# EVALUATION OF FOOD PRESENTATIONS USING PICTURE FUZZY ANALYTICAL HIERARCHY PROCESS

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**ABSTRACT**

Preparation of food is one of the basic activities that people perform throughout their lives for pleasure as well as survival. Food can be considered within the framework of gastronomy, which is defined as "the art of quality eating and drinking". There is fierce competition in the food and beverage sector for the privilege of being preferred by customers for products offered. It is vital for restaurants to have menus that are unique and consist of innovative recipes. Creative chefs are at the forefront of creating and presenting these menus. However, scoring and evaluating chefs' products is a cognitive, multi-perspective, and complicated process. In this study, for the first time in the literature, a multi-criteria decision-making (MCDM) approach was used to evaluate gastronomy products. Five food presentations that received full points in the final exam of the Korean Cuisine Practical Course at a gastronomy education institution were evaluated. The evaluation criteria for the students' food presentations were presentation, creativity of the name, taste, and fusion balance of the product (the combination of different cultures in the product). The Picture Fuzzy Analytical Hierarchy Process (AHP) method was used, and the performance ranking of the food presentations, which the judges could not determine by their direct evaluation, was revealed. The study provides an easy-to-implement and fair assessment methodology for both scoring of food presentations in educational institutions and for highly competitive cooking competitions. The developed methodology can be applied to many different evaluations of culinary products.

**Keywords:** picture fuzzy sets; Analytical Hierarchy Process; food presentation; gastronomy product


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## 1. Introduction

Food is transformed into personal taste perception through our senses. The perception of taste starts with the visual evaluation of food and is formed by chemical stimuli released during eating (Christensen, 1984; Laing & Jinks, 1996). Taste perception is personal as it is influenced by culture, memories, and emotions. Therefore, food orders, shopping lists, and favorite dishes vary from person to person. Studies in the field of neurogastronomy have been conducted on how the human brain creates taste perception (Castillo, 2014; Shepherd, 2011).

The goal in the creation of gastronomic products is that they are liked by the maximum number of consumers or that consumers are willing to invest time or money to obtain the product. While gastronomic products are evaluated by their producers according to their commercial contribution (Siró et. al, 2018), they are evaluated by their creators (chefs) using subjective elements such as visuality and taste (Ekincek & Günay, 2023). Therefore, chefs who create gastronomic products that can be evaluated differently by each consumer are expected to have many competencies (Ekincek & Günay, 2023). In the past, chefs were trained in a way that emphasized only skills and technique but lacked modern management and innovation (Jeou-Shyan & Lee, 2007); however, now they are trained as knowledgeable, talented, and creative professionals in the culinary arts departments of qualified educational institutions.

In the process of evaluating gastronomic products, plate scorings made by lecturers in educational institutions, evaluations made by judges in competitions, or online comments made by customers in the industry are based on the consumer's cognitive perception of taste. Neurogastronomy studies how this cognitive evaluation process works and on what basis the evaluators assess the foods as good or bad (Shepherd, 2011). In this study, a methodology for quantifying the evaluation of gastronomy products is presented. The evaluation is based on the scoring of food presentations of students at a gastronomy education institution within the scope of the Korean Cuisine course.

Since the evaluation of products in the field of gastronomy is carried out under multiple criteria such as flavor, visuality, creativity, etc., that can be assessed by experts through cognitive inferences, the evaluation has the structure of an MCDM problem. Criteria were identified through literature research and expert interviews, according to the nature of the units being evaluated. MCDM studies are an intensively researched area in the literature with the development of various methods and extensions with their application to different problem environments (Taherdoost & Madnchian, 2023). Traditional methods such as the AHP (Saaty, 1980), Technique for Order of Preference by Similarity to Ideal Solution - TOPSIS (Hwang & Yoon, 1981), ELECTRE (Benayoun et al., 1966), Analytic Network Process - ANP (Saaty, 1996), Preference Ranking Organization Method For Enrichment Evaluation - PROMETHEE (Brans, 1982), Decision Making Trial And Evaluation Laboratory - DEMATEL (Gabus & Fontela, 1972), Data Envelopment Analysis - DEA (Charnes et al., 1978) and other methods as well as relatively new methods such as Best Worst Method (BWM) (Rezai, 2015) and Full Consistency Method - FUCOM (Pamucar et al., 2018) have attracted considerable attention in the literature. While each method has advantages and disadvantages, the decision problems are solved by different methods depending on their structure and the experts who generate the data in the decision-making matrices.


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Although some studies have utilized MCDM methods such as the AHP and TOPSIS to evaluate performances in competitions in different fields such as sports, science, and technology (Chiu et al., 2010; Chen et al., 2014; Nisel & Özdemir, 2016; Bao et al., 2018), there are no studies in the literature on the evaluation of presentations related to gastronomy products using an MCDM approach. Due to the small number of alternatives and the jury's preference to observe the self-consistency of all units evaluated in the review phase by comparing them with each other, the AHP method based on pairwise comparisons for all units was used. Although the BWM and FUCOM methods would reduce the number of pairwise comparisons and speed up the evaluation process (Moslem, 2023; Moslem et al., 2022), the AHP method was preferred because of its ability to increase the experts' mastery of their cognitive preferences. Due to the small number of alternatives evaluated and the fact that the alternatives are tangible and consumable products exhibited in front of the experts, pairwise comparisons were used. In our study, the AHP method was chosen because of its suitability to the nature of our problem, and it supports the description of the AHP method as the most traditional and popular MCDM method in the literature (Moslem et al., 2023; Taherdoost and Madnchian, 2023).

The values of alternatives under the criteria can be determined by empirical or historical data. In these cases, solution approaches can often proceed smoothly. However, the complexity of the problem can lead to less reliable results when all the evaluation criteria are handled by experts (Duong & Thao, 2021). Experts' evaluation of food presentations based on their subjective knowledge and perception of flavor will undoubtedly involve ambiguity of expression. The problem with gastronomy product evaluation is that it by its very nature also requires the judgment of experts and attempts to deal with uncertainties in human judgment. In recent years, the AHP method has been combined with other methods, also related to fuzzy sets and their extensions to address and reduce uncertainty in human preferences.

In the decision-making environment considered within the scope of the study, one expert may use the expression "extremely good" for a product they tasted or evaluated based on its appearance, while another expert may use the expression "excellent" for a different product. Fuzzy logic is used to clarify and quantify the ambiguity in these linguistic expressions used to express human judgments. Fuzzy theory, which allows experts to use linguistic expressions instead of directly assigning a real number, provides an advantage in quantifying qualitative assessments. Fuzzy theory was proposed by Zadeh (1965) and many extensions have been introduced over the years that are frequently used in the literature. Extensions such as intuitionistic fuzzy sets (Senapati et. al., 2023; Atanassov, 2016), hesitant fuzzy sets (Torra, 2010), dual hesitant fuzzy sets (Saha et. al., 2022), pythagorean fuzzy sets (Yager, 2013) and picture fuzzy sets (Cuong & Kreinovich, 2013) consider the membership function representing uncertainty as well as non-membership functions and hesitant values. Provided that the sum of positive (membership), negative (non-membership), and neutral (hesitant) memberships is less than or equal to 1 (Akram & Shabir, 2021), uncertainty in expert judgments is handled more comprehensively by considering the agreement, disagreement, and neutrality of the decision makers. Since the picture fuzzy sets provide a wider range of choices for decision-makers to select


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membership functions, the hesitations or uncertainties of the experts in decision-making are handled more effectively (Meshram et al., 2022; Singh, 2015).

In the fuzzy logic literature, it is clear that fuzzy sets have a wide variety of extensions and are constantly evolving. In all extensions, the main goal is to increase control over uncertainties. Picture fuzzy sets are considered one of the well-known and useful tools for expressing uncertainty in complex and uncertain environments (Gündoğdu & Seyfi-Shishavan, 2022). Picture fuzzy sets are preferred in this study because they are still powerful enough to deal with uncertainty with less complex computations. In recent years, there has been an increase in the number of studies on MCDM with picture fuzzy sets (Yıldırım & Yıldırım, 2022; Simic et al., 2020; Tian & Peng, 2020; Arya & Kumar 2020; Švadlenka et al., 2020; Senapati & Chen, 2022; Qiyas et al., 2022; Aydoğmuş et al., 2021). There are AHP studies using picture fuzzy sets in the literature including Bal and Sari (2022) who presented a work environment selection problem evaluation with the Picture Fuzzy AHP method, and Meshram et al. (2022) who integrated Picture Fuzzy AHP and the linear assignment model to evaluate alternatives under multiple criteria.

This study aims to reveal the evaluation criteria, quantify the uncertainties in expert judgments and capture the differences between the presentations using the MCDM approach for five food presentations that received full points from the jury in the final exam of the Korean Cuisine course at a gastronomy education institution. Based on the related literature review and the evaluation environment required for solving the problem under consideration, the Picture Fuzzy AHP method was applied for the study. The AHP method was preferred because of its ability to increase the mastery of the cognitive preferences of the experts instead of recent techniques such as BWM or FUCOM, whose advantage is a less complicated pairwise comparisons process for the experts. To resolve the ambiguity in human judgments, the picture fuzzy sets were utilized. This study offers multiple original contributions to the literature that include the development of the MCDM approach for gastronomy product evaluation, the use of the AHP approach in scoring the edible products of the Korean Cuisine course, and the use of fuzzy logic to overcome the ambiguity in expert judgments within the scope of the evaluation. To the best of our knowledge, this is the first study in the literature that presents a fuzzy and multi-criteria evaluation methodology for grading students' food presentations in a gastronomy context.

## 2. Picture Fuzzy Sets

Picture fuzzy sets are direct extensions of intuitonistic fuzzy sets. When an intuitionistic fuzzy set gives a degree of membership and a degree of non-membership in a given set, a picture fuzzy set gives a degree of neutral membership in addition to that given by the intuitionistic fuzzy set (Cuong & Kreinovich, 2013).

Definition 1: A Picture Fuzzy Set $\tilde{F}_p$ on a universe $X$ is an object of the form (Cuong & Kreinovich, 2013):

$$\tilde{F}_p = \left\{x, \left(\mu_{\tilde{F}_p}(x), \pi_{\tilde{F}_p}(x), v_{\tilde{F}_p}(x)\right) \middle| x \in X\right\} \quad (1)$$


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where $\mu_{\tilde{F}_p}(x)$, $v_{\tilde{F}_p}(x)$ and $\pi_{\tilde{F}_p}(x)$ are the degree of membership, non-membership, and neutral of $x$ to $\tilde{F}_p$, respectively. These terms reflect people's expressions of "yes, abstention and no".

$$\mu_{\tilde{F}_p}(x): X \to [0,1], \quad v_{\tilde{F}_p}(x): X \to [0,1], \quad \pi_{\tilde{F}_p}(x): X \to [0,1] \qquad (2)$$

$\mu_{\tilde{F}_p}(x)$, $v_{\tilde{F}_p}(x)$ and $\pi_{\tilde{F}_p}(x)$ satisfy the following condition:

$$0 \leq \mu_{\tilde{F}_p}(x) + v_{\tilde{F}_p}(x) + \pi_{\tilde{F}_p}(x) \leq 1 \quad \forall x \in X \qquad (3)$$

and $1 - (\mu_{\tilde{F}_p}(x) + \pi_{\tilde{F}_p}(x) + v_{\tilde{F}_p}(x))$ is called as a refusal degree (Cuong & Kreinovich, 2013)

Definition 2: Basic operators of single-valued picture fuzzy sets (Wei, 2017);

$$\tilde{F}_p \oplus \tilde{G}_p = \left\{\mu_{\tilde{F}_p} + \mu_{\tilde{G}_p} - \mu_{\tilde{F}_p}\mu_{\tilde{G}_p}, \pi_{\tilde{F}_p}\pi_{\tilde{G}_p}, v_{\tilde{F}_p}v_{\tilde{G}_p}\right\} \qquad (4)$$

$$\tilde{F}_p \otimes \tilde{G}_p = \left\{\mu_{\tilde{F}_p}\mu_{\tilde{G}_p}, \pi_{\tilde{F}_p} + \pi_{\tilde{G}_p} - \pi_{\tilde{F}_p}\pi_{\tilde{G}_p}, v_{\tilde{F}_p} + v_{\tilde{G}_p} - v_{\tilde{F}_p}v_{\tilde{G}_p}\right\} \qquad (5)$$

$$\lambda . \tilde{F}_p = \left\{\left(1 - \left(1 - \mu_{\tilde{F}_p}\right)^{\lambda}\right), {\pi_{\tilde{F}_p}}^{\lambda}, v_{\tilde{F}_p}^{\lambda}\right\} \text{ for } \lambda > 0 \qquad (6)$$

$$\tilde{F}_p^{\lambda} = \left\{\mu_{\tilde{F}_p}^{\lambda}, \left(1 - \left(1 - \pi_{\tilde{F}_p}\right)^{\lambda}\right), \left(1 - \left(1 - v_{\tilde{F}_p}\right)^{\lambda}\right)\right\} \text{ for } \lambda > 0 \qquad (7)$$

Definition 3: Single-valued Picture Fuzzy Weighted Averaging operator (PFWA) with respect to, $w_i = (w_1, w_2, \ldots \ldots, w_n)$; $w_1 \in (0,1)$; $\sum_{i=1}^{n} w_1 = 1$ is defined as (Wei, 2017);

$$\text{PFWA}_w(\tilde{F}_1, \tilde{F}_2, \ldots, \tilde{F}_n) = w_1\tilde{F}_1 + w_2\tilde{F}_2 + \ldots + w_n\tilde{F}_n$$

$$= \left\{1 - \prod_{i=1}^{n}\left(1 - \mu_{\tilde{F}_i}\right)^{w_i}, \prod_{i=1}^{n} {\pi_{\tilde{F}_i}}^{w_i}, \prod_{i=1}^{n} {v_{\tilde{F}_i}}^{w_i}\right\} \qquad (8)$$

Definition 4: Score functions and Accuracy functions of gradation picture fuzzy numbers are defined by (Wei, 2017);

$$Score\left(\tilde{F}_p\right) = \frac{1}{2}\left(1 + 2\mu_{\tilde{F}_p} - v_{\tilde{F}_p} - \frac{\pi_{\tilde{F}_s}}{2}\right) \qquad (9)$$

$$Accuracy\left(\tilde{F}_p\right) = \mu_{\tilde{F}_p} + \pi_{\tilde{F}_p} + v_{\tilde{F}_p} \qquad (10)$$

Note that:
$\tilde{F}_p < \tilde{G}_p$ if and only if

i. $Score\left(\tilde{F}_p\right) < Score\left(\tilde{G}_p\right)$ or
ii. $Score\left(\tilde{F}_p\right) = Score\left(\tilde{G}_p\right)$ and $Accuracy\left(\tilde{F}_p\right) < Accuracy\left(\tilde{G}_p\right)$.


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## 3. Proposed methodology: Picture Fuzzy AHP

In this study, the problem of scoring food presentations is considered a MCDM problem. A methodology was developed using the Picture Fuzzy AHP method to evaluate the food presentations with the opinions of experts under the specified evaluation criteria. The purpose of the problem, determination of the criteria and alternatives to be evaluated constitute the hierarchical structure of the study. Let $A_i = \{a_1, a_2, \ldots, a_n\}$ be a discrete set of the food presentations to be evaluated, $C_j = \{C_1, C_2, \ldots, C_m\}$ be a finite set of evaluation criteria and $W_k = \{w_1, w_2, \ldots, w_l\}$ be the importance weights determined according to the level of knowledge and experience of the experts who will make the assessments, provided that $\sum_{k=1}^{l} w_k = 1$.

### 3.1 Construction of the picture fuzzy comparison matrices

Due to the nature of the AHP method, pairwise comparison matrices were constructed to provide the evaluations of all the alternatives under each criterion. In MCDM problems, the impact of criteria on the overall ranking of alternatives may not be the equal. In most decision-making problems, it is determined whether the evaluation criteria have different levels of importance on the alternatives. For this purpose, as in the evaluation of alternatives under the criteria, the criteria are also evaluated using pairwise comparisons. In order for the experts to express their judgements about the superiority of the evaluated units over each other, the evaluation scale given in Table 1 is used (Meksavang et al., 2019; Gündoğdu et al., 2021). For detailed information on pairwise comparisons, read Saaty (1988, 1980). Each decision maker creates a pairwise comparison matrix in which both criteria are compared with each other, and the alternatives are evaluated under each criterion. The pairwise comparison matrix consisting of the picture fuzzy values in which *n* alternatives are compared with each other is shown as Equation 11.

Table 1
Picture fuzzy linguistic scale (Meksavang et al., 2019; Gündoğdu et al., 2021)

| Linguistic terms for evaluation | Picture fuzzy value $(\mu, \pi, v)$ | Intensity of importance |
|---|---|---|
| Very High Importance (VHI) | (0.9, 0, 0.05) | 7 |
| High Importance (HI) | (0.75, 0.05, 0.1) | 5 |
| Slightly More Important (SMI) | (0.6, 0, 0.3) | 3 |
| Equally Important (EI) | (0.5, 0.1, 0.4) | 1 |
| Slightly Low Importance (SLI) | (0.3, 0.0, 0.6) | 1/3 |
| Low Importance (LI) | (0.25, 0.05, 0.6) | 1/5 |
| Very Low Importance (VLI) | (0.1, 0.0, 0.85) | 1/7 |

$$M_{n\times n} = \begin{pmatrix} (\mu_{11}, \pi_{11}, v_{11}) & (\mu_{12}, \pi_{12}, v_{12}) & \dots & (\mu_{1n}, \pi_{1n}, v_{1n}) \\ (\mu_{21}, \pi_{21}, v_{21}) & (\mu_{22}, \pi_{22}, v_{22}) & \dots & (\mu_{2n}, \pi_{2n}, v_{2n}) \\ \vdots & \vdots & \dots & \vdots \\ \vdots & \vdots & \dots & \vdots \\ (\mu_{n1}, \pi_{n1}, v_{n1}) & (\mu_{n2}, \pi_{n2}, v_{n2}) & \dots & (\mu_{nn}, \pi_{nn}, v_{nn}) \end{pmatrix} \quad (11)$$


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### 3.2 Consistency measurement using classical AHP

It is important to ensure that the experts' assessments of all the elements considered by the pairwise comparisons are reliable. Therefore, a consistency index check is performed for each matrix. Matrices are considered tolerably inconsistent if their consistency ratio is less than 0.10 (Gündoğdu et al., 2021). The Consistency Ratio (CR) is calculated as the Consistency Index (CI) divided by the Random Index (RI). For the Random Index (RI), the consistency indicator given in Table 2, which is related to the size of the matrix, is used, while for the CR, Equation 12 based on the maximum eigenvalue ($\lambda_{max}$) and size of the matrix is used. When calculating the maximum eigenvalue, the corresponding intensity of importance values of the linguistic expressions presented by the experts are taken into account (Gündoğdu & Kahraman, 2020; Gündoğdu et al., 2021). When calculating the maximum eigenvalue, the corresponding intensity of importance values of the linguistic expressions presented by the experts are taken into account (Gündoğdu et al., 2021; Gündoğdu & Kahraman, 2020). For intolerably inconsistent cases with a CR > 0.1, the experts are asked to reconsider their assessment.

$$CR = \frac{CI}{RI}, \text{ where } CI = \frac{\lambda_{max} - n}{n-1} \quad (12)$$

Table 2
RI values

| Matrix size | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 | 1.51 |

### 3.3 Aggregation of the experts' evaluation matrices

The experts' evaluation matrices were aggregated with the picture fuzzy weighted geometric mean operator (PFWG) by considering the importance weights of the experts, where $w_k$ is the importance weight of the expert $k$ and $\tilde{p}_{ij}$ is the aggregated picture fuzzy values in the matrix (Equation 13). Hence, to determine the weights of the criteria and evaluate the alternatives under each criterion, the expert opinions are aggregated according to their importance weights, as shown in Tables 3 and Table 4, respectively.

$$PFWG_w(\tilde{p}_{ij}) = \left[\prod_{k=1}^{l}\left({\mu_{ij}}^{(k)}\right)^{w_k}, \prod_{k=1}^{l} {\pi_{ij}}^{w_k},\ 1 - \prod_{k=1}^{l}(1 - {v_{ij}}^{(k)})^{w_k}\right] \quad (13)$$


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Table 3
Aggregated judgments of experts for pairwise comparison of the criteria

| | $C_1$ | $C_2$ | ⋯ | $C_m$ |
|---|---|---|---|---|
| $C_1$ | $PFWG_w(\tilde{p}_{11})$ | $PFWG_w(\tilde{p}_{12})$ | ⋯ | $PFWG_w(\tilde{p}_{1m})$ |
| $C_2$ | $PFWG_w(\tilde{p}_{21})$ | $PFWG_w(\tilde{p}_{22})$ | ⋯ | $PFWG_w(\tilde{p}_{2m})$ |
| ⋯ | ⋯ | ⋯ | ⋯ | ⋯ |
| $C_m$ | $PFWG_w(\tilde{p}_{m1})$ | $PFWG_w(\tilde{p}_{m2})$ | ⋯ | $PFWG_w(\tilde{p}_{mm})$ |

Table 4
Aggregated picture fuzzy values of the alternatives under each criterion

| $C_j$ | $A_1$ | $A_2$ | ⋯ | $A_n$ |
|---|---|---|---|---|
| $A_1$ | $PFWG_w(\tilde{p}_{11})$ | $PFWG_w(\tilde{p}_{12})$ | ⋯ | $PFWG_w(\tilde{p}_{1n})$ |
| $A_2$ | $PFWG_w(\tilde{p}_{21})$ | $PFWG_w(\tilde{p}_{22})$ | ⋯ | $PFWG_w(\tilde{p}_{2n})$ |
| ⋯ | ⋯ | ⋯ | ⋯ | ⋯ |
| $A_n$ | $PFWG_w(\tilde{p}_{n1})$ | $PFWG_w(\tilde{p}_{n2})$ | ⋯ | $PFWG_w(\tilde{p}_{nn})$ |

### 3.4 Calculation of criteria and the alternatives weights

In order to calculate the weights of the criteria and the alternatives under each criterion, the picture fuzzy weighted average mean operator given in Equation 8 was used. Then, the importance weights of the considered elements were obtained by performing the defuzzification process given in Equation 9, then they were normalized. Finally, the importance weights of the criteria and alternatives were obtained as in Table 5.

Table 5
Weights of the criteria and scores of the alternatives

| | $w_{C_1}$ | $w_{C_2}$ | ⋯ | $w_{C_m}$ |
|---|---|---|---|---|
| | $C_1$ | $C_2$ | ⋯ | $C_m$ |
| $A_1$ | $a_{11}$ | $a_{12}$ | ⋯ | $a_{1m}$ |
| $A_2$ | $a_{21}$ | $a_{22}$ | ⋯ | $a_{2m}$ |
| ⋯ | ⋯ | ⋯ | ⋯ | ⋯ |
| $A_n$ | $a_{n1}$ | $a_{n1}$ | ⋯ | $a_{nm}$ |

### 3.5 Ranking the alternatives

The weighted total scores for each alternative were determined by considering the scores of the alternatives under each criterion and the weights of the criteria as shown in Equation 14. Thus, the overall result was determined based on the evaluation of the alternatives by multiple experts under multiple criteria. The alternatives were ranked in terms of their importance.

$$A_i = \sum_{j=1}^{m} a_{ij} * w_{C_j} \tag{14}$$

## 4. Evaluation of food presentations using Picture Fuzzy AHP

In this study, a multi-criteria evaluation methodology is proposed using the Picture Fuzzy AHP method to evaluate students' food presentations within the scope of the final exam of the Korean Cuisine course at a gastronomy institution that provides education at the undergraduate level. Students' food presentations are the considered alternatives in this MCDM problem, and the evaluation criteria determined by the lecturers of the course were visuality, creativity of the name, taste perception and the fusion balance. The five considered food presentations are illustrated in Figure 1.


Figure 1 Evaluated food presentations

The name of food presentation number 1 is "Chingu". Chingu means friend in Korean. Food presentation number 1 is patjook, a Korean dessert filled with tas kadayif to create a fusion meal. Food presentation number 2 is a "Korean style pita" that contains bulgogi. The bulgogi, made of Korean marinated meat, is served on a pita, which has an important place in Turkish cuisine. Food presentation number 3 is "Pazıbap". In this dish, the ingredients of Kimbap, which is frequently consumed in Korean cuisine, are wrapped in chard leaves instead of leaf seaweed. Food presentation number 4 is named "Stuffed Meatball Kimbap". This dish is a Turkish stuffed meatball flavored with Korean sauces and served in the form of kimbap. The last food presentation number 5 is "Jumeok-bap with Fruit Sorbet". This dessert is a combination of Jumeok-bap, a traditional Korean food, with a sweet and fruity sorbet. The evaluation hierarchy is shown in Figure 2.


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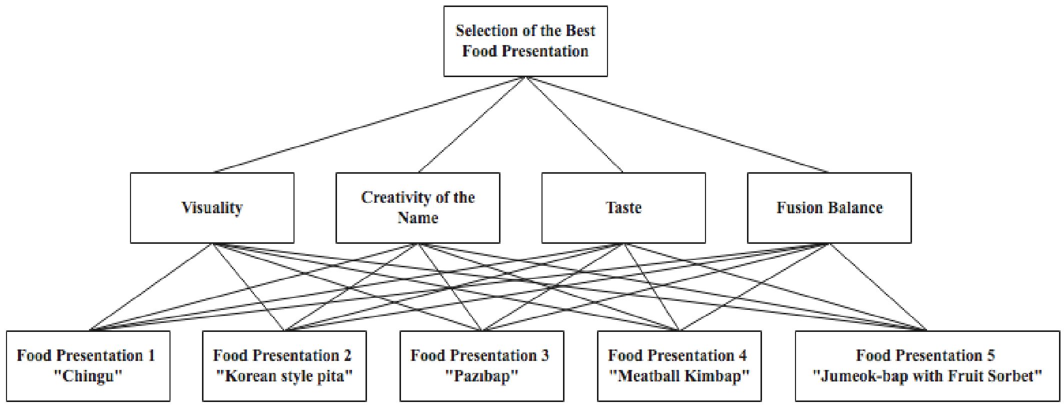


Figure 2 Evaluation hierarchy

Various methods can be used to determine the importance weight of the experts. Six experts participated in the evaluation in this study. Two of the experts (Expert 2 and Expert 6) are the lecturers of the Korean Cuisine course, while the others are lecturers in different culinary courses. The Korean Cuisine Course lecturers' opinions were given twice the weight of importance as that of the other culinary course lecturers. Accordingly, the weights of the experts were determined as 0.125, 0.25, 0.125, 0.125, 0.125 and 0.25, respectively.

Using the linguistic expressions given in Table 1, the experts made pairwise comparisons of the criteria, as shown in Table 6.

Table 6
Expert evaluations for the criteria

| | Expert1 | | | | Expert2 | | | | Expert3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Visuality | Creativity of name | Taste | Fusion balance | Visuality | Creativity of name | Taste | Fusion balance | Visuality | Creativity of name | Taste | Fusion balance |
| Visuality | EI | SMI | SMI | VHI | EI | SMI | EI | HI | EI | SMI | SLI | SMI |
| Creativity of name | SLI | EI | EI | HI | SLI | EI | SLI | SMI | SLI | EI | LI | EI |
| Taste | SLI | EI | EI | HI | EI | SMI | EI | HI | SMI | HI | EI | HI |
| Fusion balance | VLI | LI | LI | EI | LI | SLI | LI | EI | SLI | EI | LI | EI |
| | Expert4 | | | | Expert5 | | | | Expert6 | | | |
| Visuality | EI | HI | SLI | SMI | EI | SMI | SLI | SMI | EI | SMI | EI | HI |
| Creativity of name | LI | EI | VLI | SLI | SLI | EI | LI | EI | SLI | EI | SLI | EI |
| Taste | SMI | VHI | EI | HI | SMI | HI | EI | HI | EI | SMI | EI | SMI |
| Fusion balance | SLI | SMI | LI | EI | SLI | EI | LI | EI | LI | EI | SLI | EI |

After checking the consistency ratio of the matrices, the judgements of the experts for determining the weights of the criteria were aggregated using Equation 13 which resulted in the data presented in Table 7.

Table 7
Aggregated picture fuzzy criteria weights

| | Visuality | Creativity of Name | Taste | Fusion Balance |
|---|---|---|---|---|
| Visuality | (0.5, 0.1, 0.4) | (0.616, 0, 0.277) | (0.422, 0, 0474) | (0.705, 0, 0.175) |
| Creativity of Name | (0.293, 0, 0.6) | (0.5, 0.1, 0.4) | (0.266, 0, 0.627) | (0.516, 0, 0.376) |
| Taste | (0.502, 0, 0.395) | (0.652, 0, 0.240) | (0.5, 0.1, 0.4) | (0.709, 0, 0.154) |
| Fusion Balance | (0.238, 0, 0.646) | (0.412, 0, 0.474) | (0.261, 0, 0.6) | (0.5, 0.1, 0.4) |


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Following the comparison of the criteria, the experts evaluated the food presentations under the established criteria. Once the consistency of the evaluations was ensured, the judgements were aggregated by considering the importance weights of the experts and defuzzification, normalization and weight determination were performed for all matrices respectively, which resulted in the data presented in Table 8.

Table 8
Weights of the criteria and food presentation under the criteria

| | Visuality | Creativity of the name | Taste | Fusion balance |
|---|---|---|---|---|
| Weight of the criterion | 0.293 | 0.207 | 0.310 | 0.189 |
| Food No.1 | 0.274 | 0.220 | 0.231 | 0.247 |
| Food No.2 | 0.225 | 0.214 | 0.208 | 0.206 |
| Food No.3 | 0.193 | 0.198 | 0.205 | 0.202 |
| Food No.4 | 0.214 | 0.158 | 0.187 | 0.182 |
| Food No.5 | 0.094 | 0.210 | 0.169 | 0.164 |

Finally, the scores of the food presentations were obtained, as 0.244, 0.214, 0.2, 0.188 and 0.154, respectively. The multi-criteria performance ranking of the food presentations, which the experts gave full points before the study, was determined as Food No.1 > Food No.2 > Food No.3 > Food No.4 > Food No.5. Differences that the human brain cannot capture in multi-criteria evaluations were successfully revealed by the Fuzzy Picture AHP method.

## 5. Conclusion

This paper presents a comprehensive methodology for quantitatively evaluating food presentations under different criteria. The evaluation criteria used in the study can be used by judges in cooking competitions as well as for course exams in the field of gastronomy. Within the developed methodology, five food presentations that were prepared by the gastronomy students for the Korean Cuisine course exam that received full points were evaluated more effectively with Picture Fuzzy AHP. Picture fuzzy sets are more effective than other fuzzy sets when evaluations are uncertain or neutral. They represent the uncertainty in expert judgements well by providing ease of calculation through a wider range of options for membership, non-membership and hesitation. The Picture Fuzzy AHP method provides a MCDM environment that is simple and practical to implement, easily understood by experts, and similar in structure to real-life problems.

Considering the limitations of the human mind to directly evaluate multiple alternatives under multiple criteria, collecting data through pairwise comparisons of experts is a much more acceptable approach for analysts to use to make evaluations. It was observed that the Picture Fuzzy AHP method evaluated the students more fairly. This study contributes to the literature by demonstrating the usability of the MCDM approach in the evaluation of food presentations and highlighting that the Picture Fuzzy AHP method reveals differences between alternatives that the human mind cannot distinguish. The proposed evaluation methodology can be used in many real-life evaluations, such as exams of other practice courses in the field of gastronomy, as well as in the evaluation of food competitions organized worldwide. In the future, the proposed methodology can be extended with other decision-making methods and different fuzzy set extensions and to compare the results obtained.

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