Drying Drop Technology in wine quality control

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Background

It is known that solvent evaporation increases the concentration of components, which begin to form aggregates from nano- to submillimeter level. Nonuniform temperature distribution on the drop surface leads to appearance the flows dragging the aggregates to the drop's edge. Then usually gelation of organic components and crystallization of mineral ones take place closer to the central zone. Thus solid-state centrosymmetrical spot arises. We developed sensor device + software system for registering and quantitative comparison the dynamics of bottom-up processes in drying drops using Acoustical - Mechanical Impedansometry (AMI) [1]. It was found that at the same environment this dynamics could be passport characteristics of the liquid. Every test requires one drop of liquid (3 µl) without any additional reagents, and takes 15-20 min. So it is possible to make rapid evaluation of correspondence of multicomponent liquids to their own standards. This approach has been tested for medical and veterinary diagnostics [2,3], quality control of drugs, dairy foods and beverages [4]. Now we demonstrate how this technology can work in assessing the quality of wines.

Unlike many other biological fluids, sessile desiccated drops of wine do not form clear structural zones. They form gel without visible structures. Thus, the ascending part of the AMI curve reflects the changing in physical properties of the drop's material during drying. Then delamination of the drop's edge comes up [5], and this process is reflected by descending part of the curve up to an equilibrium (horizontal) level. Subsequently statistical differences between the samples (the shapes of AMI curves) calculate and display on the plane of features in coordinates of different shape indices.

Materials & Verification Tests

We tested 62 samples of different wines (in replicates) were produced by micro – winemaking department. Verification tests were made via IR-Analyser Winescan Flex (FOSS, Denmark) using adapted calibration. All the samples under comparison were tested at room conditions (T = 22-23°, H = -63-65%). The correlation coefficient K was calculated between different shape indices and the chemical components of wine samples.

Summary

It was shown that every brand of wine has its own "dynamical portrait", which depends also on the grape sort and its place of growing. Some features of the "dynamical portraits" were detected, which closely correlate with such factors as extract, reduced sugars, SO_2, phenolic derivatives, organic acids.
Really our approach is based on materials science, notably, the dynamics of material properties during phase transitions from liquid to solid state. It stands to reason that this dynamics depends on liquid content. The setup with vibrating sensor and appropriate software is good for such analysis. The technique is rapid, chip and sensitive. We hope it can be useful in monitoring of wine production, quality estimation, and detection of counterfeits.

Method

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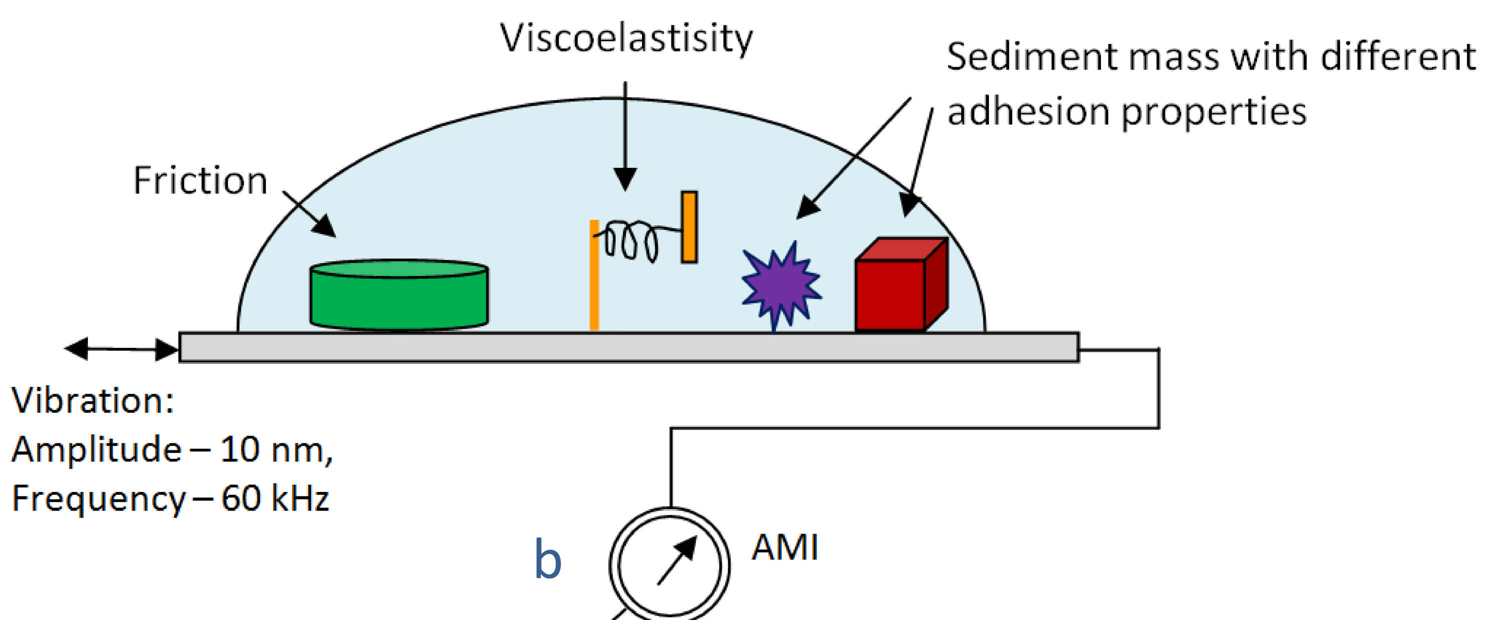

b

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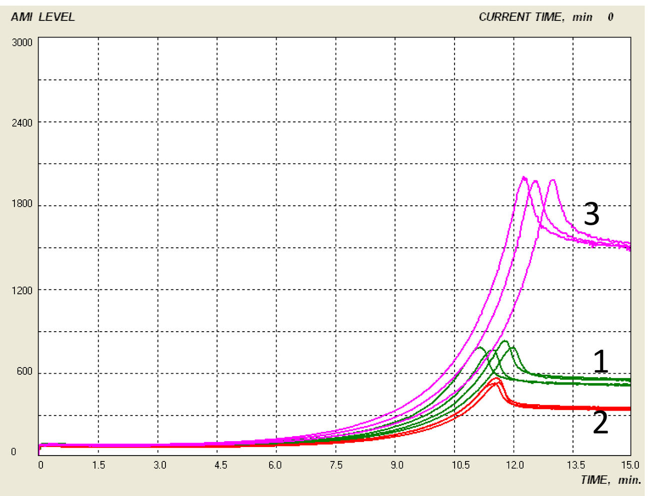

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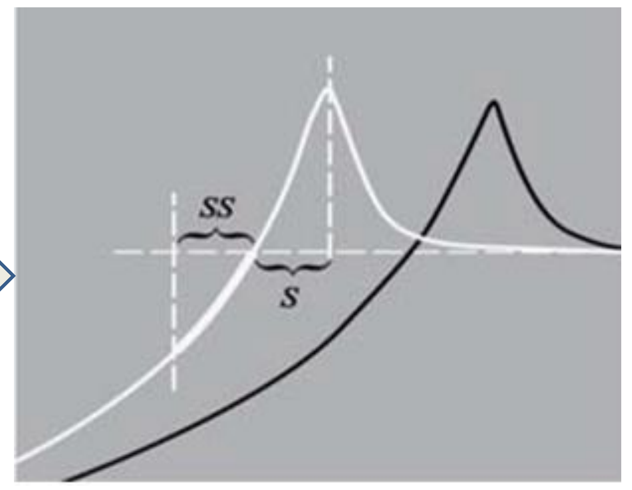

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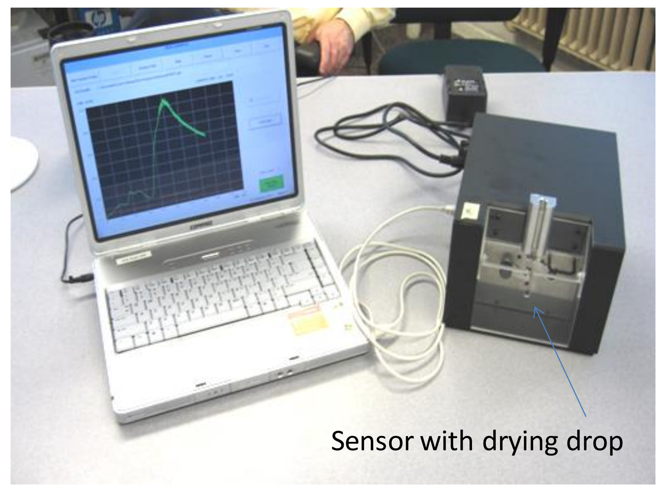

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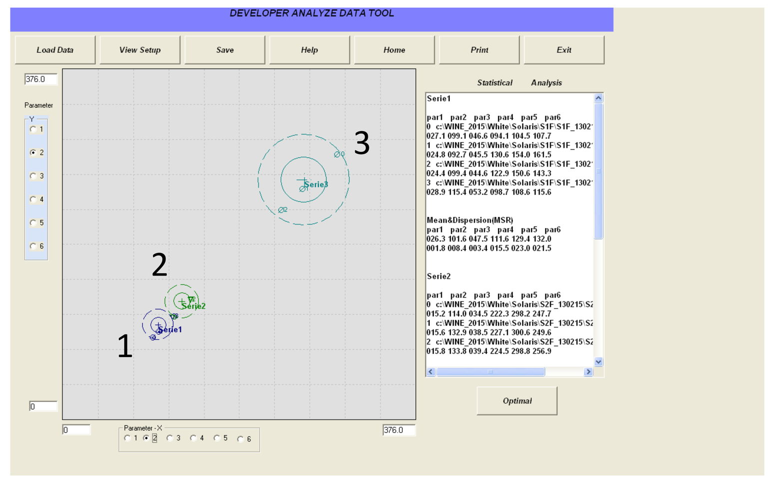
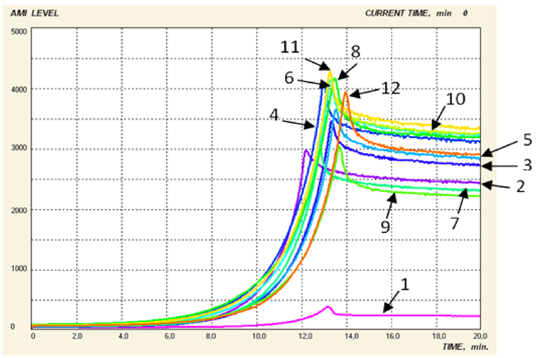


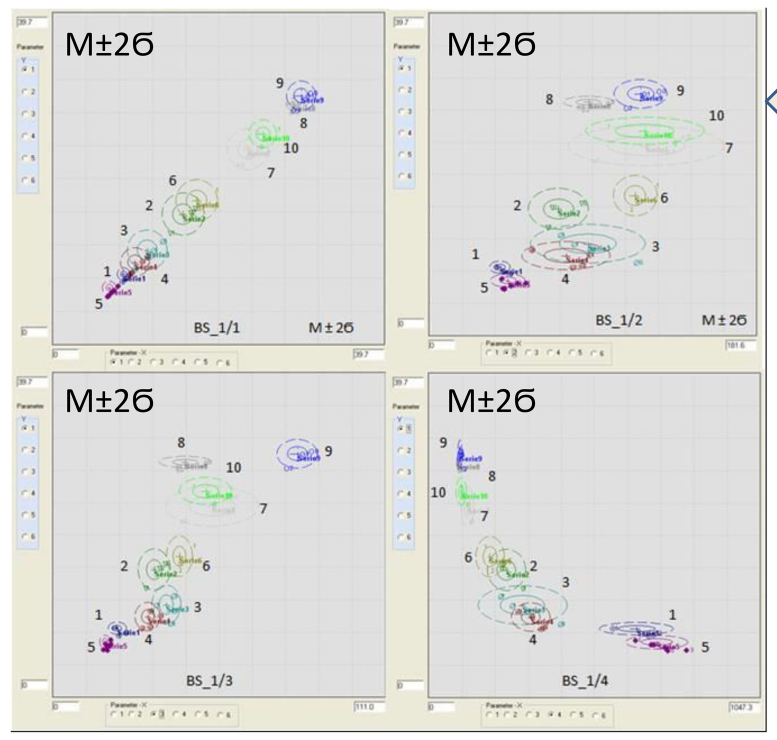
a - schematic representation of the interaction of drying droplet with an oscillating sensor;
b – registering the dynamics of Acoustical – Mechanical Impedance (AMI) of drying drop;
c – the AMI curves (dynamical portraits) of wines: 1 – Solaris 1F, 2 – Solaris -2F, 3 – Solaris -3F. One curve = one drop.
d – calculation of different Shape Indices (SI) for every curve;
e – representation of the statistical differences between wines (M ± 2б) on the plate of features in coordinates of different SI;
f - laboratory setup which makes all of these operations.

Results



Dynamical Portraits of some wines:

1 – Dry white wine "Shardone K1";
2 – White semisweet "НЦ-13";
3 – White semisweet "Muscat P1";
4 - White semisweet "К598 Д1";
5 - White semisweet "К599 Д1";
6 - White semisweet "К601 Д1";
7 – Red semisweet "3-НЦ-13";
8 - Red semisweet "Merlot K1";
9 - Red semisweet "Isabella K1";
10 - Red semisweet "К571 Д1";
11 - Red semisweet "К579 Д1";
12 - Red semisweet "К580 Д1".



10 kinds of dry wine are shown together on the planes of features in coordinates of different shape indices. There are White wines: 1 - Artemis, 2 – Bianka , 3 - Citron Magaracha, 4 – Hara, 5 – Iohaniter 1F and Red wines: 6 – Alexampelo, 7 – Apollon, 8 – Eremin, 9 – Krimbas, 10 – Makedonas.

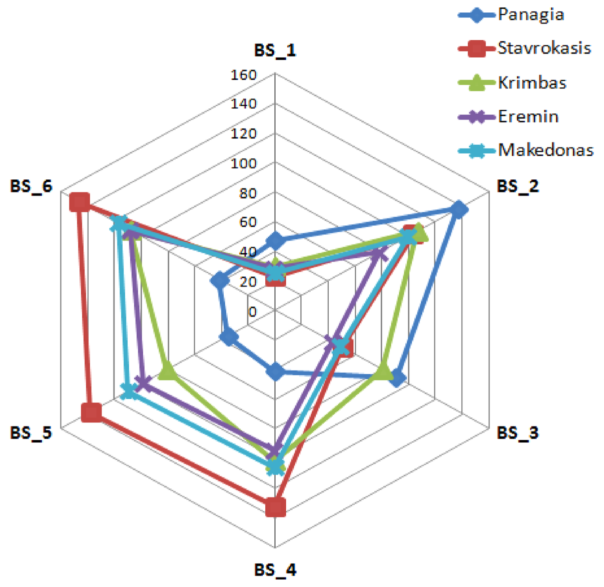
Correlation Coefficients between some Shape Indices and wine components

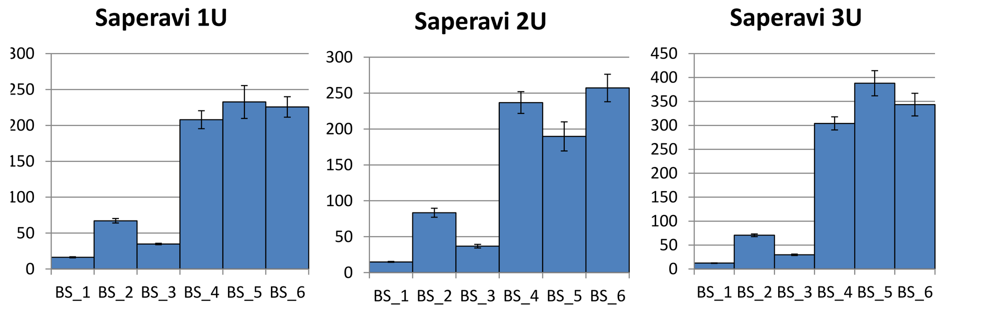
White Wines

	Ethanol	Extract	Titrat. acidity	Reduced sugars	Phenols	SO2	Tartaric acid
BS_1	0,47	0,98	0,12	0,98	0,95	0,33	-0,28
BS_2	0,09	0,73	0,01	0,78	0,71	0,6	-0,37
BS_3	0,44	0,98	0,12	0,98	0,95	0,33	-0,3
BS_4	-0,73	-0,74	-0,66	-0,63	-0,72	0,24	0,08
BS_5	-0,74	-0,69	-0,34	-0,57	-0,68	0,3	0
BS_6	-0,73	-0,74	-0,31	-0,63	-0,72	0,21	0,11
BU_1	-0,53	-0,73	-0,46	-0,69	-0,78	0,04	-0,04

Red Wines

	Ethanol	Extract	Titrat. acidity	Reduced sugars	Phenols	SO2	Tartaric acid	Anthoc.	Phenolic monomers
BS_1	0,24	0,89	0,45	0,87	0,87	0,58	-0,28	0,84	0,9
BS_2	0,38	0,54	0,17	0,74	0,58	0,57	-0,38	0,65	0,51
BS_3	0,46	0,71	0,21	0,8	0,64	0,4	-0,41	0,66	0,74
BS_4	0,04	-0,78	-0,59	-0,71	-0,66	-0,81	0,1	-0,52	-0,58
BS_5	0,03	-0,67	-0,54	-0,64	-0,58	-0,8	0,09	-0,46	-0,46
BS_6	0,06	-0,72	-0,56	-0,68	-0,61	-0,82	0,08	-0,48	-0,51
BU_1	0,36	-0,62	-0,72	-0,44	-0,71	-0,72	-0,09	-0,62	-0,47





Individual "wine profiles". Left - some dry red wines. Right – wine Saperavi produced from different version numbers of grape. BS_1 – BS_6 – Shape Indices calculated for every wine.

References

1. T. Yakhno, A. Sanin, A. Pelyushenko, et al. // Biosensors and Bioelectronics. 2007, **22**, 9-10, 2127-2131.
2. T. Yakhno, A. Sanin, V. Yakhno, et al. // IEEE Engineering in Medicine and Biology Magazine. 2005, **24**, 2, 96-104.
3. T.A. Yakhno, A.G. Sanin, IR.G.Ilyazov, et al. // J. Biomedical Science and Engineering. 2015, 8, 1-23. http://dx.doi.org/10.4236/jbise.2015.81001
4. R.Ilyazov, A.Khilko, A.Khobotov, et al. // Scientific Israel- Technological Advantages. 2012, **14**, №1, P. 106-141.
5. F. Giorgiutty-Dauphine, L. Pauchard. // Colloids and Surfaces A: Physicochem. Eng. Aspects. 2015, **466**, 203-209.