Sensory criteria assessment of fruit from *Averrhoa bilimbi* L. with comparison of Eckenrode and Fuzzy Eckenrode method

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**Abstract.** The fruit candy made of processed products made from the natural fruit of *Averrhoa bilimbi* L. whose production was abundant, recently a few to utilization. The main objective of this study was to examine the assessment of sensory criteria fruit candy from *A. bilimbi* with comparison of eckenrode and fuzzy eckenrode method. The results showed fruit candy contains a higher value of colour (0.239), wherein the aroma (0.169), taste (0.183), texture (0.211), and the overall acceptance (0.197) using the eckenrode method. On the other hand, based on the fuzzy eckenrode method were shown the value of colour (0.224), taste (0.187), aroma (0.183), texture (0.2110 and overall acceptance (0.195). Although the comparison from eckenrode and fuzzy eckenrode method appear quite stable for criterias of sensory. Finding the optimum value for an aroma in the perception of colour from fruit candy higher to eckenrode than fuzzy method. The eckenrode method provided a dynamic space in a high-level decision-making system to differ significantly. Therefore, the eckenrode method was a quite simple method to establish decisions for weighting a more definite criteria in decision making in sensory assessment to develop a natural product from *A. bilimbi*.

1. Introduction

*Averrhoa bilimbi* L. from the family Oxalidaceae was known as “belimbing wuluh”, and commonly called bilimbi [1]. *A. bilimbi* product was an underutilized fruit, however it has the potential to be processed and used as a food product [2]. It has a short shelf life after harvesting (about 4–5 days), because the fruit rapidly softens when injured [3]. It was usually used for the local dishes in food flavour, and not directly consumed on raw [4]. Processing of *A. bilimbi* into fruit candy was a better option to preserve the fruit. On the other hand, because of the extended shelf life of the fruit, the human can consume *A. bilimbi* wherever, and keep the product.

A short method to find out the respondent acceptance for the food product was to perform a sensory assessment using the opinion in the scale like or dislike [5]. The multi-criteria approximation method was weight assessment in making decisions. Therefore, this study introduces the criteria evaluation method among the eckenrode and fuzzy eckenrode method [6]. The eckenrode method was efficient and simple in determining the weighting for a decision. It was used in the degree of interest, from each of the criterias, and the sub-criteria in making decisions [7]. Therefore, it was determinate and perceived as more important which affects the total value from each selected decision. Whereas, the fuzzy eckenrode method measured the uncertainty associated with human decision to be subjective. The evaluation fuzzy theory was helped and improved when eckenrode method the failure.

Besides the decision-making method using eckenrode and fuzzy eckenrode approaches to sensory assessment systems, there are several techniques such as the elimination and choice expressing reality...
(ELECTRI), the simple additive weighting (SAW), and the analytic hierarchy process (AHP) [8-10]. However, the method was not considered to be appropriate. This study aims to develop the fruit candy from *A. bilimbi* acceptance for the respondent based on the sensory criterias (colour, aroma, taste, texture, and overall acceptance). This study also analyzed the comparison among the eckenrode and fuzzy eckenrode method.

2. Materials and method

2.1. *Averrhoa bilimbi* L. collection and processing of fruit candy

The Fresh fruit from *A. bilimbi* L. was sorted. Then, cut the point of the fruit flower. Dissolve in 800 gr of sugar for 1 kg of fruit in 500 ml of water, and wait until it boils. After that, put the fruit. The sugar water was cooked in boils, and turned off the stove. Let the fruit soak in the sugar water for 3 hours, and drain. Furthermore, the sugar water was reheated until it boiled. The fruit was soaked for 3 hours. This stage was repeated 3 times. Finally, the fruit candy was dried for 8 hours.

2.2. The sensory evaluation

The sensory assessment of *A. bilimbi* L. was included the colour, aroma, taste, texture, and overall acceptance. The characteristics of weight of respondent assessment for the criteria was analyzed based on the hedonic scale to more like or dislike which converted to the number (Table 1). Then, the selection of criteria from the total of 10 (ten) respondents were experienced in sensory evaluation. The respondents were not in state of diseases such as flu and cough to interference the sensory evaluation. To determine the criteria quality of the assessment using the eckenrode and fuzzy eckenrode method. The recommended from the best was overall acceptance from respondents.

| Number | Preferences  |
|--------|--------------|
| 1      | Most dislike |
| 2      | Dislike      |
| 3      | Ordinary     |
| 4      | Like         |
| 5      | Most like    |

2.3. The eckenrode and the fuzzy eckenrode modeling of analysis

The eckenrode method was experted opinion to perform rank for each criterion (*R*$_{1}$ to *R*$_{n}$, where n was denoted to rank, $j = 1, 2, 3, \ldots$, n; $j_{th}$ rank = *R*$_{j}$), criteria to i, indicated with *K*$_{i}$, n as a total criteria, wherein the criterias, $i = 1, 2, 3, \ldots$, n [11-12]. Then, the formula was described:

$$N_{i} = \sum_{j=1}^{r} P_{ij} \times R_{nj}, j = 1, 2, 3, \ldots, n$$

Total Value = $\sum_{i=1}^{n} N_{i}, i = 1, 2, 3, \ldots, n$

Notes:

- $R_{j}$ = The rank to j, $j = 1, 2, 3, \ldots, n$
- $K_{i}$ = Criteria Type i, $i = 1, 2, 3, \ldots, n$
- $P_{ij}$ = The number of respondents who chose the j rank, for the i criteria
- $R_{nj}$ = The multiplier-j, which is obtained from reducing the criteria or the number of ranks (n) in order of rank in the column. Therefore, it was included 5 (five) the criterias, the multiplier factor in the rank column was 3 (eg j=3) is n-j = 5-3 =2
- $B_{i}$ = The criterion of weight to i

However, the fuzzy eckenrode method weighed the calculation method. The respondents were asked to make a rating (e.g. from R1 until Rn, where n ranking, $j = 1, 2, 3, \ldots$, n, ranking $j = R_{j}$) for each
criterion (criterion i is notated with Ki, which is presented in a number of n criteria, i = 1, 2, 3,…, n). Wherein, Ni was calculated based on P_{ij} and R_{n-j}. and the formula was described [13-14]:

\[ N_i = \sum_{j=1}^{n} P_{ij} \times R_{n-j}, j = 1, 2, 3,…, n. \] \tag{3}

Total Score = \sum_{i=1}^{n} N_i, i = 1, 2, 3,…, n. \tag{4}

Notes:

R_j = The ranking-j, j = 1, 2, 3,…, n
Ki = The criterion type i, i = 1, 2, 3,…, n
P_{ij} = number of respondents who chose ranking j for criterion i
R_{n-j} = multiplier factor j, which was obtained from the reduction of number of criteria or number of ranking (which is n) with the rank order on the column. For instance, if there are five criteria, so the multiplier factor for column of 3 (three) rank (if j = 3) is n–j = 5–3 = 2
Bi = weight of criterion i

3. Result and Discussion

3.1. The comparison of criteria value from chart using eckenrode and fuzzy eckenrode method

The sensory assessment processes which include the colour, aroma, taste, texture and overall acceptance carried out the common when each of the respondents was separated and not confirmed to each other. Figure 1 shows the comparison among the eckenrode and fuzzy eckenrode method from the fruit candy product to data analyzed of A. bilimbi. The results showed that the fresh fruit had higher contents of colour, 0.239 than the texture 0.211, the aroma 0.169 based on the eckenrode method.

![Figure 1. The criteria of quality chart from A. bilimbi using eckenrode method.](image-url)
However, the fuzzy eckenrode analyzed for the colour, 0.224, the texture 0.211, the aroma 0.183, and the taste 0.187 (figure 2). The texture value of *A. bilimbi* was slightly similar to the eckenrode and the fuzzy eckenrode method. It showed 0.211. The recommended overall acceptance was higher in the eckenrode method (0.197). The differences in value variations may be due to minor differences in the formula. Based on the fuzzy eckenrode method, the overall acceptance was 0.195.

### 3.2. The comparison of alternative rank using eckenrode and fuzzy eckenrode method

The rank alternatives of criteria concern the weight in the eckenrode method in the order were the colour, texture, overall acceptance, taste and aroma [15]. Wherein, the fuzzy-eckenrode method to alternative criteria ranking concerns also the similarity order. The most common criteria of sensory used to determine the quality of any material was appearance. Its appearance includes the colour, aroma, and texture. The colour of the surface in the food was the first quality parameter which was evaluated with respondent [16]. It was found the first ranking in the eckenrode and fuzzy eckenrode method for this research. Then, it was also critical for acceptance of fruit candy products even before they entered the mouth. Besides, it was always related to the acceptability or rejection of the product.

Preserving structure in fruit candy was a major objective to the postharvest technology for plant material. Transformed structure food creation to better the purpose of product development and improvement [17]. However, the value was not stable for the criteria of sensory indicated except in the texture (figure 3). The data were evaluated by panelists using a hedonic scale. The results showed the texture had no significant impact on the scores for the analysis with the comparison method. On the other hand, a different value for aroma was observed in the comparison method in the fruit candy from *A. bilimbi* showed the greatest difference. The processing of fruit candy under dissolution condition in the water content was affected by the aroma nature [18].

|       | Colour | Texture | Aroma | Taste | Overall acceptance |
|-------|--------|---------|-------|-------|--------------------|
| Value | 0.224  | 0.211   | 0.183 | 0.187 | 0.195              |

*Figure 2. The criteria of quality chart from *A. bilimbi* using fuzzy eckenrode method.*
The texture properties measured included hardness, adhesiveness or cohesiveness, and chewiness. The adhesiveness was the negative area to the first bite, which represented the acceptable amount of fruit candy [19]. During sensory analysis, it was observed that fruit candy scored the lowest in both of the methods. The texture was the sensory and function manifestation to the structural, surface and mechanical properties in foods detected from the sight senses, touch, hearing, and kinesthetics [20–22]. These characteristics were low preferable to the respondent.

4. Conclusions
The analysis to overall acceptance to determined respondent using the eckenrode and the fuzzy eckenrode method over faster, easier, and certain. Depending on the respondent assessment from criteria of sensory sensitivity were the aroma in the perception of the colour and overall acceptance from fruit candy higher to eckenrode than fuzzy method. Based on the results of the texture, there were no significant differences between the eckenrode and the fuzzy eckenrode method. As the aroma criteria was lower from the eckenrode than the fuzzy method.

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