

Paper:

# An Affective Approach to Developing Marketing Strategies of Mineral Water

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[Received December 27, 2011; accepted April 7, 2012]

**This study is concerned with the development of marketing strategies for mineral water based on consumers' taste preferences, by analyzing the taste components of mineral water. In this study, we used a two-dimensional analysis to classify taste data. We conducted a correlation analysis to identify the characteristics of taste data. We applied a combination of principal component analysis and self-organizing map to classify mineral water tastes. Based on this evaluation, we identified some marketing strategies in the conclusion. According to this study, the taste of mineral water is not determined by the origin and is not influenced by the hardness of the water.**

**Keywords:** taste analysis, mineral water, soft computing model, SOM, Kansei engineering

## 1. Introduction

Kansei engineering (also known as affective engineering or emotion engineering) in the food and taste fields is a branch of basic sciences in consumer-oriented engineering and production that applies specific methods to concrete cases [1–4].

This concept contains two functional aspects [5]. First, it is effective in developing new markets, food industries, and even new social systems, which is used in production and marketing strategies. Second, when understanding consumer preferences on taste and smell, which are quantitatively measured using special machines, this methodology has proven useful in helping in improving existing products and optimizing production processes.

With the development of new technologies, artificial lipid membranes have been invented to imitate biological mechanisms and functions of how humans acknowledge taste. This has resulted in a boom in engineering methods to quantitatively and qualitatively evaluate food tastes. Mineral water [6, 7] originates from natural springs containing various minerals such as salts and sulfur com-

pounds. Traditionally, mineral water bottles were consumed at the source, and were perceived to have curative properties. Water which was not treated properly sometimes has an unpleasant taste or is unsuitable for drinking. Since the Second World War, mineral water markets have been successfully created in Western Europe and the USA. France is a leading consumer and producer of mineral water in the world [8].

Japanese markets are witnessing a record increase in mineral water consumption, with production and import of mineral water depicting a growing trend, and import volumes constituting around 20 percent of the overall market in 2011 [9]. However, consumption per head remains lower than that in Western countries, such as the USA and Canada. Thus, Japan remains a huge potential market. Therefore, the technique to produce a best-selling mineral water product in Japan could be of great significance. Taste continues to remain the most important element, though keeping highly demand is one of the important elements of becoming a bestselling product.

This paper is organized as follows. Section 1 illustrates the purpose of Kansei engineering in the food area and methods applied to analyze food. Section 2 discussed the application of a taste sensor employing lipid polymer membrane to solve a previously insurmountable problem. Section 3 demonstrates the characteristics of tastes and taste sensors. Marketing strategies based on mineral water's data characteristics are discussed in Section 4. Significant attributes are also highlighted using several methods. Section 5 described the marketing analyses based on taste characteristics of mineral water. Algorithms, such as SOM, PCA, and correlation were applied to analyze the nature of tastes in mineral water and to identify some common grounds. And Section 6 shows the conclusions of our study.

## 2. Background and Research Purpose

In general, there are two branches with significantly different approaches to analyzing food tastes: (1) sensory

evaluation by human beings and (2) sensory and scientific assessment applied by machines.

Sensory evaluation through feelings and tastes can be viewed as a subjective approach to analyzing food tastes. This method is based on people's subjective experiences or feelings at a point in time, and is limited by human acknowledgement. It can vary across different people, even to the extent that the same person could derive different tastes from the same food at different times, owing to differences in physical conditions, emotions, places, etc. Hence, a reliable reproduction of conditions to evaluate tastes is very difficult.

On the contrary, recent technological innovation has led to the development of special machines to address these problems. These scientific assessments include techniques such as a brix sensor, Gas Chromatography-Mass Spectrometry (GC-MS), High-Performance Liquid Chromatography (HPLC), and viscoelasticity measuring instruments.

Beullens et al. applied the electronic tongue and an Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) for rapid detection of sugars and acids in tomatoes [10]. Some supervised and unsupervised multivariate data analysis techniques, such as Principal Component Analysis (PCA) [11] and Canonical Correlation Analysis (CCA), were also applied [10]. They compare this to a new type of electronic tongue in another paper that also uses the PCA method to analyze tomato tastes [12]. He et al. proved that an electronic tongue is capable of identifying teas from different geographical origins and quality grades [13].

Despite these breakthroughs in taste analyses, there is a significant dearth of mechanical evaluation. These special machines can measure some tastes and smells according to the mass, but they cannot measure feelings and smells, which is a limitation of this approach.

In order to address this limitation, a recently invented taste sensor, employing lipid polymer membrane to measure the quantity of human beings' tastes, was used. This sensor makes it possible to evaluate food tastes by applying the Waive Rule to change feelings into quantifiable values, so that human feelings for food can be measured and evaluated.

Waive Rule is one kind of empirical rules that speculate the different degree of taste based on the putout applied taste sensor. A proportional method is applied to present the strength of discrimination threshold when facing the same kind of stimulus.

### 3. Measurements of Taste

A taste sensor can address the problem that the previous instruments faced: of not being able to determine the quantity of feelings. It utilizes a biomimetic membrane, in which lipids are immobilized to the polymer, as a transducer. Electric signals are then used to detect changes in ionization of the lipid membrane. Tastes can be identified by repeating this process in multiple ways. The taste sen-

sor not only extracts quantities of one fixed taste in the food, but also provides information on the taste's weight and qualities.

The flavors can be divided into two groups, pre-taste and post-taste, according to the time periods in which people feel and recognize them. Pre-taste is the taste at the time people eat the food. In other words, it is the taste when the food or beverage is still in the mouth. The post-taste is the lingering feeling from the taste substances left on the surface of the tongue after the food is swallowed. It is a kind of spreading of flavors in one's mouth.

Moreover, there are two more attributes included in this study, *pH* value and electric conductivity. The *pH* value demonstrates the degree of acidity and alkalinity, while electric conductivity illustrates the relationship among the foods with ionic substance. The fluctuation of this attribute's value can be seen as the lasting period of tastes.

## 4. Data Analyses of Mineral Water's Taste

In this section, we discuss several analyses dealing with the mineral water dataset. The purpose of these analyses is to identify classifications of taste attributes and mineral water commodities.

The dataset contains 15 dimensions of taste attributes and 185 samples drawn from different mineral water commodities sold in Japan. These samples are taken from producing areas all over Japan, and even include some foreign countries such as the USA and France.

### 4.1. Correlation Analysis

Correlation analysis measures the closeness of the relationship between two or more variables. In statistics, 'dependence' refers to any statistical relationship between two random variables or two sets of data. Correlation refers to one of a broad class of statistical relationships involving dependence. It is represented by a value between  $-1.00$  and  $+1.00$ .

In this case, correlation analysis was used to identify some highly related attributes, so as to enable us to reduce some dimensions.

Full-bodied flavor shows the highest correlation with bitterness with a value of 0.788. We always say that more fresh the seafood is, more delicious the taste is. This value of correlation can be seen as an evidence that why seafood is delicious, and the same can be expended on mineral water's taste.

Taste of acid flavor A is positively correlated with that of miscellaneous bitter taste in medicine, but negatively correlated with sweetness. The taste of astringency shows a relatively high positive correlation with astringency stimulus and bitterness in food, which is one type of post-taste. Moreover, salty taste depicts a high correlation with electric conductivity.

However, dimension reduction cannot be accomplished because the correlation between two attributes is not high enough. Hence, we use the Principal Component Analysis (PCA).