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The chemical composition of smokeless tobacco: A survey of products sold in the United States in 2006 and 2007

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ABSTRACT

Selected toxicant concentrations and other chemical measures have been determined for 43 U.S. smokeless tobacco products sold in 2006 and 2007. Products evaluated included moist snuff, dry snuff, loose leaf, plug, dissolvable and snus tobacco brands. Reference products available for scientific research purposes and eleven Swedish products were also evaluated and compared to the commercial products studied. Chemical endpoints determined included benzo[a]pyrene (B[a]P), N′-nitrosonornicotine (NNN), N′-nitrosoanatabine (NAT), N′-nitrosoanabasine (NAB), 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK), N-Nitrosodimethylamine (NDMA), nitrite, cadmium, lead, arsenic, nickel, chromium, chloride, water, pH and nicotine. Different toxicant profiles were observed for the products studied, with snus tobacco brands generally containing relatively low concentrations of B[a]P and tobacco specific nitrosamines (TSNAs) compared to other moist snuffs. Smokeless tobacco reference product toxicant profiles were similar to corresponding commercial products, with the exception of the TSNA content of the dry snuff reference material. TSNA concentrations observed for all commercial products were lower than historically reported values, likely reflecting changes in product shelf life, tobacco curing practices and, possibly, product blend formulations during the last 20–30 years. The survey results summarized provide a temporal point of comparison with future data anticipated from FDA "harmful and potentially harmful constituents in tobacco products" reporting.

1. Introduction

It is generally accepted that no tobacco product is safe and that quitting tobacco use is the best way to eliminate risk. For those who choose to use tobacco, reducing exposure to tobacco toxicants is regarded as one possible approach to diminishing the health risks from such products. Toxicant profiles (i.e., the chemical toxicants and associated concentrations present in smokeless tobacco or cigarette smoke) are expected to vary both within a tobacco category (e.g., one commercial brand style vs. another brand style) and across tobacco product categories (e.g., smokeless tobacco vs. cigarettes). Therefore, the type of tobacco product used as well as the manner and frequency of use may significantly affect an individual's level of risk for serious disease.

Understanding the chemical composition associated with different types of smokeless tobacco, together with the specific chemical characteristics of individual commercial products, is the first step in assessing the potential toxicity of smokeless tobacco products. The development of such information, both on a product-category and product-specific basis, is consistent with recent calls from "the strategic dialogue on tobacco harm reduction" (Zeller et al., 2009), the Life Sciences Research Office (LSRO, 2008) and the WHO Study Group on Tobacco Products (WHO, 2012). Scientists and tobacco control advocates who participated in the dialog have suggested that information regarding the amounts of toxicants in tobacco products should be readily disclosed "by brand and brand subtype" in order to educate public health officials and regulatory policymakers.

Historically, a number of studies have reported the chemical composition of smokeless tobacco products sold in the United States. Generally, such studies have been limited both in terms of the number of analytes and the number of smokeless tobacco products evaluated. For example, since the 1980s, scientists from the U.S. Department of Agriculture and the American Health Foundation have investigated tobacco alkaloid levels, characterized selected toxicants and evaluated flavor components present in smokeless tobaccos (Chamberlain et al., 1988; Brunnemann and Hoffmann, 1992; Djordjevic et al., 1993; Hoffmann et al., 1995; Brunnemann et al., 2002). These studies addressed a relatively limited number of smokeless tobacco brands (typically ~2–6). Smokeless tobacco brands have often been identified generically (e.g.,

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"Brand A") in these studies. More recent studies have also focused on either a limited number of smokeless products, often with emphasis on smokeless tobacco products introduced into the U.S. market in the last few years (Rodu and Jansson, 2004; McNeill et al., 2006; Stepanov et al., 2006; Hatsukami et al., 2007; Pappas et al., 2008; Richter et al., 2008; Stepanov et al., 2008, 2010; Klus et al., 2009).

Smokeless tobacco brands evaluated in this study include long established commercial brands, selected brands introduced more recently in the United States and several smokeless tobacco reference products intended for scientific research purposes. The established smokeless tobacco brands evaluated include moist snuff, dry snuff, loose leaf, plug and dissolvable tobacco brands sampled from the U.S. market in 2006 and 2007. The products selected for study represented a substantial portion of the total U.S. sales volume (generally ~50% or more), the principal manufacturers and the main pricing points (e.g., premium, value etc.) for each tobacco type in 2006/2007.

Several snus tobacco brands introduced in the U.S. are included in the study. "Snus" refers to a moist snuff tobacco product prepared by heat treating, rather than fermenting, the tobacco. Snus is composed of tobaccos selected for low toxicant content. Snus products may be refrigerated to maintain product quality. Since snus has been commercially available and popular in Sweden for decades, several Swedish snus brands were also studied for comparison purposes.

Smokeless tobacco reference products have been available for scientific research purposes for many years; however, there are relatively few published studies which have included these products in the study design. Reference products are prepared as a large "batch" at a single point in time, thus limiting the inherent variability of the product. Given their consistency, the inclusion of such products in research studies provides a unique means of evaluating the comparability of data generated in different studies, the consistency of data generated in laboratories over time and the differences which may occur when products are tested with more than one analytical method to determine a particular tobacco constituent. Moist snuff (2S3), dry snuff (1S2) and loose leaf reference (2S1) tobacco products are included in this work. This study assesses the relevance of these smokeless tobacco reference products to smokeless tobacco products sold in the U.S. in 2006 and 2007. Until recently, there has not been a snus reference product available. A CORESTA working group has recently prepared a set of smokeless tobacco reference products (CRP1–4) that include a snus reference product (CRP1) (http://www.tobacco.ncsu.edu/strp.html). Once reference value ranges are established for CRP1–4, it is anticipated that the new products will be widely used in smokeless tobacco research.

In June 2009, the U.S. Food and Drug Administration (FDA) assumed regulatory authority for tobacco products per the Family Smoking Prevention and Tobacco Control Act. Under the act, the FDA Center for Tobacco Products has established a list of harmful and potentially harmful constituents in tobacco products and tobacco smoke (FDA, 2012a). The list includes all of the tobacco constituents evaluated in this study, with the exceptions of chloride, NAT and NAB. Recently, the FDA Center for Tobacco Products has issued draft guidance for reporting harmful and potentially harmful constituents in tobacco products and tobacco smoke (FDA, 2012b,c). That guidance specifies six of the compounds determined in this work (arsenic, benzo[a]pyrene, cadmium, nicotine ("total and free"), NNK and NNN) for smokeless tobacco testing and reporting by brand and subbrand.

In addition to the identification of harmful and potentially harmful constituents in tobacco and tobacco smoke, the FDA Center for Tobacco Products has completed other activities which demonstrate their interest in the chemical composition of smokeless tobacco. Specifically, the Center has conducted a workshop on tobacco product analysis which included presentations on new reference products and potential methods of analysis for smokeless tobacco products (FDA, 2012d). Also, on March 1, 2012, the Tobacco Products Scientific Advisory Committee (TPSAC) submitted their final report and recommendations to FDA regarding dissolvable tobacco products (FDA, 2012e). As part of that evaluation, TPSAC reviewed available information related to dissolvable tobacco, including information on the chemical composition of dissolvable and other forms of smokeless tobacco (FDA, 2012f).

The chemical analysis schema applied in this work was intended as a "starting point," as no scientific consensus exists regarding the most significant toxicants in smokeless tobacco products. Studies that elucidate the chemical compositions of smokeless tobacco to identify the toxicants present in such products continue to be an area of active research (Rainey et al., 2011; Grimm and Lauterbach, 2011a,b,c). The tobacco constituents determined in this study represent several different chemical classes. Benzo[a]pyrene (B[a]P), N′-nitrosonornicotine (NNN), N′-nitrosoanatabine (NAT), N′-nitrosoanabasine (NAB), 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanone (NNK), N-Nitrosodimethylamine (NDMA), nitrite, cadmium, lead, arsenic, nickel and chromium were selected for study, as these chemical endpoints are among the most consistently cited tobacco toxicants. Chloride, water, pH and nicotine determinations were also conducted to further describe the chemical composition of the tobacco products studied.

2. Materials and methods

2.1. Smokeless tobacco product categories

A wide range of smokeless tobacco products are sold in the United States. Some have been commercially available for more than a hundred years and others have been introduced into the market only recently. Smokeless tobacco products differ in many respects, including the types of tobacco used in the product, physical characteristics, methods of use, duration of use and moisture content, among others. Smokeless tobacco products can be broadly categorized as chewing tobaccos, snuff tobaccos and dissolvable tobaccos. Modern chewing tobacco is produced in three forms (loose leaf, plug and twist) and may include additives such as licorice, corn syrup, molasses, saccharin, humectants and preservatives. Snuff is produced in both dry and moist forms. While traditionally a fermented tobacco product, heat-treated snuffs have been recently introduced. Dissolvable tobacco products are also a more recent addition to the marketplace. Chemical analysis results for U.S. smokeless tobacco are summarized in this work on an individual product basis and by product category. Products are categorized according to tobacco type and tax designation as dissolvable, loose leaf, plug, moist snuff or dry snuff tobaccos. A description of each product category follows. A schema summarizing how these smokeless tobacco categories fit into the larger group of smokeless tobacco categories found around the world, together with additional product descriptions, may be found in a smokeless tobacco glossary prepared by CORESTA at (http://www.coresta.org/Reports/CSTS_Smokeless-Tobacco-Glossary.pdf).

2.1.1. Loose leaf tobacco

Loose leaf tobacco is cured and sweetened like plug tobacco, but sold loose in bags rather than in plug form. Traditionally, loose leaf chewing tobacco generally is made from air-cured, cigar-leaf tobaccos grown in Pennsylvania and Wisconsin. It consists of stripped and processed tobacco leaves that are stemmed, cut or granulated and loosely packed to form small strips of shredded