Sensory Evaluation of the Selected Coffee Products Using Fuzzy Approach

M.A. Lazim and M. Suriani

Abstract—Knowing consumers' preferences and perceptions of the sensory evaluation of drink products are very significant to manufacturers and retailers alike. With no appropriate sensory analysis, there is a high risk of market disappointment. This paper aims to rank the selected coffee products and also to determine the best of quality attribute through sensory evaluation using fuzzy decision making model. Three products of coffee drinks were used for sensory evaluation. Data were collected from thirty judges at a hypermarket in Kuala Terengganu, Malaysia. The judges were asked to specify their sensory evaluation in linguistic terms of the quality attributes of colour, smell, taste and mouth feel for each product and also the weight of each quality attribute. Five fuzzy linguistic terms represent the quality attributes were introduced prior analysing. The judgment membership function and the weights were compared to rank the products and also to determine the best quality attribute. The product of Indoc was judged as the first in ranking and 'taste' as the best quality attribute. These implicate the importance of sensory evaluation in identifying consumers' preferences and also the competency of fuzzy approach in decision making.

Keywords—fuzzy decision making, fuzzy linguistic, membership function, sensory evaluation,

I. INTRODUCTION

SENSORY evaluation is one of the methods used in identifying the market acceptability especially in food or drink based products. It is useful for product development and improvement since the most important factor for a particular market can be identified and improved [1], [2]. Influential factors are essential for consumers to get the best product and for manufactures to develop and sell the best product. Sensory evaluation is also necessary to ensure that their products will be succeeding in the marketplace. Without appropriate sensory analysis, there is a high risk of market failure [3]. Sensory analysis is too commonly often overlooked as a requirement before product launched. The implications again back to the successfulness of products to survive in market. Today's consumers are discerning, demanding and more knowledgeable about food and expect products which are safe, good value and of high sensory quality. Therefore, knowing consumers' preferences and

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perceptions of the sensory characteristics of food or drink products is very important to food manufacturers.

Sensory evaluation may be seen as the scientific discipline which looks at how measurement evoked and interpret the characteristics of food and materials as they are perceived by senses. It involves the measurement and evaluation of sensory properties of food and other materials. Human judges are used to measure the flavour or sensory characteristics of food. Sensory data such as colour, smell, taste and mouth feel are obtained through subjective evaluation. This type of evaluation data are normally analyzed statistically, but it is not possible to find out from such analysis the strength and weakness of specific sensory attribute, which is responsible for acceptance and rejection of the drinks. In statistical analysis of the sensory evaluation data, average scores of attributes are generally calculated and compared with a certain significance level among the samples [4] and [5]. An alternative way had been introduced by applying fuzzy sets instead of average scores to compare the samples' attributes [6]. The fuzzy sets are not confined to a deterministic value, so they may have a merit in sensory evaluation because human expressions on feeling for foods are fuzzy rather than deterministic. In fuzzy theory, a subject can be represented by fuzzy sets with a series of elements and their membership degrees compared to crisp sets without membership [7]. The concept of the membership given to each element makes it possible to represent fuzzy states, e.g. 'very tasty' rather than a preference score of 78 %. Such fuzzy sets provide the mathematical methods that can represent the uncertainty of humans' expression.

Fuzzy approaches have been successfully applied in many experiments that involved sensory evaluation processes. [8] and [9] used fuzzy logic for quality analyses of mango bar are a few of the examples of fuzzy approach in sensory evaluation. The quality attributes responsible for higher as well lower rank were identified for further improvement of the product. They were also used this method to compare his product with the similar products available in market. Zhang and Litchfield [1] and [2] used fuzzy model to determine the importance of individual factors to the overall quality of a product. Also by adjusting the 'weighting subset', a product can be tailored for specific consumer groups or geographic regions. There were many products involved in sensory evaluation experiments. It comes from food such as sausages [10] and also drink for example mango drink [9]. The similar experiment can also be extended to coffee drinks which are considered as one of the popular drinks worldwide. The popularity of coffee drink and the importance of consumers' preferences in choosing the product motivate authors to

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further explore these relations. The undeterministic sensory impacts of coffee drinks will be evaluated using a fuzzy approach. Based on the above premises, the present study aims to rank of the selected coffee products through sensory evaluation and find out the best of quality attribute using fuzzy decision-making. It is hoped that the fuzzy approach can be used to determine the importance of individual attributes to the overall quality of a product.

The rest of this paper will be organised as follows. For the sake of clarity, the related definitions of fuzzy decision making are presented in Section 2. Ranking method using fuzzy decision making is proposed in Section 3. An empirical study to rank the coffee products and the best quality attribute is presented in Section 4. Finally, the paper is concluded in Section 5.

II. DEFINITIONS

We review one basic definition of fuzzy sets by[11] and fuzzy decision making by [12] in this section. These notions are expressed as follows.

Definition 2.1

Let U be a universe set. A fuzzy set A of U is defined by a membership function $\mu_A(x) \rightarrow [0,1]$, where $\mu_A(x)$, $\forall x \in U$, indicates the degree of x in A.

Definition 2.2

Let A be a given set of possible alternatives which contains a solution to a decision making problem under consideration. A fuzzy goal G is a fuzzy set on A characterized by its membership function

$$\mu_G : A \rightarrow [0,1]$$

which represents the degree to which the alternatives satisfy the specified decision goal. In general, a fuzzy goal indicates that a target should be obtained, but it also quantifies the degree to which the target is fulfilled.

Definition 2.3

Let A be a given set of possible alternatives which contains solution to a decision making problem under consideration. A fuzzy constraint C is a fuzzy set on A characterized by its membership function

$$\mu_C : A \rightarrow [0,1]$$

which constrains the solution to a fuzzy region within the set of possible solutions.

Definition 2.4

Let A be a given set of possible alternatives which contains a solution to a decision making problem under consideration. Let G be the set of fuzzy goals for the decision, represented by the membership function $\mu_G(a), a \in A$, and let C be the set

of fuzzy constraints represented by the membership function $\mu_C(a), a \in A$. Then the fuzzy decisions F result from the intersection of the fuzzy decision goals and fuzzy constraints, i.e.

$$F = G \cap C$$

The fuzzy decision is characterized by its membership function

$$\mu_F(a) = \mu_G(a) \wedge \mu_C(a), \ a \in A,$$

where $\wedge$ denotes the minimum operation.

Definition 2.5

The optimal decision a^* in fuzzy decision making is the decision with the largest membership value, also called the *maximizing decision*, which is defined by

$$a^* = \arg\max_{a \in A} \mu_G(a) \wedge \mu_C(a)$$

It is important to note that the distinction between the goals and constraints disappears in this model. Essentially, both the goals and the constraints are represented by membership functions defined on the set of possible alternatives.

III. FUZZY DECISION MAKING IN SENSORY EVALUATION

The model used for the analysis of sensory data was developed by Chen, et.al. (1985). Fuzzy model for the present problem has two sets: Attributes set U_f and Evaluation set V_f. The attributes set U_f includes all of the quality attributes such as colour, smell, taste and mouth feel of the products. The evaluation set V_f includes the linguistic term for each of the quality attributes, such as Excellent, Good, Medium, Fair and Not satisfactory. Then numerical values were assigned to the linguistic terms S_f : Excellent = 1, Good = 0.9, Medium = 0.7, Fair = 0.4 and Not satisfactory = 0.1. The steps in this analysis consist of the following calculations.

(i) Fuzzy Membership Function, M_f

Fuzzy membership was calculated by adding the individual linguistic term given to each of the quality attribute of the product and divided by the number of judges who tested the product.

$$M_f = \sum V_f / \text{total of judges} \tag{1}$$

(ii) Normalized Fuzzy Membership Function, N_f

Normalized fuzzy membership function was calculated by multiplying each of the above

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membership function with the assigned numerical value of the respective linguistic term S_f.

$$N_f = M_f \times S_f \qquad (2)$$

(iii)   Normalized Fuzzy Membership Function Matrix , O_f

Addition of the normalized fuzzy membership function of individual linguistic term of respective quality attributes for each the products given for sensory evaluation formed the elements of the normalized fuzzy membership function matrix. Like this, all the element of the normalized matrix were form and written in the form of a matrix called normalized fuzzy membership function matrix having its row as quality attributes and the column as samples number.

$$O_f = \sum N_f \text{ for each quality attribute} \qquad (3)$$

(iv)   Judgment Membership Function Matrix, X_f

After forming the normalized fuzzy membership function matrix, the column values of a sample were added and the individual values of the same column were divided by the 'Maximum' of the added value. The values thus obtained formed the elements of the judgment membership function matrix.

$$X_f = O_f / \max \sum O_f \qquad (4)$$

(v)   Judgment Subset, Y_f

Judgment subset, Y_f was formed by averaging the numerical weights (as fraction obtained from the percentage of marks given for individual quality attribute) given by the judges for individual quality attributes like 'colour', 'smell', 'taste', and 'mouth-feel'. Arithmetic mean method was employed to find the weights for each quality attributes.

$$\underline{Y}_f = \frac{1}{N} \sum_{i=1}^{N} x^i \qquad (5)$$

(vi)   Quality-ranking Subset , Z_f

The individual elements of the judgment membership function matrix X_f were compared with the respective elements of the judgment subset, Y_f and the minimum of them was taken to form the quality-ranking subset, Z_f . The 'and' in fuzzy operations were applied in obtaining Z_f .

(vii)   Ranking of the Sample.

From the values of each element in the quality-ranking subset, Z_f, the maximum values was taken and assigned as the rank one of the respective sample. Then the quality attribute, which gave the highest value, was considered as the reason for that

sample to get the highest rank. The 'or' in fuzzy operations were applied in making the decision.

IV   AN EXPERIMENT

Thirty residents of Kuala Terengganu City Council in Malaysia were selected as judges on the level of preferences for three coffee products. The three products of coffee drinks used in sensory evaluation were Nesc, Indoc and Incom. Approximately 150 ml of samples were prepared in a small paper cup and presented to the judges. They were asked to judge the samples quickly but not hurry and take two short sniffs of the samples before testing the samples and give the score for quality attributes in the scorecard. The judges were asked to give tick ($\sqrt{}$) mark in the respective fuzzy linguistic terms based on their own criteria and likings regarding coffee drinks. Each judge need to choose one of the fuzzy linguistic terms: 'Excellent' (EX), 'Good' (GD), 'Medium' (MD), 'Fair' (FR) and 'Not satisfactory' (NS), to show how much each sensory attributes generally contributes to the overall acceptability. The quality attributes selected for the sensory evaluation were colour, smell, taste and mouth-feel of the coffee drinks. After testing the samples, they were asked to give marks for each of the quality attributes out of 100 based on their own taste regarding coffee drinks. These marks were called as weight of each attribute. Data of the sensory evaluation were collected at the parking area of a hypermarket in Kuala Terengganu. The data were analyzed using a fuzzy decision making approach to determine the ranking of the three coffee drinks and the best quality attribute. The data collected from scorecard were analysed using Fuzzy Decision-making. The results are presented as follows.

Fuzzy Membership function M_f and Normalized Fuzzy Membership Function N_f were calculated using the Equations (1) and Equation (2). These two membership functions led to calculation of Normalized Fuzzy Membership Function Matrix O_f using Equation (3). The results are presented in Table 1.

TABLE I
NORMALIZED FUZZY MEMBERSHIP FUNCTION N_F FOR QUALITY ATTRIBUTES OF COFFEE PRODUCTS AND NORMALIZED FUZZY MEMBERSHIP FUNCTION MATRIX O_F

Quality attribute	N_f		
	Nesc	Indoc	Incom
Colour	0.820	0.887	0.643
Smell	0.770	0. 690	0. 664
Taste	0.787	0.950	0.700
Mouth feel	0.796	0.930	0.677
O_f	3.173	3.729	2.684

The matrix O_f was converted to Judgment Membership Function Matrix X_f by using Equation (4). The value of X_f and their corresponding quality attributes are shown in Table 2.

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TABLE II
JUDGMENT MEMBERSHIP FUNCTION X_F FOR QUALITY
ATTRIBUTES OF COFFEE PRODUCTS.

Quality attribute	X_f		
	Nesc	Indoc	Incom
Colour	0.220	0.238	0.172
Smell	0.206	0. 257	0.178
Taste	0.211	0.255	0.188
Mouth feel	0.213	0.249	0.182

Judgment subset Y_f was formed using the step in Equation (5). The values of the judgment membership functions X_f were then compared with the weights Y_f given by the judges for each of the quality attributes. Based on this, the quality ranking subset values Z_f were calculated. The rank of a sample was assigned from the maximum of quality ranking subset value Z_f of the sample. The quality ranking subset values Z_f and ranking according to their quality attributes and products are presented in Table 3

TABLE III
QUALITY RANKING SUBSET VALUES Z_F OF COFFEE PRODUCTS
AND RANKING

Quality attribute	Y_f	Z_f		
		Nesc	Indoc	Incom
Colour	0.191	0.173	0.173	0.172
Smell	0.253	0.206	0.238	0.178
Taste	0.353	0.211	0.255	0.188
Mouth feel	0.203	0.180	0.180	0.180
Ranking	Taste	II/Taste	I/Taste	III/Taste

The results show that sample of coffee product Indoc recorded the highest ranking followed by Nesc and Incom. For the best quality attribute, interestingly to note that 'taste' was chosen as the best quality attribute for all the sample products.

III. CONCLUSION

Amid stiff competition in marketing to fulfil customers' needs, the cost of failure is so high. In an effort to avoid market disappointment, one of the options to be considered is probing for customer satisfaction through sensory evaluation. In this study, the selected judges expressed their sensory evaluation toward the three coffee products in linguistic terms by choosing the number from provided scales. Fuzzy decision making was adopted in the analysis of sensory evaluation data for coffee drinks. Preference degrees for sensory attitudes of colour, smell, taste and mouth feel have been represented in fuzzy linguistic terms and the overall acceptability can be inferred from them by fuzzy decision making. There were seven steps before approaching to decide the rank of best coffee product as well as the best quality attribute. The results

show that the sample of product Indoc was the highest rank followed by Nesc and Incom. For the best quality attribute, all the obtained quality-ranking values agreeably to the quality of 'taste'. The results may not only offer a meter to consumers to make the best selection but more importantly how manufacturers react to these findings in an effort to meet customers' choice. Altogether, customers have played their parts in making the availability of the best products in the market.

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