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Sensory Attribute Scores of Yogurt With Different Levels of Cilembu Sweet Potato Puree

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Abstract. *Sweet potato puree can modify the color, aroma, taste, and consistency of fermented dairy products through changes in pigment, soluble-solid, and starch contributions. This study evaluated sensory attribute scores of yogurt containing Cilembu sweet potato (Ipomoea batatas (L.) Lam. 'Cilembu') at four reported formulation levels: P0 = 0%, P1 = 15%, P2 = 30%, and P3 = 45%. Each formulation contained 250 mL UHT milk, 10% (v/v) commercial yogurt starter, and 5% sugar as reported in the source protocol. The percentage basis for sweet potato and sugar and the independence of three nominal production replications were not documented sufficiently for reconstruction. Cilembu roots were baked at 150 °C for 90 min, converted to puree, incorporated into the milk base, pasteurized at 70 °C for 15 min, cooled to 40-45 °C, inoculated, and incubated at 28 °C for 8 h. Twenty-five panelists scored yellow color intensity, characteristic yogurt aroma, taste palatability, and thickness on four-point scales. The source analysis reported one-way ANOVA followed by Tukey's HSD. P3 had the highest mean for all four attributes: yellow color 3.53, yogurt aroma 3.39, taste 3.62, and thickness 3.28. However, P3 did not differ from P2 for color and did not differ from P1 or P2 for aroma; P3 was reported as distinct from all other treatments for taste and thickness. Thus, 45% produced the highest observed scores within the tested range, but it cannot be described as an optimum concentration or as evidence of functional-health benefits.*

Keywords: ***Cilembu sweet potato; sensory scoring; sweet potato puree; yogurt; yogurt texture.***

INTRODUCTION

Yogurt is a fermented dairy product whose sensory quality depends strongly on formulation, fermentation conditions, total solids, flavor development, and gel structure (Lee & Lucey, 2010; Aryana & Olson, 2017). Plant-derived ingredients are increasingly incorporated into yogurt to diversify color, flavor, texture, and product identity, but their effects are formulation-specific and should be evaluated using sensory methods that match the question being asked.

Cilembu sweet potato is a cultivar of sweet potato (*Ipomoea batatas* (L.) Lam. 'Cilembu') valued for its characteristic sweetness after heating. Sweet potato roots contain starch, simple sugars, carotenoids, phenolic compounds, and other constituents that vary among genotypes and processing conditions (Teow et al., 2007; Truong et al., 2007; Wang et al., 2016). Sweet potato starch also has distinctive swelling and pasting behavior that can influence viscosity and textural perception when incorporated into food matrices (Zhu & Wang, 2014).

In yogurt systems, increasing total solids or incorporating starch-rich ingredients can change viscosity, gel strength, syneresis, mouthfeel, and perceived thickness. Starch swelling and protein-starch interactions can increase firmness and thickness up to formulation-dependent levels, while excessive solids or hydrocolloid addition can also create undesirable cohesiveness or mouthfeel (Nguyen et al., 2017; Wong et al., 2020; Khubber et al., 2021; Arab et al., 2023). A recent study using steamed purple sweet

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potato likewise reported that sweet-potato addition modified both physicochemical and sensory properties of yogurt (Aulia et al., 2026).

Sensory interpretation also depends on the scale used. Hedonic scales ask how much a product is liked, whereas intensity or quality scales measure how strong or characteristic an attribute is. These concepts should not be interchanged because a more intense yellow color or a thicker texture is not necessarily more preferred (Hein et al., 2008; Silva et al., 2013). When the same panelists evaluate several products, observations are also repeated within assessor and the analysis should account for within-panelist dependence or assessor effects (Schlich, 1993; Jones & Wang, 2000; Brockhoff et al., 2015).

The source study used four-point attribute-specific scales: yellow color intensity, characteristic yogurt aroma, taste palatability, and thickness. Accordingly, the present revision treats the data as sensory attribute scores rather than as a single measure of consumer acceptance. The objective was to compare these four scores among yogurt formulations containing 0-45% reported Cilembu sweet potato puree and to identify the formulation with the highest observed scores within the tested range.

MATERIAL AND METHODS

Study Site and Period

The study was conducted from January to May 2026 at the Agricultural Product Processing Laboratory of Gowa Agricultural Development Polytechnic, Romang Lompoa, Bontomarannu District, Gowa Regency, South Sulawesi, Indonesia.

Materials

The main ingredients were UHT milk (Greenfields), commercial yogurt starter (Biokul), granulated sugar, and Cilembu sweet potato. The source protocol states 250 mL milk per formulation, 10% (v/v) starter, 5% sugar, and Cilembu sweet potato at the assigned treatment level. The denominator for the starter and sugar percentages was not fully specified in the archived manuscript.

Experimental Design and Formulation

The study was described as a one-factor completely randomized design with four sweet-potato treatment levels and three nominal replications, producing 12 nominal production units. However, the source record does not establish whether the three replications were independent yogurt batches produced separately or repeated subsamples from a common batch. This uncertainty limits interpretation of the production-level replication.

Table 1. Operational formulation labels used in the source study

Treatment	Reported Cilembu puree level	UHT milk	Starter	Sugar
P0	0%	250 mL	10% (v/v)	5%
P1	15%	250 mL	10% (v/v)	5%
P2	30%	250 mL	10% (v/v)	5%
P3	45%	250 mL	10% (v/v)	5%

Note: The source manuscript states that Cilembu levels were percentages 'of ingredient weight', but does not define whether the denominator was milk mass, total mix mass, or final product mass. Actual puree mass per unit and final total mass were not retained; therefore, no gram values were invented.

Preparation of Cilembu Sweet Potato Puree

Cilembu sweet potatoes were selected for visually uniform size and acceptable physical condition, washed under running water, and drained. The oven was preheated at 150 °C for 10 min. Roots were then baked at 150 °C for 90 min and turned every 30 min. After cooling, the peel was removed and the flesh was blended to obtain a homogeneous puree. Initial root mass, final puree yield, soluble-

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solids content, moisture content, and puree storage conditions were not documented.

Yogurt Production

For each treatment, 250 mL UHT milk was combined with the assigned Cilembu puree level and 5% sugar as recorded in the source protocol. The mixture was homogenized and heated at 70 °C for 15 min, cooled for approximately 30 min to 40-45 °C, inoculated with 10% commercial yogurt starter, and incubated at 28 °C for 8 h. The source record does not state container capacity, final mixture mass, how fermentation temperature was controlled, whether each replication was produced on a different day, or the duration and temperature of refrigerated storage before sensory evaluation.

Sensory Attribute Scoring

Twenty-five panelists evaluated coded samples using four-point scales. The archived record does not identify panelists as trained or untrained and does not document selection criteria, serving portion, serving temperature, palate cleanser, testing-room conditions, or whether presentation order was randomized. Only sample coding was explicitly described as random. These omissions should be addressed in future replication.

Table 2. **Sensory attributes and score meanings**

Attribute	Four-point scale	Interpretive type
Yellow color intensity	1 = not yellow; 2 = slightly yellow; 3 = yellow; 4 = very yellow	Intensity/quality
Characteristic yogurt aroma	1 = no characteristic yogurt aroma; 2 = weak; 3 = characteristic; 4 = very characteristic	Intensity/quality
Taste	1 = unpleasant; 2 = less pleasant; 3 = pleasant; 4 = very pleasant	Palatability/liking-oriented
Thickness	1 = not thick; 2 = slightly thick; 3 = thick; 4 = very thick	Intensity/quality

Note: Because color, aroma, and thickness scales primarily describe intensity or quality rather than liking, their scores are not interpreted as consumer acceptance.

Statistical Interpretation

The source manuscript reports one-way ANOVA followed by Tukey's HSD at $\alpha = 0.05$ and provides treatment means with Tukey letter groupings. Exact F statistics, degrees of freedom, p values, panelist-level scores, and dispersion measures were not retained. In addition, the source does not explain how 25 panelists were linked to three nominal production replications. Therefore, the reported mean groupings are preserved but not re-estimated. If the original panelist-level data can be recovered, a repeated-measures or mixed-effects model with panelist as a blocking/random effect would be more appropriate when the same panelists assessed all formulations (Schlich, 1993; Jones & Wang, 2000; Brockhoff et al., 2015). Because the response scales are bounded and partly ordinal, model assumptions should also be checked (Silva et al., 2013).

RESULTS AND DISCUSSION

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The source analysis reported treatment differences for all four sensory attributes. Mean scores increased numerically as the reported Cilembu puree level increased, but the post-hoc pattern differed among attributes. P3 had the highest mean for every attribute, yet it was not statistically separated from all lower treatments for color or aroma (Table 3).

Table 3. **Reported sensory attribute scores of yogurt with Cilembu sweet potato puree**

Attribute	P0 (0%)	P1 (15%)	P2 (30%)	P3 (45%)	Reported ANOVA
Yellow color	1.91 a	2.31 a	3.23 b	3.53 b	$p < 0.01$
Yogurt aroma	2.27 a	2.58 ab	3.07 ab	3.39 b	$p < 0.05$
Taste	1.36 a	1.96 b	3.06 c	3.62 d	$p < 0.01$
Thickness	2.35 a	2.54 b	3.08 c	3.28 d	$p < 0.01$

Note: Different lowercase letters within a row reproduce the Tukey grouping shown in the source figures. The aroma mean for P3 was standardized to 3.39 because the source graph, abstract, and conclusion agree on 3.39, whereas 3.93 appeared once in the narrative and was treated as a transcription error. SD/SE values were not available and were not fabricated.

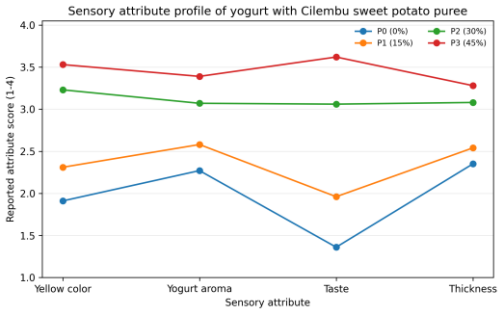


Figure 1. Reported sensory attribute profile of yogurt containing 0-45% Cilembu sweet potato puree.

The graph visualizes source means only. Error bars are not shown because panelist-level or replicate-level dispersion data were not retained in the source manuscript. Statistical interpretation should therefore rely on the reported Tukey groupings in Table 3.

Discussion

The color result primarily reflects yellow-color intensity, not color liking. P3 had the highest mean (3.53), but P3 and P2 shared the same Tukey group. The numerical increase is compatible with the larger contribution of sweet-potato pigments and heat-induced color compounds as more puree was incorporated. Sweet potato carotenoid and phenolic profiles vary markedly among genotypes (Teow et al., 2007; Wang et al., 2016), but pigment concentration was not measured in this experiment. Therefore, the mechanism should be described as plausible rather than demonstrated.

Aroma showed the weakest statistical separation. P3 had the highest mean (3.39), yet P1, P2, and P3 overlapped statistically, while P3 differed only from P0. Yogurt aroma is shaped by multiple volatile compounds including acetaldehyde, diacetyl, acetoin, acids, alcohols, and esters, and their concentrations depend on culture, raw materials, processing, and storage (Cheng, 2010; Tian et al., 2020). Because no volatile compounds were measured, the present data establish only a change in the panelists' rating of characteristic yogurt aroma.

Taste was the only attribute assessed with a scale that directly reflected palatability. P3 obtained the highest mean taste score (3.62) and was reported as significantly different from all other formulations. The increase may be related to the sweetness and flavor contribution of baked Cilembu puree, but the experimental formulation does not allow that effect to be isolated from changes in total product solids. The puree mass increased while 250 mL milk was held constant, and the denominator of the reported percentage was not defined. Consequently, P1-P3 may have differed in both sweet-potato proportion and total solids.

Thickness scores also increased and P3 was reported as distinct from the lower treatments. This response is technologically plausible because sweet potato is rich in

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starch, and starch swelling can increase viscosity, firmness, and perceived thickness in yogurt systems (Zhu & Wang, 2014; Wong et al., 2020). Studies with hydrocolloids likewise show strong links between solids, rheology, and sensory texture (Nguyen et al., 2017; Khubber et al., 2021; Arab et al., 2023). However, the present study measured perceived thickness only; viscosity, syneresis, water-holding capacity, and gel strength were not measured.

The use of baked sweet potato is relevant because cooking changes starch organization and can alter the availability of sugars and phenolic compounds. Sweet-potato composition and processing effects are well documented (Truong et al., 2007; Wang et al., 2016), but this study did not quantify sugars, starch gelatinization, carotenoids, phenolics, or moisture after baking. These characteristics should therefore not be presented as measured explanations for the sensory response.

The source manuscript originally described the product as 'functional yogurt' and discussed antioxidant, prebiotic, immune, and lactic-acid-bacteria effects. Those claims are beyond the experimental evidence. No antioxidant activity, nutrient composition, pH, titratable acidity, viable LAB count, prebiotic response, or health endpoint was measured. The revision therefore restricts the scope to sensory attributes. A direct sweet-potato-yogurt study has shown that sweet-potato incorporation can affect both sensory and physicochemical properties, but such broader claims require those endpoints to be measured explicitly (Aulia et al., 2026).

The sensory instrument itself imposes an important interpretive limitation. The yellow-color, characteristic-aroma, and thickness scales are attribute-intensity or quality scales, not hedonic acceptance scales. A higher score means more yellow, more characteristic yogurt aroma, or thicker, but does not necessarily mean more liked. Sensory studies distinguish acceptance/preference measurements from descriptive or intensity measurements because the statistical and product-development interpretations differ (Hein et al., 2008; Silva et al., 2013). Thus, the present dataset cannot support a general statement that P3 was the 'most accepted' formulation across all sensory dimensions.

The statistical structure also requires caution. If the same 25 panelists evaluated all four formulations, their observations are correlated within assessor. Repeated-measures or mixed-effects approaches can represent this dependence and separate product effects from assessor-to-assessor variation (Schlich, 1993; Jones & Wang, 2000; Brockhoff et al., 2015). The archived manuscript does not contain panelist-level scores or enough information to reconstruct such an analysis, so the original Tukey groupings are retained without claiming that the inferential model has been independently validated.

Product formulation should also be standardized in a follow-up experiment. Contemporary yogurt research demonstrates that fruit puree, starch, and hydrocolloid concentration can change texture, flavor perception, and dynamic sensory responses, but comparisons are strongest when final mass, total solids, and processing are controlled (Chadha et al., 2024; Wong et al., 2020). Future formulations should specify puree grams per 100 g final mix, sugar grams per 100 g final mix, starter volume per final milk base, and equalize total product mass or total solids where appropriate.

Overall, 45% produced the highest observed means within the range tested, with the clearest statistical superiority for taste and thickness. It should not be called an optimum concentration because higher levels were not tested and color and aroma did not show unique superiority at 45%. A stronger product-development study should combine a genuine hedonic scale with descriptive/intensity ratings, randomized serving order, documented panelist characteristics, independent production batches, pH, acidity, viscosity, syneresis, viable starter counts, and a mixed-effects statistical model.

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CONCLUSION

Increasing the reported Cilembu sweet potato puree level from 0% to 45% increased the mean scores for yellow color intensity, characteristic yogurt aroma, taste palatability, and thickness. P3 (45%) had the highest means for color (3.53), aroma (3.39), taste (3.62), and thickness (3.28). However, P3 was not significantly different from P2 for color and was not significantly different from P1 or P2 for aroma, whereas the source Tukey analysis separated P3 from all lower treatments for taste and thickness. Therefore, 45% can be described as the formulation with the highest observed scores within the tested range, not as a proven optimum concentration or as the most accepted formulation for every sensory dimension. Because the study did not measure nutritional functionality, antioxidant activity, prebiotic effects, viable lactic acid bacteria, or health outcomes, the product should not be described as a functional yogurt on the basis of these data alone. Future work should define the formulation on a final-mass basis, use independently produced replicates, apply appropriate assessor-aware statistical analysis, and combine hedonic testing with physicochemical measurements.

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