



HHS Public Access

Author manuscript

Tob Regul Sci. Author manuscript; available in PMC 2018 April 01.

Published in final edited form as:

Tob Regul Sci. 2017 April ; 3(Suppl 1): 101–116. doi:10.18001/TRS.3.2(Suppl1).11.

Surveillance of Nicotine and pH in Cigarette and Cigar Filler

Tameka S. Lawler, MPH [Chemist],

Tobacco and Volatiles Branch, US Centers for Disease Control and Prevention, Atlanta, GA

Stephen B. Stanfill, MS [Team Lead],

Tobacco and Volatiles Branch, US Centers for Disease Control and Prevention, Atlanta, GA

B. Rey deCastro, Sc.D [Statistician],

Tobacco and Volatiles Branch, US Centers for Disease Control and Prevention, Atlanta, GA

Joseph G. Lisko, MS [Team Lead],

Tobacco and Volatiles Branch, US Centers for Disease Control and Prevention, Atlanta, GA

Bryce W. Duncan, BS [PhD Candidate],

Joint School for Nanoscience and Nanoengineering, University of North Carolina at Greensboro, Greensboro, NC

Patricia Richter, PhD [Deputy Branch Chief], and

Tobacco and Volatiles Branch, US Centers for Disease Control and Prevention, Atlanta, GA

Clifford H. Watson, PhD [Director of Science]

Tobacco and Volatiles Branch, US Centers for Disease Control and Prevention, Atlanta, GA

Abstract

Objective—We examined differences between nicotine concentrations and pH in cigarette and cigar tobacco filler.

Methods—Nicotine and pH levels for 50 cigarette and 75 cigar brands were measured. Non-mentholated and mentholated cigarette products were included in the analysis along with several cigar types as identified by the manufacturer: large cigars, pipe tobacco cigars, cigarillos, mini cigarillos, and little cigars.

Results—There were significant differences found between pH and nicotine for cigarette and cigar tobacco products. Mean nicotine concentrations in cigarettes (19.2 mg/g) and large cigars (15.4 mg/g) were higher than the other cigars types, especially the pipe tobacco cigars (8.79 mg/g). The mean pH for cigarettes was pH 5.46. Large cigars had the highest mean pH value (pH 6.10) and pipe tobacco cigars had the lowest (pH 5.05).

Conclusions—Although cigarettes are the most common combustible tobacco product used worldwide, cigar use remains popular. Our research provides a means to investigate the possibility

Correspondence Ms. Lawler; tlawler@cdc.gov.

Human Subjects Statement

No human subjects were involved in this study.

Conflict of Interest Statement

The authors confirm no conflicts of interest.

of distinguishing the 2 tobacco product types and offers information on nicotine and pH across a wide range of cigarette and cigar varieties that may be beneficial to help establish tobacco policies and regulations across product types.

Keywords

nicotine; tobacco; smoking; cigarette; cigar; cigarillo; addiction

INTRODUCTION

Nearly 50 million Americans use some form of tobacco (eg, cigarettes, cigars, oral tobacco).¹ Whereas cigarettes remain the most widely used combustible tobacco product in the United States (US), over the past 8 years, adult cigarette smoking has decreased by approximately 20%. In contrast, use of other tobacco products, including cigars, is increasing steadily due to the affordable cost, flavoring, product appeal, as well as increasing social acceptance.²⁻⁵ Between 2000 and 2011, the consumption of cigar use increased by 123%.⁶

A cigarette is defined as a roll of tobacco wrapped in paper or other non-tobacco materials whereas cigars are identified as rolls of tobacco wrapped in leaves or substances that contain tobacco; however, there is no universally accepted method for categorizing cigars.⁷⁻¹¹ Descriptively, cigars are separated into 3 broad categories: little (small) cigars, cigarillos, and large cigars.^{9, 11} Little (small) cigars are predominately filtered, frequently sold in packs of 20, weigh less than 3 pounds per thousand cigars, and have been referred to as “cigarettes in disguise” because they are similar in size and shape.⁸⁻¹² Cigarillos or medium size cigars, are mostly machine-made, more affordable than cigarettes, and may or may not have filters or tips. Large cigars, which are often separated into 3 portions (wrapper, binder, and filler),⁸ are further sub-divided into 2 categories: regular and premium. Regular large cigars are typically machine manufactured, contain a wrapper made from reconstituted tobacco leaf, and weigh more than 3 pounds per thousand cigars.^{8, 10} Premium large cigars are usually hand-rolled, larger in size (more than 6 lbs per 1000 cigars), consist of 100% tobacco leaf wrapper, and contain long filler tobacco, which has higher quality tobacco and burns longer.^{8, 13} Additionally, premium large cigars are often fitted with a band label to identify the brand name or logo, have no filter, tip, or mouthpiece, and usually lack additives or characterizing flavors found in regular large cigars.⁸

Tax rates and smoking behaviors can differ among cigarette and cigar users. Because of their varying product categories and sizes, tobacco products are taxed differently in the US. Presently, cigarettes and small (little) cigars are currently taxed at a similar rate of \$1.01 per pack of 20, and large cigars are federally taxed up to \$0.4026 per cigar.¹⁴ Added tax increases the overall price and may influence which products are purchased, especially among users who may be more price sensitive (underage and low-income users). In terms of smoking behavior, cigarette smoke is commonly inhaled, and most cigarettes are fully smoked in a single session lasting less than 10 minutes.¹⁵ Cigar smoke is not typically inhaled into the lungs due to its harshness.^{15, 16} However some cigar smokers’ inhale the smoke deeply and have longer smoking sessions which can result in exposures to greater

amounts of toxic chemicals, such as carbon monoxide (CO), nicotine, hydrogen cyanide, tar, hydrocarbons, ammonia, and cadmium.^{15, 16}

In 2016, the US Food and Drug Administration (FDA) extended its authority to regulate cigars.¹⁷ Consequently, cigars are subject to regulatory oversight as are the other products listed in the Family Smoking Prevention and Tobacco Control Act of 2009. Unlike cigarettes, cigar products can be legally marketed with characterizing flavors.¹⁸ Because cigars can still use certain characterizing flavors on its packaging, such as honey, coffee, chocolate, or wine and are often cheaper in price than cigarettes, they may be an attractive tobacco option for the younger generation because they mask the harsh tobacco taste and may promote smoking initiation.^{4, 18, 19}

Numerous studies have reported nicotine yields of cigarette tobacco smoke and filler extract pH, but only a limited number of studies have measured nicotine and pH in cigar smoke or filler (whole tobacco).^{20–24} This study provides a systematic analysis of nicotine concentrations and pH levels in the tobacco filler for the following combustible tobacco categories: commercial and experimental cigarettes, cigarillos, large cigars, mini-cigarillos, little cigars, and pipe tobacco cigars. The commercial cigarette brands represent 5 US cigarette manufacturers, whereas the cigar products, both flavored and non-flavored, were from 19 manufacturers from Honduras, the Dominican Republic, and the US. In this report, when we refer to nicotine, we are describing what is often called “total nicotine,” which includes both the protonated and unprotonated (free base) forms. Although it is known that pH influences the delivery of nicotine in smoke, this article does not distinguish between the protonation states.^{23, 25, 26} Additionally, the pH that we are measuring is the pH of an extract of tobacco in aqueous solution, henceforth referred to as “filler extract pH.” The aim of this study is to provide data and insights into the association between nicotine and extract pH in the filler, as well as product characteristics that are subject to control as design features such as tobacco product size, shape, and flavor. In this study we examine the tobacco from these different classifications of tobacco products to see if there are any clear differences in product type based on nicotine or extract pH in the tobacco filler. It is important to understand these products and how they are used by the consumer to form appropriate public health messages when they lead to potential harm.

METHODS

Sample Collection

Cigarette brands—Fifty commercial cigarettes (37 non-mentholated and 13 mentholated) brands manufactured by 5 different companies (Philip Morris (PM), RJ Reynolds (RJR), Lorillard [prior to being purchased by RJR], Commonwealth Brands (Commonwealth), and Santa Fe Natural Tobacco Company [Santa Fe]) were purchased from local retail stores in metro Atlanta, Georgia. These cigarette brands were selected based on the 2010 US cigarette market share. Multiple cartons of each brand were acquired, labeled with unique identification codes, and logged into a custom database. The samples were stored at room temperature prior to analysis. A total of 7 replicates were tested for each brand. A Product Number (PN) was assigned to each product for easy reference.

Cigar brands—The Office of Regulatory Affairs (ORA)/Office of Enforcement, FDA and Field Officers shipped 49 cigar products to the US Centers for Disease Control and Prevention. Fifteen Dominican Republic and Honduras large cigars and cigarillos were acquired from online tobacco retailers and 9 additional pipe tobacco cigars, and 2 cigarillos were purchased in the metro-Atlanta area. The classification of these product types was based on the labeling of the packaging material.

Quality control (QC) materials, reference and experimental cigarettes—Two QC materials, Cooperation Centre for Scientific Research Relative to Tobacco (CORESTA) Reference Tobacco Products, CRP2 (moist snuff) and CRP3 (dry snuff) or Copenhagen moist snuff and Reference Tobacco 2S3 (moist snuff) were used in the analysis of tobacco products. North Carolina State University Tobacco Analytical Services Laboratory (TASL) (Raleigh, NC) provided the reference tobacco products without charge and the Copenhagen snuff was purchased from local retail stores in Atlanta. In addition, 3 cigarette reference materials, 3R4F, 1R5F, and CM6 were analyzed for comparison purposes. The University of Kentucky, College of Agriculture (Lexington, KY) supplied the 3R4F and 1R5F reference cigarettes, and the CORESTA Monitor cigarette (CM6) was obtained from CORESTA (Paris, France). Three single *Nicotiana tabacum* experimental cigarettes (flue-cured, burley, and oriental), were included in this study. These single tobacco type experimental cigarettes were prepared for CDC's Tobacco Analysis Laboratory by Murty Pharmaceuticals (Lexington, KY). A fourth experimental cigarette containing 100% reconstituted tobacco, also prepared by Murty Pharmaceuticals, was also tested. All QC materials, reference and experimental cigarettes were assigned a product ID, bar coded, and stored at room temperature prior to testing with the exception of CRP2, CRP3, 2S3, and Copenhagen, which were stored at -20°C until analyzed. Lastly, nicotine and pH analysis was performed on the tobacco filler and not the wrapper or binder of cigarette and cigar tobacco products.

Determination of pH

Sample pH measurements of cigarette filler were made on a single Sirius Vinotrate pH meter (Sirius Analytical Ltd., East Sussex, United Kingdom (UK)), calibrated with pH 4.01 and pH 7.00 buffers. Cigarette filler was measured in septuplicate ($N = 7$) using the standard Health Canada pH Methodology.²⁷ The Health Canada pH Method and Federal Register pH protocol²⁸ yielded comparable values (maximum 2.5% difference). For cigar tobacco filler, the average of duplicate pH measurements was determined using the pH protocol described elsewhere.²⁹

Nicotine Analysis

Nicotine concentrations were measured by a gas chromatography-mass spectrometry (GC/MS) method described previously.³⁰ Briefly, 1.0 g of product filler was extracted using 50 mL of methyl tert-butyl ether (MTBE) and 5 mL of 2N sodium hydroxide (NaOH). Samples were extracted for 2 hours, and a 1- μL aliquot was analyzed by GC/MS in selected ion monitoring (SIM) mode. The nicotine measurements of commercial cigarette brands were analyzed in septuplicate and cigar products were run in triplicate ($N = 3$).

Statistical Analysis

Nicotine concentration [mg/g] and pH levels were compared among 6 tobacco product types: large cigar, pipe cigar (pipe tobacco cigar), cigarillo, mini-cigarillo, little cigar, and cigarette. Mentholated and non-mentholated cigarettes were also compared for nicotine concentration and pH. Comparisons among product types were carried out statistically using the Kruskal-Wallis (KW) non-parametric, rank-based technique. KW analysis was used to avoid parametric assumptions about the distribution of measurements, as would be the case with, for example, analysis of variance. Statistical analysis was carried out with the NPAR1WAY subroutine of SAS version 9.3. Statistical significance was set at $p < .05$. A statistically significant hypothesis test in KW indicates that among the product types the mean of at least one product type differed significantly from the means of the other product types.

RESULTS

Cigarettes

Overall, 50 mentholated and non-mentholated cigarettes and 75 cigar brands were analyzed for pH and nicotine (Table 1). Six combustible tobacco product types were analyzed in this study (Figure 1). The nicotine concentrations in the tobacco filler varied among the manufacturers (listed in descending order of nicotine, presented in Table 1). For commercial cigarette brands, nicotine concentrations ranged from 16.2 to 26.3 mg nicotine/g tobacco (mean 19.2 mg/g; median 19.4 mg/g). Coefficient of variation (CVs) in nicotine concentrations of our measurements ranged from 0.77% to 4.67%. American Spirit Natural king hard pack (PN 1) had the highest nicotine concentration, and Phillip Morris Basic Blue 100s hard pack (PN 47) had the lowest. Among the 50 commercial cigarette brands, 4 non-mentholated brands (American Spirit Natural king hard pack (PN 1), RJR NOW Gold 100s soft pack (PN 2), RJR Carlton White 100s smooth corner hard pack (PN 3), and Lorillard Kent Golden king soft pack (PN 22)) were approximately 20% higher in nicotine (> 21 mg/g) than the 8 (7 non-mentholated and 1 mentholated) brands with the lowest nicotine concentrations (< 17 mg/g). This demonstrates how there is a wide variation of nicotine concentrations among commercial cigarette brands.

Table 1 also lists pH levels and nicotine concentrations in a variety of experimental cigarettes as well as monitor and reference products (PNs 51–57). Two reference cigarettes and one monitor product produced mean nicotine concentrations between 16.3 and 19.0 mg/g and the pH measurements ranged between pH 5.15 and 5.46. Mean nicotine and pH levels for the *N. tabacum* experimental cigarettes varied widely, ranging from 10.5 to 28.2 mg/g and pH 5.32 to pH 6.11. Moreover, the mean pH levels and nicotine concentrations for experimental cigarettes containing 100% reconstituted tobacco was pH 5.19 and 8.26 mg/g, respectively.

Figure 2 shows the distribution of cigarette filler nicotine concentrations and pH levels by tobacco manufacturer ($N = 5$), size ($N = 4$; kings, 100s, slim, and super slims), and packaging ($N = 2$; hard and soft pack). There were statistically significant differences in nicotine concentrations among manufacturer, size, and packaging ($p < .004$). Nicotine

concentrations in mentholated (13) versus non-mentholated (37) cigarette filler were not statistically different ($p = .053$). Three products, PM Marlboro Green king flip-top hard pack (PN 30), RJR Kool Green king hard pack (PN 5), and RJR Kool Green king soft pack (PN 4), had the highest nicotine concentrations among mentholated cigarettes, 20.0, 20.5, and 20.7 mg/g respectively. PM Basic Green 100s hard pack (PN 46) had the lowest nicotine concentration of all menthol cigarettes (16.5 mg/g).

The mean pH level found in the tobacco filler of non-menthol commercial cigarettes was 5.46 (pH levels ranging from 5.14 – 5.61). American Spirit Natural king hard pack (PN 1) had the lowest pH, and RJR Doral Gold king hard pack (PN 19) had the highest pH. As was observed for nicotine, there were statistically significant differences in pH among manufacturers, sizes, and packaging ($p < .001$). There were no significant differences in pH ($p = .053$) between non-mentholated and mentholated cigarette brands. Among the 13 mentholated brands, the lowest value was pH 5.36 for Lorillard Newport Green king hard pack (PN 24) and the highest value was pH 5.54 for PM Basic Green 100s hard pack (PN 46).

Cigars

The tobacco filler of 5 cigar product types was analyzed for nicotine concentrations and pH levels (Table 2). There was a wide range (7.88 – 24.8 mg/g) of nicotine concentrations observed among cigar products (mean 12.9 mg/g; median 12.2 mg/g). The lowest nicotine concentration was observed for a pipe tobacco cigar, Black & Mild Royal Wood Tip (PN 132) and Montecristo Half Corona (PN 58), a large (premium) cigar, had the highest nicotine concentration. Large cigars (9.20 – 24.8 mg/g), cigarillos (8.32 – 17.9 mg/g) and little cigars (10.3 – 19.1 mg/g) showed the largest range in nicotine concentrations within product types. Pipe tobacco (7.88 – 9.61 mg/g) and mini-cigarillos (12.2 – 12.6 mg/g) exhibited a smaller range in nicotine concentrations for the products tested. The filler extract pH of 75 cigar brands ranged from pH 4.71 in Black & Mild Apple pipe tobacco (PN 124) to pH 7.41 in Don Lino Habanitos cigarillo (PN 100). Among these cigar brands, 73% (55 out of 75) of the products had pH levels in the filler less than 6.0. Of the 20 cigar tobacco products with the highest pH levels ($pH > 6$), 85% (17 out of 20) were large cigars. In contrast, the lowest pH levels were observed in pipe tobacco cigar products.

A comparison of nicotine concentrations and pH levels in 6 combustible tobacco product types were made (Figure 3). Nicotine concentrations (Figure 3A) were significantly higher in cigarettes and large cigars than in pipe tobacco cigars ($p < .001$). The order of mean nicotine concentrations, lowest to highest, is as follows: pipe tobacco cigars (8.79 mg/g) < mini-cigarillos (12.5 mg/g) < little cigars (12.6 mg/g) < cigarillos (13.0 mg/g) < large cigars (15.4 mg/g) < cigarettes (19.2 mg/g). The mean pH levels (Figure 3B) of large cigars (pH 6.10) were significantly higher than for cigarettes (pH 5.46) and pipe tobacco cigars (pH 5.05) ($p < .001$). Mini-cigarillos, little cigars, and cigarillos products all had comparable pH levels (mean pH 5.70; $p = .580$). A summary of means and ranges for pH and nicotine in each of the combustible tobacco product categories are provided (Table 3).

DISCUSSION

Combustible tobacco products, which have been considered the most harmful forms of nicotine delivery,³¹ are available in a variety of sizes and designs, and contain different tobacco blends that can impact nicotine in the tobacco filler and pH levels.³² In this study, we analyzed the nicotine concentration and filler extract pH of 6 categories of combustible tobacco products: cigarettes, large cigars, pipe tobacco cigars, cigarillos, mini-cigarillos, and little cigars. Our results revealed statistical differences for both nicotine concentrations and pH levels among cigarettes and various types of cigar tobacco fillers.

We investigated nicotine and pH of 50 commercial cigarette brands from 5 major manufacturers. For cigarettes, the mean nicotine concentrations in tobacco filler differed across brands by only 1.5 fold. Similarly, Hammond and O'Connor³³ also found little variation in nicotine of whole tobacco or filler. The nicotine concentration in Natural American Spirit (PN 1) was much higher than all other cigarette brands. The high concentrations of nicotine present in Natural American Spirit may be due to the reported use of 100% flue-cured tobacco (PN 54), which has a higher concentration of nicotine than other tobacco types (PNs 55–57).³⁴ These findings agree with a previous report by Malson et al.³⁵ that also showed higher nicotine concentrations for this brand than for other commercial cigarettes. Notably, the same Natural American Spirit brand (PN 1) had the lowest pH. Five of the 8 cigarette brands with the lowest mean nicotine concentrations were either a Phillip Morris Basic (PNs 45–47) or RJR Doral brand (PNs 19–20). Furthermore, one of the RJR Doral brands, namely Doral Gold King hard pack (PN 19), had a low nicotine concentration and the highest mean pH value. Aside from the Natural American Spirit brand (PN 1), similar mean nicotine concentrations were seen across manufacturers; however, noticeable differences were observed in mean pH levels of PM (pH 5.48) and RJR (pH 5.46) brands compared to the Lorillard, Commonwealth, and Santa Fe products, pH 5.38, 5.32, and 5.14, respectively.

Table 2 provides 9 of the top 10 US cigar brands.³⁶ Statistical differences in pH and nicotine were found between the 5 cigar product categories. Large cigars (especially premium brands) and cigarillos had the highest mean nicotine concentration compared to little cigars, pipe tobacco cigars, and mini-cigarillos. The lowest nicotine concentrations were reported for pipe tobacco cigar products. The pH range among all cigar brands (pH 4.71 – 7.41) differed by more than 2.7 pH units. A previous study of 17 cigarillos, small cigars, and large premium cigar brands conducted by Henningfield et al.²³ found nicotine concentrations ranging from 6.3 – 16.2 mg/g and the pH levels ranging from pH 5.72 – 7.88. More than 19% (14 out of 75) of the cigar products in our study exceeded the maximum nicotine level found by Henningfield et al. In addition, our study also found 48% of cigars (36 out of 75) were less than pH 5.72, the lowest pH value identified by Henningfield et al.²³ Whether this represents a change in the product or the differences attributed to the measurements of different brands is unclear.

Product design and flavoring are important factors that can influence the appeal of tobacco products.^{3–5, 32} In cigarettes, differences in nicotine and pH were observed in the following 3 groups: manufacturer, size, and package type. The majority of the cigarette tobacco

products were 100s or king size. Of the 2 cigarette packaging types, hard packs, which consisted of products labeled flip-top box, box, hard pack, and two-way box, were the most common 20 pack cigarette type identified. Moreover, menthol is the only characterizing flavor marketed in cigarettes.³⁷ Twenty-eight percent (14 out of 50) of the cigarettes in this study were mentholated brands. No statistically significant differences were found in pH levels and nicotine concentrations between the mentholated and non-mentholated cigarette products in this study.

There is a high diversity among cigar design and packaging. Cigars are available in wooden boxes, colorful tins, and individually wrapped in plastic. The 2 main cigar shapes are parejo and figurado.³⁸ Figurados have an irregular shape and parejos, referred to as coronas, are the most familiar cigar form, have a rounded head and straight sides.³⁸ The Torpedo variety selection package provide examples (PNs 61, 66, 72) of figurados and the Lonsdale multipack (eg, PNs 60, 64, 71) and other products that display labels such as “Robusto, Churchill, and Corona,” are considered parejos.³⁸ One particular parejo product, Montecristo Half Corona (PN 58), exhibited the highest mean nicotine concentration of all cigar brands. It is also important to point out the higher standard deviation (SD) and CV found in this product as well as another premium large cigar brand, Onyx Reserve Manduro No. 4 (PN 70). A possible explanation for the higher SD and CV is due to the natural variation in the composition of whole leaf tobacco used as filler. Moreover, in this study, mini-cigarillos were categorized separately from cigarillos because they were frequently assembled in packages of 6 (as opposed to 5 per pack) and are smaller in size; yet mini-cigarillos and cigarillos had similar pH levels and nicotine concentrations. More research is needed to associate cigar nicotine delivery (strength) with the physical and chemical properties of the product. For example, premium cigar products may exhibit distinctive strengths (eg, medium and full)³⁸ to satisfy customer needs. The range of cigar sizes, blends, and lack of filter may introduce wider deliver ranges than cigarettes.

Currently, to our knowledge, there are no universally accepted criteria to classify cigars. In this study, we categorized them based on the manufacturer label. For example, Black and Mild Cigars have been classified as both a cigarillo and little cigar.^{39–42} This is the first study to categorize pipe tobacco cigars (pipe cigars) separately because they contain pipe tobacco (as stated on the packaging) and have considerably lower pH and nicotine in the tobacco filler when compared to all other cigar product types.³⁹ Pipe tobacco brands tested, which are commonly referred to as such in their brand name,⁴² showed significantly lower pH and nicotine than large cigars, mini-cigarillos, little cigars, and cigarillos ($p < .001$). Moreover, pipe tobacco cigars may contain a plastic or wood tip, reconstituted cigar tobacco in the wrapper or binder, and are associated with use practices termed “hying” and “freaking” where the products are modified to enhance nicotine delivery and make smoking the product easier, respectively.^{8, 39, 41} Additionally, there are other ways in which cigar products differ from other tobacco products. For example, some cigar products undergo a process referred to as blunting, where tobacco is removed and replaced with marijuana.^{39, 43, 44}

Historically, most US blended cigarettes are comprised of Flue-cured or Bright (Virginia), air-cured (Burley), sun-cured (Oriental or Turkish), and reconstituted tobaccos, whereas

cigar products use air-cured tobacco that is aged for a period of time and fermented.^{8, 16, 45} The tobacco blend influences the nicotine concentrations in cigarettes.³² For comparison purposes, Table 1 provides the nicotine concentrations and pH levels for a variety of reference products, as well as single tobacco type experimental cigarettes. The commercial cigarette brands, with the exception of one brand (Natural American Spirit, 26.3 mg/g), yielded similar nicotine concentrations seen in the reference cigarettes. In contrast, the nicotine concentration of the *N. tabacum* flue-cured cigarette was approximately 3.4 times higher than the 100% reconstituted tobacco experimental cigarette.

For the products included in this study, the mean nicotine concentrations increased from cigars to cigarettes: pipe tobacco cigars < mini-cigarillos < little cigars < cigarillos < large cigars < cigarettes. The measured pH levels varied by product type with the highest levels in large cigars compared to cigarettes and pipe tobacco cigars. The mean pH levels of the 6 product categories, listed in ascending order, are as follows: pipe tobacco cigars < cigarettes < mini-cigarillos < little cigars < cigarillos < large cigars. There was no statistical correlation identified between pH levels and the nicotine concentration in cigarette or cigar tobacco filler. For instance, large cigars Erik Cherry (PN 65) and H. Upmann Vintage Cameroon Belisco (PN 68) have comparable nicotine concentrations, (17 mg/g) but very different pH levels, pH 5.50 and pH 6.46, respectively. The difference in pH is possibly due to other additives specific to each product. Whereas all commercial products will deliver nicotine to the user, other factors like size, shape, and additives such as flavors, should also be considered when comparing the delivery of chemicals and toxins in tobacco products.

In this study, we analyzed a convenience-based selection of cigarettes sold in the metropolitan Atlanta area and select cigar products. Consequently, the findings may not represent all cigarette and cigar tobacco products. In addition, although nicotine and extract pH was evaluated in the tobacco filler, to fully characterize nicotine delivery to a consumer, the fraction available in the unprotonated nicotine form in smoke, should be determined. Lastly, since combustible tobacco products are agricultural based, variability in the chemistry of their tobacco blend may change based on tobacco growing and processing conditions.³²

Monitoring and understanding the harmful effects of toxic chemicals in tobacco, such as nicotine, which is the addictive drug in tobacco products, is a public health mandate. This study is among the first to try and characterize nicotine concentrations and filler extract pH from a wide range of cigarette brands and a variety of cigar product types. More research is needed to explore the construction and design of combustible tobacco products, especially the diversity of cigar types, additives, and flavors. Such research could be useful to understand how size, shape, construction, and flavor additives of cigars impact product selection and mainstream smoke deliveries. Observations from this study, which found some differences in nicotine concentrations and pH levels associated with each combustible product type, could help inform public health officials and policymakers about differing product subcategories and their influence on consumer delivery and appeal.

IMPLICATIONS FOR TOBACCO REGULATION

There are a wide array of cigarette and cigar tobacco products ranging in size, composition, and flavor additives that might impact nicotine delivery and may make them more attractive to youth and adolescents. This study is the first to report extract pH and nicotine concentrations in the tobacco filler of 6 categories of combustible tobacco products: cigarettes, large cigars, pipe tobacco cigars, cigarillos, mini-cigarillos, and little cigars. Cigarettes and large cigars contained higher nicotine concentrations compared to pipe tobacco cigars that had the lowest pH levels. Creating consistency among cigar products may be warranted to classify these tobacco product types better. Moreover, information from our report might inform product guidance and provide general knowledge that may be helpful for those involved in regulation but unfamiliar with the characteristics and chemistry of these particular products.

Acknowledgments

This research was funded by the US Food and Drug Administration (FDA), Center for Tobacco Products. We thank the Office of Regulatory Affairs (ORA)/Office of Enforcement, FDA, and Field Officers for providing a variety of tobacco products. The contents in this report are those of the authors and do not necessarily represent the views of the US Centers for Disease Control and Prevention. The use of trade names is for identification only and does not imply endorsement by the US Centers for Disease Control and Prevention. It does not represent and should not be construed to represent any agency determination or policy.

References

1. Fiore MC, Schroeder SA, Baker TB. Smoke, the chief killer -- strategies for targeting combustible tobacco use. *N Engl J Med*. 2014; 370:297–299. [PubMed: 24450888]
2. Jamal A, Homa DM, O'Connor E, et al. Current cigarette smoking among adults - United States, 2005–2014. *MMWR Morb Mortal Wkly Rep*. 2015; 64(44):1233–1240. [PubMed: 26562061]
3. US Department of Health and Human Services (USD-HHS). Preventing Tobacco Use among Youth and Young Adults: A Report of The Surgeon General. Atlanta, GA: US-DHHS, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2012.
4. Henningfield JE, Hatsukami DK, Zeller M, Peters E. Conference on abuse liability and appeal of tobacco products: conclusions and recommendations. *Drug Alcohol Depend*. 2011; 116(1–3):1–7. [PubMed: 21376479]
5. King BA, Dube SR, Tynan MA. Flavored cigar smoking among U.S. adults: findings from the 2009–2010 National Adult Tobacco Survey. *Nicotine Tob Res*. 2013; 15(2):608–614. [PubMed: 22927687]
6. US Centers for Disease Control and Prevention (CDC). Consumption of cigarettes and combustible tobacco - United States, 2000–2011. *MMWR Morb Mortal Wkly Rep*. 2012; 61(30):565–569. [PubMed: 22854624]
7. Baker F, Ainsworth SR, Dye JT, et al. Health risks associated with cigar smoking. *JAMA*. 2000; 284(6):735–740. [PubMed: 10927783]
8. Hoffmann, D., Hoffmann, I. Chemistry and toxicology. In: National Cancer Institute (NCI). , editor. Smoking and Tobacco Control. Monograph No. 9: Cigars: Health Effects and Trends. Bethesda, MD: NCI; 1998. p. 55-104. Available at: https://cancercontrol.cancer.gov/brp/tcrb/monographs/9/m9_complete.pdf [Assessed February 8, 2017]
9. Federal Trade Commission. [Accessed April 28, 2015] Cigar sales and advertising and promotional expenditures for calendar years 1996 and 1997. Available at: <https://www.ftc.gov/system/files/documents/reports/1999-report-cigar-sales-advertising-promotion/1999cigarrepor.pdf>
10. Alcohol and Tobacco Tax and Trade Bureau (TTB), Treasury. Tax classification of cigars and cigarettes (2006R-276P). *Fed Regist*. 2006; 71(206):62505–62523.

11. Kozlowski LT, Dollar KM, Giovino GA. Cigar/cigarillo surveillance: limitations of the U.S. Department of Agriculture system. *Am J Prev Med.* 2008; 34(5):424–426. [PubMed: 18407010]
12. Delnevo CD, Hrywna M. A whole ‘nother smoke” or a cigarette in disguise: how RJ Reynolds reframed the image of little cigars. *Am J Public Health.* 2007; 97(8):1368–1375. [PubMed: 17600253]
13. Law Library of Congress. [Accessed October 26, 2015] Traditional cigar manufacturing and small business jobs preservation act of 2015. Available at: <https://www.congress.gov/bill/114th-congress/house-bill/662/text>
14. Alcohol and Tobacco Tax and Trade Bureau, Treasury. [Accessed September 17, 2014] Tax and fee rates. 2013. Available at: https://ttb.gov/tax_audit/atftaxes.shtml
15. American Cancer Society (ACS). [Accessed October 28, 2010] Cigar smoking and cancer. Available at: <https://www.cancer.gov/about-cancer/causes-prevention/risk/tobacco/cigars-fact-sheet>
16. Burns, DM. Cigar Smoking: overview and current state of the science. In: National Cancer Institute (NCI). , editor. *Smoking and Tobacco Control. Monograph No. 9: Cigars: Health Effects and Trends.* Bethesda, MD: NCI; 1998. p. 1-20. Available at: https://cancercontrol.cancer.gov/brp/tcrb/monographs/9/m9_complete.pdf [Assessed February 8, 2017]
17. US Food and Drug Administration (FDA). Deeming tobacco products to be subject to the Federal Food, Drug, and Cosmetic Act, as amended by the Family Smoking Prevention and Tobacco Control Act; Restrictions on the sale and distribution of tobacco products and required warning statements for tobacco products. *Fed Regist.* 2016; 81(90):28973–9106. [PubMed: 27192730]
18. US Food and Drug Administration (FDA). [Accessed November 09, 2015] General questions and answers on the ban of cigarettes that contain certain characterizing flavors (edition 2). Available at: <http://www.fda.gov/TobaccoProducts/Labeling/ProductsIngredientsComponents/ucm183228.htm>
19. Delnevo CD, Giovenco DP, Ambrose BK, et al. Preference for flavoured cigar brands among youth, young adults and adults in the USA. *Tob Control.* 2015; 24(4):389–394. [PubMed: 24721967]
20. Elson LA, Betts TE, Passey RD. The sugar content and the pH of the smoke of cigarette, cigar and pipe tobaccos in relation to lung cancer. *Int J Cancer.* 1972; 9(3):666–675. [PubMed: 4660942]
21. Rickert WS, Robinson JC, Bray DF, et al. Characterization of tobacco products: a comparative study of the tar, nicotine, and carbon monoxide yields of cigars, manufactured cigarettes, and cigarettes made from fine-cut tobacco. *Prev Med.* 1985; 14(2):226–233. [PubMed: 4048085]
22. Henningfield JE, Hariharan M, Kozlowski LT. Nicotine content and health risks of cigars. *JAMA.* 1996; 276(23):1857–1858.
23. Henningfield JE, Fant RV, Radecki A, Frost S. Nicotine concentration, smoke pH and whole tobacco aqueous pH of some cigar brands and types popular in the United States. *Nicotine Tob Res.* 1999; 1:163–168. [PubMed: 11072397]
24. Koszowski B, Rosenberry ZR, Kanu A, et al. Nicotine and carbon monoxide exposure from inhalation of cigarillo smoke. *Pharmacol Biochem Behav.* 2015; 139(Pt A):7–14. [PubMed: 26459155]
25. Wayne GF, Connolly GN, Henningfield JE. Brand differences of free-base nicotine delivery in cigarette smoke: the view of the tobacco industry documents. *Tob Control.* 2006; 15:189–198. [PubMed: 16728749]
26. Fant, RV., Henningfield, JE. Pharmacology and abuse potential of cigars. *Smoking and tobacco control. Monograph No. 9: cigars health effects and trends.* 1998. p. 181-193.
27. Health Canada. [Accessed March 09 2012] Methods. Tobacco reporting regulations. Available at: <http://www.hc-sc.gc.ca/hc-ps/tobac-tabac/legislation/reg/indust/method/index-eng.php>
28. US Centers for Disease Control and Prevention (CDC). Annual submission of the quantity of nicotine contained in smokeless tobacco products manufactured, imported, or packaged in the United States. Notice. *Fed Regist.* 1999; 64(55):14085–14096. [PubMed: 10558405]
29. Lawler TS, Stanfill SB, Zhang L, et al. Chemical characterization of domestic oral tobacco products: total nicotine, pH, unprotonated nicotine and tobacco-specific N-nitrosamines. *Food Chem Toxicol.* 2013; 57:380–386. [PubMed: 23517910]

30. Stanfill SB, Jia LT, Ashley DJ, Watson CH. Rapid and chemically-selective quantification of nicotine in smokeless tobacco products using gas chromatography/mass spectrometry. *J Chromatogr Sci.* 2009; 47(10):902–909. [PubMed: 19930803]
31. The Tobacco Atlas. [Accessed October 09 2015] Chapter 7. Types of nicotine delivery systems. Available at: <http://www.tobaccoatlas.org/topic/nicotine-delivery-systems/>
32. Djordjevic MV, Doran KA. Nicotine content and delivery across tobacco products. *Handb Exp Pharmacol.* 2009; 192:61–82.
33. Hammond D, O'Connor RJ. Constituents in tobacco and smoke emissions from Canadian cigarettes. *Tob Control.* 2008; 17:i24–i31. [PubMed: 18768456]
34. Vu AT, Taylor KM, Holman MR, et al. Polycyclic aromatic hydrocarbons in the mainstream smoke of popular U.S. cigarettes. *Chem Res Toxicol.* 2015; 28(8):1616–1626. [PubMed: 26158771]
35. Malson JL, Lee EM, Moolchan ET, Pickworth WB. Nicotine delivery from smoking bidis and an additive-free cigarette. *Nicotine Tob Res.* 2002; 4(4):485–490. [PubMed: 12521408]
36. Ganz O, Teplitskaya L, Cantrell J, et al. Direct-to-consumer marketing of cigar products in the United States. *Nicotine Tob Res.* 2016; 18(5):864–868. [PubMed: 26377513]
37. Carpenter CM, Wayne GF, Pauly JL, et al. New cigarette brands with flavors that appeal to youth: tobacco marketing strategies. *Health Aff.* 2005; 24(6):1601–1610.
38. Cigar Aficionado. [Accessed October 07, 2015] Cigar shapes, sizes and colors. Available at: http://www.cigaraficionado.com/webfeatures/show/id/Cigar-101_8094
39. Jolly DH. Exploring the use of little cigars by students at a historically black university. *Prev Chronic Dis.* 2008; 5(3):A82. [PubMed: 18558032]
40. Cantrell J, Kreslake JM, Ganz O, et al. Marketing little cigars and cigarillos: advertising, price, and associations with neighborhood demographics. *Am J Public Health.* 2013; 103(10):1902–1909. [PubMed: 23948008]
41. Blank MD, Cobb CO, Eissenberg T, Nasim A. Acute effects of "hyping" a Black & Mild cigarillo. *Nicotine Tob Res.* 2016; 18(4):460–469. [PubMed: 25782456]
42. Corey CG, Dube SR, Ambrose BK, et al. Cigar smoking among U.S. students: reported use after adding brands to survey items. *Am J Prev Med.* 2014; 47(201):S28–S35. [PubMed: 25044193]
43. Delnevo CD, Bover-Manderski MT, Hrywna M. Cigar, marijuana, and blunt use among US adolescents: Are we accurately estimating the prevalence of cigar smoking among youth? *Prev Med.* 2011; 52(6):475–476. [PubMed: 21443900]
44. Cohn A, Cobb CO, Niaura RS, Richardson A. The other combustible products: prevalence and correlates of little cigar/cigarillo use among cigarette smokers. *Nicotine Tob Res.* 2015; 17(12):1473–1481. [PubMed: 25634932]
45. Hoffmann D, Hoffmann I. The changing cigarette, 1950–1995. *J Toxicol Environ Health.* 1997; 50:307–364. [PubMed: 9120872]

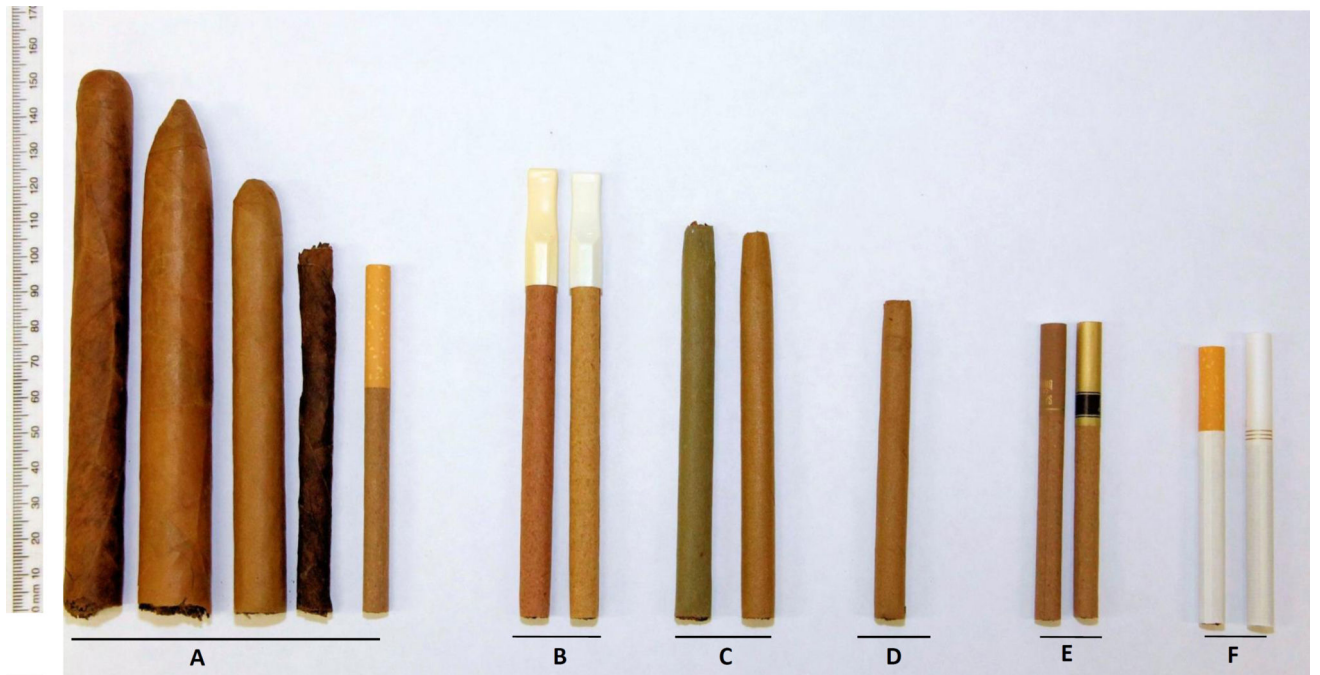


Figure 1.
Photographs of Assorted Varieties of Combustible Tobacco Products (Cigars and Cigarettes)
Based on Product Labeling

Note.

Tobacco Products: A. Large cigars (various types); B. Pipe tobacco cigars (tipped); C. Cigarillos; D. Mini-Cigarillo; E. Little Cigars (filtered); F. Cigarettes (filtered).

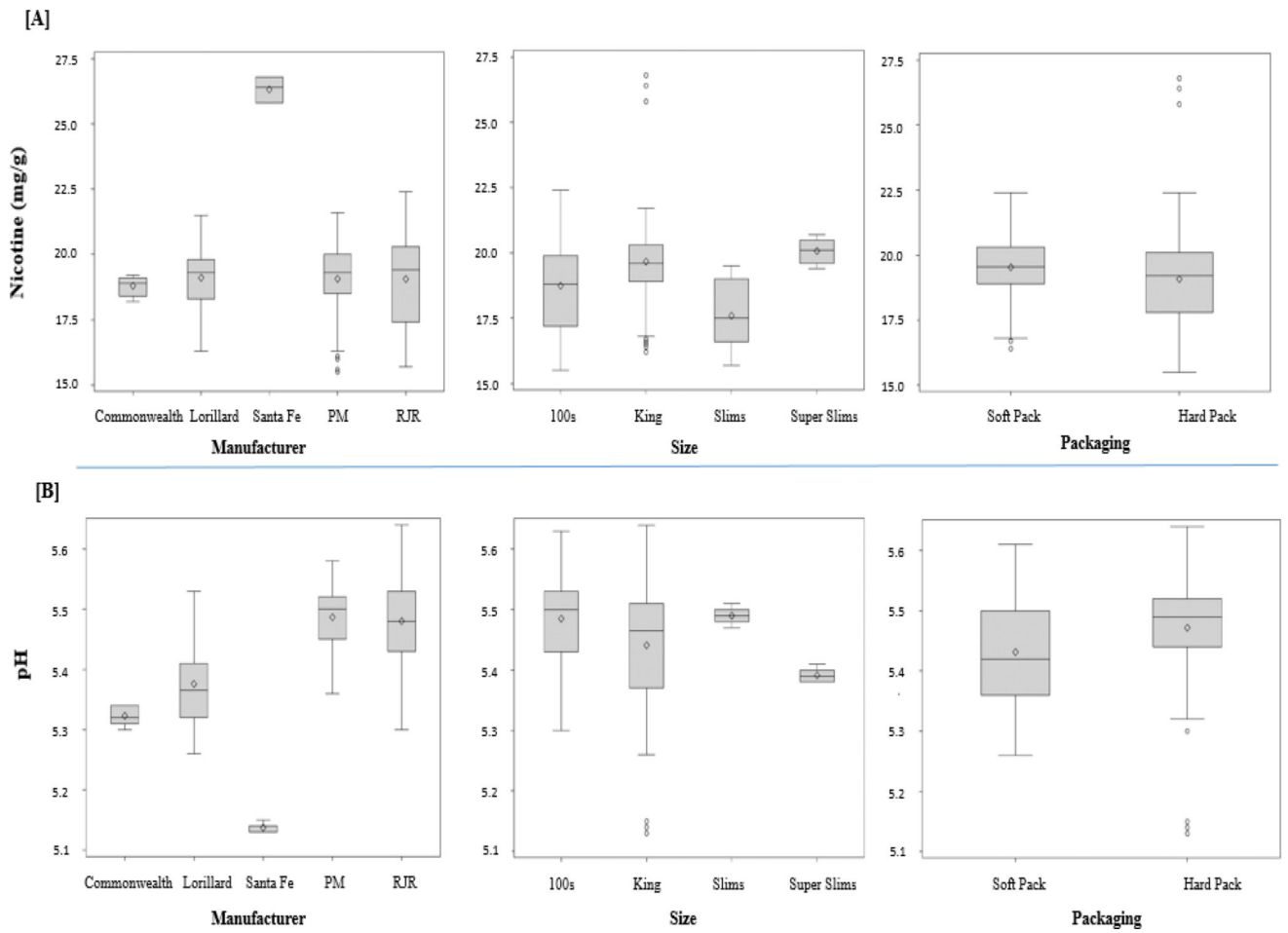


Figure 2.
An Assessment of Nicotine (mg/g) [A] and pH [B] of 50 Commercial Cigarettes by Tobacco Manufacturer (N = 5), Size (N = 4), and Packaging (N = 2) ($p < .004$)

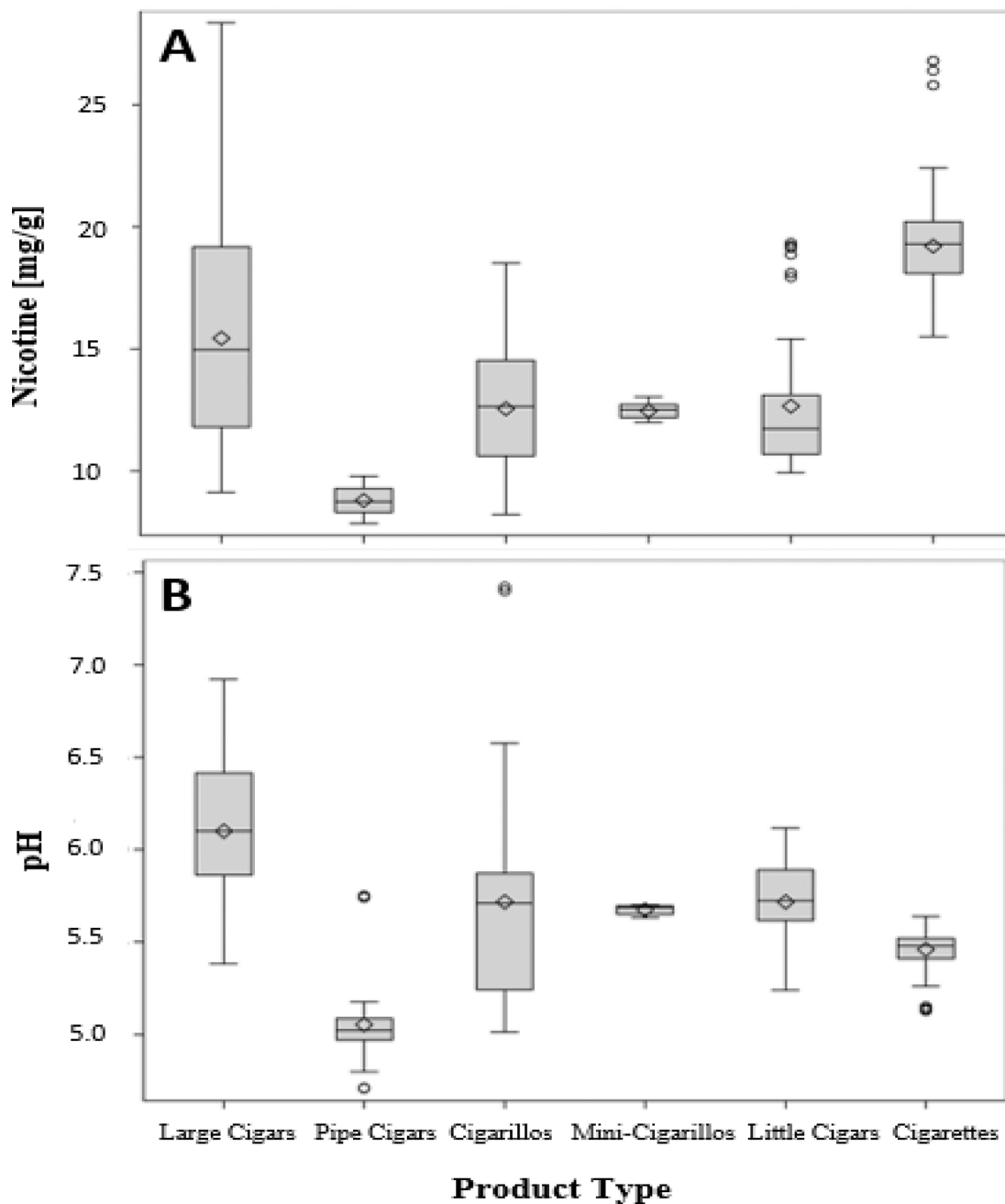


Figure 3.
 A Comparison of Nicotine (mg/g) [A] and pH [B] in Cigar and Cigarette Tobacco Filler (Pr > F < .001)

Note.

Tobacco Type (number of products): Large cigars (N = 27); Pipe cigars, Pipe tobacco cigars (N = 13); Cigarillos (N = 17); Mini-Cigarillos (N = 4); Little cigars (N = 14); US cigarette brands (N = 50).

Table 1 Nicotine Concentrations (mg/g) and pH Levels Found in the Tobacco Filler of 50 Top-selling Commercial Cigarettes (N = 7), 3 Reference, One Monitor, and Various Experimental Cigarettes

Product Number	Manufacturer ^a	Cigarette brand	Size	Package	Flavor ^b	Nicotine (mg/g)			pH		
						Mean	SD	CV (%)	d	Mean	SD
1	Santa Fe	Natural American Spirit	King	Hard Pack	NM	26.3	0.48	1.84		5.14	0.01
2	RJR	NOW Gold	100s	Soft Pack	NM	21.8	0.36	1.65		5.54	0.02
3	RJR	Carlton White	100s	Hard Pack	NM	21.7	0.34	1.58		5.60	0.02
4	RJR	Kool Green	King	Soft Pack	M	20.7	0.57	2.74		5.48	0.03
5	RJR	Kool Green	King	Hard Pack	M	20.5	0.26	1.26		5.49	0.02
6	RJR	Capri Magenta	Super Slims	Hard Pack	NM	20.1	0.50	2.47		5.39	0.01
7	RJR	Winston Red	100s	Hard Pack	NM	20.0	0.31	1.55		5.49	0.03
8	RJR	Winston White	100s	Hard Pack	NM	20.0	0.61	3.05		5.46	0.02
9	RJR	Winston Red	King	Hard Pack	NM	20.0	0.62	3.11		5.44	0.01
10	RJR	Winston Gold	King	Hard Pack	NM	19.8	0.93	4.67		5.44	0.02
11	RJR	Camel Blue	King	Hard Pack	NM	20.1	0.29	1.43		5.47	0.01
12	RJR	Camel Filters	King	Hard Pack	NM	19.4	0.36	1.84		5.33	0.01
13	RJR	Salem Gold	King	Hard Pack	M	18.8	0.48	2.55		5.40	0.02
14	RJR	Salem Green	King	Hard Pack	M	18.2	0.45	2.50		5.49	0.01
15	RJR	Salem Gold	100s	Hard Pack	M	18.0	0.64	3.56		5.51	0.03
16	RJR	Salem Silver	100s	Hard Pack	M	17.9	0.55	3.06		5.51	0.01
17	RJR	Pall Mall Blue	King	Hard Pack	NM	17.2	0.46	2.67		5.33	0.02
18	RJR	Vantage Multicolor	King	Soft Pack	NM	16.9	0.39	2.31		5.59	0.01
19	RJR	Doral Gold	King	Hard Pack	NM	16.8	0.41	2.46		5.61	0.02
20	RJR	Doral Silver	100s	Hard Pack	NM	16.7	0.51	3.04		5.57	0.01
21	RJR	Misty Blue	Slim	Hard Pack	NM	16.4	0.46	2.81		5.48	0.01
22	Lorillard	Kent Golden	King	Soft Pack	NM	21.0	0.36	1.70		5.32	0.01
23	Lorillard	True Silver	King	Soft Pack	NM	19.8	0.68	3.45		5.29	0.01
24	Lorillard	Newport Green	King	Hard Pack	M	19.4	0.15	0.77		5.36	0.01
25	Lorillard	Newport Green	King	Soft Pack	M	19.2	0.48	2.52		5.37	0.01
26	PM	Marlboro Silver	100s	Hard Pack	NM	20.8	0.40	1.92		5.56	0.02

Product Number	Manufacturer ^a	Cigarette brand	Size	Package	Flavor ^b	Nicotine (mg/g)			pH		
						Mean	SD ^c	CV (%) ^d	Mean	SD	SD
27	PM	Marlboro Silver	King	Hard Pack	NM	20.8	0.26	1.25	5.51	0.01	0.01
28	PM	Marlboro Gold	100s	Soft Pack	NM	20.5	0.55	2.68	5.43	0.02	0.02
29	PM	Marlboro Red	King	Hard Pack	NM	20.3	0.43	2.12	5.51	0.01	0.01
30	PM	Marlboro Green	King	Hard Pack	M	20.0	0.19	0.93	5.45	0.02	0.02
31	PM	Marlboro Red	King	Soft Pack	NM	19.7	0.42	2.12	5.54	0.02	0.02
32	PM	Marlboro Gold	King	Soft Pack	NM	19.7	0.37	1.87	5.47	0.01	0.01
33	PM	Marlboro Gold	King	Hard Pack	NM	19.5	0.41	2.09	5.45	0.03	0.03
34	PM	Marlboro Gold	King	Hard Pack	M	19.4	0.56	2.90	5.51	0.03	0.03
35	PM	Marlboro Red Label	King	Hard Pack	NM	19.3	0.82	4.25	5.53	0.01	0.01
36	PM	Marlboro Gold	100s	Hard Pack	NM	19.2	0.22	1.13	5.52	0.02	0.02
37	PM	Marlboro Red	100s	Soft Pack	NM	19.1	0.38	1.98	5.37	0.01	0.01
38	PM	Marlboro Red	100s	Hard Pack	NM	18.4	0.41	2.23	5.50	0.01	0.01
39	PM	Merit Gold	King	Soft Pack	NM	19.5	0.35	1.77	5.49	0.02	0.02
40	PM	Benson & Hedges LG ^e	100s	Soft Pack	NM	19.4	0.39	2.01	5.41	0.01	0.01
41	PM	Benson & Hedges Green	100s	Hard Pack	M	19.0	0.31	1.65	5.52	0.01	0.01
42	PM	Parliament Blue	King	Hard Pack	NM	19.1	0.59	3.11	5.47	0.02	0.02
43	PM	Virginia Slims Gold	Slim	Hard Pack	NM	18.8	0.62	3.27	5.50	0.02	0.02
44	PM	Basic Gold	100s	Soft Pack	NM	17.3	0.44	2.54	5.42	0.01	0.01
45	PM	Basic Gold	100s	Hard Pack	NM	16.6	0.44	2.65	5.50	0.01	0.01
46	PM	Basic Green	100s	Hard Pack	M	16.5	0.41	2.49	5.54	0.01	0.01
47	PM	Basic Blue	100s	Hard Pack	NM	16.2	0.60	3.70	5.51	0.02	0.02
48	Lorillard	Newport Green	100s	Hard Pack	M	18.4	0.34	1.83	5.41	0.02	0.02
49	Lorillard	Maverick Gold	100s	Hard Pack	NM	16.9	0.52	3.10	5.51	0.02	0.02
50	Commonwealth	USA Gold	100s	Soft Pack	NM	18.8	0.36	1.91	5.32	0.01	0.01
51	IR5F	University of Kentucky	N/A	Soft Pack	NM	16.3	0.47	2.91	5.15 ^f	0.01	0.01
52	3R4F	University of Kentucky	N/A	Soft Pack	NM	19.0	0.54	2.84	5.46	0.06	0.06
53	CM6	CORESTA	N/A	Hard Pack	NM	18.7	0.54	2.89	5.21 ^f	0.00	0.00

Product Number	Tobacco Type	Source	Curing Process	Package	Flavor	Nicotine (mg/g) ⁱ		pH ^j		
						Mean	SD	CV (%)	Mean	SD
54	Flue-cured ^g	Murty Pharm., Inc. ^h	Flue-cured	N/A	NM	28.2	0.06	0.22	5.33	0.01
55	Burley ^g	Murty Pharm., Inc. ^h	Air-cured	N/A	NM	11.4	0.10	0.86	6.11	0.05
56	Oriental ^g	Murty Pharm., Inc. ^h	Sun-cured	N/A	NM	10.5	0.18	1.75	5.32	0.03
57	Reconstituted	Murty Pharm., Inc. ^h	Flue-cured/burley	N/A	NM	8.26	0.18	2.16	5.19	0.01

Note.

^aManufacturer: Santa Fe, Santa Fe Natural Tobacco Company; RJR, R.J. Reynolds Tobacco Company; PM, Phillip Morris; Commonwealth, Commonwealth Brands

^bFlavor: NM, Non-Mentholated; M, Mentholated

^cSD, standard deviation

^dCV, coefficient of variation

^eLG, Luxury Gold

^fN = 2

^gN. *tabacum* experimental cigarettes: Flue-cured, Flue-cured or Bright (Virginia); Oriental, Oriental or Turkish

^hMurty Pharm., Inc., Murty Pharmaceuticals, Inc.

ⁱN = 3

^jN = 2

Table 2 Nicotine Concentrations (N = 3) and pH Levels (N = 2) Found in the Filler of 5 Types of Cigar Tobacco Products (N = 75)

Product Number	Manufacturer ^a	Cigar Brand ^b	Package/ Box ^c	Nicotine (mg/g)			pH	
				Mean	SD ^d	CV (%) ^e	Mean	SD
Large Cigars (N = 27)								
58	Altadis (Tab. de Garcia)	Montecristo Half Corona (M-D)	7-cigar sampler bx	24.8	3.81	15.4	6.24	0.00
59	Altadis (Tab. de Garcia)	H. Upmann New Yorker (M-D)	7-cigar sampler bx	21.4	0.69	3.23	6.51	0.08
60	Altadis (Tab. de Garcia)	H. Upmann Vintage Cameroon (L)	9-cigar sampler bx	21.1	0.49	2.33	6.21	0.07
61	Altadis (Tab. de Garcia)	Onyx Reserve Belicoso (T)	9-cigar sampler bx	20.4	0.48	2.34	6.83	0.14
62	Altadis (Tab. de Garcia)	Don Diego Privada No.1 Maduro (L)	9-cigar sampler bx	20.4	0.94	4.61	6.39	0.06
63	Altadis (Tab. de Garcia)	Backwoods Wild Rum	8 pk	19.5	1.44	7.39	5.44	0.00
64	Altadis (Tab. de Garcia)	Montecristo White Especial (L)	9-cigar sampler bx	19.0	0.71	3.75	6.50	0.03
65	Altadis (Tab. de Garcia)	Erik Cherry (Filter Tipped)	7 pk	17.3	0.42	2.41	5.50	0.00
66	Altadis (Tab. de Garcia)	Pleiades Mini Belicoso (T)	9-cigar sampler bx	17.2	0.48	2.81	6.12	0.03
67	Altadis (Tab. de Garcia)	R&J Reserve Maduro No. 4 (M-D)	7-cigar sampler bx	17.1	0.52	3.01	6.43	0.05
68	Altadis (Tab. de Garcia)	H. Upmann Vint. Cameroon Belicoso (T)	9-cigar sampler bx	17.0	0.49	2.90	6.46	0.03
69	Altadis (Tab. de Garcia)	Don Diego (T)	9-cigar sampler bx	16.1	0.80	4.99	6.45	0.05
70	Altadis (Tab. de Garcia)	Onyx Reserve Maduro No. 4 (M-D)	7-cigar sampler bx	16.1	1.70	10.6	6.43	0.05
71	Altadis (Tab. de Garcia)	Pleiades Clemenceus (L)	9-cigar sampler bx	15.9	0.79	4.98	6.44	0.08
72	Altadis (Tab. de Garcia)	Romeo y Julieta 1875 Belicoso (T)	9-cigar sampler bx	13.2	0.43	3.30	6.28	0.04
73	Good Times USA	Remington Rum Filtered	20 pk	12.9	0.55	4.22	6.03	0.03
74	Renegade Holdings	Hombre Vanilla Filtered 100s	20 pk	12.6	0.09	0.69	6.02	0.00
75	Swisher Int.	Santa Fe Sweet Grape	20 pk	12.6	0.38	3.05	5.99	0.01
76	Tantus Tobacco	Red Buck Grape Filtered	20 pk	12.3	0.44	3.56	6.10	0.01
77	US Flue Cured Tob. Growers	1839 Blackberry 100s Box	20 pk	11.9	0.42	3.51	5.84	0.00
78	Altadis USA	Hav-A-Tampa Jewels Van. Behwd. Tip	5 pk	11.6	0.36	3.09	5.60	0.01
79	Altadis USA	Dutch Masters Corona Strwbr. (Fine)	4 pk	11.8	0.48	4.06	5.83	0.04
80	Tantus Tobacco	Red Buck Strwbr. 100s Soft Filtered	20 pk	11.5	0.10	0.88	5.99	0.02
81	M&R Holdings	Dean's Chocolate 100s Large	20 pk	11.1	0.25	2.25	6.03	0.03
82	A&T Tobacco Imports	Beach Palm Vanilla 100s	20 pk	10.5	0.49	4.66	5.40	0.03

Product Number	Manufacturer ^a	Cigar Brand ^b	Package/ Box ^c	Nicotine (mg/g)			pH	
				Mean	SD ^d	CV (%) ^e	Mean	SD
83	Altadis USA	Phillies Blunt Coconut	5 pk	10.2	0.10	0.97	5.62	0.04
84	M&R Holdings	Dean's Wild Berry Large	20 pk	9.20	0.08	0.90	5.94	0.00
Cigarillos (N = 17)								
85	Swisher Int.	Swisher Blackstone Tip Cherry	5 pk	17.9	0.52	2.87	5.24	0.00
86	Altadis USA	Tampa Sweet Tip Strwb. Mild Sweet	5 pk	15.9	0.26	1.65	5.04	0.00
87	Inter-Continental Cigar	Al Capone SLJM Rum Dipped Pm.	20 pk	15.8	0.65	4.12	5.20	0.02
88	Inter-Continental Cigar	Al Capone SWEETS Cognac Dipped	10 pk	14.8	0.35	2.35	5.17	0.01
89	Altadis USA	US Dutch Masters Honey Sports (Fine)	5 pk	14.1	0.67	4.77	5.53	0.02
90	Swedish Match	White Owl White Grape	2 pk	13.6	0.25	1.81	5.65	0.01
91	Altadis USA	US Phillies Cinnamon	5 pk	13.3	0.22	1.64	5.73	0.01
92	Swisher Int.	Swisher Sweets Peach	5 pk	12.9	0.19	1.46	5.86	0.02
93	Hoyo De Monterrey	Excalibur	box of 20	12.6	0.48	3.82	6.55	0.04
94	Swisher Int.	Optimo Icy Mint	5 pk	12.5	0.17	1.32	5.72	0.02
95	A&T Tobacco Imports	Double Diamond Grape	5 pk	11.5	0.32	2.78	5.24	0.01
96	Swisher Int.	Optimo Honey	5 pk	11.3	0.55	4.89	5.75	0.00
97	Altadis USA	Phillies Berry	5 pk	10.3	0.26	2.56	5.93	0.03
98	Altadis USA	Tampa Sweet Honey Berry Mild Sweet	5 pk	9.91	0.80	8.04	5.75	0.05
99	John Middleton	Black and Mild Sweets	5 pk	9.86	0.05	0.54	5.96	0.01
100	La Aurora (D.R.)	Don Lino Habanitos	tin of 50	8.35	0.11	1.31	7.41	0.02
101	John Middleton	Black and Mild Classic	2 pk	8.32	0.12	1.43	5.48	0.01
Little Cigars (N = 14)								
102	Altadis USA	Omega Cherry	20 pk	19.1	0.24	1.27	5.64	0.01
103	Conwood	Captain Black Tahitian Sweet Cherry	20 pk	18.4	0.69	3.76	5.67	0.03
104	Conwood	Captain Black Peach Rum	20 pk	15.2	0.20	1.32	5.83	0.03
105	Swisher Int.	Santa Fe Sweet Strwb. Filtered 100s	20 pk	13.0	0.28	2.15	5.78	0.02
106	A&T Tobacco Imports	Dark Horse Sour Apple	20 pk	12.3	0.18	1.49	5.24	0.00
107	Prime Time International	Happy Hour Appletini Filtered	20 pk	12.0	0.38	3.17	5.40	0.02

Product Number	Manufacturer ^a	Cigar Brand ^b	Package/Box ^c	Nicotine (mg/g)			pH	
				Mean	SD ^d	CV (%) ^e		
108	Prime Time International	Prime Time Raspberry Filtered	20 pk	11.9	0.16	1.30	5.90	0.03
109	Prime Time International	Prime Time Rum Filtered	20 pk	11.7	0.24	2.08	5.75	0.00
110	Kretek International	Pm. One Sweet Apple Filtered 100s	20 pk	10.9	0.16	1.43	5.58	0.02
111	Prime Time International	Prime Time Wild Berry Filtered	20 pk	10.9	0.24	2.17	5.68	0.03
112	Cheyenne International	Cheyenne Xotic Berry 100s	20 pk	10.5	0.22	2.07	5.91	0.00
113	M&R Holdings	Dean's Wild Berry	20 pk	10.5	0.49	4.66	5.92	0.00
114	Prime Time International	Prime Time Cinnamon	20 pk	10.5	0.20	1.94	5.62	0.02
115	Havana Honeyys (D.)	Havana Honeyys Mint Filtered	20 pk	10.3	0.26	2.48	6.11	0.01
Mini-Cigarillos (N = 4)								
116	Swisher Int.	Optimo Mini Peach	6 pk	12.6	0.42	3.29	5.68	0.03
117	Swisher Int.	Swisher Sweets Grape Mini Tip	5 pk	12.6	0.13	1.06	5.70	0.01
118	Swisher Int.	Swisher Sweets Mini Strwbr.	6 pk	12.4	0.37	2.98	5.64	0.01
119	Swisher Int.	Optimo Mini Grape	6 pk	12.2	0.19	1.52	5.69	0.01
Pipe Tobacco Cigars (N = 13)								
120	John Middleton	Cherry Blend	5 pk	9.61	0.20	2.12	5.75	0.01
121	John Middleton	Black & Mild Jazz	5 pk	9.50	0.12	1.25	5.15	0.03
122	John Middleton	Black & Mild Wood Tip	5 pk	9.36	0.18	1.89	5.03	0.02
123	John Middleton	Black & Mild Cream	5 pk	9.24	0.30	3.20	4.81	0.01
124	John Middleton	Black & Mild Apple	5 pk	9.10	0.21	2.27	4.71	0.00
125	John Middleton	Black & Mild Royal	5 pk	9.05	0.30	3.32	5.03	0.02
126	John Middleton	Black & Mild Wine	5 pk	8.74	0.09	1.05	4.97	0.00
127	John Middleton	Black & Mild Mild	5 pk	8.68	0.11	1.26	4.97	0.01
128	John Middleton	Black & Mild Jazz Wood Tip	5 pk	8.64	0.12	1.44	5.15	0.03
129	John Middleton	Prince Albert's Soft and Sweet Vanilla	5 pk	8.33	0.11	1.35	4.99	0.01
130	John Middleton	Gold and Mild	5 pk	8.23	0.12	1.43	5.03	0.00
131	John Middleton	Prince Albert's Soft Cherry Vanilla	5 pk	7.98	0.09	1.10	5.03	0.04
132	John Middleton	Black & Mild Royal Wood Tip	5 pk	7.88	0.03	0.41	5.08	0.01

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Note.

^aManufacturer: Altadis (Tab. de Garcia), Altadis (Tabacalera de Garcia S.A.S.); Swisher Int., Swisher International Group; US Flue Cured Tob. Growers, US Flue Cured Tobacco Growers, Inc., Havana Honeys (D.), Havana Honeys Dominican.

^bCigar Brand: (M-D), Mid-Day Selections; (T), Torpedo Selections; (L), Lonsdale Selections; R&J, Romeo y Julieta; Vint., Vintage; Van. Behwd, Vanilla Birchwood; Strwbr., Strawberry; Pm., Premium.

^cPackage/Box: pk, package; bx, box.

^dSD, standard deviation.

^eCV, coefficient of variation.

Table 3

Summary Statistics for 6 Combustible Tobacco Product Categories

Tobacco Product Type	Total Brands	Nicotine (mg/g)		pH	
		Mean	Range	Mean	Range
Large Cigars	27	15.4	9.20 – 24.8	6.10	5.40 – 6.83
Pipe Tobacco Cigars	13	8.79	7.88 – 9.61	5.05	4.71 – 5.75
Cigarillos	17	13.0	8.32 – 17.9	5.72	5.04 – 7.41
Mini-Cigarillos	4	12.5	12.2 – 12.6	5.68	5.64 – 5.70
Little Cigars	14	12.6	10.3 – 19.1	5.72	5.24 – 6.11
Cigarettes	50	19.2	16.2 – 26.3	5.46	5.14 – 5.61