# Drinking Water Preference among Students in UiTM Perlis using Fuzzy AHP

**Nur Fatihah Fauzi[1]\*, Syahirah Ali Munawar[2], Huda Zuhrah Ab Halim[3]**
*[1,2,3] Faculty of Computer and Mathematical Sciences*
*Universiti Teknologi MARA, Perlis Branch, Arau Campus, 02600 Arau, Perlis, Malaysia*

*Corresponding author: \*fatihah@uitm.edu.my*

## ABSTRACT

*Due to the decrease in groundwater quality, as a result for Malaysia's to make the bottled water as their basic source of drinking water. It is a fact that each bottled water contains various types of minerals and each mineral will have its own benefits for general human health. Calcium, magnesium, zinc, iron, sodium, and more are common kinds of minerals found in bottled water. The type of minerals that are in the bottled drinking water depends on the water source. Many customers around the world, particularly Malaysians, have turned to bottled water as their primary source of potable water. The research was performed to determine the best and most preferred brands of mineral bottled water available in UiTM Arau, Perlis in terms of its advantages and everyday mineral content. Fuzzy AHP is a hybrid method that combines Fuzzy Set Theory and AHP. It has been developed to take into account uncertainty and imprecision in the evaluations. The decision-making method used by multi-criteria is the FAHP method as an approach to the problem of selection bottled with mineral water. In this paper, the mineral water brands bottled namely "Spritzer," "Bleu" and "Ice Mountain" are analyzed and presented as sold in UiTM Perlis. The criterion given is price, availability, taste, water source, and packaging. Comparison is made between these three brands to decide which of these brands is more favoured and desirable among UiTM Perlis students based on the weight of alternatives regarding the criteria. The results obtained were that Spritzer has the greatest total score with a weight of 0.439. The analysis shows that the "Spritzer" brand is better compared to the other two daily life consumption brands, which weight is 0.439 with 5 criteria. Bleu, however, offers a better weighty flavour, 0.386 of those two brands of mineral water bottles. This study can be a factor in influencing consumer behaviour and providing information to local bottled water companies' marketers. It will ultimately increase their profitability and revenue by new and better marketing techniques. In addition, bottled water producers can also produce bottled water that meets the needs of Malaysian consumers. In addition, this study will provide consumers with a greater understanding of the standard of bottled water that may affect the environment, such as pollution, etc. This study will also benefit both marketers and consumers by helping them make educated decisions on choosing the most appropriate mineral water bottled for consumption in keeping with their health concerns these days.*

*Keywords: Drinking Water, Mineral Water, Preference, Fuzzy AHP, UiTM Perlis*

## INTRODUCTION

Water is connected directly or indirectly to every aspect of day-to-day human activities and becomes basic human needs. Water functions in the human body are vital and it allows the body to perform various functions, such as blood circulation, nutrient transfer, maintenance of body temperature, digestion, saliva production and also acts as a water cushion for joints tissue and organs from a shock or damage. Thus, drinking water is a necessity for us to maintain the balance of fluids in our body. Not getting enough

water can result in dehydration that can lead to muscle weakness and cramping, lack of coordination, and increased risk of heat exhaustion and heatstroke. A human need to drink at least 2 litres of water per day to replace the water that is lost through waste removal, sweat and other functions. These might be one of the reasons for Malaysia's growing number of people turning to make the bottled water their basic source of drinking water. Water quality is therefore important to safeguard drinking water.

Safe drinking water should be free of harmful contaminations, such as bacteria, viruses, heavy metals and organic toxic substances (Gadgil, 1998). Safe drinking water is the water that is safe for drinking and can be delivered to the user. There are various forms of minerals in drinking water that can provide our health benefits. Ideally, clean drinking water consists of calcium, magnesium, zinc, chlorine, nitrates, sulphates, iodine, mercury, sodium, and potassium, although it depends on the water supply. Growing of the minerals has its own benefits, and it may have a great amount of benefit. One way to achieve the body's optimum development is by taking in the essential vitamins and minerals.

Some people currently have access to a convenient and safe home drinking water supply. This ensures water quality because it is nearly uncontaminated, resulting in water being clean and safe for consumption and can be taken directly from the tap without any fear. Most of them would prefer to drink local or imported drinking water. There are essentially two types of bottled water sold in the Malaysian market which are natural mineral water and drinking water. The bottled water can be differentiated by the bottle cap, where a coloured cap is given to natural mineral water bottles, either blue or green, while white caps are given to drinking water bottles. Natural mineral water is subterranean or tapping water (Devi and Premkumar, 2012). On the other hand, potable water is produced from sources of rivers, lakes, or underground springs.

Recently there has been a growing trend in consumer preference for bottled water over tap water or water supply towns. One of the reasons is because of the convenience that the bottled water can be carried around. Another explanation is because under some situations the household tap water which often have an unhealthy look and taste which might be attributable to the presence of toxins in the tap water from leaked pipes or other sources of corrosion. In the absence of this research, many consumers believe that other health benefits come from natural mineral waters (WHO, 2005). Most urban people in Malaysia preferred bottled water as their main resource for drinking water than tap water, this is because they are concerned about getting sick from drinking it. According to the consumer protection organisation Food and Water Watch (2007), relied more on bottled water that costs more than drinking water because they thought it is safer and safe compared with tap water. Better water sources mean lower medical expenditure, as people have low chances of falling ill.

Research on the quality and mineral content of drinking water in Malaysia was conducted by Azlan et al. (2012). The aim of the study was to identify the selected minerals in drinking water, mineral water, and tap water obtained from various geographical locations in Malaysia and to assess the selected organic and other inorganic elements in the water samples. The minerals picked were sodium, magnesium, copper, zinc, potassium, calcium, iron, chromium, gold, etc. The concentrations of the selected minerals found in each water sample have been compared to national and international degree limits. This research showed that the geographic environment had a major effect on the mineral concentrations of water that had been contaminated by contamination.

Kabilan et al. (2012) have also carried out further research on the mineral content in bottled mineral water from various brands sold in Malaysia. The most popular brands of mineral water in the Malaysian market were selected in this research, namely "Spritzer," "Ice Mountain," "Bleu," "Select" and "Cactus." The selected brands were compared and analysed to determine which brands were the most preferable in terms of benefits to one's health for everyday consumption. It showed from the findings that the "Spritzer" brand proved to be the best of all selected samples followed by the brand "Ice Mountain," "Cactus,"

"Bleu" and "Select." The only difference between the "Spritzer" and the other brands was that they had an extra mineral content, namely silica that is good for reforming the muscle and bones. In the other hand, the "Cold Lake" brand has an edge over the other four brands in terms of mineral content found in the distilled mineral water. From this study, the choice of preference in choosing the most appropriate bottled water with one's health considerations has contributed to the Malaysians.

Decision making is a very crucial action whereby needed in every action in our daily basis routine. Some personal decision made can be determine by just having a proper thinking. However, currently there are proper tools or way which can be used to make decision. One of the methods is Fuzzy Analytic Hierarchy Process (FAHP). It has been widely used for multi-criteria decision making and applied to many practical problems successfully. Method such as FAHP is used to compare performance of each criterion and justify the best solution for every case study or situation. Fuzzy however is a linguistic judgment where all the uncertainty is considered. Fuzzy numbers are subset of real number and they represent of human's confidence interval to place it in which class during their judgment (Wu et al. 2009). This is because fuzzy uses more than a single digit and sometimes even decimal. A Fuzzy AHP which was a combination of AHP and fuzzy set theory was applied to study the preference of bottled water. It is a fuzzy model with multi-criteria decision-making methods that were applicable to decision-making problems in multicriteria. This fuzzy model can also be applied to another type of application. Putra et al. (2018) conducted a study to determine the quality of gemstones to provide consumers with knowledge and help in the selection and analysis of the quality of gemstones. This study created a system and platform that could help people to evaluate and choose the best quality of gemstones using a Fuzzy AHP method accurately and effectively. Specific gravity, colour, hardness, cutting, and transparency are the parameters or characteristics used when deciding the consistency of the gemstones. The study indicated that the higher the weighting value of gemstones, the higher the gemstone quality.

Other than using Fuzzy AHP, previous research conducted by Mishra and Jha (2014) applied a different method. The research concerned an assessment of drinking water quality using the Fuzzy Drinking Water Quality Index (FDWQI) method. The finding in that study revealed that the biggest problem was that people assumed water would turn bad when it started having a bad smell, a terrible taste, or looked dirty. However, harmful pollutants and contaminants do not usually cause an odour or bad taste to water. This research had established a fuzzy index of drinking water quality, which was collected to demonstrate the clearer categorization of drinking water quality to the public. This research used fuzzy logic to evaluate water quality through the creation of a Fuzzy Expert System index for drinking water quality. Five consistency criteria have been chosen for estimating the water level. Thus, the triangle and trapezoidal membership function is used to define how to assign each point in the input space to a membership value between 0 and 1. The suitability of water sources for human consumption has therefore been described as the Water Quality Index (WQI), which is one of the most systematic and understandable ways for the public to categorize water quality as a consumer of the water resources.

This paper aims to discover the best among the selected brands of bottled water sold in UiTM Arau, Perlis based on various characteristics or preferences selections. In addition, this research also aims to examine the considerable criteria shown on a purchaser when purchasing mineral water bottled from various brands that sold in UiTM Arau, Perlis and further analysis will be performed using a fuzzy AHP method to determine the best mineral bottled water among the brands selected. The duration of this investigation is nine months. It starts in September 2019 and expires in June 2020. Thus, it will help the buyer to select the right and best mineral water bottled sold in UiTM Arau, Perlis by determining the significant criteria in buying mineral bottled water.

## RESEARCH METHODOLOGY

### Method of Data Collection

The source used for obtaining data for this study was primary data where the data was first gathered in characters and original. The data will be collected by observing and selecting 3 brands of mineral bottled water sold at UiTM Arau's cafes and mini shop, Perlis namely 'Ice Mountain,' 'Spritzer' and 'Bleu.' This study needs expert opinions and refers to the owner of cafes or mini shops in UiTM Arau, Perlis who is expert in the purchase and sale of water bottled and a few students from the Faculty of Sport Science and Recreation who were active in any sports or events in UiTM; A questionnaire is used to ascertain the drinking water choice of students at UiTM Perlis based on the expert's evaluation and interpretation of the parameters affecting both the purchasing of the bottled water and the alternatives. Price, availability, taste, water source, and packaging are criteria used. The experts were asked to compare each criterion and alternatives about each other in the questionnaire. This is to decide the expert's priorities as to which requirements are the most relevant, and to figure out the brand of mineral water the students enjoy. The experts will be chosen from among those who always buy the bottled mineral water and have bought all kinds of bottled mineral water in UiTM Arau, Perlis.

### Background

#### MCDM

Multi-Criteria Decision Making (MCDM) is a decision-making tool that incorporates both quantitative and qualitative considerations. MCDM approach issues involving multiple and conflicting alternatives. MCDM is a series of techniques that include a general alternative from the most advantageous choice to the least advantageous alternative (London School of Economics and Political Science, 2007). In an uncertain situation the decision-makers have been able to choose the most desirable and satisfactory alternative. Other MCDM methods also have been suggested to choose the probable options such as Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP). There are advantages and disadvantages to each of the methods.

#### Fuzzy

Fuzzy sets are a group of elements with membership degrees. Zadeh (1965) suggested the theory of Fuzzy Sets. The basis of this theory is a method with which decision making by attributing a degree to elements by using fuzzy descriptions belongs to a set (Konstantinidis et al., 2011). Fuzzy sets include triangular fuzzy numbers, trapezoidal fuzzy numbers, and Gaussian fuzzy numbers, which transform unknown fuzzy numbers representing language values. The fuzzy set theory can be applied in a wide range of areas where there is incomplete or indefinite information.

#### AHP

The Analytic Hierarchy Process (AHP) method is one of the decision-making methods used by Fuzzy Multiple Criteria for multiple criteria. AHP used the Fuzzy set theory and hierarchical structure analysis concepts to select the most preferable alternative among a set of likely alternatives. It allows the decision-makers to build a complex problem in the form of a simple hierarchical structure. The quantitative and qualitative factors under multiple criteria environments are evaluated in a systematic manner because it involves many attributes. It is a method for rating options or preferences and choosing the best where there are several parameters for the decision-maker. The alternatives can be decided by contrasting in pairs. The decision-maker will observe two alternatives and choose the best alternative that meets the criteria for the decision by assigning a numerical value to rank each alternative decision on a different level of preference. The scale of degree preferences used for AHP is 1-9 or 1-5 depends on the questions to be evaluated (Özdağoğlu, 2007).

**Fuzzy Analytic Hierarchy Process (FAHP)**
Fuzzy Analytic Hierarchy Process is a Fuzzy Logic Theory technique developed with the Analytic Hierarchy Process (AHP) that combines AHP with Fuzzy set theory. By using the Fuzzy AHP method, decision-makers can make more systematic and realistic decisions with appropriate criteria and alternatives in thinking about human logic.

## Method of Data Analysis

The Fuzzy AHP approach will be used before buying a mineral bottled water to assess the weight of the criteria on. Firstly, the Fuzzy AHP developed the decision hierarchy structure to clearly see the problem. These hierarchical sequences help to simplify the problem and bring it to a more readily understood condition. The study's goal is the first level of the hierarchy, while the second level of the hierarchy is the criterion used to determine the requirements used when buying mineral bottled water, and the third level is the alternatives of the variety of mineral bottled water brands that the experts choose to analyse. If the hierarchy is structured, the next step is to construct an interactive questionnaire with pairly comparisons of the specified parameters. The experts would be asked to give a nine-point scaling factor (Saaty's scale) to the relative value of each criterion, to compare each criterion with another criterion, and to compare the alternatives with other alternatives. The pair comparison matrices were generated from the pairwise comparison matrices group for each of the criteria. In the context of the weights of the criteria and alternatives, the decision on the final objective is taken. Figure below shows the hierarchical diagram:
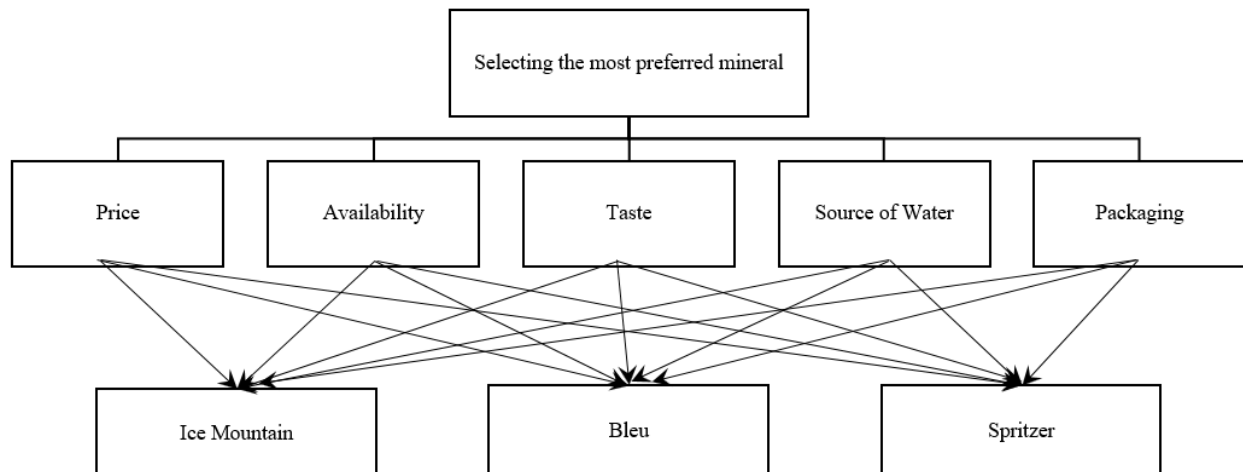


Figure 1: The hierarchy of the criteria and alternatives

## Process of Fuzzy Analytical Hierarchical Process

**Step 1: Weight scaling**
The weight is placed according to the scale of the Fuzzy Analytic Hierarchy Process (FAHP) provided in Table 3.1. The fuzzy evaluation matrix of the criteria was conducted using the linguistic variables and the triangular fuzzy numbers (TFN) using a pairwise comparison between criteria or attributes to the overall objective. The linguistic variables used to make pairwise comparisons by replacing the values into membership scales with Saaty's 1-9 scales and weighing them in the presence of indeterminateness refer to Table 3.1 (Saaty's, 1980 and 1988).

Table 1: Saaty's scale for pairwise comparison

| Fuzzy Numbers (Saaty's scale) | Linguistic Variables for Importance | Triangular Fuzzy Number (TFN) |
|---|---|---|
| 1 | $u$ is **equally important** to $v$. | (1,1,1) |
| 3 | $u$ is **slightly more important** than $v$. | (2,3,4) |
| 5 | $u$ is **strongly more important** than $v$. | (4,5,6) |
| 7 | $u$ is **very strongly more important** than $v$. | (6,7,8) |
| 9 | $u$ is **extremely more important** than $v$. | (9,9,9) |
| 2,4,6,8 | Intermediate values. | (1,2,3) (3,4,5) (5,6,7) (7,8,9) |
| Reciprocals | If activity $u$ has one of the above numbers assigned to it when compared with activity $u$, then $v$ has the reciprocal value when compared with $u$. | (1/3,1,1) (1/5,1/3,1) (1/7,1/5,1/3) (1/9,1/7,1/5) (1/9,1/9,1/7) |

**Step 2: Comparison matrices**

The evaluations are transferred to a pair-wise comparison matrix by using Saaty's scale in Table 1 where it is constructed using the Eq. 1. Let $\tilde{Y}$ serve as $nn$-judgement matrix covering all pairwise comparison where $n$ is the number of criteria to be evaluated. Each entry $\tilde{x}_{ij}$ of the matrix $\tilde{Y}$ represents the importance of $i^{\text{th}}$ criterion over $j^{\text{th}}$ a criterion, via triangular numbers.

$$\tilde{Y} = \begin{pmatrix} (1,1,1) & \tilde{x}_{12} & \tilde{x}_{1n} \\ \tilde{x}_{21} & (1,1,1) & \tilde{x}_{2n} \\ \tilde{x}_{n1} & \tilde{x}_{n2} & (1,1,1) \end{pmatrix} \tag{1}$$

However, if there are more than one decision-maker or expert, the average preferences of each decision-maker are calculated as in the Eq. 2.

$$\tilde{x}_{ij} = \frac{\sum_{k=1}^{K} \tilde{x}_{ij}}{K} \tag{2}$$

where $K$ indicate the number of decision-maker or expert and elements $i$ and $j$, $\forall i, j \in (1,2,\ldots,n)$. Eq. 3 shows the updated pairwise contribution matrix based on averaged preferences.

$$\tilde{Y} = \begin{pmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{x}_{n1} & \cdots & (1,1,1) \end{pmatrix} \tag{3}$$

**Step 3: Calculating Geometric Mean**

These basic operations are useful during the triangular fuzzy number process. Assume that $\tilde{M}_1$ and $\tilde{M}_2$ are triangular fuzzy numbers with $\tilde{M}_1 = (l_1, m_1, u_1)$ and $\tilde{M}_2 = (l_2, m_2, u_2)$.

The basic operations:

$$\tilde{M}_1 \oplus \tilde{M}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 \oplus l_2, m_1 \oplus m_2, u_1 \oplus u_2) \tag{4}$$

$$\tilde{M}_1 \otimes \tilde{M}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2) \tag{5}$$

$$\tilde{M}_1^{-1} = \left( \frac{1}{l_1}, \frac{1}{m_1}, \frac{1}{u_1} \right) \tag{6}$$

The geometric mean fuzzy comparison values of each criterion and each alternative with respect to criteria were calculated as presented in Eq. 7. Here, $\tilde{G}$ is serving as triangular values. The geometric mean of fuzzy comparison is calculated as below:

$$\tilde{G} = \left( \prod_{j=1}^{n} \tilde{x}_{ij} \right)^{\frac{1}{n}} \tag{7}$$

where $n$ represents the number of criteria that are used in the problem where $i = 1, 2, 3, \ldots, n$.

The vector summation of each geometric mean needs to be calculated first before finding the fuzzy weight for each criterion and alternatives and thus finding the (-1) power of the vector summation. The calculation on the vector summation of each geometric mean and its (-1) power is shown in Eq. 8

$$\tilde{g}_i = \left( \tilde{G}_1 \oplus \tilde{G}_2 \oplus \ldots \oplus \tilde{G}_n \right)^{-1} \tag{8}$$

**Step 4: Fuzzy Weight**

To calculate the fuzzy weight for each criterion, Eq. 9 is used. Before finding the fuzzy weight to each criterion, the vector summation of each geometric mean needs to be calculated first and thus, find the (-1) power of the vector summation.

$$\tilde{w}_i = \tilde{r}_i \otimes \left( \tilde{r}_1 \oplus \tilde{r}_2 \oplus \ldots \oplus \tilde{r}_n \right)^{-1} = (lw_i, mw_i, uw_i), \qquad i = 1, 2, \ldots, n \tag{9}$$

Since the fuzzy weight is still fuzzy triangular numbers, it needs to be de-fuzzified. The defuzzification process using the centre of area method proposed by Chou and Chang (2008) as shown in Eq. 10. $M_i$ is a real number.

$$M_i = \frac{lw_i, mw_i, uw_i}{3}, \qquad i = 1, 2, \ldots, n \tag{10}$$

**Step 5: Normalization**

$M_i$ is a non-fuzzy number and de-fuzzified weight for each criterion or each alternative thus it needs to be normalized by the following Eq. 11

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \tag{11}$$

These steps are taken to find the standardised weights of both the criteria and the alternatives. Then, the scores for each alternative are calculated by multiplying each alternative weight with related criteria. The score for each alternative is calculated by multiplying each supplier's weight according to their respective criterion. The alternative with the highest score is determined as the most appropriate brands of mineral bottled water sold at UiTM Arau, Perlis.

## FINDINGS AND DISCUSSION

The analysis of data on the different preference of criteria and alternatives in determining the most preferred mineral water bottled using Fuzzy Analytical Hypothesis Process (FAHP). The FAHP is used to determine both the weight of importance and the best alternatives for each criterion. The options with the highest score are listed as the better alternatives. While some other techniques can be built for the same problem as; TOPSIS, ELECTRE, PROMETHEE and ANP, etc., this study uses the technique of the Analytical Hierarchy Process, motivated by the Fuzzy approach. Because the priorities of the decision-makers depend on both measurable and intangible parameters, the Fuzzy Set Theory will reflect these ambiguous linguistic variables. Consequently, the Fuzzy AHP model is used to solve the reasons why unique mineral water bottled among students in UiTM Perlis is favoured, which decides the best mineral water bottled among 3 alternatives. Each of these requirements conflict with each other, the mineral water bottled solution will be successfully checked. These alternatives are checked according to five standards, namely: quality, availability, flavour, water source and packaging. FAHP is better at achieving the aim, based on this analysis. FAHP is much clearer and easy to obtain the results since it is similar for both processes which are determining the importance weight for each criterion and identifying the best alternatives. Table 2 shows the preference of three experts for each criterion that is price, availability, taste, source of water and packaging.

Table 2: Aggregated fuzzy comparison matrix of alternatives with the respect to 'Price', 'Availability', 'Taste', 'Source of Water' and 'Packaging'

| CRITERIA | ALTERNATIVES | Bleu | Spritzer | Ice Mountain |
|---|---|---|---|---|
| **Price** | **Bleu** | (1,1,1,) | (0.787,1.152,1.548) | (3,3.667,4.333) |
| | **Spritzer** | (3.111,3.778,4.5) | (1,1,1,) | (3.389,3.733,4.083) |
| | **Ice Mountain** | (0.458,0.492,0.556) | (1.481,1.87,2.37) | (1,1,1,) |
| **Availability** | **Bleu** | (1,1,1,) | (2.708,3.048,3.389) | (1.472,1.844,2.25) |
| | **Spritzer** | (2.37,2.708,3.048) | (1,1,1,) | (2.333,3,3.667) |
| | **Ice Mountain** | (2.056,2.733,3.417) | (0.472,0.511,0.583) | (1,1,1,) |
| **Taste** | **Bleu** | (1,1,1,) | (2.704,3.37,4.037) | (4.333,5.333,6.333) |
| | **Spritzer** | (3.125,3.159,3.222) | (1,1,1,) | (2.667,3.333,4) |
| | **Ice Mountain** | (0.173,0.214,0.289) | (0.464,0.5,0.567) | (1,1,1,) |
| **Source of water** | **Bleu** | (1,1,1,) | (1.048,1.722,2.4) | (3.333,4.333,5.333) |
| | **Spritzer** | (1.861,2.278,2.833) | (1,1,1,) | (3.333,4,4.667) |
| | **Ice Mountain** | (0.231,0.319,0.548) | (0.454,0.486,0.548) | (1,1,1,) |
| | **Bleu** | (1,1,1,) | (3.754,4.444,5.167) | (5,6,7) |

| **Packaging** | **Spritzer** | (0.756,1.103,1.456) | (1,1,1,) | (2,2.667,3.333) |
| | **Ice Mountain** | (0.145,0.17,0.206) | (0.5,0.567,0.75) | (1,1,1,) |

Based on the results, it shows the experts are especially concerned about the overall taste of bottled mineral water. It can be inferred from Table 3; the Spritzer provides all the best parameters excluding flavour. Because of this, Bleu gives the best taste with a weight of 0.386 among those two brands of mineral water bottles as the taste was on top of the rank in Table 4. This is because concentrations differ in each of the bottled mineral water. The mineral concentration includes various minerals in varying quantities. So, this influences the taste of bottled mineral water. Specific brands of water distilled from mineral water either have the minerals from their source or have a mixture of minerals applied back to them after purification to preserve a clear taste. This can affect a person's taste perception and make people implicitly aware of the source water quality where the water treatment process is taking place. Any of them may find it difficult to drink some mineral distilled water because it is murky, or it smells or tastes bad.

From here, it can affect customer preference in the selection of bottled mineral water as well as influence the sale of bottled mineral water sales. The owner therefore needs to consider some solution to resolve the issue. The results are shown in Table 3 and Table 5 when identifying the best alternatives, where the ranking for each alternative is based on the criteria used. As shown in Table 5, Spritzer with weight, 0.439 has the largest total score in this analysis. Therefore, it is suggested as the best and preferable mineral water bottled among 3 of them, with reference to 5 criteria which are price, availability, taste, source of water and packaging and the fuzzy preferences of experts.

Table 3: Aggregated results for each alternative according to each criterion

| CRITERIA | | Scores of Alternatives with respect to related Criteria | | |
|---|---|---|---|---|
| | **Weights** | **Bleu** | **Spritzer** | **Ice Mountain** |
| **Price** | 0.164 | 0.323 | 0.481 | 0.196 |
| **Availability** | 0.203 | 0.366 | 0.402 | 0.232 |
| **Taste** | 0.386 | 0.495 | 0.413 | 0.092 |
| **Source of water** | 0.176 | 0.423 | 0.454 | 0.122 |
| **Packaging** | 0.071 | 0.384 | 0.555 | 0.061 |
| **Total** | | 0.420 | 0.439 | 0.141 |

Table 4: The importance weight of each criterion

| Criteria | $N_i$ | Rank |
|---|---|---|
| Taste | 0.386 | 1 |
| Availability | 0.203 | 2 |
| Source of water | 0.176 | 3 |
| Price | 0.164 | 4 |
| Packaging | 0.071 | 5 |

Table 5: Alternatives ranking based on criteria

| ALTERNATIVES | Weights | Rank |
|---|---|---|
| Spritzer | 0.439 | 1 |
| Bleu | 0.420 | 2 |
| Ice Mountain | 0.141 | 3 |

## CONCLUSION AND RECOMMENDATION

Selecting alternatives is very important process, particularly in the decision-making process. In conclusion, the purposes of this report are to recognise the best and most appropriate brands of mineral bottled water available at UiTM Arau, Perlis in terms of their benefits for daily use. Research is required to establish factors for choosing bottled similar mineral water based on various characteristics and labels. The findings indicate that different individuals have specific preferences, and that these preferences can directly contribute to different perspectives. From the analysis, by comparing each mineral water bottled brand, the "Spritzer" brand is proved to be better for daily life consumption compared to the other two brands. This is accompanied by the brands "Bleu" and "Ice Mountain." Apart from that, compared to the other two brands, "Spritzer" brand has better water supply, price, packaging, and accessibility. As a result of the case study, Spritzer is seen to be more suited and preferable to the first alternatives.

Researchers may continue this research in the future but with different approach criteria and methods to see if the outcome will remain the same or not. Indeed, by adding alternatives or expert viewpoints against the analysis, it will further demonstrate the accuracy of the findings obtained from FAHP. Occasionally, different criteria are used to evaluate alternatives depending on the types of issues that the decision-makers face. It is recommended that the researcher use current criteria to determine whether the results of this study will be applicable in the future as the taste of water depends on the flavour of the person itself and the mineral concentration content in the bottled mineral water. Gradually, consumers are not especially loyal to any brands, and they are likely to buy whatever water is available and cheap. In addition, there will be new mineral water bottled brand proposals that contain more benefits and meet all consumer needs.

authors wish also to express their thanks to the very competent Reviewers for the very good comments and suggestions.

## REFERENCES

Azlan, A., Khoo, H. E., Idris, M. A., Ismail, A., & Razman, M. R. (2012). Evaluation of minerals content of drinking water in Malaysia. *The Scientific World Journal*, 9(1), 1-10. doi: 10.1100/2012/403574.

Devi, S., & Premkumar, R. (2012). Physicochemical analysis of groundwater samples near industrial area, Cuddalore District, Tamilnadu, India. *International Journal of Chemtech Research*, 4(1), 29-34.

Gadgil, A. (1998). Drinking water in developing countries. *Annual Review of Energy and The Environment*, 23(1), 253-286.

Kabilan, K., Mushilan, K., & Sivaneswari, R. (2012). Study on the contents of bottled mineral water of various brands in Malaysia. *Journal of Natural Sciences Research*, 2(4), 44-48.

Konstantinidis, K., Andreadis, I., & Sirakoulis, G. C. (2011). Application of Artificial Intelligence Methods to Content-Based Image Retrieval. *In Advances in Imaging and Electron Physics,* 169, 99-145.

Mishra, N., & Jha, P. (2014). Fuzzy expert system for drinking water quality index. *Recent Research in Science and Technology*, 6(1), 122-125.

Özdağoğlu, A., & Özdağoğlu, G. (2007). Comparison of AHP and fuzzy AHP for the multi-criteria decision-making processes with linguistic evaluations. *İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi,* 65-85.

Putra, D., Sobandi, M., Andryana, S., & Gunaryati, A. (2018). Fuzzy Analytical Hierarchy Process method to determine the quality of gemstones. *Advances in Fuzzy Systems*. doi: 10.1155/2018/9094380.

Saaty, T. L. (1988). What is the analytic hierarchy process? *In Mathematical Models for Decision Support*, 48, 109-121.

World Health Organization. Sustainable Development and Healthy Environments Cluster. (2005). Nutrients in drinking water. World Health Organization. https://apps.who.int/iris/handle/10665/43403.

Wu, H. Y., Tzeng, G. H. & Chen, Y. H. (2009). A fuzzy MCDM approach for evaluating banking performance based on Balanced Scorecard, *Expert Systems with Applications*, 36(6), 10135-10147.

Zadeh, L. A. (1965). Fuzzy sets. *Information and Control*, 8(3), 338-353.