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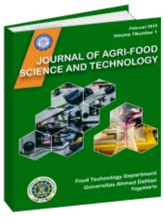

# Texture Profile Analysis of Lamtoro Gung (*Leucaena leucocephala* ssp. Glabrata (Rose) S. Zarate) Tempeh

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## ABSTRACT

*Lamtoro Gung seeds are low in fat content but rich in protein. Lamtoro Gung is often used as an alternative protein source. Lamtoro Gung is usually taken as a prepared meal containing grains and nuts. It is germinated and utilized in a variety of dishes, including* the production of tempeh. *However, nothing has been done to explain the textural profile of Lamtoro Gung tempeh, which is made by fermentation processes in various packaging materials such as plastic, banana leaves, and teak leaves. This study aims to evaluate the textural characteristics of Lamtoro Gung tempeh produced using different packaging materials and fermentation periods. This study contributes to understanding how packaging variations affect the texture of Lamtoro Gung tempeh. Tempeh made from teak leaf packaging and fermented for four days offered better texture profile hardness (195.38 N), cohesiveness (0.46), gumminess (81.57 N), and chewiness (54.99 N) higher than banana leaves; hardness (49.90 N), cohesiveness (0.29), gumminess (14.52 N), and chewiness (10.14 N) but similar to plastic; hardness (165.28 N), cohesiveness (0.45), gumminess (74.23 N), and chewiness (50.35 N). Therefore, packaging material impacts the texture profile of tempeh fermented from Lamtoro Gung seeds. Sensory evaluation of the tempeh would need to be investigated to check consumer acceptance of the product.*

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## 1. INTRODUCTION

Lamtoro Gung (*Leucaena leucocephala* ssp. Glabrata (Rose) S. Zarate) is part of the Fabaceae family. It originates from Southern Mexico and Central America but is widely cultivated in numerous regions worldwide (Devi et al., 2013). Lamtoro Gung is a plant that thrives in tropical and subtropical climates (Verma, 2016). Lamtoro Gung seeds are elliptical or oval. They are frequently consumed in Central America, Thailand, and Indonesia (Sethi &

Kulkarni, 1995). The seeds are green with a yellowish-brown kernel. Lamtoro Gung seeds have a low-fat content, typically ranging from 5.1 to 10% (Verma, 2016), while they have a high protein content. As a result, Lamtoro Gung is commonly utilized as an alternative protein source. The crude protein content of Lamtoro Gung seeds is relatively high, ranging from 31-46% (Meulen *et al*., 1979; Sethi & Kulkarni, 1995).

Lamtoro Gung has a variable amino acid composition. Lamtoro Gung primarily comprises negatively charged polar amino acids like aspartic and glutamic acids. Fresh and steaming Lamtoro Gung samples had negatively charged hydrophilic amino acids at 13.97 and 20.24 g/100 g protein, respectively (Harifah et al., 2018; Supriyadi et al., 2017). The abundance of hydrophobic and hydrophilic negatively charged amino acids in Lamtoro Gung seeds demonstrates their potential as a source of ACE-I peptide, implying that consumption of Lamtoro Gung seeds can be used as an alternative strategy for preventing hypertension, thereby reducing the risk of elevated blood. Lamtoro Gung germination has improved antihypertensive action (Fitriani et al., 2022a, 2022b).

Lamtoro Gung is typically consumed as a processed meal (Lestari et al., 2021; Magdalena et al., 2021; Winarni & Dharmawan, 2017). It is frequently utilized in various recipes, such as tempeh and sprout (Nursiwi et al., 2018; Ratnayani et al., 2019). Tempeh's flavor is influenced by the ripening (fermentation) of soybeans and other wraps, such as plastics, banana leaves, and teak leaves. Plastic packaging has advantages such as strength, lightness, rust resistance, and color options. However, it has a downside: tiny plastic molecules can migrate into packed goods, resulting in off-aromas and chemical contamination from food contact materials. Banana leaf provides natural wrapping. This product is chemical-free, easy to find and fold, and has a lovely aroma (Werdiningsih et al., 2018). Using banana leaves for wrapping tempeh has drawbacks, including a tendency to tear, lack of cleanliness, and risk of chemicals and flavors sipping into tempeh during fermentation. Teak leaves have advantages such as being chemical-free. Yet they can pose challenges by becoming irritative and tough to remove when used in their dry state (Sulistiyono et al., 2016). However, no evidence has been reported explaining Lamtoro Gung tempeh's textural profile. This tempeh is created through fermentation utilizing various packaging materials such as plastic, banana, and teak leaves. As a result, this study aims to assess the textural profile of Lamtoro Gung tempeh manufactured using various forms of packaging and fermentation timeframes. This study contributes to fresh knowledge on the impact of packaging variation during fermentation on the texture of Lamtoro Gung tempeh.

## 2. MATERIALS AND METHODS

### 2.1. Materials

This study's instruments included scales, plastic bowls, steamers, and texture analyzers (Ametek Brookfield CTX). The materials used in this research were lamtoro gung seeds obtained from Wonogiri, teak leaves (*Tectona hamiltoniana* Wall.) planted in the garden of Deresan Village, Bantul, kluthuk banana leaves (*Musa balbisiana* Colla) obtained from Bantul Market, yeast (Padi brand, Indonesia), PE plastic 6×20 cm with a thickness of 0.2 mm (Tomato Brand, Indonesia), cassava flour, and distilled water.

### 2.2. Research Methods

#### 2.2.1. Preparation of Lamtoro gung seeds

The lamtoro gung seeds are washed first, then boiled in a 1:3 seed-to-water ratio for an hour. The lamtoro gung seeds are then carefully separated from the skin and washed numerous times to ensure they are clean. Lamtoro gung seeds are then steeped in water at room temperature for 24 hours, changing the water every 8 hours. After the last soaking, the lamtoro seeds suspended in water are mixed with 25 g of coarse cassava flour and cooked for an hour.

The steamed lamtoro seeds are cooled by airing them until they reach the ambient temperature (Prameswari et al., 2021).

### 2.2.2. The process of making lamtoro gung seed tempeh

Add 1 g of yeast to the cooled lamtoro seeds and mix thoroughly. Subsequently, the yeast-treated lamtoro seeds (30 g) are wrapped in various packaging materials, such as teak leaves, banana leaves, and PE plastic. Afterward, the wrapped lamtoro seeds are fermented 24, 48, 72, and 96 hours at 25-30 °C in an incubator (Prameswari et al., 2021).

### 2.2.3. Experimental design

This research was conducted using different types of tempeh packaging. Three types of packaging are used: teak leaf packaging, banana leaf packaging, and plastic. Fermentation was carried out for four days. Each sample was repeated three times, and texture testing was carried out on each sample used.

### 2.2.4. Testing the texture of Lamtoro gung bean tempeh

Texture analysis was carried out using the Ametek Brookfield CTX texture analyzer. The texture analyzer setting can be seen in Table 1. Using the CTX software, sample post-analysis was carried out, and the following attributes were considered for all the samples: hardness, cohesiveness, adhesiveness, gumminess, chewiness, and springiness index.

Table 1. The texture analyzer setting.

| | |
|---|---|
| Test speed | 0.5 mm/s |
| Wait time | 0.5 s |
| Direction | Compression |
| Preload/stress | 1 N |
| Preload/stress speed | 300 mm/min |

### 2.2.5. Statistical analysis

All data were expressed as mean values ± standard deviation (SD) (n=3). The IBM® SPSS® statistics version 22 was used. Statistical comparison using one-way ANOVA and independent sample t-test with differences between means at the 5% ($p < 0.05$) level were considered significant.

## 3. RESULT AND DISCUSSION

The texture profile of Lamtoro gung tempeh is summarised in Table 2. Six attributes are obtained from texture analysis: hardness, cohesiveness, adhesiveness, gumminess, chewiness, and springiness index. Hardness is the maximum peak at the first pressure or first bite. The unit used is N (Indiarto et al., 2012). These results are different from research conducted by Sulistiyono et al. (2016). This research shows no significant difference (P> 0.05) between the hardness of tempeh wrapped in plastic, banana, and teak leaves at some fermentation days. Tempeh wrapped with teak leave and plastic on $4^{th}$ day of fermentation shows a significant difference.

Lamtoro gung tempeh, with the highest hardness value, was obtained from tempeh samples packaged in teak leaves for four days of fermentation (195.38 N). The texture of tempeh is caused by the yeast mycelia that connect the lamtoro seeds. The texture of tempeh can be determined by looking at whether or not the mycelia grows on the surface of the tempeh. The dense mycelia show that the tempeh texture has formed a compact mass (Kaur et al., 2024; Sulistiyono et al., 2016).

Food's cohesiveness (consistency) reveals the strength of the internal linkages that comprise its body and the extent to which it can be distorted before breaking during mastication (Radoĉaj et al., 2011; Salim et al., 2024). The ratio of the positive force area during the second compression to that of the first compression is known as cohesiveness. The pace at which the material disintegrates when subjected to mechanical force can be used to quantify it. Cohesion is demonstrated via tensile strength. Cohesion measures a product's capacity to remain coherent (Chandra & Shamasundar, 2015). The lamtoro gung tempeh samples had cohesiveness values between 0.22 and 0.46. The fermentation of teak leaves on days three and four and plastic on day four produced the highest values. The density of tempeh is closely related to the proliferation of mycelia in tempeh. Not much data was available about the changes in mycelia growth on tempeh with different packaging. However, using teak leaves and banana leaves, which have a larger space, allows for sufficient mycelial growth, but plastic packaging has restricted room, preventing mycelia from growing widely (Riski Alfanesa, Tri Rahayuni, 2021; Sayuti, 2015).

Adhesiveness is defined as the negative force area during the first bite. It shows the effort necessary to overcome the attraction forces between the surface of food and the surface of other materials with which it comes into contact (Kasapis, 2009). Table 2 shows that the maximum adhesiveness value was obtained for lamtoro gung tempeh from banana leaves packaging on day 3rd fermentation (6.78 Nmm). In contrast, the minimum adhesiveness value (0.14) has been obtained for the control sample.

Table 2. Texture profile of different lamtoro gung tempeh samples.

| Sample* | Packaging | Hardness Bite (N) | Cohesiveness | Adhesiveness (Nmm) | Gumminess (N) | Chewiness (N) | Springness Index |
|---|---|---|---|---|---|---|---|
| H0 | | $32.86^{efg} \pm 1.42$ | $0.26^{cde} \pm 0.02$ | $0.14^{d} \pm 0.01$ | $7.88^{ghi} \pm 0.76$ | $5.71^{ef} \pm 0.66$ | $0.77^{a} \pm 0.03$ |
| H1 | Banana leaves | $37.12^{defg} \pm 3.54$ | $0.25^{cde} \pm 0.02$ | $1.25^{cd} \pm 1.08$ | $9.30^{fgh} \pm 1.49$ | $6.55^{ef} \pm 0.97$ | $0.70^{b} \pm 0.01$ |
| | Teak leaves | $24.04^{fg} \pm 1.39$ | $0.24^{de} \pm 0.06$ | $2.76^{bcd} \pm 0.07$ | $4.72^{hi} \pm 0.49$ | $3.02^{f} \pm 0.37$ | $0.64^{bcdef} \pm 0.01$ |
| | Plastic | $14.36^{g} \pm 1.73$ | $0.22^{de} \pm 0.09$ | $3.25^{bcd} \pm 3.05$ | $3.05^{i} \pm 0.88$ | $1.91^{f} \pm 0.53$ | $0.63^{bcdef} \pm 0.01$ |
| H2 | Banana leaves | $38.82^{defg} \pm 1.35$ | $0.33^{bcd} \pm 0.03$ | $5.40^{ab} \pm 0.84$ | $12.97^{efg} \pm 1.64$ | $8.51^{de} \pm 1.61$ | $0.65^{bcdef} \pm 0.04$ |
| | Teak leaves | $68.46^{c} \pm 1.97$ | $0.34^{bc} \pm 0.04$ | $4.84^{ab} \pm 2.11$ | $21.16^{c} \pm 0.68$ | $14.29^{c} \pm 0.48$ | $0.68^{bcde} \pm 0.00$ |
| | Plastic | $58.41^{cde} \pm 11.26$ | $0.32^{bcd} \pm 0.03$ | $0.93^{cd} \pm 0.51$ | $18.78^{cde} \pm 5.38$ | $12.29^{cd} \pm 3.56$ | $0.65^{bcdef} \pm 0.00$ |
| H3 | Banana leaves | $42.52^{cdef} \pm 6.12$ | $0.38^{ab} \pm 0.03$ | $6.78^{a} \pm 2.90$ | $13.59^{efg} \pm 0.11$ | $9.20^{de} \pm 0.15$ | $0.68^{bcde} \pm 0.02$ |
| | Teak leaves | $66.44^{c} \pm 4.27$ | $0.43^{a} \pm 0.00$ | $4.97^{ab} \pm 0.35$ | $22.40^{c} \pm 5.49$ | $14.48^{c} \pm 3.50$ | $0.65^{bcdef} \pm 0.00$ |
| | Plastic | $60.56^{cd} \pm 3.44$ | $0.33^{bcd} \pm 0.01$ | $1.00^{cd} \pm 0.68$ | $19.70^{cd} \pm 1.50$ | $13.10^{cd} \pm 0.82$ | $0.67^{bcdef} \pm 0.01$ |
| H4 | Banana leaves | $49.90^{cdef} \pm 5.12$ | $0.29^{bcde} \pm 0.00$ | $3.16^{bcd} \pm 0.03$ | $14.52^{def} \pm 1.66$ | $10.14^{cde} \pm 1.40$ | $0.69^{bc} \pm 0.01$ |
| | Teak leaves | $195.38^{a} \pm 37.15$ | $0.46^{a} \pm 0.04$ | $3.53^{abc} \pm 0.11$ | $81.57^{a} \pm 2.70$ | $54.99^{a} \pm 2.60$ | $0.67^{bcde} \pm 0.00$ |
| | Plastic | $165.28^{b} \pm 5.16$ | $0.45^{a} \pm 0.03$ | $2.85^{bcd} \pm 0.10$ | $74.23^{b} \pm 3.06$ | $50.35^{b} \pm 3.67$ | $0.69^{bcd} \pm 0.01$ |

Results show mean values ± standard deviation. Different notations in the same column indicate significant differences ($\alpha$ = 0,05). *H0: day 0 fermentation; H1: day 1 fermentation; H2: day 2 fermentation; H3: day 3 fermentation; H4: day 4 fermentation.

Tempeh packaged in banana leaves with an incubation time of 3 days had the highest adhesiveness value (6.78 Nmm). Still, it was insignificant compared to teak leaf packaging with the same incubation duration. However, packaging with banana leaves and teak leaves for two and three days of incubation showed significant differences with plastic packaging. This is thought to be due to differences in pores in the three types of packaging used. Banana leaf and teak leaf packaging is believed to have more pores, thereby providing air circulation suitable for the growth of the fungus *Rhizopus* sp., and the fermentation process can run well (Riski Alfanesa, Tri Rahayuni, 2021; Sayuti, 2015). The more optimal the growth of the mold, the more optimal the mycelia is produced, which can influence the tempeh's density, resulting in a high adhesiveness value.

Gumminess is characterized as the combination of hardness and cohesiveness (Halim et al., 2022, 2023). Table 2 shows that lamtoro gung tempeh fermented with teak leaves on the fourth day had a more excellent gumminess value (81.57 N) than that fermented with plastic packaging on day one. A higher hardness value has resulted in increased gumminess. Gumminess is a property of semisolid foods with low hardness and high cohesion. Semisolids like tempeh rely more on gummy properties than solids (Chandra & Shamasundar, 2015).

Chewiness values for lamtoro gung tempeh samples were consistent with gumminess values. Chewiness pertains to the amount of energy needed to masticate solid foods. Chewiness is calculated as the product of gumminess and springiness, equivalent to hardness × cohesiveness × springiness (Chandra & Shamasundar, 2015). The chewiness value of lamtoro gung tempeh ranged from 1.91 to 54.99 N. Chewiness is the most difficult to evaluate precisely because mastication entails compressing, shearing, piercing, grinding, tearing, and cutting, all while being adequately lubricated by saliva at body temperatures. Chewiness is a parameter calculated by multiplying hardness, cohesiveness, and springiness. It refers to how easily a substance may be bitten (Paredes et al., 2022; Suraj et al., 2024).

Springiness is a textural characteristic closely linked to the elasticity of the sample. The height at which the meal recovers between the end of the first mouthful and the beginning of the second bite correlates with TPA springiness. A high springiness indicates a need for increased oral mastication force (Carrillo & Borthakur, 2022; Chandra & Shamasundar, 2015). The control sample (fermentation on day 0) had a more excellent springiness rating of 0.77. The springiness value of the other sample did not change significantly ($p > 0.05$).

The quality of the tempeh profile can be determined by the appearance of mycelium (Nuraini et al., 2022; Winarni & Dharmawan, 2017). Teak leaves are said to be used to package tempeh because they contain *Rhizopus oligosporus*. *Rhizopus oligosporus* synthesizes more protease enzymes (protein breaker) compared to *Rhizopus oryzae,* which synthesizes more alpha-amylase (starch breaker) (Dewi & ‘Aziz, 2011; Ezegbe et al., 2023). On the other hand, teak leaves have larger pores than banana leaves, so the longer they are fermented, the more complex the texture of the resulting tempeh. The hardness value proves this at the end of fermentation for tempeh packaged with teak leaves, which has the highest significant value. However, based on the texture profile data, packaging with teak and banana leaves gave significantly better results than plastic.

## 4. CONCLUSIONS

Tempeh is generally produced using soybeans and can be packaged in banana leaves, teak leaves, and plastic. This research explores the utilization of lamtoro gung as a commodity that is still rarely used in the food sector to make tempeh. Texture is one of the qualities of tempeh that needs to be considered. Based on this result research, tempeh produced from teak leaf packaging with fermentation for four days has a texture profile with the best scores in several attributes, such as hardness, cohesiveness, gumminess, and chewiness. The hardness value reached 195.38 N, cohesiveness 0.46, gumminess 81.57 N, and chewiness 54.99 N.

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