30 ± 3.33, respectively. Nicotine content was found to be similar among bids and chewed tobacco, whereas it was far less in cigarettes.

Our study results are in contrast with the one conducted by Reddy and Shaik in 2008, wherein nicotine concentration of chewing tobacco averaged 3.4 mg/g (range 2.6–4.1 mg/g) whereas it averaged 15 mg/g in smoking tobacco.[7] The nicotine concentration of the tobacco from the bidis averaged 26.9 mg/g, whereas it averaged 15 mg/g in the tobacco from cigarettes. The difference in the nicotine content may be attributed to the brands of bidis, cigarettes, and pan masalas that are locally available. Furthermore, gas chromatography has been used in this study for assessment of nicotine levels.

The mean nicotine content for national brands of cigarettes was 12.85 mg, and for international brands, it was 10.57, in a study conducted in Pakistan by Mahmood and Zaman in 2010. Methodology as suggested by AOAC method was used.[14]

Nicotine content of cigarettes ranged from 1.14% to 3.62%, in a study conducted by Akinyemi et al. in Nigeria 2015, using titration method, similar to the one used in the present study. The authors claim that values for the respective brands as determined in this study are within 8–20 mg/g reported for the same brands of cigarettes determined with HPLC coupled with mass spectrometric method. Hence, titration method is a viable alternative to much sophisticated methods.[18]

It is reported that the nicotine content of cigarettes was 10.2 mg/g in the US brands, 13.5 mg/g in Canadian brands, and 12.5 mg/g in the UK brands.[18] Fukumoto et al., in their study on Japanese filtered cigarettes, found 11.72 ± 2.27 (standard deviation) mg of nicotine per cigarette.[19] Pakhale and Maru in their study on Indian cigarettes have found the nicotine concentration to be 16.2 mg/g.[20] In the present study, nicotine content in the cigarettes available in Bhopal ranged from 4.34% to 17.67%. Titration method is a qualitative assessment of the nicotine content and hence expresses the concentration as percentage of nicotine in the titrate and hence makes it difficult to compare with the quantitative assessments as done by methods such as gas chromatography. Analysis in one study suggested that cigarettes from the Eastern Mediterranean, Southeast Asia, and Western Pacific WHO regions tended to have higher tar, nicotine, and CO smoke deliveries than did brands from the European, American, or African WHO regions surveyed.[21]
Some brands have a higher nicotine content than others, indicating that tobacco types or blends and tobacco casings can be used to manipulate the nicotine content and the nicotine delivery of cigarettes. The difference in the nicotine concentration between Indian cigarettes and other international brands can, perhaps, be attributed to the difference in the technique employed for estimation of nicotine. Plant variety, cultivation, curing methods, and the design of the smoking product (including the wrapper used and the presence/absence of filters differing in efficiencies) are very different in India and in Western countries. These factors are known to influence the formation and yields/levels of toxic chemicals in tobacco and tobacco smoke.[7]

Bidis, an alternate type of cigarette, consisting of finely ground, sun-dried tobacco rolled in a brown temburi (Diospyros melanoxylon) leaf is the most popular form of tobacco used in India. The nicotine content of bidis in the present study ranged from 10.07% to 21.79% and was much higher compared to cigarettes. The results are in concurrence with the studies of Reddy and Shaik,[7] 2008 and Malson et al.[22] Pakhale and Maru reported the nicotine concentration of bidis to be 37.7 mg/g.[20] Malson et al. found exported Indian brands of bidis to have a concentration of nicotine of 21.2 mg/g.[22] The differences may be attributed to the different brands of bidis used as well as the ones which are locally made.

An increased incidence of squamous cell and verrucous carcinomas of the oral cavity and pharynx has been found in patients who use chewing tobacco. The risk increases with the increase in the frequency and duration of the habit. The odds for oral cancer is estimated to be 7.3 in smokers, 1.3 in alcoholics, and 11.4 in those habituated to chewing tobacco.[7] In contrast to smokers, who absorb nicotine primarily through the pulmonary vasculature, chewing tobacco users absorb nicotine both through the buccal mucosa and the gastrointestinal tract. Tobacco-specific N-nitrosamines, present in higher concentrations in smokeless tobacco, are readily extracted by saliva; the absorption is further enhanced in alkaline environments.[7]

None of the tobacco products used in the present study displayed nicotine and tar content on their packs. Compensation techniques such as vent blocking or taking longer and deeper puffs on a cigarette are used by smokers as means of extracting a greater amount of nicotine. When a cigarette has a high level of nicotine content, the smoker may be able to extract high levels of nicotine even though smoking cigarettes with lower nicotine yields. Rather than reducing their amount of nicotine, they may simply smoke harder and longer on “light”/“ultra-light” cigarettes to achieve the same impact and the same level of nicotine they obtained with “higher” nicotine yield cigarettes.[14]

If tobacco companies were required to reduce the levels of nicotine in cigarette tobacco, young people who start could avoid becoming addicted, and long-time smokers could reduce or end their smoking. This could spare millions of people from the severe health effects of long-term smoking.[23,24]

Although the present study compares the nicotine content of smoked and chewed tobacco products commonly available in Bhopal, it may not give a conclusive idea as to what type of products are more harmful. Titration being a qualitative assessment of the nicotine content is not suitable to be compared with quantitative assessment methods as mostly reported in the literature.

Conclusions

On the basis of the present study results, it may be concluded that out of the tobacco products commonly available in Bhopal, bidis had the highest content of nicotine, followed by chewed tobacco (pan masalas) and cigarettes. Higher the amount of nicotine in a tobacco product, more is the addiction. Hence, a person trying any tobacco product for the first time may have more chances of addiction to nicotine if he/she happens to try a bidi rather than chewed tobacco or a cigarette. Since this is a qualitative assessment, comparative studies using the same products and assessing the nicotine content by titration as well as gas chromatography are required to prove the reliability of the technique used in the present study.

Financial support and sponsorship

This study was conducted with the grants provided by Indian Council of Medical Research under the Short Term Studentship program of 2015. Reference ID: STS 2015-04040. A scholarship of Rs. 10,000 was awarded for this research.

Conflicts of interest

There are no conflicts of interest.

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