ANALYSIS OF FRENCH CIGARETTES MARKET: NOTIFICATIONS, PHYSICAL CHARACTERISTICS OF CIGARETTES AND CO, NICOTINE AND TAR EMISSIONS

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ABSTRACT

Up until now some authors have examined the physical characteristics of cigarettes and the possible correlations between tar, nicotine and CO emissions, by taking a sample of a market. No complete analysis of the cigarettes of a market and their characteristics has been performed so far. This work analyzes the physical characteristics of cigarettes, tar, nicotine and CO emissions, and their probable correlations. More specifically, all types of cigarettes notified to the French market during the period 2016-2019 are analyzed. Their physical characteristics regarding pack type, number of cigarettes per pack, dimension (cigarette length, filter length and diameter and their ratios), weight (tobacco and cigarette weight) and the ratios weight/dimensions are analyzed and the average values of each parameter, as well as the standard deviation of these values and the evolution in time is presented. The emissions of tar, nicotine and CO are also analyzed, and the probable correlations between them and the physical characteristics of cigarettes are examined. This analysis shows that there is a limited number of distinct values for length, diameter, weigh and emissions. The evolution in time is quite limited. Some dimensions and weights are related to each other. Emissions are related to each other, but not to the physical characteristics of cigarettes.

KEYWORDS

Advertising and Promotion, Carcinogens, Economics, Nicotine, Tobacco Industry

1. INTRODUCTION

In 2019, tobacco sales reached 808,438 million USD worldwide. The largest markets were those of China (234,604 million USD), USA (115,155 million USD) and Germany (31,702 million USD). Also, the French tobacco market (22,383 million USD) is among the biggest in the world[9]. In tobacco market, there are many firms and products. The main product is cigarette, which occupies more than 90% of the total market[10]. According to the European Tobacco Products Directive (2014/40/EU)[3], every tobacco manufacturer or importer should declare the physical characteristics (length, diameter, weight etc.) and the chemical composition of the notified products or their emissions (tar, nicotine, CO etc.) in order to be controlled better by the European Union.

Previous works shown that the smoke emissions (tar, nicotine, CO) are influenced by the ventilation[8,11], or by the tobacco weight and tobacco circumference[2,7,8,11,12]. Other authors report that products with different characteristics (length, diameter, color or design) may have different perception to the users[4]. Few works analyzed the physical

characteristics of different brands in different markets. Some researchers in China compared the tobacco market between 2009 and 2012[8], while others compared the cigarette characteristics as a function of income of different countries [13]. Nevertheless, the results of these may not be representative of the entire market, due to the fact that these works are focused on a small part of the market. Taking into account the previous literature search, there is no complete analysis of all cigarette brands and cigarette type of a market. A complete analysis of the products of a market and their characteristics may clear better the market trends. Specifically, producers-competitors can better position their products, the authorities can set and apply regulations and consumers can compare the available products. Analyses like this are performed in other cases, such as in European automotive market [13-15], or in Chinese wine industry [5].

In this work, we perform a complete analysis of all cigarettes notified in French market from 2016 to 2019 using the data extracted from EU-CEG. Firstly, it is focused on the analysis of the physical characteristics of cigarettes and the correlations between them. Secondly, on the emissions (tar, nicotine, CO) and the correlations between them and, finally, the correlations between the physical characteristics of cigarette and their emissions. Another important factor in cigarette design is the filter and paper ventilation[8,11]. This parameter has an impact on cigarette emissions and will be analyzed in an upcoming work.

2. METHODOLOGY

The files published from the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) on its internet site [1] was used for this work. These files contain the public data of the cigarettes notified from 08/11/2016 to 27/08/2019. The cigarettes files contain the following data: country (FR in this case), product category, product type, reference code, firm name, product name,

filter or not product, number per box, box type, number of product, date of notification, last updated, product launch date, product length, product diameter, product weight, tobacco weight, filter length, filter ventilation, pressure drop with closed vents, pressure drop with open vents, tar emission, nicotine emission, CO emission. The data contained in these files were used without any involvement of ANSES in this work. It should be noticed that the files published by ANSES show only the notifications without the sales of each product. Thus, the current work is based only on notifications without taking into consideration the sales of each product.

This work analyzes initially the total number of notifications per year, the pack type and the number of cigarettes per pack. Then, the following dimensions of the notified cigarettes are analyzed: cigarette length, filter length, cigarette diameter and the ratios cigarette diameter/cigarette length and filter length/cigarette length. Next, the characteristics concerning weight are presented: cigarette weight, tobacco weight and the ratios tobacco weight/cigarette weight, cigarette weight/cigarette length and tobacco weight/cigarette diameter. At the end, tar, nicotine and CO emissions and their probable correlations with the previous characteristics are analyzed.

3. RESULTS AND DISCUSSION

The file, published from ANSESL, contains 425 cigarettes notifications in 2016, 856 in 2017, 530 in 2018 and 589 in2019. Totally 2,400 cigarettes were notified during 2016- 2019.

3.1 Pack type and number of cigarettes

Eleven different pack types are found in French cigarette market. 88.29% of the cigarettes is one type (flip top box, square corner), 3.34% concern flip top pack and 2.34% soft pack. Also, a small number of these cigarettes are commercialized in another pack type, but other two do not have any declaration of pack type. About the number of cigarettes per pack, there are packs included 20, 25, 30, 35 and 40. Most

of them have 20 cigarettes per pack, however, there was a decrease from 86.1% (2016) to 66.4% (2019). The packets of 25, 30, 35 and 40 cigarettes represent a small percentage, but the number of 30 cigarettes packs increased from 7.6% (2016) to 22.1% (2019). All the above data show that there is a shift of the market to packs containing more cigarettes than 20.

3.2 Dimension

3.2.1 Cigarette length

Fourteen different distinct cigarette lengths are recorded. 68.0% of the cigarettes notifications have length, 83mm, 10.2% have 99mm and 9.17% 84mm. Although, there is a small number of notifications with different cigarette length and other two do not have any declaration of cigarette length. The average cigarette length of all notification in French market is 86.03mm (±7.16mm SD, 8.33% RSD). The mean cigarette length remains quite constant from 2016 to 2019, as the mean average of each year differs less than ±1.53% of the 4 years mean value. Previous studies (using only some cigarette products) reported that the average length for the high income countries is 84.53mm[7].

3.2.2 Filter length

Nine distinct filter lengths are detected. The most common filter lengths are 27mm and 21mm. 45.89% of the cigarette notifications have 27mm, while 35.16% have 21mm. Also, 7.77% and 7.43% have filter length 22mm and 30mm respectively. However, there is a small percentage of the notifications (0.92%) with no filter and other five notifications have no declaration of filter length. The average filter length of all notifications is 24.32mm (±3.53mm SD, 14.52% RSD). The mean filter length remains quite constant during the 4 years studied, as the mean average of each year differs less than ±5.3% of the all years mean value. An average length of 22.61mm for the high income countries has been reported by previous studies, using only some products[7].

3.2.3 Cigarette diameter

Sixteen distinct cigarette diameters are found in notified cigarettes. 51% of the cigarette notifications have diameter 7.8mm, which is the most common. 85.7% have diameter from 7.79mm to 7.83mm. 9.8% have from 5.40mm to 6.10mm (called 'slim' cigarettes). Although, the other diameters correspond to a very low percentage and other two have no diameter number reported. The average diameter of all notifications is 7.56mm (±0.99mm SD, 13.05% RSD). The mean diameter remains quite constant during the 4 years studied, as the mean average of each year differs less than ±3.1% of the all years mean value. An average diameter of 7.64mm for the high income countries has been reported by previous studies, using only some products[7].

3.2.3 Ratios Cigarette diameter/ cigarette length- Filter length/ cigarette length

For each cigarette, the ratios cigarette diameter/ cigarette length and filter length/ cigarette length are calculated. The average value of the first ratio is 0.089 (±0.017 SD, 18.98% RSD) and of the second ratio is 0.282 (±0.032 SD, 11.40% RSD). The mean values of those ratios remain quite constant from 2016 to 2019, as the mean value of each year differs less than ±4.1% and ±3.0% respectively of the 4 years mean value.
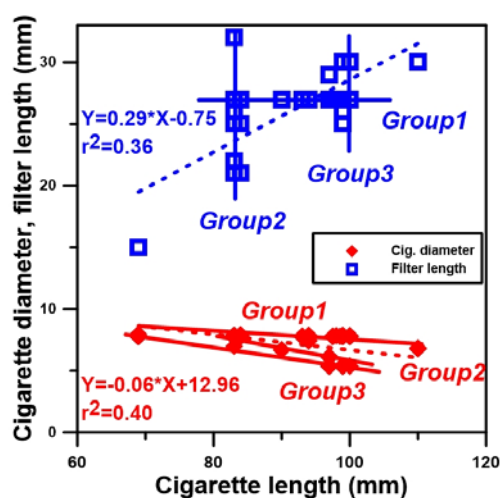

Figure 1. Cigarette diameter (in red) and filter length (in blue) versus cigarette length.

Figure 1 shows that three groups of cigarettes can be formed in each case. On the lower area

of the diagram, the first group (Group 1) contains cigarettes of a constant diameter of about 7.8mm, but the other two groups (Group 2, Group 3) show a decreased trend, as the length increases. On the upper area of the diagram, the first group (Group 1) includes cigarettes that filter length is constantly 24mm as the cigarette length increases, but the other two groups (Group 2, Group 3) have constant cigarette lengths of about 85mm and 100mm respectively, independently of the filter length. Also, there are two points, one of a very low cigarette and filter lengths (69mm-15mm) and one of very high cigarette and filter lengths (110mm-32mm). All the cigarettes without filter have the same length 69mm.

3.3 Weight

3.3.1 Tobacco weight

The average tobacco weight of all notified cigarettes is 582.51mg (±111.32mg SD, 19.11% RSD). As it is shown in Figure 2, tobacco weight presents a quite broad scattering, as 227 different weight are notified. 3.2% of all notifications have tobacco weight 605mg, while other 27 weight values have more than 1%. However, two main areas can be retrieved. One at 500-800mg ('normal' cigarettes), which is divided in two sub-areas: i) 510-610mg (58.8% of all) and ii) 613- 936mg (32.3% of all) and one around 340- 495mg ('light' cigarettes, 8.9% of all). The mean tobacco weight remains quite constant during the 4 years studied, as the mean average of each year differs less than ±2.05% of the all years mean value. An average tobacco weight of 650mg for the high income countries has been reported by previous studies, using only some products[7] .

3.3.2 Cigarette weight

The average cigarette weight of all notified cigarettes is 825.46mg (±120.84mg SD, 14.64% RSD). Cigarette weight presents a quite broad scattering, as 314 different weight are notified (Figure 2). 8.17% of all notifications have cigarette weight 809mg, while other 16 weight values correspond more than 1% of the notifications each. However, three main areas can be retrieved. One at 500-666mg ('light' cigarettes) containing the 10.26% of the total notifications, one from 714 to 950mg corresponding to 70.65% of all and one from

950 to 1131mg ('heavier' cigarettes) corresponding to 10.09%. The average tobacco weight remains quite constant during the 4 years studied, as the mean average of each year differs less than ±2.0% of the all years mean value.
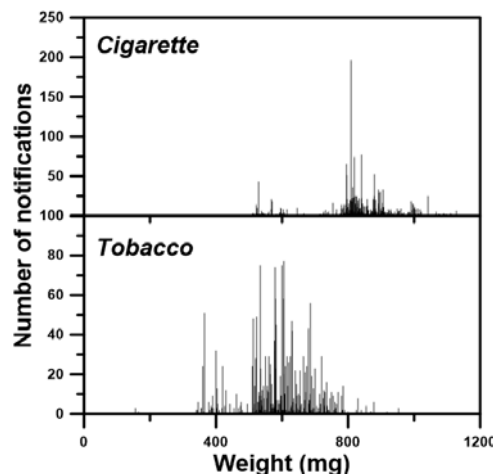

Figure 2. Number of notifications per cigarette weight and tobacco weight.

3.3.3 Ratio Tobacco weight/ Cigarette weight

As expected, there is a linear correlation between tobacco weight and cigarette weight. The equation y=0.78x-56.32 (r^2=0.80) indicates that the average filter and paper weight is around 56mg.

3.3.4 Cigarette weight versus Cigarette length and Tobacco weight versus Net cigarette length

The correlation between cigarette weight and cigarette length is searched in two cases: the first one is the correlation between total cigarette weight and total cigarette length and the second is the correlation between tobacco weight and net cigarette length (without filter) (Figure3). Figure 3 shows that there is a general increased trend weight with length, in both cases. Although, a closer analysis indicates that there are several distinct lengths with broad range of weight values. Some of these cases are shown in Figure 3 with vertical lines. The 'light' cigarettes form a separate cluster of points at the bottom of each figure.
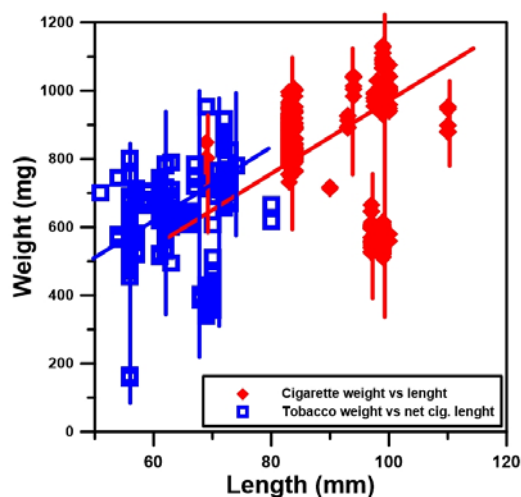
Figure 3 Cigarette weight versus cigarette length and tobacco weight versus net cigarette length.

3.3.4 Cigarette and Tobacco weight versus Cigarette diameter

The correlation between cigarette and tobacco weight and cigarette diameter is also searched (Figure 4).
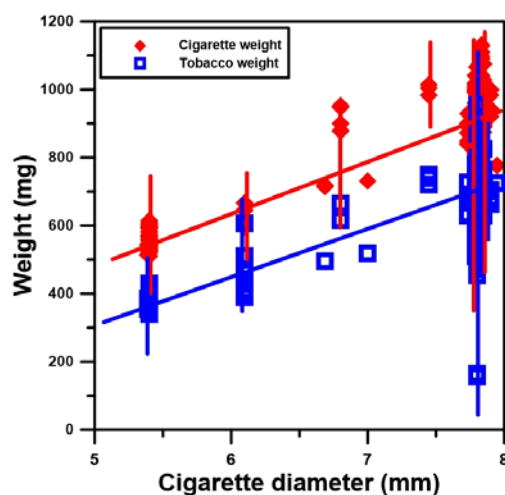

Figure 4. Cigarette and tobacco weight per cigarette diameter.

According to the Figure 4, there is a general increased trend of both cigarette and tobacco weight with diameter. Also, several fixed diameters have a very large range of weight, despite the fact that cigarette diameter has only a small number of distinctive values. The "light" cigarettes form a separate cluster of points at the left bottom of each group of points.

3.4 Emissions

The analysis of cigarettes regulated emissions: tar, nicotine and CO (pollutants) is recorded.

Directive 2014/40/EU sets a limit of 10mg for tar and CO 1mg for nicotine. For each one of these emissions, there are some values exceeding the legislative limits. Tar: 10.1mg (2 notifications), 10.2 (2), 10.4 (6), 10.6 (2), 10.6 (37), 11.1 (4); Nicotine: 5 (2), 6 (3), 7 (3) and CO: 10.2 (2), 10.4 (2), 10.7 (4), 11 (4). All these values are excluded, due to the fact that these may be not real or error in notification.

3.4.1 Tar, nicotine and CO emissions

Tar, nicotine and CO emissions are notified in a quite low number of distinct values: 25 in the case of tar, 26 in the case of nicotine and 24 in the case of CO. Six, three and four of these values respectively are excluded from the following figures as being higher than the respective legislative limits. For all the pollutants, only three values occupy the 75-80% of all notifications, while one occupying the 35-50% of them (Figure 5). About tar, these three values are: 10mg (50.1%), 7mg (15.8%) and 8mg (12.8%). In the case of nicotine: 0.8mg (35.6%), 0.6mg (21%) and 0.7mg (18.6%). About CO: 10mg (47.33%), 9mg (19.77%) and 8mg (42%). It is clear that the majority of the notified cigarettes are near the upper legislative limit of the three pollutants or close to that. The average tar emission value is 8.43mg (±2.30mg SD, 27.30% RSD), while the average nicotine emissions is 0.70mg (±0.52mg SD, 74.9% RSD) and the average CO emissions value is 8.63mg (±2.38mg SD, 27.59% RSD). %. The values of tar and CO emissions are quite concentrated near the average value, but those of nicotine are more dispersed. For all three pollutants, the mean values remain quite constant during the 4 years studied here, as the mean value of each year differs less than 6.5%, 3.6% and 7.2% for tar, nicotine and CO emissions values respectively of the all years mean value.
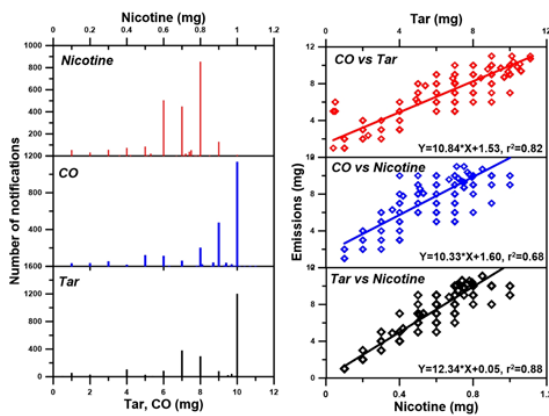
Figure 5. Nicotine, CO and tar emissions per number of notifications and correlations of CO versus tar and nicotine and tar versus nicotine emissions.

3.4.2 Correlations between tar, nicotine and CO emissions

According to Figure 5, there is a general linear relationship for the three combinations (CO vs tar- CO, tar vs nicotine), indicating that each cigarette has high or low emissions for the three pollutants.

3.4.3 Correlations between emissions, and physical characteristics of cigarettes

Previous search indicates that tobacco weight or other physical characteristics have an impact on the three pollutants[2,6,8,11,12]. To confirm these, the three pollutants are correlated with cigarette and filter length, tobacco and cigarette weight and cigarette diameter in three steps.

In the first step, all points are used. No correlation between the above parameters is shown. In the second step, three different ventilation values are used: 26% (low ventilation), 58% (medium ventilation) and 73% (high ventilation). Filter ventilation, as main parameter, influences these emissions[8,11]. The corresponding numbers of points are 170, 33 and 38 respectively. No correlation is found. In the third step, for each one of the above ventilation values, all parameters are kept constant, except of one each time, for example only filter length varies with constant diameter, weight, etc. In this case, there are always very few points. Again, no correlation is found. The above results show that no correlation between tar, nicotine and CO emissions with cigarette or filter length,

tobacco or cigarette weight exist and tobacco companies adjust these emissions by adjusting multiple parameters each time. Previous authors indicate the existence of some correlations, but these works are based only in some products and not on an entire market.

4. CONCLUSIONS

A complete analysis of the 2,400 cigarettes notified in the French market during 2016-2019, concerning the physical characteristics of the cigarettes, tar, nicotine and CO emissions and their correlations is performed. From the eleven different pack types found, only one concerns the 90% of the notifications. The majority of the notifications concerns packs with 20 cigarettes; however with a constant decrease, while the percentage of 30 cigarettes packs increases.

Low (9-16) distinct values for cigarette and filter lengths and diameters were notified. Very few (3-4) values of these parameters correspond to the 90% of the notifications, giving a low dispersion of these parameters. One tenth of the notifications corresponds to the so-called "slim" cigarettes. The average cigarette length of all notifications is 86.03mm, that of the filter 24.32mm and the average diameter 7.56mm. All cigarettes without filter have the same length of 69mm. The mean values of these three parameters remain quite constant during the 4 years studied here.

The relation between cigarette diameter and filter length versus cigarette length show a general linear relationship between the filter length and cigarette length. However, a group of cigarettes with a constant diameter and filter length, independently of the cigarette length can be found. Other two groups show a decreased trend of diameter with cigarette length or constant cigarette lengths independently of the filter length.

Tobacco and cigarette weight values show a quite broad scattering, as 227 and 314 different weights are notified respectively. The average tobacco and cigarette weight is 582.51 and 825.46mg respectively, with a quite low

dispersion. No distinct value occupies a significant part of the values notified and the 'light' cigarettes correspond to about 10% of the notifications. The mean tobacco and cigarette weight remain quite constant during the 4 years studied here. There is a quite good linear correlation between tobacco weight and cigarette weight. There is a general increased trend of weight with length and diameter, but with several distinct lengths or diameters with broad range of weight values.

tar, nicotine and CO emissions are notified in about 25 distinct values. For all three pollutants, only three values occupy the 75-80% of the total notifications. The majority of products are notified near the upper legislative limit. The average tar, nicotine and CO emission value is 8.43, 6.99 and 8.63mg. The values of tar and CO emissions are quite concentrated near the average value, but those of nicotine are more dispersed. For all three pollutants, the mean values remain quite constant during the 4 years studied here. Each cigarette has high or low emissions for the three pollutants.

Some works, studying a limited number of products, indicate that tobacco weight or other physical characteristics have an impact on tar, nicotine or CO emission. However, taking into consideration the entire market, no correlation between tar, nicotine and CO emissions with cigarette or filter length, tobacco or cigarette weight can be found.

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