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Research Article

Sensory characteristics and driver of liking of bottled drinking water in Indonesia

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Abstract

Several factors determine the quality of drinking water, including sensory attributes. This study aimed to investigate the sensorial profiles of eight bottled drinking waters representing mineral, demineralized, oxygenated, and alkaline waters in the Indonesian market. In addition, the correlation between sensorial attributes and liking of bottled drinking water was also explored. The flash profiling method was employed involving 44 semi-trained panelists (mean age 19.8 ± 0.84, 32% men and 68% women) to characterize the sensory profiles of the bottled drinking water. In addition, the liking score was also asked using a 10-cm line scale. There were significant differences for astringency ($p=0.012$), bubbles ($p<0.001$), and fruity tastes ($p=0.014$) across the bottled-drinking water samples, indicating that oxygenated water has a higher intensity for these attributes. The mineral water was preferred as compared to the demineralized, oxygenated, and alkali water based on the PCA analysis. The sensorial attributes of cooling, sweet taste, and smoothness were positively correlated with consumer acceptability of bottled-drinking water while attributes of plastic taste, bitter, sour, salty, mineral taste, astringent, earthy, thickness, fruity, and bubbles were negatively correlated with liking. This is the first study investigating the sensory profiles and the driver of liking of commercial bottled-drinking water in the Indonesian market and the results can be used for the improvement and development of bottled-drinking water that will deliver the desirable profiles for consumers.

Keywords

bottled-water, drinking-water, flash profiling, preferences, water

Abbreviations

ANOVA – analysis of variance; PCA – principal component analysis; TDS – total density solid

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Introduction

Water is essential for human life. Our bodies consist of 60 - 80% water (Kavouras and Anastasiou 2010). Water has numerous roles in the human body. It acts as a building material, a solvent, a medium for metabolism and various biochemical reactions, a reactant, a carrier for nutrient and waste products, as well as maintaining thermoregulation (Jéquier and Constant 2010; Lukito 2021). Inadequate water intake may lead to dehydration which results in the impairment of health conditions. Dehydration at low or medium levels have been reported to alter cognitive performances in both adults (Cian et al. 2000; Gopinathan et al. 1988) and in children 10 - 12 years old (Bar-Or et al. 1980). Inadequate water consumption is also highly correlated with low peristaltic movement and may lead to constipation (Arnaud 2003; Robson et al. 2000). Further, low water intake can result in headaches, reduced alertness and concentration, and reduced physical performance (endurance) (Ritz and Berrut 2005; Shirreffs et al. 2004).

Humans require around 2 - 6 L of water per day and this requirement varies from person-to-person (Grandjean et al. 2003). Factors such as body weight, physical activities, age, climate (temperature), and daily food consumption influence water need (Jéquier and Constant 2010; Popkin et al. 2010). Indonesia is a tropical country and thus people may suffer from dehydration due to the heat and humidity (Fritz 2022). A study by Laksmi et al. (2018) concluded that water was the most frequently consumed drink in Indonesia, however, around 20 - 30% of the population does not have sufficient total fluid intake. There are many factors influence adequate intake of fluid and one important consideration driving people to drink is the water quality (Teillet et al. 2010)

The quality of drinking water becomes a universal concern since water is a basic foundation of human diet and at the same time it can act as a medium for disease transmission and contaminants (World Health Organization 2010). In Indonesia, the standard quality of drinking water is regulated by the Indonesia National Standard Quality (SNI 3553-2015). This regulations include the standards for physical, chemical, organic chemistry, microbiology, and radioactive parameters (SNI 3553-2015). In addition, the sensory characteristics of bottled-drinking water cannot be neglected. The sensorial characteristic is a part of water quality assessment and plays a significant role in consumer preferences (Pacheco et al. 2018; Teillet et al. 2010). For example, a study reported by Pacheco et al. (2018) suggest that the mineral concentrations were affecting the sensory characteristic of bottled-drinking water and significantly influence consumer liking. Furthermore, sensory characteristics were reported as important perceptions for the quality and acceptability of drinking-water (Whelton et al. 2007) with taste and odor become the main concern for consumers preferences (Akcaalan et al. 2022; Bae et al. 2007).

Little focus has been given to the preferred sensory characteristic of water. The relationship between the sensory profiles and preferences may lead to consumer loyalty to the specific bottled-drinking water brand. This has not studied yet with the commercials bottled-drinking water in Indonesia. The objective of this study was to investigate the sensorial properties of commercial bottled-drinking water that available in the Indonesia market, and to analyze the driving factors for the liking of this product. The rapid descriptive analysis of flash profiling was employed to characterize the sensory attributes of bottled-drinking water using semi-trained panelists. Flash profiling method is a rapid descriptive method that able to provide the understanding of the sensory positioning of the product (Liu et al. 2018). This method has been used for quantifying sensory profiles of different foods and demonstrate good validity and reliability as compared to the classical descriptive method (Kalschne et al. 2019; Liu et al. 2018).

Materials and Methods

Samples. There were eight commercial bottled-drinking water evaluated in this study. This includes mineral water (4 samples), demineralize water (1 sample), oxygen water (1 sample) and alkali water (2 samples with different pH of 8 and 9, respectively). The complete samples involved in this study are presented in Table 1. The selection of the samples were based on the most common of bottled-drinking water product found in the Indonesian market (Sunardi et al. 2022). Moreover, mineral water, alkaline water, oxygen water, and demineralized water are the types of bottled drinking-water that are widely known among

Indonesians. All the samples were purchased from the local supermarket. We did not disclose the original name and brand of the bottled-drinking water in this study since our research was focus on the type of the bottled-water (mineral, de-mineral, oxygenated, alkaline) thus all the samples were remained coded in this article.

Table 1. The samples of bottled drinking water

Samples	Type of water
Min-1	Mineral water
Min-2	Mineral water
Min-3	Mineral water
Min-4	Mineral water
DEM	Demineralize water
OXY	Oxygen water
ALK-pH 8	Alkaline water with pH 8
ALK-pH 9	Alkaline water with pH 9

Participants. There were 44 semi-trained panelists (mean age 21.81 ± 0.84, 32% men and 68% women) selected to join the study. The panelists were recruited from the students and staff of Bina Nusantara University, Alam Sutera Campus, Jakarta, Indonesia. Prior to the evaluation, the panelists were given a brief explanation of the study objective and the outline regarding the flash profiling procedure. The panelists were introduced to the lexicons of drinking water prior to the test. The list of lexicons and the selection for references refers to the study reported by Rey-Salgueiro et al. (2013). All participants were voluntary and provided their written consent form before participating in the test. However, a small token of appreciation was given to them after completing all the session. The procedure has been approved by the ethics committee of Research and Technology Transfer Office, Bina Nusantara University and followed the Helsinki Declaration regarding the use of human subjects (WMA 2013).

Methods The sensory test follows the rapid descriptive method of flash profiling (Delarue 2015; Liu et al. 2018). The test was divided into two sessions. The first session was term generation and scale training. In this session, the samples were served simultaneously to the panelists. The water samples were served in a 30 ml clean glass-jar cup. Note that disposable plastic cups were not used in this study to avoid flavor and odors transfer from the plastic material. The panelists were then asked to identify the attributes that best described the differences between samples. They were instructed to write down as many descriptive attributes as they could and were asked to list the attributes by categories (i.e. texture, appearance, aroma, and taste) (Delarue 2015). Panelists are allowed to re-taste the sample multiple times. The first session took approximately 40 - 60 min to complete. All the descriptive attributes collected in this session were then tabulated to be analyzed further. The similar attributes (i.e. sweet, sweetness; clean, clear) were merged together. The attributes generated by the panelists were then checked whether it is listed in the standard lexicon of drinking water or not (Marcussen et al. 2013; Rey-Salgueiro et al. 2013). The complete attributes evaluated in this study are presented in Table 2.

All the attributes presented in Table 2 were then informed to the panelists aiming to have the same understanding of each term among them. The attributes were then evaluated in the second session. In this session, panelists were asked to assess each sample for their overall liking and were asked to provide a rating score of their perceived intensity level from “low” (weak intensity) on the left side to “high” (strong intensity, right side) for each attribute using the 10 cm line scale while the liking was measured using the same scale but with different anchor of “extremely dislike” in the left to the “extremely like” on the right (Ho 2019; Pimentel et al. 2016). All the water samples were coded with three-digit random code and were evaluated in a randomized order to avoid any bias from the evaluation.

The ANOVA was used to investigate the significant differences across samples for their sensory attributes and liking. Moreover, a pairwise comparison test was performed using Tukey’s test at 5% significance level if the ANOVA results found to be significant. The PCA was conducted to analyze the intensity attributes and liking score obtained from the flash profiling. The PCA analysis was aimed to map the products’ attributes and its liking. The average intensity attributes and the

Table 2. The evaluated attributes of bottled-drinking water

Sensory attributes	Definition	Reference
Overall liking	Preference of the sample from all aspects	(Ho 2019)
Mineral	Smell and taste like minerals (metal and medical) are related to the taste and smell of metal cans, aluminum foil, medicine, and hospitals	(Marcussen et al. 2013)
Astringent	Assess the extent of dryness 10 second after swallowing	(Leone et al. 2022)
Bitter	Intensity of the basic taste characterized by solution of bitter (quinine and caffeine)	(Darıcı et al. 2021)
Bubbles	Appearance attribute according to the size and number of the ring of foam in the sample that forms on the surface	(Kemp et al. 2019)
Cooling	Assess the cooling sensation 10 second after swallowing; not affected by the temperature	(Phetxumphou et al. 2017)
Sweet	Intensity of the basic taste characterized by solution of sucrose	(Olsson et al. 2018)
Fruity	Fruity, green apple, coconut taste like	(Yang et al. 2021)
Plastic	Flavor associated with plastic	(Phetxumphou et al. 2017)
Smoothness	Assess how gentle and soft the liquid feels in the mouth	(Darıcı et al. 2021)
Thickness	Assess how viscous, thick, and heavy the product is in the mouth	(Darıcı et al. 2021)
Sour	Intensity of the basic taste characterized by solution of citric acid	(Olsson et al. 2018)
Salty	Intensity of the basic taste characterized by solution of salt	(Olsson et al. 2018)
Earthy	Flavor associated with decaying vegetation and damp plant soil	(Yang et al. 2021)

overall liking score were tabulated in a contingency table with samples placed in rows and score for each intensity attributes and liking as columns. The descriptive attributes were involved as main variables while liking score added as supplementary quantitative data. The correlation between sensory attributes and overall liking was calculated using the Pearson correlation coefficient. All the data were analyzed using XLSTAT sensory version (Addinsoft, France, version 2022.1).

Results and Discussion

Sensory characteristics. Based on the ANOVA results (Table 3), there were significant differences of sensory attributes across bottled-drinking water for astringency ($p=0.012$), bubbles ($p<0.001$) and fruity taste ($p=0.014$). The oxygenated sample (OXY) has a highest intensity for astringency, and this was significantly higher with mineral water (Min-2, Min-3) as they were the samples with the least astringent taste. Moreover, oxygenated water (OXY) was also characterized as the most having bubbles with intense fruity taste compared to the other samples.

Based on the PCA results presented in Fig. 1, the F1 axes divided the samples into two categories, the left side (Min-1, Min-2, Min-3, Min-4 and ALK-pH8) were dominated by mineral water, except for ALK-pH8 which is categorized as alkaline water with pH 8. The right side of F1 consisted of alkaline (ALK-pH9), demineralized, and oxygenated water. The alkaline water (ALK-pH9), demineralized

Table 3. Sensory attributes of bottled drinking water

Sensory attributes	Min-1	Min-2	Min-3	Min-4	DEM	OXY	ALK-pH8	ALK-pH9	*p*-value
Mineral	4.1±2.9	4.0±2.8	3.5±2.7	4.0±2.5	4.4±3.0	4.4±2.5	3.6±2.6	4.1±2.6	0.701
Astringent	2.7±2.4	2.6±2.2	2.6±2.5	3.0±2.6	3.9±3.0	4.4±3.0	3.2±2.8	3.5±2.7	**0.012**
Bitter	2.6±2.3	2.6±2.1	2.4±2.2	2.8±2.6	3.5±2.6	3.5±2.6	2.6±2.4	2.8±2.3	0.330
Bubbles	2.5±2.1	0.8±1.1	0.6±0.5	0.6±1.0	0.8±1.1	8.8±1.0	0.6±0.8	0.8±0.6	**< 0.001**
Cooling	5.2±2.9	4.4±2.8	5.3±3.1	6.5±2.9	4.1±2.7	5.1±2.9	4.9±2.7	4.5±2.6	0.195
Sweet	3.0±2.5	2.3±2.1	2.6±2.2	2.8±2.1	2.3±2.1	3.3±2.6	2.5±2.1	2.7±2.3	0.513
Fruity	1.6±1.2	2.1±2.0	1.5±2.1	1.9±2.2	1.8±2.1	3.1±3.0	1.8±2.0	1.2±1.2	**0.014**
Smoothness	5.4±2.6	5.7±2.7	5.7±2.6	6.0±2.5	5.6±2.5	5.5±2.5	5.6±2.6	5.2±2.4	0.897
Thickness	3.4±2.3	2.8±2.4	2.6±2.4	2.5±2.3	3.4±2.6	3.1±2.3	2.8±2.2	3.4±2.2	0.325
Sour	1.4±1.2	1.8±1.9	1.7±2.0	1.5±1.2	2.4±2.2	2.1±2.0	1.4±1.2	1.9±2.0	0.165
Salty	2.1±2.0	1.9±2.0	1.5±1.2	1.9±1.7	2.3±2.1	1.7±1.4	1.6±1.4	1.5±1.4	0.549
Earthy	2.1±2.0	2.0±1.9	2.1±2.6	1.8±2.0	2.7±2.4	1.7±1.4	2.0±2.0	1.8±1.5	0.613
Plastic	2.0±1.7	2.5±2.1	2.0±2.3	2.2±2.1	3.2±2.7	2.8±2.3	2.3±2.1	2.3±2.1	0.280

Min = mineral, DEM = de-mineral, OXY = oxygenated, ALK = alkaline

water (DEM) and oxygenated water (OXY) were separated in different directions indicating that they have distinct sensorial attributes of bottled-drinking water.

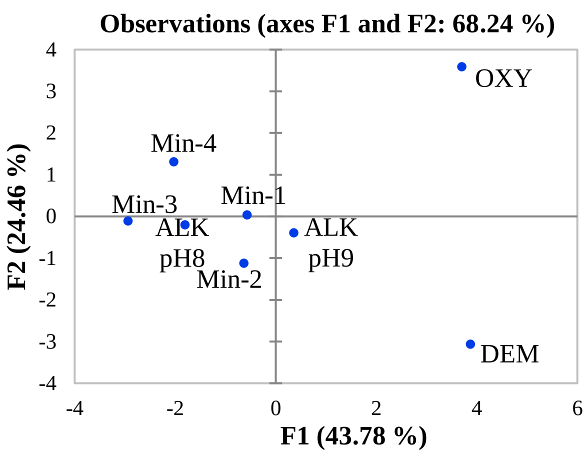

Figure 1. Position of each sample based on sensory characteristic in the PCA results (Min – mineral, DEM – demineralized, OXY – oxygenated, ALK – alkaline)

The oxygenated water (OXY) was characterized as the sample with high bubbles formation as compared to the other bottled-drinking water samples. The bubbles were formed due to oxygenated process when oxygen injected to the water during bottling process (Sunardi et al. 2022). The oxygen gas trapped in water molecules form the bubbles that are noticed by consumers. This process makes this sample have a significant quantity of bubbles compared to other non-oxygenated water. Oxygenated drinking water is believed to improve hydration especially after strenuous physical activities. The extra oxygen contained in the water was expected to replace the loss of oxygen more efficiently and results in improving physical performance (Sunardi et al. 2022). However it was stated that breath of a fresh air contains more oxygen than a liter of ingested oxygenated water (Piantadosi 2006). The oxygen form in water cannot be absorbed as gas exchange as oxygen intake occurs in the human lung, thus the amount of oxygen in water can be neglected (Piantadosi 2006; Sunardi et al. 2022).

The astringency in the oxygenated water sample (OXY) may be perceived due to the presence of magnesium since OXY sample declared added magnesium in the labels. The magnesium content at a level of 100 - 500 $mg.L^{-1}$ can contribute to an astringent taste (van der Aa 2003). Generally, the average level of magnesium content in bottled-drinking water was reported at around 50 $mg.L^{-1}$ and this level will not affect to the taste of the water (van der Aa 2003). Moreover, some minerals that are naturally available in drinking water such as Al, Ca.

Cu, Fe, Mg, and Zn (Marcussen et al. 2013) also contributes to the astringent taste. The Indonesian Standard National Agency (SNI 3553:2015) have placed the maximum Fe (0.1 mg.L^{-1}) and Mn (0.05 mg.L^{-1}) in the bottled mineral water. In addition, the Ministry of Health of The Republic of Indonesia (Regulation No 492/MENKES/ Per/IV/2010) have declared the maximum content of Al (0.2 mg.L^{-1}), Cu (2 mg.L^{-1}), Zn (3 mg.L^{-1}), F (1.5 mg.L^{-1}) and Se (0.01 mg.L^{-1}). According to the research reported by Rahayu and dan Tahril (2013) the Fe and Zn concentrations in the source of drinking water were considered as high compared to the standard regulation. Thus, this may affect the taste of the bottled drinking water as reported in this study. Moreover, the sterilization process of the drinking water via ozone disinfection may increase the fruity taste intensity (Bicknell and Jain 2001). This fruity taste was also represented in the oxygenated water-bottled sample which used the same sterilization technique.

Interestingly, our results show that the alkaline sample (ALK-pH8) has similar attributes with other mineral waters (Min-1, Min-2, Min-3, and Min-4). This may be due to the low alkali level (pH 8) as compared to the other alkaline water sample which has pH of 9 (ALK-pH9). Alkaline water is the water with pH above the neutral (higher than pH 7) or usually between pH 8 to 9 (SNI 3553:2015). The pH level in water strongly determined the taste of drinking water. A pH range of 6.5-8.5 is desirable to avoid bitter taste in water (Marcussen et al. 2013; Whelton et al. 2007) this also the reason that the ALK-pH8 samples (alkali water with pH8) and other mineral water samples have similar characteristics while the alkali water with a high pH (ALK-pH9) may already developed a bitter taste due to high pH level. Moreover, according to Indonesia National Agency of Drug and Food Control (BPOM), the pH of alkaline water is regulated to be in a range between 8.6 - 9.5, thus the ALK-pH8 (with pH 8) did not resemble the BPOM regulation and not able to be included as alkaline water based on this regulation.

According to Marcussen et al. (2013) drinking-bottled water is defined as all types of waters for human consumption marketed in bottles. Bottled water is normally divided into different categories depending on its origin and treatments such as spring water (origin) or oxidation, ozonation, and demineralization (treatments). Bottled-drinking water is a product that differs by its source. The physicochemical parameters are a result of the characteristic from the environment where the water was sourced. The packaging will also significantly affect the taste and aroma of bottled-mineral water (Marcussen et al. 2013; Rey-Salgueiro et al. 2013). Furthermore, the mineral content of drinking-bottled water may be influenced by packaging type. The previous study has indicated that the mineral content of Pb, U, Zr, Li, K, Na, and Th were found to be different when the water stored in the glass-bottled compared to plastic-bottles (Shotyk and Krachler 2007). In our study, all of the water samples were packaged in a plastic-bottle. However, plastic bottle packaging made from PET, HDPE, and PP materials can be degraded and affect the flavor of bottled-drinking water and this can contribute to the plastic taste due to chemical migration during storage (Bach et al. 2012).

Bottled-drinking water contains more than 30 compounds of major ions and elements (Marcussen et al. 2013). The taste of drinking water is a result of a complex mix and combination of anions, cations, and minerals (Burlingame et al. 2007; Marcussen et al. 2013). The composition depends where the water is sourced such as whether it was from natural mineral water or spring water and depend on the process (mineralized or demineralized) (Marcussen et al. 2013; Whelton et al. 2007). Mineral content has become a standard worldwide to determine the taste quality of drinking water (Whelton et al. 2007). Moreover, the process of drinking water such as reverse osmosis, filtration, and desalination was reported to also significantly affect the taste of water (Burlingame et al. 2007; Curto et al. 2021).

Driver of liking for bottled drinking water. Fig. 2 demonstrates the association between the samples of bottled-drinking water, sensory attributes, and the overall liking based on the PCA. The two biplot axes of F1 and F2 represent around 68% of the data variability. The results show that overall liking was closely correlated with the attributes of smoothness and cooling and these attributes were closely associated with mineral water. In addition, sensory profiles such as astringent, bitter taste, mineral taste, plastic taste, and sour taste were in the different direction of liking, indicating that these attributes were associated with disliking. Most of these attributes were associated with oxygenated water (OXY). However, based on the ANOVA analysis of the overall liking attributes, no significant differences across samples were observed (p= 0.183), suggesting that there were no differences in terms of consumers' acceptability across bottled-drinking water.

The oxygenated sample (OXY) was characterized as the sample with the most intense astringent, bubbles, and fruity taste based on the PCA result presented in Fig. 2 and from the ANOVA analysis explained previously in Table 3.

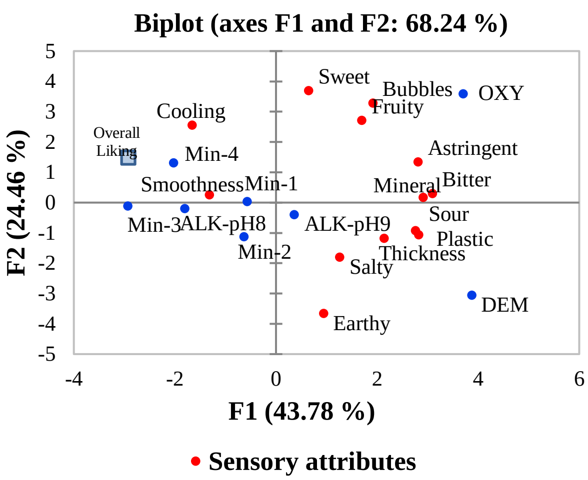

Figure 2. PCA results of commercial bottled-drinking water and overall liking

The intense astringent was considered to decrease liking in this sample. Astringents can be caused by both organic and inorganic components in the water. Astringency in drinking water has been reported to be associated with consumer disliking for drinking water (Pacheco et al. 2018; Platikanov et al. 2017), thus this corroborates with our results since the oxygenated sample (OXY) was characterized by intense astringent taste. Moreover, this sample was also close to bitter attribute and may lead to disliking. Bitter taste has been widely reported to be associated with food rejection (Glendinning 1994; Mennella et al. 2013) and this taste has been disliked since infancy (Forestell and Mennella 2017). The bitter intensity perceived in oxygenated water-bottled may contributed to the disliking of this sample. The correlation analysis was also conducted to measure the relationship between sensory attributes and liking of bottled-drinking water (Table 4). The overall liking has a significant and positive correlation with the attribute of cooling (r=0.61, p< 0.05), sweet taste (r=0.20, p< 0.05), and smoothness (r=0.17, p< 0.05). However, the correlation for sweetness and smoothness was found to be weak. Moreover, liking has a strong and negative correlation with plastic taste (r=-0.96, p< 0.05), bitter taste (r=-0.86, p< 0.05), sour taste (r=-0.82, p< 0.05), and mineral taste (r=-0.81, p< 0.05). In addition, liking also showed to be negatively correlated with astringent (r=-0.65, p< 0.05), salty (r=-0.60, p< 0.05), earthy (r=-0.57, p< 0.05), thickness (r=-0.54, p< 0.05) and fruity (r=-0.40, p< 0.05) while the attributes of bubbles have a significant but weak correlation in decreasing consumers' liking of bottled-drinking water (r=-0.27, p< 0.05).

The results obtained in this study corroborates with a previous study reported by Pacheco et al. (2018) which stated that the overall liking of bottled mineral water was closely associated with sweet taste. In addition, the same study also showed that the attributes of plastic taste, mustiness, and viscosity (thickness) lowered consumer liking if these attributes present in the bottled-drinking water (Pacheco et al. 2018). A study by Platikanov et al. (2017) also suggests that the attributes of residual plastic taste, musty taste, metallic taste, medicine taste, and viscosity significantly impacted liking and decreased the acceptability of drinking water. This was in line with the results obtained from our study. In this study, we did not find any statistical differences based on the ANOVA results of liking for bottled-drinking water, however, the PCA results indicated that mineral water was preferred compared to demineralized and oxygenated water. This corroborates previous results from Falahee and MacRae (1995) which concluded that drinking water with mineral contents were liked better as compared to distilled water (without mineral). Some minerals such as calcium and sodium can affect consumer preferences of drinking bottled water and the addition of these cations aim to produce a clean and fresh taste of drinking water (Burlingame et al. 2007). However, this taste cannot be perceived until the actual mineral content significantly exceeds the person's taste threshold and this depends on each person's taste sensitivity. The taste of water is largely affected by the human taste buds conditions and their sensitivity rely on salivary constituents in human palate (Burlingame et al. 2007).

Table 4. The correlation between sensory profiles and liking of bottled-drinking water

Variables	Mineral	Astringent	Bitter	Bubbles	Cooling	Sweet	Fruity	Smoothness	Thickness	Sour	Salty	Earthy	Plastic	Overall liking
Mineral	**1**													
Astringent	**0.67**	**1**												
Bitter	**0.86**	**0.90**	**1**											
Bubbles	**0.51**	**0.68**	**0.57**	**1**										
Cooling	**-0.29**	**-0.24**	**-0.30**	**0.04**	**1**									
Sweet	**0.26**	**0.40**	**0.22**	**0.78**	**0.46**	**1**								
Fruity	**0.44**	**0.57**	**0.56**	**0.84**	**0.05**	**0.43**	**1**							
Smoothness	**-0.29**	**-0.38**	**-0.19**	**-0.24**	**0.58**	**-0.28**	**0.19**	**1**						
Thickness	**0.66**	**0.43**	**0.47**	**0.22**	**-0.60**	**0.18**	**-0.12**	**-0.83**	**1**					
Sour	**0.72**	**0.71**	**0.84**	**0.30**	**-0.55**	**-0.12**	**0.32**	**-0.23**	**0.45**	**1**				
Salty	**0.58**	0.02	**0.41**	**-0.06**	**-0.09**	**-0.15**	**0.05**	**0.20**	**0.37**	**0.244**	**1**			
Earthy	**0.16**	0.03	**0.28**	**-0.42**	**-0.52**	**-0.59**	**-0.31**	-0.01	**0.34**	**0.384**	**0.616**	**1**		
Plastic	**0.72**	**0.73**	**0.88**	**0.30**	**-0.57**	**-0.23**	**0.49**	**-0.08**	**0.36**	**0.851**	**0.405**	**0.469**	**1**	
Overall liking	**-0.81**	**-0.65**	**-0.86**	**-0.27**	**0.61**	**0.20**	**-0.40**	**0.17**	**-0.54**	**-0.82**	**-0.60**	**-0.57**	**-0.96**	**1**

The bold numbers were significant different at p< 0.05

The correlation analysis was calculated based on Pearson correlations

This includes saliva flow since saliva bathes the taste buds and play essential role in taste sensitivity (Matsuo 2000). In addition, anions such as bicarbonate, chloride and sulfate can affect the taste of drinking water (Burlingame et al. 2007). Bicarbonate and carbonate are the major ions contributing to alkalinity and buffer capacity in water, but the addition of this ions can affect pH and alter the taste of water significantly (van der Aa 2003).

The most important minerals for humans to maintain their normal metabolism function are sodium, chloride, potassium, and sulfate (Burlingame et al. 2007) and these are the minerals that has been mostly found and added in bottled-drinking water and may provide a balance taste of drinking water.

Conclusions

The mineral, demineralized, oxygenated and alkaline bottled drinking water evaluated in this study have different sensorial characteristics. The consumer preference showed to be directed towards mineral water, however, no significant differences found for liking across the bottled-drinking water samples. We found that the attributes of cooling, sweet taste and smoothness were positively correlated with liking while attributes of plastic taste, bitter taste, mineral taste, sour taste, astringent, saltiness, earthiness, thickness, fruit taste, and the presence of bubbles were negatively correlated with liking. We suggest evaluating the sensory attributes of bottled-drinking water using classical descriptive analysis in the future study to compare the results obtained from this study based on rapid descriptive test (flash profile). Moreover, the TDS was not measured in this study thus putting this as a limitation and future work to do. In addition, a bigger sample sized is recommended for future studies to better represent the number of commercial bottled-drinking water available in the Indonesian market. More research is needed with the focus on individual differences of preferences on bottled-drinking water and the combination effect between natural mineral content, water processing, and packaging on the taste of drinking water and its acceptability.

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