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FULL PAPER

Sensory profiling of tempe functional drink powder using rate-all-that-apply method

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Abstract

Tempe is an Indonesian traditional fermented food that is made from soybean. Tempe has a high potential to be developed as a functional drink product due to its physiological functions for health. The development of tempe-based products such as tempe drink powder is commonly related to its sensory evaluation aspects. Therefore, the purpose of this study was to achieve the most preferred formulation for tempe drink by consumers and to identify the sensory attributes using the rate-all-that-apply (RATA) method. The RATA test was performed correspondingly with the hedonic rating test to achieve the sensory profile as well as the consumer preferences level of the product. The tests were conducted by involving fifty semi-trained panelists, then the data were analyzed using one -way ANOVA, Principal Component Analysis (PCA), Pearson correlation and spider web methods. There were four formulas (F1, F2, F3, F4) for the tempe drinks tested with various compositions of tempe flour, maltodextrin, guar gum, sugar and flavour. The formula tested and chosen had overall scores of like slightly (5.58), colour (5.40), aroma (5.62), taste (5.44) and mouthfeel (5.16). Based on the PCA biplot chart, there was a correlation between the sample formula with sensory attributes of 94.52% with data variation which consisted of 31.19% (F1) and 63.33 (F2). The result of the analysis showed that each formula had unique sensory formula due to each formula being mapped in different quadrants. The dominant attributes which were found in the tempe drink powder were vanilla, milky, umami, bitter aftertaste and particles. The most preferred formula by the panelists was F1 which had dominant attributes of milky and vanilla.

1. Introduction

Currently, tempe is well-known as one of the world's superior functional foods due to its nutrition and non-nutritive compounds in the form of bioactive compounds that contribute to various health benefits. Various diversification methods have been done to increase the added value of tempe, so alternative processed products can be produced which helps to extend the shelf-life of tempe, add more product variation, as well as to obtain better nutrition benefits (Puteri *et al*., 2018). One of the ways is to process tempe into powdered tempe drink products. The modification of tempe into a powdered tempe drink is one form of innovation to provide alternative ways of consuming tempe, increase the shelf-life, and maintain the nutrition and health benefits (Astawan *et al*., 2016). Tempe drink powder is processed food that is made from tempe as the main ingredient and food additives which are formulated into its powdered form and need to be mixed with water before consumption. The development of this drink product is an approach to fulfill the protein intake as a functional drink claim, which is 25 g of soybean protein per day (Harland and Haffner, 2008).

There are various studies on the health benefits of consuming tempe drinks regularly. The consumption of tempe drink 3 glasses per day for 4 weeks in a row showed evidence of significantly lower levels of blood LDL in hypercholesterolemia subjects (Wirawanti *et al*., 2017), lower blood pressure in hypertension subjects (Ansarullah *et al*., 2017), lower blood glucose in diabetes patients (Yoshari *et al*., 2019; Astawan, Rahmawati, Cahyani *et al*., 2020) and can also prevent osteoporosis (Astawan, Wresdiyati, Subarna *et al*., 2020; Wresdiyati *et al*., 2021).

In product development, one of the aspects which play an important role in sensory evaluation. The sensory evaluation technique is to obtain a detailed and

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comprehensive product sensory profile. The consumer panelists are able to explain the attributes that they taste in a product with more familiar terms so the results would be product characteristics with familiar attributes. Consumer-based sensory evaluation methods continuously developed along with the ever-increased demand to reduce time and cost for descriptive tests with trained panelists, such as the quantitative descriptive analysis (QDA) (Cortés-Diéguez *et al*., 2020). Several consumer-based sensory evaluation methods can be utilized, such as flash profiling (ranking-based sensory profile determination), free-choice profiling (free sensory profile determination), projective mapping, sorting and check-all-that-apply (CATA) (Dehlholm *et al*., 2012; Santos *et al*., 2013; Dos Santos *et al*., 2015; Liu *et al*., 2018).

Rate-all-that-apply (RATA) is a modified and developed method from the CATA method. RATA method is able to collect information regarding product sensory characteristics based on consumer perception by assessing the intensity score on the intended sensory attributes. RATA method can result in intensity score from certain product sensory attributes which cannot be obtained using CATA method, receiving direct feedback from consumers and do not have to train panelists since the test use consumer panelists (Lawless and Heymann, 2013; Ares *et al*., 2014; Kemp *et al*., 2018). RATA testing is commonly conducted simultaneously with rating hedonic tests to see the consumer's preferences level for a certain product (Traill *et al*., 2019; Xu *et al*., 2020; Souza Gonzaga *et al*., 2021). The sensory test for powdered tempe drink products has never been done previously.

This became the basis of this study, which is to evaluate the sensory profile of tempe drink powder products using consumer-based approach to identify the attributes which determine the consumers liking using the RATA method and determine the consumer's preference level for powder tempe drink product.

2. Materials and methods

2.1 Production of tempe flour

The main ingredient used in this study was fresh tempe made from soybean obtained from Rumah Tempe Indonesia (RTI), located in Cilendek, Bogor. To prepare the tempe flour, the tempe was cut into smaller pieces using a hand chopper, and then blanched with hot steam (100°C) for 10 mins. Next, the tempe was dried using fluidized bed dryer at 43±2°C for 4 hrs. The tempe was dried-milled using disc mill and sieved using 100-mesh sieve.

2.2 Production of tempe drink powder

Additional ingredients such as sugar, maltodextrin, guar gum and flavoring were mixed using a mixer. Then, the mixture was added with tempe flour gradually until all components were mixed homogeneously. There were four formulas used in this study: F1 which consisted of 70% tempe flour, 18.23% maltodextrin and 1.77% guar gum; F2 which consisted of 70% tempe flour and 20% maltodextrin; F3 which consisted of 78.13% tempe flour, 10% maltodextrin and 1.87% guar gum; and F4 formula which is the tempe drink formula that has been patented by Astawan *et al*. (2019). In each formula, low-calorie sugar and vanilla identical flavor were added to the mixture, with respective amount of 10% and 0.3%. Then, the tempe drink powder products were packed in tightly-sealed sachet packaging.

2.3 Preparation of tempe drink powder samples

The sample preparation was started by diluting the tempe drink powder into drinking water. The serving size was 20 g of tempe drink powder mixed into 150 mL of water. For the sensory test, a sample volume of 40 mL of the product was served in a 50 mL plastic glass.

2.4 Sensory evaluation of tempe drink powder

The sensory tests were performed in three stages, starting with the panelists selection, followed by focus group discussion (FGD) and hedonic rating test or RATA. The selection of panelists was performed by distributing questionnaires to 100 consumers, in general, to search panelists with the criteria of having consumed soy-based products previously and do not have allergy reactions to soy products and their derivatives. The FGD involved 10 semi-trained panelists to determine the attribute terms which are commonly used by consumers for the RATA test. The hedonic rating test was done on colour, aroma, taste, mouthfeel and overall acceptance attributes. The scales for the hedonic rating test were 7 rating scales from 1 (extremely dislike) to 7 (highly like). The RATA test was performed on 10 attributes which were the result of FGD with a rating scale from 1 (very weak) to 5 (very strong). The test involved 50 semi-trained panelists.

2.5 Data analysis

The hedonic rating test data were analyzed using the SPSS application to determine the differences in data on each formula. The RATA test data was processed using ANOVA, Principal Component Analysis (PCA), Pearson correlation and spider web using XLSTAT 2021 application.

3. Results and discussion

3.1 Panelist profile

The panelist profile in this study can be seen in Figure 1. There were 100 general consumers who participated in the selection process to select fifty panelists for further study. The total consumer panelists to fulfill the requirements for reducing sensory test bias ranges from minimum 50 to 100 panelists (Purchas, 2014). The age of panelists in this study were ranging from 15 – 35 years old, with education level from high school to postgraduate and the gender ratio of the panelists was 61% female and 39% male. From the survey, it is implied that the majority of consumers (46.3%) rarely consume soy-based beverage products or other similar products.

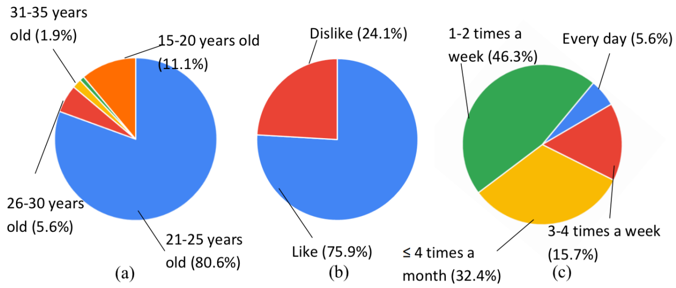
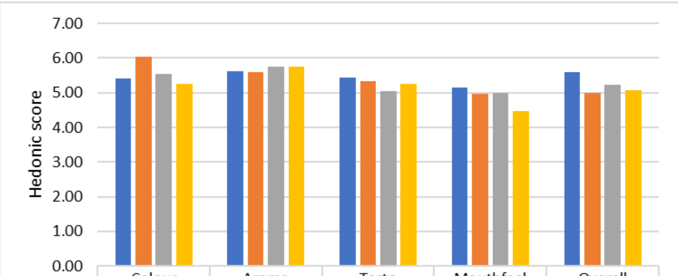


Figure 1. Consumer profile based on (a) age of the panelist (b) preferences in soy products (c) soy product consumption frequency.

3.2 Hedonic rating test

The hedonic rating test was performed to determine the preferences level of panelists on tempe drink powder, with the tested attributes such as colour, aroma, taste, mouthfeel and overall. Therefore, the most liked formula could be obtained. The scale used for this test ranged from 1 (dislike extremely) to 7 (like extremely). The hedonic rating test analysis result is shown in Figure 2.



	Colour	Aroma	Taste	Mouthfeel	Overall
F1	5.40	5.62	5.44	5.16	5.58
F2	6.04	5.58	5.34	4.96	5.00
F3	5.54	5.74	5.04	5.00	5.22
FP	5.24	5.74	5.24	4.46	5.06

Figure 2. Result of hedonic rating test on tempe drink powder product.

Based on the result of the sensory test, all four formulas had significant differences ($p < 0.05$) in colour, mouthfeel and overall sensory attributes, but no significant differences were found in aroma and taste attributes ($p > 0.05$). F1 was the selected formula because it was preferred by the panelists due to the highest overall score, which was 5.58 (like slightly to like). F1 was not significantly different from F3, but it was significantly different from F2 and F4. All tempe drink powder formulas (F1, F2, F3) were better compared with F4 (patented formula). This shows that the newest tempe drink powder formula has improved sensory characteristics compared with the patented formula (F4).

In colour attribute, F2 had the highest score (6.04) and was significantly different from other formulas. The significant difference found in F2 was due to the highest maltodextrin content in the formula. Maltodextrin is considered to increase the whiteness intensity and brightness value of a product (Mishra *et al.*, 2014).

In the mouthfeel attribute, F1 and F3 had the highest scores and were significantly different from F4. The addition of guar gum stabilizer in F1 and F3 was able to increase the smoothness of the drink due to the ability of the stabilizer in improving the drink consistency (Liu *et al.*, 2020). In addition to stabilising the dispersed system, maltodextrin is also considered to improve the smoothness level of a product, so it can reduce the gritty sensation of the tempe flour (Divya *et al.*, 2012; Jafari *et al.*, 2021).

3.3 Rate-all-that-apply test

The Rate-all-that-apply (RATA) test was conducted with the objective to determine the sensory attributes of tempe drink powder. Panelists were asked to taste the samples and evaluate the attributes in the questionnaires. The intensity scales were 5-scale from the lowest (1) to the highest (5). The FGD was initially conducted with ten panelists who have done multiple sensory analysis and were articulate in describing food attributes. Through FGD process, based on mutual consensus, there were 9 sensory attributes along with their descriptions (Table 1). The sensory attribute characteristics evaluated were whiteness, mushroom odour, vanilla aroma, umami, milky, nutty, bitter aftertaste, particles and body thickness. An additional attribute based on overall liking was carried out to determine the formula which has the most preferred attributes. Gunawan-Puteri *et al.* (2015) reported that sensory attributes of tempe consist of sour, umami, bitter, salty, sweet, beany, yeasty, pungent, floury and gritty. The intensity scores of the RATA test from each formula are shown in Table 2.

Sensory profiling was conducted by utilizing 50 semi-trained panelists to evaluate the intensities of each attribute. Based on 10 selected sensory attributes, F2 had the highest whiteness intensity. F1, F3 and F4 were similar in whiteness intensity, which could be explained

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Table 1. RATA test sensory attributes.

Attribute	Description
Whiteness	White colour intensity
Beany	Particular aroma found in tempe (unpleasant beany odour)
Vanilla	Vanilla aroma
Umami	Umami taste
Milky	Taste associated with the characteristics of milk
Nutty	Taste associated with the characteristics of legumes
Bitter aftertaste	Bitter taste that lingers in the mouth after being swallowed
Particles	Gritty or coarse sensation in the mouth
Body thickness	Thick or viscous sensation in the mouth
Overall liking	Liking to overall attributes

Table 2. RATA test result

Formula	Tempe drink powder sensory attributes									
	Whiteness	Mushroom odour	Vanilla	Umami	Milky	Nutty	Bitter aftertaste	Particles	Body thickness	Overall liking
F1	2.83^{a}	2.15^{a}	3.44^{a}	3.35^{ab}	3.24^{b}	2.74^{a}	2.65^{ab}	2.41^{a}	2.63^{b}	3.57^{b}
F2	3.67^{b}	2.13^{a}	3.26^{a}	3.30^{ab}	3.13^{b}	2.50^{a}	2.31^{a}	2.22^{a}	1.89^{a}	3.04^{a}
F3	2.80^{a}	1.91^{a}	3.35^{a}	2.87^{a}	3.15^{b}	2.77^{a}	3.11^{bc}	2.61^{a}	3.33^{c}	3.22^{ab}
F4	2.86^{a}	3.87^{b}	2.96^{a}	3.37^{b}	2.61^{a}	2.91^{a}	3.43^{c}	3.22^{b}	3.04^{bc}	3.06^{a}
Pr > F	<0.0001	<0.0001	0.066	0.027	0.004	0.149	0.000	0.000	<0.0001	0.024
Significant	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes

Mean values with different superscripts within the same row are statistically significantly different ($p<0.05$).

by the highest maltodextrin content in F2. There was no significant difference in the vanilla and nutty aroma intensity even though some noticeable differences in each aroma attribute were observed. Intriguingly, mushroom odour and umami taste were highest in F4, which had the highest intensity in those two attributes. F4 had the highest particles and bitter aftertaste. In contrast, F4 had the lowest milky attribute of all formulas tested. F3 had the highest body thickness intensity, in contrast, F2 had the lowest intensity. Tempe seemed to increase the mushroom odour, umami, bitter aftertaste and particle intensity, whereas guar gum seemed to increase the body thickness intensity. Overall, it could be seen that F4 had the highest intensity in most attributes compared to the other formula, although F1 had the highest overall liking intensity of all formulas tested.

The RATA test result was analyzed using spider web chart (Figure 3). Based on the spider web chart, F1 had the most similarities with F3 but did not have similarities with F2 and F4. The analysis result showed that the most dominant attributes found in tempe drink powder products were vanilla, milky, umami, bitter aftertaste and particles. The panelists were able to identify attribute differences significantly on whiteness, mushroom odour, umami, milky, bitter aftertaste, particles, body thickness, and overall liking attributes.

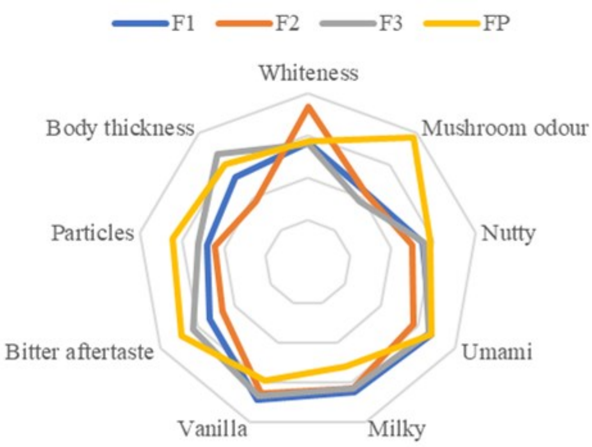

Figure 3. Spider web chart.

PCA biplot chart can illustrate the correlation between sensory attributes of each sample or formula (Ghosh and Chattopadhyay, 2012). The sensory profile of tempe drink powder is shown in biplot chart from PCA (Figure 4). It can be seen in Figure 4, the 94.52% variation of the data could be explained by the PCA, which consists of 31.19% from F1 and 63.33% from F2. Ghosh and Chattopadhyay (2012) explain that a good PCA graph is when 70% of the diversity of the data can

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explain the relationship between the product and its sensory attributes.

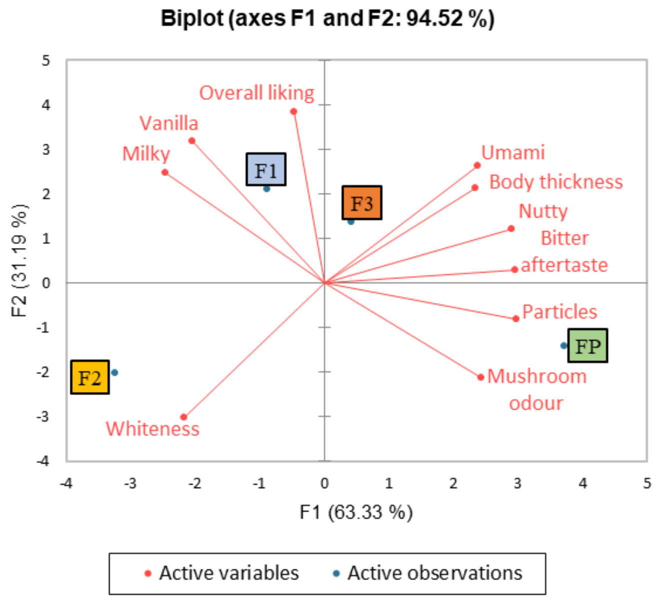

Figure 4. PCA biplot chart of tempe drink powder and its attributes

Samples that are close and mapped in different quadrants can be concluded to share similar impressions but still can be differentiated based on individual characteristics (Keenan *et al.*, 2012). The result of the analysis shows that each formula has unique sensory attribute characteristics due to each formula being mapped in different quadrants. The F3 was separated in the first quadrant from the other formula. F3 has the characteristics of body thickness, umami, nutty and bitter aftertaste. At the same time, F1 was also separated in the second quadrant from the other formula. F1 has the sensory characteristics of vanilla and milky. F1 sample also has the highest overall liking, which means it had the highest liking level. In quadrant III, F2 sample has a high whiteness characteristic. Lastly, in quadrant IV, F4 sample has sensory attributes of particles and mushroom odour.

This PCA result can determine the correlation between each sensory attribute, which can be seen in Table 3. The correlation between sensory attributes is considered as strong when the r-value is ≥ 0.75 (Kemp *et al.*, 2018). Samples that are close or positively correlated have similar descriptions, while samples that are in opposite positions or negatively correlated have different descriptions. If a specific sensory attribute experience increases in intensity while another sensory attribute also experiences the same, this will be considered as positively-correlated. On the contrary, if a specific sensory attribute experience a decrease in intensity when another sensory attribute experiences an increase in intensity, this is considered negatively correlated. In the PCA chart, the further the attribute point from the center chart point, the more attributes can be explained by the PCA biplot chart (Varela and Ares, 2014).

According to the correlation matrix obtained, milky and vanilla sensory attributes had the strongest correlation (r = 0.976). The positive correlation shows that the higher the milky taste in tempe drink powder, the higher the vanilla taste that can be perceived. The milky and vanilla were influenced by the addition of vanilla flavoring and maltodextrin which add smoothness (mouthfeel) to the drink as well as increase the intensity of vanilla attribute further (Erdem *et al.*, 2014). The unique attribute of tempe drink powder is umami, which is perceived to experience increased intensity if nutty and body thickness attributes experience increased intensity as well. Volatile compounds like trimethyl-pyrazine and 2,3-dimethyl-pyrazine are suspected to contribute to

Table 3. Pearson correlation matrix of tempe drink powder and its attributes.

Attributes	Whiteness	Mushroom odour	Vanilla	Umami	Milky	Nutty	Bitter aftertaste	Particles	Body thickness	Overall liking
Whiteness	1	-0.23	-0.03	-0.98	0.18	-0.88	-0.74	-0.57	-0.90	-0.51
Mushroom odour	-0.23	1	-0.92	0.38	-0.97	0.65	0.67	0.89	0.24	-0.42
Vanilla	-0.03	-0.92	1	-0.09	0.98	-0.45	-0.60	-0.80	-0.14	0.74
Umami	-0.98	0.38	-0.09	1	-0.30	0.93	0.77	0.65	0.84	0.48
Milky	0.18	-0.97	0.98	-0.30	1	-0.63	-0.73	-0.91	-0.30	0.59
Nutty	-0.88	0.65	-0.45	0.93	-0.63	1	0.94	0.89	0.85	0.13
Bitter aftertaste	-0.74	0.67	-0.60	0.77	-0.73	0.94	1	0.94	0.87	-0.19
Particles	-0.57	0.89	-0.80	0.65	-0.91	0.89	0.94	1	0.66	-0.31
Body thickness	-0.90	0.24	-0.14	0.84	-0.30	0.85	0.87	0.66	1	0.15
Overall liking	-0.51	-0.42	0.74	0.48	0.59	0.13	-0.19	-0.31	0.15	1

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nutty attributes (Peng *et al*., 2014; Fadel *et al*., 2018). The bitter aftertaste attribute in tempe drink powder is affected by amino acids such as proline, valine, leucine, phenylalanine and tryptophan which strongly contribute to the appearance of bitterness in tempe flour (Aluko, 2017; Rahmawati *et al*., 2021). The bitter aftertaste attribute has a positive correlation with nutty, particles and body thickness. The higher the percentage of tempe flour used in the drink formulation, the higher the bitter aftertaste, nutty, particles and body thickness attributes intensity will become.

The strongest negative correlation (r = -0.970) is shown in mushroom odour and milky or vanilla attributes. This implies that the addition of vanilla flavoring and maltodextrin is able to reduce the mushroom odour attributed intensity in tempe drink powder products. Several volatile components contribute to the appearance of mushroom odour in tempe, namely 3-octanone and 1-octen-3-ol (Mei Feng *et al*., 2007). The umami attribute is perceived to experience an intensity decline when the whiteness attribute intensity increases due to the negative correlation value (r = -0.981). The increased tempe flour concentration used in the formula is shown to increase the umami attribute as well as reduce the whiteness intensity in tempe drink powder. The umami attribute appears due to the presence of glutamic acid that is formed during the soybean fermentation process in tempe production (Gunawan-Puteri *et al*., 2015). The glutamic acid content will continue to increase as the length of soybean fermentation increases (Shiga *et al*., 2014; Zhang *et al*., 2020).

4. Conclusion

The formula of tempe drink powder with the highest overall score is F1. Based on the RATA test result, the dominant attributes found in tempe drink powder are vanilla, milky, umami, bitter aftertaste, and particles. Overall, the PCA managed to yield clear separation and grouping of each formula. Pearson correlation was conducted between each attribute and the overall liking score. It was found that two attributes, namely, milky and vanilla, were the favorable attributes indicated by the significant correlation which was only found in F1. Therefore, F1 is close to product characteristics that are preferred by consumers.

Conflict of interest

The authors declare no conflict of interest.

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