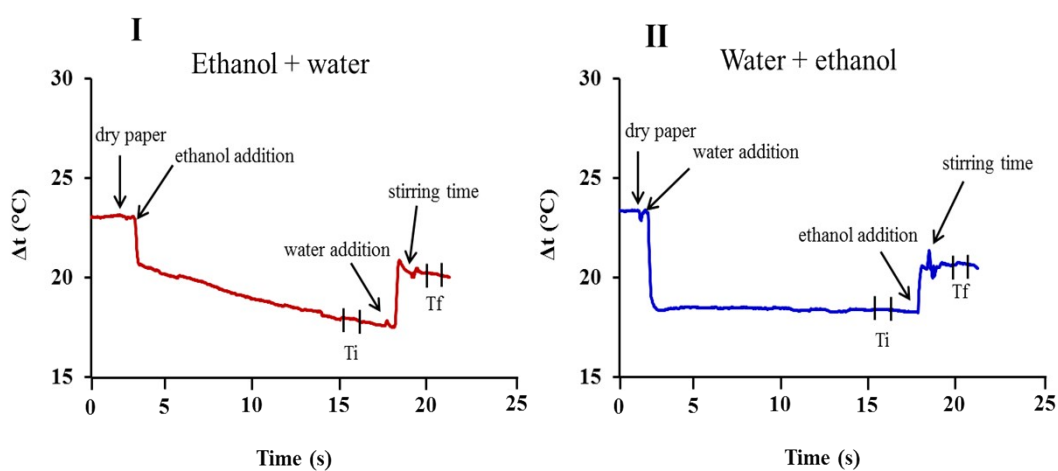Supplementary information

Manuscript: *Feasibility of Paper Microzone Plates for Greener Determination of Alcoholic Content of Beverages by Thermal Infrared Enthalpimetry*

S1. Analytical signals obtained from reaction of (I) ethanol and water, and (II) water and ethanol where Ti is initial temperature and Tf is final temperature.

S2. Calibration curve obtained using reference hydroalcoholic solutions (25–60%, v/v). Error bars are reported as standard deviation of measurements (n = 24).

Plot of ΔT (°C) versus Ethanol concentration (%, v/v):

$$y = 0.0968x - 1.7131$$
$$R^2 = 0.9994$$
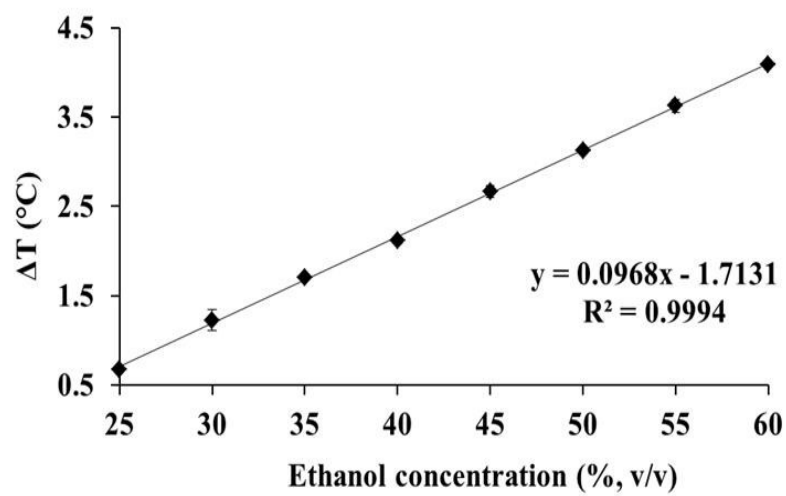
S3. GAPI parameters for analytical procedures for determination of ethanol content of distilled beverage by TIE-P, TIE-PS and AOAC 942.06.

Category	TIE-P	TIE-PS	AOAC 942.06
Sample Preparation			
Collection	-	-	-
Preservation	Unnecessary	Unnecessary	Unnecessary
Transport	-	-	-
Storage	Store the sample at room temperature and without light	Store the sample at room temperature and without light	Store the sample at room temperature and without light
Type of method: direct or indirect	Unnecessary sample preparation and determination in the same reactor	Unnecessary sample preparation and determination in the same reactor	Requires a preliminary stage of distillation
Scale of sample preparation	-	-	-
Solvents/reagents used	Green solvents/reagents used	Green solvents/reagents used	Green solvents/reagents used
Additional treatments	None	None	Weighing the solution after distillation
Reagent and Solvents			
Amount	0.05 mL of water 0.05 mL of ethanol standard/sample	1.2 mL of water 1.2 mL of ethanol standard/sample	100 mL of sample 100 mL of water
Health hazard	Green solvents	Green solvents	Green solvents
Safety hazard	Low flammability or instability	Low flammability or instability	Low flammability or instability
Instrumentation			
Energy	0.001	0.001	10.67
Occupational hazard	-	-	-
Waste	0.01 mL	2.4 mL	200 mL
Waste treatment	Requires degradation	Requires passivation	Requires passivation
Quantification	Yes	Yes	Yes

S4. Comparison of analytical parameters for selected analytical methods described in literature for the determination of alcoholic content of beverages.

Technique	Sample	LOD	R²	RSD	Reference
Attenuated total reflectance spectroscpy	Gin, rum, vodka, whisky and wine	*n.i*	0.9910	*n.i*	S1
Colorimetry using a Smartphone	Beer, wine, vodka and cachaça	0.25%	0.999	0.76-5.97%	S2
Colorimetry using a Smartphone	Cachaça	0.19%	0.9963	0.1-0.2%	S3
Colorimetry using a Smartphone	Distilled beverages	2.1%	0.998	1.2%	S4
Capillary electrophoresis by photo-oxidation assisted ultraviolet detection	Vodka	34.9 mg L^{-1}	0.987-0.999	*n.i*	S5
Electrochemical paper-based microfl uidic devices (ePADs)	Beer	0.25 mM	0.9898	15%	S6
Fluorometric detection	Distilled beverages, beer and yogurts	1-1.86%	0.9630-0.9934	1.33%	S7
FIA amperometric	Sugar cane spirit, sake, rum and wine	0.4%	0.998	1.83 -7.07%	S8
Gas Chromatography (GC)	Red wine and whisky	0.5 µg/mL*	0.999	2.1 -3.4%	S9

Method	Sample	LOD	R²	Precision (RSD)	Ref.
Gas Chromatography (GC)	Wine	1.23% *	0.999	1.02%	S10
High performance liquid chromatography (HPLC)	White and red wine, sake, shochu, brandy, whisky	*n.i*	*n.i*	1.44- 2.36%	S11
Instrument-free method based on visible chemical waves	Beer, colored whisky, and vodka	*n.i*	0.9980	< 3%	S12
NIR and Raman spectrometry	Whisky, vodka and sugary alcoholic drinks	*n.i*	*n.i*	0.5-2.3%	S13
Potentiometric microbial biosensor	Solution of ethanol	*n.i*	0.9972	>6%	S14
Raman spectroscopy	Solution of ethanol	1.2 mM	0.998	2.9-5.9%	S15
Redox titration, paper-based analytical devices	Whiskey	2.1%	0.992	0.8-9.4%	S16
TIE-flow	Cachaça, cognac, and vodka	23.41%	0.9961	0.26-2%	S17
TIE-P	Vodka, cachaça and gym	19.7%	0.9994	0.5-2.9%	This work
TIE	Vodka, whisky, and cachaça	18.7%	0.99995	0.73 -1.07%	S18
TIE	Wine	0.58% - 1.05%,	0.9987	0.98 to 1.80%	S19

n.i: not informed
* limit of quantification (LOQ) informed
TIE: Thermal infrared enthalpimetry

References

S1.   R. Nagarajan, A. Gupta, R. Mehrotra and M. M. Bajaj, *Journal of Automated Methods and Management in Chemistry*, 2006, **2006**, 5.

S2.   L. P. D. Benedetti, V. B. dos Santos, T. A. Silva, E. Benedetti, V. L. Martins and O. Fatibello, *Analytical Methods*, 2015, **7**, 4138-4144.

S3.   F. C. Bock, G. A. Helfer, A. B. da Costa, M. B. Dessuy and M. F. Ferrao, *Food Analytical Methods*, 2018, **11**, 1951-1957.

S4.   O. R. Marinho, M. J. A. Lima, F. R. P. Rocha, B. F. Reis and M. Y. Kamogawa, *Microchemical Journal*, 2019, **147**, 437-443.

S5.   J. D. Oliver, M. Gaborieau and P. Castignolles, *Journal of Chromatography A*, 2014, **1348**, 150-157.

S6.   F. J. V. Gomez, P. A. Reed, D. Gonzalez Casamachin, J. Rivera de la Rosa, G. Chumanov, M. F. Silva and C. D. Garcia, *Analytical Methods*, 2018, **10**, 4020-4027.

S7.   N. L. T. Nguyen, S. H. Baek, Z. A. Akbar, S. Y. Jang, S. Ha, J. P. Park and T. J. Park, *Biochip Journal*, 2018, **12**, 240-248.

S8.   T. Paixao, D. Corbo and M. Bertotti, *Analytica Chimica Acta*, 2002, **472**, 123-131.

S9.   M.-L. a. C. Wang, Youk-Meng and Su, Nan-Wei and Lee, Min-Hsiung, *Journal of Food and Drug Analysis*, 2003, **11**, 133-140.

S10.   C. Y. Zhang, N. B. Lin, X. S. Chai, L. Zhong and D. G. Barnes, *Food Chemistry*, 2015, **183**, 169-172.

S11.   T. Yarita, R. Nakajima, S. Otsuka, T. Ihara, A. Takatsu and M. Shibukawa, *Journal of Chromatography A*, 2002, **976**, 387-391.

S12.   T. Somboon and S. Sansuk, *Food Chemistry*, 2018, **253**, 300-304.

S13.   A. Nordon, A. Mills, R. T. Burn, F. M. Cusick and D. Littlejohn, *Analytica Chimica Acta*, 2005, **548**, 148-158.

S14.   L. Rotariu, C. Bala and V. Magearu, *Analytica Chimica Acta*, 2004, **513**, 119-123.

S15.   I. H. Boyaci, H. E. Genis, B. Guven, U. Tamer and N. Alper, *Journal of Raman Spectroscopy*, 2012, **43**, 1171-1176.

S16.   S. A. Nogueira, A. D. Lemes, A. C. Chagas, M. L. Vieira, M. Talhavini, P. A. O. Morais and W. K. T. Coltro, *Talanta*, 2019, **194**, 363-369.

S17.   R. B. d. Santos, P. F. Filoda, I. D. Teixeira, G. A. Helfer, R. O. Santos, A. S. Oliveira, J. S. Barin, B. Tischer and A. B. d. Costa, *Talanta*, 2019, **200**, 67-71.

S18.   A. S. Oliveira, F. M. Dalla Nora, R. O. Mello, P. A. Mello, B. Tischer, A. B. Costa and J. S. Barin, *Talanta*, 2017, **171**, 335-340.

S19.   A. S. Oliveira, C. A. Ballus, C. R. Menezes, R. Wagner, J. N. G. Paniz, B. Tischer, A. B. Costa and J. S. Barin, *Food Chemistry*, 2018, **258**, 59-62.