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Still 'Cool': tobacco industry responds to state-wide menthol ban with synthetic coolants

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ABSTRACT

Introduction In December 2022, California (CA) enforced a voter-approved regulation restricting the retail sale of flavoured tobacco products, including menthol cigarettes. Shortly after, new products emerged on the market containing similar blue and green package colours yet with 'non-menthol' descriptors. Using chemical analyses, we measured the content of menthol and 15 other cooling chemicals in Californian cigarettes with 'non-menthol' descriptors and compared concentrations to similar 'menthol'-labelled counterparts available in New York State (NY).

Methods A convenience sample of 10 brands and types of cigarettes in CA were purchased based on package colours suggesting a cooling effect and/or 'non-menthol' descriptors. The exact brand and type of cigarettes (with menthol descriptors) were purchased in NY. Cigarettes from CA were compared with equivalent cigarettes from NY on package design and colours, cigarette physical characteristics and the presence of cooling additives.

Results Menthol was not detected in any CA cigarette, except for Maverick-green box type, while its presence was confirmed in most NY counterpart products. A synthetic cooling chemical WS-3 was not detected in any NY cigarettes but was detected in four CA brands and types with implied cooling effect, ranging from 1.24 ± 0.04 to 1.97 ± 0.05 mg/cigarette.

Conclusion While manufacturers have removed menthol descriptors from CA packaging and the menthol ingredient from cigarettes, synthetic cooling chemicals detected in several CA brands suggest that cooling sensory effects may still be sustained. Policymakers must consider both the chemical ingredients themselves and sensory effects in future regulatory approaches.

INTRODUCTION

Flavourings in tobacco products improve sensory experiences by masking the harshness of inhaled smoke and also increase the product's appeal to potential users.^{1,2} Menthol is among the most commonly used flavourings in various tobacco products.³ As part of strategies to reduce tobacco use, several countries, starting with Canada in 2015⁴ and more recently in the European Union in 2020,^{5,6} have imposed bans on characterising flavours, including menthol, in some or all tobacco products.⁷ Canada and Germany have also banned the use of substitute synthetic cooling flavouring chemicals that mimic the sensory effects of menthol.⁸ The USA currently prohibits the sale of flavoured combustible cigarettes (other than menthol), though flavours are permitted in cigars,

WHAT IS ALREADY KNOWN ON THIS SUBJECT

- ⇒ Menthol is a critical additive tobacco manufacturers use to improve the smoking experience among tobacco users and attract new users.
- ⇒ The synthetic cooling chemicals that may cause sensory experiences similar to menthol have been recently reported in various tobacco products, including e-cigarettes and nicotine pouches.

WHAT IMPORTANT GAPS IN KNOWLEDGE EXIST ON THIS TOPIC

- ⇒ Little is known about synthetic cooling chemicals in cigarettes marketed after menthol restrictions are implemented.
- ⇒ It is unknown whether manufacturers are compliant with new menthol restrictions by removing menthol from cigarettes, or by removing menthol descriptors from packaging while replacing menthol with other cooling flavouring chemicals.

WHAT THIS STUDY ADDS

- ⇒ 'Non-menthol' cigarettes marketed in California with implied cooling effects did not contain menthol, yet some brands contained a synthetic cooling chemical WS-3.
- ⇒ Our findings raise concerns about potential industry strategies to respond to menthol restrictions by replacing this common additive with synthetic analogues.

smokeless tobacco, roll-your-own/loose tobacco, shisha and e-cigarettes. While a federal flavour ban on menthol cigarettes and cigars may be forthcoming,⁹ the state of California (CA) prohibited in December 2022 the retail sale of most flavoured tobacco products, including those with characterising menthol flavours, defined as 'a distinguishable taste or aroma, or both, other than the taste or aroma of tobacco'.¹⁰

We have recently reported new marketing campaigns in CA of rebranded cigarettes with 'fresh' and 'crisp' alongside 'non-menthol' descriptors.¹¹ RJ Reynolds, one of the biggest US manufacturers of menthol cigarettes, has launched a 'California, We've Got You Covered' campaign¹² to suggest sustained cooling sensory experience from rebranded products. It is unclear whether the industry has updated descriptors on cigarette packages or modified their product formulations by



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Figure 1 Images of 'Non-Menthol' and 'Menthol' cigarettes purchased in California and New York State.

removing or replacing menthol with alternative cooling flavourings. Indeed, speculation of industry response has included using alternative cooling agents, such as WS-3 and WS-23,^{13–15} which have similar cooling effects but without delivering a characterising menthol flavour.¹⁶

This study aimed to assess the content of menthol and 15 cooling agents in 'non-menthol' marketed cigarettes purchased in CA and compare these cooling agents to their 'menthol'-labelled counterparts purchased in New York State (NY).

MATERIALS AND METHODS

Cigarettes

Cigarettes with 'non-menthol' package descriptors from 10 brands and types were purchased from large-chain stores and independently owned retailers located in the Greater Los Angeles area, as previously described,¹¹ and San Francisco, CA (figure 1). Comparator products with similar package colours yet containing 'menthol' labelling from the same brands and types were purchased from gas stations around Buffalo, NY. Newport-red box 'non-menthol' cigarettes were available in both CA and NY. Products were obtained between January and March 2023 and stored at $-20\pm 4^{\circ}\text{C}$ until analysis. Physical and chemical tests described below were conducted after cigarettes were conditioned for 48 hours at $22\pm 4^{\circ}\text{C}$ with 60% relative humidity.¹⁷

Labelling differences were compared by evaluating pack and logo primary colours as well as text or descriptive language of expressed (eg, 'menthol') and implied (eg, 'fresh') flavour descriptors, following similar methodology as previously reported.¹⁸ To understand whether manufacturers modified the physical characteristics of cigarettes, we measured tobacco rod and filter length, diameter and weight using callipers and an analytical balance.¹⁹ Ventilation and proximity to the mouth end were determined by examining filter paper vent holes using a lightbox. Rod and filter density were calculated as previously reported.¹⁹ All measurements were performed in triplicate. Moisture content was assessed once from the tobacco filler of five cigarettes using a moisture analyser (HB43-S, Mettler

Toledo). We used Mann-Whitney non-parametric t-tests to compare differences between CA and NY cigarettes.

Cigarette preparation

The tobacco filler was separated from the non-tobacco material (NTM; filter and remaining paper rod) and placed in preweighed Erlenmeyer flasks. If flavour capsules were found in a product, they were removed and manually crushed in a separate preweighed flask. Forty millilitres of methanol extraction solution containing 0.025 mg/mL internal standards (online supplemental table 1) was added, and each flask was mixed for 2 hours. All cigarettes were analysed in triplicate. Weight differences of tobacco filler, NTM and capsules between replicates did not exceed 20%.

Cooling flavouring chemical analysis

Neat standards of the 16 cooling flavouring chemicals, including l-menthol and synthetic coolants WS-3 and WS-23, and internal standards assessed in the study were purchased from multiple vendors (online supplemental table 1). Calibration standards and quality controls ranging from 0.00025 to 0.5 mg/mL (equivalent to cigarette content from 0.01 to 20.0 mg/cigarette) were prepared to calibrate and validate the analytical method. Quantitative analysis was performed using a 7890B/5977A gas chromatography/mass spectrometry system (Agilent Technologies; California) following parameters listed in online supplemental table 2. Separation was achieved, where ion spectra and retention times were matched to calibration standards acquired in each batch (online supplemental figure 1). Three highly abundant ions for each analyte were selected as additional identifiers (online supplemental table 2). Quantitation was performed using peak area and internal standard response from calibrations exceeding correlation values (r^2) of 0.985. Parametric t-tests were used to compare chemical differences between CA and NY cigarettes. Chromatograms were visually inspected for additional non-targeted peaks.

Table 1 Concentration of cooling agents in tobacco, non-tobacco material and capsules between California (CA) and New York State (NY) cigarettes

	L-Menthol		WS-3		Carvone		Menthyl acetate	
	CA	NY	CA	NY	CA	NY	CA	NY
Kool Green*								
Tobacco filler (mg/filler)	<LLOQ	1.46±0.15†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
NTM (mg/NTM)	<LLOQ	0.67±0.06†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Total (mg/cigarette)	<LLOQ	2.13±0.11†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Kool Blue								
Tobacco filler (mg/filler)	<LLOQ	1.04±0.04†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
NTM (mg/NTM)	<LLOQ	1.75±0.06†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	0.01±0.00†
Total (mg/cigarette)	<LLOQ	2.79±0.05†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	0.01±0.00†
Maverick Green								
Tobacco filler (mg/filler)	0.02±0.00	1.37±0.01†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
NTM (mg/NTM)	<LLOQ	1.38±0.05†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Total (mg/cigarette)	0.02±0.00	2.74±0.06†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Newport Green*								
Tobacco filler (mg/filler)	<LLOQ	1.68±0.08†	1.27±0.09	<LLOQ†	<LLOQ	<LLOQ	<LLOQ	<LLOQ
NTM (mg/NTM)	<LLOQ	0.75±0.05†	0.07±0.00	<LLOQ†	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Total (mg/cigarette)	<LLOQ	2.43±0.04†	1.34±0.09	<LLOQ†	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Newport Red‡								
Tobacco filler (mg/filler)	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
NTM (mg/NTM)	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Total (mg/cigarette)	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Newport EXP Mix Blue§								
Tobacco filler (mg/filler)	<LLOQ	–	1.90±0.05	–	<LLOQ	–	<LLOQ	–
NTM (mg/NTM)	<LLOQ	–	0.07±0.00	–	<LLOQ	–	<LLOQ	–
Total (mg/cigarette)	<LLOQ	–	1.97±0.05	–	<LLOQ	–	<LLOQ	–
Newport EXP Max Green§								
Tobacco filler (mg/filler)	<LLOQ	–	1.68±0.08	–	<LLOQ	–	<LLOQ	–
NTM (mg/NTM)	<LLOQ	–	0.08±0.00	–	<LLOQ	–	<LLOQ	–
Total (mg/cigarette)	<LLOQ	–	1.75±0.07	–	<LLOQ	–	<LLOQ	–
Camel Crush Silver								
Tobacco filler (mg/filler)	<LLOQ	1.65±0.09†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
NTM (mg/NTM)	<LLOQ	1.94±0.18†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Total (mg/cigarette)	<LLOQ	3.59±0.26†	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Capsule (mg/capsule)	<LLOQ	4.35±0.28†	<LLOQ	<LLOQ	0.03±0.00	0.03±0.00	<LLOQ	0.06±0.01†
Camel Crush Blue								
Tobacco filler (mg/filler)	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
NTM (mg/NTM)	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Total (mg/cigarette)	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ	<LLOQ
Capsule (mg/capsule)	<LLOQ	4.53±0.02†	<LLOQ	<LLOQ	0.02±0.00	0.03±0.00¶	<LLOQ	0.06±0.00†
Camel Crisp Green§								
Tobacco filler (mg/filler)	<LLOQ	–	1.18±0.04	–	<LLOQ	–	<LLOQ	–
NTM (mg/NTM)	<LLOQ	–	0.06±0.00	–	<LLOQ	–	<LLOQ	–
Total (mg/cigarette)	<LLOQ	–	1.24±0.04	–	<LLOQ	–	<LLOQ	–

Average concentration±SD.
Unless otherwise indicated, n=3.
Parametric t-test comparisons. <LLOQ values treated as <LLOQ/√2. LLOQ values are 0.02 (menthol and WS-3) and 0.01 (carvone and menthyl acetate).
*n=6.
†Indicates statistical significance (p<0.001).
‡No implied cooling-like flavour. Both CA and NY descriptors are 'non-menthol'.
§No comparator product available in NY.
¶Indicates statistical significance (p<0.05).
<LLOQ, below lower limit of quantitation; NTM, non-tobacco material (filter and paper).

RESULTS

Package design, flavour descriptors and physical characteristics

Differential packaging was observed only with the use of 'non-menthol' flavour descriptors among CA brands, rather than 'menthol' among NY brands (figure 1). Newport EXP (Max and Mix, figure 1H) and Camel Crisp (not shown) were only

available in CA, suggesting these were newly marketed. CA Camel Crush-silver and blue logo types have replaced expressed 'menthol' with implied 'oasis' descriptors (figure 1E,F). The use of 'non-menthol' descriptors was also used to imply the absence of menthol flavour among CA and NY Newport-red box (figure 1D), which were available prior to the ban, and NY Camel Crush-blue logo (figure 1F).

Notably, CA Newport-green box cigarettes weighed significantly less than the NY counterparts. Also, CA Maverick-green box contained two rows of ventilation holes, whereas the NY equivalent was not visibly ventilated (online supplemental table 3 and online supplemental figure 2).

Content of menthol and alternative cooling agents

Menthol was not detected in any CA cigarette's NTM (filters). In the Maverick brand, menthol was present in the tobacco filler at a substantially lower concentration compared with the NY equivalent (0.02 ± 0.00 mg/cigarette vs 2.74 ± 0.06 mg/cigarette, $p < 0.05$) (table 1). In contrast, menthol was detected in the tobacco filler and NTM from most NY cigarettes, ranging in total content from 2.13 to 3.59 mg/cigarette. NY Camel Crush-blue logo and Newport-red box did not contain menthol in the filler or NTM. Among NY Camel Crush capsules, menthol content averaged 4.44 ± 0.20 mg/capsule.

The synthetic cooling chemical WS-3 was identified in two brands of CA cigarettes: Newport and Camel, ranging from 1.24 ± 0.04 to 1.97 ± 0.05 mg/cigarette, where over 90% of the content was found in the tobacco filler. Dihydroxyacetone, which provides both cooling and sweet sensations, was found in the tobacco filler of all CA and NY cigarettes. Dihydroxyacetone failed to meet acceptable calibration criteria; therefore, content was not reported. Menthyl acetate was measured in NY cigarettes only (Kool-blue box and Camel Crush-silver and blue logo). Carvone, a minty flavouring used in commercial wintergreen-flavoured products, was detected in CA and NY Camel Crush cigarette capsules. We did not find the remaining 11 cooling agents, or other untargeted coolants in any tested cigarette from CA or NY (online supplemental table 1 and online supplemental figure 3).

DISCUSSION

Our results indicate that the menthol descriptor was removed from package labelling, and that the menthol ingredient was removed from tobacco filler, and NTM in most cigarettes sold in CA after restrictions on flavoured tobacco products was introduced. One brand, Maverick-green box, contained menthol at a level similar to previously reported content identified in traditional non-mentholated cigarettes.²⁰ Manufacturers have historically added low amounts of menthol below detectable characterising thresholds, yet still sufficient to activate cellular signalling, providing cooling effects in the upper respiratory tract.²¹ Several Newport and Camel brands appear to have replaced menthol with WS-3. For example, Newport-green box contained 2.43 mg menthol among NY cigarettes, while CA equivalents contained 1.34 mg WS-3 per cigarette. Selected brands also introduced filter ventilation and reduced weight, which act to reduce harshness and increase perceived smoothness.^{22 23}

Synthetic coolants, such as WS-3, can exert similar cooling effects as menthol by binding to the same cellular receptors (TRPM8 and TRPA1).²⁴ For some coolants, including WS-3, the relative agonistic potency is greater, producing more intense lingering cooling effects.²⁵ Notably, an estimated 1200 synthetic coolants have been developed to mimic, intensify or prolong cooling effects compared with menthol.^{25 26} While our results did not identify additional synthetic coolants, manufacturers may continue modifying ingredient lists in place of menthol bans. If there is demand for synthetic cooling agents by the tobacco industry in response to menthol bans, we may observe the increased presence of new cooling agents in various tobacco

products. Industry methods measuring synthetic coolants Evercool 180 and 190 were recently published, although cigarette content was not reported.²⁷ Analogously, increased availability and use of previously costly synthetic nicotine observed in US e-cigarettes after national flavour bans,²⁸ in an attempt to remain unregulated by the Food and Drug Administration, has illustrated the industry's attention to synthetic alternatives as a means of evading regulation.

A significant limitation of our study is that we purposely selected a small convenience sample of products from CA which included 'non-menthol' wording on the packaging. As such, this study's results may not represent all brands and industry strategies. For example, prior industry testing with WS-14 has been reported.²⁹ Further, it is unknown whether these products are available in other regions in the USA with menthol cigarette bans. Additional surveillance is needed to understand whether 'non-menthol' cigarettes will become more widely marketed with forthcoming menthol bans, or whether CA is simply a test market for these products.

CONCLUSIONS

Our results suggest that CA's menthol ban resulted in new cigarette formulations, which included WS-3, likely to sustain cooling sensations after removing menthol. Further investigation is needed to understand whether WS-3 and other synthetic coolants provide characteristic tastes or aromas besides tobacco in these products. Future policies around flavoured tobacco products should comprehensively consider the sensory effects and the chemistry of tobacco products.

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Supplemental Table 1 – Targeted Cooling Agents and Internal Standards

Compound Name	CAS	Vendor
1,4-Cineole	470-67-7	Acros Organics
Carvone ¹	99-49-0	TCI
Dihydroxyacetone	96-26-4	Sigma-Aldrich
Ethyl Salicylate	118-61-6	TCI
Eucalyptol	121-32-4	Alfa Aesar
Fenchol	1632-73-1	TCI
Isomenthol	20752-33-4	TRC
Isopulegol	7786-67-6	Sigma-Aldrich
L-Menthol ²	2216-51-5	Acros Organics
Menthone	14073-97-3	Alfa Aesar
Menthyl Acetate ¹	16409-45-3	TCI
Methyl Salicylate	119-36-8	Sigma-Aldrich
Piperitone ¹	89-81-6	TCI
Pulegone	89-82-7	TCI
WS-3	39711-79-0	TCI
WS-23	51115-67-4	TCI
Internal Standards		
Acenaphthene-d10	15067-26-2	CIL
Chlorobenzene-d5	3114-55-4	CIL
Naphthalene-d8	1146-65-2	SCBT

Acros Organics, Fair Lawn, NJ, USA | TCI (Tokyo Chemical Industry), Tokyo, JPN | Sigma-Aldrich, St. Louis, MO, USA | Alfa Aesar, Ward Hill, MA, USA | TRC (Toronto Research Chemicals), Toronto, CAN | CIL (Cambridge Isotope Laboratories, Inc.), Andover, MA, USA | SCBT (Santa Cruz Biotechnology), Dallas, TX, USA | BOC (BOC Sciences), Shirley, NY, USA

CAS = Chemical Abstracts Service

¹Mixture of (R)-(-) & (S)-(+) isomers.

²Calibrated with L-isomer only. Chromatographic separation between isomers is unknown.

Targeted analytes with cooling effects are a subset from the larger analytical method, which measures 35 total chemicals. Additional chemicals include: 2,3,5-trimethylpyrazine (CAS 14667-55-1), 5-(hydroxymethyl)furfural (67-47-0), acetoin (513-86-0), benzaldehyde (100-52-7), benzyl alcohol (100-51-6), butanoic acid (107-92-6), cinnamaldehyde (14371-10-9), ethyl maltol (4940-11-8), ethyl vanillin (121-32-4), eugenol (97-53-0), furaneol (3658-77-3), isovanillin (621-59-0), limonene (138-86-3), linalool (78-70-6), maltol (118-71-8), nicotine (54-11-5), raspberry ketone (5471-51-2), triacetin (102-76-1), and vanillin (121-33-5).

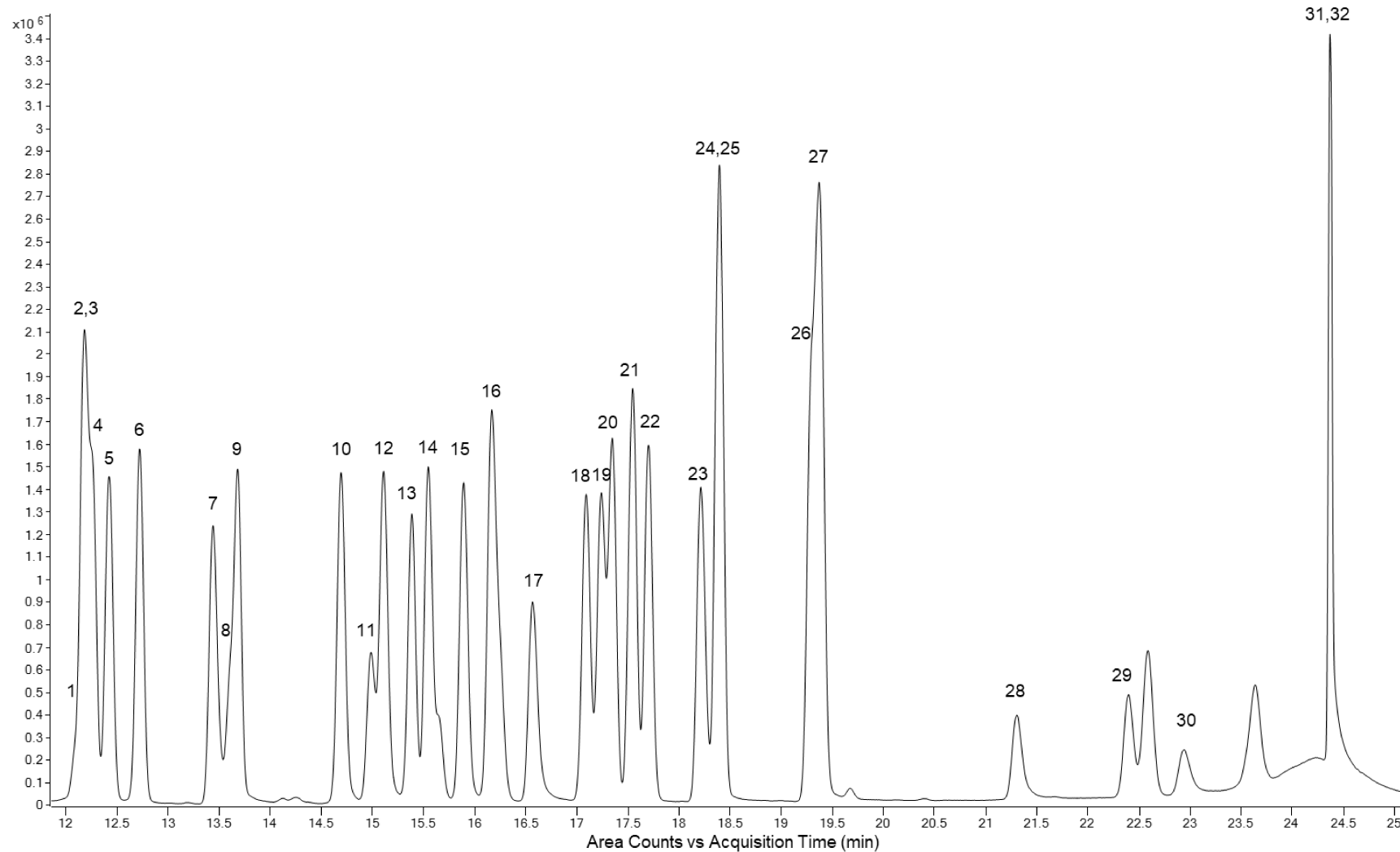
We detected linalool in CA capsules only (n=6, average=0.07±0.01 mg/capsule) & NY capsules only (n=9, average=0.05±0.01 mg/capsule), triacetin in CA cigarettes (n=36, average=8.2±1.5 mg/cigarette) & NY cigarettes (n=30, average=7.7±1.9 mg/cigarette), and nicotine in CA cigarettes (n=36, average=9.1±1.3 mg/cigarette) & NY cigarettes (n=30, average=8.8±1.1 mg/cigarette). Note, average concentrations of triacetin and nicotine are estimated, as several cigarettes exceeded the upper calibration range for these analytes. Re-analysis with dilutions was not performed.

Supplemental Table 2 – Instrument Parameters

Gas Chromatograph	Agilent 7890B
Mass Spectrometer	Agilent 5977A
Column	Agilent DB-624UI - 30m, 0.32mm, 1.8µm [123-1334UI]
Inlet	EPC capillary split/ splitless
Injection Volume	1 µl
Injection	Splitless
Injection Port Liner	Splitless; Single Taper, Ultra Inert liner with glass wool [5190-2293]
Inlet Temp	250°C
Septum Purge Flow	3.0 mL/min
Gas Saver	20 mL/min after 2.0 minutes
Carrier Gas	Helium, ramped flow
Oven Program	70 °C for 0 min, then 4°C/min to 80°C, Hold for 1.0 min, then 50°C/min to 180°C, Hold for 0 min, then 5°C/min to 240°C, Hold for 0 min, then 55°C/min to 260°C, Hold for 9.2 min
MSD Transfer Line	250°C
MSD Source / Quad Temp	230°C / 150°C
MSD Acquisition Mode	Full Scan, positive ionization
Start & End Masses	30-300 amu
Scan Speed	1,562 [N=2] (u/s)
EM Settings	Gain Factor = 1
Quantitation (bold) & Qualifier Ions	<p>1,4-Cineole (111,125,154) 2,3,5-Trimethylpyrazine (122,42,81) 5-(hydroxymethyl)furfural (97,126,69) Acetoin (45,43,88) Benzaldehyde (106,105,77) Benzyl Alcohol (108,79,107) Butanoic Acid (60,73,55) Carvone (82,108,93) Cinnamaldehyde (131,132,103) Dihydroxyacetone (31,43) Ethyl Maltol (140,139,125) Ethyl Salicylate (120,166,92) Ethyl Vanillin (137,166,138) Eucalyptol (108,154,139) Eugenol (164,149,131) Fenchol (81,80,121) Furaneol (128,57,43) Isomenthol (123,138,109) Isopulegol (121,136,154) Isovanillin (151,152,73) Limonene (68,93,136) Linalool (71,93,121) Maltol (126,71,97) Menthol (123,138,109)</p>

	<p>Menthone (112,139,154) Menthyl Acetate (95,123,138) Methyl Salicylate (120,152,92) Nicotine (84,133,162) Piperitone (110,82,137) Pulegone (81,152,109) Raspberry Ketone (107,164,77) Triacetin (43,103,145) Vanillin (151,152,81) WS-3 (100,87,211) WS-23 (129,114,128) Acenaphthene-d10 (164,162,160) Chlorobenzene-d5 (117,82,119) Naphthalene-d8 (136,137,108) Pyridine-d5 (84,56,54)</p>
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Supplemental Figure 1 – Total Ion Chromatogram from Calibration Standard



1 – Dihydroxyacetone	5 – Limonene	9 – Linalool	13 – Menthone	17 – Ethyl Maltol	21 – Ethyl Salicylate	25 – Triacetin	29 – Ethyl Vanillin
2 – Benzaldehyde	6 – Eucalyptol	10 – Fenchol	14 – L-Menthol	18 – Pulegone	22 – Piperitone	26 – Eugenol	30 – Isovanillin
3 – 2,3,5-Trimethylpyrazine	7 – Benzyl Alcohol	11 – Maltol	15 – Isomenthol	19 – Carvone	23 – Cinnamaldehyde	27 – Nicotine	31 – WS-3
4 – 1,4-Cineole	8 – Furaneol	12 – Isopulegol	16 – Methyl Salicylate	20 – Menthyl Acetate	24 – WS-23	28 – Vanillin	32 – Raspberry Ketone

The complete analytical run contains 35 flavoring chemicals. **Bold** represent the 16 targeted cooling compounds. Chromatogram narrowed to show first and last targeted cooling chemical (12-25 min)

Supplemental Table 3 – Physical Characteristic Differences between California (CA) and New York State (NY) Cigarettes

	Length (mm)			Diameter (mm)			Weight ⁴ (mg)			Density (mg/cm ³)			Vent Distance from Mouth End ⁵ (mm)			% Moisture ⁶	
	CA	NY	<i>P</i> -value ⁷	CA	NY	<i>P</i> -value ⁷	CA	NY	<i>P</i> -value ⁷	CA	NY	<i>P</i> -value ⁷	CA	NY	<i>P</i> -value ⁷	CA	NY
Kool Green¹																	
Tobacco Rod	60.7± 0.4	61.2± 0.7	0.340	7.3±0.3	7.4±0.4	0.699	636.2± 56.3	679.3± 13.3	0.394	247.4± 12.1	261.8± 37.1	0.699	---	---	---	11.8	16.4
Filter	20.5± 0.6	20.8± 0.3	0.318	7.3±0.2	7.3±0.1	0.981	108.4± 2.6	112.0± 3.8	0.132	126.0± 5.9	129.0± 3.8	0.394	12.8±0.8	12.7±0.5	0.740	---	---
Total	82.5± 0.2	83.0± 0.2	0.015	---	---	---	744.6± 56.1	791.3± 14.3	0.240	---	---	---	---	---	---	---	---
Kool Blue																	
Tobacco Rod	54.3± 0.3	54.7± 0.3	0.600	7.5±0.3	7.4±0.2	0.700	601.9± 18.2	631.1± 4.2	0.100	254.4± 10.2	271.9± 2.6	0.100	---	---	---	12.4	14.4
Filter	26.2± 0.3	26.0± 0.0	>0.990	7.4±0.0	7.5±0.2	0.700	136.1± 3.6	135.6± 1.2	>0.999	120.9± 3.6	119.1± 7.4	>0.999	12.3±0.3	12.7±0.6	0.600	---	---
Total	82.2± 0.2	82.1± 0.1	0.400	---	---	---	738.0± 21.8	766.7± 5.4	0.100	---	---	---	---	---	---	---	---
Maverick Green																	
Tobacco Rod	71.5± 0.0	71.3± 0.3	>0.999	7.5±0.2	7.5±0.2	>0.999	817.6± 8.2	869.8± 19.4	0.100	260.8± 13.4	277.1± 14.9	0.400	---	---	---	15.6	16.4
Filter	26.8± 0.3	26.5± 0.5	0.700	7.6±0.1	7.3±0.1	0.100	155.9± 2.6	165.5± 4.3	0.100	128.5± 4.1	147.7± 2.1	0.100	12.5±0.0 & 13.5±0.0	NONE	---	---	---
Total	99.3± 0.0	99.2± 0.2	0.600	---	---	---	973.5± 10.7	1035.3 ±18.8	0.100	---	---	---	---	---	---	---	---
Newport Green¹																	
Tobacco Rod	70.8± 0.7	71.1± 0.2	0.318	7.5±0.3	7.7±0.1	0.623	776.9± 31.5	834.7± 18.1	0.009	248.0± 19.6	255.7± 14.2	0.310	---	---	---	14.7	16.1
Filter	26.6± 0.2	26.6± 0.4	>0.999	7.7±0.1	7.5±0.2	0.156	157.7± 3.6	167.8± 3.0	0.004	128.7± 7.7	142.4± 10.3	0.093	NONE	12.8±0.3	---	---	---
Total	98.7± 0.3	98.9± 0.1	0.065	---	---	---	934.6± 32.3	1002.5 ±16.9	0.004	---	---	---	---	---	---	---	---
Newport Red²																	
Tobacco Rod	70.7± 0.6	71.3± 0.6	0.600	7.6±0.2	7.4±0.0	0.700	763.5± 9.4	802.7± 29.6	0.200	238.1± 12.1	259.5± 8.7	0.200	---	---	---	---	---
Filter	26.5± 0.0	26.7± 0.3	>0.999	7.6±0.0	7.6±0.2	0.800	157.7± 2.0	161.7± 0.9	0.100	130.6± 2.7	133.0± 6.0	>0.999	12.5±0.5	12.7±0.6	>0.999	12.8	17.0
Total	99.0± 0.0	99.0± 0.1	0.400	---	---	---	921.2± 8.4	964.4± 28.7	0.100	---	---	---	---	---	---	---	---

Newport EXP Mix Blue³																		
Tobacco Rod	71.3± 0.6	---	---	7.0±0.1	---	---	796.33 (±15.7 3)	---	---	291.91 (±10.4 9)	---	---	---	---	---	---	14.5	---
Filter	26.0± 0.0	---	---	7.4±0.1	---	---	155.3± 2.7	---	---	139.4± 3.3	---	---	12.0±0.0 & 13.0±0.0	---	---	---	---	---
Total	98.6± 0.3	---	---	---	---	---	951.6± 17.8	---	---	---	---	---	---	---	---	---	---	---
Newport EXP Max Green³																		
Tobacco Rod	71.3± 0.6	---	---	7.5±0.3	---	---	787.4± 36.9	---	---	248.2± 13.6	---	---	---	---	---	---	15.2	---
Filter	26.3± 0.3	---	---	7.4±0.2	---	---	149.7± 2.2	---	---	134.2± 7.9	---	---	NONE	---	---	---	---	---
Total	98.6± 0.2	---	---	---	---	---	937.1± 39.0	---	---	---	---	---	---	---	---	---	---	---
Camel Crush Silver																		
Tobacco Rod	54.8± 0.6	55.3± 0.3	0.400	7.5±0.3	7.7±0.1	0.400	665.3± 9.7	679.3± 1.5	0.100	277.0± 15.9	262.8± 7.6	0.400	---	---	---	---	15.7	15.1
Filter	26.2± 0.3	26.3± 0.3	>0.999	7.4±0.1	7.4±0.2	0.700	179.9± 4.4	174.4± 1.0	0.200	161.6± 7.2	154.9± 11.0	0.400	18.0±0.0	19.0±0.0	0.100	---	---	---
Total	82.6± 0.2	83.1± 0.2	0.100	---	---	---	845.2± 7.8	853.7± 2.1	0.400	---	---	---	---	---	---	---	---	---
Camel Crush Blue																		
Tobacco Rod	55.2± 0.3	55.2± 0.3	>0.999	7.2±0.1	7.5±0.2	0.200	656.5± 14.4	660.4± 14.8	>0.999	296.3± 9.4	272.8± 16.6	0.100	---	---	---	---	16.3	14.4
Filter	26.0± 0.0	26.3± 0.3	0.400	7.3±0.1	7.3±0.2	>0.999	177.9± 1.1	170.5± 7.7	0.200	165.5± 3.8	154.0± 10.9	0.100	18.0±0.0	18.5±0.0	0.100	---	---	---
Total	82.6± 0.0	83.0± 0.2	0.100	---	---	---	834.4± 14.5	830.9± 19.2	>0.999	---	---	---	---	---	---	---	---	---
Camel Crisp³																		
Tobacco Rod	58.8± 0.3	---	---	7.3±0.3	---	---	651.6± 21.9	---	---	265.0± 25.0	---	---	---	---	---	---	14.0	---
Filter	20.3± 0.3	---	---	7.4±0.0	---	---	111.8± 1.9	---	---	129.6± 3.4	---	---	NONE	---	---	---	---	---
Total	80.1± 0.1	---	---	---	---	---	763.3± 22.3	---	---	---	---	---	---	---	---	---	---	---

CA = California, NY = New York State | average ± standard deviation

Unless otherwise indicated, n=3

¹n=6²No implied cooling flavor. Both CA & NY descriptors are "non-menthol".

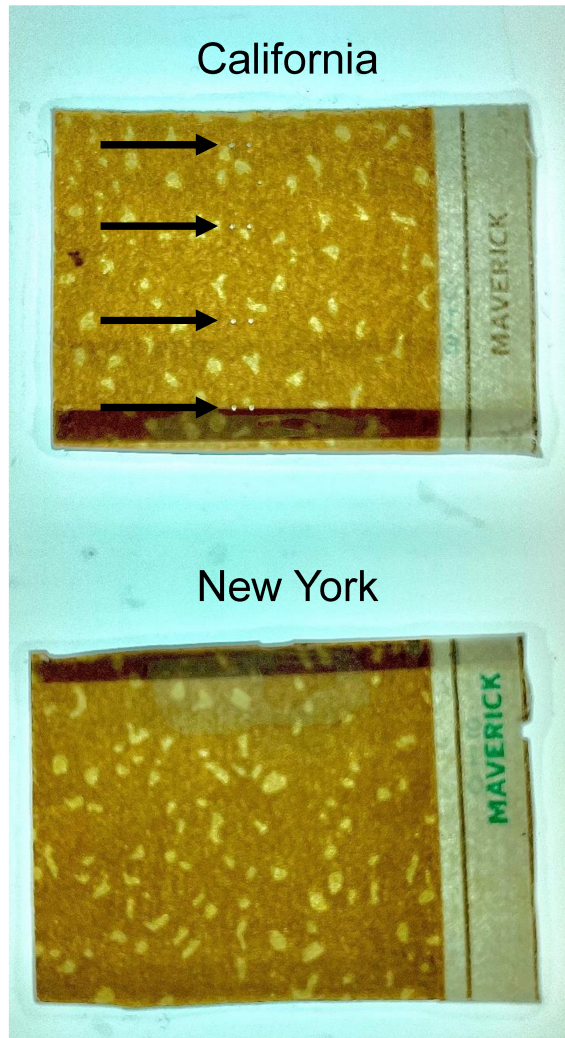
³No comparator product available in NY.

⁴Weight includes flavor capsule, which is embedded in the filter of Camel Crush cigarettes

⁵Vent holes were either not present (NONE), a single row, or two rows. Cigarettes with double vent holes rows are displayed starting with the distance closest to the mouth end, followed by the further set.

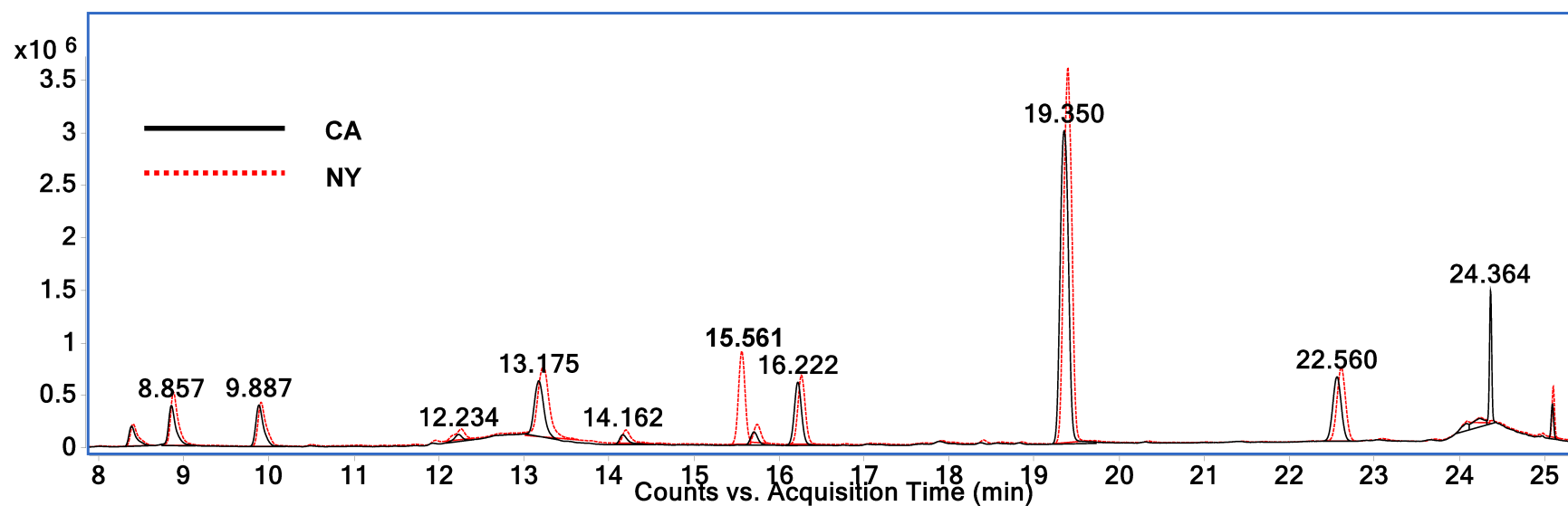
⁶per combined tobacco of 5 cigarettes. Measurements were taken once. Differences between moisture determined using Relative Percent Deviation (RPD) where **bold** indicates values which exceeds $\pm 20\%$ between CA and NY cigarettes. RPD calculated as the difference in values (CA – NY) divided by the average.

⁷Non-parametric Mann-Whitney comparisons. Statistical significance $p < 0.05$.

Supplemental Figure 2 – Ventilation Differences between Maverick Green Box Cigarettes Purchased in California and New York State

Black arrows indicate the location of ventilation holes. California Maverick green box cigarettes contained two rows of ventilation holes, while New York State equivalents did not contain any visible ventilation.

Supplemental Figure 3 – Chromatogram Overlays of Newport Green Box Cigarettes Purchased in California (CA) and New York State (NY)



Chromatogram narrowed to show first and last eluted chemical (8-25.5 min).

Menthol was detected in NY cigarette only (RT = 15.561) whereas WS-3 was detected in CA cigarette only (RT = 24.364). No other differences were observed.