COMPUTER SUPPORTED PROFILE ANALYSIS OF SENSORY QUALITY OF HUNGARIAN MINERAL WATERS

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ABSTRACT

Quality is of ever-growing importance today in every field of life, including food and agriculture. Several quality evaluation methods are available for the assessment of food and beverage products. These methods are of high accuracy and they use state-of-the-art technology. Instrumental and sensory analysis provides different kind of information, which supports professionals in decision making. To investigate the real importance of this quality parameter we analyzed several still bottled waters, which are available on the Hungarian market, with the aim of searching for differences between the products. The applied qualitative method – software-supported profile analysis – is suitable for comparing samples in a much detailed way. In the current paper we publish the result of a recent study, which involved the majority of the relevant still bottled waters available in Hungary. The examined waters were: Mohai Ágnes, Veritas, Óbudai Gyémánt, Balfi, Fonyódi, tap water (as a control sample). Some major findings in our research are the following. The high HCO_3 content waters (like Mohai and Balfi), showed a more intense acidic character. The low mineral content waters did not differ significantly from each other. The tap water, which served as a control sample, was clearly distinguishable by the panellists.

INTRODUCTION

Sensory analysis is an essential part of food quality. It involves several fields of consumer sciences (e.g. marketing, psychology, decision making and behaviour sciences) and also integrates food technology and physiology issues. Majority of sensory tests are applied in product developments. Mineral water from that point of view is an 'outlier' product, since in this industry the role of product development is much smaller. The natural mineral water shall be bottled with minimal changes in the product (e.g. reducing Fe or Mn content). However, the differences between products, or batches can be measured by the application of sensory tests.

Since in the literature there is only a limited number of publication on this topic, it seemed reasonable to investigate this research area.

The first water related survives were dealing with drinking water samples. The quality of tap water is an important issue not only in poor, or developing countries, but in other regions as well. In this latter case the quality complaints are usually focusing on sensory faults or defects. Two American papers (Krasner et al., 1985; Suffet et al. 1988) were the first in the literature in this field, followed by two more recent, South-Korean research (Bae et al., 2002, 2007). Just as a comparison, I did not find any Hungarian publication in the international literature about drinking water sensory evaluation.

Certainly, the mineral water industry is applying sensory investigations in production quality control, but these projects are not public, so it gives no contribution to the scientific committee. In these 'in-house' tests usually trained panellists or experts are performing the evaluation. The primary goal of these procedures is to provide, that the water is free from any sensory bias.

In my research I set up a different approach. My goal was to compare products of different origin in order to establish their sensory profiles. This approach was used in an earlier study of Aishima (2007) and colleagues, who also compared the sensory profiles of mineral waters available in Japan. During the procedure I tried to confirm or reject a hypothesis, whether the average consumer is able to percieve those differences between them.

To investigate another issue concerning waters, I involved a tap water sample in my research. There are different type of consumer attitudes towards water. Some people say, that mineral water is superior to tap water, because the latter has poorer quality. But there is another segment, who contradicts this statement. I found two similar studies, one in France, and one in Japan. In the French research (Teillet et al., 2007) consumers compared tap water samples and bottled mineral water products. In a Japanese study (Koseki et al., 2003) 4 European and 2 Japanese mineral waters were compared to three tap water samples, which were treated with different technologies (alkali-ionization and activated carbon filtration). This latter study was initiated by the fact, that between 1990 and 1999 bottled water consumption doubled (from 10 to 20 l/capita), and at the same time 4 million household water treating devices were sold.

MATERIALS AND METHODS

Mineral water samples

In my research I've investigated the sensory quality of the following Hungarian mineral waters:

Mohai Ágnes, Veritas, Óbudai Gyémánt, Balfi, Fonyódi, tap water (as a control sample, taken in Budapest, at the University Campus).

Sensory test method

Profile analysis was the applied test method (ISO 11035:1994). This is a longer test procedure, with at least four phases, as follows:

1. In the first step of profile analysis the assessors are introduced with the samples to be tested. They define those sensory attributes, which are the most characteristic to the samples. At that time each panellist works individually, separated in the test booths. Everyone uses his own words to describe the sensory impressions.

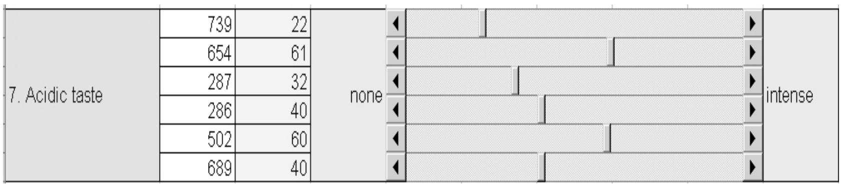

Figure 1

Evaluation of the acidic taste on an unstructured scale, created by ProfiSens.

2. In the following phase the panel members work together. This step is called consensus group. The panellists are trying to create a common list of descriptors from the individual lists, which were created in the first step. The main criteria for this common list: each sensory attribute on the list has to be clearly defined and understood by all panel members. In case of every attribute the panel have to find an evaluation method. Mostly, scales were applied to measure the intensity of the attributes. For each scale a minimum and maximum label was necessary. These labels were created by the panel. For example, the 'intensity of acidic taste' is a sensory attribute. The two labels were 'not perceivable' (for the minimum value), and 'intense' for the maximum value (see Figure 1.).

Once, the consensus is reached the panel leader creates the score sheet. It can be most effectively done by the application of a specialized software (in my case it was the ProfiSens). First the major parameters of the evaluation shall be specified through a dialogue box (see Figure 2.). The panel leader can choose from three major options. Firstly, the software is able to create uniform test codes for the purpose of the consensus group. Secondly, the collected attributes can be entered here, creating a new test project. And thirdly, the data analysis can be initiated. This way we can analyze data of non-computerized tests, if the results are properly tabulated. For this purpose the software creates a basic file only, which is necessary to start the analysis. So if a lab uses only a single computer, evaluations can be performed on paper, but data analysis can be automated. In my research I used a fully-computerized lab, so all the procedures were done electronically. It is also necessary to specify the evaluation method (see Figure 3.).

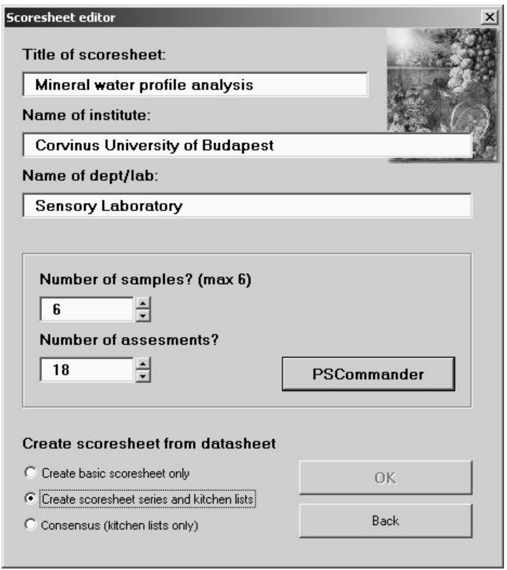

Figure 2
Main dialogue box of ProfiSens.

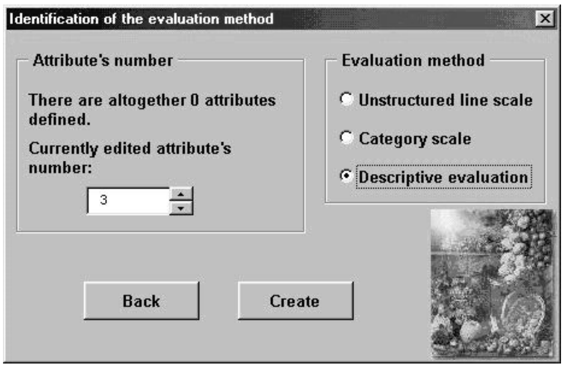

Figure 3
Choice of evaluation method for the sensory attributes.

During the consensus group the attributes are usually listed in a file. Our software makes it possible to import this file into the system. This feature is called ProfiSens Commander because of its similarity to the well-known Norton Commander (see Figure 4.).

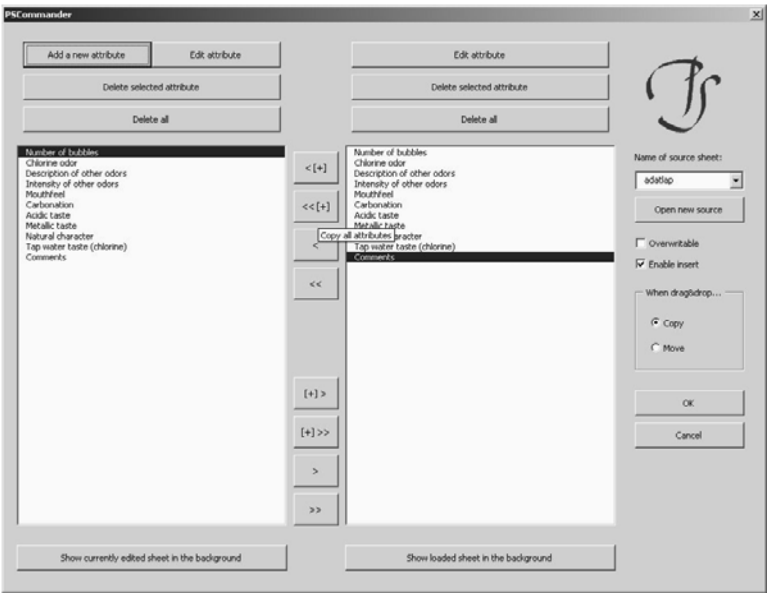

Figure 4
Importing the consensus list by the ProfiSens Commander.

ProfiSens also generates the test design (sample codes and a presentation order for each assessor). The score sheets are copied to the panellists' computers through the LAN (see Figure 5.).

3. Assessors work separately in the sensory booths. They evaluate the samples according the previously defined terminology. Samples are presented in a random order for each panellist to balance the carry-over effects. Sample codes are three-digit random numbers.

4. After score sheets have been filled out, data analysis protocols begin to explore differences among the tested samples. Statistical evaluation can be performed with built-in modules or sheets can be exported to several statistical applications (Kókai et al., 2002).

RESULTS AND DISCUSSION

The major result of a profile analysis is a special type of graph, which is often called spider-web or radar-plot in other applications. However in sensory research this graph is called the sensory profile of the evaluated products (see Figure 6.).

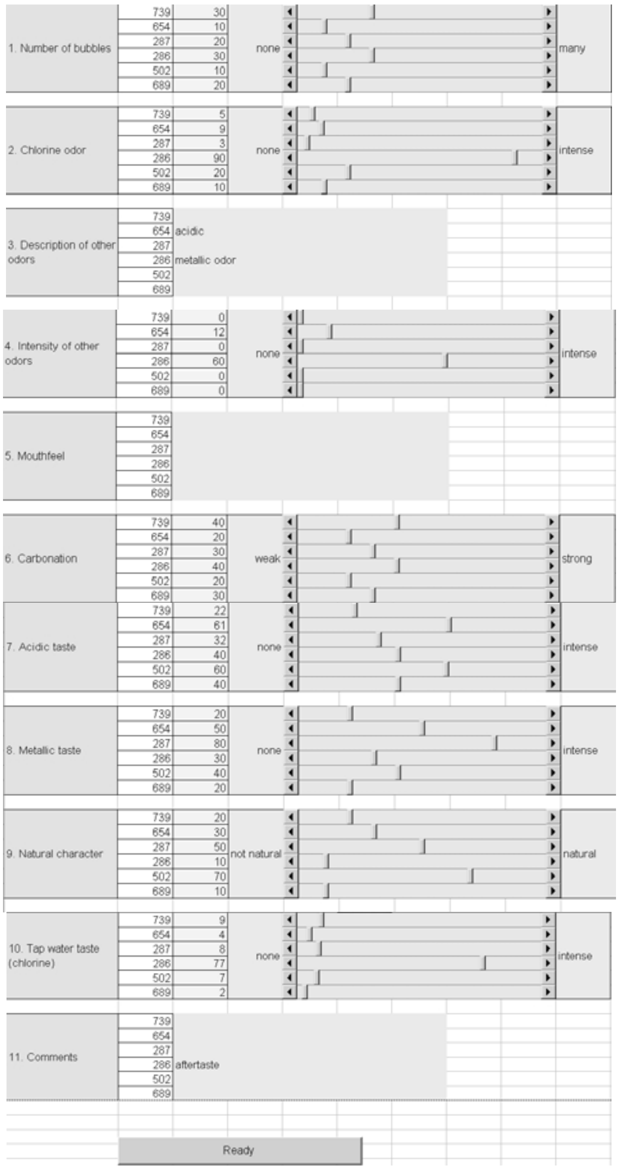

Figure 5
Structure of the score sheet

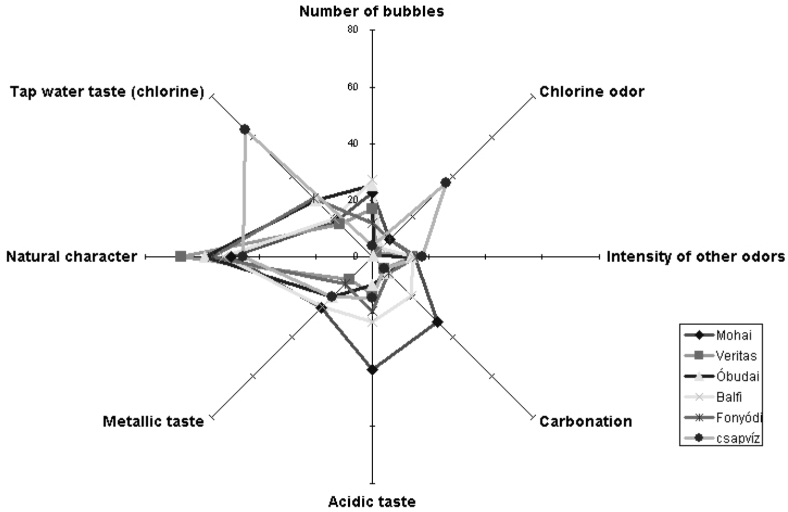

Figure 6
Sensory profiles of the evaluated mineral waters
and the tap water sample.

As two people can significantly differ in their profiles, similarly two products can be projected in a two-dimension space this way. Where the profiles are almost overlapping each other, there are not real differences between them, in the other attributes the different might be significant. Of course, if we want to understand the importance of these differences, statistical evaluation is necessary. This evaluation is performed separately for each sensory attribute. To demonstrate the principles of the analysis one attribute will be discussed thoroughly, in case of the other characteristics only the conclusions will be drawn.

First a one-way ANOVA is performed on the tabulated results of the individual panellists data. If the calculated ‘F’-value is larger or equal with the critical ‘F’-value, then it can be concluded, that at least two samples are different at the given significant level (rejecting the H_0 zero hypothesis, that the samples did not differ in this attribute). First the analysis is executed on the p=5% level, and if the zero hypothesis can be rejected, then the p=1% level should be also investigated. In case of the acidic taste the ANOVA gave significant result on both levels (see Table 1.), so I rejected the zero hypothesis.

Table 1
One-way ANOVA of the intensity values in acidic taste

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10405,19	5	2081,04	3,22	0,00961	2,30
Within Groups	65839,06	102	645,48			
Total	76244,25	107				

In every attribute, where the H_0 was rejected a pair wise significant comparison is necessary to find out, which samples are different from each other. If the difference between the intensity values of two samples is larger or equal than the least significant difference (sd), than this is a significant difference. This comparison is usually summarized in a table or matrix (see Table 2.).

Table 2.
Matrix of the least significant differences in acidic taste

Acidic taste	sd(5%)=16,80, sd(1%)=22,23					
between samples	Mohai	Veritas	Óbudai	Balfi	Fonyódi	tap water
Mohai	-	1%	1%	no	5%	1%
Veritas	26,83	-	no	no	no	no
Óbudai	29,67	2,83	-	no	no	no
Balfi	16,72	10,11	12,94	-	no	no
Fonyódi	20,78	6,06	8,89	4,06	-	no
tap water	25,17	1,67	4,50	8,44	4,39	-

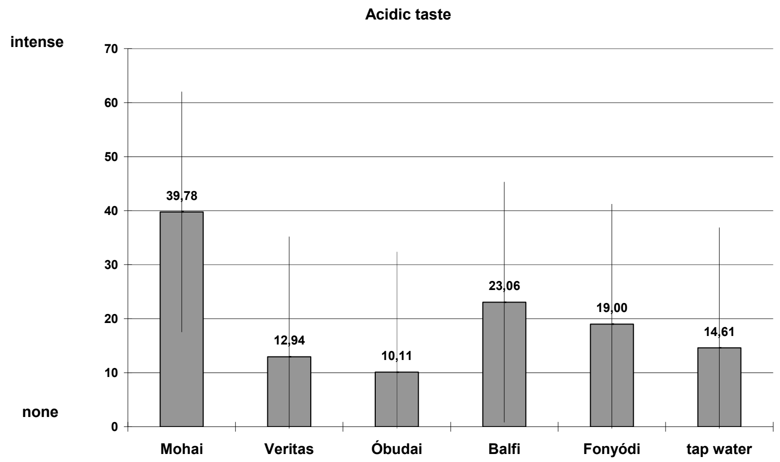

Figure 7
Intensity of the acidic taste in the water samples.

In acidic taste the 'Mohai' and 'Balfi' samples are rather different from the other waters, The hydrogen-carbonate content of this two water is 1450,0 mg/l and 1098,0 mg/l, respectively. Those waters which contain lower amount of this component (Óbudai = 445,0 mg/l, Fonyódi = 543,0 mg/l, Veritas = 311,0 mg/l) did not differ from each other significantly. So the untrained panellists were able to differentiate between the high and the low hydrogen-carbonate content waters. The intensity values of the acidic taste is represented on Figure 7.

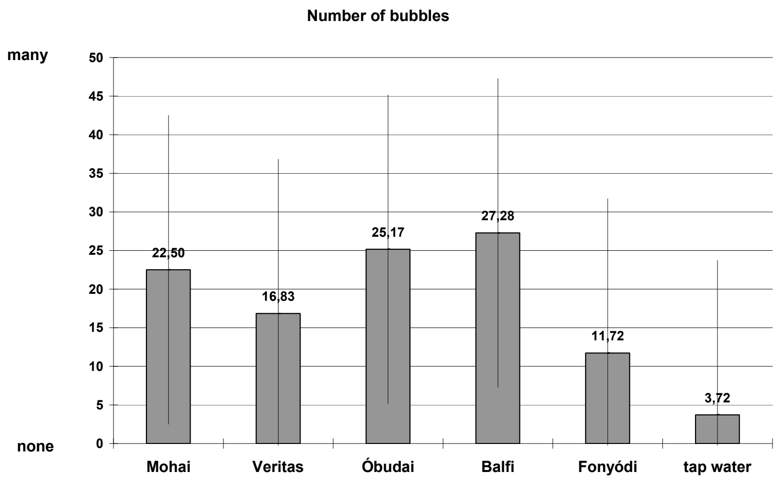

Figure 8
Differences in the number of bubbles among the water samples.

Table 3.
Matrix of the least significant differences in the number of bubbles

Number of bubbles	sd(5%)=15,11, sd(1%)=20,00					
between samples	Mohai	Veritas	Óbudai	Balfi	Fonyódi	tap water
Mohai	-	no	no	no	no	5%
Veritas	5,67	-	no	no	no	no
Óbudai	2,67	8,33	-	no	no	1%
Balfi	4,78	10,44	2,11	-	5%	1%
Fonyódi	10,78	5,11	13,44	15,56	-	no
tap water	18,78	13,11	21,44	23,56	8,00	-

The most bubbles were found in the 'Óbudai' and 'Balfi' samples. The difference between 'Óbudai' and 'Veritas' was significant only at the p=5% level. 'Balfi' and 'Veritas' did not differ in this attribute according to the statistical evaluation. The least bubbles are in 'Fonyódi', 'Mohai' and the tap water samples. The intensity values of this attribute and the pair wise statistical comparison is shown in Figure 8. and Table 3.

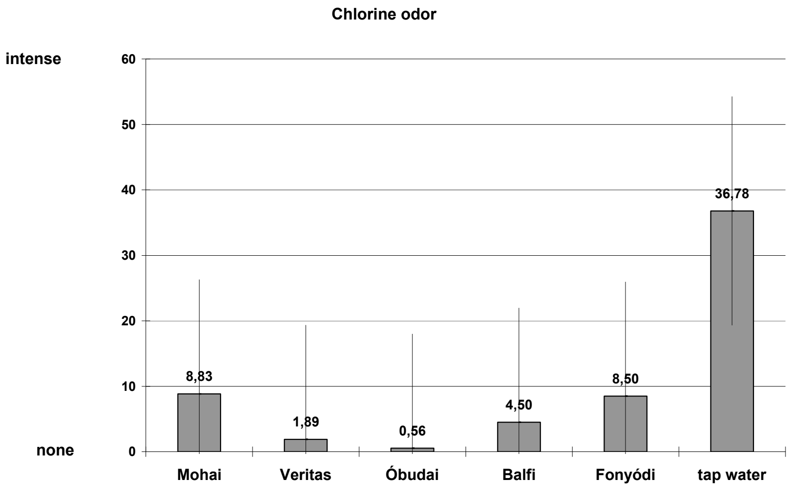

Figure 9
Intensity of chlorine odour in the water samples.

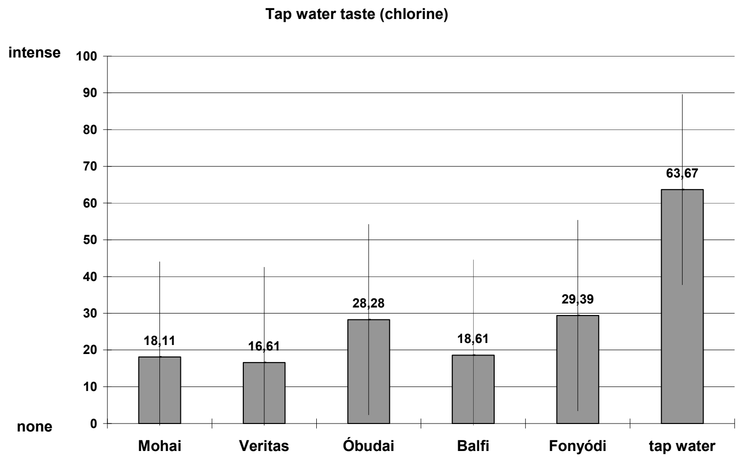

Figure 10
Intensity of chlorine taste in the water samples.

Table 4.
Matrix of the least significant differences in chlorine odour

Chlorine odor	sd(5%)=13,19, sd(1%)=17,45					
between samples	Mohai	Veritas	Óbudai	Balfi	Fonyódi	tap water
Mohai	-	no	no	no	no	1%
Veritas	6,94	-	no	no	no	1%
Óbudai	8,28	1,33	-	no	no	1%
Balfi	4,33	2,61	3,94	-	no	1%
Fonyódi	0,33	6,61	7,94	4,00	-	1%
tap water	27,94	34,89	36,22	32,28	28,28	-

The panellists were able to surely distinguish the tap water according to the chlorine odour and the chlorine taste. The intensity values of these two attributes were moving together. Tap water was separated from the other samples on the p=1% significance level (see Figure 9-10. and Table 4-5.). Among the bottled waters there was no significant difference in this sensory attributes.

Table 5.
Matrix of the least significant differences in chlorine taste

Tap water taste (chlorine)	sd(5%)=19,60, sd(1%)=25,94					
between samples	Mohai	Veritas	Óbudai	Balfi	Fonyódi	csapvíz
Mohai	-	no	no	no	no	1%
Veritas	1,50	-	no	no	no	1%
Óbudai	10,17	11,67	-	no	no	1%
Balfi	0,50	2,00	9,67	-	no	1%
Fonyódi	11,28	12,78	1,11	10,78	-	1%
tap water	45,56	47,06	35,39	45,06	34,28	-

All the water samples were non-carbonated, however there was a certain level of difference among them. According to mineral water experts, the cause of this phenomenon is the natural carbon-dioxide content of the samples. In carbonation 'Mohai' and 'Balfi' differed on p=0,05 level from 'Fonyódi' and from the tap water sample (see Figure 11. and Table 6.).

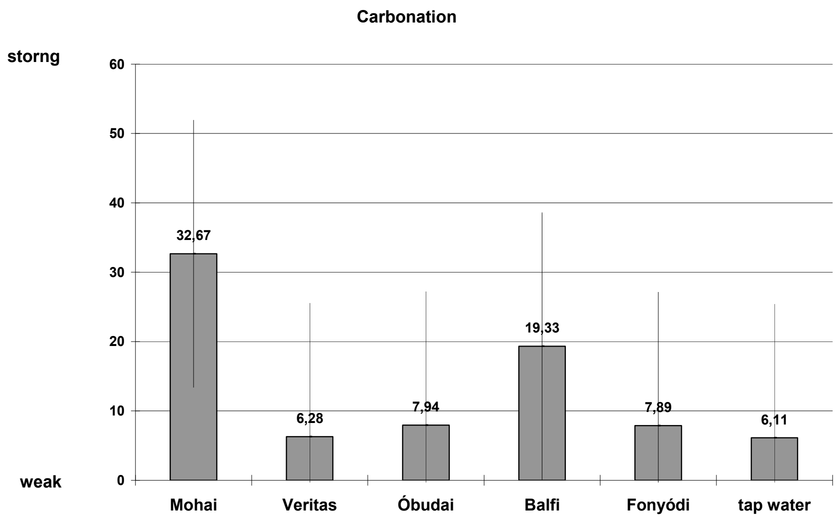

Figure 11
Intensity of carbonation in the water samples.

Table 6.
Matrix of the least significant differences in carbonation

Carbonation	sd(5%)=14,56, sd(1%)=19,26					
between samples	Mohai	Veritas	Óbudai	Balfi	Fonyódi	tap water
Mohai	-	1%	1%	no	1%	1%
Veritas	26,39	-	no	no	no	no
Óbudai	24,72	1,67	-	no	no	no
Balfi	13,33	13,06	11,39	-	no	no
Fonyódi	24,78	1,61	0,06	11,44	-	no
tap water	26,56	0,17	1,83	13,22	1,78	-

According to the panellists 'Veritas' was the sample with the most natural character, however in this attribute the difference was not significant. In the mouth feel, in the metallic taste and in the intensity of other odours there was also no significant difference among the tested samples.

On the summarized profile diagram of the samples the different character of the tap water can be clearly seen. The differences among the mineral waters are also demonstrated in an objective way. Table 7. summarizes the minimal level of significant differences between the samples for each attribute.

Table 7.
Significant differences in the sensory attributes among the samples

Attributes	Minimal level of the significant differences	
	p=0,05	p=0,01
Number of bubbles	✓	✓
Chlorine odor	✓	✓
Intensity of other odors	×	×
Mouthfeel	×	×
Carbonation	✓	✓
Acidic taste	✓	✓
Metallic taste	×	×
Natural character	×	×
Tap water taste (chlorine)	✓	✓

Discussion

According to the sensory evaluation of the water samples there is a strong difference between the tap water and the bottled waters in the intensity of chlorine odour and chlorine taste. It is important to emphasize, that the quality of tap water differs widely, depending on the water network and water resource conditions. However it was an important part of this research to involve this sample from two points. Firstly, there are certain common beliefs whether the tap water differs from mineral water or not, and secondly because other researchers also involved that type of samples in their studies. In acidic taste the high hydrogen-carbonate content 'Mohai' and Balfi' were different from the low ones. The panellists were not able to make difference between the members of this latter group (low hydrogen-carbonate content) from the sensory point of view. There were some attributes in which the samples did not differ significantly: natural character, mouth feel and metallic taste. It does not mean that those attributes are not important, only indicates that in this sample group there were no differences in these issues. On the other hand, during a profile analysis all the sensory attributes are contributing to the value of the test result.
My studies confirmed that profile analysis is a suitable method for the sensory analysis of bottled waters. It is especially true, if there is a special software, which supports the procedure, e.g. ProfiSens®. By the application of this software the design of the test can be done automatically, data collection is much easier, and data analysis is faster. The time necessary for the study has been decreased, and the panellists can see the test results almost in real-time. The test outcomes can be integrated in to the production or research activities. The sensory attributes of the waters can be described in a comprehensive way.
My survey showed that a product, which seems to be very simple, can be rather complicated from the consumer of the producer point of view. The research outcomes proved that the applied research methods are effective in the analysis of mineral waters. Since consumption patterns and market conditions are changing continuously, similar studies are necessary in the future to monitor these factors, and to contribute to the success of the bottled water market.

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