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Investigation on the Controlling Matters Variation in Cigarette Smoke

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Abstract

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The legislative norms introduction for controlling in cigarette smoke matters content – nicotine, tars and carbon monoxide (CO) puts the necessity for determining permissible limits of its variation. The aim of present investigation is determination variation (permissible limits) of controlling components (nicotine, tars and CO) in cigarette smoke and its comparison with these found in some cigarette trade brands and standard norms. The methodical approach for determination investigated matters variation is based on investigation cigarettes produced of the same tobacco (mono cigarettes) with three levels nicotine - low, middle and high, with the same materials and physical properties i.e. in conditions in which the method accuracy or other accidental objective and subjective factors can influence on smoke composition. The chemical composition is determined of the chosen tobacco according to known routine methods. The obtained results are processed variation statistical. The availability of definite functional dependences is checked between controlling components of tobacco smoke (nicotine, tars and CO) and correlation coefficients between them. The values should use for assessment permissible variation of smoke matters over normative levels for different cigarette brands: for nicotine – 0.1 mg/cig, for tars – 1 mg/cig and for carbon monoxide – 2 mg/cig. The determined deviations in controlling matters content in tobacco smoke are lower for cigarettes with relative lower smoke matters content and higher for these with high.

Key words: cigarettes, cigarette smoke, nicotine, tars, carbon monoxide (CO), cigarette brands, standard norms, functional dependences, correlation coefficients

Introduction

The legislative norms introduction for controlling matters content – nicotine, tars and carbon monoxide (CO) puts the necessity for determining permissible limits of its variation in cigarette smoke. It is necessary with a view to control of the normative and reported values of different cigarette brands producers.

It is known that, in the control of these matters content in smoke its variation depends on the accuracy determination method in the first place which is regulated in the relevant standards. The significant number factors connected to production process influence on smoke composition at the same time. The variation of the tobacco smoke composition most frequently is due to no observing blend's recipe composition and/or no standardization of the components (tobacco). The variation (changeability) indexes of auxiliary materials (cigarette papers, filters) and mostly filter ventilation have substantial influence similarly. It should be notice observance parameters of the technological processes and different cigarettes physical indexes not in last place. All these factors have significance for supporting tobacco smoke composition and consumer (smoke) qualities constancy.

The investigations of different authors are dedicated to determination tobacco smoke composition and its variation under influence of different factors (Browne, 1990; Davids and Nielsen, 1999; Popova and Georgiev, 1998). The main precursors of matters determining tars content in tobacco smoke are found, mainly lipid complex and potassium and these matters production depending on tobacco blend composition (Piriou, 1993; Popova, 2000).

The variation, prognostication and control of controlling matters content in cigarette smoke have been subject of a number of investigations (Norman, 1998; Piriou, 1993; Popova, 2000; Stoilova, 2006). The results of these investigations have been reason for normative limits determination permissible for these matters content in cigarette trade brands.

The different methods for control, the taking average samples as the conditions for test implementation are regulated in different standards of ISO and BSS (Bulgarian State Standards).

The permissible variations compared to normative indexes for standardization must not pass ± 1mg/cig for condensate and ± 0.1 mg/cig for nicotine according to BSS ISO 8243.

The legislative norms are passed for controlling components content in tobacco products and are regulated in different normative documents in the most countries USA, Canada and European Union countries. This put the necessity of strict control for deviation determination over permissible norms in nicotine; tars and CO smoke content in produced cigarette brands.

The variation determination of cigarette smoke controlling components in different cigarette brands has importance not only for controlling observance standing norms (TTPL and different standards) and nicotine, tars and CO values on the cigarette packing but for smoke properties quality and constancy. The composition constancy is a synonym of high quality as for all taste products as for tobacco products.

The variation will be in permissible limits or out of them depending on the influence of all indicated above factors irrespective of correctly implementation analyses and respective method's accuracy. We should understand „permissible or normal" variation as the interval (limits) in which respective index changes in constant values of factors (blend, auxiliary materials, physical indexes, process parameters) and under influence accidental subjective factors. The assessment of the variation should accomplish on the basis statistic criteria as in all cases as in this case. The confidence interval (reliability interval) of respective index average values is recom-

mended take into account in results analysis for assessment the permissible limits of variation.

The aim of present investigation is determination variation (permissible limits) of controlling components (nicotine, tars and CO) in cigarette smoke and its comparison with these found in some cigarette trade brands and standard norms.

For realization of that put aim is necessary implementation of following tasks:

1. Determination the permissible limits of controlling indexes variation of cigarette smoke.

2. Determination the availability of definite dependences between controlling indexes in tobacco smoke.

3. Comparison the determined (obtained) permissible limits with these defined in some trade brands and standard requirements.

Materials and Methods

The methodical approach for determination investigated matters variation is based on investigation cigarettes produced of the same tobacco (mono cigarettes) with three levels nicotine - low, middle and high, with the same materials and physical properties i.e. in conditions in which the method accuracy or other accidental objective and subjective factors can influence on smoke composition.

The different tobacco samples are analyzed in advance for realization of the set purpose with a view to choose the three levels nicotine content - low, middle and high, respectively these are: B-1, B-2 and B-3.

The soluble sugars, overall nitrogen and ash content are determined of the chosen tobacco according to known routine methods.

The cigarettes are produced of three kinds B-1, B-2 and B-3 with the same auxiliary materials (cigarette papers and filter) and the same physical indexes (length, diameter, moisture content and draw resistance) in respective tobacco preparation. The 10 separate samples about 20 cigarettes for sample of every kind of cigarettes (B-1, B-2 and B-3) are analyzed chosen in advance according to standardized requirements (BSS ISO 8243, 2002). In this way the main requirement is realized - the objective factors constancy influenced on tobacco smoke composition.

The analyses are accomplished on ISO methods for content of:

-Nicotine in smoke – ISO 3400;

- Tar in smoke – ISO 4387, ISO 10362-2 and ISO 3308;

- Carbon monoxide – ISO 8454.

The obtained results are processed variation statistical as determined: average value (x_{av}), standard deviation (s), variation coefficient (v), percentage error (p), confidence interval (γ), minimum and maximum value of every kind of cigarettes (B-1, B-2 and B-3).

The ratio nicotine/tars for the three kinds of cigarettes are determined for the second task implementation. The availability of definite functional dependences is checked between controlling components of tobacco smoke (nicotine, tars and CO) and correlation coefficients between them by using computer program.

The two brands cigarettes are chosen from trade net with different level of nicotine, tars and CO content in smoke - FSP and FOR taken during different period of time for realization the third task. The sample taking is accomplished according to requirements (BSS ISO 8243, 2002). The ten samples are analyzed of every

brand. The same statistical indexes are determined on the base obtained data as mentioned above for the three kinds of cigarettes (B-1, B-2 and B-3).

The results processing is accomplished by using the computer program STATISTIKA. The check for adequacy and importance is accomplished in confidence level α=0.05 for deduced regression equations and correlation dependences.

Results and Discussion

Determination the permissible limits of variation controlling matters in tobacco smoke.

The chemical composition values of the investigated tobacco (B-1, B-2 and B-3) are presented in Table 1.

The chosen tobacco are with different level of the nicotine content as have seen: B-1 with nicotine 1.01%, B-2 with 2.19% and B-3 with 3.63% and soluble sugars, overall nitrogen and ash content respectively.

The physical indexes are presented of the laboratory produced cigarettes of the three tobacco samples in Table 2.

The cigarettes are produced of cigarette paper with permeability 50 CU and filter with denier Y 2.5/32000.

As the data show no deference in physical indexes between cigarettes with the exception of mass which variation is in permissible limits.

The statistical indexes for nicotine, tars and carbon monoxide content in smoke of the analyzed ten samples every kind of tobacco respectively cigarettes (B-1, B-2

Table 1

Chemical composition of the investigated tobacco

Sample	Nicotine, %	Reduced sugars, %	Overall nitrogen, %	Ash, %
B-1	1.01	27.30	1.98	10.60
B-2	2.19	20.60	1.53	10.69
B-3	3.63	15.40	2.10	10.17

Table 2

Physical indexes of the laboratory produced cigarettes

Physical indexes of cigarettes	Measure	B-1	B-2	B-3
Length	mm	83	83	83
Diameter	mm	7.75	7.75	7.75
Draw resistance	mm H_2O	120	125	115
Mass	mg	1036	1018	1010
Moisture content	%	13.5	13.5	13.1
Tipping paper length	mm	25	25	25
Filter length	mm	20	20	20

and B-3) are presented in Table 3.

The indexes characterizing variation – percentage error (p) and variation coefficient (v) have different values for one matter in different nicotine levels (for B-1, B-2 and B-3). The values of these indexes are maximum for nicotine for B-1, for tars – B-2 and for CO for B-1 except for the relative error (p) for CO.

The confidence interval (reliability interval) characterizes variation (+ and -) of average value of the respective index. Its values are the lowest for nicotine and range in limits from ± 0.02 mg/cig to ± 0.06 mg/cig as seen from the obtained data (Table 3), followed by tars from ± 0.15 mg/cig to ± 0.26 mg/cig and its values are maximum for CO from ± 0.30 mg/cig to ± 0.45 mg/cig for three tobacco kinds.

The obtained values are significantly lower than the regulated variation (nicotine ± 0.1 mg/cig and tars ± 1 mg/cig) according BSS ISO 8243. It is due to fact that the standard allows significantly higher deviations what obtained real in practice and they are due to influence of the above mentioned factors and the confidence interval can't use for assessment variation smoke matters for cigarette brands taken from trade net.

The obtained results of investigation (Table 3) give reason to accept that for assessment permissible variation (over normative) of the controlling smoke matters of different cigarette brands we must take the average difference between minimum and maximum of the three kinds of tobacco (B-1, B-2 and B-3) which is as follow: for nicotine – 0.14 mg/cig, for tars –1.13 mg/cig and for CO – 1.66 mg/cig. Therefore the permissible values over norm mustn't exceed 0.1 mg/cig, 1 mg/cig and for CO – 2 mg/cig what values correspond to approved standard norms for nicotine and tars.

Investigation availability of the definite dependences between controlling matters in cigarette smoke

The obtained results (Table 3) show average value of the ratio nicotine/tars 0,05, 0.10 and 0.13 respectively for three tobacco kinds B-1, B-2 and B-3. It is confirmed that with nicotine increasing in to-

Table 3

Statistical indexes

Stat. Indexes	Measure	B-1			B-2			B-3		
		Nicotine	Tars	CO	Nicotine	Tars	CO	Nicotine	Tars	CO
X_{av}	mg/cig	0.68	14.79	15.50	1.65	16.97	15.36	2.52	18.77	12.89
S	mg/cig	0.02	0.24	0.71	0.04	0.41	0.47	0.10	0.43	0.50
V	%	3.53	1.64	4.59	2.36	2.42	3.08	3.81	2.32	3.88
P	%	2.23	1.04	2.90	1.50	1.50	1.93	2.40	1.46	2.45
Min	mg/cig	0.65	14.40	14.40	1.59	16.40	14.60	2.40	18.30	12.00
Max	mg/cig	0.72	15.10	16.50	1.70	17.80	16.00	2.69	19.60	13.50
Y	mg/cig	0.68± 0.015	14.79± 0.153	15.50± 0.45	1.65± 0.025	16.97± 0.26	15.36± 0.30	2.52± 0.06	18.77± 0.14	12.89± 0.32

bacco the content of the same increases in the tars i.e. the tars increase in slighter degree than nicotine in smoke.

The check is accomplished for the definite dependences determination between tobacco smoke components on the base obtained results of thirty investigated samples (ten of every tobacco kind) by using different test of STATISTIKA program.

The obtained regression equations and linear dependence drawings between nicotine/tars, nicotine/CO and tars/CO are presented graphic on Figures 1, 2 and 3.

The points are grouped in three areas and correspond to investigate nicotine levels as respectively it re-cover because of little differences obtained in determination nicotine content of the same sample.

The correlation coefficients are in this case (for linear function): $r_1 = 0.972$; $r_2 = -0.793$; $r_3 = -0.744$ and respectively the coefficient of multitude correlation is $R_1 = 0.978$.

The correlation coefficients are for non-linear (quadratic) function: $r_1 = 0.973$; $r_2 = -0.796$; $r_3 = -0.754$ and respectively the coefficient of multitude correlation is $R_2 = 0.977$.

The coefficients are sufficiently high in two cases (for linear and non-linear dependence) as seen which indicates

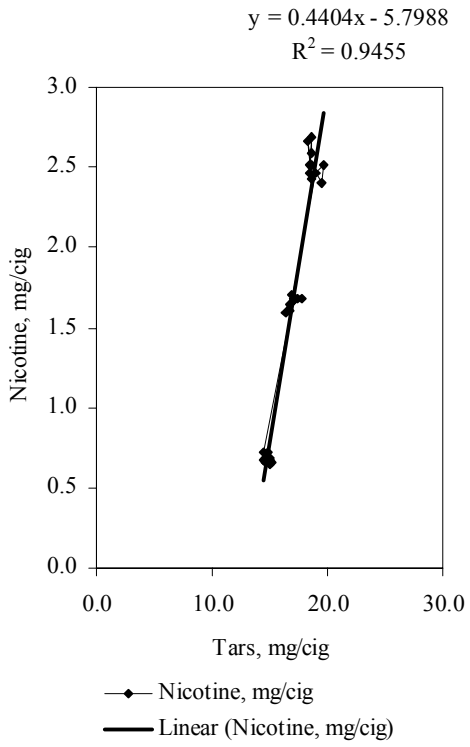

Fig. 1. Linear dependence between nicotine and tars

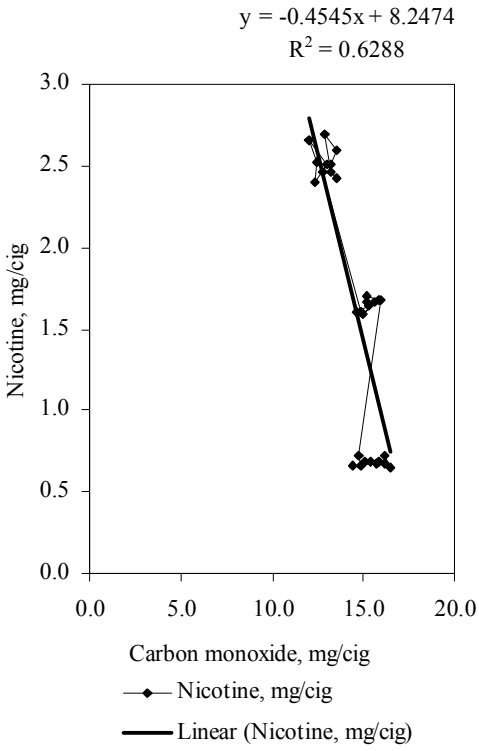

Fig. 2. Linear dependence between nicotine and carbon monoxide

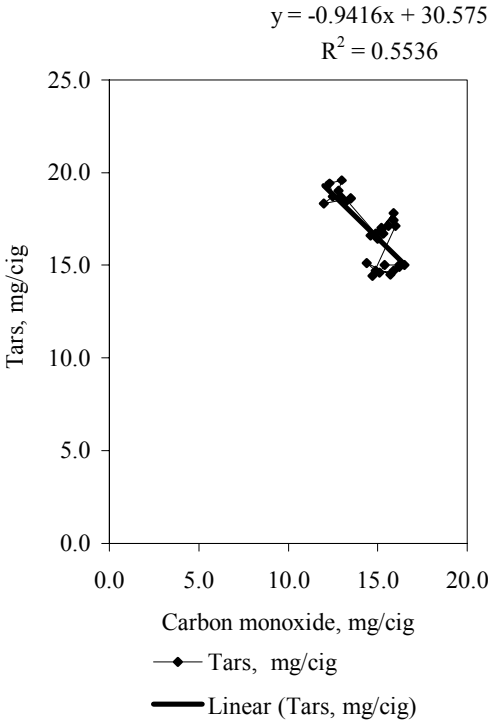

Fig. 3. Linear dependence between tars and carbon monoxide

clearly expressed dependence between investigated indexes. The values of multitude correlation (R) are high between three investigated components – nicotine, tars and CO. The results differs inessential for two functions. The difference is minimum for graphic presenting and because of that only the drawings of linear functions are presented.

The correlation between nicotine and tars is positive and with nicotine increasing the tars increase too; the nicotine is in negative correlation with CO; the correlation between tars and CO is negative.

According **t-** criterion of Student – **t** in all cases for r>0.5 and n>25 with probability bigger than 95% is available reliability (significance) of obtained coefficients and therefore the **t-** determination is purposeless (Lakin, 1990).

Comparison the determined limits of variation smoke composition with these of the trade cigarette brands

The data for physical indexes and smoke composition (mentioned on packing) in investigated two cigarette brands are presented in Table 4.

The nicotine content in tobacco for two cigarette brands is respectively: FSP – 1.35% and FOR – 1.51%.

The cigarette brands are chosen (from the same firm-producer) differing essentially in respect of tobacco smoke composition as seen from Table 4.

The statistical indexes for tobacco smoke composition of investigated ten samples of every brand are presented in Table 5.

The deviations are in comparison of the obtained average values for nicotine, tars and CO of analyzed brands with indicated on the packing: for nicotine +0.04 and –0.3 mg/cig; for tars +0.5 and –1.4 mg/cig and CO –1.3 and –2 mg/cig. Higher values are found for the first brand (FSP) with respect to nicotine and tar what are lower than ± 0.1mg/cig and respectively ±1.0mg/cig. The results are lower than indicated on the packing in the rest cases. As we compare these differences independently if they are positive or negative i.e. increasing or decreasing with definite permissible differences (deviations) it is seen that for cigarette FSP they are lower as for FOR they are higher. Therefore for cigarettes with lower nicotine content in smoke the deviations from permissible limits are lower as for cigarette with higher nicotine the deviations are higher.

It is outlined that for lower values of the matters in smoke its variation – abso-

Table 4

Physical indexes and chemical composition of investigated cigarette brands - FSP and FOR

I.Physical indexes	Measure	FSP	FOR
Length	mm	83	83
Diameter	mm	7.63	7.77
Mass	mg	940	934
Moisture content	%	11.16	11.77
Tipping paper length	mm	29	27
Filter length	mm	20	20
Ventilation	%	61.80	43.90
II. Smoke composition			
Nicotine	mg/cig	0.3	1.0
Tars	mg/cig	3.0	10.0
Carbon monoxide	mg/cig	5.0	11.0

Table 5

Statistical indexes

Stat. Indexes	Measure	FSP			FOR		
		Nicotine	Tars	CO	Nicotine	Tars	CO
X_{av}	mg/cig	0.34	3.54	3.73	0.70	8.57	9.00
S	mg/cig	0.02	0.40	0.41	0.03	0.75	1.04
V	%	5.72	11.40	10.89	3.67	8.78	11.55
P	%	3.55	7.22	6.89	2.26	5.54	7.31
Min	mg/cig	0.30	3.10	3.25	0.66	7.50	8.11
Max	mg/cig	0.37	4.20	4.33	0.73	9.65	11.60
Y	mg/cig	0.338± 0.012	3.54± 0.256	3.73± 0.257	0.695± 0.016	8.568± 0.476	8.999± 0.657

lute and relative is lower and vice versa. For higher values the probability for higher deviations of normative indexes is bigger.

The analogous investigation has accomplished for correlative dependences determination between the smoke components and for investigated trade cigarette brands. The results are as follows:

For linear function: $r_1 = 0.969$; $r_2 = 0.946$; $r_3 = 0.987$.

For non-linear function: $r_1 = 0.981$; $r_2 = 0.982$; $r_3 = 0.994$.

The values for multitude correlation (R) between three investigated components – nicotine, tars and CO are respectively for linear function $R_1 = 0.979$ and for non-lin-

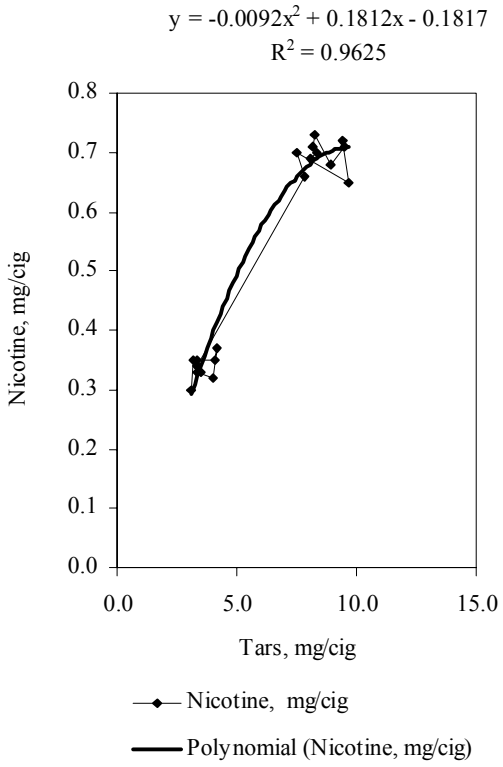

Fig. 4. Polynomial dependence between nicotine and tars

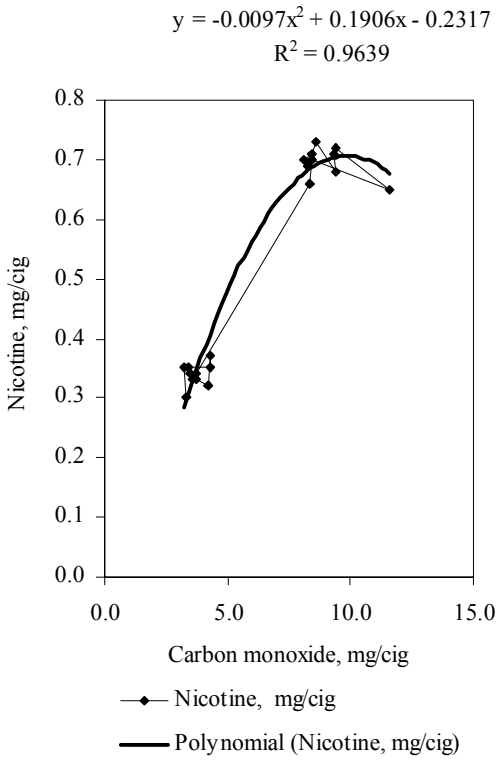

Fig. 5. Polynomial dependence between nicotine and carbon monoxide

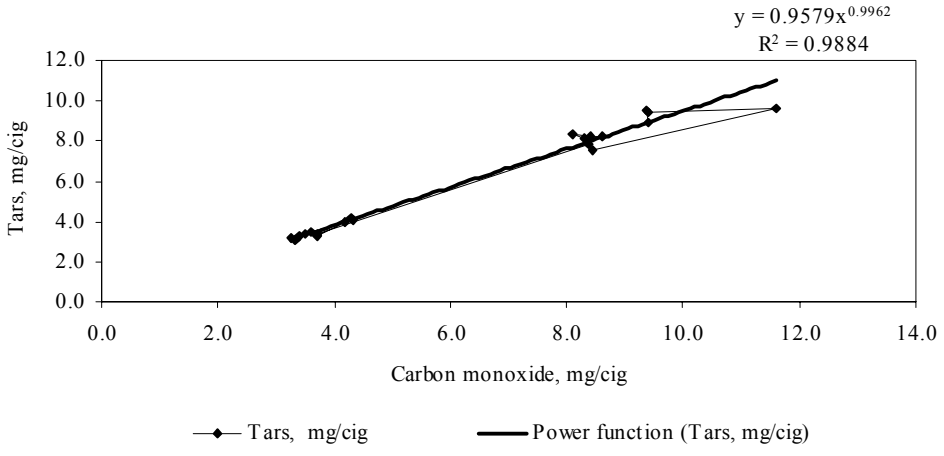

Fig. 6. Power function between tars and carbon monoxide

ear function $R_2 = 0.957$.

The drawings are presented for quadratic function for dependences nicotine/tars, nicotine/CO and correlation degree of tars/CO and obtained regression equations on Figures 4, 5 and 6.

As seen the results for correlation coefficients are analogous (inessential differing) with these of first investigation.

These coefficients are higher for nonlinear functions as in computer processing function is searched in which the error (standard deviation) is lowest.

Conclusion

The following conclusions can make in result of the investigation for permissible variation determination of controlling matters in tobacco smoke:

The lowest values has nicotine variation with confidence interval in limit from 0.02 to 0.06 mg/cig, followed by tars from 0.15 to 0.26 mg/cig and the highest is for carbon monoxide from 0.30 to 0.45 mg/cig.

The confidence interval of controlling matters in smoke shouldn't use for assessment its real variation. The values should use for assessment permissible variation of smoke matters over normative levels for different cigarette brands: for nicotine – 0.1 mg/cig, for tars – 1 mg/cig and for carbon monoxide – 2 mg/cig.

It is confirmed that with increasing nicotine content in tobacco, the tars in smoke increase in higher degree. The ratio nicotine/tars are 0.05; 0.10 and 0.13 for nicotine in tobacco about 1%; 2.19% and 3.63%. The high expressed correlative dependence near functional has between investigated smoke matters nicotine, tars and carbon monoxide. The correlation coefficients don't differ for linear and quadratic function and they are as follow:

Nicotine/tars – 0.97; Nicotine/CO – 0.79; Tars/CO – 0.74 and Nicotine/tars/CO – 0.97.

The determined deviations in controlling matters content in tobacco smoke are lower for cigarettes with relative lower smoke matters content and higher for these with high.

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