THE INNOVATIVE METHOD FOR QUALITY CONTROL AND SAFETY OF ALCOHOLIC BEVERAGES

L.N. Sobolenko[1,2], D.V. Yushkevitch[1], K.V. Furmanova[1,2]

[1] Research Institution "Institute for Nuclear Problems" of the Belarusian State University, Bobrujskaya street 11, Minsk, 220006. Belarus,
E-mail: lidia.sobolenko@gmail.com, yushkevitchdv@gmail.com, furmanova02.02@mail.ru
[2] Belarusian State University, Nezalezhnosti Ave. 4, Minsk, 220030. Republic of Belarus.

IX BELARUSIAN-CHINESE YOUTH INNOVATION FORUM
"NEW HORIZONS - 2022"

Interstate and international standards for the determination of volatile components, including methyl alcohol, in alcoholic products

GB/T 11858-2009
GB/T 15038-2008
GB 5009.266-2016
GB/T 10781-2021

BIS IS 3752:2005(R2009)

Commission Regulation (EC) No. 2870/2000

AOAC Official Methods 972.10/11, 2005

Norma Mexicana NMX-V-005-NORMEX-2018

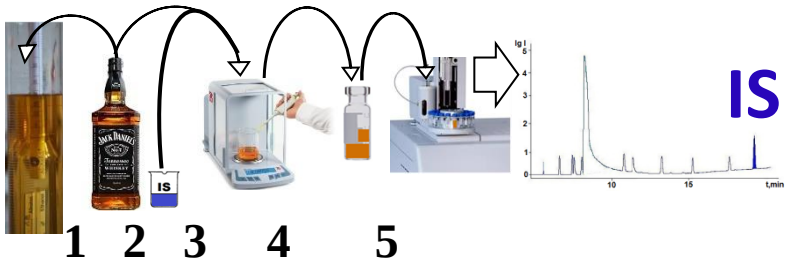
GOST 30536
GOST 31684
GOST 33833
GOST 33834
GOST 33408
GOST 32013
GOST 31811
GOST 14138
GOST 32039
GOST 12280
GOST 13194
GOST 32070
GOST 32036
GOST 10749.3
GOST 10749.6
GOST 10749.13
GOST 10749.14
GOST R 57893
GOST R 52363
GOST R 51999
GOST R 55878
GOST R 57893
STB GOST R 51698

All listed national standards are harmonized with Regulation (EC) 2870/2000 and use the **traditional internal standard method**

In the EAEU states, more than 20 standards operate simultaneously using the **external standard method**

An idea... with long exposure

Today: **Traditional internal standard method.**
China, India, EU, USA, Mexico, etc.



In accordance with the traditional method of internal standard, the concentration of the *i*th component in terms of mg/kg is determined by the following formula:

$$C_i(\text{mg/kg}) = RRF_i^{IS} \cdot \frac{A_i}{A_{IS}} \cdot C_{IS}(\text{mg/kg})$$

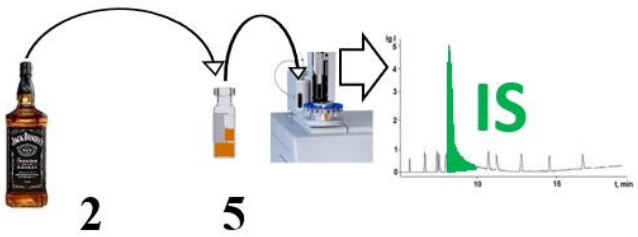
The values of the relative response coefficients of the detector to the investigated volatile component relative to the response to the selected internal standard are calculated using the following formula:

$$RRF_i^{IS} = \frac{C_i^{calibr}(\text{mg/kg})}{C_{IS}^{calibr}(\text{mg/kg})} \cdot \frac{A_{IS}^{calibr}}{A_i^{calibr}}$$

To calculate the concentration of the component, expressed in mg/L AA, it is necessary to measure the density of the sample and determine its strength (volume content of ethanol):

$$C_i(\text{mg/L } AA) = RRF_i^{IS} \cdot \frac{A_i}{A_{is}} \cdot C_{IS}(\text{mg/kg}) \cdot \frac{\rho_{sample}(\text{kg/L}) \cdot 100\ \%}{\text{"Strength" } (\%,\ ABV)}$$

Tomorrow: **Innovative approach**
China, India, EU, USA, Mexico, etc.



In accordance with the method "Ethanol as an internal standard", the concentration of the *i*th component in the dimension mg/L of anhydrous alcohol (AA) is determined by the following form

$$C_i(\text{mg/L } AA) = RRF_i^{Eth} \cdot \frac{A_i}{A_{Eth}} \cdot \rho_{Eth}(\text{mg/L})$$

The values of the relative coefficients of the detector response to the investigated volatile component relative to the response to ethanol are calculated using the following formula:

$$RRF_i^{Eth} = \frac{C_i^{calibr}(\text{mg/L } AA)}{\rho_{Eth}(\text{mg/L})} \cdot \frac{A_{Eth}^{calibr}}{A_i^{calibr}}$$

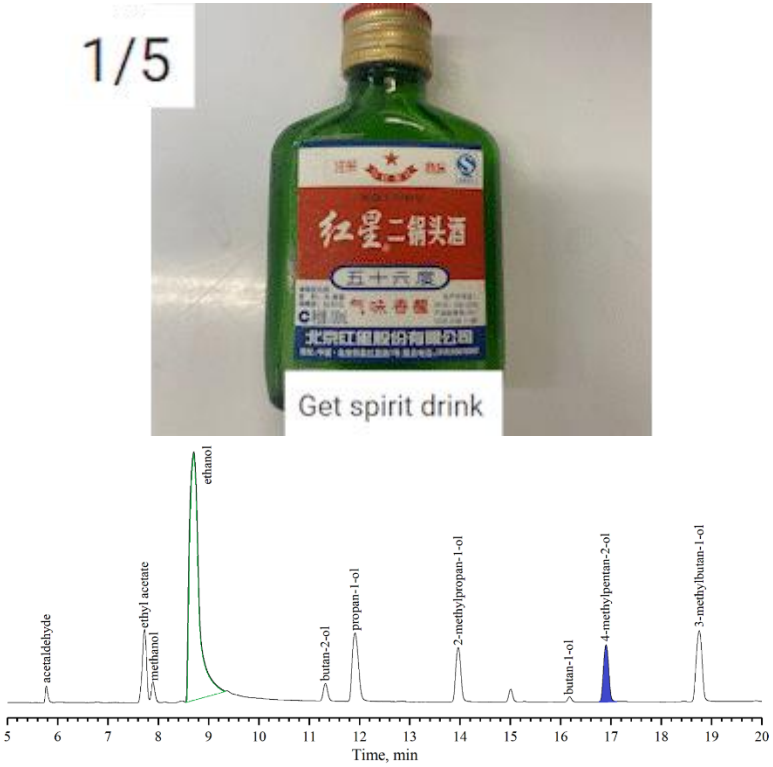
1. There is no need to add any internal standard to the sample.
2. Ethanol is always present in alcoholic products and its concentration in mg/L AA is always known with a 100% guarantee and is equal to the density of ethanol ρ_{Eth} = *789270* mg/L.

Made

1. *Journal of AOAC International*, ***1999***, 82(6), 1375-1388, https://doi.org/10.1093/jaoac/82.6.1375
2. *Journal of Agricultural and Food Chemistry*, **2013**, 61, 2950-2956. https://doi.org/10.1021/jf3044956
3. *Journal of Chemical Metrology*, **2018**, 12, 59-69. http://doi.org/10.25135/jcm.14.18.02.063
4. *Journal of AOAC International*, **2019**, 102(2), 669-672. https://doi.org/10.5740/jaoacint.18-0258
5. *42nd World Congress of Vine and Wine*, **2019**, 02030. https://doi.org/10.1051/bioconf/20191502030
6. *Journal of Mass Spectrometry*, **2019**, e4493. https://doi.org/10.1002/jms.4493
7. *Food Control*, **2021**, 107528. https://doi.org/10.1016/j.foodcont.2020.107528
8. *Food Chemistry*, **2020**, 128107 https://doi.org/10.1016/j.foodchem.2020.128107
9. *Food Analytical Methods*, **2021**, 14, 2088-2100. https://doi.org/10.1007/s12161-021-02047-8
10. *Journal of Chemical Metrology*, **2021**, 15(2), 113-123. http://doi.org/10.25135/jcm.66.2111.2259
11. *Journal of Food Composition and Analysis*, **2022**, 104772. https://doi.org/10.1016/j.jfca.2022.104772
12. *Пиво и напитки*, **2019**, 4, 41-45. https://doi.org/10.24411/2072-9650-2019-10005
13. *Журнал Белорусского государственного университета. Химия*, **2020**, 1. 74-87. https://doi.org/10.33581/2520-257X-2020-1-74-87
14. *Бутлеровские сообщения*, **2020**, 64(12), 60-75. https://doi.org/10.37952/ROI-jbc-01/20-64-12-60
15. *Пиво и напитки*, **2021**, 3, 13-18. https://doi.org/10.52653/PIN.2021.3.3.005
16. *Контроль качества продукции*, **2021**, 11, 34-38. https://ria-stk.ru/mos/adetail.php?ID=204383
17. *Заводская лаборатория*, **2022**, 88(5), 13-21. https://doi.org/10.26896/1028-6861-2022-88-5-13-21
18. Способ определения в этанолсодержащей жидкости газохроматографическим методом концентрации летучих примесей / *Eurasian Patent № 036994*, 2021, https://www.eapo.org/ru/patents/reestr/patent.php?id=36994
19. Improved document COMMISSION REGULATION EC2870/2000 https://elab.bsu.by/download.php?id=308
20. Improved document OIV-MA-BS-14, https://elab.bsu.by/download.php?id=312
21. Improved document OIV-MA-AS312-03A https://elab.bsu.by/download.php?id=317
22. Improved document OIV-MA-AS315-27 https://elab.bsu.by/download.php?id=316
23. Improved document Indian Standard 3572-2005, https://elab.bsu.by/download.php?id=315
24. Improved document Norma Mexicana NMX-V-005-NORMEX-2013 https://elab.bsu.by/download.php?id=311
25. Improved document National standards of People's Republic of China GB/T 15038 https://elab.bsu.by/download.php?id=309
26. Improved document National standards of People's Republic of China GB/T 11858 https://elab.bsu.by/download.php?id=307
27. Improved document AOAC Official Method 972.10 (USA), https://elab.bsu.by/download.php?id=306
28. Improved document AOAC Official Method 972.11 (USA), https://elab.bsu.by/download.php?id=305
29. Improved document ГОСТ 30536-2013 https://elab.bsu.by/download.php?id=314
30. Improved document СТБ ГОСТ Р 51698-2001 https://elab.bsu.by/download.php?id=313

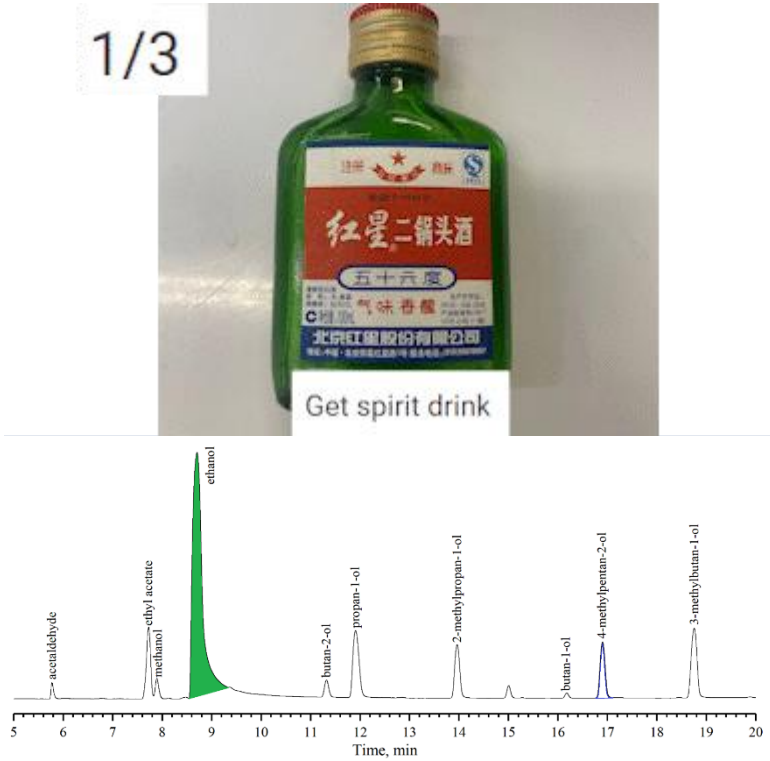
It is possible to make the method easier, cheaper, trust and robust

Today: **Method of Internal Standard. Traditional way**
China, India, EC, USA, Mexico et al.



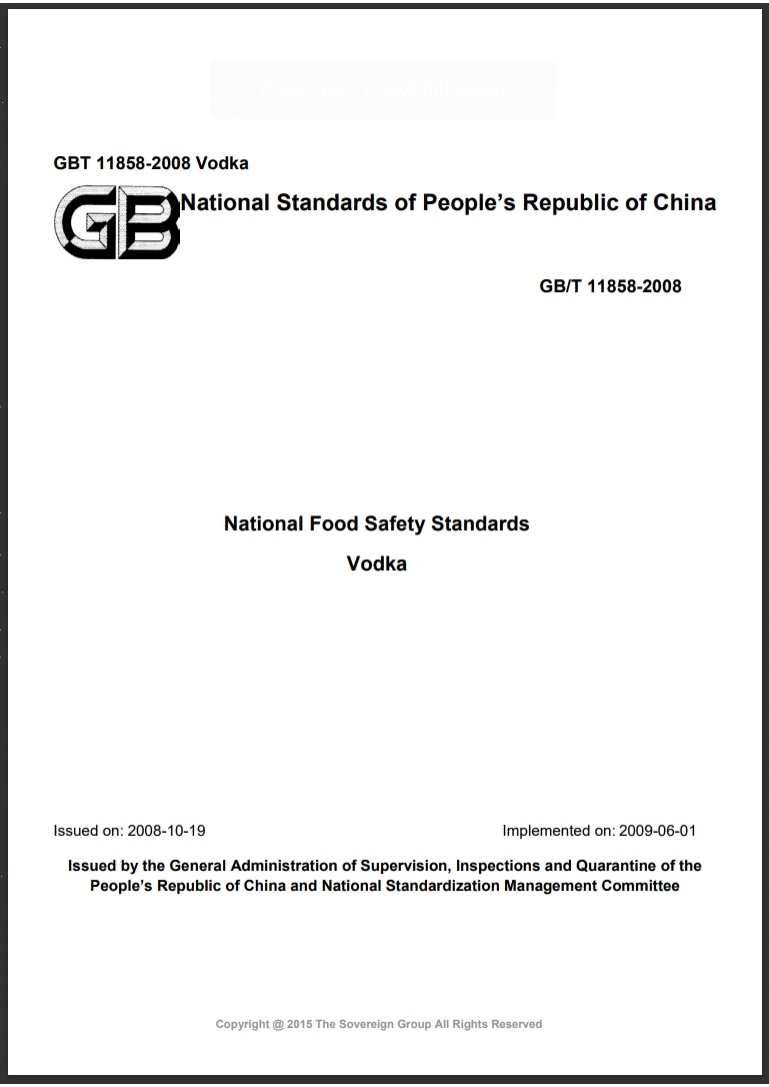
$$C_i(\text{mg/L } AA) = RRF_i^{IS} \cdot \frac{A_i}{A_{is}} \cdot C_{IS}(\text{mg/kg}) \cdot \frac{\rho_{sample}(\text{kg/L}) \cdot 100\ \%}{\text{"Strength"}\ (\%,\ ABV)}$$

Tomorrow: **Innovative approach**
China, India, EU, USA, Mexico, etc.



$$C_i(\text{mg/L AA}) = RRF_i^{Eth} \cdot \frac{A_i}{A_{Eth}} \cdot 789300\ (\text{mg}/L)$$

GB/T 11858-2008 Standards are simpler, faster, easier, cheaper and more reliable



GBT 11858-2008 Vodka

National Standards of People's Republic of China

GB/T 11858-2008

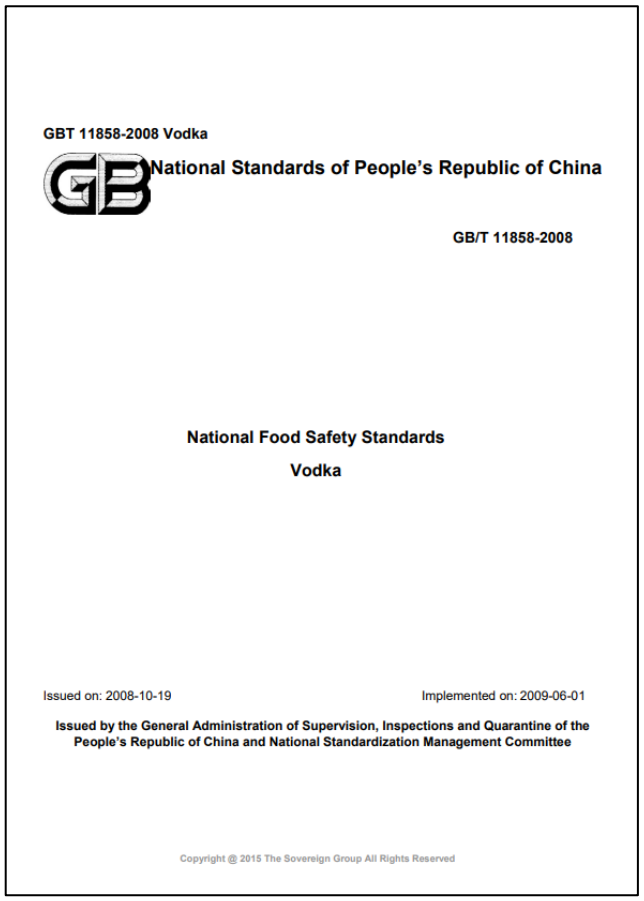
National Food Safety Standards

Vodka

Issued on: 2008-10-19 Implemented on: 2009-06-01

Issued by the General Administration of Supervision, Inspections and Quarantine of the People's Republic of China and National Standardization Management Committee

Minimal remarks to the standard GTB 11858-2008 are impressive



GBT 11858-2008 Vodka

National Standards of People's Republic of China

GB/T 11858-2008

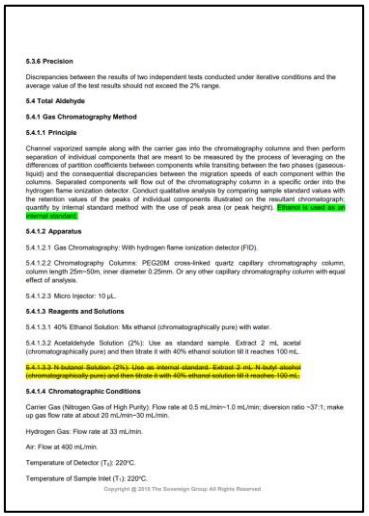
National Food Safety Standards

Vodka

Issued on: 2008-10-19

Implemented on: 2009-06-01

Issued by the General Administration of Supervision, Inspections and Quarantine of the People's Republic of China and National Standardization Management Committee



5.3.6 Precision

Discrepancies between the results of two independent tests conducted under iterative conditions and the average value of the test results should not exceed the 2% range.

5.4 Total Aldehyde

5.4.1 Gas Chromatography Method

5.4.1.1 Principle

Channel vaporized sample along with the carrier gas into the chromatography columns and then perform separation of individual components that are meant to be measured by the process of leveraging on the differences of partition coefficients between components while transiting between the two phases (gaseous-liquid) and the consequential discrepancies between the migration speeds of each component within the columns. Separated components will flow out of the chromatography column in a specific order into the hydrogen flame ionization detector. Conduct qualitative analysis by comparing sample standard values with the retention values of the peaks of individual components illustrated on the resultant chromatograph; quantify by internal standard method with the use of peak area (or peak height). Ethanol is used as an internal standard.

5.4.1.2 Apparatus

5.4.1.2.1 Gas Chromatography: With hydrogen flame ionization detector (FID).

5.4.1.2.2 Chromatography Columns: PEG20M cross-linked quartz capillary chromatography column, column length 25m~50m, inner diameter 0.25mm. Or any other capillary chromatography column with equal effect of analysis.

5.4.1.2.3 Micro Injector: 10 μL.

5.4.1.3 Reagents and Solutions

5.4.1.3.1 40% Ethanol Solution: Mix ethanol (chromatographically pure) with water.

5.4.1.3.2 Acetaldehyde Solution (2%): Use as standard sample. Extract 2 mL acetal (chromatographically pure) and then titrate it with 40% ethanol solution till it reaches 100 mL.

5.4.1.3.3 N-butanol Solution (2%): Use as internal standard. Extract 2 mL N-butyl alcohol (chromatographically pure) and then titrate it with 40% ethanol solution till it reaches 100 mL.

5.4.1.4 Chromatographic Conditions

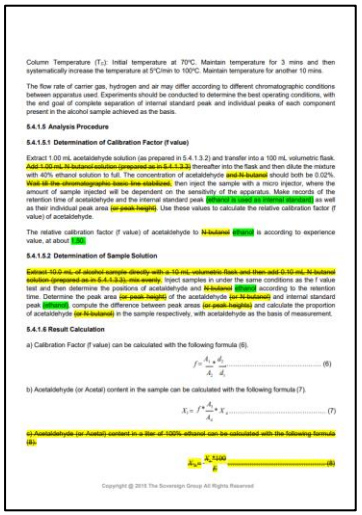
Carrier Gas (Nitrogen Gas of High Purity): Flow rate at 0.5 mL/min~1.0 mL/min; diversion ratio ~37:1; make up gas flow rate at about 20 mL/min~30 mL/min.

Hydrogen Gas: Flow rate at 33 mL/min.

Air: Flow at 400 mL/min.

Temperature of Detector (T_D): 220°C.

Temperature of Sample Inlet (T_1): 220°C.



Column Temperature (T_C): Initial temperature at 70°C. Maintain temperature for 3 mins and then systematically increase the temperature at 5°C/min to 100°C. Maintain temperature for another 10 mins.

The flow rate of carrier gas, hydrogen and air may differ according to different chromatographic conditions between apparatus used. Experiments should be conducted to determine the best operating conditions, with the end goal of complete separation of internal standard peak and individual peaks of each component present in the alcohol sample achieved as the basis.

5.4.1.5 Analysis Procedure

5.4.1.5.1 Determination of Calibration Factor (f value)

Extract 1.00 mL acetaldehyde solution (as prepared in 5.4.1.3.2) and transfer into a 100 mL volumetric flask. Add 1.00 mL N-butanol solution (prepared as in 5.4.1.3.3) thereafter into the flask and then dilute the mixture with 40% ethanol solution to full. The concentration of acetaldehyde and N-butanol should both be 0.02%. Wait till the chromatographic basic line stabilized, then inject the sample with a micro injector, where the amount of sample injected will be dependent on the sensitivity of the apparatus. Make records of the retention time of acetaldehyde and the internal standard peak (ethanol is used as internal standard) as well as their individual peak area (or peak height). Use these values to calculate the relative calibration factor (f value) of acetaldehyde.

The relative calibration factor (f value) of acetaldehyde to N-butanol (ethanol is according to experience value, at about 1.50.

5.4.1.5.2 Determination of Sample Solution

Extract 10.0 mL of alcohol sample directly with a 10 mL volumetric flask and then add 0.10 mL N-butanol solution (prepared as in 5.4.1.3.3), mix evenly. Inject samples in under the same conditions as the f value test and then determine the positions of acetaldehyde and N-butanol (ethanol according to the retention time. Determine the peak area (or peak height) of the acetaldehyde (or N-butanol) and internal standard peak (ethanol), compute the difference between peak areas (or peak heights) and calculate the proportion of acetaldehyde (or N-butanol) in the sample respectively, with acetaldehyde as the basis of measurement.

5.4.1.6 Result Calculation

a) Calibration Factor (f value) can be calculated with the following formula (6).

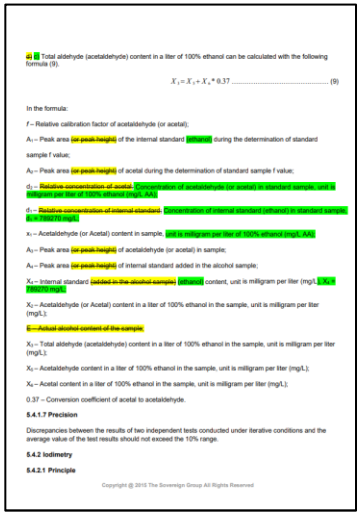
$$f = \frac{A_1 \times d_1}{A_2 \times d_2} \quad (6)$$

b) Acetaldehyde (or Acetal) content in the sample can be calculated with the following formula (7).

$$X_1 = f \times \frac{A_3}{A_4} \times X_4 \quad (7)$$

c) Acetaldehyde (or Acetal) content in a liter of 100% ethanol can be calculated with the following formula (8).

$$X_{1,0} = \frac{X_1 \times 100}{E} \quad (8)$$



a) Total aldehyde (acetaldehyde) content in a liter of 100% ethanol can be calculated with the following formula (9).

$$X_1 = X_3 \times f \times X_4 * 0.37 \quad (9)$$

In the formula:

f – Relative calibration factor of acetaldehyde (or acetal);

A_3 – Peak area (or peak height) of the internal standard (ethanol) during the determination of standard sample f value;

A_4 – Peak area (or peak height) of acetal during the determination of standard sample f value;

d_1 – Relative concentration of acetal; Concentration of acetaldehyde (or acetal) in standard sample, unit is milligram per liter of 100% ethanol (mg/L AA);

d_2 – Relative concentration of internal standard; Concentration of internal standard (ethanol) in standard sample, d_2 = 789270 mg/L;

x_1 – Acetaldehyde (or Acetal) content in sample, unit is milligram per liter of 100% ethanol (mg/L AA);

A_3 – Peak area (or peak height) of acetaldehyde (or acetal) in sample;

A_4 – Peak area (or peak height) of internal standard added in the alcohol sample;

X_4 – Internal standard (added in the alcohol sample) (ethanol) content, unit is milligram per liter (mg/L X_4 = 789270 mg/L);

X_1 – Acetaldehyde (or Acetal) content in a liter of 100% ethanol in the sample, unit is milligram per liter (mg/L);

E – Actual alcohol content of the sample;

$X_{1,0}$ – Total aldehyde (acetaldehyde) content in a liter of 100% ethanol in the sample, unit is milligram per liter (mg/L);

X_0 – Acetaldehyde content in a liter of 100% ethanol in the sample, unit is milligram per liter (mg/L);

X_4 – Acetal content in a liter of 100% ethanol in the sample, unit is milligram per liter (mg/L);

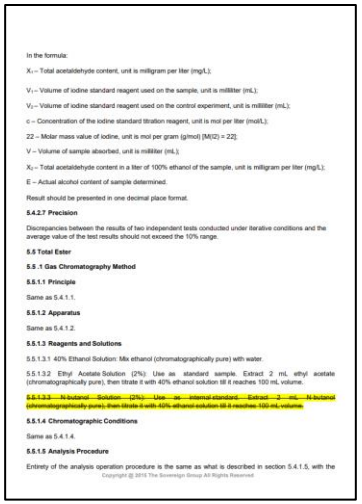
0.37 – Conversion coefficient of acetal to acetaldehyde.

5.4.1.7 Precision

Discrepancies between the results of two independent tests conducted under iterative conditions and the average value of the test results should not exceed the 10% range.

5.4.2 Iodimetry

5.4.2.1 Principle



In the formula:

X_1 – Total acetaldehyde content, unit is milligram per liter (mg/L);

V_1 – Volume of iodine standard reagent used on the sample, unit is milliliter (mL);

V_2 – Volume of iodine standard reagent used on the control experiment, unit is milliliter (mL);

c – Concentration of the iodine standard titration reagent, unit is mol per liter (mol/L);

22 – Molar mass value of iodine, unit is mol per gram (g/mol) [M(I2) = 22];

V – Volume of sample absorbed, unit is milliliter (mL);

X_0 – Total acetaldehyde content in a liter of 100% ethanol of the sample, unit is milligram per liter (mg/L);

E – Actual alcohol content of sample determined.

Result should be presented in one decimal place format.

5.4.2.7 Precision

Discrepancies between the results of two independent tests conducted under iterative conditions and the average value of the test results should not exceed the 10% range.

5.5 Total Ester

5.5 .1 Gas Chromatography Method

5.5.1.1 Principle

Same as 5.4.1.1.

5.5.1.2 Apparatus

Same as 5.4.1.2.

5.5.1.3 Reagents and Solutions

5.5.1.3.1 40% Ethanol Solution: Mix ethanol (chromatographically pure) with water.

5.5.1.3.2 Ethyl Acetate Solution (2%): Use as standard sample. Extract 2 mL ethyl acetate (chromatographically pure), then titrate it with 40% ethanol solution till it reaches 100 mL volume.

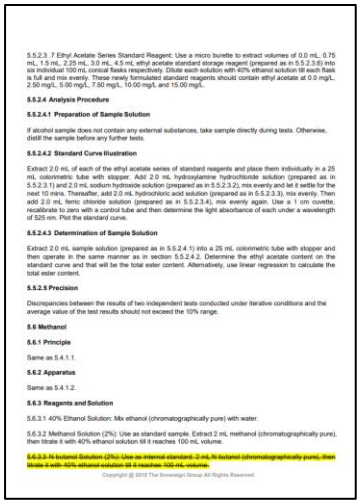
5.5.1.3.3 N-butanol Solution (2%): Use as internal standard. Extract 2 mL N-butanol (chromatographically pure), then titrate it with 40% ethanol solution till it reaches 100 mL volume.

5.5.1.4 Chromatographic Conditions

Same as 5.4.1.4.

5.5.1.5 Analysis Procedure

Entirety of the analysis operation procedure is the same as what is described in section 5.4.1.5, with the



5.5.2.3 7 Ethyl Acetate Series Standard Reagent: Use a micro burette to extract volumes of 0.0 mL, 0.75 mL, 1.5 mL, 2.25 mL, 3.0 mL, 4.5 mL ethyl acetate standard storage reagent (prepared as in 5.5.2.3.6) into six individual 100 mL conical flasks respectively. Dilute each solution with 40% ethanol solution till each flask is full and mix evenly. These newly formulated standard reagents should contain ethyl acetate at 0.0 mg/L, 2.50 mg/L, 5.00 mg/L, 7.50 mg/L, 10.00 mg/L and 15.00 mg/L.

5.5.2.4 Analysis Procedure

5.5.2.4.1 Preparation of Sample Solution

If alcohol sample does not contain any external substances, take sample directly during tests. Otherwise, distill the sample before any further tests.

5.5.2.4.2 Standard Curve Illustration

Extract 2.0 mL of each of the ethyl acetate series of standard reagents and place them individually in a 25 mL colorimetric tube with stopper. Add 2.0 mL hydroxylamine hydrochloride solution (prepared as in 5.5.2.3.1) and 2.0 mL sodium hydroxide solution (prepared as in 5.5.2.3.2), mix evenly and let it settle for the next 10 mins. Thereafter, add 2.0 mL hydrochloric acid solution (prepared as in 5.5.2.3.3), mix evenly. Then add 2.0 mL ferric chloride solution (prepared as in 5.5.2.3.4), mix evenly again. Use a 1 cm cuvette, recalibrate to zero with a control tube and then determine the light absorbance of each under a wavelength of 525 nm. Plot the standard curve.

5.5.2.4.3 Determination of Sample Solution

Extract 2.0 mL sample solution (prepared as in 5.5.2.4.1) into a 25 mL colorimetric tube with stopper and then operate in the same manner as in section 5.5.2.4.2. Determine the ethyl acetate content on the standard curve and that will be the total ester content. Alternatively, use linear regression to calculate the total ester content.

5.5.2.5 Precision

Discrepancies between the results of two independent tests conducted under iterative conditions and the average value of the test results should not exceed the 10% range.

5.6 Methanol

5.6.1 Principle

Same as 5.4.1.1.

5.6.2 Apparatus

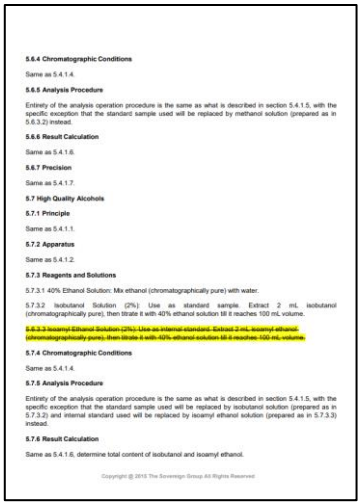
Same as 5.4.1.2.

5.6.3 Reagents and Solution

5.6.3.1 40% Ethanol Solution: Mix ethanol (chromatographically pure) with water.

5.6.3.2 Methanol Solution (2%): Use as standard sample. Extract 2 mL methanol (chromatographically pure), then titrate it with 40% ethanol solution till it reaches 100 mL volume.

6.6.3.3 N-butanol Solution (2%): Use as internal standard. 2 mL N-butanol (chromatographically pure), then titrate it with 40% ethanol solution till it reaches 100 mL volume.



5.6.4 Chromatographic Conditions

Same as 5.4.1.4.

5.6.5 Analysis Procedure

Entirety of the analysis operation procedure is the same as what is described in section 5.4.1.5, with the specific exception that the standard sample used will be replaced by methanol solution (prepared as in 5.6.3.2) instead.

5.6.6 Result Calculation

Same as 5.4.1.6.

5.6.7 Precision

Same as 5.4.1.7.

5.7 High Quality Alcohols

5.7.1 Principle

Same as 5.4.1.1.

5.7.2 Apparatus

Same as 5.4.1.2.

5.7.3 Reagents and Solutions

5.7.3.1 40% Ethanol Solution: Mix ethanol (chromatographically pure) with water.

5.7.3.2 Isobutanol Solution (2%): Use as standard sample. Extract 2 mL isobutanol (chromatographically pure), then titrate it with 40% ethanol solution till it reaches 100 mL volume.

5.7.3.3 Isoamyl Ethanol Solution (2%): Use as internal standard. Extract 2 mL isoamyl ethanol (chromatographically pure), then titrate it with 40% ethanol solution till it reaches 100 mL volume.

5.7.4 Chromatographic Conditions

Same as 5.4.1.4.

5.7.5 Analysis Procedure

Entirety of the analysis operation procedure is the same as what is described in section 5.4.1.5, with the specific exception that the standard sample used will be replaced by isobutanol solution (prepared as in 5.7.3.2) and internal standard used will be replaced by isoamyl ethanol solution (prepared as in 5.7.3.3) instead.

5.7.6 Result Calculation

Same as 5.4.1.6, determine total content of isobutanol and isoamyl ethanol.

The use of the proposed method ensures high reliability of the data obtained, significantly reduces time, labor, material and financial costs. Analysis of volatile compounds in spirit drinks has never been so easy. Here you can read modified text of official method, which allows to carry out analysis of alcoholic beverages using the developed method.

The places in the text document to be deleted are highlighted in yellow. Embedded parts of the test are highlighted in green.

Determination of methanol in alcoholic beverages

Result for	 40 % ABV	 40 % ABV	 43 % ABV	 40 % ABV	 40 % ABV	 40 % ABV	 40 % ABV	 47 % ABV	 45 % ABV
	Rum	**Whiskey**	**Bourbon**	**Grain spirit**	**Brandy**	**Grappa**	**Calvados**	**Gin**	**Slivovice**
Official method, mg/L AA	22.2±0.5	132±2	88.4±1.2	110±1.6	297±2	414±5	910±5	4.16±0.09	10546±97
Developed method, mg/L AA	22.3±0.6	130±1	88.9±0.5	111±0.7	297±1	412±2	913±2	4.19±0.16	10603±18
Δ, %	**0.7**	**-0.9**	**0.6**	**0.9**	**-0.2**	**-0.6**	**0.3**	**0.8**	**0.5**
Result for	 38 % ABV	 14.5 % ABV	 38 % ABV	 15 % ABV	 18 % ABV	 8.5 % ABV	 70 % ABV	 27.5 % ABV	 40 % ABV
	Tsikoudia	**Sake**	**Tequila**	**Vermouth**	**Nalewka**	**Mulled wine**	**Rectified spirit**	**Cocktail**	**Vodka**
Official method, mg/L AA	755±50	18.2±1.3	1456±35	17.5±0.1	168±5	25.3±3.0	6.05±0.39	77.3±0.7	21.8±0.2
Developed method, mg/L AA	761±20	18.1±1.4	1460±10	17.6±0.2	169±4	25.1±2.7	6.03±0.40	76.3±1.5	21.7±0.2
Δ, %	**0.8**	**-1.0**	**0.3**	**0.6**	**0.9**	**-0.6**	**-0.4**	**-1.2**	**-0.7**
Result for	 38 % ABV	 17 % ABV	 35 % ABV	 25 % ABV	 16 % ABV	 16.5 % ABV	 35 % ABV		 56 % ABV
	Liqueurs								**Baijiu**
	Sambuca	**Egg**	**Herbal**	**Limon**	**Cherry**	**Raspberry**	**Sloe gin**		
Official method, mg/L AA	2.32±0.04	9.75±0.28	19.5±0.1	29.1±0.9	9.77±1.34	127±5	20.5±0.7		115±5
Developed method, mg/L AA	2.34±0.05	9.81±0.14	19.6±0.1	29.4±1.0	9.82±1.27	126±4	20.7±0.4		116±4
Δ, %	**0.8**	**0.7**	**0.4**	**0.8**	**0.5**	**-1.1**	**0.5**		**0.6**

The relative difference between obtained values of concentrations (**Δ, %**) measured in accordance with the GB/T 11858-2008 according to the official internal standard method and in accordance with the proposed modified internal standard method does not exceed **1.5 %**.

Determination sums of aldehydes, esters and highs alcohols in alcoholic beverages

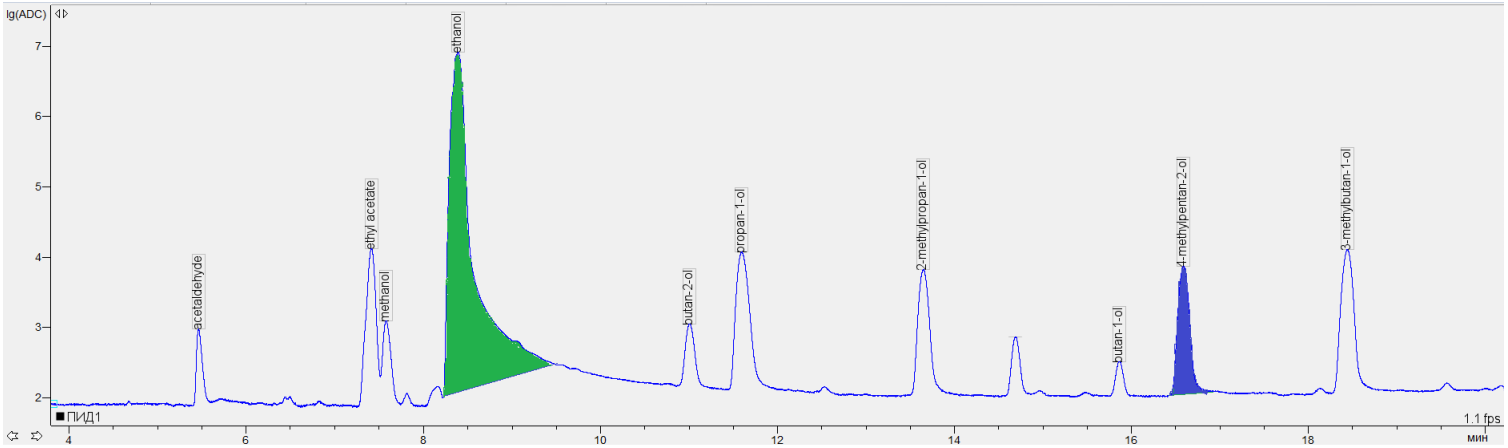
Result for	 40 % ABV	 40 % ABV	 43 % ABV	 40 % ABV	 40 % ABV	 40 % ABV	 40 % ABV	 47 % ABV	 45 % ABV
	Rum	**Whiskey**	**Bourbon**	**Grain spirit**	**Brandy**	**Grappa**	**Calvados**	**Gin**	**Slivovice**
Official method, mg/L AA	48.1 / 145 / 1043	162 / 589 / 6693	150 / 645 / 5546	44.0 / 84.7 / 4662	143 / 396 / 4801	191 / 289 / 2113	182 / 583 / 3690	1.70 / 0 / 1.54	210 / 907 / 6255
Developed method, mg/L AA	48.4 / 146 / 1051	160 / 584 / 6635	151 / 649 / 5580	44.4 / 85.4 / 4703	142 / 396 / 4794	190 / 288 / 2100	182 / 585 / 3702	1.72 / 0 / 1.55	211 / 912 / 6288
Δ, %	0.7 / 0.7 / 0.7	-0.9 / -0.9 / -0.9	0.6 / 0.6 / 0.6	0.9 / 0.9 / 0.9	-0.2 / -0.2 / -0.2	-0.6 / -0.6 / -0.6	0.3 / 0.3 / 0.3	0.8 / - / 0.9	0.5 / 0.5 / 0.5
Result for	 38 % ABV	 14.5 % ABV	 38 % ABV	 15 % ABV	 18 % ABV	 8.5 % ABV	 70 % ABV	 27.5 % ABV	 40 % ABV
	Tsikoudia	**Sake**	**Tequila**	**Vermouth**	**Nalewka**	**Mulled wine**	**Rectified spirit**	**Cocktail**	**Vodka**
Official method, mg/L AA	356 / 266 / 2297	37.6 / 47.0 / 1367	34.8 / 126 / 2895	30.5 / 0 / 5.94	47.4 / 74.4 / 10.3	22.7 / 55.9 / 871	4.83 / 25.2 / 0	61.9 / 84.0 / 728	0.504 / 0 / 0
Developed method, mg/L AA	359 / 268 / 2316	37.2 / 46.5 / 1352	34.9 / 127 / 2904	30.6 / 0 / 5.98	47.8 / 75.1 / 10.4	22.5 / 55.6 / 866	4.81 / 25.1 / 0	61.1 / 83.0 / 719	0.50 / 0 / 0
Δ, %	0.9 / 0.8 / 0.9	-1.1 / -1.1 / -1.1	0.4 / 0.3 / 0.3	0.6 / - / 0.6	0.9 / 0.9 / 0.9	-0.6 / -0.5 / -0.6	-0.4 / -0.4 / -	-1.3 / -1.2 / -1.2	-0.7 / - / -
Result for	 38 % ABV	 17 % ABV	 35 % ABV	 25 % ABV	 16 % ABV	 16.5 % ABV	 35 % ABV		 56 % ABV
	Liqueurs								
	Sambuca	**Egg**	**Herbal**	**Limon**	**Cherry**	**Raspberry**	**Sloe gin**		**Baijiu**
Official method, mg/L AA	4.20 / 0 / 2.44	6.89 / 0 / 125	38.1 / 13.5 / 9.39	25.1 / 0 / 0	18.4 / 266 / 0	36.6 / 31.8 / 0	1.12 / 0 / 0		63.9 / 1072 / 2114
Developed method, mg/L AA	4.24 / 0 / 2.46	6.94 / 0 / 125	38.2 / 13.5 / 9.43	25.3 / 0 / 0	18.5 / 267 / 0	36.2 / 31.5 / 0	1.13 / 0 / 0		64.3 / 1079 / 2128
Δ, %	0.8 / - / 0.8	0.8 / - / 0.7	0.4 / 0.4 / 0.4	0.8 / - / -	0.5 / 0.6 / -	-1.0 / -1.1 / -	0.6 / - / -		0.6 / 0.6 / 0.6

Aldehydes = acetaldehyde + acetal / Esters = ethyl acetate / Highs alcohols = butan-2-ol + propan-1-ol + 2-methylpropan-1-ol + butan-1-ol + 3-methylbutan-1-ol

The relative difference between obtained values of concentrations (**Δ, %**) measured in accordance with GB/T 11858-2008 according to the official internal standard method and in accordance with the proposed modified internal standard method does not exceed **1.5 %**.

Detailed analysis of Baijiu

56 % ABV



Baijiu analysis measured in accordance with the GB/T 11858-2008 and in accordance with developed method "Ethanol as Internal Standard"

Compound	Concentration, **mg/L AA**		The relative difference between obtained results, Δ, %
	Official method **GB/T 11858-2008** **IS – 4-methylpentan-2-ol**	Developed modified method **IS – ethanol**	
1. Acetaldehyde	63.9	64.3	0.62
2. Ethyl acetate	1071.9	1078.9	0.65
3. Methanol	115.7	116.4	0.60
4. Butan-2-ol	63.9	64.3	0.62
5. Propan-1-ol	895.5	901.4	0.66
6. 2-methylpropan-1-ol	365.1	367.5	0.66
7. Butan-1-ol	13.2	13.3	0.75
8. 3-methylbutan-1-ol	776.1	781.2	0.65

The relative difference between obtained values of concentrations (**Δ, %**) measured in accordance with the GB/T 11858-2008 according to the official internal standard method and in accordance with the proposed modified internal standard method does not exceed **1.0 %.**

1 400 million

1 400 million

450 million

333 million

Belarus Researchers and Researchers of the People's Republic of China should not refuse to ensure that the quality and safety of the millions of liters of alcoholic beverages produced every day around the world are controlled according to the method they have developed.

Support: https://elab.bsu.by/elib/?i=11
E-mail: elab@inp.bsu.by