HOW DO PEOPLE FEEL ABOUT HAMBURGERS? -ANALYSIS BASED ON SENSORY EVALUATION AND DECISION TREE-

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ABSTRACT. People pay attention to the appearance of a dish; hence, considering the component of dishes and discussing the relationship between the feelings inspired by dishes and their images are interesting research topics. We exposed 50 participants to pictures of 66 types of hamburgers from three hamburger chains and conducted a sensory evaluation. Analysis based on the decision tree was applied to the sensory evaluation results, and we validated the characteristics of hamburgers. In summary, the participants tend to feel that the deliciousness and gorgeousness of hamburgers are primarily defined by whether the color of the hamburger is different from green and red. Sliced vegetables appear to have a larger volume; thus, the presence of sliced onion, lettuce, and cabbage may make them appear healthier. Further, we verified the adequacy of the decision tree. The decision tree will be a sufficient structure if more sufficient explanatory variables are prepared. Keywords: Hamburger, Feeling, Sensory evaluation, Decision tree

1. Introduction. It is said that people pay attention to the appearance of a dish. The images of dishes, such as the color of vegetables and well-roasted meat, arouse the appetite. In contrast, a mono-colored dish or dish that lacks the color variation does not awaken a person's appetite; hence, it can be deduced that the color of the dish influences the feeling of deliciousness [1]. Some previous studies have investigated the relationship between the appearance of dishes and the feeling of deliciousness. For example, a study investigated how the visual volume and height of food on a plate influence our impression of the food [2]. Another study determined that altering the color of food and drink changes people's expectations and their taste and flavor perceptions, and changing the background color can significantly influence taste/flavor expectations/perceptions [3]. Okajima et al. investigated how the visual texture and appearance of food influences its perceived taste and flavor by developing an augmented reality system [4,5]. Sakurai et al. suggested that the size around the food, especially the size of the visual dish, changes the perception of satiety [6]. Piqueras-Fiszman et al. examined the extent to which the color of the plate may influence the gustatory and hedonic experiences of a complex food [7]. Generally, these studies primarily considered simple-looking food and investigated changes in images only when the color or size of the dish or background is altered. Therefore, to comprehensively investigate the relationship between the appearance and perceptions of a dish, we should consider more complex dishes. In other words, we should consider the component of dishes and discuss the relationship between the perception and appearance of the dish. There

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are indeed many other dishes besides hamburgers, but our feelings are influenced by the dish and the elements that make up the dish, such as the shape, bowls, and plates. In this study, we considered hamburgers as an example of a dish. This is because the shape of each hamburger does not differ. Additionally, since most hamburgers are not served on a plate, we can only consider the influence of the hamburger.

Hamburgers are one of the most popular foods globally, and many types of hamburgers have been produced. In his research, Samuel demonstrated that three-quarters of all food establishments sell at least one type of hamburger, and out of 80% of these establishments, hamburgers are their best-selling food on the menu [8]. According to government data since the mid-1970s, beef consumption has been dwindling in the United States, falling from a peak of 94 pounds per person per year in 1976 to 54 pounds in 2014. Over the past 15 years, per capita beef consumption has decreased by 20%. However, hamburgers have gone the opposite route, gaining popularity, even as Americans lose their taste for the broader beef and meat categories. Currently, we consume significantly less beef but substantially more hamburgers, about six extra burgers per person, or 30% more than the usual consumption [9]. Another study demonstrated that, in 2017/2018, the average person in the United Kingdom (UK) consumed just under a kilogram of burgers out of a home per year, or 19 g per week. Since 2006, although consumption was its lowest in 2013 (15 g), but has since increased [10]. Additionally, there are many variations of hamburgers. These variations are due to the combination of components, such as buns, patties, vegetables, toppings, and sauce. Therefore, the appearance of a hamburger may be influenced by the combination of these components.

In this study, we analyze the feelings of deliciousness, gorgeousness, and healthiness, considering the entire color of hamburgers and their various components, such as buns, patties, vegetables, toppings, and sauce. Conventionally, food analyses have focused solely on the appearance or color of the dish. However, as the novelty of this research, we included the components of the dish. We also employ the decision tree as a statistical method to investigate and analyze the relationship between food appearance and feeling.

We used the experimental results obtained from 50 participants to analyze the specifics of hamburgers and estimate the best technique for making delicious, gorgeous, and healthy hamburgers. To apply the methods and results, the characteristics of hamburgers that people like will be elucidated, which may be beneficial in marketing hamburgers. In addition to hamburgers, this method will be applied to other dishes and their respective marketing.

The remainder of the paper is organized as follows. Section 2 explains the experimental and analysis method. Section 3 discusses the experimental results. Section 4 considers about the results of experiment. Finally, Section 5 presents the conclusion.

2. Materials and Methods.

2.1. Experimental conditions. Fifty persons (47 males and three females, between 19 and 54 years old) participated in the experiment. It would be preferable to conduct the experiment with many participants because the more time the experiment is conducted, the more reliable the results are. However, we limited the number of participants to 50. The participants are mainly students at the author's university and are mostly male. Therefore, there was a large bias in the number of male and female participants. These participants sat in a chair and were instructed to look at the monitor of a laptop computer on the table in their front. Then, a picture of a hamburger was displayed on the laptop computer. When the picture of the hamburger was displayed, each participant was instructed to evaluate the deliciousness ("score of deliciousness"), gorgeousness ("score of

gorgeousness"), and healthiness ("score of healthiness") of the food on the following basis: do not think (feel) at all = 1 point; average = 5 points; and strongly think (feel) = 10 points. In this study, 1 and 2 points, 3 and 4 points, 5 and 6 points, 7 and 8 points, and 9 and 10 points are summarized as "worst", "poor", "middle", "high", and "excellent", respectively. The pictures of 66 hamburgers were prepared for this experiment. Thus, each participant repeated this procedure 66 times (the reason for 66 times will be discussed later). The order of the picture display was altered based on each participant, considering the order effect. Here 50 participants were divided into five groups. The order of the picture display was altered for each group, considering the sequential effect.

The pictures of the hamburgers used for the experiment are from the hamburger chain shops (bland): BK, Mc, Mos. We selected the hamburgers of these chain shops for the experiment because they seemed familiar to each participant. The details of these hamburger chain shops are presented as follows.

BK: BK is the second-largest fast-food hamburger chain in the world, founded in 1954 [11]. It has about 12,000 stores worldwide [12]. As of January 26, 2021, it has 56 stores in Japan [13]. It was ranked 7th according to its number of stores in Japan on January 26, 2021 [14].

Mc: Mc is the largest fast-food hamburger chain in the world, founded in 1940. It has about 32,000 stores worldwide [12]. As of January 26, 2021, it has 2,909 stores in Japan, and it is the first largest hamburger chain based on its number of stores as of January 26, 2021 [14].

Mos: Mos is a Japanese international hamburger chain founded in 1972; it has 1,679 stores worldwide [15]. As of March 2020, it has 1,718 stores in Japan; it is the second-largest hamburger chain based on the number of stores as of January 26, 2021 [14].

For the experiment, 20, 25, and 21 pictures were adopted for the BK, Mc, and Mos hamburgers, respectively. The components of each hamburger, buns, patties, vegetables, toppings, and sauce were analyzed based on the pictures on the website of the hamburger chains. Table 1 presents the components of each hamburger categorized and classified based on the analysis results. The categorization and classification results obtained will be used in the following section.

Category	Classification				
Buns	normal, griddle cake, with sesame, muffin, special, double-buns				
	shrimp potion, sausage, chicken, chicken crisp, teriyaki-chicken,				
Patty	teriyaki-pork, beef, fish potion, bacon, loin cutlet, ground meat,				
	double-patty				
Sauce	BBQ, ketchup, BK sauce, Big Mac sauce, aurora sauce, mustard,				
	cutlet sauce, creamy sauce, tartar sauce, cheese sauce, teriyaki sauce,				
	mayonnaise sauce, meat sauce, Japanese style sauce				
Topping	onion, tomato, lettuce, cabbage, jalapeno pepper, avocado, mayon-				
	naise, onion ring, cheese, hash browns, pickles, bacon, egg				
Topping is sliced	Yes, No				

TABLE 1. Category and classification of each hamburger component

The background of each hamburger's picture was trimmed, and the red (R) and green (G) colors of all hamburgers, excluding these backgrounds, were calculated. For the calculation, we considered the HSV color space. First, as a preprocessing step, to avoid the detection of white and dark colors, we referred to the precedent [16] and targeted pixels with saturations greater than 45 and values greater than 32. To avoid the detection of

white and dark colors, as a preprocessing step, we focused on pixels with saturations greater than 45 and values greater than 32. Pixels with large values between 0 and 30 and between 150 and 180 are considered red. Similarly, pixels with large values between 30 and 85 are considered green. For each hamburger, we calculated the percentage of red and green pixels out of the total number of pixels in the preprocessed hamburger image.

We assumed that R (tomato or ketchup color), G (lettuce), and "other than R and G" (buns) influence the perception of people. Therefore, we define the "ELSE" color rate (i.e., except R and G rate) by

$$(ELSE rate) = 100.0 - (R rate) - (G rate)$$

For the hamburger's color, we adopted the R, G, and ELSE rates for the analysis because, as mentioned above, the R, G, and ELSE rates indicate the rates of red vegetables (tomato or ketchup), green vegetables (lettuce or cabbage), and other components, except for red and green vegetables (buns or patties), respectively.

2.2. Analysis method. We used decision trees to investigate and analyze the relationship between the objective and explanatory variables. This is because decision trees are suitable methods for analyzing the relationship between the components of foods, which are explanatory variables, and the person's feeling, which is an objective variable. These relationships can be visualized. Decision trees are versatile machineearning algorithms that can perform classification and regression tasks. They are conventionally believed to be very powerful algorithms that can fit complex datasets. Additionally, decision trees are fundamental components of random forests, which are among the most potent machine learning algorithms available today [17]. There have been several studies on decision trees. Tso and Yau considered the conventional regression analysis, decision tree, and neural network to predict electricity energy consumption [18]. Azar and El-Metwally developed decision support systems based on decision tree classifiers, which are essential in medical decision-making [19]. There are other previous studies that focus on analyzing social problems [20,21]. However, as far as our survey, few previous studies applied decision trees to a person's feeling [21]. Additionally, applying a decision tree to analyzing food emotional perception has not been considered. Therefore, in this study, we applied the decision tree to the objective and explanatory variables described above. The rules that explain the objective variables were determined using the explanatory variables. To construct the decision tree, we adopted the CART (Classification and Regression Tree) algorithm. The maximum depth of the decision tree was set to 10 provisionally. Generally, the depth of the decision tree is determined by tuning complexity parameters to simplify the decision tree. However, we think that the detailed structure of the hamburger is important and visual. Therefore, we did not choose the depth of the decision tree by tuning complexity parameters. Furthermore, we used R version 4.0.3 to analyze the acquired data. To prepare the data for analysis, we define the following parameters.

Here, $Y_{i_{d}}^{(j)}$ (i = 1, ..., 50; j = 1, ..., 66) represents the score of deliciousness that the *i*th participant assigns to the *j*th hamburger, and vector $\boldsymbol{y}_{d} = \left(y_{1_{d}}^{(1)}, y_{1_{d}}^{(2)}, ..., y_{i_{d}}^{(j)}, ..., y_{50_{d}}^{(66)}\right)^{\mathrm{T}}$ is defined. Therefore, \boldsymbol{y}_{d} is a 3300 × 1 vector. Similarly, $y_{i_{g}}^{(j)}$ (i = 1, ..., 50; j = 1, ..., 66) and $y_{i_{h}}^{(j)}$ (i = 1, ..., 50; j = 1, ..., 66) are the scores of gorgeousness and healthiness that the *i*th participant assigns to the *j*th hamburger, respectively, and vector $\boldsymbol{y}_{g} = \left(y_{1_{g}}^{(1)}, y_{1_{g}}^{(2)}, ..., y_{i_{g}}^{(j)}, ..., y_{50_{g}}^{(66)}\right)^{\mathrm{T}}$ and $\boldsymbol{y}_{h} = \left(y_{1_{h}}^{(1)}, y_{1_{h}}^{(2)}, ..., y_{i_{h}}^{(j)}, ..., y_{50_{h}}^{(66)}\right)^{\mathrm{T}}$ are defined.

Next, x_k (k = 1, ..., 46) is defined as a flag indicating the materials that were used. Here, $x_k^{(j)} = 1$ if the food components are used in the *j*th hamburger. The meanings of $x_k^{(j)}$ are presented in Table 2. For example, the food components of the 1st hamburger were labeled as follows: "buns: normal, patty: beef, sauce: ketchup and mustard, topping: pickles". Therefore, $x_1^{(1)}$, $x_4^{(1)}$, $x_{20}^{(1)}$, $x_{24}^{(1)}$, and $x_{43}^{(1)}$ were set to 1, and the other parameters were set to 0. As another example, the food components of the 10th hamburger were

TABLE 2. Definition of $x_k^{(j)}$. Here, $x_1^{(j)}$ represents "the flag indicating whether normal buns are used in the *j*th hamburger or not".

Buns	$x_1^{(j)}$	normal	Sauce	$x_{19}^{(j)}$	BBQ
	$x_2^{(j)}$	griddle cake		$x_{20}^{(j)}$	ketchup
	$x_3^{(j)}$	with sesame		$x_{21}^{(j)}$	BK sauce
	$x_4^{(j)}$	muffin		$x_{22}^{(j)}$	Big Mac sauce
	$x_5^{(j)}$	special		$x_{23}^{(j)}$	aurora sauce
	$x_6^{(j)}$	double-buns		$x_{24}^{(j)}$	mustard
Patty	$x_{7}^{(j)}$	shrimp potion		$x_{25}^{(j)}$	cutlet sauce
	$x_8^{(j)}$	sausage		$x_{26}^{(j)}$	creamy sauce
	$x_9^{(j)}$	chicken		$x_{27}^{(j)}$	tartar sauce
	$x_{10}^{(j)}$	chicken crisp		$x_{28}^{(j)}$	cheese sauce
	$x_{11}^{(j)}$	teriyaki-chicken		$x_{29}^{(j)}$	teriyaki sauce
	$x_{12}^{(j)}$	teriyaki-pork		$x_{30}^{(j)}$	mayonnaise sauce
	$x_{13}^{(j)}$	beef		$x_{31}^{(j)}$	meat sauce
	$x_{14}^{(j)}$	fish potion		$x_{32}^{(j)}$	Japanese style sauce
	$x_{15}^{(j)}$	bacon		$x_{33}^{(j)}$	onion
	$x_{16}^{(j)}$	loin cutlet		$x_{34}^{(j)}$	tomato
	$x_{17}^{(j)}$	ground meat		$x_{35}^{(j)}$	lettuce
	$x_{18}^{(j)}$	double-patty		$x_{36}^{(j)}$	cabbage
		Topping	$x_{37}^{(j)}$	jalapeno pepper	
			$x_{38}^{(j)}$	avocado	
			$x_{39}^{(j)}$	mayonnaise	
			$x_{40}^{(j)}$	onion ring	
			$x_{41}^{(j)}$	cheese	
			$x_{42}^{(j)}$	hash browns	
			$x_{43}^{(j)}$	pickles	
			$x_{44}^{(j)}$	bacon	
			$x_{45}^{(j)}$	egg	
				$x_{46}^{(j)}$	onion/lettuce/cabbage is sliced

labeled as follows: "buns: double-buns with sesame, patty: double beef patty, sauce: Big Mac sauce, topping: sliced lettuce and cheese". Therefore, $x_3^{(10)}$, $x_6^{(10)}$, $x_{13}^{(10)}$, $x_{18}^{(10)}$, $x_{22}^{(10)}$, $x_{35}^{(10)}$, $x_{41}^{(10)}$ and $x_{46}^{(10)}$ were set to 1, and the other parameters were set to 0. We define the matrix **A** consisting of parameter x as follows:

$$\mathbf{A} = \begin{bmatrix} x_1^{(1)} & x_2^{(1)} & \cdots & x_{46}^{(1)} \\ \vdots & \vdots & \vdots & \vdots \\ x_1^{(66)} & x_2^{(66)} & \cdots & x_{46}^{(66)} \\ x_1^{(1)} & x_2^{(1)} & \cdots & x_{46}^{(1)} \\ \vdots & \vdots & \vdots & \vdots \\ x_1^{(66)} & x_2^{(66)} & \cdots & x_{46}^{(66)} \end{bmatrix}$$

Here, column k of matrix **A** consists of the repeated 66 times (i.e., the number of participants) of the vector $(x_k^{(1)}, x_k^{(2)}, \ldots, x_k^{(66)})^{\mathrm{T}}$. Therefore, the dimension of the matrix **A** is $3300 (= 66 \times 50) \times 46$. We considered y_d , y_g , and y_h , and x as objective and explanatory variables, respectively. For the decision trees, 80% of data from all hamburgers, BK, Mc, and Mos were used as training data, and the remaining 20% were used as test data.

3. Results.

3.1. Decision tree of all hamburgers. Figure 1 shows the decision tree of all hamburgers. The decision tree for the feeling of deliciousness for all hamburgers is shown in Figure 1(a). As shown in Figure 1(a), the participants do not feel that the hamburger is delicious if the color besides red (e.g., tomato or ketchup) and green (e.g., lettuce and cabbage) is too much. It means that the hamburger consists of many buns and patties, with fewer red and green vegetables. Conversely, the participants feel that the hamburger is more delicious if the hamburger contains moderate amounts of (over 56.504% of the total area) red and green vegetables. It means that the participants may feel that the hamburger is delicious if the hamburger contains more than 45% (i.e., 100% - 56.504%) of red and green vegetables in all areas.

Figure 1(b) shows the decision tree for the feeling of gorgeousness for all hamburgers. As shown in Figure 1(b), initially, the participants feel that the hamburger is gorgeous if the buns are with sesame. Next, we consider a hamburger without sesame buns. If the "ELSE" rate is more than 59.249% (i.e., the hamburger contains many buns and patties, and contains green and/or R approximately less than 40%), many participants feel that the hamburger is not gorgeous. For the hamburger with an "ELSE" rate of less than 59.249%, the feeling of gorgeousness depends on whether the green color is more than 0.394% or not. If the green color is more than 0.394%, gorgeousness of the hamburger or not. Conversely, if the green color is less than 0.394%, gorgeousness of the hamburger depends on whether the patty of the hamburger is not double, the gorgeousness depends on whether cheese is used in the hamburger or not.

Figure 1(c) shows the decision tree for the feeling of healthiness for all hamburgers. As shown in Figure 1(c), if the rate of the green color is less than 1.654%, the participants feel that the hamburger is unhealthy. They feel that the hamburgers are healthier if the tomato is used in the hamburgers. In contrast, the participants feel that the hamburgers are healthier if the rate of the green color is more than 10.827%. Additionally, the



FIGURE 1. Decision tree for all hamburgers: (a) Deliciousness, (b) gorgeousness, and (c) healthiness



FIGURE 2. Decision tree for BK hamburgers: (a) Deliciousness, (b) gorgeousness, and (c) healthiness

participants feel that the hamburgers are healthier if sliced onion, lettuce, or cabbage is used in the hamburger.

3.2. Decision tree of BK. Figure 2 shows the decision tree for BK hamburgers. The decision tree for the feeling of deliciousness for BK hamburgers is shown in Figure 2(a). As shown in Figure 2(a), the decision tree of deliciousness for BK hamburgers is relatively simple. If the BK hamburger uses bacon as a topping, the participants feel the BK hamburger is delicious. However, if the BK hamburger uses a topping besides bacon, participants feel it is less delicious. The deliciousness is the most significant difference between all hamburger brands in this study.

Figure 2(b) shows the decision tree for the feeling of gorgeousness for BK hamburger. As shown in Figure 2(b), on average, the score is highest if onions and pickles are used for the topping, and the rate of color different from green and red is less than 33.493%. Conversely, the score is the lowest if onions are not used for topping, and the sauce is other than a BBQ sauce. The score tendency when onions and pickles are used for topping and the rate of color different from green and red is less than 33.493% is slightly similar to when onions are not used for topping, and BBQ sauce and double-patty are used in the hamburger.

Figure 2(c) shows the decision tree for the feeling of healthiness for BK hamburgers. As shown in Figure 2(c), the participants do not feel that the hamburger is healthy if lettuces are not used in the hamburger. Additionally, even if lettuces are used, the participants do not feel that the hamburger is healthy without tomatoes. In contrast, if the lettuce and tomato are used in the hamburger, the participants feel the hamburger is healthy if the rate of the red color is less than 56.771%.

3.3. Decision tree of Mc. Figure 3 shows the decision tree for Mc hamburgers. The decision tree of the feeling of deliciousness for Mc hamburgers is shown in Figure 3(a). As shown in Figure 3(a), many participants feel that the hamburger is delicious if lettuces are used in the hamburgers. Even if lettuces are not used, they feel that the hamburger is delicious if double patties are used in the hamburger, and buns of the hamburger are normal. However, the participants do not feel that the hamburger is delicious without lettuces, double patties, and cheeses.

Figure 3(b) shows the decision tree for the gorgeous feeling of Mc hamburgers. As shown in Figure 3(b), on average, participants feel the hamburgers are gorgeous when lettuces are used in the hamburger. In contrast, they do not feel the hamburgers are gorgeous if lettuces, double patties, and cheeses are not used in the hamburger. Even if lettuces are not used in the hamburgers, they feel gorgeous if the hamburgers are with double-patty.

Figure 3(c) shows the decision tree of the feeling of healthiness for Mc hamburgers. This decision tree is relatively simple. If the rate of G, i.e., green vegetable, is more than 0.19%, participants feel that the hamburger is healthier. This decision tree structure is quite intuitive and simple.

3.4. Decision tree of Mos. Figure 4 shows the decision tree for Mos hamburgers. The decision tree for the feeling of deliciousness for Mos hamburgers is shown in Figure 4(a). As shown in Figure 4(a), if the ELSE rate is less than 59.249%, participants feel the hamburgers are delicious. If the ELSE rate is more than 59.249%, and the mustard is not used, the tendency that participants feel that the hamburger is delicious is similar to when the ELSE rate is less than 59.249%. However, the score decreases if the ELSE rate is more than 59.249%, and the mustard is used.



FIGURE 3. Decision tree of Mc hamburgers: (a) Deliciousness, (b) gorgeousness, and (c) healthiness



FIGURE 4. Decision tree of Mos hamburgers: (a) Deliciousness, (b) gorgeousness, and (c) healthiness

Figure 4(b) shows the decision tree of the gorgeous feeling for Mos hamburgers. As shown in Figure 4(b), the participants feel the hamburger is the most gorgeous if the ELSE rate is less than 55.353%. The tendency of the gorgeousness score when the ELSE rate is less than 59.249% and mustard is used for the patty of the hamburger is the same as when the ELSE rate is less than 55.353%. The ELSE rate is more than 59.249%, and chicken is not used for the patty when most participants feel the hamburger is not gorgeous if red and green vegetables are used less than about 40%, and the patty is different from chicken.

Figure 4(c) shows the decision tree for the feeling of healthiness for Mos hamburgers. This decision tree appears to be relatively simple. If the rate of G is more than 11.87%, many participants feel the hamburger is healthy. Additionally, if the rate of R is more than 22.237%, more participants feel the hamburger is healthy. However, if the rate of G is less than 5.097%, and meat sauce is not used to the hamburger, many participants feel the hamburger is unhealthy.

4. Discussion.

4.1. The trends for hamburger brands. First, we consider the trends for all hamburger brands. Note that this study is limited to three hamburger brands; therefore, this consideration may not appear to be generalizable. The point is that this study focuses on the effectiveness of the methodology.

For hamburgers as a whole, it seems that the deliciousness and gorgeousness of hamburgers are defined primarily by whether the color of the hamburger is different from green and red. Additionally, the gorgeousness of a hamburger is defined by whether sesame seeds are used in the hamburger bun or not. It means that the deliciousness and glamour of a hamburger are defined by whether it contains green or red vegetables, such as lettuce or tomato. Ingredients, such as mustard, double patties, and cheese, seem to affect the gorgeousness. In terms of health, the percentage of lettuce and other greens and the presence of tomatoes are essential factors. Additionally, the slices of onion, lettuce, and cabbage affect the healthiness of the dish. Sliced vegetables appear to have a larger volume; thus, the presence of sliced onion, lettuce, and cabbage may make them appear healthier.

Next, we discuss the characteristics of each hamburger brand. For BK hamburger (Figure 2(a)), it is mainly the presence of bacon that determines the perception of deliciousness. BK is said to have been flame-grilled since its inception and uses real fire to serve beef patties [23]. Therefore, BK is thought to be particular about its meat, and the results in Figure 2(a) may represent this. For the gorgeousness, the onion plays an essential role in determining the gorgeousness (Figure 2(b)). This could also be said to be a characteristic of BK's hamburger. For Mc and Mos, the color of the hamburger, including green vegetables, plays an essential role in making it gorgeous. However, for BK, the percentage of green is related to the second node in the decision tree of BK. Since BK is particular about beef patties [23], it is interesting to note the influence of green vegetables instead of meat on the gorgeousness of BK. For healthiness, the BK hamburgers are unhealthy if too much red color is used. Therefore, for the BK hamburgers, it is true that the green and red vegetable defines healthiness.

For Mc, Figures 3(a) and 3(b) show that people do not find Mc's burgers delicious and gorgeous if lettuces are not used. For deliciousness, the score tends to be higher when lettuce and bacon are used in the ingredients or when double patties are used for the

patties, even if lettuce is not used. Therefore, people seem to find Mc hamburgers with lots of meat to be delicious. Additionally, people tend to find it more delicious if the bun is not normal, and the patties are doubled without lettuces. It means that the patties, vegetables, and buns determine the taste of the hamburger. For gorgeousness, it seems that part of the tree structure is similar to that of deliciousness, and people tend to find a hamburger tastier if lettuce is used or if the patties are double. Finally, for healthiness, the structure is very simple. If a lot of green vegetables are used, people tend to feel that it is healthy.

For Mos, Figures 4(a) and 4(b) show that if the percentage of ELSE is low, i.e., the hamburgers are perceived as delicious and gorgeousness if a lot of green and red vegetables are used. Therefore, the volume of green and red vegetables determines the deliciousness and gorgeousness of the Mos hamburgers. This tendency is related to healthiness. The feeling about the Mos hamburgers depends on the volume of red and green color. It suggests that ingredients and toppings have a slight effect on the sensation. It is said that Mos has many hamburgers used as vegetables [24]. The results shown in Figure 4 may confirm this.

4.2. Adequacy of the decision tree. For verifying adequacy of the decision tree model, the accuracy rate of the result of estimation by the decision tree model of each hamburger brand and actual value for deliciousness, gorgeousness, and healthiness are evaluated. The 20% test data were used to verify the adequacy. The result is shown in Table 3.

	All	Mc	BK	Mos
Deliciousness	0.403	0.344	0.370	0.405
Gorgeousness	0.438	0.452	0.400	0.471
Healthiness	0.506	0.556	0.490	0.443

TABLE 3. Adequacy of the decision tree

As shown in Table 3, the accuracy is between 0.344 and 0.556. Therefore, the decision tree represents (at most) only 50% of the explanatory power for the deliciousness, gorgeousness, and healthiness of the original hamburger. For the feeling about the deliciousness, gorgeousness, and healthiness of the hamburger, the decision tree of healthiness seems to have relatively high accuracy. This is because the feeling about healthiness mainly depends on the color of the hamburger, and people are instructed that "green and red vegetable is healthy". Therefore, the structure of the decision tree tends to be simple, and the adequacy of healthiness is relatively high value.

However, the accuracy of the decision trees for deliciousness and gorgeousness was low. This may be because sensations related to deliciousness and taste cannot be simply explained by the contents examined in this paper, such as the types of buns and toppings and the color of the hamburger. The decision tree is also of insufficient structure because there were not enough explanatory variables. The small number of participants may be due to the low accuracy. However, the result of decision tree is adequate because this is approximately related to our sensitivity, and the method introduced in this paper, decision tree based on sensory evaluation, seems to be efficient to explain how person feels the deliciousness, gorgeousness, and healthiness to the hamburgers.

5. **Conclusion.** In this study, we proposed a method to verify and visualize how people feel about a hamburger based on a decision tree. We elucidated the characteristics of three different hamburger chains and the factors that make people consider the hamburger to be delicious, gorgeous, and healthy from the perspective of the hamburger components. We

believe that the proposed method can be applied in marketing to developing a strategy for preparing hamburgers that appeal to the senses and perception of the consumer. However, our analysis is limited to three hamburger chains. Therefore, to apply this method to other hamburger chains, we need to generalize this approach. Additionally, we consider more proper explanatory variables and construct a decision tree based on these more proper explanatory variables. We also must perform a sensory evaluation on more people, especially women, and it is desirable to find gender differences in perception. These issues will be addressed in future studies.

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