Cigar Smoking Methods Sub-Group

Technical Report

Cigar Smoke Analysis
16th Collaborative Study
2022

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Statistical Analysis and Author:
Michael J. Morton,
Altria Client Services, U.S.A.

Co-ordinators:
Thomas Lindegaard & Bas de Jager,
Scandinavian Tobacco Group, The Netherlands

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1. INTRODUCTION

In 2006 the CORESTA Scientific Commission gave the Cigar Smoking Methods Sub-Group (CSM SG) the responsibility to conduct periodic collaborative studies to improve repeatability and reproducibility of measurement methods of different cigar sizes and types.

The purpose of the 16th Collaborative Study is to estimate the mean values, repeatability, and reproducibility for NFDPM (tar), nicotine, carbon monoxide and other measures for different sizes and types of cigar products and test pieces and to provide a tool for participating laboratories to prove competence in cigar smoke analysis. The test items included are listed in Table 1.

Table 1: Physical characteristics of the tested products.

Product Code	Supplied by	Test Items per port	Nominal Weight	Nominal Diameter	Nominal Length
O (CM9)	Bo/Ce	2	0,943 g	7,8 mm	84,0 mm
K (1C1)	UoK	1	6,4 g	15,9 mm	136,5 mm
L (1C2)	UoK	2	1,4 g	7,8 mm	99,0 mm
M (1C3)	UoK	2	2,7 g	11,0 mm	109,5 mm
N (1C4)	UoK	1	3,2 g	12,8 mm	103,0 mm
	Bo is Borgwaldt, Ce is Cerulean, and UoK is University of Kentucky				

2. ORGANISATION

2.1 Participants

Seven laboratories took part in this collaborative study and were included in the statistical evaluation. The participating laboratories are shown in Table 2. In this report, the data are displayed by laboratory code and the codes are not in the same order as the listing shown in Table 2.

Table 2: List of Participating Laboratories

Laboratory	Country
Essentra	Indonesia
Global Laboratory Services	United States
Manifattura Sigaro Toscano SpA	Italy
Reemtsma	Germany
Scandinavian Tobacco Group BV	The Netherlands
University of Kentucky	United States
Villiger Söhne GmbH	Germany

2.2 Protocol

Participants were requested to follow the protocol for the 16th CS (provided in Appendix A) to analyse the 4 cigar products (K, L, M, N) and the test piece (O) and to report the seven parameters listed in Table 3. A test result is the outcome from a single port and the number of test items per port is shown in Table 1.

Table 3: Parameters to be reported

Parameter	Number of replicates	Unit	Code
Conditioned Weight	5	mg/cigar	Weight
Total Particulate Matter	5	mg/cigar	TPM
Water content (smoke)	5	mg/cigar	Water
Smoke Nicotine	5	mg/cigar	Nicotine
Nicotine Free Dry Particulate Matter (Tar)	5	mg/cigar	NFDPM (Tar)
Carbon Monoxide	5	mg/cigar	CO
Puff count	5	1/cigar	Puff

The data are listed in Appendix B and graphs of the data are shown in Appendix C.

3. RESULTS

As the number of participants is low, losing any laboratories to outlier identification would make the number of remaining laboratories too low to calculate r & R. For that reason, as in the 2020 and 2021 studies, the robust approach described in ISO 5725 part 5 was used to estimate the mean values, repeatability, and reproducibility. This approach has the advantage of not being strongly influenced by outlying data and does not require outlier identification.

Z-scores were also calculated to give an indication to the laboratories whether their results agree with those of the other participating laboratories.

3.1 Repeatability and reproducibility estimates

Repeatability and reproducibility limits were calculated for each product and each parameter. The results are summarized in Table 4.

Table 4: Mean value, repeatability, and reproducibility estimates
Weight (mg/test item)

Product	Mean	N Labs	r	r (%)	R	R (%)
K (1C1)	6273	7	839	13,4 %	1449	23,1 %
L (1C2)	1350	7	58,1	4,3 %	88,0	6,5 %
M (1C3)	2741	7	270	9,8 %	300	10,9 %
N (1C4)	3134	7	308	9,8 %	308	9,8 %
O (CM9)	943	7	36,3	3,9 %	41,7	4,4 %

Nicotine (mg/test item)

Product	Mean	N Labs	r	r (%)	R	R (%)
K (1C1)	3,08	7	1,245	40,4 %	4,061	131,7 %
L (1C2)	1,14	7	0,167	14,6 %	0,268	23,5 %
M (1C3)	1,98	7	0,371	18,7 %	0,770	38,8 %
N (1C4)	3,15	7	0,944	30,0 %	1,946	61,8 %
O (CM9)	1,39	7	0,147	10,6 %	0,442	31,9 %

TPM (mg/test item)

Product	Mean	N Labs	r	r (%)	R	R (%)
K (1C1)	98,3	7	28,61	29,1%	64,34	65,4%
L (1C2)	22,9	7	3,71	16,2%	8,83	38,6 %
M (1C3)	63,3	7	8,54	13,5 %	20,75	32,8 %
N (1C4)	63,5	7	14,20	22,4 %	22,01	34,7 %
O (CM9)	15,8	7	2,91	18,4 %	4,24	26,9 %

Water (mg/test item)

Product	Mean	N Labs	r	r (%)	R	R (%)
K (1C1)	12,83	7	5,718	44,6 %	12,430	96,9 %
L (1C2)	1,27	7	0,389	30,7 %	0,694	54,8 %
M (1C3)	4,71	7	1,303	27,6 %	3,506	74,4 %
N (1C4)	5,59	7	2,619	46,9 %	6,168	110,4 %
O (CM9)	1,23	7	0,361	29,2 %	1,813	146,9 %

NFDPM (Tar, mg/test item)

Product	Mean	N Labs	r	r (%)	R	R (%)
K (1C1)	82,4	7	23,19	28,1 %	55,92	67,9 %
L (1C2)	20,4	7	3,59	17,6 %	9,10	44,6 %
M (1C3)	56,8	7	7,00	12,3 %	17,65	31,1 %
N (1C4)	54,8	7	11,86	21,6 %	17,17	31,3 %
O (CM9)	13,2	7	2,68	20,4 %	3,81	28,9 %

Carbon Monoxide (CO, mg/test item)

Product	Mean	N Labs	r	r (%)	R	R (%)
K (1C1)	218,3	7	41,84	19,2 %	108,81	49,8 %
L (1C2)	33,6	7	6,90	20,6 %	12,38	36,9 %
M (1C3)	102,1	7	12,51	12,3 %	28,55	28,0 %
N (1C4)	102,6	7	29,27	28,5 %	56,29	54,9 %
O (CM9)	10,1	7	1,70	16,8 %	5,34	52,9 %

Puff Count (puffs/test item)

Product	Mean	N Labs	r	r (%)	R	R (%)
K (1C1)	78,5	7	14,48	18,4 %	72,18	92,0 %
L (1C2)	21,7	7	2,16	9,9 %	3,93	18,1 %
M (1C3)	38,3	7	4,91	12,8 %	11,46	29,9 %
N (1C4)	45,0	7	8,89	19,8 %	18,99	42,2 %
O (CM9)	12,5	7	1,08	8,7 %	2,24	17,9 %

Tables comparing this year's results to the 2020 and 2021 results are given in Appendix D. Test Item O was not included in the 2020 study. The comparison shows that the mean values for this year's smoke results were generally similar to those in 2020 and 2021. This year's nicotine results for cigar K, average of 3,08 mg/cigar, were quite different from those of 2020 and 2021, averages of 2,06 mg/cigar and 2,36 mg/cigar, respectively. From the graphs in Appendix C, Labs 2, 3, 4, 5, and 6 gave nicotine results similar to those in 2020 and 2021; however the other labs gave much higher results. The differences in nicotine for cigar K are somewhat troubling, but because of the extreme variability were not even statistically significantly different from one another. The reproducibility for nicotine for cigar K was also quite a bit larger than in 2020 and 2021. In this and some other instances, the r & R values differ somewhat, but variability is quite difficult to estimate accurately, especially with so few participating laboratories, and overall the r & R values were comparably large in both studies. So, generally, the 2022 results were in reasonable agreement with the 2020 and 2021 results.

3.2 Z-Scores

Z-scores give an indication of how well laboratory results agree with assigned values. The test items in this study were given assigned values based on the results of this collaborative study, so the z-scores calculated here give an indication of how well each laboratory agreed with the other laboratories in the study. Generally, if $|z| < 2$, the laboratory result is considered acceptable, $2 \le |z| < 3$, the value is treated as a warning, and if $|z| \ge 3$, the laboratory result is considered to be a signal to investigate. It should be noted, however, that because of the extreme variability of cigars, and the small number of participating laboratories, it is difficult to detect minor laboratory deviations in this study. The z-scores are shown in Table 5. In the table, $|z|>2$ is indicated by a red font. There are some z-scores with $|z|>3$ that merit investigation by the affected laboratories.

Table 5. Z-scores

Z-scores for Weight

Laboratory	K	L	M	N	O
1	0,33	2,17	-0,27	0,38	0,20
2	-0,52	-1,10	0,32	-0,22	-1,30
3	0,81	-0,63	0,14	1,22	-0,83
4	-0,63	0,62	0,54	0,53	0,90
5	1,39	0,37	1,38	0,23	-0,17
6	-1,12	-0,39	-0,88	-0,64	0,00
7	-0,26	-0,37	-1,23	-1,98	1,19

Z-scores for Nicotine

Laboratory	K	L	M	N	O
1	0,67	1,22	-0,35	0,19	-0,20
2	-0,58	0,29	1,24	0,20	-0,01
3	-0,79	-4,83	-3,94	-1,16	-1,59
4	-0,50	-0,63	-0,46	-0,23	-0,01
5	-0,81	0,61	0,54	0,39	1,42
6	1,42	-0,19	0,51	1,99	0,55
7	0,59	0,20	0,02	-0,89	-0,25

Z-scores for TPM

Laboratory	K	L	M	N	O
1	0,87	0,90	0,35	0,09	-0,08
2	-0,97	0,65	0,91	0,17	1,26
3	-0,25	-1,16	-2,42	-0,35	0,09
4	-0,92	-0,87	-0,59	-0,91	-1,42
5	-0,56	1,07	0,99	0,56	0,87
6	1,14	-0,42	0,18	1,85	-0,46
7	0,69	-0,17	-0,34	-1,06	-0,26

Z-scores for Water

Laboratory	K	L	M	N	O
1	-0.10	-0.61	-1.34	-0.26	0.71
2	-0.93	-0.26	0.78	-0.26	-0.03
3	0.73	5.27	0.02	1.10	1.63
4	-1.32	-1.21	-0.87	-1.15	-0.88
5	1.11	0.64	0.78	0.41	0.11
6	0.53	0.19	0.91	1.03	-0.43
7	-0.02	-0.25	-0.29	-0.88	-0.97

Z-scores for NFDPM (Tar)

Laboratory	K	L	M	N	O
1	0,96	0,90	0,66	0,18	-0,48
2	-0,85	0,66	0,82	0,29	1,46
3	-0,39	-1,33	-2,70	-0,81	-0,65
4	-0,72	-0,71	-0,53	-0,71	-1,07
5	-0,82	1,00	0,95	0,50	0,73
6	1,07	-0,39	-0,03	1,75	-0,33
7	0,74	-0,12	-0,38	-0,95	0,34

Z-scores for CO

Laboratory	K	L	M	N	O
1	1,07	0,85	-0,08	0,53	-1,26
2	-0,63	-0,05	0,84	0,25	0,52
3	-3,25	-2,95	-3,75	-3,74	-1,11
4	-0,40	0,23	-0,21	-0,27	0,25
5	0,53	1,17	1,26	1,16	1,16
6	0,48	-0,46	-0,02	0,48	0,40
7	0,44	-0,24	-0,28	-0,65	0,04

Z-scores for Puff Count

Laboratory	K	L	M	N	O
1	-0,76	-0,16	0,50	-0,12	0,64
2	0,87	0,36	0,49	1,33	0,48
3	0,09	-1,34	-0,93	-0,94	-1,08
4	0,02	0,18	-0,72	-0,60	-0,40
5	1,41	1,95	1,16	1,15	1,43
6	-0,91	-0,65	-1,07	-0,42	-0,74
7	-0,71	0,11	0,56	-0,40	-0,33

Values in red font have $|z|>2$.

4. SUMMARY AND CONCLUSIONS

Due to the small number of participating laboratories, outlier detection was not applied. The mean value, repeatability, and reproducibility were estimated by the robust statistical methods described in the standard ISO 5725 – part 5.

Most of the mean values were in reasonable agreement with the 2020 results. Even the ones that appeared to be rather different were not statistically significantly different. The r & R results indicated large variability, but that is in line with the inherent variability seen with cigars. The z-scores indicated reasonable agreement among the laboratories, however, there were a few concerning z-scores exceeding $|z|>3$ that warrant investigation by the corresponding laboratory.

APPENDIX A – Test Protocol

CORESTA

Sub-Group Cigar Smoking Methods

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Protocol for the 16th Collaborative Study (2022)
on
Repeatability and Reproducibility

1.   Preamble:

In this protocol, reference is often made to CORESTA Recommended Methods (*CRM*) nr 46 (June 2018), 64 (May 2018), 65 (August 2019), 66 (Nov. 2005), 67 (Nov. 2005) and 68 (Jan. 2010). To avoid any misunderstanding, please note that these Recommended Methods are the final versions as published on the CORESTA website www.coresta.org.

2.   Introduction:

In the web meeting of our Sub-Group Cigar Smoking Methods 29th September 2020, we agreed to conduct this 15th Collaborative Study on repeatability and reproducibility. The timeline and the products of this study was discussed.

Next products are selected:

Product O: CM9, CORESTA approved monitor, (Borgwaldt (Bo)/Cerulean (Ce))

Product K: 1C1 (University of Kentucky (ctrp.uky.edu)), Larger machine-made cigar

Product L: 1C2 (University of Kentucky (ctrp.uky.edu)), Machine-made filtered cigar.

Product M: 1C3 (University of Kentucky (ctrp.uky.edu)), Small machine-made cigarillo.

Product N: 1C4, (University of Kentucky (ctrp.uky.edu)), Large machine-made cigar with natural wrapper,

Later, all these products are only identified with a product code.

3.   Scope of the study:

The purpose of this 16th Collaborative Study is to determine the repeatability r and reproducibility R for the yields obtained from the 5 selected products when smoked with a *Puff Volume* as described in CORESTA Recommended Method nr 64 and 65:

- Cigars with diameter **≤ 12,0 mm**: puff volume = 20 ml
- Cigars with diameter > **12,0 mm**: puff volume = y = $0,139 \, x^2$,
    where: y = puff volume, in ml (to the nearest 1 ml)
          x = cigar diameter, in mm (to the nearest 0,1 mm),
       measured 33 mm from mouth end, after cutting if cutting is required.

In this protocol:

- TPM, Water, Nicotine and NFDPM will be determined for 5 different products by all participating laboratories, following the methodology as described in CORESTA Recommended Methods No. 64, 65, 66 and 67.

- Carbon Monoxide (CO) will be determined by those laboratories having the equipment for CO analysis, following the methodology as described in CORESTA Recommended Method No. 68.

- The diameter measurements will be done using contactless diameter measurement equipment to the extent possible, to eliminate the effects attributable to other measurement methods.

- Note on the form (Apparatus and Remarks), a description of the holder that is used to smoke the product: the type (bobbin, labyrinth seal or custom made) and the size of the opening.

- The sealing area of the cigar holder lays between 10 and 20 mm measured from the mouth end (see figure 1, 4.9.3. CRM64). Note the used sealing area, on the form, as the distance between the mouth end and the most distant sealing.

- According to CRM64, 5.3.6." The diameter of the filter pad disc shall be selected based on the expected TPM yield". Note the used filter disc size (44 mm, 55 mm or 92 mm) on the form, for each product.

- Conditioning specifications of the cabinet will stay strict: the weight of the conditioned CM9 will determine whether conditioning was performed in an acceptable way. Only if the CM9 is between agreed weight limits, the conditioning of any test piece can be initiated.

4.   Definition:

For this Collaborative Study, the definition for **one single result** is as described in CORESTA Recommended Method No. 65 (paragraph 7.6):

4.1   For cigars with a diameter $\leq$ **12,0 mm**:

"One single result for TPM, Water, Nicotine and NFDPM is defined as the result obtained from smoking 1 cigar or the average result obtained from smoking 2 cigars"

i.e. for this 16th collaborative study: product codes <u>O, L and M</u> (see paragraph 5 below).

4.2   For cigars with a diameter $\geq$ **12,1 mm:**

"One single result for TPM, Water, Nicotine and NFDPM is defined as the result obtained from smoking 1 cigar."

i.e. for this 16th collaborative study: product code <u>K and N</u> (see paragraph 5 below).

5. Products & Puff Volumes:

For this Collaborative Study the following products have been selected:

Product Code	Supplied by	Reported Weight (g)	Reported Diameter (mm)	Reported Length (mm)
O (CM9)	Bo/Ce	0,943	7,8	84,0
K (1C1)	UKY	6,4	15,9	136,5
L (1C2)	UKY	1,4	7,8	99,0
M (1C3)	UKY	2,7 +/- 0,2	11,0	109,5
N (1C4)	UKY	3,2	12,8	103,0

(The values above are reported on the CORESTA certificate or by UKY ctrp)

Note 1: It is advised to take – at receipt of the samples - the necessary precautions to prevent contamination of your premises by tobacco pests, e.g. by freezing the samples for a period of time.

Note 2: The puff volume will be calculated on the basis of the average cigar diameter of the test portion, using an <u>optical measurement method</u>. If no optical equipment can be used for product K and N, please use the provided diameter (as reported) by the STG laboratory.

Note 3: **Please use your own stocks CM9, 1C1, 1C2, 1C3 and 1C4. If needed, Product O can be ordered at Borgwaldt (contact: BKC@borgwaldt.com) or at Cerulean (contact: info@cerulean.com). Product K, L, M and N can be ordered at "The Center for Tobacco Reference Products" University of Kentucky (https://ctrp.uky.edu /).**

6. Puff frequency, Puff duration and Butt length:

For **all 5** product codes:

Puff frequency	=	40 seconds
Puff duration	=	1,5 seconds
Butt length	=	33 mm, or inbuild filter length +8 mm, to the longest.

7. Protocol:

Note 1: This protocol is to be read together with Excel file **"Form SG CSM 16th CS r&R.xlsx"**. This file contains 7 worksheets, named as follows:

O, K, L, M, N, Apparatus & Remarks and CO-measurement

Note 2: Carbon Monoxide is measured in <u>volume %</u>. This percentage is to be converted to <u>mg/cigar</u>, considering the puff volume, puff number, atmospheric pressure, temperature and number of cigars smoked.

The CO measurement is to be done following CORESTA Recommended Method no 68: "Determination of Carbon Monoxide in the mainstream of cigars by non-dispersive infrared analysis". In the Excel file provision is made for reporting CO – results, both in mg/cigar and as %.

Note 3: In CRM 65, under paragraph 7.6.8, reference is made to eventual rotation of the filter holder when the cigar is burning unevenly.

In the Excel file provision is made for reporting the number of rotations that was required to ensure the even burning during the machine smoking of every individual cigar.

1.1   The cigars of the 5 products, were at random selected.
Make sure, your **test sample** contains 20 individual cigars, intended for:
- Smoking
- a duplicate test portion (according to CRM65, 7.1.3) for smoking, in case some cigars would be damaged during handling.
- Moisture measurement.

Make sure not to select defective products for conditioning.

1.2   The quality of the conditioning atmosphere (chamber) should be verified based on the weight of the CM9 test piece after at least 72h of conditioning. The reported weight of this monitor test piece is **943** mg, with a standard deviation (s) of 4,69 mg per monitor, when measuring 20 monitor test pieces. The weight should be between **934** mg and **952** mg / CM09 test piece. If this is not the case, smoking cannot be started, and the conditioning parameters should be checked going forward. Note the weight of the 20 (CM9) test pieces on the corresponding worksheet of the form, for each smoke run.

1.3   Condition the selected products according to CORESTA Recommended Method No. 46 (Equilibrium shall be attained when the relative variation of the mass of the sample or test piece is not greater than 0,1 % in 24 h;).

1.4   After conditioning, determine the moisture content for the 5 products (according to **CRM 76, 3 hours @100 C**) and note the result:" Moisture Content after conditioning" on the corresponding worksheet of the form.

1.5   Determine the average length of <u>all</u> the conditioned cigars (to the nearest 0,5 mm). Note the results on the corresponding worksheet of the form.

1.6   Determine for each individual cigar: The Weight (in mg/cigar) and Pressure Drop (in mmWG). Average the results. And, note the average result of the weight on the corresponding worksheet of the Form.

1.7   Determine the average diameter, @15 mm and @33 mm from the mouth end, of <u>all</u> the conditioned cigars (to the nearest 0,1 mm), if possible, using an optical measurement device.

If this equipment is not available, please use the diameter as reported, to define the holder construction, but, still report your measurements on the form, using your own method.
- Note the average result @33 mm on the corresponding worksheet of the Form.
- Note the average result @15 mm on the worksheet of the Form "Apparatus & Remarks" to select the seal.
- Report your own measurement technique on worksheet "Apparatus & Remarks" of the Excel file.

1.8   The Products with **code K and N** will be smoked based on the puff volume calculated according to the average cigar diameter @ 33 mm, as measured by the respective laboratories (following CRM 65, 7.5.1 cigar diameter data – average diameter of the conditioned cigars) or according to the prescribed diameter (see point 5 in this protocol!). Use the correct configuration for the Holder Construction (see the APPENDICES of CORESTA Recommended Method no 64) and taking at least one clearing puff at the end (see paragraph 7.6.8 of CRM 65).

The puff volume y is dependent on the diameter of the cigar (x) as follows:

• For cigars with a diameter ≥ 12,1mm: **y = 0,139 * x²**

where: y = puff volume, in ml (to the nearest 1 ml)

x = cigar diameter, in mm (to the nearest 0,1 mm)

Note the calculated puff volume on the corresponding worksheet of the Form.

Products O, L and M will be smoked based on a puff volume of 20 ml.

1.9 **For products O, L, M**: Select at random **10 cigars of each product to** smoke and note: the individual weights and the individual pressure drops, <u>of the selected</u> cigars, on the corresponding worksheet of the Form**.**

1.10 **For products K and N**: Select at random **5 cigars of each product** to smoke and note: the individual weights and the individual pressure drops, of the selected cigars, on the corresponding worksheet of the Form.

1.11 According to the chosen **smoking plan**, each individual product code has to be smoked on **5 smoke channels, giving 5 "single results".**

Smoking Run O:

cigar 1 and 2 on channel 1 (2 cigars on 1 filter) results in single result O1
cigar 3 and 4 on channel 2 (2 cigars on 1 filter) results in single result O2
cigar 5 and 6 on channel 3 (2 cigars on 1 filter) results in single result O3
cigar 7 and 8 on channel 4 (2 cigars on 1 filter) results in single result O4
cigar 9 and 10 on channel 5 (2 cigars on 1 filter) results in single result O5

Smoking Run K:

cigar 1 on channel 1 (1 cigar on 1 filter) results in single result K1
cigar 2 on channel 2 (1 cigar on 1 filter) results in single result K2
cigar 3 on channel 3 (1 cigar on 1 filter) results in single result K3
cigar 4 on channel 4 (1 cigar on 1 filter) results in single result K4
cigar 5 on channel 5 (1 cigar on 1 filter) results in single result K5

Smoking Run L:

cigar 1 and 2 on channel 1 (2 cigars on 1 filter) results in single result L1
cigar 3 and 4 on channel 2 (2 cigars on 1 filter) results in single result L2
cigar 5 and 6 on channel 3 (2 cigars on 1 filter) results in single result L3
cigar 7 and 8 on channel 4 (2 cigars on 1 filter) results in single result L4
cigar 9 and 10 on channel 5 (2 cigars on 1 filter) results in single result L5

Smoking Run M:

cigar 1 and 2 on channel 1 (2 cigars on 1 filter) results in single result M1
cigar 3 and 4 on channel 2 (2 cigars on 1 filter) results in single result M2
cigar 5 and 6 on channel 3 (2 cigars on 1 filter) results in single result M3
cigar 7 and 8 on channel 4 (2 cigars on 1 filter) results in single result M4
cigar 9 and 10 on channel 5 (2 cigars on 1 filter) results in single result M5

Smoking Run N:

cigar 1 on channel 1 (1 cigar on 1 filter) results in single result N1
cigar 2 on channel 2 (1 cigar on 1 filter) results in single result N2
cigar 3 on channel 3 (1 cigar on 1 filter) results in single result N3
cigar 4 on channel 4 (1 cigar on 1 filter) results in single result N4
cigar 5 on channel 5 (1 cigar on 1 filter) results in single result N5

1.12 Prepare 5 smoke channels, consisting of the filter (smoke trap holder) and the cigar holder).

1.12.1 A trained operator should seal the cigar in the holder by selection of right configuration: bobbin, sleeve (and end-seal), from table 1 in CORESTA Recommended Method no 64. Various solutions are possible that seals the cigar in the sealing area between 10 and 20 mm from the mouth end. It is possible to seal with labyrinth seals or other custom-made configurations, in the sealing area of the cigar. Report your choice of sealing (bobbin, sleeve, end-seal or labyrinth/custom made seal) on the worksheet of the Form "Apparatus & Remarks".

1.12.2 Attention must be given for maximum TPM loads. The size of the smoke trap has to be chosen to allow smoking without overload. Note the diameter of the filter pad of your choice.

1.12.3 Some products have an inbuild filter. The standard butt length is described under 7.4.1 (CRM65) as: The standard butt length to which cigars shall be marked. The longest of:

- 33 mm, or

- inbuilt filter + 8 mm, or

- artificial mouthpiece + 17 mm

1.13 Note the insertion depth and the sealing area on the corresponding worksheet.

- the insertion depth is defined as the distance, in mm, from the mouth end of the cigar to the front of the cigar holder (should be 28 mm).

- The sealing area is the distant in mm between the mouth-end and the most distant sealing on the cigar (between 10-20 mm).

1.14 Note the date of smoking and the atmospheric conditions of the smoking room.

Measure the ambient airflow in mm/sec, before lighting the cigars, at the position of the fire end of each individual cigar. Note the result on the corresponding worksheet.

1.15 Follow the procedures as described in CORESTA Recommended Methods nr 64, 65, 66 and 67 for the determination of TPM, Nicotine, Water and NFDPM. Report any deviations from these CRM's in your analysis, referring to the paragraph concerned, on worksheet "Apparatus & Remarks" in the Form.

1.16 Note the Puff Number, Number of Lighting Puffs, Number of Relights and Number of Rotations for each individual cigar on the corresponding worksheet.

1.17 Note TPM, Nicotine and Water on the corresponding worksheet under "mg /cigar" (or "mg / 2 cigars").

1.18 Determine carbon monoxide, following CORESTA Recommended Method no 68. Report your CO-results, for every individual channel, on the corresponding worksheet:

1.18.1 in mg/cigar, as calculated from the formula in paragraph 9.2 of CORESTA Recommended Method no 68.

1.18.2 in %, as read from your CO measuring equipment.

7.19 Check or complete worksheet **"Apparatus & Remarks":**

- your company name.
- report for the 5 products the used filter pad diameter
- report for the 5 Products the diameter of
- Bobbin, sleeve and end seal or,
- Opening labyrinth seal.   or,
- Description custom made solution.
- report any deviations from CORESTA Recommended Methods no 64, 65, 66 and 67.
- report any deviations from CORESTA Recommended Method no 68 (CO analysis).
- report your technique for diameter measurement.

7.20 Complete worksheet "**CO-measurement"**

7.21 Return your completed Excel file "Form SG CSM 16th CS r&R.xls" to:

Bas de Jager
Deadline: 30-June-2022

All data sets received will be checked for obvious errors. After these checks, you will be contacted, if necessary, for confirmation or correction of the data. The results will be forwarded to a statistician for analysis. A coded number will be assigned to each participating laboratory, in confidence.

Please do not modify any data sheet in the reporting forms.

APPENDIX B – Data Listing

Cigar	Lab	TPM mg/test item	Nicotine mg/test item	Water mg/test item	NFDPM mg/test item	CO mg/test item	Puffs puffs/test item	Weight mg/test item
K	1	107,0	3,21	10,6	93,2	258,9	54,7	6237
K	1	113,0	3,54	13,2	96,2	276,8	64,0	6420
K	1	119,0	4,47	15,7	98,9	240,7	61,0	6034
K	1	124,0	4,48	10,9	108,6	255,5	57,0	6877
K	1	120,0	4,39	11,8	103,8	255,4	59,0	6528
K	2	69,1	1,98	7,4	59,8	182,3	111,0	6296
K	2	78,6	2,15	9,8	66,6	220,4	104,0	6500
K	2	90,0	2,78	10,6	76,7	187,6	94,0	5405
K	2	86,6	2,65	11,1	72,9	178,0	102,0	5937
K	2	65,5	1,83	6,4	57,2	208,2	92,0	6081
K	3	97,0	1,99	17,6	77,5	99,5	83,0	6705
K	3	68,0	1,31	10,9	55,8	104,3	87,0	6903
K	3	100,0	2,35	16,5	81,1	95,9	80,0	6290
K	3	103,0	2,22	16,9	83,9	93,5	78,0	6538
K	3	97,0	2,02	17,1	77,9	106,0	76,0	6716
K	4	87,0	2,50	8,5	76,0	208,7	80,0	6130
K	4	89,7	2,67	8,7	78,3	211,5	72,0	5747
K	4	73,1	1,97	6,7	64,4	224,6	84,0	6615
K	4	65,1	2,14	6,3	56,6	172,8	80,0	5702
K	4	79,9	2,66	7,2	70,0	200,9	78,6	5769
K	5	83,6	2,17	14,2	67,3	227,7	111,6	6724
K	5	98,9	2,12	20,6	76,1	256,2	113,9	6901
K	5	80,6	1,94	16,5	62,2	233,5	120,6	6671
K	5	79,1	1,51	15,6	61,9	228,1	122,5	7275
K	5	90,6	2,03	19,8	68,8	243,4	102,4	6867
K	6	120,8	4,94	15,1	100,8	236,3	56,0	5844
K	6	121,7	4,76	14,9	102,0	226,8	53,0	5585
K	6	124,5	5,21	15,3	104,0	248,0	56,0	5825
K	6	120,6	5,05	14,9	100,6	225,2	54,0	5744
K	6	123,9	5,34	14,5	104,0	243,5	58,0	5895
K	7	102,8	3,00	11,1	88,7	259,6	64,0	6447
K	7	103,5	3,10	11,0	89,4	234,6	64,0	5964
K	7	116,6	4,36	14,3	98,0	213,7	59,0	6073
K	7	108,5	3,67	13,3	91,5	242,0	61,0	6289
K	7	132,8	5,40	14,1	113,3	221,3	54,0	6007
L	1	26,5	1,20	1,0	24,3	40,4	21,5	1409

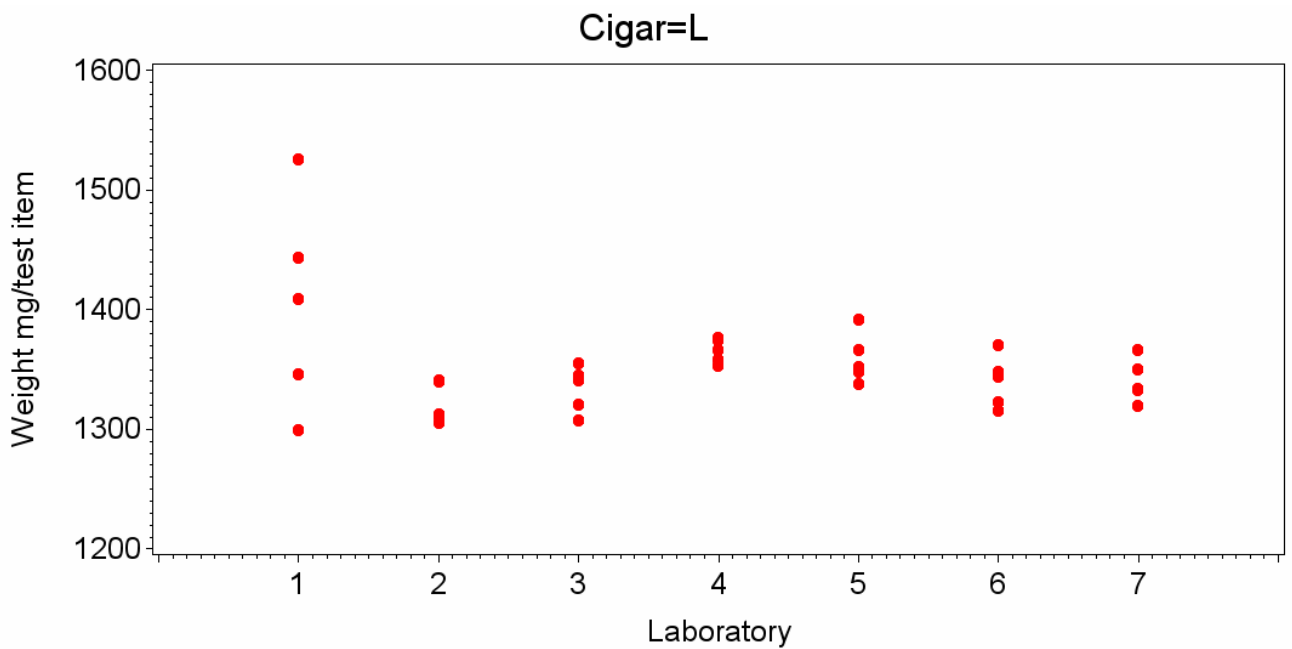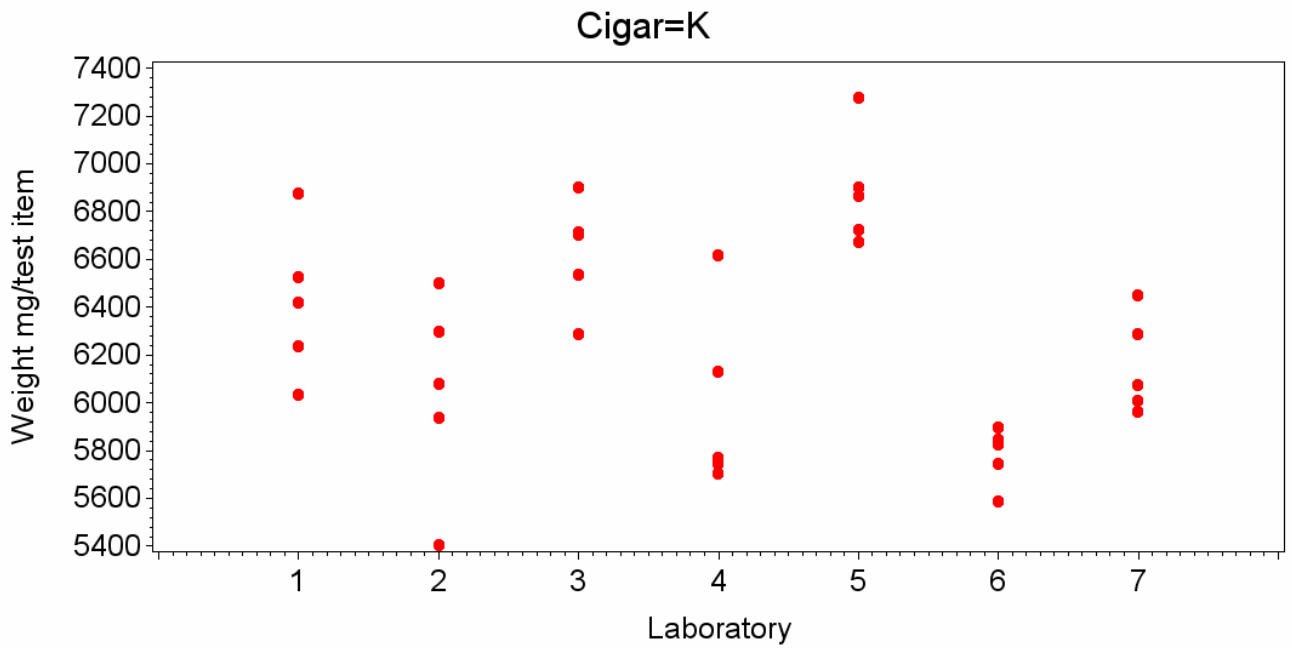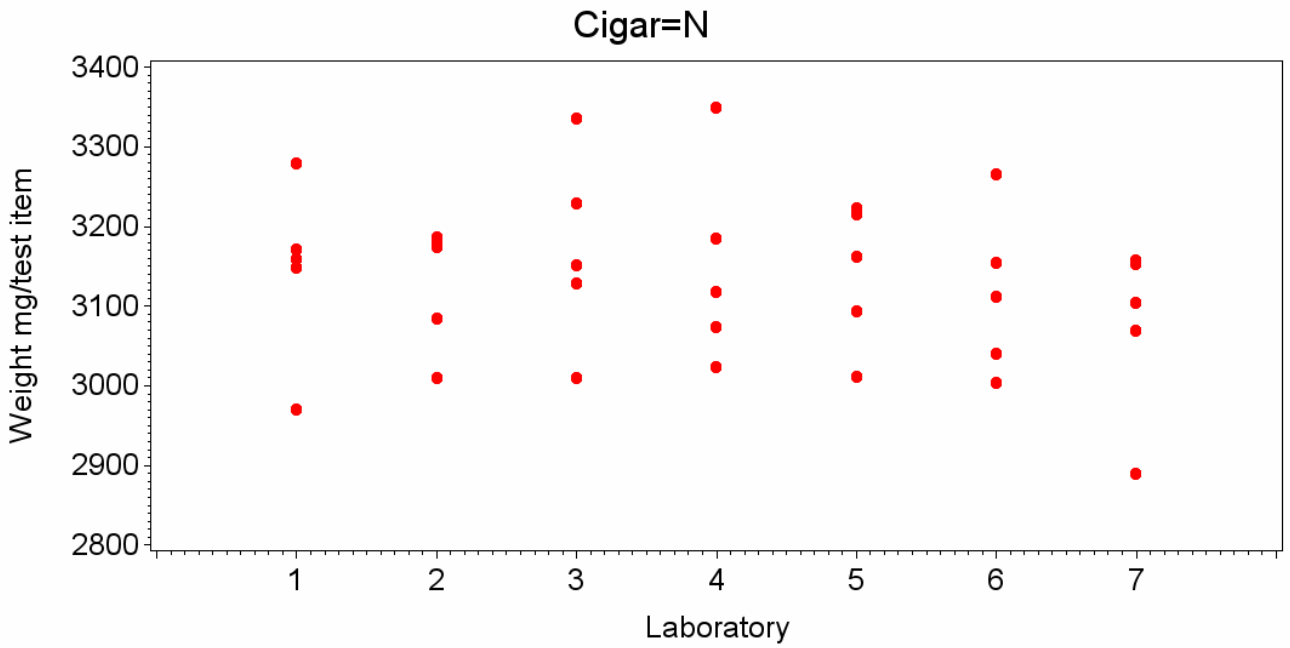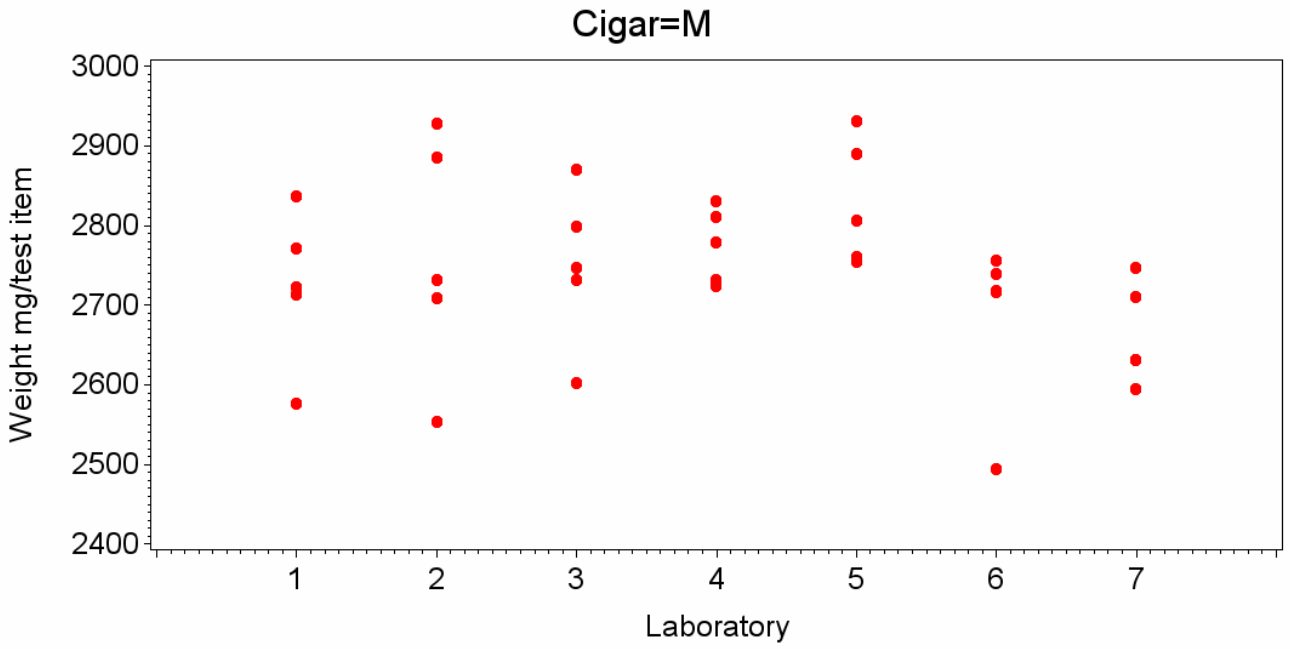| Cigar	Lab	TPM mg/test item	Nicotine mg/test item	Water mg/test item	NFDPM mg/test item	CO mg/test item	Puffs puffs/test item	Weight mg/test item
L	1	28,0	1,27	1,2	25,5	36,6	20,7	1300
L	1	24,5	1,17	1,1	22,2	38,2	22,5	1444
L	1	24,5	1,35	1,1	22,0	33,7	20,2	1346
L	1	24,0	1,21	1,2	21,6	35,2	22,8	1525
L	2	25,7	1,23	1,3	23,1	34,6	22,0	1313
L	2	23,1	1,14	1,2	20,7	32,0	23,1	1340
L	2	25,8	1,12	1,4	23,2	35,3	21,8	1341
L	2	22,8	1,10	1,1	20,6	29,1	22,3	1306
L	2	26,5	1,24	1,0	24,3	36,0	21,7	1310
L	3	21,0	0,77	2,5	17,7	22,7	20,0	1321
L	3	19,0	0,74	2,3	16,0	23,8	21,0	1345
L	3	19,5	0,78	2,4	16,3	22,7	20,0	1341
L	3	20,0	0,75	2,4	16,9	22,1	19,5	1308
L	3	18,0	0,75	2,4	14,8	20,0	20,0	1355
L	4	19,7	1,10	0,9	17,6	32,6	21,5	1374
L	4	20,8	1,06	1,0	18,8	31,4	21,9	1353
L	4	20,6	1,08	1,1	18,4	36,5	21,0	1358
L	4	19,8	1,15	0,9	17,7	33,9	24,0	1367
L	4	21,0	1,08	1,1	18,8	37,9	21,4	1376
L	5	25,9	1,22	1,7	23,0	38,9	24,0	1392
L	5	25,2	1,19	1,1	23,0	37,7	24,3	1366
L	5	26,6	1,16	1,5	24,0	39,6	24,1	1348
L	5	26,7	1,24	1,5	23,9	36,1	24,5	1352
L	5	25,8	1,14	1,4	23,3	38,0	23,9	1338
L	6	22,0	1,13	1,2	19,6	31,2	20,2	1316
L	6	24,9	1,28	1,6	22,0	37,0	20,4	1322
L	6	19,2	0,96	1,4	16,8	28,6	21,6	1348
L	6	21,7	1,17	1,2	19,3	30,2	21,3	1344
L	6	20,6	1,09	1,1	18,4	32,0	21,2	1371
L	7	23,1	1,06	1,2	20,9	35,2	23,0	1320
L	7	21,4	1,16	1,1	19,1	30,6	21,5	1334
L	7	22,5	1,16	1,3	20,0	34,1	21,0	1350
L	7	22,6	1,19	1,2	20,2	31,5	21,9	1333
L	7	22,5	1,22	1,3	20,0	31,8	22,0	1367
M	1	65,5	1,86	3,0	60,6	109,1	40,7	2836
M	1	75,0	2,21	2,9	69,9	103,1	42,3	2577
M	1	59,5	1,75	3,2	54,5	94,9	39,0	2722
M	1	65,5	1,84	3,4	60,3	98,6	38,7	2713
M	1	63,0	1,84	3,1	58,1	101,1	40,4	2772

Cigar	Lab	TPM mg/test item	Nicotine mg/test item	Water mg/test item	NFDPM mg/test item	CO mg/test item	Puffs puffs/test item	Weight mg/test item
M	2	66,1	2,16	5,2	58,8	115,7	42,4	2928
M	2	71,4	2,21	5,9	63,2	96,4	35,9	2554
M	2	66,6	2,18	5,2	59,2	119,3	41,5	2885
M	2	73,4	2,49	6,3	64,6	102,8	39,5	2709
M	2	70,4	2,42	5,6	62,4	116,1	41,5	2731
M	3	48,5	1,10	4,7	42,7	62,7	32,5	2603
M	3	43,0	0,89	4,5	37,6	69,4	36,0	2870
M	3	49,0	1,07	5,1	42,9	67,5	35,0	2747
M	3	45,5	0,96	4,4	40,1	70,4	36,5	2799
M	3	47,0	1,01	4,9	41,0	64,6	34,0	2732
M	4	61,7	1,94	4,0	55,8	99,6	36,0	2731
M	4	60,7	1,94	3,8	54,9	102,1	36,5	2831
M	4	56,7	1,77	3,3	51,6	101,9	35,5	2811
M	4	59,5	1,81	3,7	54,0	98,9	34,5	2724
M	4	57,8	1,88	3,7	52,2	98,2	35,4	2778
M	5	74,3	2,32	6,5	65,5	114,4	42,4	2760
M	5	66,9	1,99	5,1	59,9	115,3	42,7	2889
M	5	69,4	2,11	5,0	62,3	111,2	42,2	2755
M	5	66,9	1,97	5,6	59,2	113,9	44,2	2932
M	5	73,2	2,20	6,0	65,0	114,9	42,0	2806
M	6	60,5	2,00	5,2	53,3	102,4	33,5	2717
M	6	64,1	2,08	5,6	56,4	101,8	34,5	2740
M	6	66,0	2,06	6,2	57,8	96,8	32,0	2495
M	6	64,7	2,23	5,9	56,5	103,7	35,5	2756
M	6	67,4	2,19	6,0	59,2	104,9	35,8	2718
M	7	62,3	2,08	4,4	55,8	89,3	40,5	2711
M	7	59,0	1,82	3,7	53,4	107,0	44,2	2747
M	7	59,4	1,90	3,8	53,7	101,0	40,5	2631
M	7	63,9	2,13	5,4	56,3	99,1	37,5	2632
M	7	60,3	2,01	4,6	53,6	101,1	39,5	2595
N	1	54,0	2,75	4,2	47,0	100,9	43,1	3279
N	1	68,0	3,36	5,6	59,1	99,1	45,0	3158
N	1	65,0	3,35	5,1	56,5	112,3	44,0	3172
N	1	64,0	3,30	5,6	55,1	118,0	44,0	3148
N	1	69,0	3,59	4,8	60,7	129,2	45,0	2970
N	2	69,0	4,16	5,1	59,8	95,4	44,0	3174
N	2	62,9	3,32	4,3	55,3	111,5	51,0	3186
N	2	75,4	3,46	7,1	64,8	122,1	56,0	3085
N	2	56,4	2,58	5,1	48,7	86,8	57,8	3011

Cigar	Lab	TPM mg/test item	Nicotine mg/test item	Water mg/test item	NFDPM mg/test item	CO mg/test item	Puffs puffs/test item	Weight mg/test item
N	2	59,0	2,84	3,7	52,4	119,5	57,0	3181
N	3	69,0	2,77	8,7	57,5	33,3	36,0	3128
N	3	58,0	2,04	7,2	48,7	36,1	39,0	3229
N	3	57,0	2,49	7,0	47,5	39,8	43,0	3151
N	3	59,0	2,28	7,2	49,5	37,0	40,0	3335
N	3	63,0	2,54	9,0	51,5	33,3	38,0	3010
N	4	59,9	3,03	4,0	52,9	96,3	39,0	3074
N	4	61,9	3,60	3,2	55,1	108,4	44,0	3118
N	4	56,1	2,68	3,2	50,2	106,6	45,0	3349
N	4	58,2	3,12	3,4	51,7	90,7	38,4	3024
N	4	52,1	2,59	2,5	47,1	86,7	40,0	3185
N	5	66,4	3,38	5,7	57,3	119,0	55,6	3094
N	5	69,2	3,47	6,1	59,6	123,5	48,5	3224
N	5	60,1	2,94	5,8	51,3	116,3	55,9	3162
N	5	69,5	3,64	7,6	58,3	135,0	49,7	3215
N	5	70,1	3,56	6,9	59,7	122,4	50,6	3011
N	6	77,6	4,79	7,6	65,2	116,6	41,0	3112
N	6	73,5	4,06	6,3	63,1	97,8	39,0	3004
N	6	81,3	4,54	9,6	67,2	107,5	41,0	3040
N	6	74,7	4,37	7,9	62,4	120,1	44,0	3155
N	6	69,6	4,23	7,1	58,3	113,7	47,0	3266
N	7	56,2	2,71	3,0	50,5	89,4	40,0	3104
N	7	52,5	2,25	3,3	46,9	96,2	46,0	2890
N	7	59,0	2,75	3,8	52,5	82,6	40,0	3157
N	7	55,6	2,63	4,8	48,2	79,3	41,4	3069
N	7	59,9	2,61	4,0	53,3	107,1	45,3	3154
O	1	17,5	1,45	1,7	14,3	7,6	13,2	942
O	1	15,0	1,32	1,7	11,9	7,3	13,5	948
O	1	14,0	1,32	1,6	11,1	7,1	12,3	946
O	1	17,0	1,41	1,5	14,1	8,1	12,9	944
O	1	15,0	1,29	1,9	11,8	8,9	12,9	944
O	2	18,1	1,46	1,3	15,3	12,0	13,2	930
O	2	17,4	1,37	1,4	14,6	12,1	12,0	907
O	2	17,8	1,43	1,2	15,2	11,4	13,8	962
O	2	17,6	1,35	1,2	15,0	9,3	12,5	919
O	2	15,7	1,32	1,0	13,3	10,5	12,7	936
O	3	18,0	1,18	2,3	14,5	8,6	12,0	947
O	3	15,0	1,08	2,2	11,7	8,3	11,5	933
O	3	15,5	1,15	2,2	12,1	8,3	11,5	932

Cigar	Lab	TPM mg/test item	Nicotine mg/test item	Water mg/test item	NFDPM mg/test item	CO mg/test item	Puffs puffs/test item	Weight mg/test item
O	3	16,5	1,21	2,3	13,0	8,6	12,0	950
O	3	14,5	1,12	2,3	11,1	6,5	11,5	915
O	4	13,7	1,41	0,6	11,7	10,5	12,3	947
O	4	15,2	1,40	0,7	13,0	10,7	12,0	928
O	4	13,8	1,35	0,6	11,8	10,5	12,3	977
O	4	14,1	1,39	0,7	12,0	10,7	12,0	955
O	4	13,8	1,38	0,8	11,6	10,5	12,5	949
O	5	16,8	1,60	1,8	13,4	12,3	13,8	956
O	5	16,3	1,63	1,0	13,7	12,3	13,2	933
O	5	17,7	1,63	1,4	14,7	12,5	13,7	937
O	5	16,2	1,53	0,9	13,8	12,1	13,5	940
O	5	17,3	1,61	1,5	14,2	12,0	13,4	940
O	6	13,9	1,50	1,0	11,4	10,9	12,8	958
O	6	16,0	1,42	1,0	13,6	10,9	11,9	944
O	6	16,7	1,53	1,1	14,1	10,6	11,9	937
O	6	15,0	1,46	0,9	12,6	11,0	11,5	928
O	6	14,6	1,45	0,8	12,3	10,7	11,7	947
O	7	15,5	1,30	0,4	13,7	10,7	12,5	944
O	7	15,4	1,38	0,6	13,4	9,5	12,5	960
O	7	15,3	1,42	0,7	13,2	10,5	12,0	948
O	7	16,1	1,38	0,6	14,1	9,5	12,2	960
O	7	15,2	1,28	0,7	13,2	10,7	12,0	959

For visual consistency, the number of decimal places is the same for each listed number of a given analyte. Trailing zeros were not always provided, but only added here to have a common format.

APPENDIX C – Data graphs

Weight

Cigar=K

Cigar=L

Cigar=M

Cigar=N

Cigar=O

Nicotine

Cigar=K

Cigar=L

Cigar=M

Cigar=N

Cigar=O

TPM

Cigar=K

Cigar=L

Cigar=M

Cigar=N

Cigar=O

NFDPM (Tar)

Cigar=K

Cigar=L

Cigar=M

Cigar=N

Cigar=O

CO

Cigar=K

Cigar=L

Cigar=M

Cigar=N

Cigar=O

Water

Cigar=K
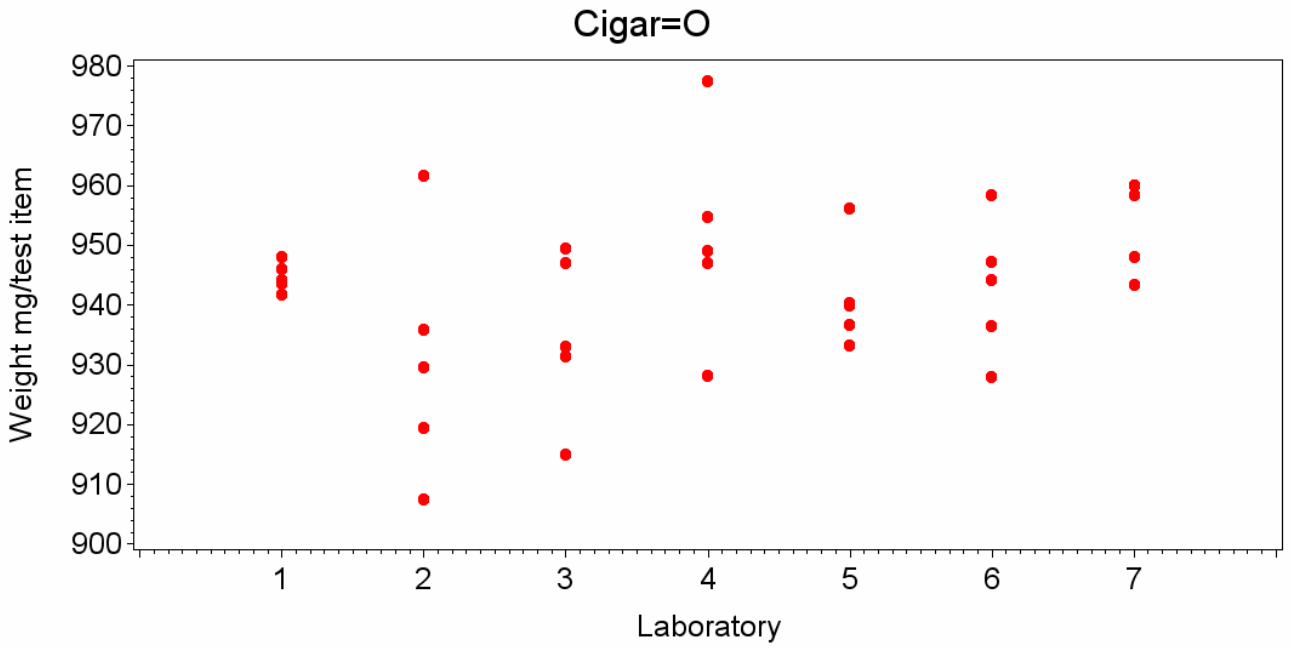
Cigar=L

Cigar=M
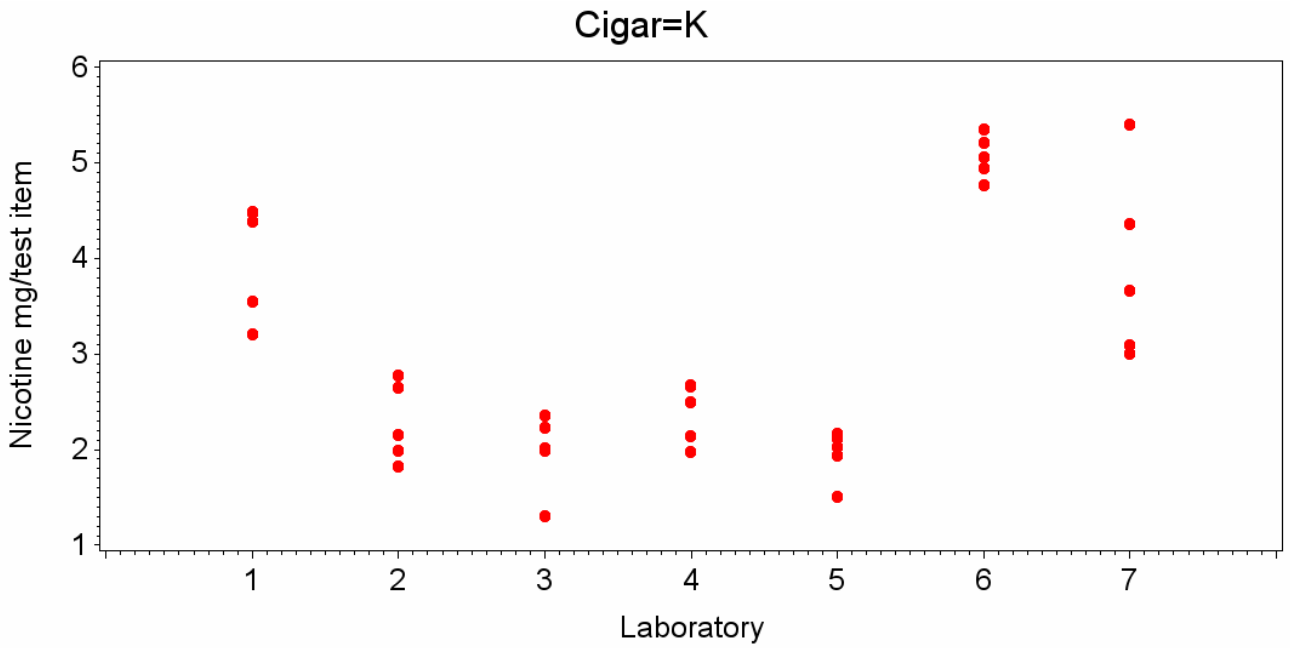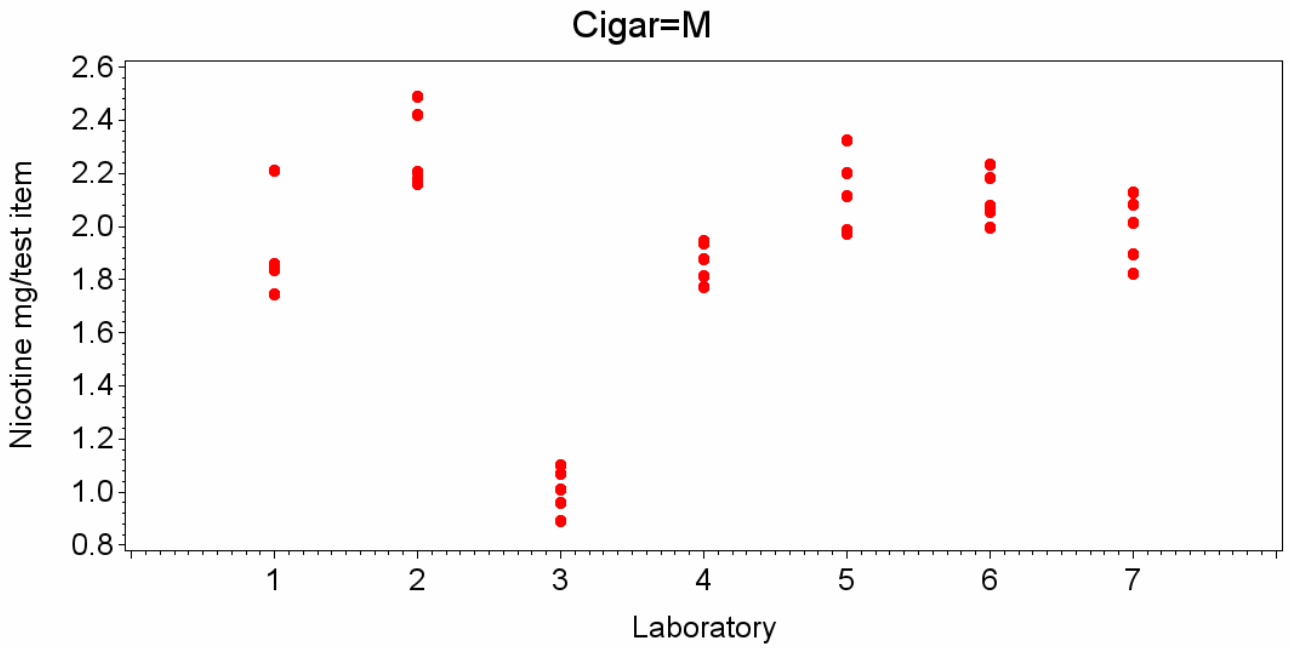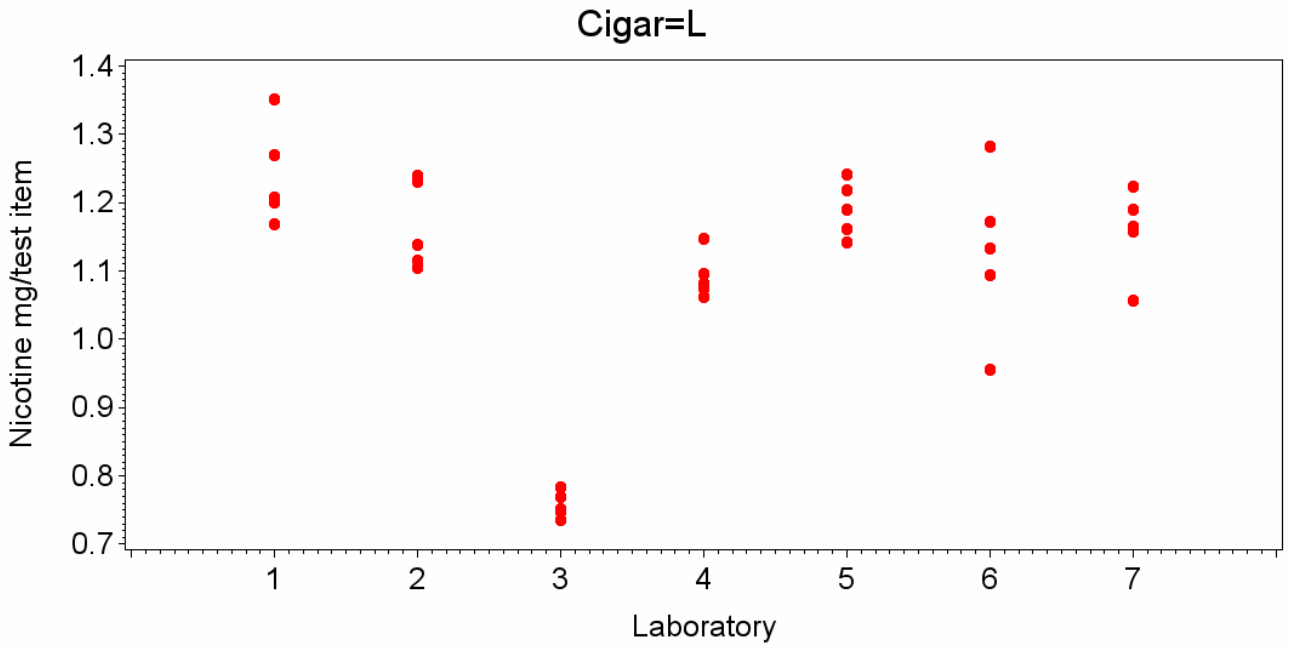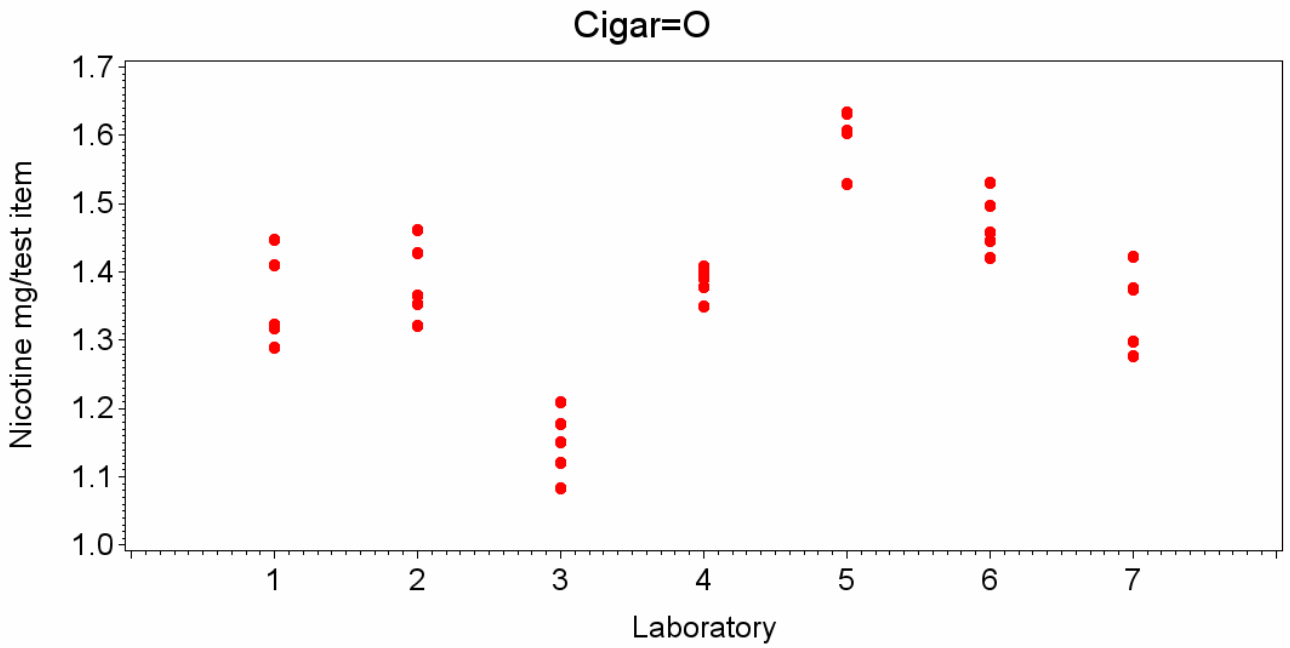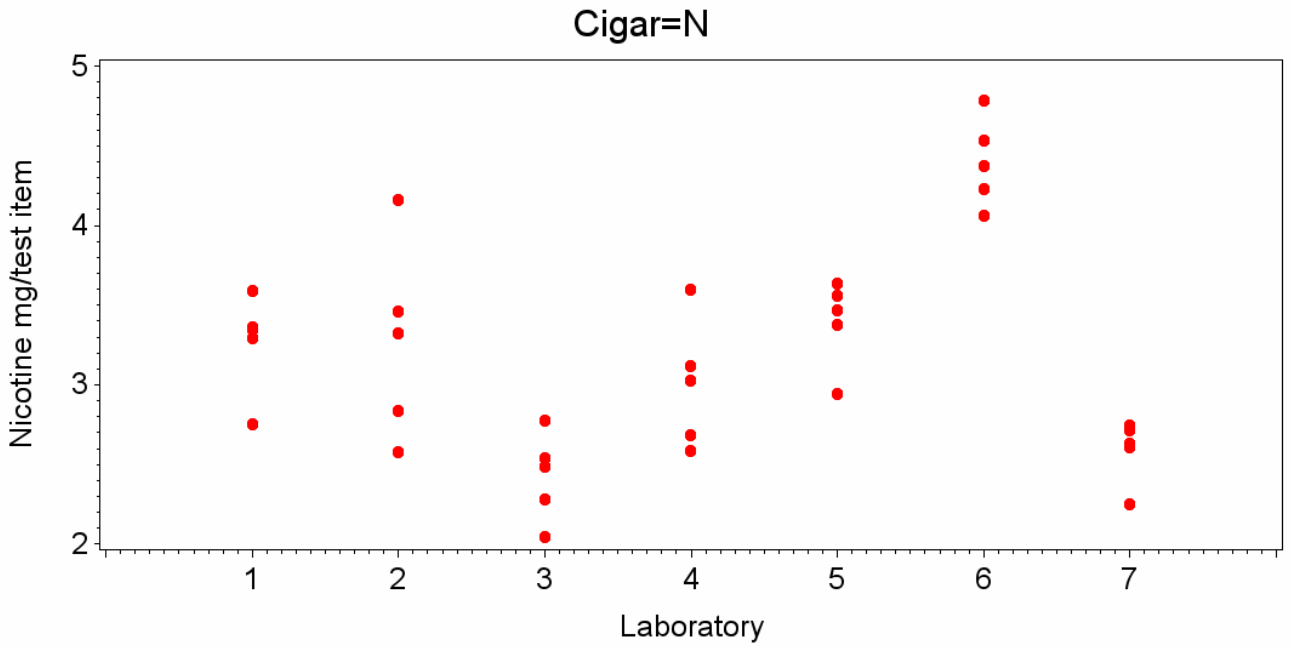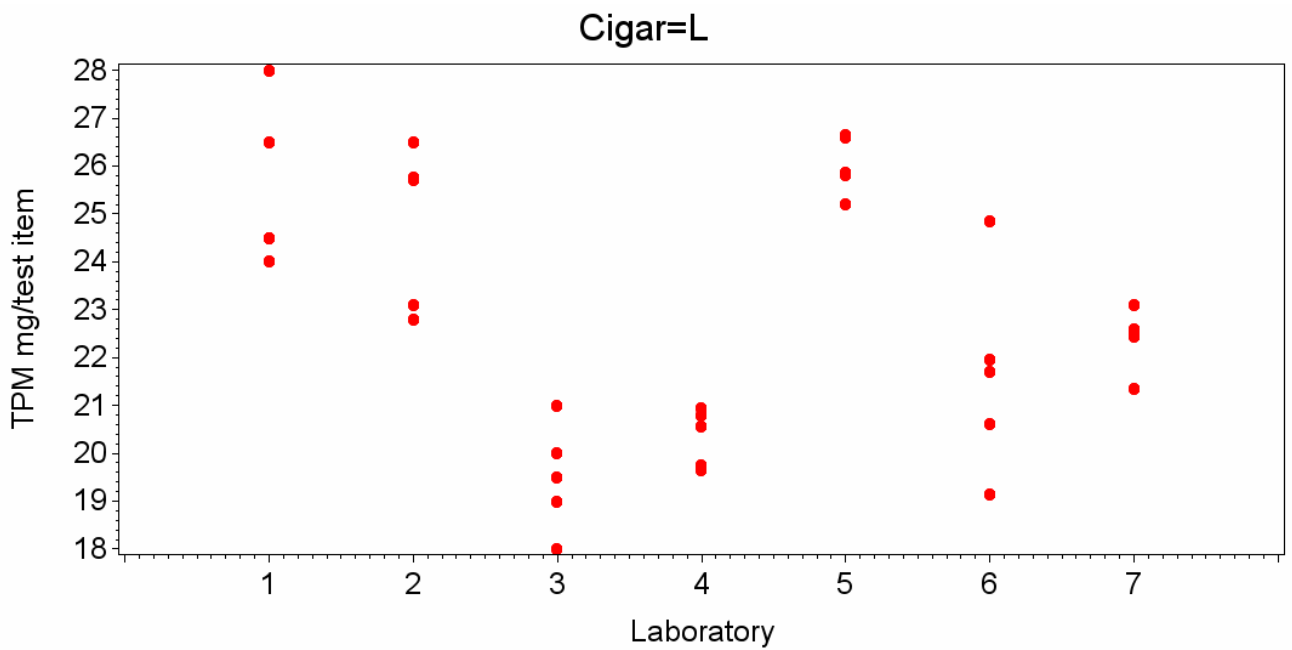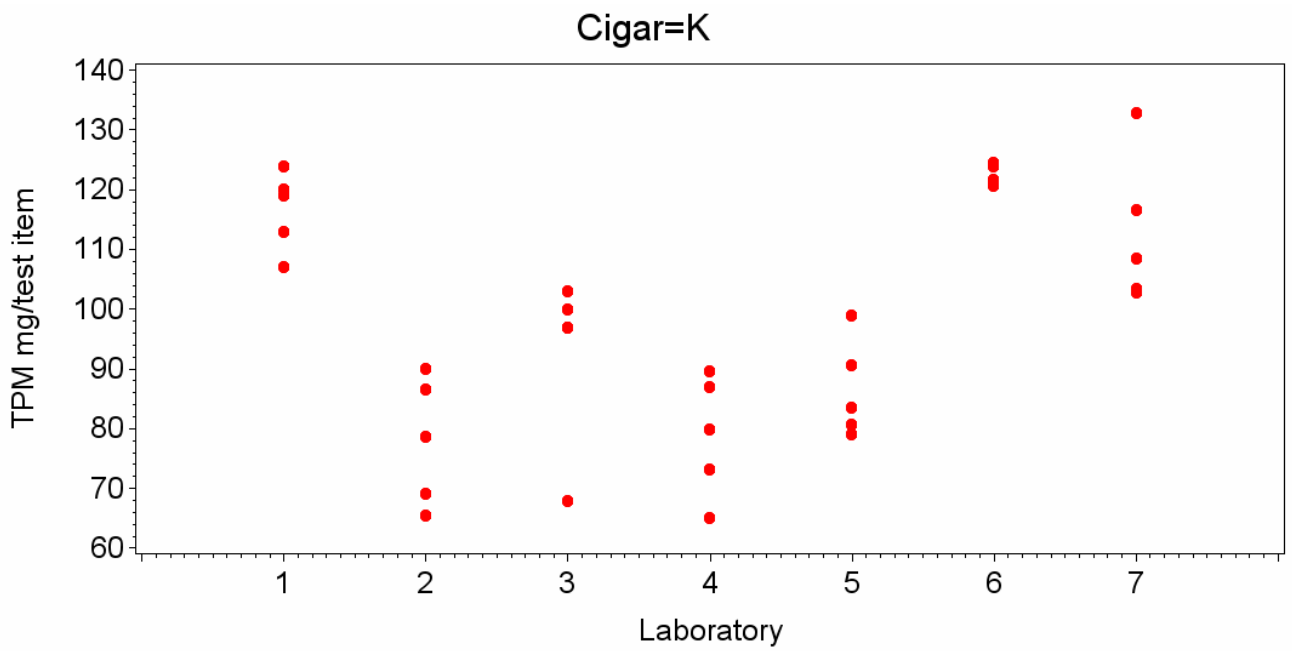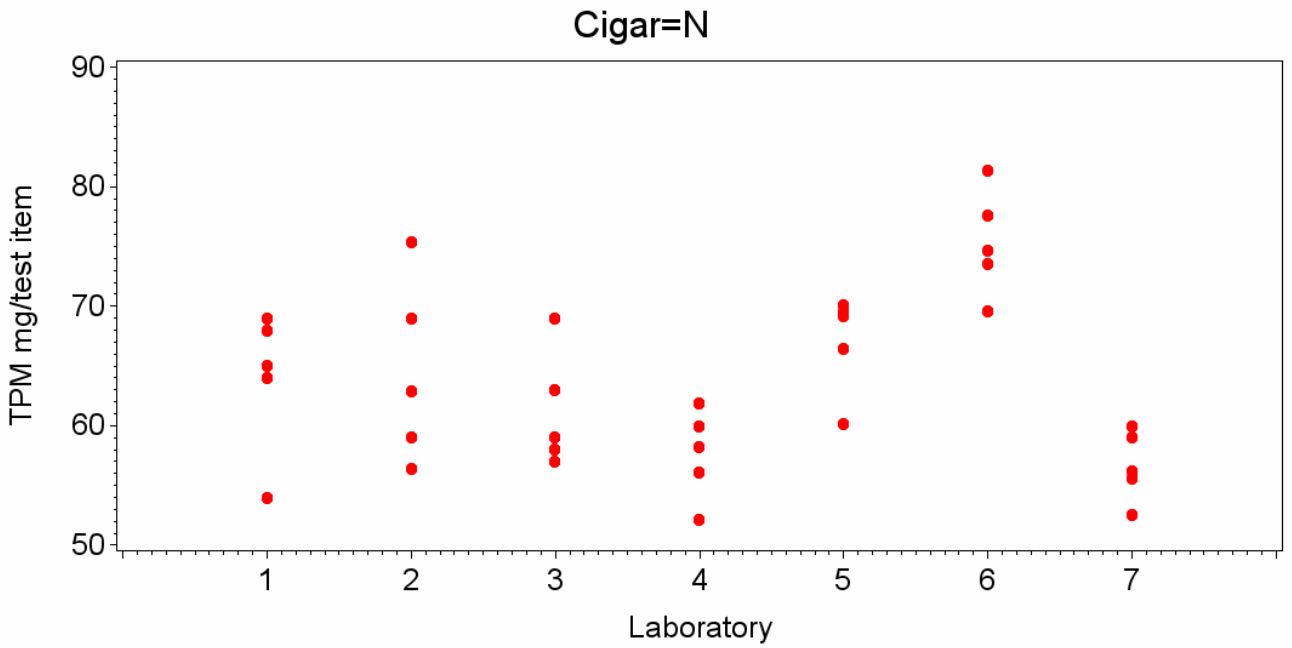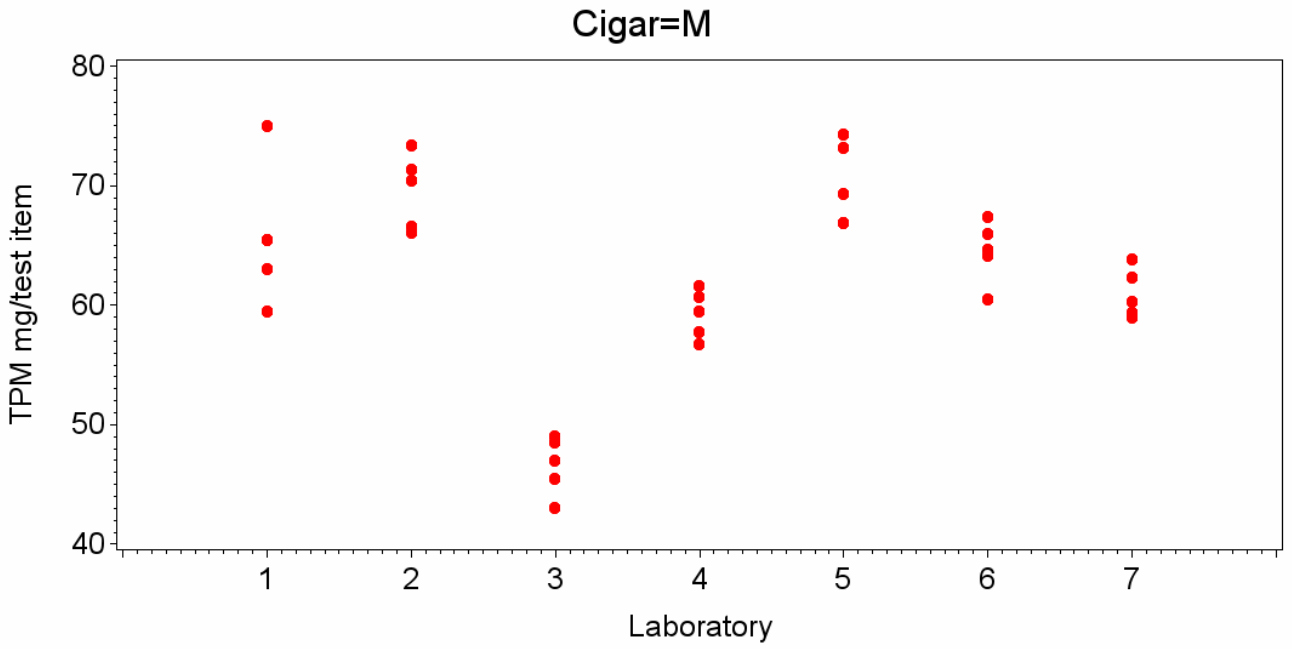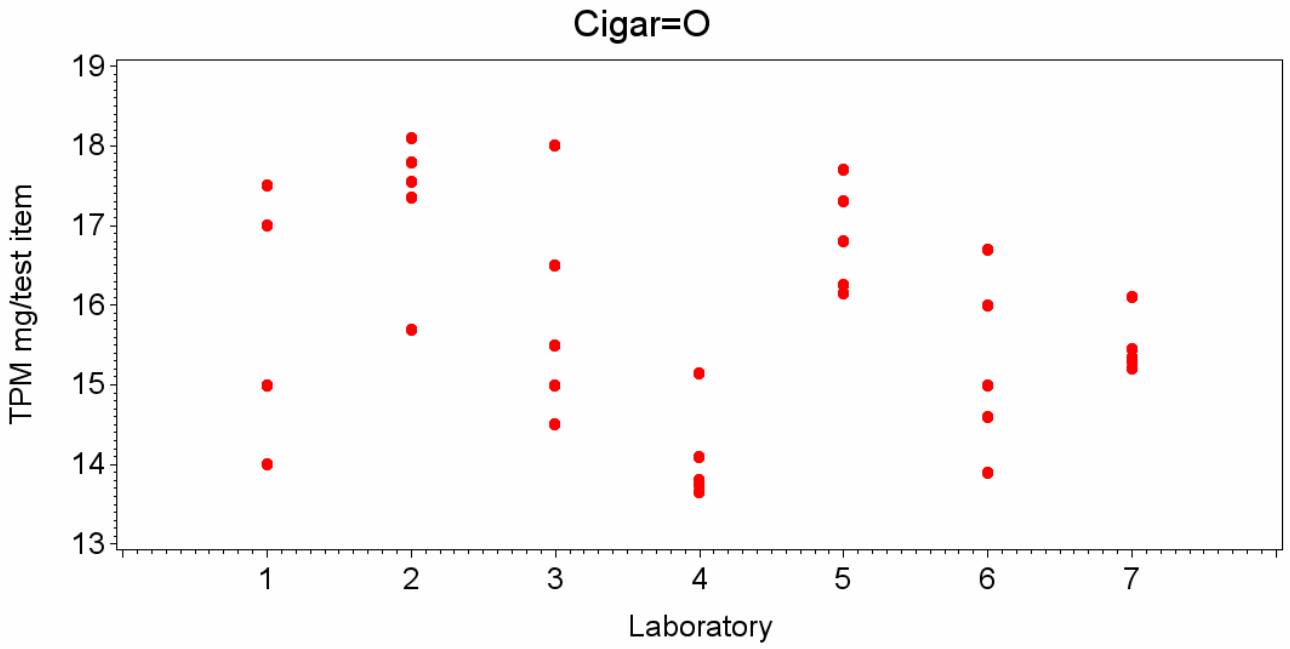
Cigar=N

Cigar=O
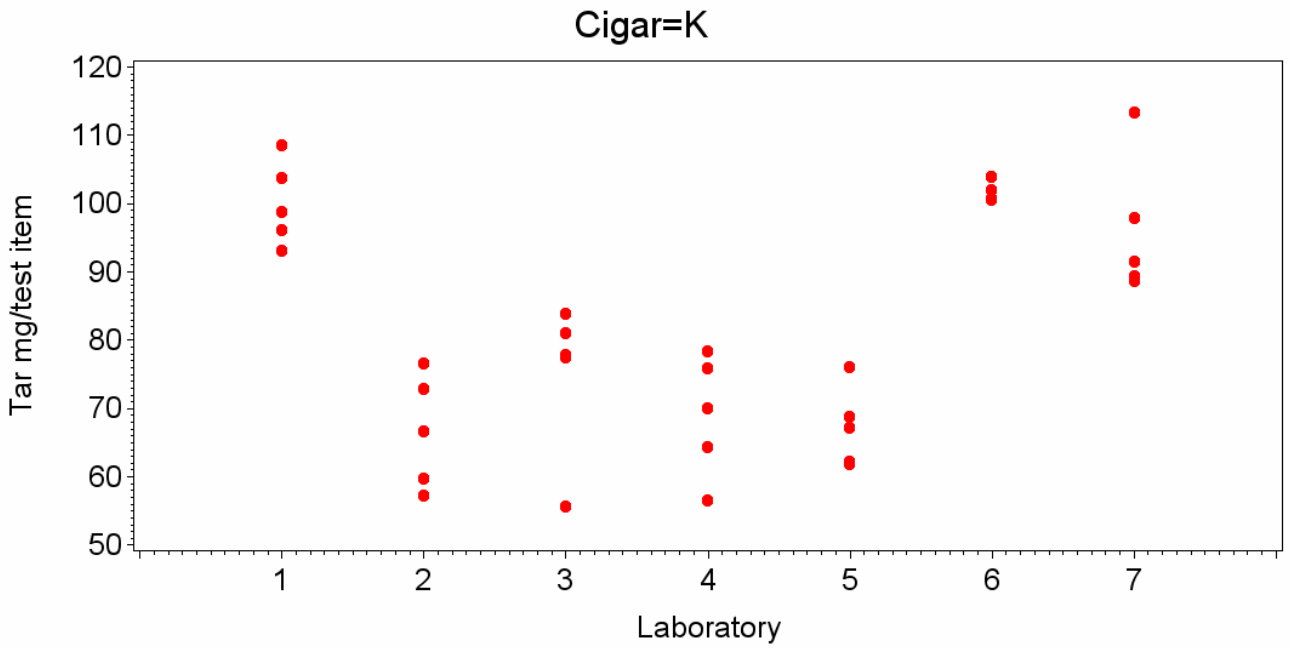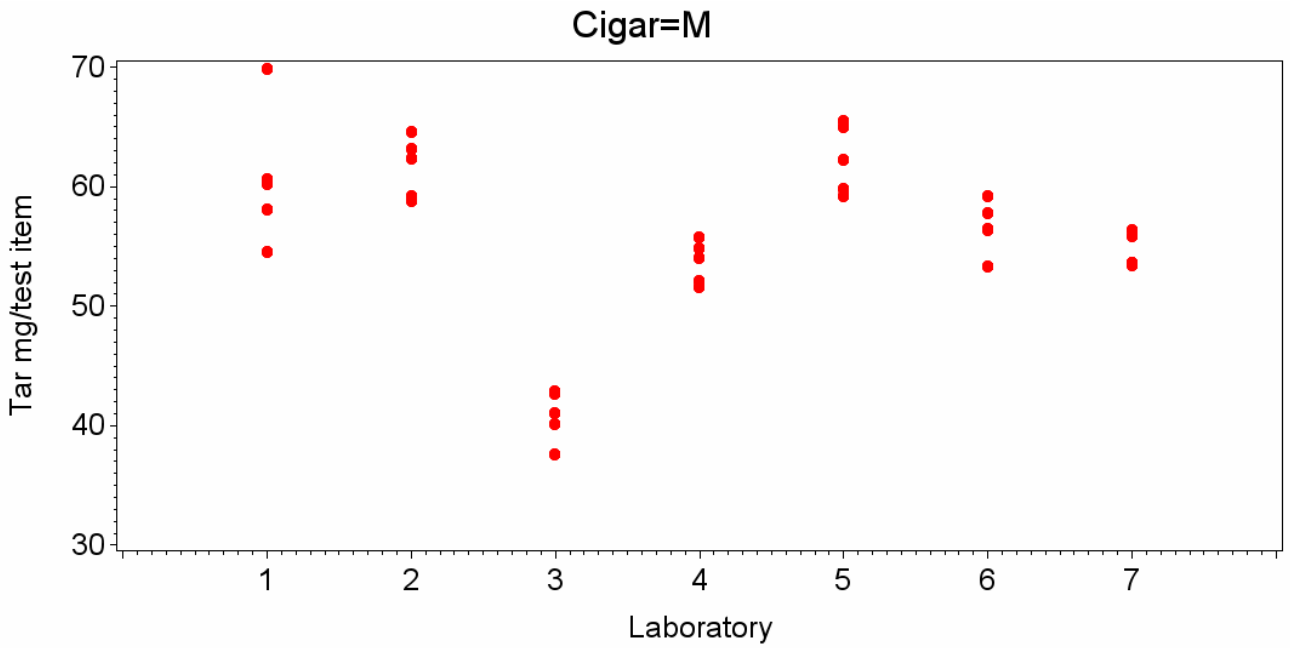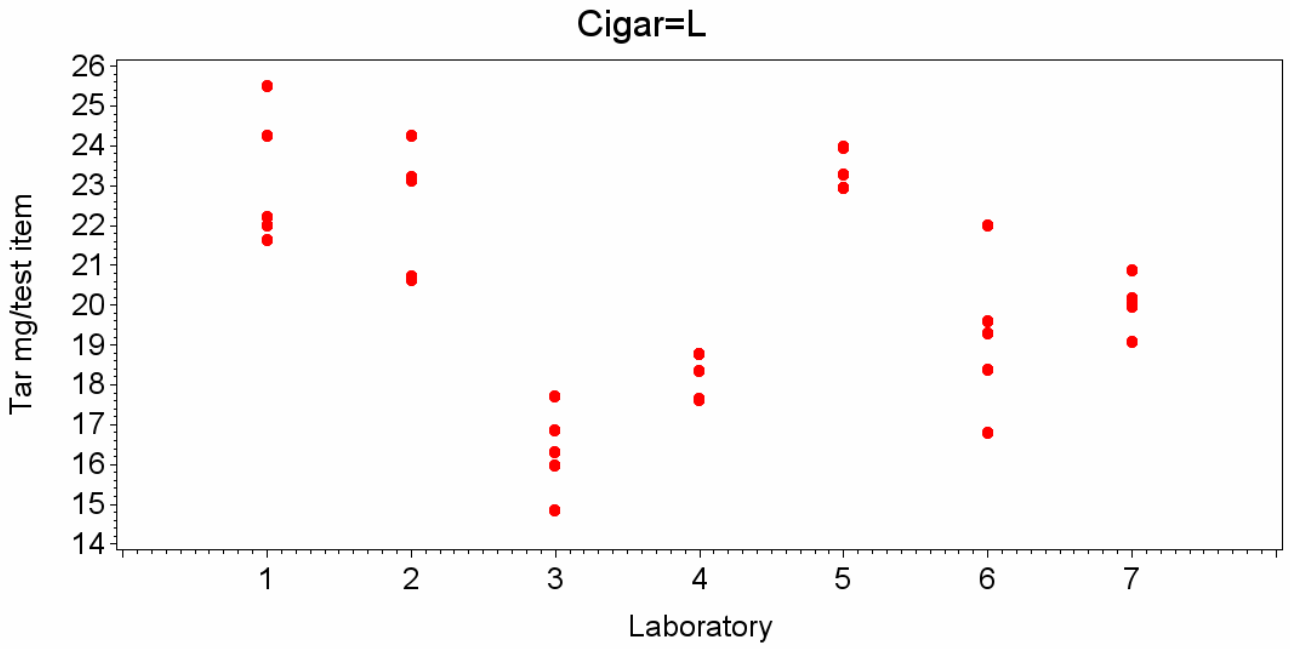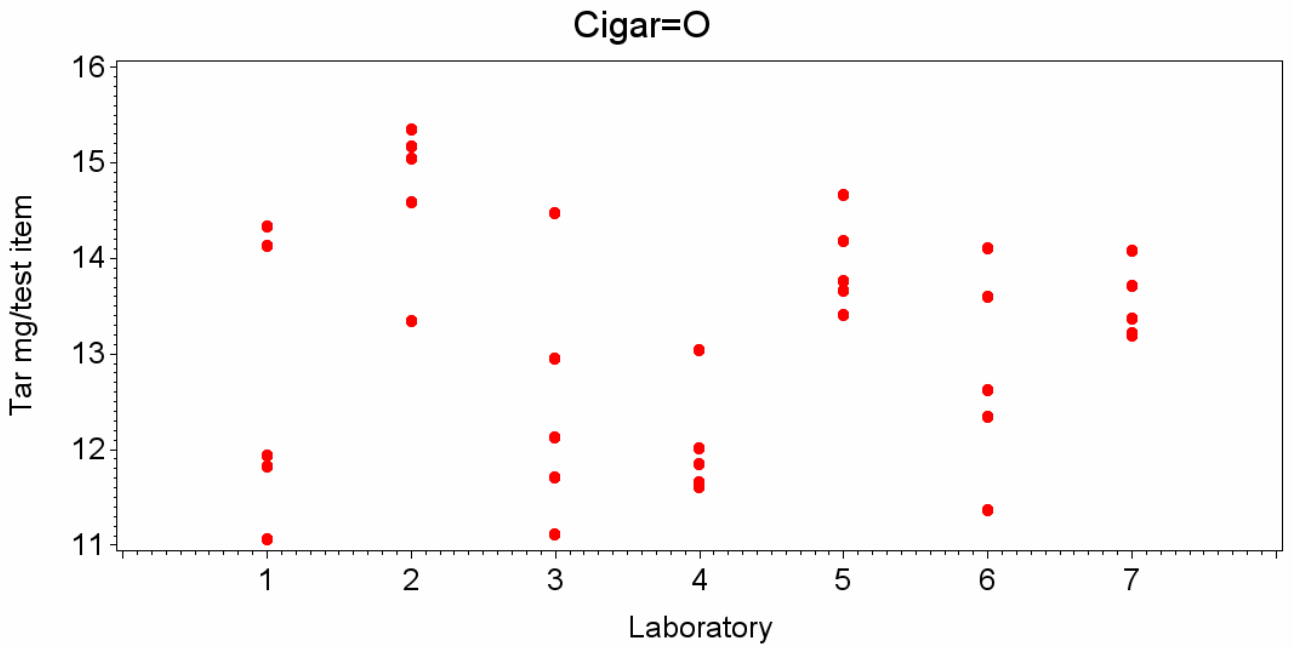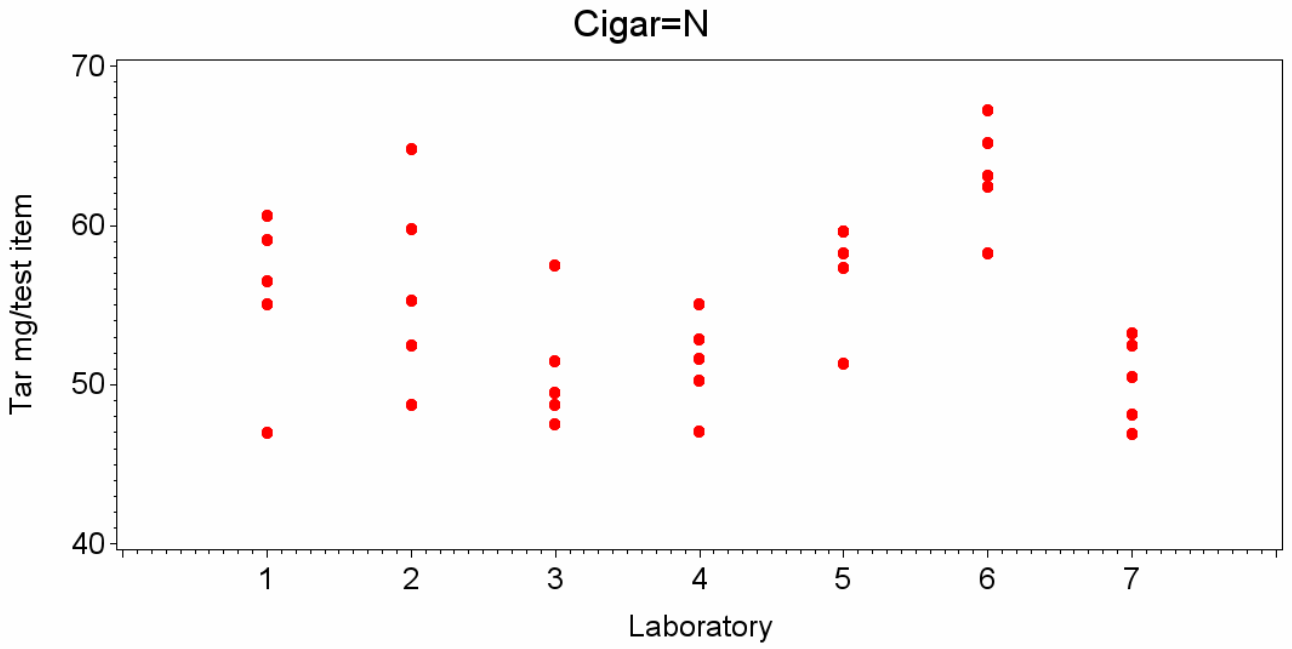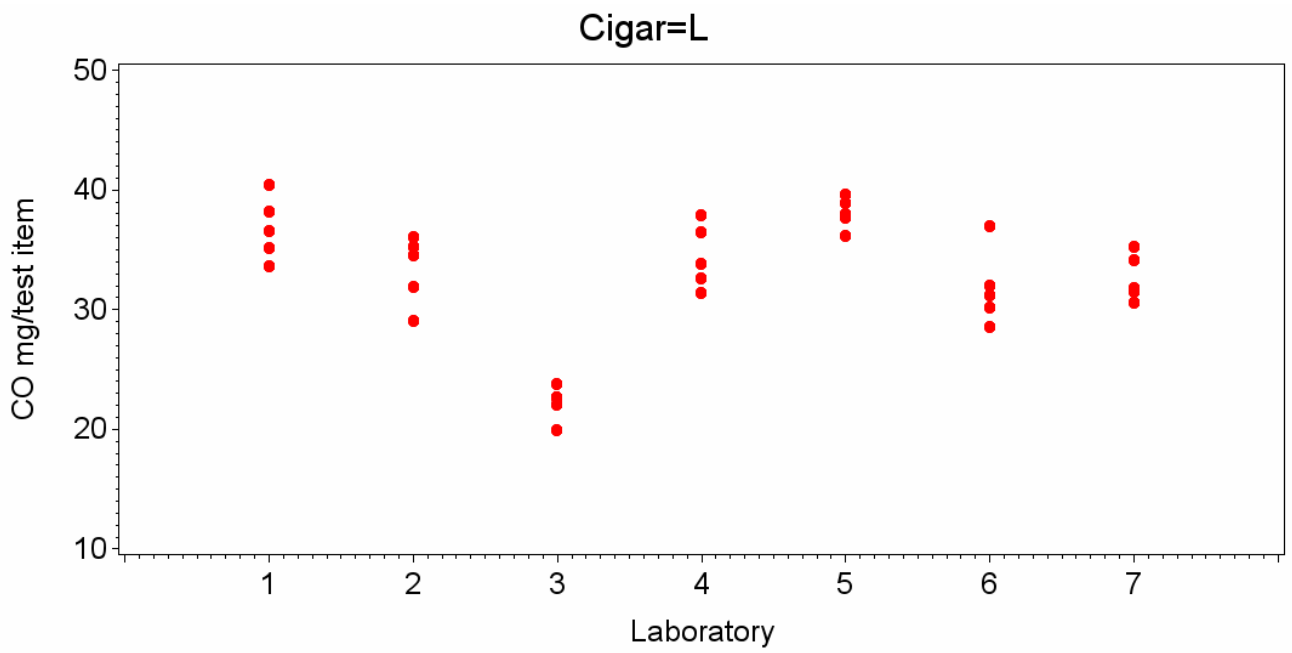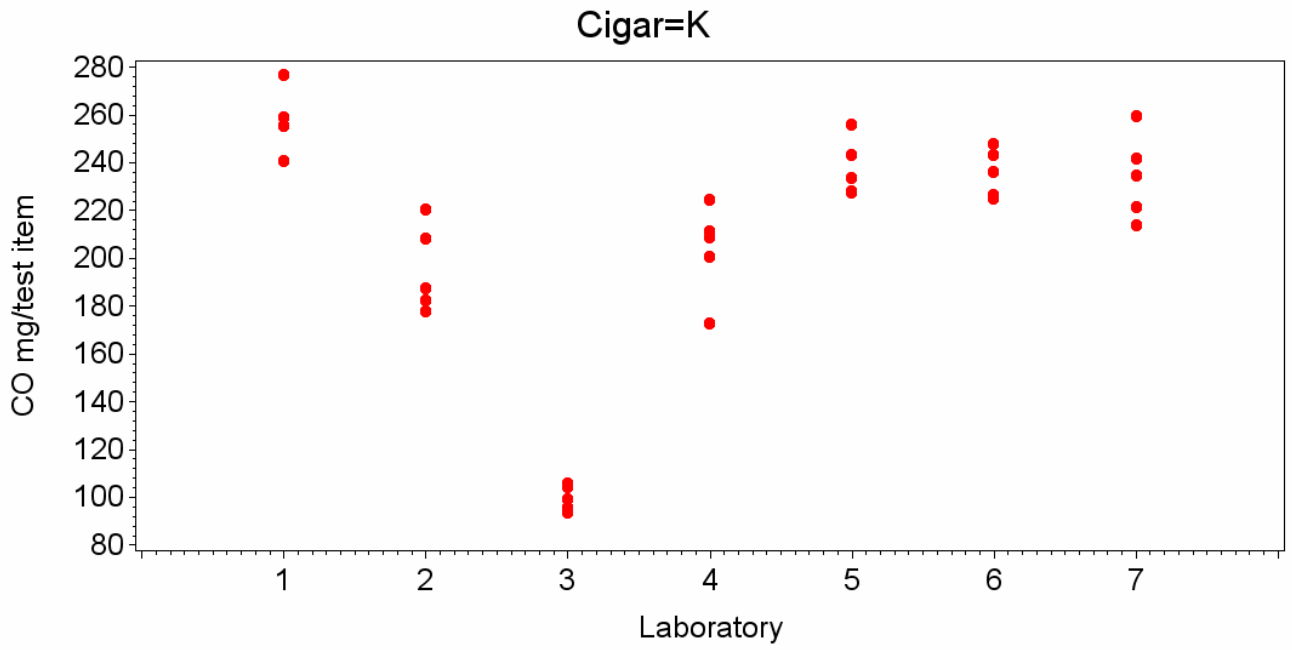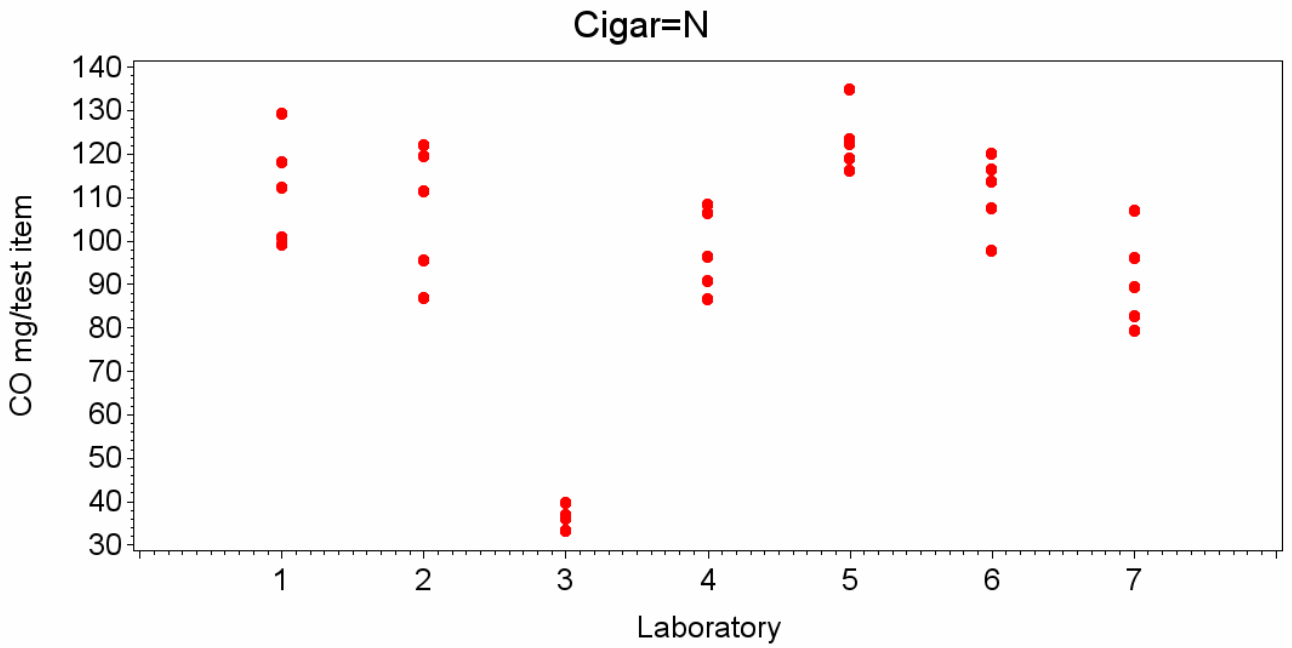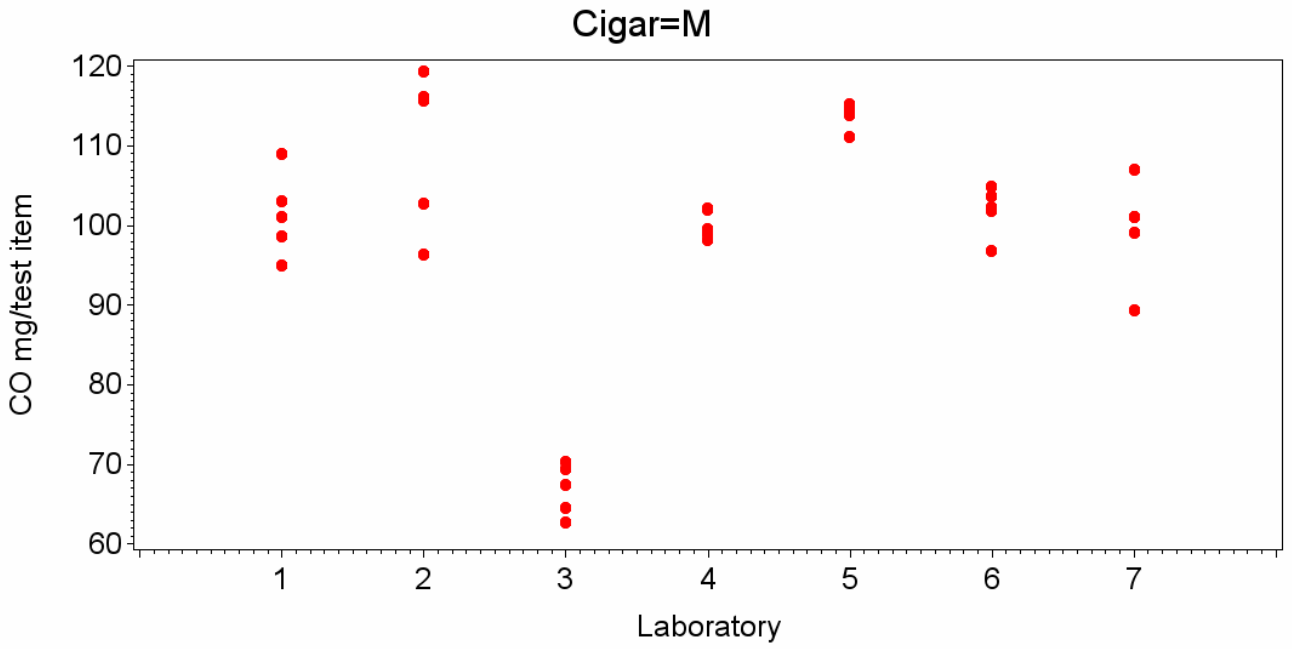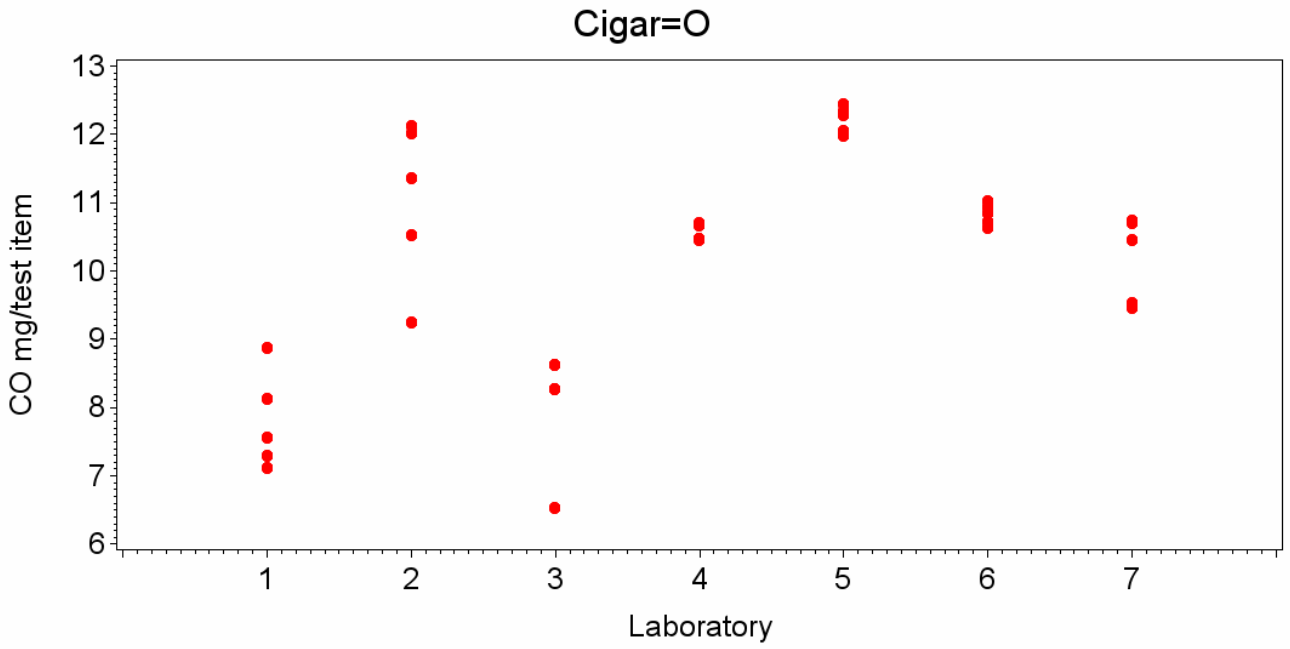
Puff Count
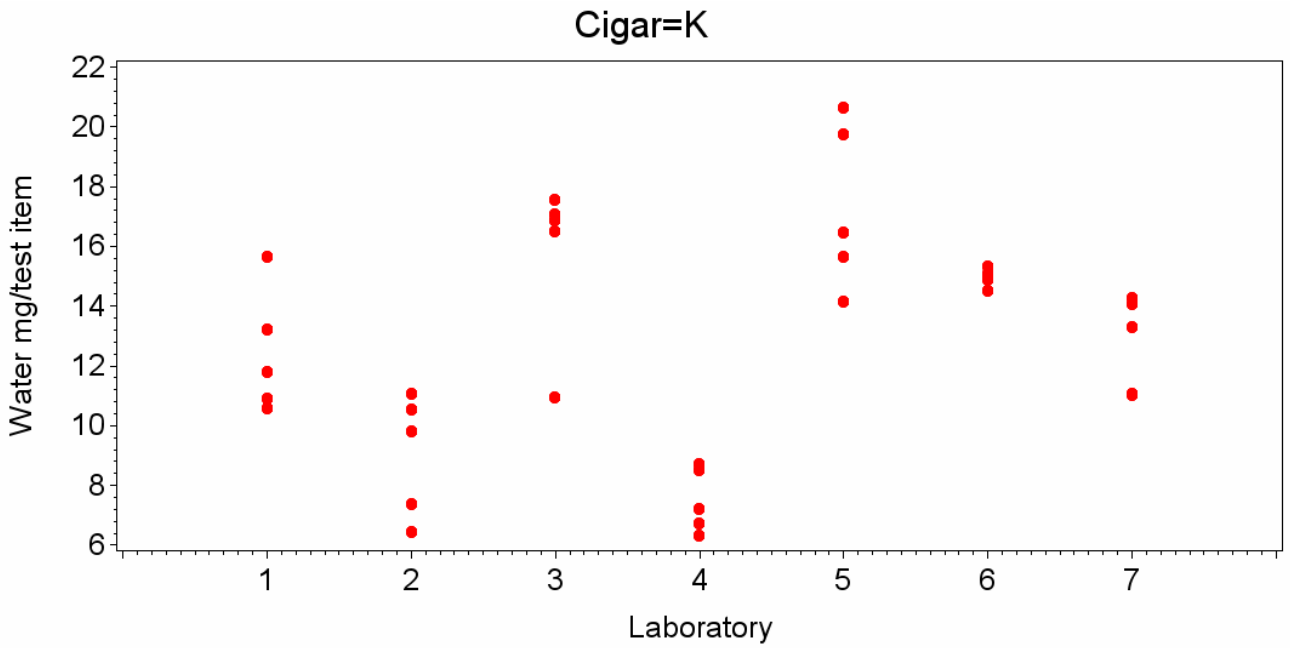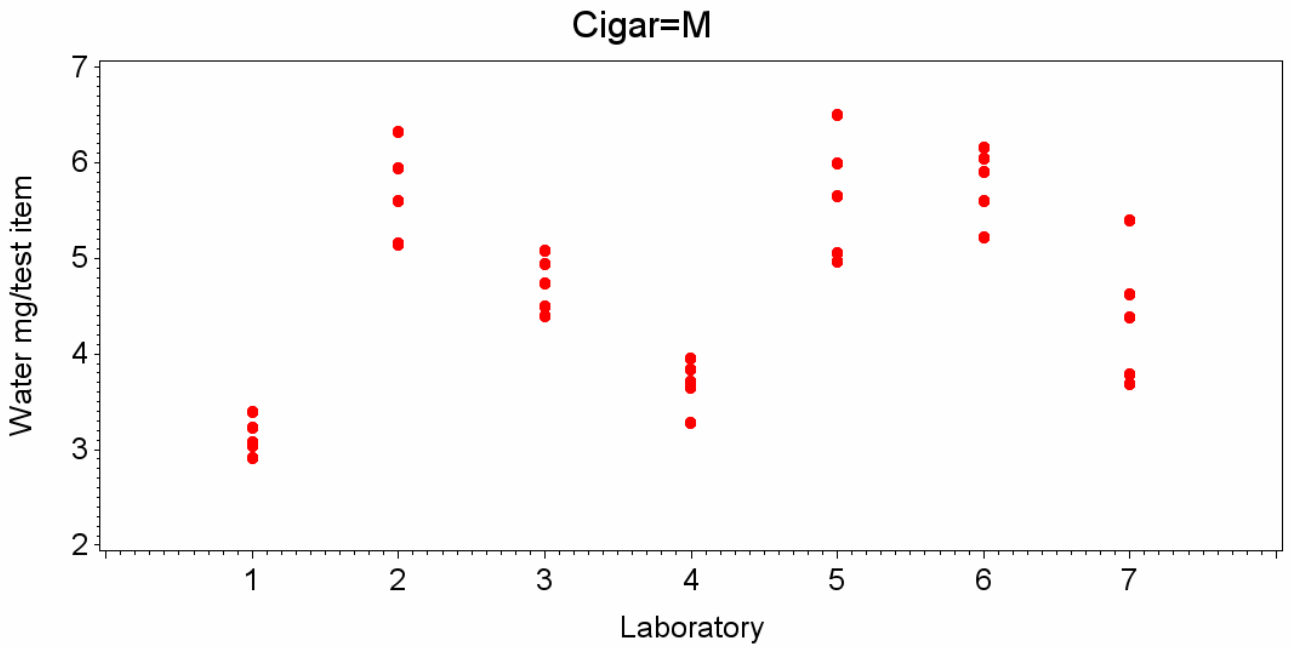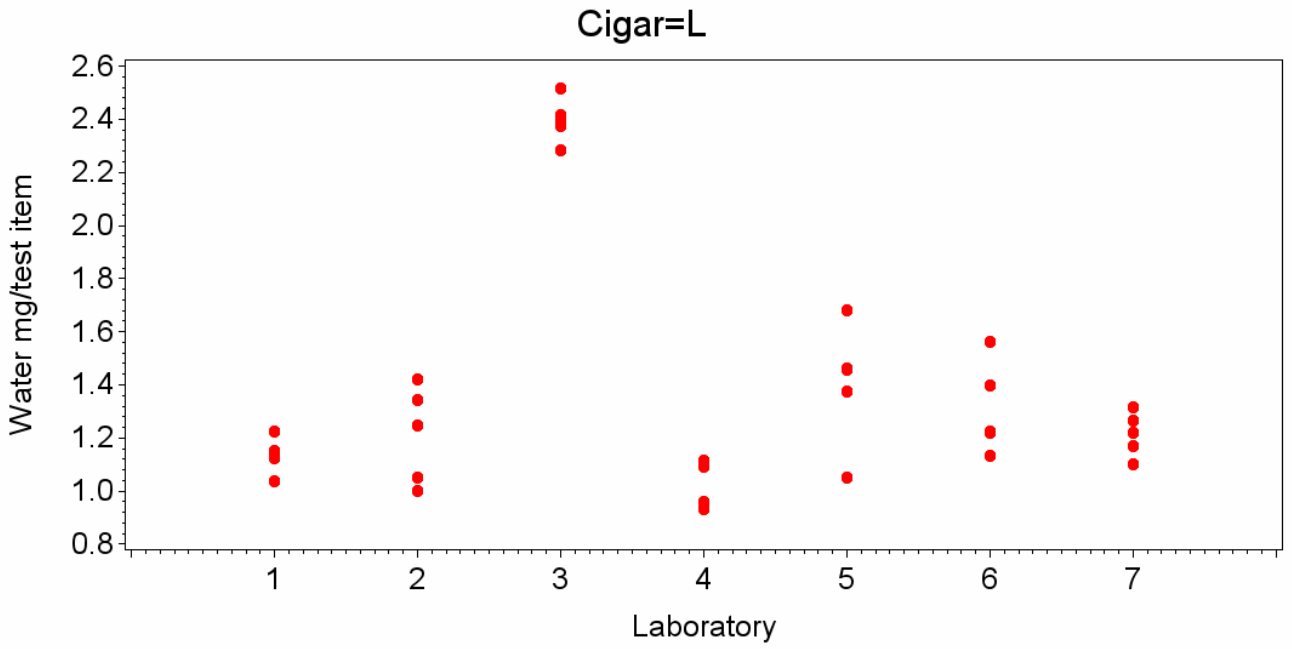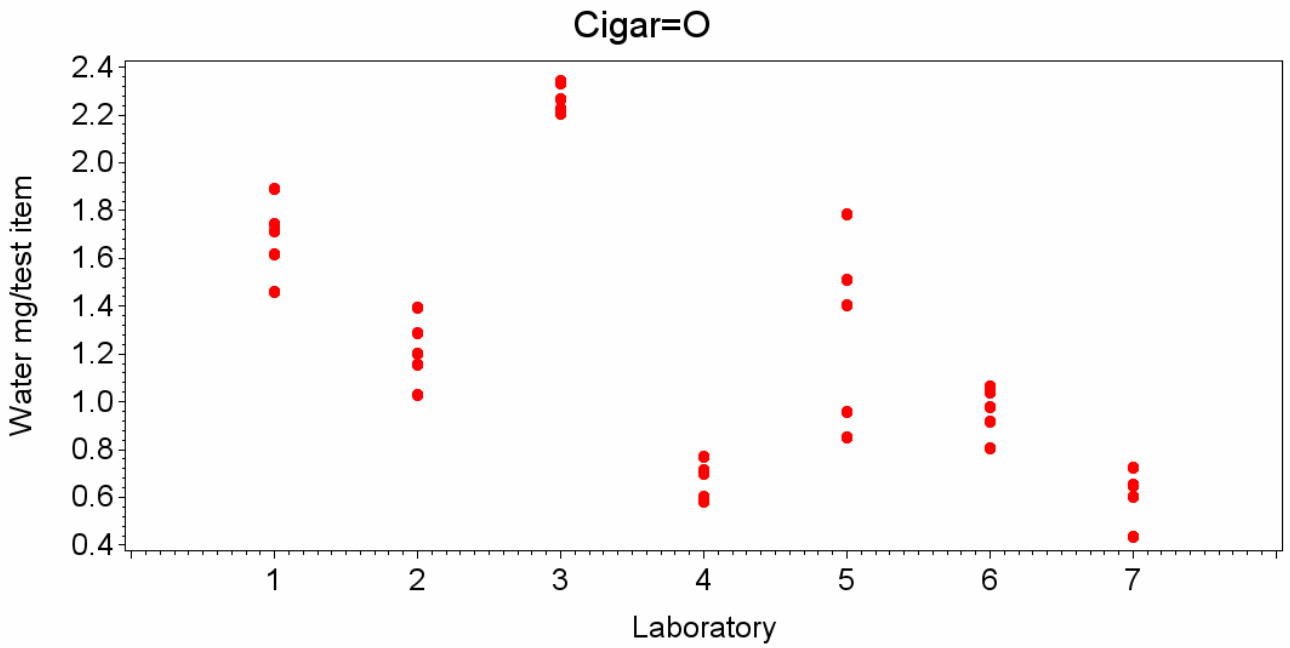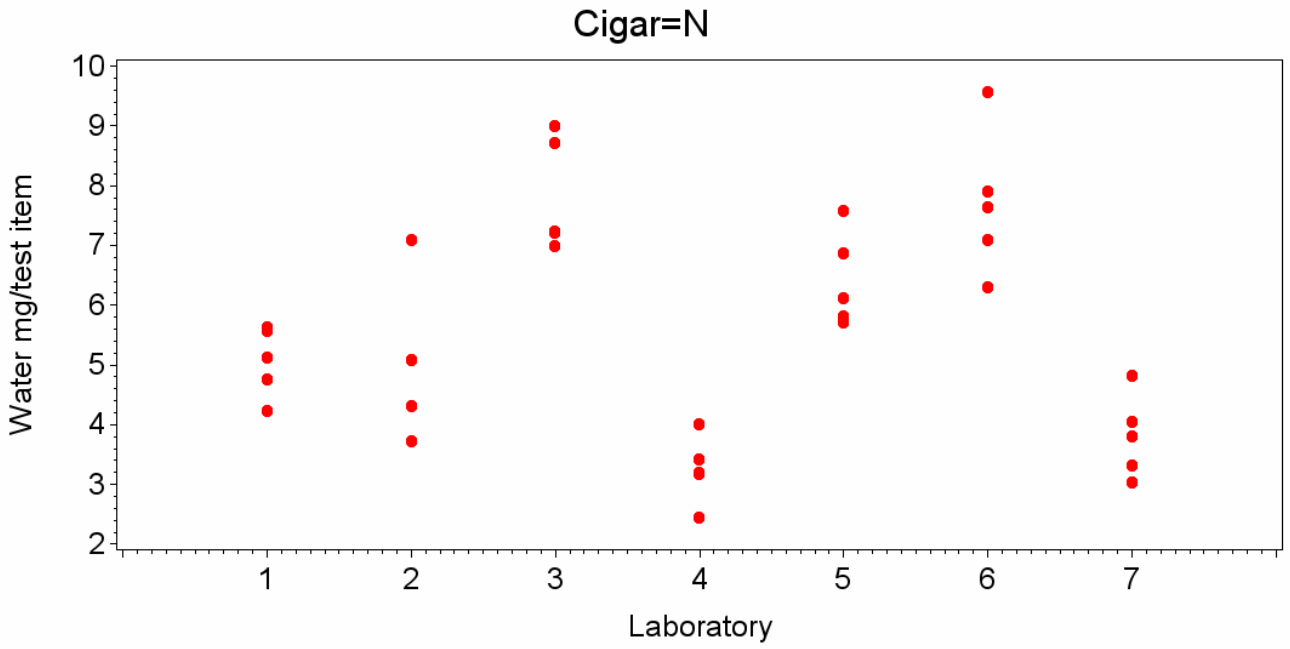
Cigar=K
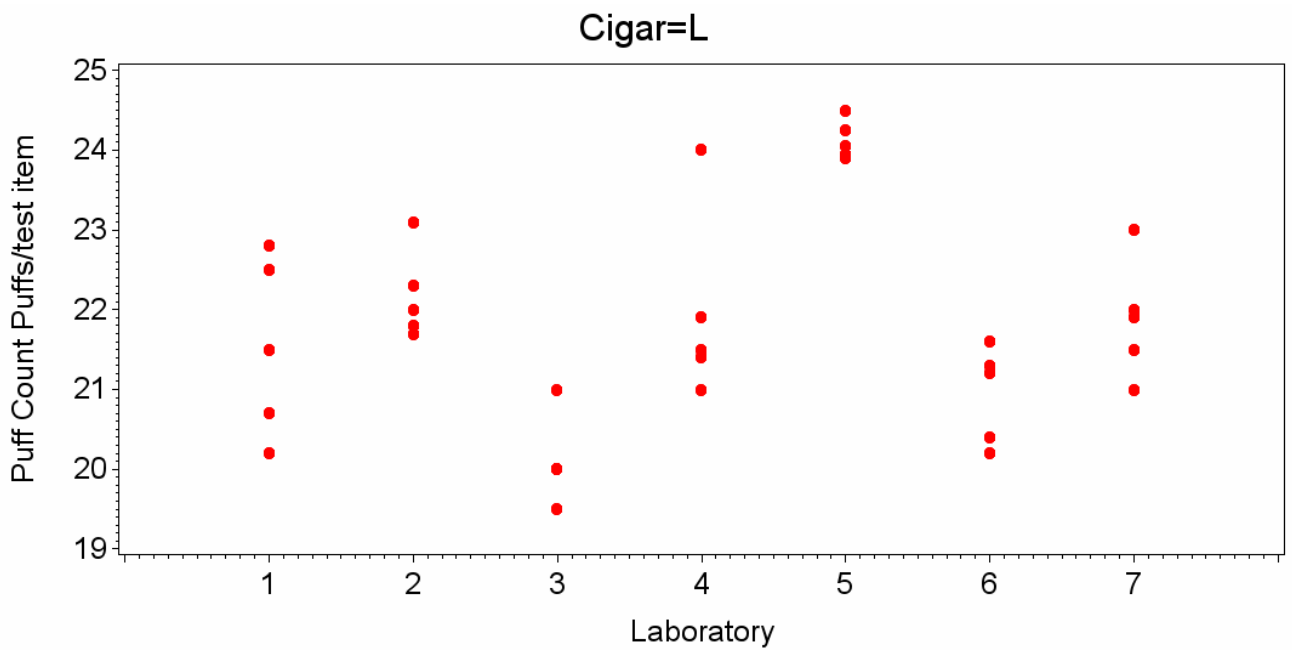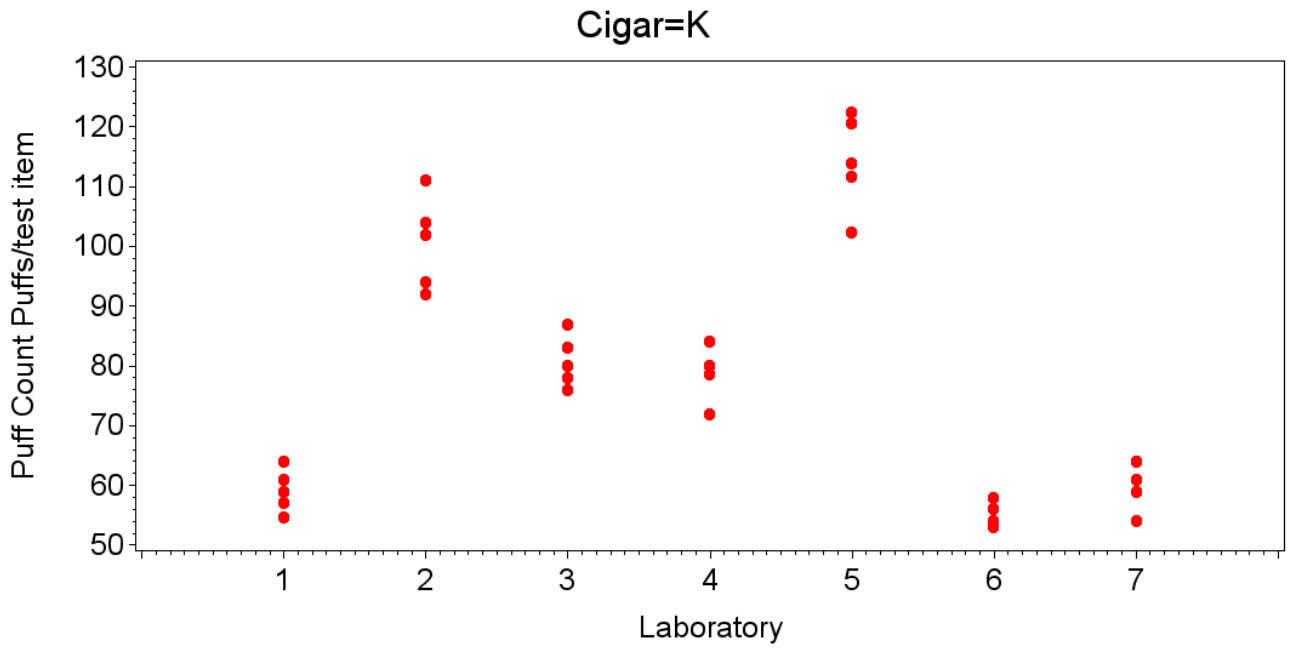
Cigar=L

Cigar=M

Cigar=N

Cigar=O

APPENDIX D – Comparison to the 2020 and 2021 Results

Mean Values

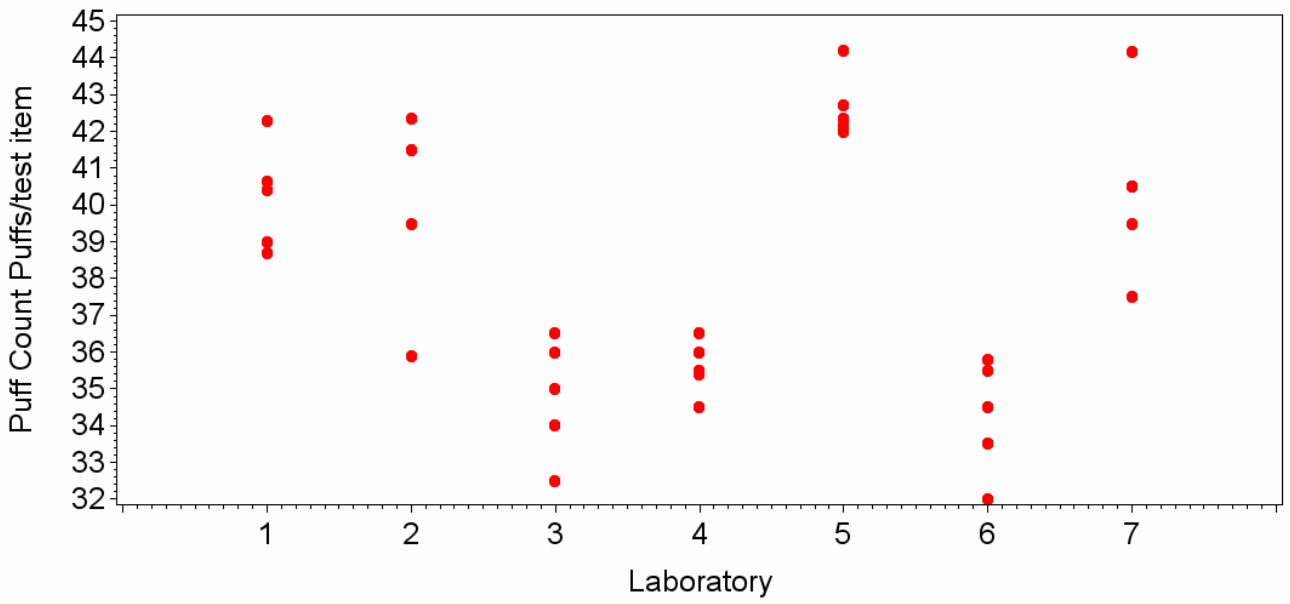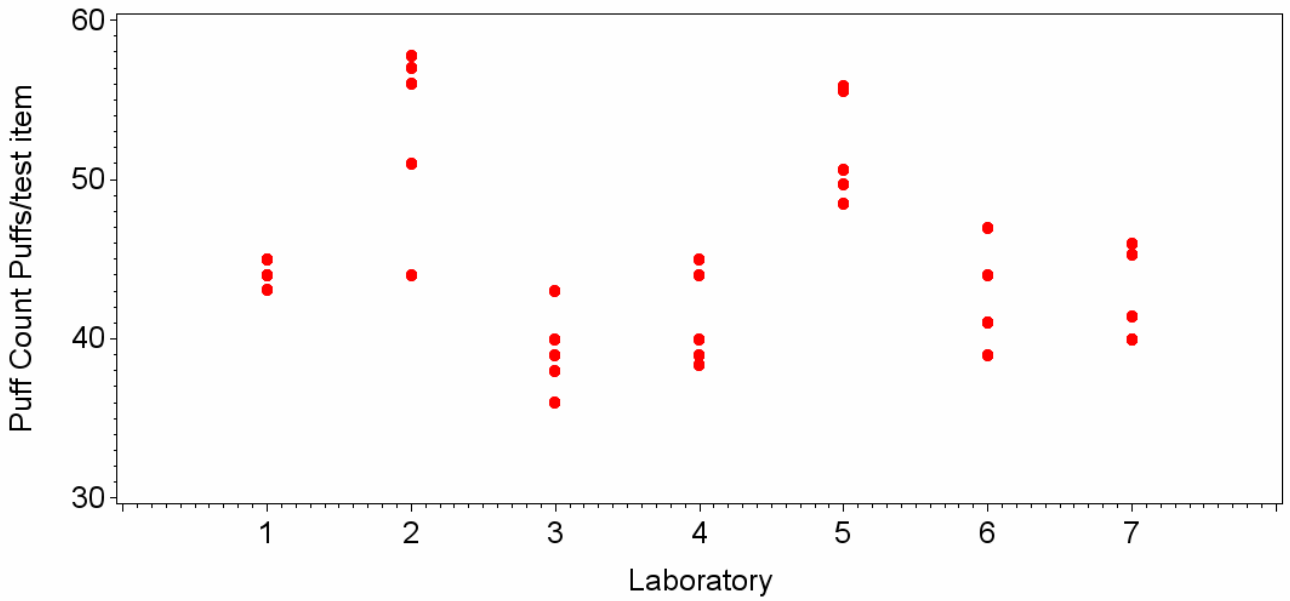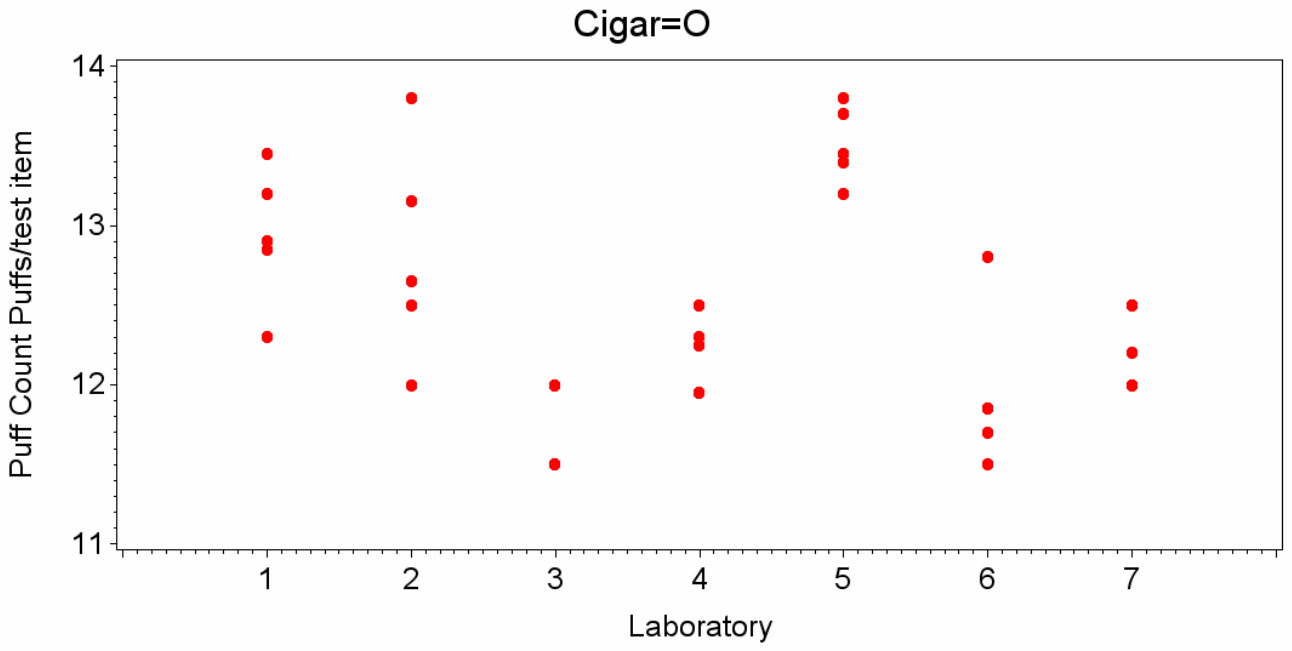| Test Item	Weight (mg/test item)			Nicotine (mg/test item)			TPM (mg/test item)			NFDPM (Tar, mg/test item)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022
K	6521	6493	6273	2,06	2,36	3,08	77,93	92,04	98,3	63,6	76,8	82,4
L	1338	1339	1350	1,06	1,1	1,14	21,99	23,17	22,9	19,4	20,7	20,4
M	2747	2738	2741	1,67	1,91	1,98	59,41	62,24	63,3	53,5	55,9	56,8
N	3132	3170	3134	2,67	3,04	3,15	57,99	62,05	63,5	51,1	54,1	54,8
O	–	942	943	–	1,38	1,39	–	15,52	15,8	–	13,0	13,2

Test Item	Carbon Monoxide (mg/test item)			Water (mg/test item)			Puff Count (puffs/test item)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
K	177	221	218	10,13	12,47	12,83	94,8	86,6	78,5
L	32	33	34	1,41	1,33	1,27	20,7	21,2	21,7
M	96	101	102	4,29	4,39	4,71	35,9	37,2	38,3
N	92	96	103	4,24	4,78	5,59	43,4	44,2	45,0
O	–	10,4	10,1	–	1,06	1,23	–	12,2	12,5

Repeatability Limits (r)

Test Item	Weight (mg/test item)			Nicotine (mg/test item)			TPM (mg/test item)			NFDPM (Tar, mg/test item)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022
K	1008	982	839	0,92	0,88	1,24	26,07	26,07	28,61	22,0	20,3	23,2
L	55	58	58	0,22	0,26	0,17	5,25	5,25	3,71	4,6	3,8	3,6
M	231	214	270	0,22	0,35	0,37	9,1	9,1	8,54	8,1	9,0	7,0
N	246	221	308	1,10	1,00	0,94	18,82	18,82	14,20	15,2	12,2	11,9
O	–	17	36	–	0,17	0,15	–	–	2,91	–	2,4	2,7

Test Item	Carbon Monoxide (mg/test item)			Water (mg/test item)			Puff Count (puffs/test item)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
K	72,5	75,0	41,8	5,65	8,34	5,72	16,1	20,8	41,8
L	9,5	8,3	6,9	0,87	0,66	0,39	2,5	2,3	2,2
M	16,8	13,2	12,5	1,29	1,90	1,30	3,3	3,3	12,5
N	28,3	22,7	29,3	3,15	3,28	2,62	10,3	8,3	29,3
O	–	2,4	1,7	–	0,45	0,36	–	0,7	1,7

Reproducibility Limits (R)

Test Item	Weight (mg/test item)			Nicotine (mg/test item)			TPM (mg/test item)			NFDPM (Tar, mg/test item)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022	2020	2021	2022
K	1503	1038	1449	1,89	1,85	4,06	46,09	57,28	64,34	32,9	103,3	55,9
L	60	61	88	0,69	0,48	0,27	8,71	7,08	8,83	8,1	13,7	9,1
M	244	240	300	1,0	0,56	0,77	17,67	17,32	20,75	16,4	26,2	17,6
N	316	260	308	2,01	2,16	1,95	25,9	29,84	22,01	21,6	58,2	17,2
O	–	29	42	–	0,47	0,44	–	5,19	4,24	–	4,9	3,8

Test Item	Carbon Monoxide (mg/test item)			Water (mg/test item)			Puff Count (puffs/test item)		
	2020	2021	2022	2020	2021	2022	2020	2021	2022
K	128,0	103,3	108,8	11,00	11,57	12,43	81,6	69,3	72,2
L	12,5	13,7	12,4	1,14	0,97	0,69	4,5	4,5	3,9
M	30,6	26,2	28,5	2,26	2,75	3,51	6,4	6,2	11,5
N	38,6	58,2	56,3	6,15	7,17	6,17	12,2	13,3	19,0
O	–	4,9	5,3	–	1,11	1,81	–	2,8	2,2