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## Rheological properties and sensory perception of *kue lapis* with spatial distribution of sucrose and vanilla aroma

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## Rheological properties and sensory perception of *kue lapis* with spatial distribution of sucrose and vanilla aroma

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**Abstract.** Sugar overconsumption has been related to nutrition-linked pathologies such as obesity, diabetes and other health problems. However, the presence of sugar in processed foods is needed because sugar functions as a flavor generator and can affect the sensory properties. Therefore, this study investigated the effect of the spatial distribution of sucrose and aroma on rheological properties and sensory perception of traditional food. To do so, we performed our experiments using *kue lapis*, a traditional food of Indonesia, which consist of four layers and were designed with the same total amount of sucrose and vanilla aroma but varied in their spatial distribution. Panelist (n=20) rated the intensity of salty, sweet, sour, bitter tastes as well as vanilla aroma intensity and liking for each product. The results showed that products with addition of vanilla aroma having a higher aroma intensity regardless of the location of aroma and sucrose on each layer. In addition, products with added sucrose distributed in only one layer (top layer) and heterogeneous of aroma have a higher sweetness perception ( $p < 0.05$ ).

### 1. Introduction

Research on sugar reduction has been extremely relevant due to the significant development of diseases caused by excessive sugar consumption such as diabetes and obesity. Furthermore, significantly reduced the amount of sugar in daily life has potential to reduce healthcare costs. However, sugar is related to technical functions in foods including preservation and water binding. Beyond technical consequences, sugar reduction has a major impact on multiple sensory characteristics of a food including its texture, flavour and mouthfeel [1]. Therefore, strategies are needed to ensure that sugar reduction in food products is acceptable to consumer.

Several studies have been conducted on manipulating the delivery of taste stimuli to enhance taste perception. Among others, Holm et al., (2009) and Mosca et al., (2010) explored the effects of inhomogeneous distribution of tastants to enhance taste intensity [2,3]. Results reported by the authors showed that sucrose heterogeneously distributed in gel could enhance. Similarly, Noort et al., (2010) studied the influence of inhomogeneous distribution of NaCl on saltiness intensity using bread [4]. Such an increase was observed when in inhomogeneous samples with the highest taste contrast level. It was reported that Emorine et al., (2015) [5] used multilayered products in which sodium and ham aroma were varied in their spatial distribution and a consumer panel rated the intensity of salty, sweet, sour, bitter and umami tastes as well as ham and cheese aroma for each product. The results showed that products with a higher heterogeneity of salt distribution were perceived as saltier and heterogeneous products were as well liked by consumers compared to the homogeneous products. Moreover, it is noteworthy that similar results were reported on aroma perception for heterogeneous



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distribution of volatile compounds in gels [6,7]. In addition, the use edible film for increasing sensory perception is a promising since it has function as carrier of volatile compound related to perception [8]

In addition to manipulating the delivery of taste stimuli, some authors also reported the use congruent taste-odour pairs to enhance taste intensity. Labbe et al., (2006) used two types of flavourings, which were cocoa and vanilla aroma [9]. The results reported by the authors indicated that cocoa beverage led to an enhancement of bitterness induced by the cocoa flavouring and an increase in sweetness from the vanilla flavouring. In addition, Lawrence et al., (2009) used salt-associated odour in water solution containing a low concentration of sodium chloride and found that congruency aroma could be used to enhance saltiness perception [10]. The use of congruent mixtures of aroma and taste are of great importance on consistent enhancements of perception [11]. Adding incongruent mixture of aroma and taste can either show no significant in perception from when the stimuli are individually perceived, or suppression [12].

This research was intended to enrich scientific information whether spatial distribution of sucrose and vanilla aroma (associated to sweet perception) could enhance sweet taste perception on a traditional food in Indonesia. In the present study, spatial distribution of sucrose and vanilla aroma were applied on *kue lapis*, a traditional food of Indonesia with a good taste and texture containing sugar. This traditional foods prepared with traditional methods using old recipes such as coconut milk, rice and tapioca flour.

## 2. Material and methods

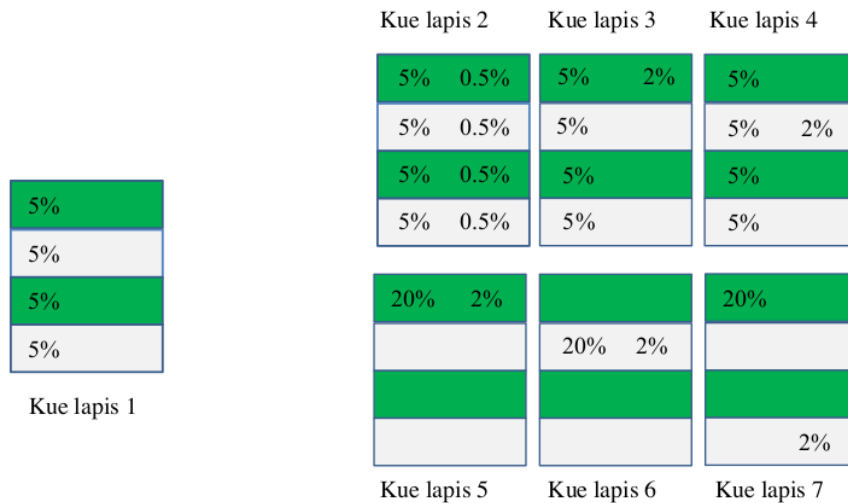
### 2.1. Materials

*Kue lapis* consisted of four layers was made of rice flour, modified cassava flour, coconut milk, vanilla aroma, mineral water and food coloring. All the ingredients were food grade and obtained from local supermarket. Sucrose purchased at local chemical store was also a food grade.

### 2.2. Methods

**2.2.1. Preparation of *kue lapis*.** *Kue lapis* were prepared according to common use procedure. Rice and tapioca flour were mixed and stirred while heating for 10 min. Then, coconut milk was added into a mixture gradually until the coconut milk was dissolved. The mixture was then divided into four parts. Sucrose and vanilla aroma was then added into each layer. Food coloring was also added to second and fourth layer. Each layer was steamed for 15 minutes until hardened.

**2.2.2. Spatial distribution of sucrose and vanilla aroma (adopted from Emorine et al., 2015) [5].** Seven *kue lapis* containing the same total amount of sucrose and vanilla aroma, 20% (w/w) and 2% (w/w), respectively were produced. The spatial distribution of sucrose and vanilla aroma on each layer was adopted from Emorine et al., 2015 (Figure 1). The products were coded according to the distribution of sucrose and vanilla aroma on each layer. *Kue lapis* 1 refers to product with distribution 5% of sucrose on each layer without vanilla aroma (unflavored products) addition. *Kue lapis* 2 refers to product with distribution 5% of sucrose and 0,5% of vanilla aroma on each layer. *Kue lapis* 3 refers to product with distribution 5% of sucrose on each layer and added 2% of vanilla aroma on top layer. *Kue lapis* 4 refers to product with distribution 5% of sucrose on each layer and added 2% of vanilla aroma on third layer. *Kue lapis* 5 refers to product with distribution 20% of sucrose and added 2% of vanilla aroma on top layer. *Kue lapis* 6 refers to product with distribution 20% of sucrose and added 2% of vanilla aroma on third layer. *Kue lapis* 7 refers to product with distribution 20% of sucrose on the top layer and added 2% of vanilla aroma on bottom layer.



**Figure 1.** Kue lapis with spatial distribution of sucrose and vanilla

### 2.3. Rheology measurements

Compression tests were carried out using a Texture Analyser (TA-Xt plus) on each product (3 replicates). The day of analysis, the samples were prepared in the same way as for sensory evaluations but they were let cooled until room temperature. Two-cycle compressions were performed at a constant speed of  $0.5 \text{ mm.s}^{-1}$ . The samples were compressed with a cylindrical probe of 36 mm until a deformation rate of 75% of the initial height was induced. After a backup at  $5 \text{ mm.s}^{-1}$ , a second cycle compression was run under the same conditions. The developed forces were measured with a load cell (5 kg).

### 2.4. Sensory evaluation

**2.4.1. Panellists.** Twenty panelists are students of food science and technology study programme. These panelists had received a brief explanation of each of the sensory attributes, which were salty, sweet, sour, bitter, aroma intensity, elasticity and liking.

**2.4.2. Sensory evaluation procedure.** Intensity evaluation of the sensory perception by the panelist was carried out by asking the panelist to eat the whole product and to rate their liking on a linear scale with the anchor point 0 to 10 (0: I do not like, 10: I like very much). During this time, panellists were asked to cleanse their mouth by rinsing their mouth with mineral water. Each panelist were served with duplicate samples in different seasons. Mineral water was provided to cleanse the palate between samples during evaluation. The samples (kue lapis), sized  $2 \times 2 \text{ cm}^2$  was put in the serving and then they were coded with three digit random numbers. The liking test was took place one week later in the same condition and in the same batch of products.

### 3. Data analysis

Statistical analysis for rheological properties and sensory analysis of seven kue lapis was performed using one-way analysis of variance (ANOVA) and Bonferonni test to determine the significant

difference among means at the level of  $p = 0.05$ . Principal Component Analysis (PCA) were performed with the PCA function of the *FactoMineR* package. R software (R version 3.6.2) (2019-12-12) were conducted for data analyses.

## 4. Results and Discussion

### 4.1. Influence of product on rheological properties

In the present study we investigated rheological properties between product (*kue lapis*) with particular concern as to whether the addition of sucrose and vanilla aroma modified the hardness and elasticity of products. Compression test were carried out on seven *kue lapis* varying addition of sucrose and vanilla aroma. One-way ANOVA was carried out on two rheological properties. The results indicated that the *kue lapis* factor significantly influenced the springiness ( $F(6;7)=6,30$ ,  $p=0,01$ ). Post-hoc tests indicated that *kue lapis* with sucrose and vanilla aroma distributed on top layer and first layer (bottom layer) (*kue lapis* 7) tended to be significant to product with only sucrose without aroma (*kue lapis* 1). These results underlined that addition sucrose on top layer affect *kue lapis*' structure particularly springiness due to microstructure of the product matrices were modified [13,14] during heating process. In the same way, one-way ANOVA was carried out on hardness with *kue lapis* as factor revealed that *kue lapis* did not influence hardness ( $F(6;7)=0,93$ ,  $p=0,53$ ).

### 4.2. Influence of product on sensory perception

The sensory data gained in the present study were analysed to figure out the effect of sucrose and vanilla aroma varying distributed on each layer of *kue lapis* on taste and texture perception. We performed a series of ANOVAs on each sensory descriptor, which were sweetness, sourness, saltiness, bitterness, vanilla aroma intensity, elasticity and liking ratings, with the products as the fixed factors. The results showed that no significant effect were observed on saltiness ( $F(6, 273)=0,28$ ,  $p=0,94$ ), sourness ( $F(6; 273)=1,60$ ,  $p=0,15$ ), bitterness ( $F(6; 273)=1,08$ ,  $p=0,37$ ), and elasticity ( $F(6; 273)=1,28$ ,  $p=0,27$ ). The vanilla aroma intensity of *kue lapis* is depicted on Figure 2. This figure clearly indicates that a significant effect of *kue lapis* ( $F(6; 273)=5,98$ ,  $p<0,0001$ ) were obtained for aroma intensity. Post-hoc tests indicated that *kue lapis* added with vanilla aroma have higher intensity than *kue lapis* without vanilla aroma addition. *Kue lapis* with sucrose and vanilla aroma distributed on each layer (*kue lapis* 2) and product with sucrose and vanilla aroma distributed on top layer (*kue lapis* 5) have higher in comparing between vanilla aroma-flavored *kue lapis*.

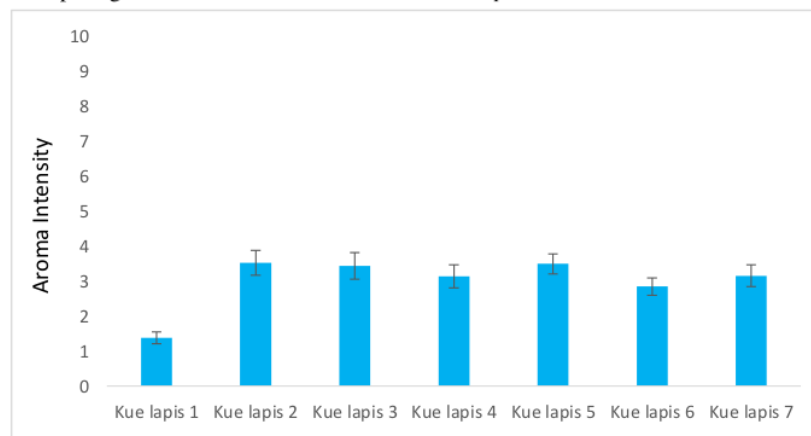


Figure 2. Aroma intensity mean score for each layer of product

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For sweetness perception, ANOVA showed a significant *kue lapis* effect ( $F(6;273)=3.77, p=0.001$ ). Post-hoc analyses revealed that *kue lapis* added with sucrose 20% and 2% vanilla aroma on the top layer (*kue lapis* 5) and sucrose 20% on top layer while 2% vanilla aroma on first layer (*kue lapis* 7) were significant more sweetness than unflavoured *kue lapis* added only sucrose (*kue lapis* 1) (Figure 3). Indeed, we observed that *kue lapis* with added sucrose distributed in only one layer (*kue lapis* 5 to *kue lapis* 7) showing a higher sweetness perception. It means that spatial distribution of sucrose was sufficient for sweetness perception. Emorine et al., 2015 revealed that saltiness enhancement was observed on food product as the salt was placed in only one layer [5]. Heterogeneity of the distribution of tastants that enhanced taste perception has been described in liquid solutions and gels [2,3]. On liking, scores ranged from 1,58 to 2,91 and a ANOVA was carried out on liking scores and revealed no significant effect of *kue lapis* ( $p>0.05$ ).

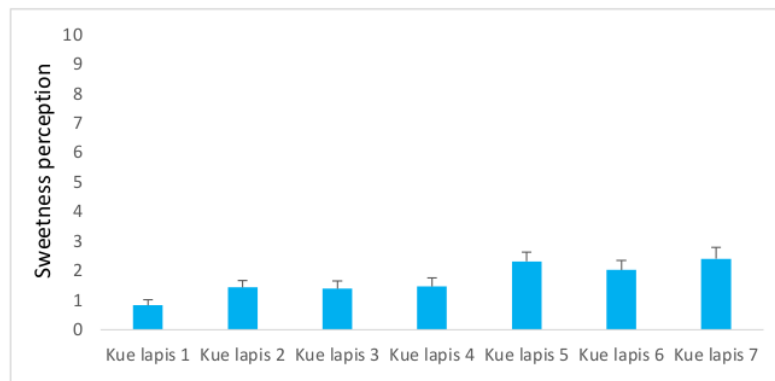


Figure 3. Sweetness perception mean scores for each layer of product

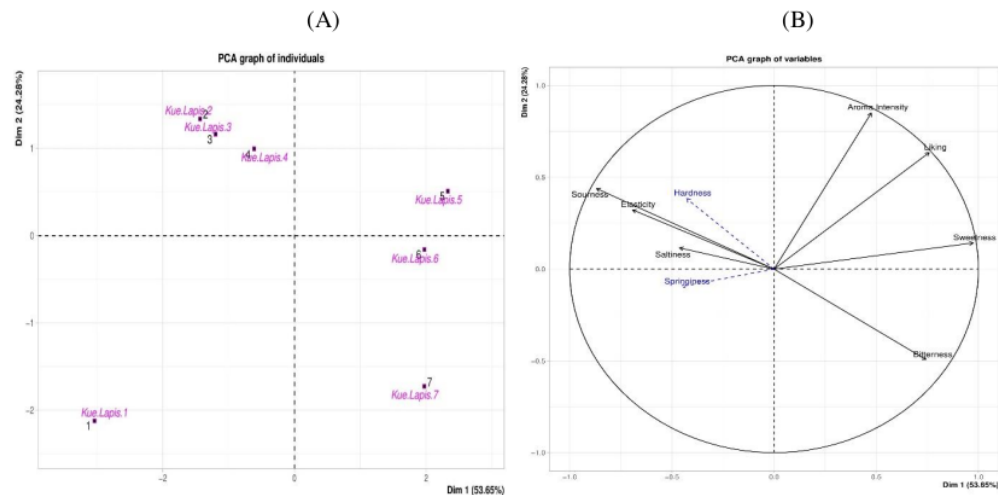


Figure 4. A biplot representation based on the two first dimensions of a PCA performed on sensory evaluation. Data obtained on the seven *kue lapis*.

In the present study, we carried out principal component analysis (PCA). The biplot illustrating the information for both products and variables is represented for two first dimensions of PCA (77.93% of total variance) are represented on Fig. 4A and B, respectively. *Kue lapis* with sucrose distributed on each layer (homogenous) presented the highest hardness, which indicated the product had the hardest and less elastic structure. Meanwhile *kue lapis* with sucrose and vanilla aroma distributed only on top layer (kue lapis 5 and kue lapis 6) were perceived more sweet and like. It could be due to heating process boosted the diffusion of sucrose and aroma to adjacent layer of *kue lapis* resulting sucrose and vanilla aroma concentrations remained significant in all the layered. Emorine et al., 2015 [5] reported that multi-layered model snack with added salt located in only one layer, particularly in an external layer can enhance saltiness enhancement. In contrast *kue lapis* that were unflavoured (kue lapis 1) located to the bottom left part of the map. However, *kue lapis* with homogeneous addition of sucrose (kue lapis 2, kue lapis 3, kue lapis 4) were linked to the perceived texture and more sourness.

## 5. Conclusion

The results showed that in *kue lapis*, which is consisted of four layer in the present study, spatial distribution of sucrose and aroma influence the sensory perception, particularly sweetness perception. Sweetness perception can be increased by distribution of sucrose on top layer while aroma on both top and bottom layer. Further studies should consider diffusion of tastant and aroma among layer and the release of volatile compound of food ingredients used in *kue lapis* manufacturing.

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