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Chemical and Sensory Evaluation on Several Varieties of *Salak* (*Salacca zalacca*) Fruit from Indonesia

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***Abstract*— *Salak* (*Salacca zalacca*) is an indigenous plant in Indonesia. It is widely distributed in several areas, such as Yogyakarta, Bali, Sumatra, and Maluku. Several varieties of *salak* have been developed as a part of the government's plant-breeding program. However, a detailed characterization of the sensory properties has not been reported. This study evaluated the chemical characteristics and consumer acceptance from six different varieties, namely Pondoh Super, Pondoh Madu, Pondoh Gading, Sari Intan 48, Sari Intan 295, and Sari Intan 541. Chemical characteristic tests included moisture content, fruit acidity (pH), total soluble solids, reducing sugar concentration, and vitamin C. Sensory evaluation on acceptance attributes, such as peel and flesh color, texture, aroma, taste, and overall preference, was carried out by 40 untrained panelists. The results revealed that the chemical and sensory characteristics varied among 6 varieties. Sari Intan 48 had the highest moisture content and pH compared to other varieties. *Salak* Pondoh Super had the highest levels of reducing sugar and vitamin C. On the other hand, Sari Intan 295 had the highest total soluble solids content. Male, female, and young panelists preferred the taste of Sari Intan 295. There was no significant difference in the parameters of peel color, flesh color, texture, aroma, taste, and overall preference in the adult panelists group. The group of panelists over 51 years old preferred the taste of the Sari Intan 541. A sour taste significantly affected panelists' acceptance of *salak* fruit.**

***Keywords*— Snakefruit; genotype; chemical properties; sensory properties; hedonic scale.**

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I. INTRODUCTION

Indonesia is a tropical country with a high diversity of fruits. *Salak* (snakefruit) is one of the native fruits from Indonesia that is currently being developed as an export commodity. The production of *salak* fruit is increasing at around 36.64% from 896,504 (2018) to 1,225,008 tons in 2020 [1]. This fruit is an essential trading commodity due to its significant economic value.

Indonesia is the center of salak origin and has a high diversity of varieties. *Salak* was first described by Voss in 1895 [2] known as Javanese *salak*. However, it has now spread throughout the Indonesian archipelago [3]. In the current development, this fruit is known by various names, such as *salak* Pondoh in Yogyakarta, *salak* Bali in Bali, and *salak* Soya in Ambon. *Salak* Pondoh is known for its superior quality among other varieties. It is sweeter than another cultivar, even in unripe fruits with no bitter or sour component. [4]. According to Djafaar [5], there are three types of *salak* Pondoh cultivated in Yogyakarta: Pondoh Hitam, Pondoh Super, and Pondoh Manggala. To crossbreed between varieties, Pondoh Madu and Pondoh Gading were developed. The Agency for Agricultural Research and Development, through the Research Institute for Tropical Fruits located in Solok, West Sumatra, has produced several hybrids. The crossbreeding involved some varieties such as *salak* Bali, *salak* Pondoh, *salak* Sidempuan, *salak* Mawar, and several local superior varieties of *salak*. Three new superior hybrids of *salak*, namely Sari Intan 48 (*salak* Gula Pasir × *Salak* Pondoh Super), Sari Intan 541 (*salak* Bali Gondok × *Salak* Pondoh Super), and Sari Intan 295 (*salak* Pondoh × *salak* Mawar) were released in 2009 [6]. Sari Intan 295 is a progeny of a female parent, Pondoh Super, from Tempel, Sleman Yogyakarta, and a male parent, *salak* Mawar, from Bogor. Sari Intan 541 was from a cross between *salak* Bali Gondok as female elders from Sibetan, Karangasem, and the male elder, Pondoh Super from Tempel, Sleman Yogyakarta. Meanwhile, Sari Intan 48 results from a cross between *Salak* Gula Pasir and Pondoh Super.

A great diversity of *Salak* varieties in the market relates to the variation of their physical, chemical, and sensory properties. Characterization of chemical components in *salak* fruit is essential due to its relation to nutritional properties. On the other hand, the physical and sensory properties of *salak* fruit significantly affect consumer acceptance. However, a detailed study of the newly developed salak fruit's physical, chemical, and sensory properties is still limited. A comprehensive report on these topics is urgently required, especially on freshly developed varieties. This information is essential for industries to obtain *Salak* fruit as an ingredient/final product with desired characteristics.

Sensory science provides objective information about the consumer's understanding of a product, the acceptance or rejection of stimuli, and the description of the emotions evoked. It is possible to answer how consumers perceive a product through discriminative and descriptive techniques. [7]. This is important to enable a fair comparison between fruit products. This study used quantitative hedonic analysis on *salak* fruit from different varieties. Several sensory attributes were analyzed, such as appearance, texture, and taste. Evaluation of the chemical characteristics of six varieties of *Salak*, namely Pondoh Super, Pondoh Madu, Pondoh Gading (from Sleman, Yogyakarta), Sari Intan 48, Sari Intan 295, and Sari Intan 541 (from Bintan, Riau) was also carried out. This is to provide more information for consumers and industries to select the product based on their preferences and desired properties [8], [9].

II. Materials and Method

A. Materials

Six varieties of *salak* used in this study were Pondoh Super, Pondoh Madu, and Pondoh Gading, obtained from Sleman Regency, Yogyakarta Province, and Sari Intan 48, Sari Intan 295, and Sari Intan 541 were obtained from Bintan Regency, Riau Island Province. *Salak* fruits used in this study were fresh harvest fruit with a maturity level of 60-70% or six months after flowering. The physical characteristics of *salak* fruits are presented in Table 1.

TABLE I
THE PHYSICAL CHARACTERISTIC OF *SALAK* FRUITS FROM DIFFERENT VARIETIES

***Salak* Varieties**	**Fruit Characteristics**							
	Shape	**Color**		**Taste**			**Texture**	**Aroma**
		Peel	**Flesh**	**Sweet**	**Bitter**	**Sour**		
Pondoh Super[12]	upside down egg	dark brown	chalk white	Sweet	not bitter	not sour	hard	less flavorful
Pondoh Madu[13]	triangle, oval	shine brown	yellowish white	sweet, honey-like	not bitter	not sour	crunchy and soft	less flavorful
Pondoh Gading[14]	triangle, oval	greenish	yellowish white	sweet (ripe fruit)	bitter (young fruit)	slightly sour	slightly crunchy	less flavorful
Sari Intan 48[15]	Slightly oval	dark brown	yellowish white	very sweet	not bitter	not sour	slightly soft	very fragrant
Sari Intan 295[16]	Slightly oval	dark brown	creamy white	very sweet	not bitter	not sour	slightly crunchy	fragrant
Sari Intan 541[17]	short triangle	dark brown	yellowish cream	very sweet	not bitter	not sour	crunchy	fragrant

Figure 1 shows the color of the peel and flesh of *salak* fruits. Chemicals used include metaphosphoric acetic acid (Merck, Darmstadt, German), 2.6 dichlorophenol indophenol (Merck, Darmstadt, German), Nelson Arsenomolybdat reagent (Nitrakimia, Bantul, Indonesia), Nelson A reagent (Nitrakimia, Bantul, Indonesia), and Nelson B (Nitrakimia, Bantul, Indonesia). All materials used in this study were analytic-grade chemicals.

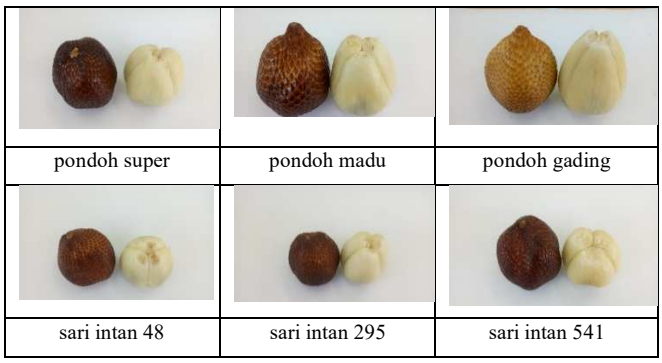

Fig. 1 The color of peel and flesh of *salak* fruits

B. Analysis

1) pH analysis: The pH value of *salak* fruit was analyzed using a pH meter (SCHOOT Instruments). Ten grams of *salak* fruit flesh were ground and placed in a container. The pH measurement was carried out by dipping the pH meter's glass electrode into the mashed pulp of the *salak* fruit. The pH meter was calibrated with a standard buffer at room temperature, pH 4.0 and 7.0, before use.

2) Moisture Content: Moisture content was analyzed based on the method of [10] . The principle of the oven method was that water molecules were removed or evaporated by heating at a temperature of 100°C until constant weight. The empty weighing bottle was dried in an oven at 100˚C for 1 hour and then cooled in a desiccator for 10 mins. 1-2 g of *salak* fruit sample was cut into pieces and put in the weighing bottle. The drying was carried out in an oven (Memmert 845, Memmert, Germany) at 100˚C for 24 hours. The sample was then removed from the oven, placed in a desiccator for 10 minutes, and weighed. Water content was calculated by equation (1) :

$$\text{Water content (\%)} = \frac{B-C}{B-A} \text{ x } 100\% \quad (1)$$

where A is the weight of the empty weighing bottle (g), B is the weight of the weighing bottle and initial sample (g), and C is the weight of the weighing bottle and dry sample (g).

3) Reducing Sugar: Reducing sugar content was measured by using the Nelson Somogyi method. One mL of *Salak* fruit filtrate (obtained from the juice of *Salak* fruit) was diluted 2.500 times. One mL of Nelson C reagent was added and heated in boiling water for 20 mins. After cooling, 1 mL of Arsenomolybdate reagent was added, and the solution was vortexed. Distilled water with a volume of 10 mL was added to dilute the solution. Absorbance readings were carried out at a wavelength of 540 nm (Spectrophotometer UV Vis-1280, Shimadzu, Japan). Reducing sugar content was calculated by equation (2):

$$\text{Reducing sugar (\% b/b)} = \frac{concentration\ (mg)}{sample\ weight\ (mg)} \text{ x fp x } 100\% \quad (2)$$

where fp is the dilution factor.

4) Total Soluble Solid: Total soluble solid was measured with a digital portable refractometer [11]. As much as 1-2 drops of *salak* fruit juice were put in the prism of the refractometer, and then the reading was. The total soluble solid number was observed and expressed in Brix.

5) Vitamin C: The 2.6 D (Dichlorophenolindophenol) titration was used to determine vitamin C levels. Acetic metaphosphoric acid solution was prepared by diluting 50 mg of sodium 2,6-dichlorophenol indophenol with 50 mL of 0.84% sodium bicarbonate solution (w/v). The solution was then shaken vigorously, and water was added to make up to 200 mL. The solution was then filtered and stored in a sealed amber glass bottle. 2,6-diklorofenol-indofenol solution was prepared by weighing 15 g of metaphosphoric acid in 40 mL of glacial acetic acid. The solution was then diluted with water to a volume of 500 mL and stored in a cool place. It should only be used within 2 days. Vitamin C was analyzed using 2 mL of the sample solution. The sample was then added with 5 mL of metaphosphoric-acetic acid. The solution was titrated with 2,6-dichlorophenol indophenol until a pink color formed. A blank was determined using Aquadest. Vitamin C levels were calculated by equation (3):

$$\text{Vitamin C (mg/g)} = \frac{(Vt-Vb)\ x\ Balancing\ x\ Vl}{Vp\ x\ Bs} \quad (3)$$

where Vt is the titration volume of the sample, Vb is the titration volume of blanko, Vl is the flask volume, Vp is the sample volume, and Bs is the sample weight.

6) Sensory Analysis: Sensory evaluation of the six varieties of *salak* fruit was carried out using a hedonic scale. 40 untrained panelists tested the *salak* fruits. They were selected by considering gender and age group based on information from previous studies [11]–[13]. The panelists consisted of 23 females and 17 males [18]. Fourteen panelists were 15-25 years old (young), twelve were 26–51 years old (adult), and fourteen were over 51. Samples were plated on white plastic plates and coded with random three-digit numbers; rinse with mineral water was made compulsory after testing each sample. The observed parameters were peel color, flesh color, texture, aroma, taste, and overall acceptance with a scale of 1-5 (1 = dislike extremely, 2 = dislike, 3 = neutral, 4 = like, 5 = like extremely) [19].

7) Statistical analysis: The experiments were performed in triplicate. Chemical attributes were analyzed using variance analysis. Sensory data were analyzed using the Kruskal-Wallis and Mann-Whitney tests. The data were processed using SPSS 16 software (IBM Corp, Armonk, NY, USA).

III. Results and Discussion

A. Chemical Characteristic of Salak Fruit

The chemical characteristics of Indonesian *salak* fruits were diverse. The moisture content of the six *salak* varieties ranged from 78.55% to 81.75%. The water contents of Sari Intan 48, Sari Intan 295, and Sari Intan 541 were similar to that of those reported by the Ministry of Agriculture [20]. Generally, the moisture contents of *salak* fruits from Indonesia were less than that of Thailand (81.04±0.4%), except for Sari Intan 48 (Table 2). The moisture content of Sari Intan 48 was significantly different ($p>0.05$) from other *Salak* varieties but not significantly different ($p<0.05$) from that of Pondoh Super. The moisture content is an essential component in fruit that affects its appearance, texture or hardness, and taste. The pH of *Salak* fruit ranged from 4.15 to 5.23. Sari Intan 48 had the highest pH value. This was in agreement with the description of the Sari Intan 48, which was characterized by a non-sour taste and very sweet attributes (Table 1). The pH value of Sari Intan was reported to be related to total acid concentration. *Salak* with a higher pH has less total acid [22]. Sari Intan 48 had lower total acid (0.82) than Sari Intan 295 (0.51-1.23) and 541(0.34-1.25).

The reduced sugar content of the six varieties of *salak* fruit varied from 14.42% to 30.63% (Table 2). Pondoh Super had the highest reducing sugar content (30.63%) and was significantly different ($p<0.05$) from other varieties. This was consistent with a previous report that the total sugar of Pondoh Super was higher (14.50%) than Pondoh Madu (13.38%) and Pondoh Gading (12.37) [23]. Sugar content in fruit is influenced by variety and maturity level [22]. It was reported that the sugar content increased during ripening, and the reducing sugar content was related to the gritty texture of the *salak* Pondoh [11].On the other hand, the total soluble solids of the six varieties ranged from 22.55 to 23.83 °Brix. The total soluble solid of Sari Intan 295 was the highest (23.82 ± 0.31°Brix), followed by Pondoh Super (23.05 ± 0.38°Brix). These values were significantly different from the other *salak* varieties. Total soluble solid values obtained in this study were higher than that previously reported (18.00 to 21.45 °Brix) [3]. Similarly, the total soluble solids of Pondoh Super and Sari Intan 541 were higher than those reported by the Kementan (10-19 Brix) [17]. Meanwhile, Sari Intan 48 and Sari Intan 295 had higher values than those previously reported (20-20.8 and 19-21 Brix, respectively) [3], [18],. Harvest time and fruit ty affect total soluble solids in climacteric fruits such as *Salak*. Late-harvested fruit had dry matter content, high total soluble solids, and low acid content [3]. Total soluble solids are also affected by altitude. The *salak* Gula Pasir grown at an altitude of 460 m asl had higher total soluble solids than those grown at 700 m asl [24]. *Salak* Pondoh grown in low altitudes and with low dust fraction had increased sugar content [3].

Vitamin C can be found in local fruits such as lemon, lime, guava, apple, pineapple, and *Salak* [3], [11], [25],. The

content of vitamin C varied from one fruit to another, even between cultivars [31]–[33]. Pondoh Gading had the highest vitamin C content, which was not significantly different ($p<0.05$) from Pondoh Super variety (Table 2). Vitamin C levels of the six types of *salak* analyzed in this study were higher than those reported in the previous study [18].

TABLE II
CHEMICAL CHARACTERISTICS OF *SALAK* FRUIT FROM DIFFERENT VARIETIES

***Salak* varieties**	**Moisture content (%)**	**pH**	**Reducing sugar (% db)**	**Total soluble solid (°Brix)**	**Vitamin C (mg/g)**
Pondoh Super	80.51 ± 0.79^{ab}	4.42 ± 0.23^{bc}	30.64 ± 0.86^{a}	23.05 ± 0.38^{b}	1.58 ± 0.20^{ab}
Pondoh Madu	79.51 ± 0.79^{bc}	4.31 ± 0.23^{bc}	18.92 ± 0.39^{b}	22.75 ± 0.25^{bc}	1.10 ± 0.04^{bc}
Pondoh Gading	78.55 ± 0.79^{c}	4.15 ± 0.23^{c}	15.89 ± 0.51^{b}	22.80 ± 0.28^{bc}	1.66 ± 0.30^{a}
Sari Intan 48	81.75 ± 0.79^{a}	5.23 ± 0.23^{a}	14.42 ± 1.41^{b}	22.98 ± 0.12^{bc}	0.87 ± 0.31^{c}
Sari Intan 295	80.09 ± 0.79^{b}	4.66 ± 0.23^{b}	15.96 ± 0.63^{b}	23.82 ± 0.31^{a}	0.86 ± 0.11^{c}
Sari Intan 541	79.39 ± 0.79^{bc}	4.55 ± 0.23^{bc}	19.04 ± 6.65^{b}	22.55 ± 0.38^{c}	1.13 ± 0.14^{bc}

* The data displayed were the mean ± standard deviation. Mean values with the different letter in the same column were significantly different, $p < 0.05$.

TABLE III
SALAK FRUIT PREFERENCE TEST ON GENERAL PANELISTS

***Salak* varieties**	**Peel color**	**Flesh color**	**Texture**	**Aroma**	**Taste**	**Overall**
Pondoh Super	3.73 ± 0.77^{ab}	3.93 ± 0.61^{a}	3.67 ± 0.80^{a}	3.63 ± 0.48^{a}	3.56 ± 0.71^{b}	3.76 ± 0.58^{b}
Pondoh Madu	3.98 ± 0.69^{c}	3.85 ± 0.65^{a}	3.97 ± 0.83^{a}	3.73 ± 0.81^{a}	3.75 ± 0.86^{b}	3.79 ± 0.83^{b}
Pondoh Gading	3.78 ± 1.06^{bc}	3.83 ± 1.09^{a}	3.53 ± 1.02^{a}	3.58 ± 0.86^{a}	2.95 ± 1.01^{a}	3.26 ± 0.87^{a}
Sari Intan 48	3.43 ± 0.80^{a}	3.78 ± 0.61^{a}	3.92 ± 0.53^{a}	3.68 ± 0.75^{a}	3.77 ± 0.83^{b}	3.82 ± 0.67^{b}
Sari Intan 295	3.35 ± 0.65^{a}	3.70 ± 0.75^{a}	3.88 ± 0.87^{a}	3.60 ± 0.97^{a}	4.15 ± 0.79^{c}	3.82 ± 0.81^{b}
Sari Intan 541	3.48 ± 0.84^{ab}	3.65 ± 0.73^{a}	3.70 ± 0.95^{a}	3.45 ± 0.71^{a}	3.83 ± 0.92^{bc}	3.75 ± 0.80^{b}

*Values were presented as mean (n = 40) ± standard deviation; Score 1 = Very Dislike, 2 = Dislike, 3 = Neutral, 4 = Like, 5 = Very Like. Values with different superscript in the same column were significantly different ($p < 0.05$).

B. Sensory Characteristic of Salak Fruit

The preferences of panelists for the peel color, flesh color, texture, aroma, taste, and overall attributes of *salak* from various varieties were diverse (Table 3). Flesh color, texture, and aroma of the six *salak* varieties were not significantly different ($p>0.05$), indicating the similarity in those characteristics. On the other hand, significant differences ($p<0.05$) in the characteristic of *salak* fruit were observed in peel color, aroma, taste, and overall preference attribute.

The preference of panelists for the peel color of *salak* fruit ranged from 3.35 (somewhat like) to 3.98 (liked). Panelists preferred the peel color of Pondoh Madu with a score of 3.98, followed by Pondoh Gading and Pondoh Super. The peel color of Pondoh Madu was preferred due to its shiny brown appearance. The appearance of fruit peel color is one of consumers' most crucial sensory parameters. It is related to the decision-making process when purchasing the fruit.

Changes in fruit peel color are associated with maturity. In some fruits, this is an important quality indicator, and the plant pigments determine the color of the fruit skin and pulp, including chlorophyll (green), carotenoids (yellow and orange), anthocyanins (red, blue, and purple) [26]For *salak* varieties observed in this study, the peel with a lighter/shiny brown color was preferred to that with a dark brown color.

The flesh color of *salak* is generally yellowish white and turns to yellowish brown after storage [21]. According to Martins et al.[27], color is one of the parameters for evaluating food product and can confirm its quality. Foods with attractive colors create a positive impression, although they don't necessarily taste good. Panelists' preference for the color of *salak*'s flesh was not significantly different ($p<0.05$) between varieties. The flesh color of Pondoh Super is creamy white, Pondoh Madu is yellowish white with the inside of the fruit there is a liquid-like honey [27], pondoh Gading is yellowish white [27], Sari Intan 48 is yellowish white, Sari Intan 295 is lime white and Sari Intan 54 is yellowish cream. This result indicated that the white and yellowish-white color of the flesh were both positively preferred by the panelists. They represented a good quality *salak* fruit. The white flesh of the *salak* fruit was associated with a sweet taste and less bitterness [6] [26].

Panelists' levels of preference for the aroma of *salak* from different varieties were in the range of 3.45 to 3.73 (somewhat like) and no significant difference ($p>0.05$) was observed. The highest mean score of panelists' acceptance of aroma was obtained on the Pondoh Madu. Sari Intan 541 varieties had the lowest acceptance in terms of aroma. This was different from the result of the previous study. The aroma of Sari Intan 48, Sari Intan 541, and Sari Intan 295 were fragrant, while the aroma of Pondoh Super was less sharp [6]. According to Liu et al.[27], the volatile compounds identified in Pondoh Super were diverse. The volatiles of *salak* could be extracted using the supercritical fluid extraction (SFE) method and has the potential to be utilized in the pharmaceuticals and fragrances industries [28].

The texture of *Salak* is a very important factor to evaluate as it relates to its physical properties. The flesh of *salak* is firmer during maturation and becomes softer after maturation.[27]. The panelist's level of preference for the texture of several varieties of *salak* was in the range of 3.53 (somewhat like) to 3.92 (like). There was no significant difference ($p>0.05$) evaluated. Previous studies showed that the flesh texture of Sari Intan 48 is relatively soft, Sari Intan 541 is crunchy, and Pondoh Super is hard [16]. This indicated that the texture of *salak* fruit analyzed in this study might be in a similar firmness level, resulting in less variation of acceptance level by the panelist.

The sweet taste of *salak* is influenced by the variety and level of maturation [27]. The value of taste preference ranged from 2.95 (almost neutral) to 4.15 (like). The Panelists preferred the taste of Sari Intan 295. Other *salak* varieties had significantly lower acceptance ($p<0.05$). The results of this

sensory test were in agreement with the analysis of total soluble solids. Sari Intan 295 had the highest total soluble solids compared to other varieties of *salak*, which was 23.83 °Brix (Table 2).

The overall acceptance value of six varieties of *salak* fruit was in the range of 3.26 to 3.82 (somewhat like). Sari Intan 48 and Sari Intan 295 had the highest overall preference values but were not significantly different ($p>0.05$) from Pondoh Super, Pondoh Madu, and Sari Intan 541. Pondoh Gading had the lowest overall preference. This was in agreement with the previous research that the Sari Intan 295 had advantages in terms of fruit quality, namely thick flesh, no bitter taste, very sweet (total soluble solid was in a range of 19 – 21 °Brix), no sour taste, fragrant fruit aroma, slightly crunchy texture, blackish brown peel color, and creamy white flesh color.

C. Consumer Characteristic

Male and female consumers differ in their sensory assessment of a product. Knowing the character of consumers is important because their characteristics and social influence factors play in their buying decisions [29][28] [27]. In this study, we employed male (42,5%) and female (57,5%) panelists with three age categories, namely young (15 to 25 years old), adult (26 to 51 years old), and old (>51 years old) (Table 4)

TABLE IV
CHARACTERISTICS OF PANELIST

Variable	Category	Percentage (%)
Gender	Male	42.5
	Female	57.5
Age group (years)	Young (15-25)	35.0
	Adult (26-51)	30.0
	Old (>51)	35.0

1) Salak Fruit Preference Test on Male Panelists: Male panelists' assessment of six salak varieties showed a significant difference in taste attributes (Table 5). Male panelists preferred Sari Intan 541 because of its very sweet taste [16]Pondoh Gading was the least preferred variety due to its slightly sour taste. However, the male panelists' overall assessment of all varieties of *salak* was not significantly different ($p>0.05$).

TABLE V
SALAK FRUIT PREFERENCE TEST ON MALE PANELISTS

***Salak* Varieties**	**Peel color**	**Flesh color**	**Texture**	**Aroma**	**Taste**	**Overall**
Pondoh Super	3.53 ± 0.78^{a}	3.88 ± 0.58^{a}	3.47 ± 0.70^{a}	3.71 ± 0.46^{a}	3.59 ± 0.84^{b}	3.81 ± 0.63^{a}
Pondoh Madu	4.00 ± 0.77^{a}	3.82 ± 0.71^{a}	4.06 ± 0.80^{a}	3.65 ± 0.84^{a}	3.82 ± 0.86^{b}	3.82 ± 0.86^{a}
Pondoh Gading	3.29 ± 1.18^{a}	3.65 ± 1.13^{a}	3.35 ± 1.19^{a}	3.47 ± 0.92^{a}	2.82 ± 0.98^{a}	3.12 ± 0.96^{a}
Sari Intan 48	3.24 ± 0.88^{a}	3.76 ± 0.64^{a}	3.88 ± 0.47^{a}	3.59 ± 0.84^{a}	3.76 ± 0.88^{b}	3.71 ± 0.57^{a}
Sari Intan 295	3.24 ± 0.73^{a}	3.53 ± 0.92^{a}	3.82 ± 0.86^{a}	3.65 ± 1.08^{a}	3.88 ± 0.76^{b}	3.71 ± 0.82^{a}
Sari Intan 541	3.18 ± 0.78^{a}	3.71 ± 0.67^{a}	3.53 ± 0.98^{a}	3.35 ± 0.84^{a}	3.65 ± 1.08^{b}	3.47 ± 0.78^{a}

Remarks: Values were presented as mean (n=17) ± standard deviation; Score 1 = Very Dislike, 2 = Dislike, 3 = Neutral, 4 = Like, 5 = Very Like. Values with different superscript in the same column were significantly different ($p < 0.05$).

2) Salak Fruit Preference Test on Female Panelists: Female panelists' assessment of six varieties of *salak* showed differences in their preferences for peel color and taste (Table 6). A previous study [30] found that women have a better sense of smell than men. However, in this study, female panelists stated that there was no significant difference in the aroma of the six varieties of *salak* fruit. This indicated that the aroma of *salak* samples was similar. The most preferred peel color was Pondoh Gading, which was brownish yellow, and the most disliked was Sari Intan 295, which was blackish brown. This was in agreement with Djaafar et al. [5] and Zhao et al. [28]Female panelists preferred Sari Intan 295, which has a very sweet taste, and disliked Pondoh Gading because of its slightly sour taste. This was similar to the male panelists' results. Overall, sensory test results showed no significant difference between male and female panelists in terms of their preference for *salak* fruit. This was in agreement with the study of Hasanah et al.[30]. According to Effah-Manu [31], female or male, however, influenced preferences for pounded yam descriptors such as mouldability, lumpiness, and color. However, in this case, the preference of *Salak* by panelists was gender insensitive.

TABLE VI
SALAK FRUIT PREFERENCE TEST ON FEMALE PANELISTS

***Salak* Varieties**	**Peel color**	**Flesh color**	**Texture**	**Aroma**	**Taste**	**Overall**
Pondoh Super	3.87 ± 0.74^{ab}	3.96 ± 0.62^{a}	3.82 ± 0.83^{a}	3.57 ± 0.50^{a}	3.55 ± 0.58^{b}	3.73 ± 0.54^{a}
Pondoh Madu	3.96 ± 0.62^{ab}	3.87 ± 0.61^{a}	3.91 ± 0.85^{a}	3.78 ± 0.78^{a}	3.70 ± 0.86^{b}	3.76 ± 0.81^{a}
Pondoh Gading	4.13 ± 0.80^{b}	3.96 ± 1.04^{a}	3.65 ± 0.87^{a}	3.65 ± 0.81^{a}	3.05 ± 1.02^{a}	3.36 ± 0.77^{a}
Sari Intan 48	3.57 ± 0.71^{a}	3.78 ± 0.59^{a}	3.95 ± 0.56^{a}	3.74 ± 0.67^{a}	3.77 ± 0.79^{b}	3.91 ± 0.73^{a}
Sari Intan 295	3.43 ± 0.58^{a}	3.83 ± 0.56^{a}	3.91 ± 0.88^{a}	3.57 ± 0.88^{a}	4.35 ± 0.76^{c}	3.91 ± 0.79^{a}
Sari Intan 541	3.70 ± 0.80^{ab}	3.61 ± 0.77^{a}	3.83 ± 0.92^{a}	3.52 ± 0.58^{a}	3.96 ± 0.75^{b}	3.96 ± 0.75^{a}

Remarks: Values were presented as mean (n=23) ± standard deviation; Score 1 = Very Dislike, 2 = Dislike, 3 = Neutral, 4 = Like, 5 = Very Like. Values with different superscript in the same column were significantly different ($p < 0.05$).

3) *Sensory characteristics of salak fruit according to the age of the panelists:* The panelists aged between 15 to 25 years gave different values for the peel color and taste attribute (Table 7). Other parameters such as flesh color, texture, aroma, and overall were not significantly different ($p<0.05$). Young panelists preferred the Pondoh Super and Pondoh Madu peel color, which had a combination of yellow and brown color. The young panelists gave a taste value ranging from 2.79±0.56 to 4.00±0.85. They were found to be sensitive to sour and sweet taste. Pondoh Gading was disliked

due to its slightly sour taste. Meanwhile, the highest taste value was Sari Intan 295 because of its sweeter taste. Panelists aged 26 to 51 gave preference values that were not significantly different for all tested parameters (Table 8). But overall, they gave the highest preference value to *salak* fruit Sari Intan 48 and Sari Intan 295. This indicated that these consumers are less selective in this age range. They may be more tolerant of a sour tastthanto young and senior panelists. Senior panelists (>51 years old) were more selective in terms of the taste attribute of *salak* fruit. This showed that the consumer's age significantly affects their preferences for the *salak* fruit. This might be attributed to the changes of sensitivity in the sensory receptors during aging [32].

TABLE VII
SALAK PREFERENCE TEST ON YOUNG PANELISTS (15 TO 25 YEARS OLD)

***Salak* Varieties**	**Peel color**	**Flesh color**	**Texture**	**Aroma**	**Taste**	**Overall**
Pondoh Super	4.07 ± 0.59^{b}	3.93 ± 0.46^{a}	3.64 ± 0.72^{a}	3.64 ± 0.48^{a}	3.50 ± 0.50^{ab}	3.71 ± 0.45^{a}
Pondoh Madu	4.00 ± 0.38^{b}	3.93 ± 0.59^{a}	3.64 ± 0.61^{a}	3.71 ± 0.70^{a}	3.57 ± 0.73^{ab}	3.79 ± 0.77^{a}
Pondoh Gading	3.57 ± 0.98^{ab}	3.29 ± 1.16^{a}	3.21 ± 0.94^{a}	3.29 ± 0.88^{a}	2.79 ± 0.56^{a}	3.21 ± 0.86^{a}
Sari Intan 48	3.57 ± 0.62^{ab}	3.50 ± 0.63^{a}	3.79 ± 0.41^{a}	3.36 ± 0.61^{a}	3.29 ± 0.88^{a}	3.57 ± 0.73^{a}
Sari Intan 295	3.43 ± 0.49^{a}	3.64 ± 0.48^{a}	3.57 ± 0.73^{a}	3.21 ± 0.77^{a}	4.00 ± 0.85^{b}	3.64 ± 0.72^{a}
Sari Intan 541	3.57 ± 0.62^{ab}	3.43 ± 0.49^{a}	3.14 ± 0.64^{a}	3.14 ± 0.74^{a}	3.50 ± 0.63^{ab}	3.50 ± 0.63^{a}

Remarks: Values were presented as mean (n=14) ± standard deviation; Score 1 = Very Dislike, 2 = Dislike, 3 = Neutral, 4 = Like, 5 = Very Like. Values with different superscript whitin the same column differed significantly ($p < 0.05$).

TABLE VIII
SALAK PREFERENCE TEST ON ADULT PANELISTS (26 TO 51 YEARS OLD)

***Salak* varieties**	**Peel color**	**Flesh color**	**Texture**	**Aroma**	**Taste**	**Overall**
Pondoh Super	3.58 ± 0.49^{a}	3.67 ± 0.62^{a}	3.45 ± 0.50^{a}	3.50 ± 0.50^{a}	3.73 ± 0.62^{a}	3.91 ± 0.51^{a}
Pondoh Madu	4.00 ± 0.58^{a}	3.67 ± 0.47^{a}	4.00 ± 1.04^{a}	3.83 ± 0.90^{a}	3.75 ± 0.92^{a}	3.73 ± 0.86^{a}
Pondoh Gading	3.75 ± 1.09^{a}	4.00 ± 1.00^{a}	4.00 ± 0.91^{a}	3.67 ± 0.75^{a}	3.27 ± 1.29^{a}	3.09 ± 0.90^{a}
Sari Intan 48	3.42 ± 0.64^{a}	3.83 ± 0.55^{a}	3.91 ± 0.51^{a}	3.83 ± 0.69^{a}	4.00 ± 0.60^{a}	4.00 ± 0.60^{a}
Sari Intan 295	3.42 ± 0.49^{a}	3.92 ± 0.86^{a}	4.42 ± 0.64^{a}	4.42 ± 0.76^{a}	4.25 ± 0.60^{a}	4.18 ± 0.72^{a}
Sari Intan 541	3.50 ± 0.65^{a}	3.42 ± 0.86^{a}	3.75 ± 1.01^{a}	3.58 ± 0.64^{a}	3.58 ± 1.04^{a}	3.83 ± 0.80^{a}

Remarks: Values were presented as mean (n=12) ± standard deviation; Score 1 = Very Dislike, 2 = Dislike, 3 = Neutral, 4 = Like, 5 = Very Like. Values with different superscript in the same column were significantly different ($p < 0.05$).

TABLE IX
SALAK PREFERENCE TEST ON SENIOR PANELISTS (OVER 51 YEARS OLD)

***Salak* varieties**	**Peel color**	**Flesh color**	**Texture**	**Aroma**	**Taste**	**Overall**
Pondoh Super	3.50 ± 0.98^{a}	4.14 ± 0.64^{a}	3.86 ± 0.99^{a}	3.71 ± 0.45^{a}	3.50 ± 0.91^{a}	3.69 ± 0.72^{a}
Pondoh Madu	3.93 ± 0.96^{a}	3.93 ± 0.80^{a}	4.29 ± 0.70^{a}	3.64 ± 0.81^{a}	3.93 ± 0.88^{ab}	3.85 ± 0.86^{a}
Pondoh Gading	4.00 ± 1.07^{a}	4.21 ± 0.86^{a}	3.43 ± 1.05^{a}	3.79 ± 0.86^{a}	2.86 ± 1.06^{a}	3.43 ± 0.82^{a}
Sari Intan 48	3.29 ± 1.03^{a}	4.00 ± 0.53^{a}	4.07 ± 0.59^{a}	3.86 ± 0.83^{a}	4.07 ± 0.70^{ab}	3.93 ± 0.59^{a}
Sari Intan 295	3.21 ± 0.86^{a}	3.57 ± 0.82^{a}	3.71 ± 0.96^{a}	3.29 ± 0.88^{a}	4.21 ± 0.86^{b}	3.71 ± 0.88^{a}
Sari Intan 541	3.36 ± 1.11^{a}	4.07 ± 0.59^{a}	4.21 ± 0.86^{a}	3.64 ± 0.61^{a}	4.36 ± 0.81^{b}	3.93 ± 0.88^{a}

Remarks: Values were presented as mean (n=14) ± standard deviation; Score 1 = Very Dislike, 2 = Dislike, 3 = Neutral, 4 = Like, 5 = Very Like. Values with different superscript in the same column were significantly different ($p < 0.05$).

IV. CONCLUSION

As evaluated in this study, *Salak* fruit in Indonesia had diverse characteristics. They had significant variation in their chemical content and physical properties. This diversity affected consumer preferences for the fruit. From the results of this study, the occurrence of a sour taste was the main reason affecting the consumer's acceptance. The plant-breeding strategy of *Salak* can be focused on obtaining *salak* with high sweetness, less astringent, and sour taste. Furthermore, the product development from *Salak* should consider the market segment since the consumer's age significantly affects its acceptance.

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REFERENCES

[1] Badan Pusat Statistik, *Statistic year book of Indonesia 2020*, vol. 1101001. BPS Statistic Indonesia, 2020. [Online]. Available: https://www.bps.go.id/publication/2020/04/29/e9011b3155d45d70823c141f/statistik-indonesia-2020.html.

[2] R. Prihatini, D. Dinarti, A. Sutanto, and Sudarsono, "Development of Hermaphrodite Salacca (Salacca zalacca) SNAP Marker: A Novel Conservation Tool," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1105, no. 1, 2022, doi: 10.1088/1755-1315/1105/1/012030.

[3] I. K. Sumantra *et al.*, "Agronomic Characters and Quality of Fruit of Salak cv. Gulapasir Planted in Various Agro-Ecosystems," *Jordan J. Biol. Sci.*, vol. 16, no. 2, pp. 207–221, 2023, doi:10.54319/jjbs/160205.

[4] T. Atmowidi, S. Kahono, Dorly, S. D. Rahmawati, D. Reinaldo, and E. S. Ummah, "The diversity of insect visitors on Indonesian salacca (salacca spp.) in mekarsari fruits garden, Bogor, Indonesia," *Acta Univ. Agric. Silvic. Mendelianae Brun.*, vol. 69, no. 2, pp. 267–273, 2021, doi: 10.11118/actaun.2021.024.

[5] T. F. Djaafar *et al.*, "Mutu Fisik Buah Salak Pondoh (Salacca edulis Reinw): Pengaruh Pelilinan dan Pengemasan Menggunakan Kantong Plastik Low Density Polyethylene," *agriTECH*, vol. 42, no. 2, p. 113, 2022, doi: 10.22146/agritech.55376.

[6] S. Hadiati, T. Budiyanti, M. Istianto, and M. Firiani, "Efek Urine Sapi terhadap Keberhasilan Cangkok Salak [Effects of Cow Urine on Salak Graft Success]," *J. Budid. Pertan.*, vol. 16, no. 1, pp. 61–64, Jun. 2020, doi: 10.30598/jbdp.2020.16.1.61.

[7] C. Marques, E. Correia, L.-T. Dinis, and A. Vilela, "An Overview of Sensory Characterization Techniques : Profiling Methods," *Foods*, vol. 11, no. 3, p. 255, 2022, doi: 10.3390/foods11030255.
[8] F. D. Mihafu, J. Y. Issa, and M. W. Kamiyango, "Implication of sensory evaluation and quality assessment in food product development: A review," *Curr. Res. Nutr. Food Sci.*, vol. 8, no. 3, pp. 690–702, 2020, doi: 10.12944/CRNFSJ.8.3.03.
[9] M. A. Drake, M. E. Watson, and Y. Liu, "Sensory Analysis and Consumer Preference: Best Practices," *Annu. Rev. Food Sci. Technol.*, vol. 14, no. March, pp. 427–448, 2023, doi: 10.1146/annurev-food-060721-023619.
[10] I. Mulyawanti, S. M. Widayanti, K. T. Dewandari, and E. S. Iriani, "The Effect of Packaging Methods on Characteristics of Zalacca During Storage," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1024, no. 1, 2022, doi: 10.1088/1755-1315/1024/1/012030.
[11] M. Mohd Ali, N. Hashim, S. Abd Aziz, and O. Lasekan, "Pineapple (Ananas comosus): A comprehensive review of nutritional values, volatile compounds, health benefits, and potential food products," *Food Res. Int.*, vol. 137, p. 109675, 2020, doi:10.1016/j.foodres.2020.109675.
[12] Kementerian Pertanian "Ministry of Agriculture," "Lampiran Keputusan Menteri Pertanian No 272/Kpts/TP.240/4/1988 [Appendix Decree of the Minister of Agriculture No 272/Kpts/TP.240/4/1988]," 1988.
[13] Kementerian Pertanian "Ministry of Agriculture," "Lampiran Keputusan Menteri Pertanian No 122/Kpts/LB.240/2/2004 [Appendix of Decree of Ministry og AgricultureNo 122/Kpts/LB.240/2/2004]," |p. 1, 2004.
[14] Kementerian Pertanian "Ministry of Agriculture," "Lampiran Keputusan Menteri Pertanian [Decree of Ministry of Agriculture]," 2000.
[15] Kementerian Pertanian "Ministry of Agriculture," "Lampiran Keputusan Menteri Pertanian No 3510/Kpts/SR.120/10/2009 [Appendix of Decree of Ministry Agriculture No 3510/Kpts/SR.120/10/2009]," 2009.
[16] Kementerian Pertanian, "Lampiran Keputusan Menteri Pertanian, 'Appendix of Ministry of Agriculture Decree,'" 2010.
[17] Kementerian Pertanian "Ministry of Agriculture," "Lampiran Keputusan Menteri Pertanian No 3511/Kpts/SR.120/10/2009 [Appendix of Decree of Ministry of Agriculture No 3511/Kpts/SR.120/10/2009]," p. 1, 2009.
[18] T. Sarkar, M. Salauddin, S. Kumar Hazra, and R. Chakraborty, "A novel data science application approach for classification of nutritional composition, instrumental colour, texture and sensory analysis of bael fruit (Aegle marmelos (L) correa)," *Int. J. Intell. Networks*, vol. 1, no. May, pp. 59–66, 2020, doi: 10.1016/j.ijin.2020.07.003.
[19] M. AL-Rawas *et al.*, "Water sorption, solubility, degree of conversion, and surface hardness and topography of flowable composite utilizing nano silica from rice husk," *J. Mater. Res. Technol.*, vol. 15, pp. 4173–4184, 2021, doi: 10.1016/j.jmrt.2021.10.024.
[20] Kementerian Pertanian "Ministry of Agriculture," "Lampiran Keputusan Menteri Pertanian No 2082/Kpts/SR.120/5/2010 [Appendix of Decree of Ministry of Agriculture No 2082/Kpts/SR.120/5/2010]," 2010.
[21] S. Phothisuwan, P. Koomhin, N. Matan, and N. Matan, "Quality maintenance of salacca fruit with a carnauba wax coating containing orange oil and detection of sensory perception improvement with electroencephalography to appraise brain responses," *Lwt*, vol. 147, no. April, p. 111628, 2021, doi: 10.1016/j.lwt.2021.111628.
[22] H. Zhong *et al.*, "Comprehensive metabolomics-based analysis of sugar composition and content in berries of 18 grape varieties," *Front. Plant Sci.*, vol. 14, no. June, pp. 1–14, 2023, doi:10.3389/fpls.2023.1200071.
[23] T. Budiyanti, S. Hadiati, D. Fatria, and T. Budiyanti, "Evaluation and selection of salacca hybrid population based on fruit characters," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 497, no. 1, 2020, doi:10.1088/1755-1315/497/1/012005.
[24] E. J. Ordoñez Trejo, S. Brizzolara, V. Cardillo, B. Ruperti, C. Bonghi, and P. Tonutti, "The impact of PGRs applied in the field on the postharvest behavior of fruit crops," *Sci. Hortic. (Amsterdam).*, vol. 318, no. April, 2023, doi: 10.1016/j.scienta.2023.112103.
[25] H. Chen, H. Lin, X. Jiang, M. Lin, and Z. Fan, "Amelioration of chilling injury and enhancement of quality maintenance in cold-stored guava fruit by melatonin treatment," *Food Chem. X*, vol. 14, no. December 2021, p. 100297, 2022, doi: 10.1016/j.fochx.2022.100297.
[26] A. P. Yasmin, "Hubungan beberapa Faktor Tanah dengan Tingkat Kemanisan Buah Salak Pondoh (Salacca zalacca Gaertner Voss.) di Kecamatan Sinembah Relationship between some Soil Factors and the Sweetness Level of Salak Pondoh Fruit (Salacca zalacca Gaertner Voss.) in the," Universitas Sumatera Utara, 2022.
[27] M. M. Martins, E. Saldaña, A. C. B. Teixeira, M. M. Selani, and C. J. Contreras-Castillo, "Going beyond sensory and hedonic aspects: A Brazilian study of emotions evoked by beef in different contexts," *Meat Sci.*, vol. 180, no. May, 2021, doi:10.1016/j.meatsci.2021.108536.
[28] Z. Zhao *et al.*, "Comprehensive evaluation of aroma and taste properties of different parts from the wampee fruit," *Food Chem. X*, vol. 19, no. July, p. 100835, 2023, doi: 10.1016/j.fochx.2023.100835.
[29] A. Berri and L. Toma, "Factors influencing consumer use of social supermarkets in the UK: A redistribution model providing low-cost surplus food," *Clean. Responsible Consum.*, vol. 10, no. July, p. 100133, 2023, doi: 10.1016/j.clrc.2023.100133.
[30] Y. T. Chao, D. Woosch, M. Pieniak, and T. Hummel, "Gender difference in ratings of odor intensity during olfactory training," *J. Sens. Stud.*, vol. 37, no. 6, pp. 1–9, 2022, doi: 10.1111/joss.12784.
[31] L. Effah-Manu, F. D. Wireko-Manu, J. K. Agbenorhevi, B. Maziya-Dixon, and I. N. Oduro, "Gender-Disaggregated Consumer Testing and Descriptive Sensory Analysis of Local and New Yam Varieties," *Foods*, vol. 12, no. 3, 2023, doi: 10.3390/foods12030537.
[32] W. S. Choi and H. S. Seo, "Effects of Age Group, Gender, and Consumption Frequency on Texture Perception and Liking of Cooked Rice or Bread," *Foods*, vol. 12, no. 9, pp. 1–19, 2023, doi:10.3390/foods12091793.