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Use of Lamtoro Seeds (Leucaena Leucocephala) in Tempeh

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ABSTRACTS

Leucaena (Lamtoro), known in Indonesia as petai cina (Chinese petai) or petai selong (Selong petai), is a plant from the legume family. Tempeh is a fermented food product made from soybeans or various other types of beans with the help of the fungi Rhizopus oligosporus and Rhizopus oryzae found in tempeh yeast. The purpose of this study was to determine the organoleptic characteristics, standard recipe, and consumer acceptance of lamtoro seed tempeh. The research method used was an experimental, quantitative approach. The data collection technique was an observation test conducted by four panelists, namely Lecturers from the Department of PKK FKIP USK. The acceptance test was conducted by a panel of 30 student panelists from iUSK. Based on the results of the resource person test, the highest value was obtained for 40 gr lamtoro seed tempeh (TBL193), with color 5.75, aroma 5.75, texture 6.25, and taste 5.5. The results of the consumer test showed the highest value, namely 40 g lamtoro seed tempeh (TBL193), with color 3.61, aroma 3.63, texture 3.5, and taste 3.51. The results of the hypothesis test showed that Ha was accepted because it significantly influenced the organoleptic properties of lamtoro seed tempeh.

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1. INTRODUCTION

Plants are God's creations, possessing a wide variety of benefits, including serving as a food source for all living things. Indonesia is a country rich in natural food resources, including grains, which contain a variety of nutrients to meet daily nutritional needs (Dermoredjo et al., 2024). Leucaena (Leucaena lamtoro), known in Indonesia as petai cina (Chinese petai) or petai selong (Selong petai), is a legume plant that thrives in various locations throughout Indonesia.

In Central Aceh, lamtoro trees are cultivated as shade trees for coffee plants, protecting the coffee plants from the sun's rays and preventing the ripe coffee cherries from burning. Leucaena seeds are a versatile legume, and they are generally grown in mixed cropping systems. Leucaena seeds contain a high level of vegetable protein, around 30-40%. Besides protein, lamtoro seeds are also rich in several other important nutrients, including calories, carbohydrates, calcium, phosphorus, iron, and vitamins A, B1, and C (Saputri et al., 2021; Aquino-González et al., 2023).

Lamtoro seeds contain relatively high levels of protein compared to other seeds such as peanuts, tolo beans, and red beans. The protein content of lamtoro seeds is almost equal to that of soybeans (30-40%) (Aquino-González et al., 2023). Lamtoro seeds can be used as food ingredients. In some regions in Indonesia, young lamtoro seeds can be processed into botok and lalapan, and they can also be used as medicine and animal feed; however, they are often not utilized, so they are wasted (Mufidah et al., 2018).

Familiar plant protein sources used as bases for fermentation include soybeans and other beans, such as peanuts, bean curd, and pigeon peas. Among these ingredients, soybeans are the most widely used as the main ingredient in fermented foods in many countries due to their very high protein content (Qomariyah & Utomo, 2016).

In recent years, soybean production has continued to decline. Indonesia's soybean production reached 0.8 million tons. This production only meets 20% of national demand. Meanwhile, 80%, or approximately 3.2 million tons, is still imported from other countries, primarily the United States, which has caused soybean prices to continue to rise. Therefore, to reduce soybean use, innovative raw material alternatives are needed in the tempeh-making process. One alternative raw material for tempeh production is lamtoro seeds (Nursiwi et al., 2021; Raida et al., 2025).

Tempeh is a food product made from fermented soybeans or other legumes using the fungi Rhizopus oligosporus and Rhizopus oryzae, which are found in tempeh starter cultures (Kristiadi & Lunggani, 2022). Tempeh is traditionally produced and is a source of plant-based protein. Tempeh contains various nutrients essential to the body, including protein, fat, carbohydrates, and minerals (Qomariyah & Utomo, 2016).

Due to these issues, lamtoro plants are currently used only as shade trees, and their seeds are processed into foods such as botok (a type of fermented soybean cake) in some areas of Indonesia. This article aims to develop a food product made from lamtoro seeds: lamtoro seed tempeh.

The theoretical benefits of this research are expected to broaden knowledge of tempeh production and provide the public with the latest information on processing lamtoro seeds into tempeh as a substitute for soy-based vegetable protein sources. The practical benefits of this research are expected to provide innovative ideas to meet nutritional needs, especially protein needs, by utilizing lamtoro seeds as a basic ingredient in tempeh production. This study aims to determine the organoleptic characteristics of lamtoro seed tempeh, standardize the recipe, and assess consumer acceptance of the product.

Leucaena lamtoro, also known as petai cina or petai selong, is a plant with diverse uses. It is a type of shrub from the Fabaceae (Leguminosae) family, often used for reforestation and

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erosion prevention (Ichsannudin et al., 2024). Native to tropical America, lamtoro was introduced to Java hundreds of years ago for agricultural and forestry purposes, and has since spread to other islands in Indonesia (Sharma et al., 2022).

Leucaena leucaena (lamtoro) plants are known for their rapid growth and adaptability to a wide range of soil types and climates. Leucaena leucaena plants adapt effectively to tropical climates. Furthermore, they can adapt to soils with moderate acidity (pH 5.5-6.5) and to temperate climates (Sutaryono & Sari, 2023).

The lamtoro plant has an upright stem that is brownish-white or reddish-brown, with fork-like branches. Its leaves are small with a double-pinnate leaf vein pattern, consisting of 4 to 8 pairs, and each leaf stalk has 11 to 22 leaflets. Its flowers are white, cup-shaped or rounded, and are a type of compound flower that resembles a cup without any leaf padding. It is also self-pollinating (Sutaryono & Sari, 2023).

Leucaena leucocephala (Leucaena leucocephala) seeds, also known as mlandingan, are a food commodity in Indonesia known for their delicious taste and high protein content. Leucaena fruit resembles pods found in bunches. Each bunch contains 20-30 pods, while each pod contains 15-30 seeds. Leucaena has flat, oval-shaped seeds with a strong odor. Leucaena seeds turn blackish-brown when ripe. Leucaena seeds have a good chemical composition, including 30-40% protein, 6.13% fat, 8.79% crude fiber, and 9.32% minerals (Widayat et al., 2021).

Not only that, but petai cina also contains vitamins A and B, as well as saponins, which have anti-inflammatory properties. Its seeds are oval and flat, and when ripe, petai cina seeds turn brown and contain mimosine, leucanin, leucanol, and protein (Rashid et al., 2021).

Initially, lamtoro seeds were only used as an addition to vegetable dishes in several regions of Indonesia, such as botok and oblok-oblok (Rachma et al., 2022). However, with advances in research technology, more and more new benefits of the seeds have been discovered. People can experience various benefits from consuming lamtoro seeds, including aiding in the healing of external wounds and improving blood circulation (Maharani et al., 2025).

Leucaena leucocephala seeds are known to have healing properties widely believed by the community, including their use as a remedy for stomach aches (Azizul et al., 2020). Furthermore, lamtoro seed extract has been reported to be beneficial as an anthelmintic, a blood sugar-lowering agent, and a broad-spectrum bacterial growth inhibitor (Chowtivannakul et al., 2016; Juanico & Flores, 2019). Recently, Leucaena leucocephala seed oil has been utilized in engineering as a novel biopharmaceutical, playing a role in biomembrane modeling to determine the lipophilicity of drugs and xenobiotics.

The term tempeh is listed in the Javanese-Dutch dictionary and is described as a dish made from fermented soybeans or soybean meal, then baked or fried in a compressed form (Romulo & Surya, 2021). However, tempeh has likely been around for at least several centuries, as evidenced by its widespread consumption patterns, geographic distribution, popularity, and the diverse varieties that have become an integral part of Javanese cuisine (Romulo & Surya, 2021).

Tempeh is a fermented food product made from soybeans or various other types of beans with the help of Rhizopus oryzae or Rhizopus oligosporus fungi found in tempeh yeast. (Salim, 2017). Processing soybeans into tempeh increases their nutritional value, especially their protein content, making them easier to digest, absorb, and utilize by the body (Salim, 2017). Tempeh contains various nutrients the body needs, such as protein, fat, carbohydrates, and minerals. In every 100 g of tempeh, there are 20.8 g of protein, 8.8 g of fat, 13.5 g of

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carbohydrates, 0.19 mg of vitamin B1, and 155 mg of calcium, but only a little fiber (Salim, 2017).

In Indonesia, there are various types of tempeh, including tempeh gembus made from tofu dregs, tempeh lamtoro made from lamtoro seeds, tempeh benguk made from koro benguk seeds, tempeh koro made from koro seeds, tempeh bongkrek made from coconut dregs, gude tempeh made from pigeon peas, tempeh bungkil made from the dregs of peanut oil, and soybean tempeh made from soybeans (Aryanta, 2020).

Termpe is made from three main ingredients: young lamtoro (Leucaena leucocephala) seeds, also known as mlandingan, a food commodity in Indonesia known for its delicious taste and high protein content. The morphology of the lamtoro fruit resembles that of bunches of pods. Each bunch contains 20-30 pods, while each pod contains 15-30 seeds. Leucaena has flat, oval-shaped seeds with a strong odor. Leucaena seeds have a good chemical content, including 30-40% protein, 6.13% fat, 8.79% crude fiber, and 9.32% minerals (Widayat et al., 2021).

Tempeh yeast is composed of several species from the genera Rhizopus, Aspergillus, and Mucor. During fermentation, yeast generally thrives at optimal levels of substrate and carbohydrates. The most common fungi found in tempeh are Rhizopus oligosporus and Rhizopus aryzae, both of which play a crucial role in the fermentation process (Widayat et al., 2021).

Tempeh yeast is a key supporting ingredient in the tempeh-making process, particularly during fermentation. Two types of tempeh yeast are available on the market: leaf yeast and powdered yeast. Both types are of equal quality and can be used in the tempeh fermentation process. However, powdered yeast is easier to use because it allows more accurate measurements. Several factors can influence the quality of tempeh yeast, including: the quality of the tempeh used as the base ingredient, the quality and quantity of the medium, the moisture content of the yeast, the storage method, and the shelf life (Widayat et al., 2021).

Rice flour, which consists of carbohydrates, fats, proteins, minerals, and vitamins, is an alternative base ingredient in composite flour formulations. Rice flour is an intermediate product used as a raw material in further industrial processes. When used in food processing, rice flour creates a smooth texture without causing stickiness during cooking. Rice flour is opaque, meaning it remains translucent after processing (Afgani, 2023).

Rice flour is made from white rice that has been washed and soaked to achieve the desired fineness. Rice flour has a higher protein content than rice starch, approximately 5.2–6.8% in rice flour and 0.2–0.9% in rice starch. The main component of rice is carbohydrates. These carbohydrates include starch, the main component, and minor components such as sugars, cellulose, hemicellulose, and pentoses. Starch comprises 85–90% of the dry weight of rice, pentoses 2.0–2.5%, and sugars 0.6–1.4% of the dry weight of brown rice. Therefore, starch characteristics are important determinants of rice's physicochemical properties.

2. METHODS

The approach used in this study was quantitative. The research employed in this study was experimental, aiming to determine the effects of certain variables on other variables under controlled conditions. In this study, the experiment used lamtoro seeds in tempeh.

This research was conducted under research permit number 1228/UN11.F6/PK. 03.08/2025, issued by the Dean of the Faculty of Teacher Training and Education/UN11.F6/PK.03.08/2025 and lasted for six months. The subjects in this study comprised four panelists, Lecturers of the Culinary Arts Department of Family Welfare

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Education, Faculty of Teacher Training and Education, Syiah Kuala University, and 30 consumer panelists, consisting of USK students. At the same time, the object of this study was fried lamtoro seed tempeh.

The independent variable in this study was tempeh using lamtoro seeds. The dependent variable was the organoleptic characteristics (color, aroma, texture, and taste) of tempeh using lamtoro seeds.

Research instruments serve as aids for systematic, objective data collection related to the phenomenon being studied. In this study, the instruments used included a sensory evaluation test and an acceptability test.

The hypothesis in this study was analyzed using the Paired Sample T-Test method at a significance level of 0.05. Data from the organoleptic test observations were then statistically processed using SPSS 26.0.

3. RESULTS AND DISCUSSION

The results of the panelists' observation tests on lamtoro seed tempeh, focusing on characteristics (color, aroma, texture, and taste), are shown in **Table 1** and **Figure 1**.

Table 1. Results of the Observation Test of Lamtoro Seed Tempeh by 4 Panelists.

No	Rated aspect	Treatment	
		TBL193	TBL391
1	Color	5.75	5.75
2	Aroma	5.75	5.75
3	Texture	6.25	5
4	Flavor	5.5	5.25
Total Value		23	21.75
Average Value		5.75	5.4

(Source: Primary Data, 2025)

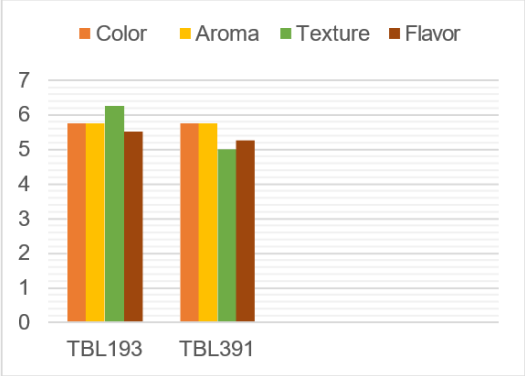

Figure 1. Results of the Panelists' Observations of the Organoleptic Characteristics of Lamtoro Seed Tempeh

The results of the observation test, 40 g lamtoro seed tempeh (TBL193) and 60 g lamtoro seed tempeh (TBL391) obtained that the highest value between the two was 40 g lamtoro seed tempeh with an average value in terms of color of 5.75, which indicates that the color of the tempeh is slightly golden brown, in terms of aroma is 5.75, which indicates that the aroma of the tempeh is slightly fragrant, in terms of texture is 6.25, which indicates that the texture of the tempeh is crispy and in terms of taste is 5.5, which indicates that the taste of the tempeh is slightly savory.

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The average consumer assessment of the organoleptic characteristics (color, aroma, texture, and taste) of lamtoro seed tempeh is shown in **Figure 2**.

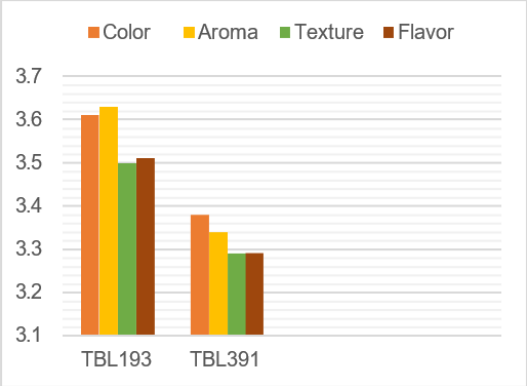

Figure 2. Average Consumer Acceptance of Lamtoro Seed Tempeh

Based on **Figure 2**, the results of the observation test of 40 g lamtoro seed tempeh (TBL193) and 60 g lamtoro seed tempeh (TBL391) showed that the highest value between the two was 40 g lamtoro seed tempeh (TBL193) with an average value in terms of color of 3.61, which indicates that the color of the tempeh is neutral, in terms of aroma 3.63, which indicates that the aroma of the tempeh is neutral, in terms of texture is 3.5, which indicates that the texture of the tempeh is neutral and in terms of taste is 3.51, which indicates that the taste of the tempeh is neutral.

Based on the research results, the informants chose 40 g of lamtoro seed tempeh (TBL193) for its color, aroma, texture, and taste.

The informant chose the first treatment of lamtoro seed tempeh (TBL193) for color because it was slightly golden brown compared to the second treatment. Frying at the right temperature produced a golden-brown color on the fried tempeh and was preferred by the informant. Color is formed when light is reflected by objects, captured by the sense of sight, and perceived, resulting in human perception and emotional responses to the reflected light. (Saragih & Kristiana, 2020).

The informant chose the first treatment of lamtoro seed tempeh (TBL193) for its aroma, as it is slightly more fragrant than the second treatment. The proper frying process affects the aroma of tempeh, which initially has a fermented aroma from the Rhizopus fungus used in fermentation. Aroma is a smell that arises from chemical stimuli detected by the olfactory nerves in the nasal cavity (Negara et al., 2016). This aroma greatly determines the food's deliciousness and influences consumer acceptance. Food without an aroma is usually less popular.

The informant chose the first treatment of lamtoro seed tempeh (TBL193) for texture because it was crispier than the second treatment. The cutting process of the tempeh affects its texture when fried. Texture is one of the physical and sensory properties that consumers use to assess the quality of food products (Megavitry & Widodo, 2024).

Taste is the tongue's reaction to stimuli from food (Megavitry & Widodo, 2024). The informant chose the first treatment (TBL193) for its taste because it was slightly more savory than the second treatment. Frying the lamtoro seed tempeh in the right oil produced a savory flavor.

After conducting several organoleptic tests, the standard recipe for lamtoro seed tempeh that received the highest score from the informants was 40 g lamtoro seed tempeh (TBL193). The recipe for 40 g lamtoro seed tempeh is: 40 g young lamtoro seeds, 15g rice flour, and 5 g tempeh yeast.

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30 USK students conducted consumer acceptance and preference tests on the organoleptic characteristics of 40 g lamtoro seed tempeh (TBL193) and 60 g lamtoro seed tempeh (TBL391). The results showed that consumer panelists preferred 40 g lamtoro seed tempeh (TBL193) over 60 g lamtoro seed tempeh (TBL391) in terms of color, aroma, texture, and taste. The average color value was obtained (3.61). The average panelists preferred lamtoro seed tempeh with a small amount of lamtoro seeds added, as the resulting color was green with a slight brownish tinge (Qomariyah & Utomo, 2016). For aroma, the average value was obtained (3.63). The fewer lamtoro seeds added, the more panelists preferred the more fragrant aroma of tempeh (Qomariyah & Utomo, 2016).

In terms of texture, the average value was obtained (3.5), and in terms of taste, the average value was obtained (3.51). Tempeh with a small amount of lamtoro seeds produced a taste increasingly preferred by the panellists (Qomariyah & Utomo, 2016). It can be concluded that 40 g lamtoro seed tempeh (TBL193) had the highest value. Based on observation and acceptance tests conducted by sources and consumers, both groups preferred 40 g lamtoro seed tempeh (TBL193) over 60 g lamtoro seed tempeh (TBL391). This includes the color, aroma, texture, and taste of 40 g lamtoro seed tempeh (TBL193).

The use of lamtoro (Leucaena leucocephala) seeds in tempeh represents a recent culinary innovation that has gained attention in Indonesia's traditional food landscape. This fermented product, locally known as tempe lamtoro or tempe mlanding, originated from Central Java, particularly in the Mojopuro region of Wonogiri, where it has been traditionally produced during the lamtoro harvest season (Prameswari et al., 2021). Although lamtoro seeds are used in botok—a traditional Javanese steamed dish made with grated coconut and spices—this preparation is found only in some regions of Indonesia, particularly Central and East Java on the island of Java (Sethi & Kulkarni, 1995). The limited geographical distribution of botok and other lamtoro-based dishes reflects a lack of knowledge about the culinary and nutritional potential of this legume across the Indonesian archipelago.

Leucaena seeds contain remarkably high levels of vegetable protein, ranging from 23.17% to 31.1% on a dry-matter basis, making them an up-and-coming alternative to soybeans for protein supplementation (Ahmed & Abdelati, 2009; Raju et al., 2025). The protein profile of L. leucocephala seeds is particularly noteworthy, as it is relatively rich in essential amino acids, including isoleucine, leucine, phenylalanine, and histidine, with lysine and methionine also present in moderate amounts (Sethi & Kulkarni, 1995). This amino acid composition is comparable to that of alfalfa, another well-known protein-rich legume. Furthermore, lamtoro seeds contain significant concentrations of minerals, particularly calcium (1.8-2.19% DM), potassium (1.1-1.45% DM), and trace minerals such as iron and boron (Ayssiwede et al., 2010; Raju et al., 2025), contributing to their nutritional value as a functional food ingredient.

Leucaena seeds are also easier to find than soybean seeds because they are commonly used as hedges (living fences), shade plants for coffee and cocoa plantations, and in soil conservation practices across tropical and subtropical regions (De Angelis et al., 2021). The plant's fast growth rate, drought resistance, and ability to fix atmospheric nitrogen make it an economically viable and sustainable crop (Raju et al., 2025). However, this widespread availability as an ornamental and agricultural support plant paradoxically limits knowledge of their culinary uses among the general population. Most communities are unaware that the mature seeds can be processed into nutritious food products through proper preparation methods.

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Despite its nutritional benefits, the Utilization of lamtoro seeds for human consumption faces challenges due to the presence of mimosine, a toxic non-protein amino acid that constitutes approximately 60% of total free amino acids (4-7% dry matter in seeds) and can cause adverse health effects such as alopecia, growth retardation, goiter, and reduced fertility in animals when consumed without proper processing (Sethi & Kulkarni, 1995; De Angelis et al., 2021). However, traditional fermentation processes used in tempeh production, particularly with Rhizopus oligosporus, have been shown to significantly reduce mimosine content by 64-67% and other antinutritional factors such as trypsin inhibitors and phytates by up to 65%, while simultaneously enhancing digestibility and developing beneficial bioactive compounds (Prameswari et al., 2021). This detoxification mechanism makes fermented lamtoro products, such as tempeh, a safe and nutritious food option.

The extended fermentation process characteristic of tempe mlanding—which can last 60-120 hours, compared to the typical 36-48 hours for soybean tempeh—further enhances its unique flavor profile and increases soluble protein content from 3.02% to 22.62% dry matter (Prameswari et al., 2021). This prolonged fermentation develops distinctive sensory characteristics, including a more pungent umami taste, a brownish color, and a characteristic ammonia aroma, making it suitable as a seasoning or condiment in traditional Javanese cuisine. Despite these promising attributes, the lack of widespread knowledge about processing techniques, nutritional benefits, and safe consumption practices continues to limit the broader adoption of lamtoro seeds as a mainstream alternative protein source in Indonesia's food system.

A hypothesis test was conducted to assess the validity of the initial assumption that adding lamtoro seeds affects the organoleptic quality of lamtoro seed tempeh. Based on the data analysis, the alternative hypothesis (Ha) is accepted because there are significant differences in the parameters of color, aroma, texture, and taste between the TBL193 and TBL391 treatments. Lamtoro seeds influence the organoleptic characteristics (color, aroma, texture, and taste) of lamtoro seed tempeh. There is an influence of lamtoro seeds on consumer preferences for lamtoro seed tempeh. The hypothesis has been proven after the data analysis is processed. The results of the analysis on the organoleptic characteristics of lamtoro seed tempeh in terms of color, aroma, texture, and taste using Paired Sample T-Test analysis at a significance level of 0.05, and obtained significant results <0.05, so that H0 is rejected and Ha is accepted because there are significant differences in preferences.

4. CONCLUSION

Based on the observation test conducted by the resource person on the organoleptic characteristics of lamtoro seed tempeh, the highest overall scores were obtained for the 40 g formulation (TBL193), which achieved an average color score of 5.75 (described as slightly golden brown), an aroma score of 5.5 (slightly fragrant tempeh), a texture score of 6.25 (crispy), and a taste score of 5.5 (slightly savory). For the 60 g lamtoro seed tempeh formulation, the highest values recorded were an average color score of 5.75 (slightly golden brown), an aroma score of 5.75 (slightly fragrant tempeh), a texture score of 5.0 (slightly crunchy), and a taste score of 5.25 (slightly savory). The standard recipe that received the highest evaluation from the interviewee was the 40 g lamtoro seed tempeh (TBL193), consisting of 40 g young lamtoro seeds, 15 g rice flour, and 5 g tempeh yeast. Furthermore, the consumer acceptance test also indicated that the highest acceptance was found for the

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40 g lamtoro seed tempeh (TBL193), with average scores of 3.61 for color, 3.63 for aroma, 3.50 for texture, and 3.51 for taste, all of which were categorized as neutral.

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