Harmonizing machine testing measurements on premium cigar mainstream smoke

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Outline

Review cigar classifications and definitions

Mainstream smoke generation for chemical analysis

Available guidance on machine testing

Smoking parameter's impact on mainstream smoke deliveries

Particulate Matter	*Methods: nicotine, TSNAs, Metals, PAHs, AA, Phenols, Menthol, Humectants, HCN…*
Vapor Phase	*Carbon Monoxide, Carbonyls, VOCs*

Consider future steps to help harmonize intra- and inter-laboratory comparability

Topography

Summary

Cigars come in many shapes and sizes

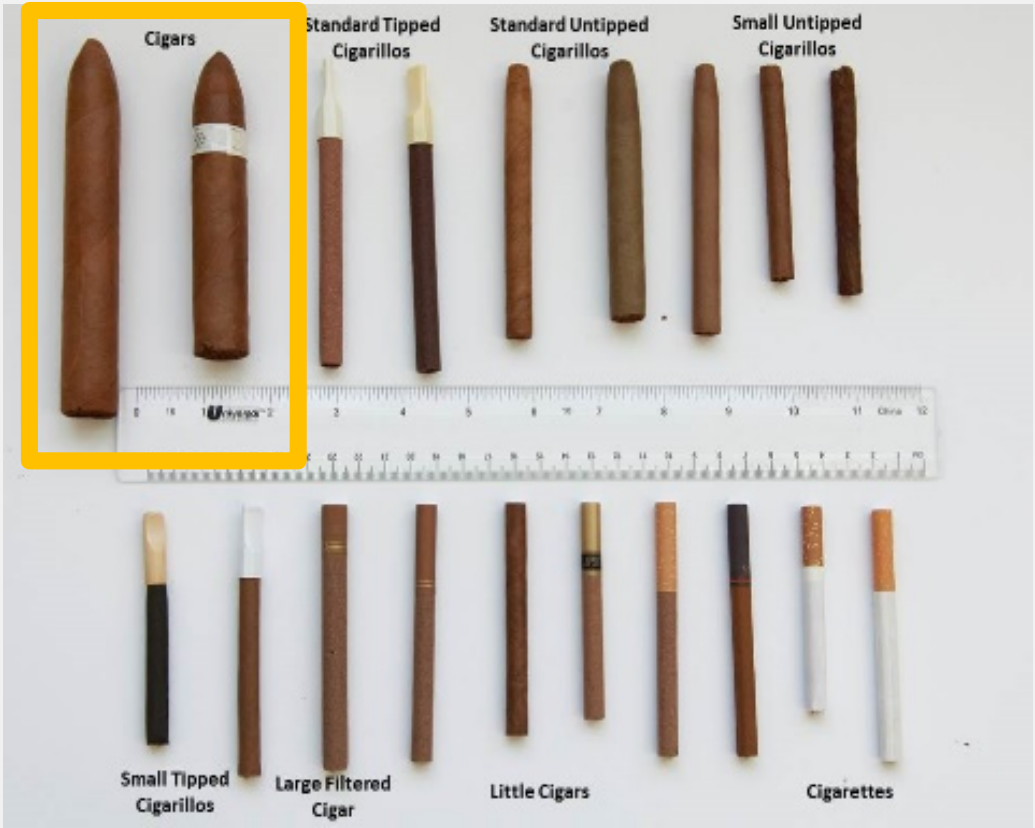
Variability exist across:

- Diameter
- Weight
- Tobacco (or source)
- Shape
- Tip
- Uniformity
- Manufacturing
  - Machine rolled
  - Hand Rolled

Focus on large cigars

Less studied than cigarettes or little cigars in part because of their variation in shape and sizes.

Large cigars are less uniform in shape and size, require different smoking machines, and require special holders.



Cigar definitions are weight based

Federal law (section 5702(c) of Title 26 of the United States Code) defines tobacco products as cigars, cigarettes, smokeless tobacco, pipe tobacco and roll-your-own tobacco.

Small cigars: 3lbs or less per 1000 sticks (≤ 1.36 grams/cigar)

Large: cigars: >3lbs for 1000 sticks (>1.36 grams/cigar)

https://www.ttb.gov/main-pages/federal-excise-tax-inrease-and-related-provisions

Large cigars deliver similar chemicals as other combustible tobacco products

Smoke yields of leading U.S. cigarettes[a] without and with filter tips, little cigars with filter tips, cigars[b], and premium cigars[b] 1997

Parameters	Pall Mall Non-filter Cigarettes	Marlboro Filter Cigarettes	Swisher Sweets Little Cigars	King Edward Cigars	Macanudo Premium Cigars
Length (mm)	85	85	100	138	176
Weight (g)	1.1	1.0	1.24	8.06	8.01
Puff (No)	11	10	18.5	89.7	119.4
Total Smoke (L)	0.385	0.35	0.4	1.8	2.4
"Tar" (mg)	26	16	24	37	44
CO (mg)	18	14	38	96	97
Nicotine (mg)	1.7	1.1	3.8	9.8	13.3
BaP (ng)	20	16	26.2	96.0	97.4
NNN (ng)	280	200	595	1225	1225
NNK (ng)	160	130	310	1200	1145

[a]The cigarettes were smoked under FTC conditions: 1 puff/min, 35 ml, 2-second puff duration butt length NF, 23 mm; F., 29 mm. (FTC) Pillsbury et al., 1969

[b]Little cigars, cigars; and premium cigars were smoked under the conditions of the International Committee for Cigar Smoke Study (ICCSS): 1 puff/40 seconds, 20 ml, 1.5-second puff duration, butt length 33 mm. Values are averages of 3 runs. (ICCSS) International Committee for Cigar Smoke Study, 1974.

Abbreviations: BaP, Benzo (*a*) pyrene; NNN, N[1]-nitrosonornicotine; NNK, 4-(methylnitrosamino) -1-(3-pyridyl)-1-butanone.

Cigars: Health Effects and Trends. Tobacco Control Monograph No. 9. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute. NIH Pub. No. 98-4302, February 1998. https://cancercontrol.cancer.gov/sites/default/files/2020-08/m09_complete.pdf

Large cigar deliveries are higher than smaller combustible tobacco products

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Nicotine (mg)	1.7	1.1	3.8	9.8	13.3	7X
BaP (ng)	20	16	26.2	96.0	97.4	5X
NNN (ng)	280	200	595	1225	1225	4X
NNK (ng)	160	130	310	1200	1145	7x

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Cigar smoke has similar chemical profiles as other combustible tobacco products.

At first glance, it might appear deliveries roughly correlate with tobacco mass.

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Tobacco weight does not fully explain differences in relative deliveries

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8x

1.6x

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Tar has long been surrogate for chemicals in mainstream total particulate matter.

What impact does smoking regimen have on deliveries and reproducibility?

Cigars: Health Effects and Trends. Tobacco Control Monograph No. 9. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute. NIH Pub. No. 98-4302, February 1998. https://cancercontrol.cancer.gov/sites/default/files/2020-08/m09_complete.pdf

Large cigar machine smoking differs from cigarette smoking

Most commonly used protocols
are specified by CORESTA

- CRM_46-June2018_Atmosphere for Conditioning and Testi...
- CRM_47_Cigar Sampling.pdf
- CRM_64-May2018_Cigar Smoking Machine Specifications_...
- CRM_65-Aug2019_NFDPM.pdf
- CRM_66-March2020_Nicotine.pdf
- CRM_67-March2020_water.pdf
- CRM_68-March2020_CO.pdf

Example of cigar smoking machine

Large cigar's diverse physical attributes necessitates a few loosely specified parameters to accommodate routine machine smoking

Air flow – loosely covered

Leak checking – challenging for nonuniform products

Tip cutting – not covered

Puffing regimen – differs from other products

Self-extinguishing/re-lighting – generally not an issue with cigarettes or little cigars

Parameter recording – key parameters to ensure comparability

Air flow – Characterization

Characterizing air flow along the burning cigar is important.

Too little air flow, smoke builds up inside containment area and could spill out exposing operator. The sidestream smoke originates in an oxygen starved environment and can have much higher chemical content than mainstream smoke.

Too high air flow results in increased static burn rate, decreased puff count and lower TPM collected. Can have dramatic impact on nicotine and other mainstream smoke constituents.

Specification – Visually inspect for stable 10 cm sidestream smoke column

Fairly Subjective
Highly influenced by surrounding environment

Leak checking is important to ensure no leakage between cigar and holder

Leakage around seals would result in dilution of mainstream smoke and lower smoke yields.

Bobbin with latex sleeve for seal

Color coded bobbins have range of diameter for cigars.

Sleeve within bobbin opens (vacuum) to insert cigar then closes. Seals well with cigars with smoother surfaces and cylindrical geometries.

Leak checking done indirectly using flow rates and puff profiles.
No "test device" or "virtual cigar" commercially available for leak checking.

Tip cutting can impact premium cigar mainstream smoke delivery

Premium cigars typically require tip cutting.

Most common styles are; punch (not shown), “V” cut, and circular cut.

Cut position and depth impacts pressure drop and flow dynamics.

“V-shape cut” “Circular cut”

The machine smoking large cigar regimen is based on product diameter.

Puffing regimen – specified: maintain flow characteristics, minimize self-extinguishing

Puffing regimen for premium cigars are for product or design comparisons not estimating human exposures!

Puff duration:	1.5 s
Puff Interval:	40 s
Puff Volume:	Cigar diameter $\leq$ 12 mm*, 20 mL Cigar diameter > 12 mm, $0.139*D^2$ (D = cigar diameter in mm)
Potential issues:	Occasionally, a cigar will self-extinguish

*Diameter is measured 33mm from mouth end

Potential steps to improve harmonization between studies

- Air flow checks: Visually ensure a stable 10cm static smoke plume is obtained at edges and middle of smoking machine. *Option: Once optimized, measure air flow. Option: Smoke QC cigar at random ports and use resulting TPM and puff count as QC metrics.*
- Leak checks: Visually inspect and replace bobbin seals as needed. Leak check as specified by smoking machine manufacturer. Confirm no cracks or openings in cigar wrapper. Ensure puff profile is correct. *Option: Create "virtual" premium cigar with fixed pressure drop using 3D printing technology to verify pressure differential is correct.*
- Tip cutting: Record type and depth of cut. *Option: Measure pressure drop after cutting.*
- Self-extinguishing actions: If cigar is re-lit, record how this was accomplished.

Data Reporting: To optimize cross-study companions, record cigar mass before and after smoking, and record puff count so comparisons possible on a per stick, per tobacco mass, or per unit smoke volume basis.

Conventional smoking topography measures

Observation/filming

Pros: Provides information of puff count, duration, and interval

Cons: No puff volume information

Pressure transducer

Pros: Provides information on puff count, duration, interval, and volume

Cons: Perturbs naturalistic smoking

Filter butt analysis

Pros: Provides estimates of constituent deliveries per stick, total smoke volume

Cons: No individual puff information, only works on filtered tobacco products

Conventional smoking topography for large cigar applications

Missing from all approaches is information on inhalation patterns, oral absorption, saturated saliva ingestion.

Due to alkalinity of cigar smoke, conventional wisdom dictated that large cigar smoke was not inhaled, but at least one study indicated some inhalation does occur.*

Topography evidence suggests that dual users of cigarette and large cigar adapt their smoking behaviors to achieve similar plasma nicotine levels.**

Cigar topography provides insights on behavior but does not directly measure exposure.

*McDonald et Al, Deposition of Cigar Smoke Particles in the Lung: Evaluation with Ventilation Scan Using 99m Tc-Labeled Sulfur Colloid Particles J Nucl Med (2002) 43:1591–1595

**Rosenberry et al (2018) Large Cigars: Smoking Topography and Toxicant Exposure, Nic Tob Res 20:2, 183–191,

Summary

- We reviewed how premium cigar mainstream smoke samples are generated under standardized machine testing conditions.
- Careful attention to details and providing key parameters associated with premium cigar testing will enhance generalizability between studies.
- As with all machine testing of tobacco products, the information on mainstream smoke constituents provides information on chemical deliveries, comparison between products, and the impact of product design characteristics.
- Machine testing does not yield direct information on human consumption or exposures. Various topography techniques can yield information on consumption patterns. However, detailed biomarker studies on cigar smokers are the “gold-standard” for exposure assessment.

Thank you

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