Comparison of Effects of Addition of Ingredients on Cigarette and Cigar Smoke Constituents

Abstract 3520
Poster Board P310

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Abstract

For cigars, unlike cigarettes, there are few studies examining the effect of addition of ingredients on levels of cigar smoke constituents. In this study, five cigar ingredients (ethyl levulinate (ELL), gamma-undecalactone (GUL), phenethyl isobutyrate (PEIB), sucralose (SUC), and tripropionin (TPP)) were included at four concentrations in cigarette and cigar tobacco, ranging from zero to levels far in excess of normal use levels. Cigarettes and tipped-cigars were made and tested for the levels of 18 Harmful and Potentially Harmful Constituents (HPHCs) from the FDA abbreviated list of HPHCs and catechol, *o*-toluidine, phenol, water, tar and total particulate matter using validated analytical methods. Cigarettes were puffed in accordance with the ISO puffing regimen and tipped-cigars were puffed in accordance with the CORESTA puffing regimen. ANOVA was used to compare the pattern of results from cigarettes to tipped-cigars as a function of ingredient concentration (significance $p \leq 0.05$) using TPM or tar yield as covariates.

Taking account of testing multiplicity, the conclusions regarding the effects of the added ingredients were analogous whether the ingredient was added to cigarettes or cigars. However, cigars show much wider variation in physical properties such as weight and correspondingly much wider variation in smoke yield than cigarettes. The wide smoke yield variation often resulted in a need to normalize cigar constituent yields to overall cigar yields (TPM or tar) which was often unnecessary with cigarettes.

The vast majority of ingredients either show a negative relationship to constituent yield or do not show statistically significant increases in yield with increased ingredient inclusion levels. If the effects are consistent, the smaller variation in cigarette yield would make it easier to detect ingredient effects when the ingredient is added to cigarettes than when added to cigars.

Objective

- Compare the effects of added ingredients on HPHC smoke yields when testing is conducted in tipped cigars vs. when the testing is conducted in cigarettes

Materials & Methods

Cigars

- tipped
- average weight 2.75 g
- average length 126 mm
- CORESTA smoking regimen:
  20 cc/1.5 second duration puffs
  taken every 40 seconds

Cigarettes

- filtered
- average weight 0.95 g
- average length 84 mm
- ISO smoking regimen:
  35 cc/2.0 second duration puffs
  taken every 60 seconds

Testing

- Testing conducted in ISO 17025 accredited laboratory and all methods were validated and on the laboratory's scope of accreditation.

Ingredients

- Sucralose (SUC), Ethyl Levulinate (ELL), Phenethyl Isobutyrate (PEIB), Tripropionin (TPP), Gamma-Undecalactone (GUL)
- Products were made with no added ingredients, a typical application level (1X), a higher level approximately 10 times higher than typical application (10X), and an extreme application that was 50 or 100 times the typical application rate (50X/100X)

Analytes

- Products were smoked for the FDA Abbreviated HPHC list (18 analytes), plus *o*-toluidine, phenol, catechol, and benzo(a)anthracene
  - Total particulate matter and tar were also calculated when applicable

Analyses

- Statistical methods: one-way analysis of variance
  - Where available and statistically significantly ($p<0.05$) related to analyte yield, TPM was used as a covariate to improve precision of the comparisons – particularly beneficial with the cigar comparisons because of the wide TPM variation
  - For carbonyls where TPM was not available or in cases where TPM was not related to analyte yield, TPM was not used as a covariate
- The ingredient effect was statistically significant if the linear contrast of the ordinal ingredient levels (including the zero level) was statistically significant ($p<0.05$, separately examined with and without a Bonferroni correction for testing multiplicity)
  - The effect was positive if statistically significant and the linear contrast was positive and negative if statistically significant and the linear contrast was negative

Results

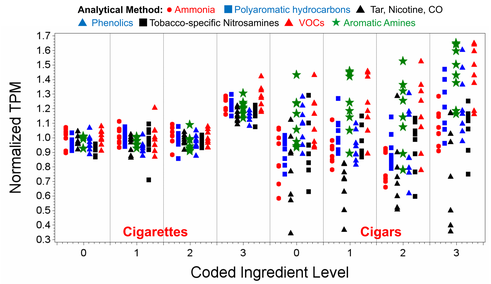
Target Application Rates and Analyzed Levels

Ingredient	Mol Wt (g/mol)	Target Application (ppm)		
Sucralose (SUC)	398	150	1500	7500
Ethyl Levulinate (ELL)	144	720	7200	36000
Phenethyl Isobutyrate (PEIB)	192	68	680	6800
Tripropionin (TPP)	260	1205	12050	60250
Gamma-Undecalactone (GUL)	184	1000	10000	50000

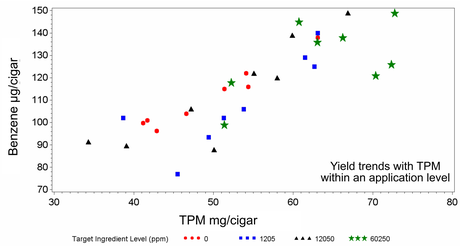
Cigar Levels	Analyzed Levels (ppm)		
Sucralose (SUC)	166	1628	7354
Ethyl Levulinate (ELL)	52.0	423	2097
Phenethyl Isobutyrate (PEIB)	24.0	243	3129
Tripropionin (TPP)	54.3	515	20899
Gamma-Undecalactone (GUL)	452	4356	34012

Cigarette Levels	Analyzed Levels (ppm)		
Sucralose (SUC)	143	1461	7161
Ethyl Levulinate (ELL)	29.0	258	2056
Phenethyl Isobutyrate (PEIB)	18.8	147	1615
Tripropionin (TPP)	107	1297	25732
Gamma-Undecalactone (GUL)	385	4796	29788

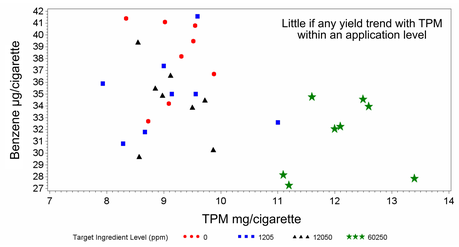
Normalized Cigarette and Cigar TPM with Tripropionin (TPP)



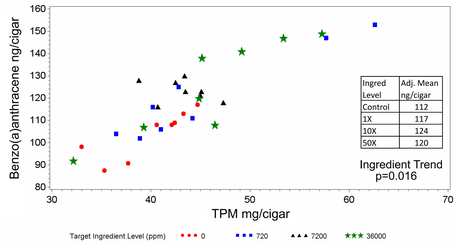
Benzene vs. Cigar TPM with Tripropionin (TPP)



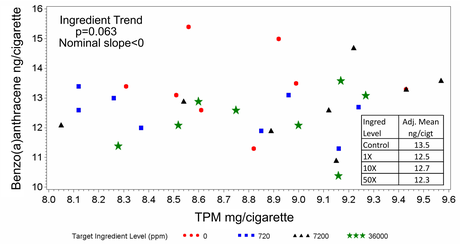
Benzene vs. Cigarette TPM with Tripropionin (TPP)



Benzo(a)anthracene vs. Cigar TPM with Ethyl Levulinate (ELL)



Benzo(a)anthracene vs. Cigarette TPM with Ethyl Levulinate (ELL)



- Cigar yields were much more variable than cigarette yields as illustrated in the TPM graphs below
- Of the 109* analyte/ingredient combinations, 3 were statistically significant and positive for cigarettes and 3 were statistically significant and positive for cigars and only 1 after adjustment for testing multiplicity

*PEIB was found to co-elute with nicotine, so nicotine yield could not be tested for that ingredient, resulting in 109 testable combinations.

Number of Constituents and Their Effect on HPHC Yields

Not Adjusting for Testing Multiplicity

	Cigars	Cigarettes
No Effect	74	66
Positive Trend	2	2
Negative Trend	33	41

With Bonferroni Adjustment for Testing Multiplicity

	Cigars	Cigarettes
No Effect	87	88
Positive Trend	0	0
Negative Trend	22	21

General Pattern

- For the vast majority of constituent/ingredient combinations, the trend was either no effect or a downward trend of constituent yield with target ingredient inclusion level whether testing was conducted on cigarettes or cigars
- Accounting for testing multiplicity, there were no analyte yields that statistically significantly trended up with ingredient inclusion level

Conclusions

- Cigar smoke yields are much more variable than cigarette smoke yields.
- Because of the wide smoke yield variation with cigars, adjustment for TPM yields becomes very important when possible. *Note: TPM is not measured with the carbonyl smoke method so those were compared without TPM adjustment.*
- Allowing for testing multiplicity there were no differences in conclusions across the five ingredients and twenty-two HPHC constituents evaluated.