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EFFECT OF TWEEN 80 CMC FORMULATION ON SENSORY QUALITY AND SHELF-LIFE ESTIMATION OF LIQUID COCONUT MILK

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Abstract

This study evaluated the sensory quality and estimated the shelf life of liquid coconut milk formulated with Tween 80 and carboxymethyl cellulose (CMC) using a hedonic test within an Accelerated Shelf Life Testing (ASLT) framework. A two-factor factorial completely randomized design (CRD), comprising six formulations (P1–P6) and two storage temperatures (X1 and X2), was conducted with three replicates at the Food Processing and Quality Analysis Laboratory, Sambas State Polytechnic, from May to August 2026. The coconut milk was pasteurized at 70–75 °C for 15 min and then stored under X1 (ambient temperature, 27–30 °C) and X2 (refrigerated temperature, 0–4°C). A nine-point hedonic test involving 25–30 semi-trained panelists assessed color, aroma, taste, texture, and overall acceptability on days 0, 3, 5, and 7. The acceptance threshold was set at an overall score of ≥5.0. Initial overall scores ranged from 6.90 to 7.24 and remained above the cutoff through day 3, but fell below 5.0 by day 5. The effects of formulation, temperature, and their interaction were not statistically significant from day 0 through day 5, but were highly significant on day 7. Regression-based estimates indicated a sensory shelf life of 4.64–4.85 days under X1 and 4.87–6.20 days under X2, with formulation P3 (2 g Tween 80 : 2 g CMC per kg) under X2 showing the longest estimated shelf life. These findings indicate that cold-chain management and a hedonic cutoff of 5.0 can serve as operational references for estimating the sensory shelf life of stabilized pasteurized coconut milk.

Keywords: accelerated shelf-life testing; CMC; hedonic test; liquid coconut milk; Tween 80

INTRODUCTION

Demand for coconut-milk-based products has increased alongside the wider consumption of plant-based foods and the diversification of coconut products in domestic and global markets. Maintaining quality during distribution and storage is a critical issue because coconut milk emulsions are susceptible to phase separation, aroma changes, and declining consumer acceptance (Beegum et al., 2025; Chen et al., 2024a; Deng et al., 2024). These changes make sensory evaluation a practical indicator that directly reflects consumer perceptions of product quality. This broader context highlights the need to investigate the sensory-based shelf life of liquid coconut milk.

Locally extracted liquid coconut milk often has a short shelf life when stored at ambient or refrigerated temperatures without adequate formulation control. Changes in aroma, color, texture, and taste have been reported during the storage of liquid coconut products and their derivatives (Cruz et al., 2026; Jacob et al., 2023; Wang et al., 2020). In laboratory-scale processing units and micro, small, and medium-sized enterprises (MSMEs), day-to-day organoleptic assessments are commonly used without a systematically defined acceptance threshold. This practical situation indicates the need for an experimental design that combines stabilizer formulation with storage testing at different temperatures.

Ideally, liquid coconut milk should remain acceptable to panelists through the end of the distribution chain; in practice, however, sensory scores can decline rapidly after extraction. Shelf-life extension strategies involving pasteurization, natural preservatives, and packaging have been developed, but their application to locally produced liquid coconut milk formulated with Tween 80–CMC remains limited (Beegum et al., 2025; Boonmeesuk et al., 2024; Setiawan et al., 2024). The gap between expected quality standards and actual storage practices creates a practical need for shelf-life estimation based on sensory acceptance criteria. This practical gap provides the starting point for the quality-evaluation framework used in this study.

This study addresses the gap by comparing changes in sensory scores for liquid coconut milk formulated with Tween 80–CMC (P1–P6) during storage at ambient (27–30 °C) and refrigerated (0–4 °C) temperatures, with shelf life estimated within an ASLT framework using regression and an Arrhenius plot. The novelty lies in estimating shelf life using measurable sensory-acceptance criteria across this factorial treatment matrix, rather than claiming integration of multiple quality parameters that has already been widely reported (Beegum et al., 2025; Boonmeesuk et al., 2024; Shahbaz et al., 2025). The manuscript is limited to sensory data and does not include physicochemical or microbiological analyses. The research objectives are described below.

The rationale for this study stems from the need for food-processing industries and laboratories to have a shelf-life reference that can be verified through periodic sensory testing. The general objective was to evaluate sensory quality and estimate the shelf life of liquid coconut milk formulated with Tween 80–CMC using Accelerated Shelf Life Testing. The specific objectives were to: (1) identify the sensory-quality characteristics of liquid coconut milk; (2) analyze changes in sensory attributes during storage; (3) determine a sensory acceptance threshold as an indicator of the end of shelf life; and (4) estimate shelf life based on sensory-test results (Beegum et al., 2025; Shahbaz et al., 2025; Sustkova & Cizkova, 2024).

Theoretically, this study is expected to enrich frameworks for estimating the shelf life of coconut-based emulsions using sensory acceptance as an indicator in a factorial formulation–temperature design. Its practical contribution is intended for food-processing laboratories and MSMEs seeking recommendations on Tween 80–CMC formulations and storage conditions that slow the decline in acceptance (Boonmeesuk et al., 2024; Jacob et al., 2023; Setiawan et al., 2024). The findings may also inform the development of internal quality-control procedures based on a sensory cutoff. The following section describes the materials, experimental design, and testing procedures.

LITERATURE REVIEW

Recent studies have shown that thermal treatments, cold plasma, and process engineering can affect coconut milk stability and aroma profiles (Chen et al., 2024a; Deng et al., 2024; Tiravibulsin et al., 2021). Spoilage monitoring has also expanded to include descriptive sensory methods, electronic noses, and integrated quality parameters during storage (Beegum et al., 2025; Cruz et al., 2026; Wang et al., 2020). However, existing work has largely emphasized physicochemical and microbiological changes or processing technologies, while shelf-life determination based on sensory acceptance scores in emulsifier–thickener formulations has not been explicitly established. This state of the art provides an opportunity to synthesize evidence on sensory variables and the Accelerated Shelf Life Testing (ASLT) method.

The sensory quality of liquid coconut milk is defined as panelists' responses to the product's organoleptic characteristics, including color, aroma, taste, texture, and overall acceptability as an indicator of acceptance (Asih et al., 2021; Beegum et al., 2025; Pachekrepapol et al., 2021). Each attribute is measured using panelists' hedonic scores on the sensory-evaluation instrument specified by the researchers and then analyzed in relation to storage time and temperature. This indicator framework enables the acceptance threshold to be defined as a critical point for the end of the product's shelf life. These sensory indicators are considered alongside the role of Tween 80 and CMC in maintaining emulsion stability.

Coconut milk emulsion stability depends on fat content, interfacial interactions, and the use of stabilizing agents that affect texture and sensory acceptance (Boonmeesuk et al., 2024; Chen et al., 2024b; Pachekrepapol et al., 2021). Tween 80 functions as a non-ionic emulsifier, whereas CMC acts as a thickening hydrocolloid that can help prevent phase separation. The combinations of Tween 80 and CMC levels in this study were arranged as treatments P1–P6 to examine sensory responses during storage. This synthesis indicates that stabilizer formulations should be tested factorially under different storage temperatures.

Methods for determining food shelf life include real-time storage tests and accelerated approaches that increase the rate of deterioration by raising the temperature (Setiawan et al., 2024; Shahbaz et al., 2025; Sustkova & Cizkova, 2024). ASLT can provide shelf-life estimates in a relatively short period when quality parameters are monitored periodically at refrigerated and ambient temperatures and then modeled using regression and Arrhenius analysis. The application of ASLT to coconut-based products has demonstrated the relevance of sensory parameters as part of shelf-life evaluation (Beegum et al., 2025; Boonmeesuk et al., 2024; Shahbaz et al., 2025). This methodological foundation informed the storage design used in the present study.

Previous empirical findings have not consistently identified the primary determinant of the end of liquid coconut milk shelf life, which may be driven by sensory changes, oxidation, or microbial growth (Beegum et al., 2025; Cruz et al., 2026; Wang et al., 2020). A theoretical limitation arises when shelf-life models do not explicitly

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link an emulsifier–thickener formulation matrix with sensory acceptance thresholds in a multi-temperature ASLT design (Chen et al., 2024b; Shahbaz et al., 2025; Sustkova & Cizkova, 2024). This empirical and theoretical gap remains insufficiently addressed for pasteurized liquid coconut milk formulated with Tween 80–CMC. Identifying this gap directs the novelty of the present study toward sensory-based shelf-life estimation.

METHOD

This study used a quantitative approach and a true experimental design. A two-factor factorial completely randomized design (CRD) with three replicates was applied to support treatment reproducibility (Boonmeesuk et al., 2024; Setiawan et al., 2024; Shahbaz et al., 2025). The first factor was the combination of Tween 80 and CMC formulations (P1–P6), and the second was storage temperature (X1 = ambient, 27–30 °C; X2 = refrigerated, 0–4 °C). Shelf life was estimated using an ASLT approach, with regression of sensory scores and an Arrhenius plot based on empirical data from the two temperatures. The factorial design enabled the main effects and formulation temperature interaction to be examined.

The study was conducted from May to August 2026 at the Food Processing and Quality Analysis Laboratory, Sambas State Polytechnic, West Kalimantan, Indonesia. The four-month period covered formulation, pasteurization, periodic storage, and sensory testing on days 0, 3, 5, and 7. The laboratory setting was selected to enable monitoring of temperature control, processing hygiene, and panel standardization. These temporal and spatial conditions define the context for interpreting the results.

The main materials were grated coconut flesh, warm water, Tween 80, and CMC. Formulations per 1 kg of liquid coconut milk were as follows: P1 (1 g Tween 80 : 2 g CMC); P2 (1 g Tween 80 : 3 g CMC); P3 (2 g Tween 80 : 2 g CMC); P4 (2 g Tween 80 : 3 g CMC); P5 (3 g Tween 80 : 2 g CMC); and P6 (3 g Tween 80 : 3 g CMC). Primary data consisted of panelists' sensory scores, while secondary data were drawn from scientific literature on the quality and shelf life of coconut products (Beegum et al., 2025; Sustkova & Cizkova, 2024; Wang et al., 2020). These material specifications and data sources support experimental transparency and reproducibility.

Liquid coconut milk was prepared through the following steps: (1) grating the coconut flesh; (2) adding warm water at a ratio of 1:0.4; (3) extracting the coconut milk; (4) homogenizing the mixture; (5) pasteurizing at approximately 70–75 °C for 15 min; (6) cooling; (7) packaging in sterilized containers; and (8) storing according to the assigned treatment. Mild pasteurization was selected to reduce the initial microbial load while retaining the characteristic sensory properties of coconut milk, in line with thermal-processing approaches used for liquid coconut milk (Boonmeesuk et al., 2024; Deng et al., 2024; Tiravibulsin et al., 2021). No chemical preservatives were used apart from Tween 80 and CMC as formulation components. This procedure served as the standard protocol for all experimental units.

Product storage followed the ASLT framework under two empirical conditions: refrigeration (0–4 °C) and ambient temperature (27–30 °C). Quality parameters were monitored periodically through sensory tests on days 0, 3, 5, and 7 to capture trends in declining acceptance (Beegum et al., 2025; Shahbaz et al., 2025; Sustkova & Cizkova, 2024). The temperature difference was used to estimate the rate of decline in sensory scores and project shelf life through regression and an Arrhenius plot in Microsoft Excel. This storage design formed the basis for sensory-based shelf-life estimation.

The dependent variable was sensory quality, measured using a hedonic test of liking for color, aroma, taste, texture, and overall acceptability (Asih et al., 2021; Beegum et al., 2025; Pachekrepapol et al., 2021). The independent variables were formulation (P1–P6), storage temperature (X1 and X2), and storage time. A nine-point hedonic scoring sheet was used to evaluate consumer acceptance of the food product, with the following interpretation: scores of 1–3 (dislike extremely to dislike slightly), 4 (neutral), 5–6 (like slightly to like moderately), and 7–9 (like very much to like extremely). These operational definitions ensured that all responses analyzed were measurable.

The target population comprised semi-trained panelists associated with the Food Processing and Quality Analysis Laboratory at Sambas State Polytechnic. A small-scale preliminary test was conducted to familiarize panelists with the hedonic attributes before the main data collection. The main test involved 25–30 semi-trained panelists selected purposively. Inclusion criteria were no coconut allergy and healthy senses of smell and taste; exclusion criteria included a history of coconut allergy or relevant sensory impairment. Product experimental units were prepared in triplicate for each treatment combination according to the factorial CRD. Separating familiarization from the main test helped maintain consistency in panel assessments.

Data analysis was conducted in several stages: (1) tabulation of scores for each attribute and overall acceptability; (2) factorial CRD analysis of variance (ANOVA) to test the effects of P, X, and the PX interaction at

a significance level of $\alpha = 0.05$; (3) post-hoc testing when significant effects were found; and (4) regression modeling of scores against time at each temperature, together with an Arrhenius plot, to estimate shelf life until the acceptance cutoff was reached (Boonmeesuk et al., 2024; Shahbaz et al., 2025; Sustkova & Cizkova, 2024). The acceptance threshold was set at a mean overall-acceptability score of ≥5.0 (slightly like); the product was considered to have passed the end of its sensory shelf life when the mean score fell below 5.0. SPSS, Minitab, or R was used for ANOVA, while Microsoft Excel was used for regression and the Arrhenius plot. Statistical significance was defined as $p < 0.05$.

RESULTS AND DISCUSSION

Results

Sensory-quality analysis evaluates panelists' responses to the organoleptic attributes of food products, which cannot be fully replaced by instrumental measurements alone (Asih et al., 2021; Beegum et al., 2025; Pachekrepapol et al., 2021). A nine-point hedonic scale was selected to map liking for the color, aroma, taste, texture, and overall acceptability of liquid coconut milk during storage. The analysis aimed to identify the initial acceptance profile, track score changes over time and across temperatures, and determine the end point of shelf life using an agreed acceptance criterion. An overall-acceptability score of ≥5.0 was adopted as the acceptance threshold (slightly like), whereas a score below 5.0 indicated that the product had passed the end of its sensory shelf life. This approach is consistent with sensory-acceptance evaluation and shelf-life estimation frameworks for coconut products and food products more broadly (Beegum et al., 2025; Boonmeesuk et al., 2024; Shahbaz et al., 2025; Sustkova & Cizkova, 2024). Combining factorial ANOVA, score trends over time, and cutoff-based shelf-life estimation was intended to make the findings useful for formulation and storage recommendations. The following sections present the empirical results.

Table 1. Hedonic scores for the sensory attributes of liquid coconut milk on day 0 (n = 30)

Treatment	Storage temperature	Aroma	Color	Texture	Taste	Overall*
P1	Ambient	7.37	7.40	7.33	6.73	7.21
P1	Refrigerated	7.23	6.93	7.57	7.23	7.24
P2	Ambient	6.73	7.47	7.00	7.10	7.08
P2	Refrigerated	6.73	7.47	7.27	7.07	7.13
P3	Ambient	6.93	6.83	6.90	7.37	7.01
P3	Refrigerated	7.40	7.33	6.73	7.23	7.18
P4	Ambient	6.93	7.57	7.23	6.73	7.12
P4	Refrigerated	7.47	7.00	7.10	6.73	7.08
P5	Ambient	7.47	7.27	7.07	6.93	7.18
P5	Refrigerated	6.83	6.90	7.00	7.10	6.96
P6	Ambient	6.73	7.47	7.27	7.07	7.13
P6	Refrigerated	6.93	6.83	6.90	6.93	6.90

Note: *Overall = mean of the four hedonic attributes. Scale: 1–9.

As shown in Table 1, all P1–P6 treatment combinations under both ambient and refrigerated storage had overall-acceptability scores ranging from 6.90 to 7.24. These values were within the like-to-very-much-like range and well above the 5.0 cutoff. The highest aroma scores were recorded for P5 at ambient temperature (7.47) and P4 under refrigeration (7.47), while the highest taste score was observed for P3 at ambient temperature (7.37). The

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highest texture score was found for P1 under refrigeration (7.57), suggesting that the formulation containing 1 g Tween 80 and 2 g CMC per kg maintained a thickness perceived favorably by panelists at the beginning of storage. The differences among treatments were relatively small, indicating a broadly similar initial sensory profile before storage-related deterioration occurred.

Table 2. Changes in overall-acceptability scores during storage (n = 30)

Treatment	Storage temperature	Day 0	Day 3	Day 5	Day 7
P1	Ambient	7.21	5.81	4.61	4.22
P1	Refrigerated	7.24	5.93	4.61	4.61
P2	Ambient	7.08	5.96	4.58	4.15
P2	Refrigerated	7.13	6.07	4.51	4.27
P3	Ambient	7.01	5.93	4.62	4.26
P3	Refrigerated	7.18	5.79	4.67	5.33
P4	Ambient	7.12	5.99	4.61	4.22
P4	Refrigerated	7.08	5.98	4.57	4.35
P5	Ambient	7.18	6.09	4.48	3.97
P5	Refrigerated	6.96	5.92	4.64	4.43
P6	Ambient	7.13	6.07	4.51	4.02
P6	Refrigerated	6.90	6.03	4.64	4.63
Mean	Ambient	7.12	5.97	4.57	4.14
Mean	Refrigerated	7.08	5.95	4.61	4.60

According to the changes presented in Table 2, overall acceptability remained above the cutoff on days 0 and 3 (mean scores of 5.97 at ambient temperature and 5.95 under refrigeration on day 3), but fell below 5.0 on day 5 (4.57 at ambient temperature and 4.61 under refrigeration). The decline from day 0 to day 5 was approximately 2.5 score units at both temperatures, indicating a shift from liking to neutral or slightly disliking the product. One exception was P3 under refrigeration on day 7, when the score rose to 5.33, while all other treatments remained below 5.0. This pattern should be interpreted cautiously because the day-5 score for P3 under refrigeration was already 4.67. Refrigeration appeared to moderate the decline during the final observation period, as the day-7 mean was higher under refrigeration (4.60) than at ambient temperature (4.14).

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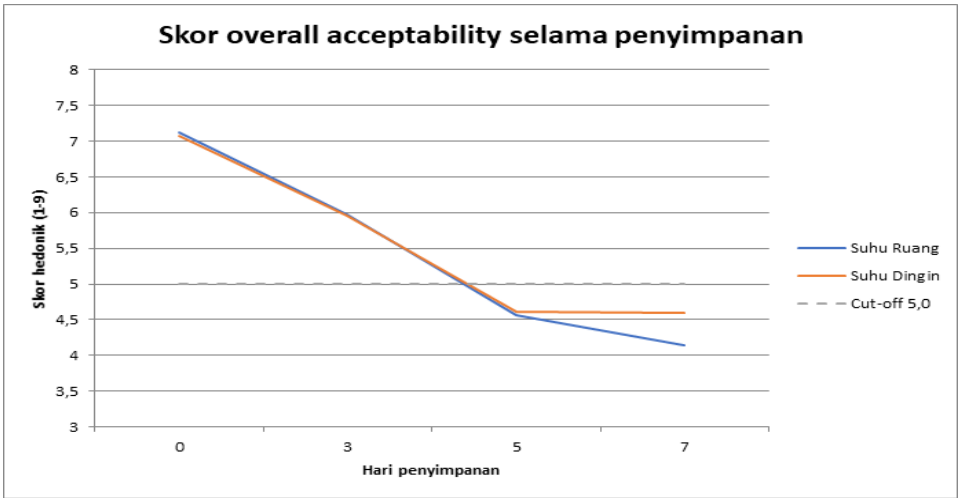


Figure 1. Trend in the overall-acceptability scores of liquid coconut milk stored at ambient and refrigerated temperatures for 7 days (the dashed line indicates the 5.0 cutoff).

As shown in Figure 1, the two temperature curves followed nearly parallel trajectories through day 5 and crossed the 5.0 cutoff between days 3 and 5. After day 5, the curve for ambient storage continued to decline to approximately 4.1, whereas the refrigerated-storage curve remained relatively stable at around 4.6. This pattern indicates that the mean sensory-acceptance threshold was crossed before day 5 and that refrigeration provided relative protection during the final observation period.

Table 3. Summary of factorial CRD ANOVA for the effects of formulation (P), temperature (X), and the PX interaction on overall acceptability

Day	F value (P)	P result	F value (X)	X result	F value (PX)	PX result	CV (%)
0	1.333	NS	0.690	NS	1.833	NS	6.48
3	1.627	NS	0.189	NS	0.928	NS	8.13
5	0.972	NS	1.767	NS	1.653	NS	6.05
7	12.932	**	84.273	**	8.199	**	11.00

Note: NS = not significant; ** = highly significant (α = 0.05). Critical F values for P/PX (0.05) = 2.240 and for X (0.05) = 3.868.

The ANOVA results in Table 3 indicate that the effects of P, X, and PX were not statistically significant on days 0, 3, or 5 (all calculated F values were below the critical F values). The pattern changed on day 7, when the calculated F values were 12.932 for P, 84.273 for X, and 8.199 for PX, all reported as highly significant. The coefficient of variation increased from 6.48% on day 0 to 11.00% on day 7, indicating greater variability in panelists' responses as sensory deterioration progressed. The strong temperature effect on day 7 was consistent with the difference in mean overall acceptability under refrigeration versus ambient storage (4.60 versus 4.14).

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Table 4. Estimated sensory shelf life based on linear regression of overall scores against time to the 5.0 cutoff

Treatment	Estimated shelf life at ambient temperature (days)	Estimated shelf life under refrigeration (days)
P1	4.78	5.22
P2	4.75	4.87
P3	4.84	6.20
P4	4.85	4.93
P5	4.64	5.01
P6	4.66	5.29
Range	4.64–4.85	4.87–6.20

As shown in Table 4, all formulations stored at ambient temperature had estimated sensory shelf lives of 4.64–4.85 days before overall acceptability reached 5.0. Refrigerated storage extended the estimates to 4.87–6.20 days. P3 under refrigeration had the longest estimate (6.20 days), whereas P2 under refrigeration had the shortest (4.87 days). Differences among formulations at ambient temperature were narrow (<0.3 days), so formulation-related advantages were more apparent under refrigerated conditions. For most treatments, these estimates indicate a practical sensory shelf-life window of approximately 4.5–5 days at ambient temperature and nearly 5–6 days under refrigeration.

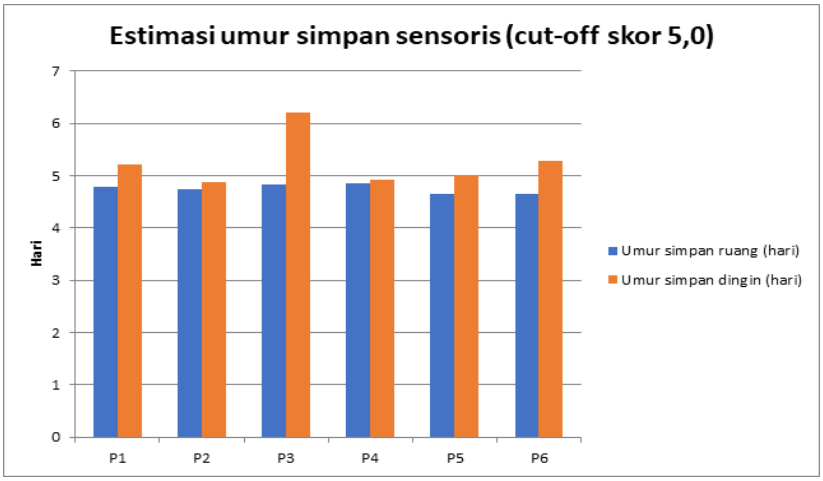


Figure 2. Estimated sensory shelf life of formulations P1–P6 at ambient and refrigerated temperatures (sensory cutoff score = 5.0).

As shown in Figure 2, the refrigerated-storage bars were consistently higher than or equal to those for ambient storage across P1–P6. The highest value was observed for P3 under refrigeration, while the lowest ambient-temperature estimate was associated with P5 (4.64 days). This visualization supports the conclusion that Tween 80–CMC formulation had a limited effect on sensory persistence at ambient temperature, whereas differences among formulations were more evident under refrigeration.

Overall, panelists accepted all P1–P6 liquid coconut milk formulations at the beginning of storage (overall scores of approximately 7). Scores remained above the cutoff through day 3 but fell below the acceptance threshold by day 5. The effects of formulation and temperature became highly significant only on day 7, when sensory deterioration was more advanced. Regression estimates placed the end of sensory shelf life at 4.6–4.9 days under ambient conditions and 4.9–6.2 days under refrigeration, with P3 under refrigeration emerging as the most promising treatment for sensory persistence.

Discussion

The high initial acceptance scores across all formulations indicate that the combination of Tween 80–CMC and mild pasteurization produced liquid coconut milk that was well accepted by the semi-trained panelists. Overall scores of approximately 7 on day 0 are consistent with reports that freshly processed liquid coconut products retain consumer-acceptable sensory characteristics before further deterioration occurs (Beegum et al., 2025; Pachekrepapol et al., 2021; Wang et al., 2020). The similarity of scores among P1–P6 at the initial stage also helps explain why formulation effects were not statistically significant at that point. These findings suggest that formulation-related differences become more apparent after the product experiences storage stress.

The sharp decline in scores after day 3 reflects the sensitivity of coconut milk emulsions to storage time, particularly in aroma, taste, and texture, which may change because of lipid oxidation, phase separation, and shifts in volatile compounds (Chen et al., 2024a; Deng et al., 2024; Wang et al., 2020). Ambient-temperature storage accelerated the decline in acceptance relative to refrigeration, consistent with the principles of food-deterioration kinetics underlying ASLT (Jacob et al., 2023; Shahbaz et al., 2025; Sustkova & Cizkova, 2024). The crossing of the 5.0 cutoff between days 3 and 5 places the end of sensory shelf life within a relatively short window for a pasteurized product without additional preservatives. This pattern highlights temperature control throughout the cold chain as a key factor in maintaining consumer acceptance.

The nonsignificant ANOVA results on days 0–5, followed by highly significant results on day 7, may reflect a shift from initial sensory uniformity to differentiated deterioration. The strongest temperature effect on day 7 (the calculated F value for X substantially exceeded its critical value) supports the interpretation that refrigeration slowed sensory degradation more effectively than adjustment of the Tween 80–CMC ratio alone (Boonmeesuk et al., 2024; Chen et al., 2024b; Setiawan et al., 2024). The significant PX interaction on day 7 indicates that the advantage of a particular formulation became apparent only at a more advanced stage of deterioration. This helps explain why P3 under refrigeration had the longest estimated shelf life, while formulation differences under ambient storage remained small.

The estimated shelf life of 4.64–4.85 days at ambient temperature and 4.87–6.20 days under refrigeration places this product among liquid foods requiring rapid distribution or a maintained cold chain. These estimates are shorter than those reported for some coconut products whose shelf life has been extended using natural preservatives or advanced processing technologies, but they may be realistic for pasteurized coconut milk stabilized without additional antimicrobial additives (Beegum et al., 2025; Boonmeesuk et al., 2024; Shahbaz et al., 2025). P3 (2 g Tween 80 : 2 g CMC per kg) under refrigeration emerged as the most promising candidate because it may balance emulsification and viscosity without an excessive hydrocolloid load. This balanced ratio may help maintain the fat–water interface and slow the decline in overall scores under refrigerated conditions.

The overall-acceptance threshold of ≥5.0 provided an operational criterion for identifying the end of sensory shelf life because it corresponds to a shift from slightly liking the product toward neutral or lower acceptance. Using a panel-based cutoff is consistent with shelf-life evaluation practices that treat sensory acceptance as a consumer-relevant indicator (Asih et al., 2021; Beegum et al., 2025; Sustkova & Cizkova, 2024). This methodological choice may be practically useful for MSMEs and food-processing laboratories that do not always have access to routine microbiological testing. The findings suggest that Tween 80–CMC formulation supports initial product quality, whereas refrigeration and the hedonic cutoff of 5.0 are central to estimating the sensory shelf life of pasteurized liquid coconut milk.

Limitations and Future Research Agenda

The empirical scope of this study was limited to hedonic sensory parameters; therefore, physicochemical and microbiological changes were not verified in parallel. Overall acceptability was calculated as the mean of four attributes, so separate interpretation of individual attributes will be necessary if formulation optimization is intended to target aroma, taste, or texture specifically. Empirical data at an accelerated temperature of 37 °C were not available; consequently, the ASLT estimate relied on two temperature conditions (ambient and refrigerated storage) and regression of sensory scores over time. The semi-trained panel of 25–30 participants was suitable for acceptance testing but did not represent a broader market-level consumer panel.

Future research should follow four directions. First, pH, viscosity, total plate count, and oxidation indices should be integrated to clarify the relationship between sensory acceptance and food safety. Second, additional, fully documented accelerated-temperature conditions should be included to support a more robust three-point Arrhenius plot. Third, quantitative descriptive analysis and instrument-based spoilage monitoring (e.g., an electronic nose) should be used to identify deterioration descriptors that precede a decline in hedonic scores.

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Fourth, pilot-scale testing in MSME distribution chains should assess the reliability of an overall-acceptability cutoff of ≥5.0 as an operational quality criterion for storing and selling stabilized pasteurized coconut milk.

CONCLUSION

Liquid coconut milk formulated with Tween 80–CMC (P1–P6) showed acceptable initial sensory characteristics, with overall-acceptability scores of approximately 7 on day 0 under both ambient and refrigerated storage. Scores declined gradually but remained above the cutoff through day 3, before falling below 5.0 on day 5. An overall-acceptability threshold of ≥5.0 can be used as an indicator of the end of the product's sensory shelf life. Regression estimates placed sensory shelf life at 4.64–4.85 days at ambient temperature and 4.87–6.20 days under refrigeration, with P3 (2 g Tween 80 : 2 g CMC per kg) under refrigeration showing the longest estimate.

The practical implications are that distribution and sale of stabilized pasteurized coconut milk should prioritize cold-chain management and that stock turnover at ambient temperature should not exceed four to five days. Formulation P3 may be considered a starting point for optimizing refrigerated products at laboratory and MSME levels. Future studies should include physicochemical and microbiological parameters and fully documented accelerated-temperature conditions to strengthen ASLT estimates and ensure that shelf-life claims are supported by food-safety evidence.

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AUTHOR CONTRIBUTIONS

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