Changes in tar yields and cigarette design in samples of Chinese cigarettes, 2009 and 2012

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ABSTRACT

Background China is home to the greatest number of smokers as well as the greatest number of smoking-related deaths. An active and growing market of cigarettes marketed as 'light' or 'low tar' may keep health-concerned smokers from quitting, wrongly believing that such brands are less harmful.

Objective This study sought to observe changes in cigarette design characteristics and reported tar, nicotine and carbon monoxide (TNCO) levels in a sample of cigarette brands obtained in seven Chinese cities from 2009 to 2012.

Methods Cigarettes were purchased and shipped to Roswell Park Cancer Institute, where 91 pairs of packs were selected for physical cigarette design characteristic testing and recording of TNCO values. Data analysis was conducted using SPSS, and was initially characterised using descriptive statistics, correlations and generalised estimating equations to observe changes in brand varieties over time.

Findings Reported TNCO values on packs saw mean tar, nicotine and CO levels decrease from 2009 to 2012 by 7.9%, 4.5% and 6.0%, respectively. Ventilation was the only cigarette design feature that significantly changed over time ($p<0.001$), with an increase of 31.7%. Significant predictors of tar and CO yield overall were ventilation and per-cigarette tobacco weight, while for nicotine tobacco moisture was also an independent predictor of yield.

Conclusions The use of ventilation to decrease TNCO emissions is misleading smokers to believe that they are smoking a 'light/low' tar cigarette that is healthier, and is potentially forestalling the quitting behaviours that would begin to reduce the health burden of tobacco in China, and so should be prohibited.

INTRODUCTION

Low-tar cigarettes are widely promoted throughout China via advertising and cigarette packs with prominently displayed tar values.[1] The State Tobacco Monopoly Administration (STMA) has also reduced maximum limits on International Organisation for Standardization (ISO) tar ratings over time, from 17 mg in 2001 to 15 mg in 2004, to 12 mg in 2011.[1] This has helped to promote 'low-tar' cigarettes as less dangerous.[2] Indeed, China lags in broad public awareness that cigarettes marketed as 'low tar/light' are not necessarily less hazardous.[3 4] The Global Adult Tobacco Survey (GATS) 2010 found that 86% of respondents thought that light/low-tar cigarettes were better for one's health compared to regular cigarettes.[5] Even those with more education, such as healthcare professionals and teachers, had high levels of misperception.[5]

Reduced tar and 'safer' cigarettes remain a priority for STMA. In 2009, over 3 billion Yuan (~US $490 million) was expended on 'low-tar' cigarette research and development.[1] However, independent research shows that smoking cigarettes with lower machine yields of tar (according to ISO machine measures) is not associated with lower levels of nicotine metabolites or total polycyclic aromatic hydrocarbons (PAHs) in Chinese smokers' urine.[2] This is consistent with a large body of literature in Western countries pointing to little benefit from low-tar cigarettes.[6] Reducing tar levels is typically achieved through cigarette engineering, changing features such as filter density, tipping paper length, filter ventilation levels and tobacco density.[6] Our research group has shown that UK manufacturers complied with a 2 mg reduction in the tar ceiling enacted in 2004 (from 12 to 10 mg) by increasing filter ventilation, while other facets of engineering remained essentially unchanged.[7] Typically, smokers of low-yield cigarettes can compensate for lowered yields of tar and nicotine by smoking more intensively (eg, more puffs, larger puffs, blocking filter vents, smoking more cigarettes).[8] Thus a disconnect exists between machine-measured yields and exposures among smokers.

Following on our earlier report on Chinese cigarette design features,[9] this paper presents data on the physical design characteristics of a variety of popular cigarette brands manufactured and sold in China in 2009 and 2012, coincident with Framework Convention on Tobacco Control (FCTC) implementation in China and a reduction in the tar limit from 15 to 12 mg.[10] Thus, our study design was capable of assessing which changes in cigarette design were associated with this lowering of the limits on tar ratings, comparable to our earlier work on UK cigarettes.[7] We sought to explore on which brands tar, nicotine and carbon monoxide yields (as reported on packages) declined and what changes in cigarette design might best explain those changes.

METHODS

The cigarettes analysed for this study were purchased at two time points (2009 and 2012) from seven cities: Beijing, Changsha, Kunming, Shanghai, Shenyang, Guangzhou and Yinchuan.[11] Field workers visited three large retail stores in each city and bought packs of cigarettes until every brand family and brand variety available in each year was purchased (total n=2,052; 2009, n=907; 2012, n=1145). The packs were shipped to the

Tobacco Research Laboratory at Roswell Park Cancer Institute (RPCI), where they were catalogued and stored unopened at −20°C until analysis. From this larger set we randomly selected 91 pairs of cigarettes based on Universal Product Code matching to measure tar and ventilation at 2009 and 2012. Before testing, in accordance with ISO 3402:1999, the packs were conditioned for a minimum of 48 h at 22±2.0°C and 60±2.0% relative humidity in an environmental chamber. Cigarette physical and design characteristics were assessed following previously published procedures by the same laboratory.[12–14] For a given brand, five cigarettes were selected randomly from each pack after conditioning for physical analysis and the data averaged. Digital callipers were used to measure the entire cigarette length, the tobacco rod length and diameter and the filter length and diameter. Filter weight measurements were made gravimetrically using a Mettler-Toledo analytical balance. The tipping paper was removed from each filter, and its length and the presence of any vent holes were performed using a light box and a transparent ruler. The tobacco moisture and tobacco weight were analysed using a halogen moisture analyser (HR83 or HB43-S, Mettler-Toledo, Columbus, Ohio, USA). The moisture content was determined as the per cent change in weight after heating the tobacco from five cigarettes with a halogen bulb at 125°C. Filter ventilation and pressure drop were measured using a KC-3 apparatus (Borgwaldt-KC, Richmond, Virginia, USA). The level of the paper porosity was measured using the vacuum method on a PPM1000M device (Cerulean, Milton Keynes, UK). Tar, nicotine and carbon monoxide yield values were obtained from the product packages. Analyses were conducted from January to March 2013.

Data analysis was conducted using Statistical Package for the Social Sciences V.21.0 (IBM, Armonk, New York, USA). The sample was initially characterised using descriptive statistics, and correlations of design characteristics were also analysed. Changes in brand varieties over time were assessed within-participants using generalised estimating equations (GEE). Models used a normal distribution with identity link function and exchangeable working correlation matrix unless otherwise noted.

Table 1 Average Chinese TNCO and cigarette design characteristics by year

	Year	N	Mean	SD	Minimum	Maximum
Tar	2009	99	11.87	2.09	5.00	15.00
	2012	98	10.93	2.09	5.00	15.00
Nicotine	2009	99	1.05	0.21	0.00	1.40
	2012	98	1.01	0.19	0.40	1.30
CO	2009	96	12.70	1.94	6.00	15.00
	2012	93	11.98	2.00	6.00	15.00
Cigarette length (mm)	2009	99	83.80	2.07	73.49	93.84
	2012	98	83.94	2.44	73.79	96.85
Per cigarette weight (g)	2009	99	0.66	0.07	0.45	0.98
	2012	98	0.65	0.05	0.49	0.76
Tobacco rod length (mm)	2009	99	59.48	3.64	49.68	68.59
	2012	98	59.57	3.17	53.76	68.48
Filter length (mm)	2009	91	23.69	3.55	15.70	29.84
	2012	85	24.12	3.06	18.67	29.96
Tipping paper (mm)	2009	99	30.58	2.78	23.95	36.49
	2012	98	30.90	2.86	23.84	36.76
Cigarette pressure drop	2009	94	110.94	12.76	72.50	146.30
	2012	93	109.08	13.34	59.80	144.90
Ventilation (%)	2009	94	8.28	10.43	0.00	48.00
	2012	93	10.91	11.35	0.00	46.90
Cigarette paper vacuum porosity	2009	93	54.97	10.17	28.47	81.49
	2012	93	54.96	9.17	33.58	78.32
Tobacco moisture (%)	2009	99	15.55	2.42	10.59	18.08
	2012	97	15.97	1.46	12.04	18.81
Rod density	2009	99	252.75	23.62	157.67	343.26
	2012	98	253.40	20.09	192.47	316.10
Filter density	2009	91	121.09	23.45	42.80	343.26
	2012	84	119.11	10.93	97.01	198.13
Overwrap (mm)	2009	91	6.81	2.22	2.55	13.34
	2012	85	6.57	1.86	3.61	11.42

N=99 for 2009 and N=98 for 2012. Deviations due to unlabelled TNCO values, multipart filters that do not conform with measurement protocols, products over or undersized for measurement equipment and equipment failures.
TNCO, tar, nicotine and carbon monoxide.

RESULTS

Tar and ventilation levels

We identified eight brands as having major design changes in the 2-year study period (see online supplementary Table S1). These included the addition of a two-part filter or a charcoal filter (examples in see online supplementary Figure S1A), or implementing filter patterning (see online supplementary Figure S1B). Huanghelou implemented a channelled filter design reminiscent of Barclay cigarettes, introduced in 1980 in the USA which has been shown to be particularly susceptible to blockage by the smoker in the normal course of puffing, yielding much greater tar delivery than its ISO tar rating.[15]

Tar, nicotine and carbon monoxide (TNCO) and cigarette design characteristics

Table 1 presents the design characteristics of Chinese cigarettes from 2009 and 2012. Between 2009 and 2012, mean ISO tar levels decreased by 7.9% (from 11.9 to 10.9 mg), nicotine levels decreased by 4.5% (from 1.1 to 1.0 mg), and CO levels decreased by 5.7% (from 12.7 to 12.0 mg). Mean ventilation levels increased substantially, by 31.7% (from 8.3% to 10.9%). Of the unventilated cigarettes in 2009, 4.4% became ventilated in 2012, while 2.2% of ventilated cigarettes in 2009 lost ventilation in 2012. Furthermore, 1.1% of charcoal-containing filtered cigarettes did not have charcoal filters in 2012, and 2.2% of non-charcoal containing filtered cigarettes became charcoal-filtered in 2012.

Correlations of cigarette design characteristics and TNCO

Correlations among cigarette design characteristics and tar, nicotine and CO can be found in online supplementary Table S2. Tar, nicotine and CO were significantly intercorrelated (all higher than 0.68). Additionally, ventilation had by far the strongest correlations with tar (−0.66), nicotine (−0.54) and CO (−0.74).

Generalised estimating equations of cigarette design characteristics by year

We next examined whether ventilation, tobacco weight, rod and filter density, tobacco moisture and pressure drop changed as a function of time (Table 2). Significant changes with time were found for only ventilation (B=2.33, S.E.=0.77, p=0.002), which increased between 2009 and 2012. If the analysis is limited to only those cigarette brands with a tar yield above 12 mg in 2009 (ie, those needing to reduce tar to comply), mean ventilation shows an increase, although not statistically significant (B=0.355; p=0.086).

Relationship of cigarette design features to reported TNCO yields

Stepwise GEE models with unstandardised β estimates were conducted for each of tar, nicotine and carbon monoxide. Year was the primary predictor. Ventilation was the first design feature

Table 2 Changes in various cigarette design features from 2009 to 2012

Variable	B	SE	Hypothesis test Wald χ^2	df	Significance
Ventilation*	2.33	0.77	9.178	1	0.002
Pressure drop	−1.52	1.37	1.223	1	0.269
Percent moisture	0.247	0.193	1.628	1	0.202
Filter density	−1.93	2.57	0.564	1	0.452
Rod density	0.27	2.61	0.010	1	0.918
Tobacco weight per cigarette	−0.01	0.006	2.556	1	0.110

*GEE with tweedie distribution (due to significant number of zero values) and log link function.
GEE, generalised estimating equations.

forced into the model because of its known association with TNCO, followed by tobacco weight, filter density, overwrap and tobacco moisture, based on their bivariate associations with TNCO (Table 3). For tar as well as nicotine, predictors were ventilation ($p<0.001$) and per cigarette tobacco weight ($p=0.020$ and $p=0.011$, respectively). Predictors of CO were also ventilation and per cigarette tobacco weight, as well as filter density. Other measured design features did not contribute significantly to the model.

DISCUSSION

O'Connor and colleagues demonstrated that the UK tobacco industry met the 2001 European Union (EU) regulatory standard of lowering yields to tar (10 mg), nicotine (1 mg) and CO (10 mg) by increasing filter ventilation.[8] The results of the present study, which examined changes in cigarette design characteristics and reported tar, nicotine and carbon monoxide levels in selected Chinese cigarette brands from 2009 and 2012, demonstrate that the Chinese tobacco industry met the 2011 requirement to reduce tar limits from 15 to 12 mg in a similar fashion. Cigarette ventilation, as expected, was the most important predictor of yields, and was the only design parameter that significantly changed (a 31.7% increase) from 2009 to 2012, replicating the results found in the UK in 2004.[16 17]

Table 3 Primary predictors of TNCO yields

Dependent variable	Parameter	B	SE	Hypothesis test Wald χ^2	df	Significance
Tar*	Year	−0.046	0.0113	16.986	1	<0.001
	Ventilation	−0.010	0.0015	46.037	1	<0.001
	Per cigarette tobacco weight	0.625	0.2694	5.383	1	0.020
Nicotine	Year	−0.029	0.0090	10.704	1	0.001
	Ventilation	−0.008	0.0012	42.441	1	<0.001
	Per cigarette tobacco weight	0.399	0.1572	6.459	1	0.011
CO*	Year	−0.029	0.0099	8.649	1	0.003
	Ventilation	−0.009	0.0011	66.476	1	<0.001
	Per cigarette tobacco weight	0.529	0.1900	7.742	1	0.005
	Filter density	−0.001	0.0003	5.690	1	0.017

*GEE with gamma distribution and log link function.
GEE, generalised estimating equations.
TNCO, tar, nicotine and carbon monoxide.

In addition, a subset of brands appear to be innovating in terms of filter design, employing filters with pictograms carved in the ends, channelled filters, dual filters and carbon filters. Future research will need to monitor such innovation as the Chinese market develops to determine if such products obtain significant market share. However, given the substantial evidence that increasing filter ventilation leads to no benefits in actual exposure and uptake, the public health consequences of the lowering of tar ratings in China are trivial if present at all. But in fact the publicity and marketing associated with China's increasing focus on lowering tar limits, coupled with the lack of real health benefits, portends a significant negative impact on public health because Chinese smokers are much more likely than smokers in other countries to believe that light/low-tar cigarettes are less harmful: 71% of Chinese smokers believe that light/low-tar cigarettes are less harmful,[4] which suggests that the Chinese industry's campaign of promoting such cigarettes will continue to appeal to the 300 million Chinese smokers who are likely to be increasing in their awareness of the harms of smoking and will wrongly see light/low-tar cigarettes as a way to reduce their risk.[1] As a result, Chinese smokers may well respond to increasing awareness of health harms of cigarettes by switching brands with lower tar levels rather than by quitting.

As in Western countries from the 1950s through the 1980s, when cigarette smoking was definitively linked to increased disease risks, the Chinese tobacco industry has responded to increasing health concerns around smoking by promoting cigarettes that delivered less tar in measurements made by machine smoking of cigarettes using a fixed pattern of smoking.[6 18–20] In the US, Canada and EU, research and court cases have demonstrated the fallaciousness of these products in terms of health benefit, and efforts have been made to counter market the products.[6 21–23] However, in the Chinese case, there are structural reasons for the continued marketing of low-tar cigarettes despite a large body of evidence that they will not reduce disease burden. Importantly, there are broader political considerations intertwined in the domestic tobacco trade, such as tax revenues, which have important impacts on tobacco control efforts.[24] The decision-making structure of the implementation of the FCTC remains in the hands of the Ministry of Industry, Innovation and Technology (MIIT), of which STMA/CNTC is a part. STMA has invested heavily in 'low-tar' cigarette research, one of their important research and development goals.

The current study is limited in several ways. While significant differences were seen between TNCO yields and cigarette ventilation over time, the ISO yields reported on the packs were not tested directly by our laboratory. So it is possible for discrepancies to exist between labelled and measured values. ISO yields are problematic themselves, as they are not representative of smoking behaviour or exposure.[6 19] Nonetheless, the consistency of findings with the existing literature is encouraging.

The promotion of light/low-tar cigarettes in China represents a significant barrier to reducing smoking in China, the most important preventable cause of death and disease in the world's largest country. China should not only ban misleading descriptors such as low tar, light as they already have, but also ban other misleading claims equating lower tar numbers with low harm or high technology. While removing misleading descriptors is helpful, it is not likely to lead to lasting reductions in misperceptions,[25] which appear to be driven in large part by filter ventilation.[13] As others have recommended, China should also remove TNCO numbers from the pack, as they are irrelevant indicators of human health risk. Otherwise, continued promotion of misperceptions about low-tar cigarettes, coupled with

China's limited implementation of other FCTC recommended policies on taxation, smoke-free spaces and health warning labels, will likely prolong the tobacco epidemic.

What this paper adds

- ▶ The marketing of 'light' and 'low tar' cigarettes in China has resulted in consumer misperceptions of their harmful effects. These lower International Organization for Standardisation (ISO) tar yields can be attributed to design features, such as filter ventilation.
- ▶ We found that across 4 years, to comply with reduced ISO tar ceilings, Chinese cigarette manufacturers increased ventilation to reduce tar levels.
- ▶ Misleading descriptors and ISO yields should be removed from the pack to help address consumer misperceptions.

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Contributors RJO and GTF conceived the study. LMS, BAZ and RVC led data analysis. QL and JY contributed to data collection. All authors contributed to data interpretation and manuscript preparation.

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Competing interests None declared.

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Supplemental Table 1: **Tar and Ventilation Levels of Chinese Cigarette Brands in 2009 and 2012**

UPC	Brand Name	2009		2012	
		Tar (mg)	Ventilated	Tar (mg)	Ventilated
6901028000642	Shuangxi	13	Yes	12	Yes
6901028000987	Shuangxi	13	Yes	12	Yes
6901028001465	Shuangxi	13	Yes	12	Yes
6901028001618	Shuang Xi	11	Yes	10	Yes
6901028002097	Cocopalm	13	Yes	12	Yes
6901028002752	Cocopalm	13	Yes	12	Yes
6901028011075	Jiatianxia	13	Yes	13	Yes
6901028015417	Zhenlong	13	Yes	12	Yes
6901028024969	The X Catena Pride	8	Yes	8	No
6901028024990	Pride	13	Yes	12	Yes
6901028025812	Pride	6	Yes	8	Yes
6901028028356	Tianxiaxiu	14	Yes	14	Yes
6901028036672	Huang Guoshu	13	Yes	13	Yes
6901028036795	Huang Guo Shu	13	Yes	12	Yes
6901028037891	Huangguoshu	12	Yes	12	Yes
6901028045483	Camellia	13	Yes	12	No
6901028048231	Hongtashan	12	Yes	12	Yes
6901028055055	Honghe	12	Yes	13	Yes
6901028055086	Honghe	12	Yes	12	Yes
6901028055208	Honghe	12	Yes	12	Yes
6901028065078	Lan zhou	13	Yes	8	Yes
6901028065399	Lan zhou	13	Yes	8	Yes
6901028065580	Lan zhou	11	Yes	8	Yes
6901028071468	Zhongnanhai	5	Yes	5	Yes
6901028071499	Zhongnanhai	8	Yes	8	Yes
6901028071529	Zhongnanhai	5	No	5	No
6901028071765	Zhongnanhai	8	Yes	8	Yes
6901028072458	Beijing	12	Yes	12	Yes
6901028072601	Zhongnanhai	13	Yes	12	Yes
6901028075763	Chunghwa	13	Yes	12	Yes
6901028075770	Chunghwa	13	Yes	12	Yes
6901028075831	Double Happiness	8	Yes	8	Yes
6901028075992	Double Happiness	12	Yes	12	Yes
6901028076333	Memphis Blue	9	Yes	9	Yes
6901028090902	Renmin Dahuitang Ben Xiang	10	No	10	Yes
6901028092944	Renmin Dahuitang	13	Yes	12	Yes

Supplementary Files

Supplemental Table 1: **Tar and Ventilation Levels of Chinese Cigarette Brands in 2009 and 2012**

UPC	Brand Name	2009		2012	
6901028093187	Renmin Dahuitang	14	Yes	13	Yes
6901028095884	Huang Guo Shu	13	Yes	12	Yes
6901028099776	Chang Baishan	5	Yes	5	Yes
6901028112772	Nanjing	12	Yes	12	Yes
6901028114448	Suyan	15	Yes	12	Yes
6901028115292	Yi Pin Mei	12	Yes	11	Yes
6901028118170	Liqun	13	No	12	Yes
6901028124027	Huang Shan	12	Yes	12	Yes
6901028132268	Derby	12	Yes	12	Yes
6901028133470	Jinsheng	14	Yes	11	Yes
6901028137287	Septwolves	13	Yes	12	Yes
6901028137683	Septwolves	13	No	12	Yes
6901028138154	Marlboro	12	Yes	12	Yes
6901028138291	Marlboro	8	Yes	8	Yes
6901028138352	Septwolves	13	Yes	12	Yes
6901028150255	Taishan	12	Yes	12	Yes
6901028150361	Taishan	8	Yes	8	Yes
6901028162104	Dihao	13	Yes	13	No
6901028179423	Hongjinlong	14	No	14	No
6901028179652	Huanghelou	12	Yes	12	Yes
6901028180177	Hongjinlong	15	Yes	10	Yes
6901028180399	Hongjinlong	13	Yes	11	Yes
6901028180498	Hongjinlong	12	Yes	10	Yes
6901028184120	Huanghelou	12	Yes	8	Yes
6901028185394	Huanghelou	10	Yes	8	Yes
6901028185424	Huanghelou	12	Yes	8	Yes
6901028191029	Baisha	13	Yes	12	Yes
6901028191043	Baisha	13	No	12	Yes
6901028193498	Furongwang	15	Yes	12	Yes
6901028193818	Mellow Furong	12	Yes	12	Yes
6901028193856	Furongwang	12	Yes	12	No
6901028193917	Furongwang	10	No	8	No
6901028194594	Furongwang Starry Cerulean Sky	11	No	11	No
6901028195638	Marlboro	12	Yes	12	Yes
6901028195669	Marlboro	8	Yes	8	Yes
6901028196222	Baisha	13	Yes	12	Yes
6901028196499	Baisha	13	Yes	11	Yes
6901028196956	Harmonization	12	No	12	No

Supplementary Files

Supplemental Table 1: Tar and Ventilation Levels of Chinese Cigarette Brands in 2009 and 2012					
UPC	**Brand Name**	**2009**		**2012**	
6901028199414	Furong	12	Yes	11	Yes
6901028207874	Xiongshi	11	Yes	11	Yes
6901028208802	Huang Shan	13	Yes	12	Yes
6901028225601	Huang Shan Sinicism	12	Yes	12	Yes
6901028301718	Dafengshou	13	Yes	11	Yes
6901028309226	Nation	15	No	15	No
6901028310611	Yun Yan	12	Yes	12	Yes
6901028314169	Hongtashan	12	Yes	12	Yes
6901028314626	Hong Mei	13	Yes	12	Yes
6901028315005	Hongtashan	13	Yes	12	Yes
6901028315524	Yuxi	10	Yes	10	Yes
6901028315555	Hongtashan	10	Yes	10	No
6901028316989	Yuxi	12	Yes	12	Yes
6901028317122	Yuxi	12	No	12	Yes
6901028345750	Dahongying	15	Yes	15	Yes
6901028936132	Haomao	12	No	12	No

Supplementary Files

Supplemental Figure 1. Filter Design Innovations, China, 2012

Supplemental Figure 1A) Two part filters

i. ii. iii.

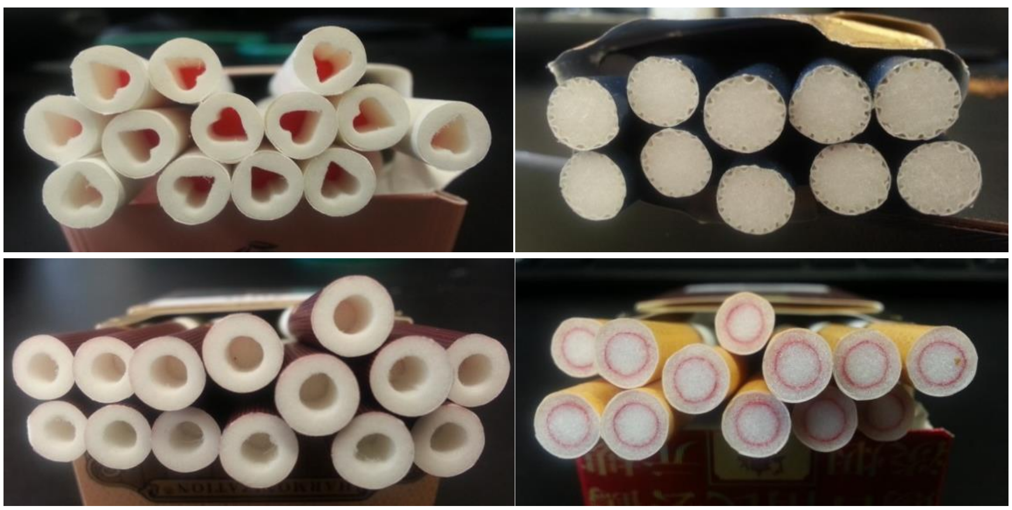
i. Green dalmatian filter found in Yuxi brand.

ii. Rainbow dalmatian filter found Eight 8mg brand.

iii. Plain two part filters in some Huanghelou cigarettes.

Supplemental Figure 1B) Filter end designs

i.) La Rose ii.) Huanghelou



iii.) Furongwang iv.) Harmonization

Supplementary Files

Supplemental Table 2: Pearson Correlations Among Chinese Cigarette Design Characteristics

	Tar	Nicotine	CO	Cigarette Length	Tipping Length	Tobacco Rod Length	Filter Length	Tobacco Moisture (%)	Paper Vacuum Porosity	Paper Pressure Porosity	Cigarette Pressure Drop	Ventilation	Per Cigarette Weight	Rod Density
Tar	1	.860**	.852**	-.234**	-.332**	.202**	-.455**	-.224**	-.094	-.119	.254**	-.664**	.366**	.162*
Nicotine	.860**	1	.716**	-.234**	-.178*	.045	-.249**	-.365**	.004	-.009	.111	-.610**	.284**	.221**
CO	.852**	.716**	1	-.173*	-.364**	.284**	-.522**	-.184*	-.167*	-.189*	.328**	-.744**	.290**	.065
Cigarette Length	-.234**	-.234**	-.173*	1	.210**	.417**	.207**	.090	.210**	.211**	.062	-.078	-.198**	-.174*
Tipping Length	-.332**	-.178*	-.364**	.210**	1	-.592**	.788**	-.196**	.160*	.173*	-.277**	.133	-.276**	.184**
Tobacco Rod Length	.202**	.045	.284**	.417**	-.592**	1	-.780**	.169*	-.093	-.104	.112	-.198**	.225**	-.274**
Filter Length	-.455**	-.249**	-.522**	.207**	.788**	-.780**	1	-.153*	.244**	.263**	-.115	.253**	-.374**	.199**
Tobacco Moisture (%)	-.224**	-.365**	-.184*	.090	-.196**	.169*	-.153*	1	.032	.025	-.054	.157*	-.027	-.111
Paper Vacuum Porosity	-.094	.004	-.167*	.210**	.160*	-.093	.244**	.032	1	.990**	.047	.043	-.188*	-.045
Paper Pressure Porosity	-.119	-.009	-.189*	.211**	.173*	-.104	.263**	.025	.990**	1	.038	.041	-.214**	-.054
Cigarette Pressure Drop	.254**	.111	.328**	.062	-.277**	.112	-.115	-.054	.047	.038	1	-.372**	.133	-.010
Ventilation	-.664**	-.610**	-.744**	-.078	.133	-.198**	.253**	.157*	.043	.041	-.372**	1	-.068	.044
Per Cigarette Weight	.366**	.284**	.290**	-.198**	-.276**	.225**	-.374**	-.027	-.188*	-.214**	.133	-.068	1	.666**
Rod Density	.162*	.221**	.065	-.174*	.184**	-.274**	.199**	-.111	-.045	-.054	-.010	.044	.666**	1
Overwrap	.229**	.148*	.256**	-.096	.099	.394**	-.534**	-.042	-.219**	-.228**	-.189*	-.133	.261**	-.025

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).