About Validation of a Method for the Determination of Volatile Compounds in Spirituous Beverages Using Contained Ethanol as a Reference Substance

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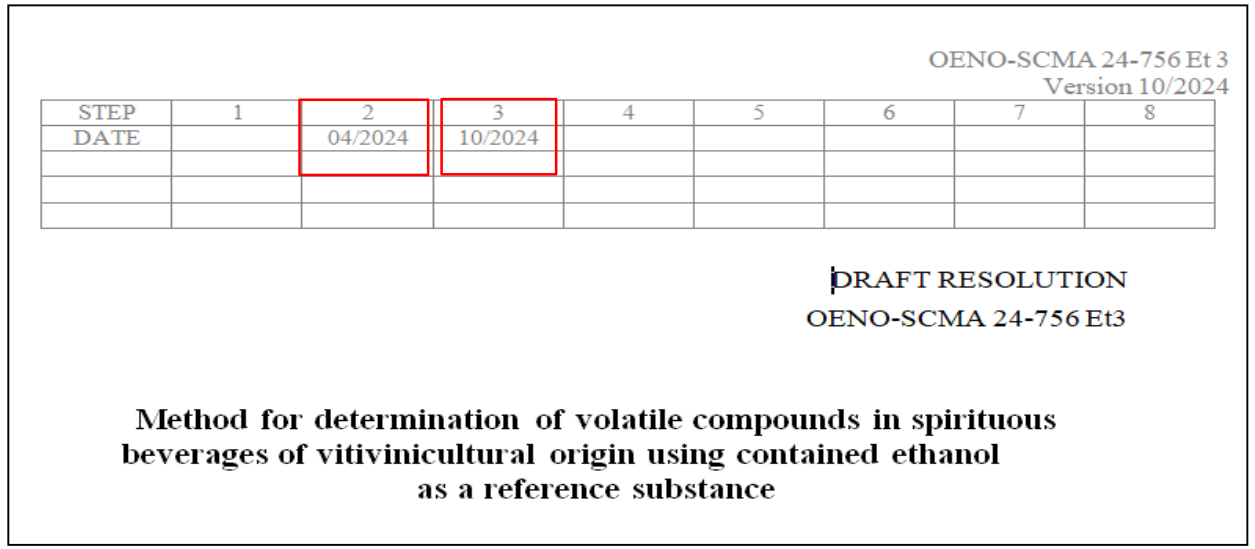
67th Session of the Sub-Commission Methods of Analysis

Proposal of the Russian Federation for new work on

«Method for determination of volatile compounds in spirituous beverages of vitivinicultural origin using contained ethanol as a reference substance»

Project presentation
Saturday 6th April 2024

The new approach has been proposed for standardization as an official OIV method of analysis, and is currently under consideration as draft resolution OENO-SCMA 24-756 “Method for determination of volatile compounds in spirituous beverages of vitivinicultural origin using contained ethanol as a reference substance”.

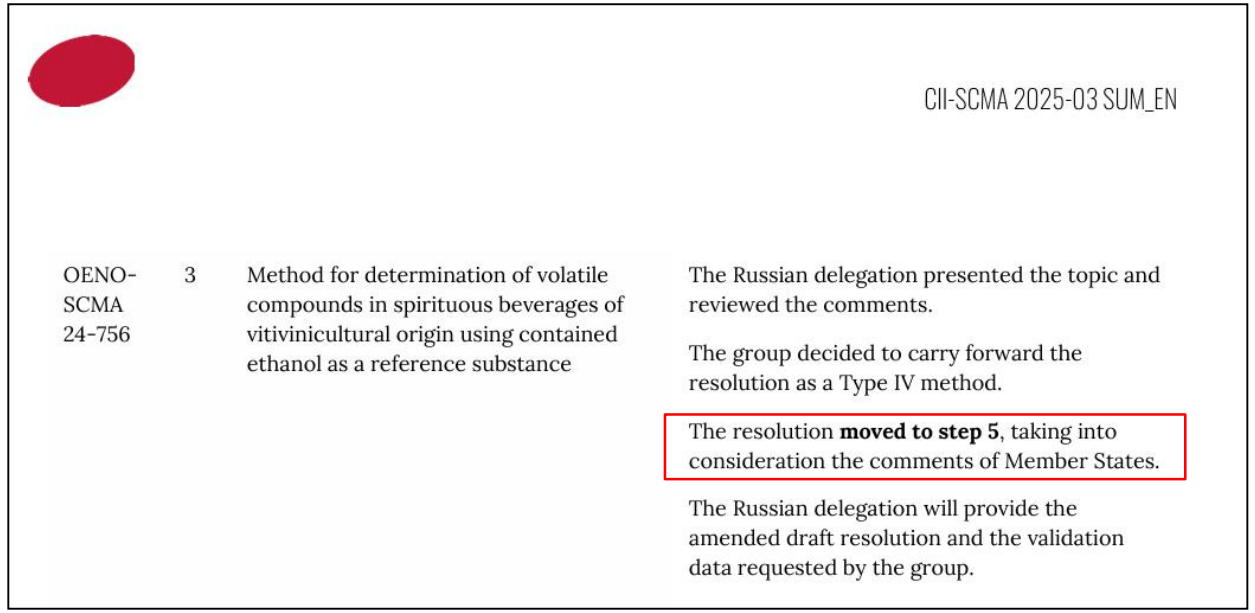


OENO-SCMA 24-756 Et 3
Version 10/2024

STEP	1	2	3	4	5	6	7	8
DATE		04/2024	10/2024					

DRAFT RESOLUTION
OENO-SCMA 24-756 Et3

Method for determination of volatile compounds in spirituous beverages of vitivinicultural origin using contained ethanol as a reference substance



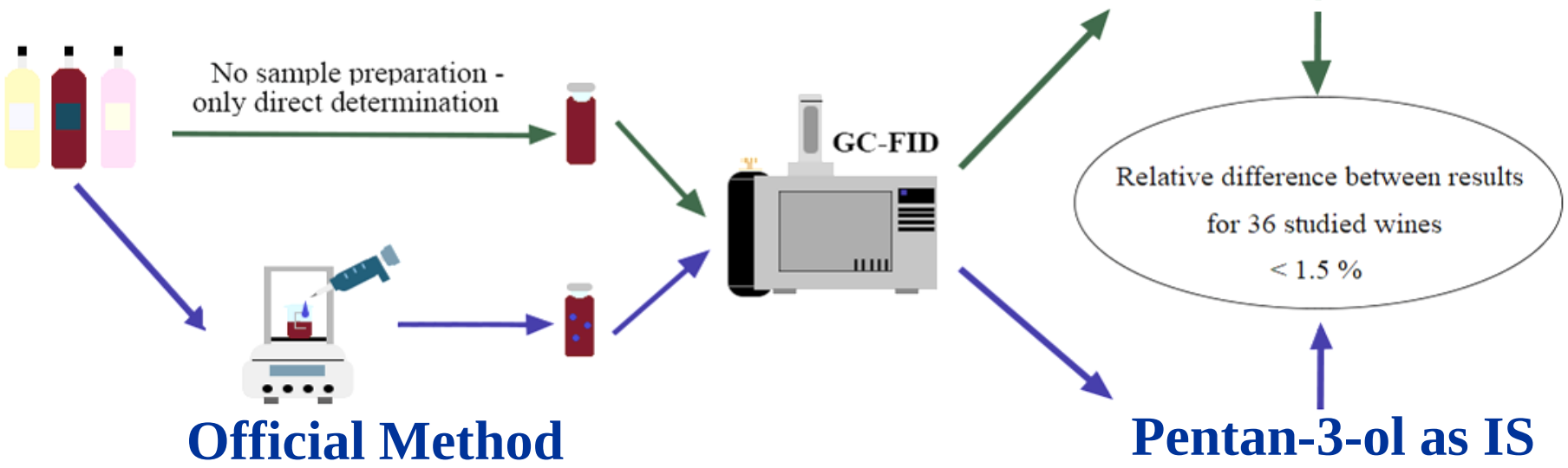
CII-SCMA 2025-03 SUM_EN

OENO-SCMA 24-756	3	Method for determination of volatile compounds in spirituous beverages of vitivinicultural origin using contained ethanol as a reference substance	The Russian delegation presented the topic and reviewed the comments. The group decided to carry forward the resolution as a Type IV method. The resolution **moved to step 5**, taking into consideration the comments of Member States. The Russian delegation will provide the amended draft resolution and the validation data requested by the group.

➢ **The method for the determination of volatile compounds in spirituous beverages from grapes or other plant raw materials using ETHANOL as a reference substance (RS) was proposed firstly in 2013**

New Method

Ethanol as Reference Substance (EthRS)



Its quintessence is: to use ETHANOL as RS for the analysis of an alcohol product in order to increase the accuracy of measurements and to obviate the need for the IS addition because ethanol is contained in the sample in any case

The advantages of new method using ETHANOL as a reference substance (RS)

- the absence of the need to measure the strength of the analyzed sample
- the concentration of volatile impurities is calculated based on measurements directly in units of g/100 L of anhydrous alcohol (g/100 L AA) or mg/L of anhydrous alcohol (mg/L AA)
- method is suitable for the determination of a broad set of volatile substances with an analyte content from 0.2 g/100 L AA upto 1500 g/100 L AA in spirits produced from grapes, wines and other alcohol-containing products

Since 2013, new method has undergone comprehensive testing and validation on wide range of alcoholic beverages as well as other alcohol-containing products


Single-Laboratory Validation of a Gas Chromatographic Method of Direct Determination of Volatile Compounds in Spirit Drinks: Need for an Improved Interlaboratory Study


Interlaboratory study of ethanol usage as an internal standard in direct determination of volatile compounds in alcoholic products


The Method for Direct Gas Chromatographic Determination of Acetaldehyde, Methanol, and Other Volatiles Using Ethanol as a Reference Substance: Application for a Wide Range of Alcoholic Beverages

- Firstly, validation of the method for alcoholic beverages was performed in the single laboratory

  S.V. Charapitsa, S.N. Sytova, A.L. Korban, L.N. Sobolenko, J. AOAC Int., ***102****, 669-672 (2019)*

- Then some interlaboratory study was carried out

  S. Charapitsa, S. Sytova, A. Korban, L. Sobolenko, V. Egorov, S. Leschev, M. Zakharov, R. Čabala, R. Busarova, I. Shestakovich, A. Tolstouhova, S. Ondroušek, J. Vávra, M. Yilmaztekin, T. Cabaroglu, BIO Web Conf., ***15****, 02030 (2019)*

- The developed method was tested across a variety of compounds, demonstrating improved detection and quantification limits compared to the official method

  S. Charapitsa, S. et al, Food Control., ***120****, 107528 (2021)*

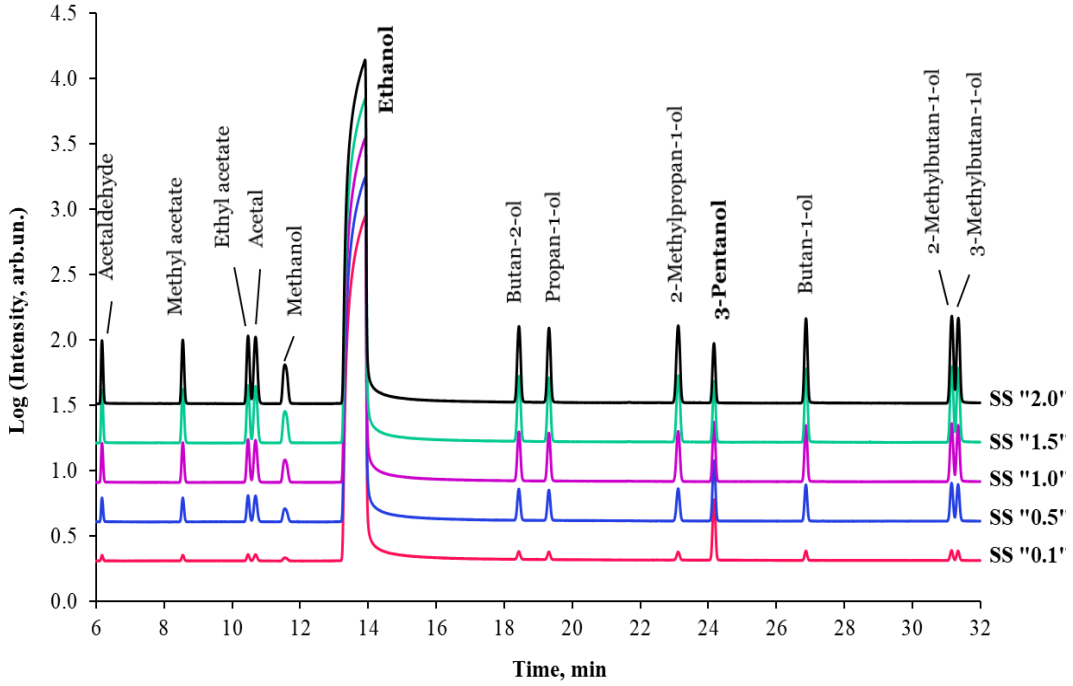
  S. Charapitsa, et al, J. Food Composition. Analysis, ***114****, 104772 (2022)*

The problem considered in the work is how one can do validation of the new method using contained ethanol as a RS on the basis of archived experimental data (chromatograms)

- archived data can be taken from analysis of an alcoholic beverage samples by the Commission Regulation EC2870/2000 method using internal standard pentan-3-ol or other internal standards.
- the external standard (ES) method is applied in many laboratories in a number of countries and the data obtained by the ES method can also be recalculated by the new method using ethanol as an internal standard.

It necessary to note: when performing any analysis, modern gas chromatographs register all component peaks in the sample including the peak of ethanol;
no other measurements or manual procedures except those indicated in standards are required.

The description of the validation of the proposed method is based on data obtained earlier in the testing laboratory during the validation of the method in accordance with regulation EC2870/2000



The certified values of concentration of the compounds in units of **µg/g**

Table 1

Compound	"0.1"	"0.5"	"1.0"	"1.5"	"2.0"
acetaldehyde	19.2	95.7	181	278	372
methyl acetate	30.7	152	288	443	592
ethyl acetate	27.7	138	260	400	535
acetal	24.9	124	233	359	480
methanol	21.6	108	203	312	418
2-butanol	22.4	111	210	323	432
n-propanol	21.8	108	204	314	420
2-methylpropan-1-ol	21.3	106	200	308	412
n-butanol	22.3	111	210	322	431
2-methylbutan-1-ol	23.1	115	217	333	446
3-methylbutan-1-ol	22.1	110	208	320	428

and in units of **mg/L AA**

Table 2

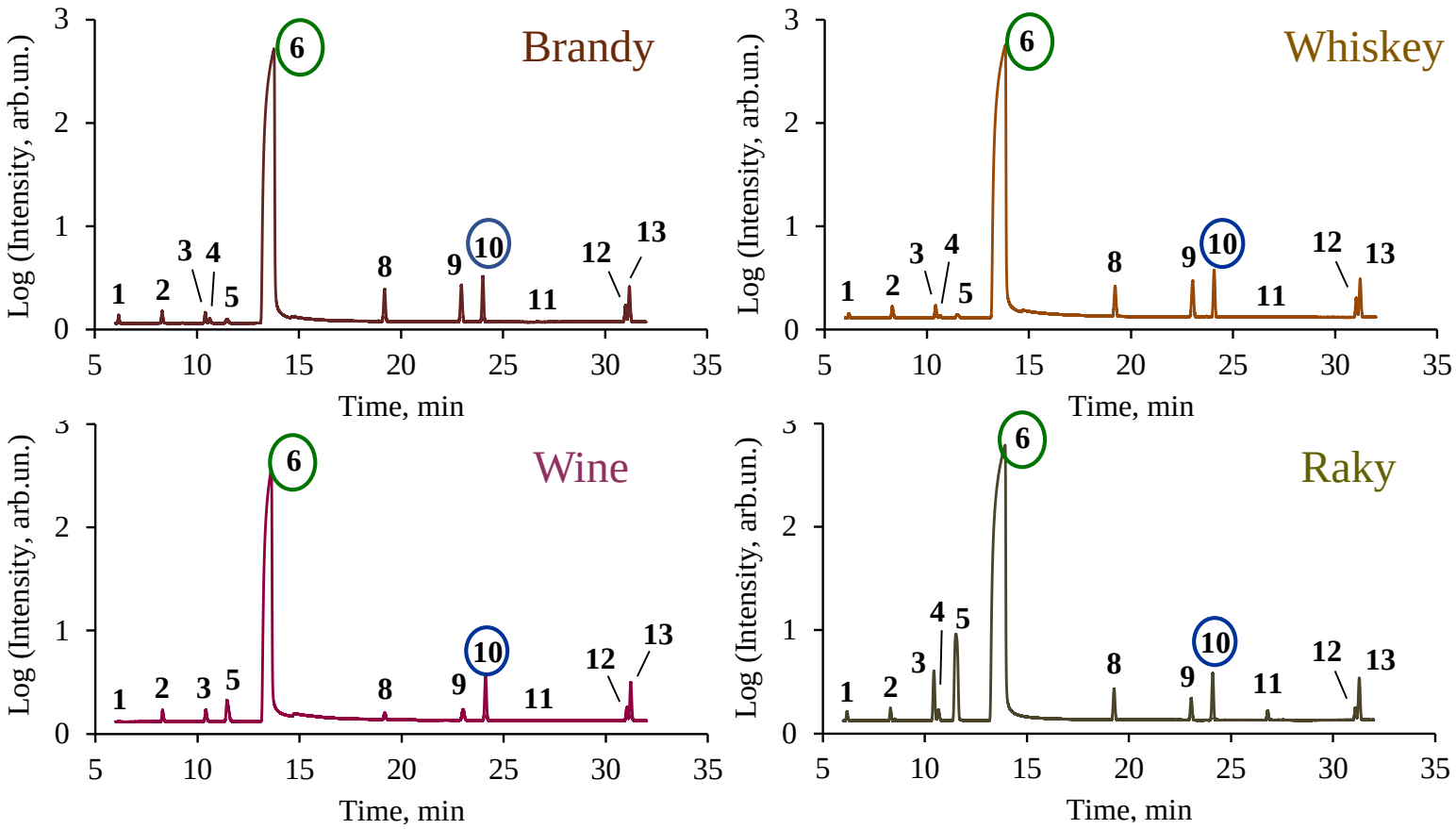
Compound	"0.1"	"0.5"	"1.0"	"1.5"	"2.0"
acetaldehyde	45.6	227	428	658	881
methyl acetate	72.7	361	683	1049	1404
ethyl acetate	65.7	326	617	948	1268
acetal	58.9	293	553	850	1138
methanol	51.3	255	481	740	990
2-butanol	53.0	264	498	766	1024
n-propanol	51.6	256	484	744	996
2-methylpropan-1-ol	50.5	252	474	729	976
n-butanol	52.9	263	497	764	1022
2-methylbutan-1-ol	54.7	272	514	790	1058
3-methylbutan-1-ol	52.5	261	493	758	1014

The density of 40 % water-ethanol solution was 948.06 g/L.

The data: **the chromatograms of standard solutions (SSs) of volatile compounds in water-ethanol solution with *ABV* of 40% at 5 concentration levels**

$$C\ [\text{mg/L AA}] = \frac{\tilde{C}\ [\mu\text{g/g}] \cdot \rho_{SS}\ [\text{g/L}]}{1000 \cdot (ABV_{SS}/100\%)}$$

The data include the chromatograms of 4 spirituous beverages



The *ABV* values of the spirituous beverages:

34.4 % in brandy
41.0 % in whiskey
18.1 % in wine
48.0 % in raki

The density of the beverages in units g/L:

956.48 of brandy
946.40 of whiskey
975.60 of wine
934.02 of raki

Chromatograms of spirituous beverages. 1 – acetaldehyde, 2 – methyl acetate, 3 – ethyl acetate, 4 – acetal, 5 – methanol, **6 – ethanol**, 8 – n-propanol, 9 – 2-methylpropan-1-ol, **10 – pentan-3-ol**, 11 – n-butanol, 12 – 2-methylbutan-1-ol, 13 – 3-methylbutan-1-ol.

- All samples of the SSs and beverages were with addition of ~220 µg/g pentan-3-ol (traditional IS).
- The archived data include 3 chromatograms of each SSs and 2 chromatograms of each spirituous beverages.

The calibration and the measurement of standard solutions for the linearity checking

Relative Response Factors

One-point calibration based on the parameters of SS “1.0”

Pentan-3-ol IS

$$RRF_i^{p3} = \frac{\tilde{C}^{certified}_{i,"1.0"} \cdot \sum_{k=1}^{n}\left(A_{i,k,"1.0"} / A_{p3,k,"1.0"}\right)}{\tilde{C}^{certified}_{p3,"1.0"} \cdot \sum_{k=1}^{n}\left(A_{i,k,"1.0"} / A_{p3,k,"1.0"}\right)^2}$$

Ethanol RS

$$RRF_i^{eth} = \frac{C^{certified}_{i,"1.0"} \cdot \sum_{k=1}^{n}\left(A_{i,k,"1.0"} / A_{eth,k,"1.0"}\right)}{\rho_{eth} \cdot \sum_{k=1}^{n}\left(A_{i,k,"1.0"} / A_{eth,k,"1.0"}\right)^2}$$

The ***FID response linearity*** has been checked by successively analyzing in triplicate each of the SSs for 4 concentration levels “0.1”, “0.5”, “1.5” and “2.0”.

- **X-axis** is concentration of the *i-th* volatile compound in SS*j* (mg/L AA)/ density of anhydrous ethanol (789270 mg/L);
- **Y-axis** is a detector response to the *i-th* compound (peak area), obtained during measurement of SS*j* / detector response to the ethanol (peak area), obtained during measurement of SS*j*.

The values of the calibration coefficients RRF and the parameters of linearity R^2

Table 3

Compound	IS: pentan-3-ol		RS: ethanol	
	RRF^{p3}	R^2	RRF^{eth}	R^2
acetaldehyde	2.139	0.99988	1.229	0.99991
methyl acetate	2.650	0.99988	1.522	0.99989
ethyl acetate	1.892	0.99990	1.087	0.99991
acetal	1.418	0.99990	0.815	0.99995
methanol	2.030	0.99990	1.166	0.99998
2-butanol	1.099	0.99993	0.631	0.99999
n-propanol	1.130	0.99995	0.649	0.99999
2-methylpropan-1-ol	0.954	0.99993	0.548	0.99998
n-butanol	1.025	0.99993	0.589	0.99998
2-methylbutan-1-ol	0.940	0.99995	0.540	0.99999
3-methylbutan-1-ol	0.948	0.99991	0.545	0.99997

Metrological characteristics of the methods

$$RSD_{i,j} = SD_{i,j} \cdot 100\% / \langle C \rangle_{i,j}^{measured}$$

$$bias_{i,j} = \frac{\langle C \rangle_{i,j}^{measured} - C_{i,j}^{certified}}{C_{i,j}^{certified}} \cdot 100\%$$

$$LOQ = k_Q \cdot \frac{SD_{"0.1"}}{\sqrt{n}}$$

$$LOD = 3 \cdot \frac{SD_{"0.1"}}{\sqrt{n}}$$

Table 6

Compound	IS: pentan-3-ol		RS: ethanol	
	LOD	*LOQ*	*LOD*	*LOQ*
acetaldehyde	3.63	12.1	3.65	12.2
methyl acetate	1.57	5.22	1.45	4.85
ethyl acetate	1.17	3.89	1.23	4.09
acetal	1.00	3.33	0.91	3.02
methanol	0.92	3.07	0.92	3.07
2-butanol	0.35	1.17	0.36	1.20
n-propanol	0.36	1.21	0.41	1.36
2-methyl-1-propanol	1.22	4.05	1.29	4.29
n-butanol	1.21	4.04	1.17	3.89
2-methyl-1-butanol	0.38	1.26	0.47	1.56
3-methyl-1-butanol	0.45	1.43	0.34	1.15

in units of mg/L AA

It was revealed that the *RSD*, *bias*, *LOD* and *LOQ* values determined using ethanol as the RS do not differ significantly from the data obtained by the traditional method with pentan-3-ol as IS

Table 4

Compound	*RSD (%)* at IS: pentan-3-ol				*RSD (%)* at RS: ethanol				*ΔRSD, (%)*			
	"0.1"	"0.5"	"1.5"	"2.0"	"0.1"	"0.5"	"1.5"	"2.0"	"0.1"	"0.5"	"1.5"	"2.0"
acetaldehyde	4.8	1.1	0.6	0.4	4.8	1.0	0.5	0.4	0.0	0.1	0.1	0.0
methyl acetate	1.3	0.3	0.2	0.2	1.2	0.2	0.3	0.2	0.1	0.1	-0.1	0.0
ethyl acetate	1.1	0.2	0.2	0.1	1.2	0.4	0.3	0.1	-0.1	-0.1	-0.1	0.0
acetal	1.0	0.1	0.5	0.3	0.9	0.0	0.4	0.4	0.1	0.1	0.1	-0.1
methanol	1.0	0.5	0.2	0.1	1.0	0.5	0.1	0.1	0.0	0.0	0.1	0.0
2-butanol	0.4	0.3	0.1	0.1	0.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0
n-propanol	0.4	0.2	0.3	0.1	0.5	0.1	0.1	0.1	0.0	0.0	0.2	0.0
2-methyl-propan-1-ol	1.4	0.2	0.2	0.1	1.5	0.1	0.1	0.1	-0.1	0.1	0.1	0.0
n-butanol	1.3	0.1	0.1	0.1	1.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0
2-methyl-butan-1-ol	0.4	0.1	0.1	0.1	0.5	0.0	0.1	0.1	-0.1	0.1	0.0	0.0
3-methyl-butan-1-ol	0.5	0.5	0.5	0.2	0.4	0.5	0.3	0.2	0.1	0.0	0.2	0.0

Table 5

Compound	*bias (%)* at IS: pentan-3-ol				*bias (%)* at RS: ethanol				*Δ|bias|, (%)*			
	"0.1"	"0.5"	"1.5"	"2.0"	"0.1"	"0.5"	"1.5"	"2.0"	"0.1"	"0.5"	"1.5"	"2.0"
acetaldehyde	-3.1	-1.7	0.3	-0.4	-3.3	-1.4	0.2	0.3	-0.1	0.3	0.0	0.0
methyl acetate	-4.9	-3.4	-0.4	-1.0	-5.0	-3.1	-0.4	-0.3	-0.1	0.3	-0.1	0.7
ethyl acetate	-6.0	-2.9	-0.3	-0.9	-6.2	-2.6	-0.3	-0.2	-0.1	0.3	-0.1	0.7
acetal	-3.1	-1.7	-0.1	-1.1	-3.2	-1.4	-0.2	-0.4	-0.1	0.3	-0.1	0.7
methanol	2.7	-0.3	0.1	-1.1	2.6	0.0	0.0	-0.3	0.1	0.3	0.1	0.7
2-butanol	-1.6	-1.0	0.3	-0.7	-1.8	-0.7	0.3	0.1	-0.1	0.3	0.1	0.6
n-propanol	-1.4	-0.5	0.5	-0.4	-1.6	-0.2	0.4	0.3	-0.1	0.3	0.1	0.1
2-methyl-propan-1-ol	-1.7	-1.2	0.5	-0.4	-1.8	-0.9	0.4	0.4	-0.1	0.3	0.1	0.0
n-butanol	0.0	-0.9	0.7	-0.3	-0.1	-0.6	0.6	0.4	-0.1	0.3	0.1	-0.1
2-methyl-butan-1-ol	0.1	-0.5	0.6	-0.2	-0.1	-0.2	0.5	0.6	0.0	0.3	0.1	-0.4
3-methyl-butan-1-ol	0.0	-0.8	0.9	0.0	-0.1	-0.5	0.9	0.7	-0.1	0.3	0.1	-0.7

Synchronous analysis of archived data of spirituous beverages

$$\tilde{C}^{measured}_{i,k,j} = RRF^{p3}_{i} \cdot \tilde{C}^{certified}_{p3,j} \cdot A_{i,k,j} / A_{p3,k,j}$$

$$\langle C \rangle^{measured}_{i,j} = \frac{\langle \tilde{C} \rangle^{measured}_{i,j} \times \rho_{beverage}}{1000 \cdot (ABV_{beverage}/100\%)}$$

$$C^{measured}_{i,k,j} = RRF^{eth}_{i} \cdot \rho_{eth} \cdot A_{i,k,j} / A_{eth,k,j}$$

- The values of concentration obtained in the cases of the data processing with IS pentan-3-ol and RS ethanol have not significant differences and the variances do not surpass 0.4 %.
- The absolute values of differences between the *RSD* obtained by the methods with pentanol-3-ol and ethanol do not exceed 0.3 % for wine, 2.0 % for raki, 0.1 % for brandy and 0.8 % for whiskey.

Table 7

Compound	*C* (mg/L AA) at IS: pentan-3-ol				*C* (mg/L AA) at RS: ethanol				$\Delta C \times 100\%/(C_{average})$, %			
	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey
acetaldehyde	18.7	116	96.7	53.5	18.7	116	96.8	53.7	-0.3	-0.4	-0.2	-0.4
methyl acetate	470	24.7	228	234	471	24.8	228	235	-0.3	-0.4	-0.2	-0.4
ethyl acetate	401	939	149	171	402	943	150	171	-0.3	-0.4	-0.2	-0.4
acetal	-	116	50.5	25.3	-	117	50.6	25.4	-	-0.4	-0.2	-0.4
methanol	1199	5183	82.2	68.9	1203	5203	82.3	69.2	-0.3	-0.4	-0.2	-0.4
2-butanol	-	-	-	-	-	-	-	-	-	-	-	-
n-propanol	141	297	399	353	141	298	400	354	-0.3	-0.4	-0.2	-0.4
2-methyl-propan-1-ol	249	169	423	408	250	170	424	409	-0.3	-0.4	-0.2	-0.4
n-butanol	6.60	55.5	2.54	3.30	6.62	55.7	2.54	3.31	-0.3	-0.4	-0.2	-0.4
2-methyl-butan-1-ol	218	77.0	133	147	219	77.3	133	147	-0.3	-0.4	-0.2	-0.4
3-methyl-butan-1-ol	864	379	361	370	866	381	361	372	-0.3	-0.4	-0.2	-0.4

Table 8

Compound	*RSD (%)* at IS: pentan-3-ol				*RSD (%)* at RS: ethanol				*ΔRSD, (%)*			
	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey
acetaldehyde	6.4	1.0	3.6	1.1	6.7	2.9	3.5	1.8	-0.3	-1.9	0.1	-0.8
methyl acetate	1.3	1.1	1.7	0.6	1.0	0.9	1.6	0.2	0.3	0.2	0.1	0.5
ethyl acetate	6.5	2.3	2.2	0.2	6.2	0.3	2.3	0.6	0.3	2.0	-0.1	-0.4
acetal	-	1.9	0.7	2.2	-	0.0	0.6	3.0	-	1.9	0.1	-0.8
methanol	0.3	2.1	0.2	3.2	0.0	0.2	0.3	2.4	0.3	1.9	-0.1	0.8
2-butanol	-	-	-	-	-	-	-	-	-	-	-	-
n-propanol	0.3	2.0	0.6	1.0	0.0	0.1	0.7	0.2	0.3	1.9	-0.1	0.8
2-methyl-propan-1-ol	0.1	2.3	0.5	0.9	0.4	0.4	0.5	0.1	-0.3	1.9	0.0	0.8
n-butanol	6.6	0.8	1.4	2.5	6.9	1.1	1.5	1.7	-0.3	-0.3	-0.1	0.8
2-methyl-butan-1-ol	0.7	2.1	0.3	2.5	1.0	0.1	0.3	1.7	-0.3	2.0	0.0	0.8
3-methyl-butan-1-ol	1.1	2.1	0.7	1.4	1.4	0.1	0.8	0.6	-0.3	2.0	-0.1	0.8

Archived data analysis using external standard method and proposed ethanol as RS

External Standard (ES): 5-levels calibration

Concentrations

$$\tilde{\tilde{C}}_{i,j}[\text{mg/L}] = \tilde{C}_{i,j}[\mu\text{g/g}] \cdot \rho_{SS}[\text{g/L}]/1000$$

Response Factors

$$RF_i = \frac{\sum_{j=1}^{l}\sum_{k=1}^{n}\left(\tilde{\tilde{C}}_{i,j}^{certified} \cdot A_{i,k,j}\right)}{n \cdot \sum_{j=1}^{l}\left(A_{i,k,j}\right)^2}\left[\frac{\text{mg/ L}}{\text{units of peak area}}\right]$$

l is the number of levels of concentrations

$\boldsymbol{l}$ **= 5** for the assay of SSs “0.1”, “0.5”, “1.0”, “1.5”, “2.0”

The values of RF, R^2 and maximums of RSD and bias obtained for SSs by methods ES and RS ethanol

Table 9

Compound	$RF \cdot 10^{-5}$	R^2	RSD^{max} (%)		$bias^{max}$ (%)	
			ES	RS	ES	RS
acetaldehyde	0.134	0.9996	4.7	4.8	3.5	3.3
methyl acetate	0.167	0.9995	1.6	1.2	4.6	5.0
ethyl acetate	0.119	0.9995	1.7	1.1	5.9	6.2
acetal	0.893	0.9994	1.9	0.9	2.9	3.2
methanol	0.127	0.9996	1.6	1.0	2.8	2.6
2-butanol	0.690	0.9996	1.7	0.4	1.9	1.8
n-propanol	0.704	0.9995	1.7	0.5	1.9	1.6
2-methylpropan-1-ol	0.595	0.9996	1.6	1.5	2.1	1.8
n-butanol	0.641	0.9995	1.7	1.3	1.3	0.6
2-methylbutan-1-ol	0.585	0.9996	1.7	0.5	1.0	0.6
3-methylbutan-1-ol	0.588	0.9994	1.8	0.5	1.5	0.9

* units of $RF \cdot 10^{-5}$ are (mg/L)/(peak area units) (for 40 % v/v);
** units of *LOD* and *LOQ* are mg/L AA.

- Coefficient $\boldsymbol{R^2}$ is much greater at method with ethanol RS for all compounds than at ES method.
- The $\boldsymbol{RSD^{max}}$ values determined using ethanol as the RS are the best for the all compounds (except for acetaldehyde)

Synchronous analysis of archived data of spirituous beverages

$$\tilde{\tilde{C}}^{measured}_{i,k,beverage}[\text{mg/L}] = RF_i \cdot A_{i,k,beverage}$$

$$C^{measured}_{i,beverage}[\text{mg/L AA}] = \frac{\tilde{\tilde{C}}^{measured}_{i,beverage}[\text{mg/L}]}{(ABV_{beverage}/100\%)}$$

$$C^{measured}_{i,k,j} = RRF^{eth}_i \cdot \rho_{eth} \cdot A_{i,k,j} / A_{eth,k,j}$$

- It's revealed that the absolute values of differences between the *RSD* obtained by the method of external standard and new method with RS ethanol do not exceed
  - 0.3 % for wine,
  - 0.1 % for raki,
  - 0.4 % for brandy and
  - 0.2 % for whiskey.

Table 10

Compound	*C* (mg/L AA) at ES method				*C* (mg/L AA) at RS: ethanol				$\Delta C \times 100\%/(C_{average})$, %			
	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey
acetaldehyde	18.6	115	96.0	53.3	18.7	116	96.8	53.7	-0.9	-0.8	-0.8	-0.8
methyl acetate	470	25	228	235	471	24.8	228	235	-0.3	-0.1	-0.2	-0.2
ethyl acetate	400	941	149	171	402	943	150	171	-0.4	-0.3	-0.3	-0.3
acetal	-	116	50.4	25.3	-	117	50.6	25.4	-	-0.3	-0.3	-0.3
methanol	1196	5183	81.9	68.8	1203	5203	82.3	69.2	-0.6	-0.4	-0.5	-0.4
2-butanol	-	-	-	-	-	-	-	-	-	-	-	-
n-propanol	140	296	396	351	141	298	400	354	-1.0	-0.8	-0.9	-0.9
2-methyl-propan-1-ol	247	168	420	406	250	170	424	409	-1.0	-0.8	-0.9	-0.9
n-butanol	6.55	55.2	2.51	3.28	6.62	55.7	2.54	3.31	-0.8	-1.0	-0.3	-0.3
2-methyl-butan-1-ol	216	76.5	131	146	219	77.3	133	147	-1.2	-1.0	-1.1	-1.1
3-methyl-butan-1-ol	855	376	357	367	866	381	361	372	-1.4	-1.2	-1.3	-1.3

Table 11

Compound	*RSD (%)* at ES method				*RSD (%)* at RS: ethanol				*ΔRSD, (%)*			
	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey	Wine	Raki	Brandy	Whiskey
acetaldehyde	7.0	3.0	3.9	1.6	6.7	2.9	3.5	1.8	0.3	0.1	0.4	-0.2
methyl acetate	0.7	1.0	2.0	0.0	1.0	0.9	1.6	0.2	-0.3	0.1	0.4	-0.2
ethyl acetate	5.9	0.2	1.9	0.4	6.2	0.3	2.3	0.6	-0.3	-0.1	-0.4	-0.2
acetal	-	0.2	1.1	2.8	-	0.0	0.6	3.0	-	0.1	-0.4	-0.2
methanol	0.4	0.1	0.1	2.6	0.0	0.2	0.3	2.4	0.3	-0.1	-0.1	0.2
2-butanol	-	-	-	-	-	-	-	-	-	-	-	-
n-propanol	0.4	0.0	0.3	0.4	0.0	0.1	0.7	0.2	0.3	-0.1	-0.4	0.2
2-methyl-propan-1-ol	0.7	0.3	0.1	0.3	0.4	0.4	0.5	0.1	0.3	-0.1	-0.4	0.2
n-butanol	7.2	1.2	1.1	1.9	6.9	1.1	1.5	1.7	0.3	0.1	-0.3	0.2
2-methyl-butan-1-ol	1.3	0.0	0.1	1.9	1.0	0.1	0.3	1.7	0.3	-0.1	-0.3	0.2
3-methyl-butan-1-ol	1.7	0.0	0.4	0.8	1.4	0.1	0.8	0.6	0.3	-0.1	-0.4	0.2

Conclusion

- New method offers a fast, cost-effective and accurate additional tool to the traditional procedures, ensuring reliable performance across diverse alcoholic matrices.
- The values of the concentration of volatile compounds in alcoholic beverages during traditional IS according ES2870 procedure and external calibration method cannot be calculated without determining the strength of the alcoholic beverage. Thus, the accuracy of determining the density and strength of each analyzed alcohol-containing sample affects the accuracy of determining the content of volatile compounds in them. However, when working with proposed method using ethanol as a reference substance, determining the strength of the analyzed sample is not required and does not affect the accuracy of the results obtained.
- The proposed approach enables the reprocessing and analysis of different chromatographic data, significantly enhancing its efficiency.
- Following the materials of the work done, everyone can validate the new method in their own laboratory by using of existing archived experimental data and ensure that the method works and is effective.

- *Determining volatile compounds in spirituous beverages of different origin has never been so easier.*

Thank you for your attention!