Effects of Alternative Sweeteners on the Quality of Ready-to-Use Yentafo Sauce

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Abstract

The objective of this study was to develop a ready-to-use Yentafo sauce by substituting sucrose with alternative sweeteners to meet increasing consumer demand for healthier food options. The study compared the effects of acesulfame K, sucralose, and stevia with a sucrose control. Physicochemical characterization, sensory evaluation, and accelerated shelf-life testing were conducted to evaluate product quality and stability. The results indicated that stevia provided a sweetness profile and sensory acceptance comparable to the sucrose control. The replacement of sucrose with alternative sweeteners did not significantly affect key physicochemical parameters. Sensory evaluation further demonstrated that the stevia formulation achieved the highest overall acceptance among the tested sweeteners. Based on accelerated shelf-life testing and Q_{10} prediction, the developed reduced-sugar Yentafo sauce exhibited an estimated shelf life of approximately 44 days at an ambient temperature of 30 °C. In conclusion, the stevia-based formulation presents a promising reduced-sugar alternative that maintains the sensory characteristics of traditional Yentafo sauce while meeting consumer demand for healthier seasoning products.

Keywords: *Yentafo sauce, Stevia, sweetener, reduced-calorie product, accelerated shelf-life*

1. Introduction

Yentafo sauce is a traditional Thai seasoning commonly used in Yentafo noodle soup. It is distinguished by its pink color, unique sweet and sour flavor, and viscous texture, which are derived from fermented soybean paste combined with other ingredients such as vinegar, sugar, and chili. This sauce plays a crucial role in defining the sensory characteristics of Yentafo noodles, as it directly affects the appearance, flavor balance, and overall consumer acceptance of the dish.

In recent years, the demand for ready-to-use and convenience foods has increased significantly, with the convenience food market in Thailand projected to grow steadily and generate higher revenue over the coming years (USDA Foreign Agricultural Service [USDA FAS], 2025). As a result, Yentafo sauce has increasingly been developed in ready-to-use forms, where consistent product quality, storage stability, and extended shelf life are required. These requirements necessitate careful formulation design to maintain both sensory quality and product stability during storage.

In traditional formulations, table sugar (sucrose) is commonly used as the sweetening agent in Yentafo sauce. Beyond providing sweetness, sucrose contributes to flavor balance and enhances overall savoriness, as it has been shown to suppress sourness and influence flavor perception in complex taste systems (Ramsey & Swiegers, 2025). In addition, sucrose contributes to water activity (A_w) control by binding free water molecules and reducing molecular mobility. It also influences the glass transition behavior of concentrated systems, thereby enhancing structural rigidity during storage (Roos & Karel, 1991). Furthermore, sucrose increases total soluble solids and viscosity, contributing to desirable mouthfeel and suspension stability (Maskan & Göğüş, 2000). From a sensory perspective, sucrose plays an important role in flavor masking, suppressing sourness and bitterness while enhancing overall flavor harmony in complex taste systems. Consequently, sucrose contributes not only to sweetness but also to the overall sensory quality and physicochemical stability of the product.

However, increasing consumer awareness of health concerns associated with high sugar intake has led to a growing demand for reduced-sugar food products. Many consumers report cutting back on sugar due to long-term health concerns and show interest in lower-sugar options (Chen et al., 2022), including traditional sauces. Reducing sucrose in Yentafo sauce presents a formulation challenge, as sugar reduction may influence not only sweetness perception but also texture, appearance, and product stability. Therefore, sugar-reduction strategies should consider both sensory quality and physicochemical properties.

Sugar reduction is often achieved by replacing sucrose with high-intensity sweeteners such as sucralose, stevia, and acesulfame K (McKenzie & Lee, 2022). These sweeteners can provide sweetness with minimal caloric contribution and are commonly used in reduced-sugar food products. However, replacing sucrose may influence the physicochemical properties of food systems due to the loss of bulking effects and changes in total soluble solids, which can affect moisture content, viscosity, and overall product stability (Pongsawatmanita et al., 2002). Therefore, evaluating the impact of alternative sweeteners on both sensory perception and physicochemical characteristics is essential when developing reduced-sugar sauce formulations.

Although sugar reduction has been widely studied in beverages and confectionery products, limited information is available regarding its application in traditional Thai sauces. In particular, it remains unclear whether reduced-sugar Yentafo sauce has been systematically evaluated in terms of physicochemical stability, sensory quality, and shelf-life performance. In addition to formulation design, shelf-life stability is a key consideration for ready-to-use sauce products. Sugar reduction may influence product stability by altering water activity (a_w) and physicochemical interactions, potentially accelerating quality deterioration (Chen et al., 2022). Accelerated shelf-life testing (ASLT), combined with predictive models such as the Q_{10} method, provides an effective approach for evaluating storage stability under controlled conditions.

To our knowledge, no previous study has systematically evaluated the effects of alternative sweeteners on the physicochemical, sensory, and shelf-life properties of ready-to-use Yentafo sauce. Therefore, this study aimed to develop a reduced-sugar ready-to-use Yentafo sauce by evaluating the effects of different alternative sweeteners on product quality. It also assessed the storage stability of the developed formulation using accelerated shelf-life testing.

2. Objectives

1) To evaluate the effects of alternative sweeteners on the physicochemical and sensory properties of reduced-sugar ready-to-use Yentafo sauce.

2) To assess the physicochemical and color stability of the developed reduced-sugar Yentafo sauce during accelerated storage and to predict shelf life using the Q_{10} model.

3. Materials and Methods

3.1 Preparation of ready-to-use Yentafo sauce

All ingredients required for preparation of ready-to-use (RTU) Yentafo sauce were purchased from local supermarkets. The list of ingredients included Yentafo-based sauce (Supawan & Co Co. Ltd., Bangkok, Thailand), granulated sugar (Mitr Phol Sugar Corp. Ltd., Suphanburi,Thailand), mild chili sauce (Thai Theparos Public Co. Ltd., Samutprakarn, Thailand), red fermented bean curd (Kilane Foods Co. Ltd., Samutprakarn, Thailand), garlic (*Allium sativum* L. cv. Chinese), and red chili (*Capsicum annuum* L. cv. Jinda). The Yentafo-based sauce (commonly referred to as red sauce) used in this research was based on a Hainanese formulation, primarily consisting of rice flour, chili, tomato, pickled garlic, vinegar, sugar, salt, artificial color, and preservatives. However, the exact formula of the RTU Yentafo sauce remained proprietary and could not be disclosed due to trade secret protections held by the commercial producer. Only the sugar content of the formulation was disclosed, which was 14.44% (w/w).

To prepare RTU Yentafo sauce, all ingredients were weighed according to the formulation and were mixed at high speed for 3 min in a blender with a 2 L blending container (SHARP EMC-15, Thai City Electric Co. Ltd., Bangkok, Thailand). The mixture was then transferred to a stockpot and pasteurized at 85 °C for 15 min in a hot water bath (Teangpook et al., 2023). The pasteurized sauce was immediately hot-filled into 250 mL glass bottles and promptly secured with a metal lug cap to ensure a hermetic seal. The bottled sauce was then cooled to room temperature in a tap water bath. The bottles were finally blow dried and kept in a refrigerator (4 °C) until further analysis.

3.2 Determination of non-sugar sweeteners effects on qualities of RTU Yentafo sauce

RTU Yentafo sauce samples were prepared; however, granulated sugar was replaced with alternative sweeteners to reduce sugar consumption, resulting in the development of a healthier alternative seasoning. The sweeteners used in this study included sucralose (E955), stevioside (E960A), and acesulfame potassium (Acesulfame K, E950) (Bangkok Chemical Co. Ltd., Bangkok, Thailand). The sweeteners selected for this study were chosen based on their common use in commercial seasoning sauce production. The concentrations of sucralose, stevioside, and acesulfame K added to the sauce were 0.024%, 0.048%, and 0.072% (w/w), respectively. These levels were calculated based on their relative sweetness compared to sucrose: 600, 300, and 200 times, respectively (U.S. Food and Drug Administration, 2023). The samples were evaluated for their physicochemical properties and sensory characteristics as described in the previous experiment. The most suitable sweetener was then selected for the subsequent experiment.

3.3 Accelerated shelf-life testing (ASLT)

Based on the results from the previous experiment, another two sets of RTU Yentafo sauce samples were prepared for ASLT. Each set of samples was stored separately for 4 weeks in a temperature-controlled chamber (IN series, Memmert GmbH + Co. KG., Schwabach, Germany) set at 45 and 55°C. Samples stored at both conditions were randomly selected at the initial stage (week 0) and at 2-week intervals during storage for analysis. The samples were evaluated for the change in their (a_w) pH, and instrumental color. The shelf-life of the sample when stored at 30 °C was then calculated based on Q_{10} values obtained from the shelf-life of the samples stored at 45 and 55 °C.

3.4 Evaluation of RTU Yentafo sauce quality

3.5.1 Physicochemical Properties

Water activity (a_w) and moisture content of the samples were measured using a water activity meter (AquaLab Series 3TE, METER Group, Pullman, Washington, USA) at 25°C and a moisture analyzer (MA 30, Sartorius AG, Göttingen, Germany) at 120°C. The pH value was determined using a pH meter (ST300, OHAUS Corp., Parsippany, New Jersey, USA). A tristimulus colorimeter (CR-10, Konica Minolta Inc., Japan) was used to measure the instrumental color of the samples and expressed in CIE Lab color space (L*, a*, and b*). The total color difference (**ΔE**) was then calculated and reported.

3.5.2 Sensory Characteristics

Sensory evaluation was conducted using an acceptance test based on a 9-point hedonic scale with 30 semi-trained panelists. Test samples were prepared by diluting 43 g of RTU sauce with 145 g of boiling water, corresponding to a 1:3.37 (w/w) ratio. This ratio was derived from standard restaurant practices for preparing Yentafo broth used in various Yentafo-based dishes, such as rice noodle soup. Subsequently, 15 mL portions at a temperature ranging from 60 – 70 °C were served to each panelist.

3.5 Statistical Analysis

A completely randomized design (CRD) was used in all experiments except for a sensory evaluation, which was conducted using randomized complete block design (RCBD). All experiments were performed in triplicate. The data were expressed as mean ± standard deviation (SD). Statistical comparisons were performed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT). A significance level of $p < 0.05$ was used to determine statistical differences.

4. Results and Discussion

4.1 Effect of Alternative Sweeteners on the Quality of Yentafo Sauce

The physicochemical properties of Yentafo sauce prepared with different sweeteners are presented in **Table 1.** The replacement of sucrose with high-intensity sweeteners (sucralose, stevia, and acesulfame K) had no significant effect on the pH and water activity (a_w) of the Yentafo Sauce ($p > 0.05$). However, the moisture content of sweetener-substituted formulations was significantly higher than that of the control. This increase is likely due to the absence of sucrose, which typically functions as a bulking agent and binds water molecules. Therefore, the reduction in total solids contributed to variation in initial viscosity, specifically, formulations with sucralose and acesulfame K exhibited higher apparent viscosity than those with stevia or the control. Regarding sensory evaluation, the formulation containing stevia received the highest overall liking scores among the alternative sweeteners and showed no significant difference compared to the sucrose control ($p > 0.05$).

Table 1 Physicochemical properties of Yentafo sauces formulated with different sweeteners

Sweetener Treatment	%Moisture content	pH	a_w	Overall acceptability
Refined sugar (control)	40.14 ± 2.53a	3.81 ± 0.01a	0.939 ± 0.00a	6.17 ± 1.32a
Sucralose	69.03 ± 0.87c	3.81 ± 0.03a	0.958 ± 0.00b	6.33 ± 1.67a
Stevia	70.31 ± 2.57c	3.83 ± 0.01a	0.958 ± 0.00b	6.57 ± 1.41a
Acesulfame-K	64.38 ± 1.75b	3.82 ± 0.01a	0.961 ± 0.00c	6.17 ± 1.46a

Note: a_w = water activity; values are expressed as mean ± standard deviation.

4.2 Shelf-life Stability Quality

Table 2 shows the changes in physicochemical properties of the developed Yentafo sauce during accelerated storage at 45°C and 55°C. The storage stability was evaluated based on moisture content, a_w, pH, and color parameters (L*, a*, b*). Regarding pH, a slight increase was observed during the initial stage of storage at both temperatures ($p > 0.05$). The pH increased from 3.84 ± 0.05 at week 0 to approximately 4.03 ± 0.02 at week 1 and remained constant thereafter. This initial shift may be attributable to buffering capacity equilibrium or the minor degradation of organic acids within the sauce. Regarding moisture content and $a_{w,}$ significant fluctuations were detected ($p > 0.05$). At 45 °C, the moisture content increased from 51.56% to 57.91% by week 2, before decreasing to 49.65% by week 5. A similar trend was observed for a_w, which ranged between 0.940 and 0.950. These variations suggest that, despite these shifts, the product maintained a relatively stable intermediate moisture state throughout the storage period.

As presented in **Table 2**, the L* value increased with storage time. Conversely, a decreasing trend in a* and b* values was observed, particularly at the higher temperature. Specifically, at 45 °C, the a* value decreased from 28.00 to 21.17 by week 5. At 55 °C, quality deterioration progressed more rapidly, indicating a shorter shelf life based on physicochemical changes.. Notably, by week 4, the a* value became negative (indicating a shift away from redness), reflecting a substantial color change. This parameter is a critical quality index for the characteristic pink-red appearance of Yentafo sauce (Table 3)**.** This is likely attributable to temperature-driven pigment degradation and chemical interactions in the sauce matrix, which is consistent with known temperature effects on food quality deterioration (de Bouillé & Beeren, 2016).

Table 2 Changes in physicochemical properties of the developed Yentafo sauce during accelerated storage at 45 °C and 55 °C

Temp (°C)	Week	Moisture (%)	a_w	pH	L*	a*	b*	Δ*E**
45°C	0	51.56 ± 4.67^{a}	0.940 ± 0.003^{a}	3.84 ± 0.05^{a}	28.87 ± 0.12^{b}	28.00 ± 2.10^{c}	43.23 ± 0.38^{c}	0.00
	1	56.82 ± 0.62^{b}	0.947 ± 0.001^{c}	4.03 ± 0.02^{b}	29.37 ± 0.55^{b}	29.63 ± 0.68^{c}	42.50 ± 0.87^{c}	1.86
	2	57.91 ± 0.78^{b}	0.950 ± 0.002^{d}	3.97 ± 0.05^{b}	28.03 ± 0.21^{a}	22.80 ± 0.56^{ab}	39.50 ± 0.56^{a}	6.45
	3	-	-	-	-	-	-	4.80
	4	56.75 ± 0.57^{b}	0.943 ± 0.001^{b}	4.04 ± 0.08^{b}	29.33 ± 0.31^{b}	23.83 ± 0.60^{b}	40.90 ± 0.44^{b}	4.80
	5	49.65 ± 0.72^{a}	0.947 ± 0.002^{c}	4.00 ± 0.03^{b}	31.00 ± 0.36^{c}	21.17 ± 1.04^{a}	39.37 ± 0.45^{a}	8.13
55°C	0	51.53 ± 3.21^{a}	0.940 ± 0.006^{a}	3.84 ± 0.04^{a}	28.73 ± 0.06^{a}	29.33 ± 0.96^{d}	43.03 ± 0.81^{d}	0.00
	1	58.92 ± 1.02^{b}	0.948 ± 0.001^{b}	3.98 ± 0.01^{b}	28.07 ± 0.15^{a}	21.83 ± 0.75^{c}	39.17 ± 0.29^{b}	8.46
	2	56.88 ± 2.55^{b}	0.947 ± 0.005^{ab}	3.92 ± 0.02^{ab}	30.63 ± 0.21^{b}	19.77 ± 0.45^{b}	37.33 ± 0.47^{a}	11.30
	3	-	-	-	-	-	-	-
	4	-	0.944 ± 0.001^{ab}	3.98 ± 0.08^{b}	36.90 ± 1.08^{c}	-1.80 ± 0.56^{a}	40.33 ± 0.21^{c}	32.30

Note: a_w = water activity; L*, a*, and b* are CIE Lab color parameters representing lightness, redness/greenness, and yellowness/blueness, respectively; ΔE* = total color difference.

4.3 Shelf-life prediction using Q10 approach

The shelf life at accelerated temperatures was determined to be 30 days at 45 °C and 14 days at 55 °C, based on the established quality acceptability criteria. The Q_{10} value was calculated as 2.14. Using this Q_{10} relationship, the predicted shelf life at a standard storage temperature of 30 °C was approximately 44 days. To predict the shelf life at room temperature (30 °C), the temperature sensitivity coefficient (Q_{10}) was calculated using the equation below;

$$Q_{10} = \left(\frac{\theta_T}{\theta_{T+10}}\right)$$

$$Q_{10} = \left(\frac{30}{14}\right)$$

$$= 2.1429$$

$$t_{T1} = (t_{T2})(Q_{10}^{\frac{\Delta T}{10}})$$

$$t_{T30} = (30)(2.1429^{0.5})$$

$$t_{30} = 43.92\text{days}$$

$$\approx 44\ \text{days}$$

The shelf-life of the Yentafo sauce was estimated to be approximately 44 days at room temperature. Therefore, to ensure product stability and commercial viability, the use of UV-protective packaging or the optimization of thermal processing is recommended.

5. Conclusion

This study successfully developed a reduced-sugar ready-to-use Yentafo sauce by evaluating the effects of alternative sweeteners. Among the tested substitutes, stevia was identified as the most suitable alternative to sucrose. The data indicated that the stevia-formulated sauce maintained physicochemical properties, such as pH and water activity (a_w), comparable to the control. Unlike sucralose and acesulfame K, which altered the viscosity profile, stevia provided a viscosity profile similar to the traditional formulation. Moreover, sensory evaluation confirmed that the stevia-based sauce received the highest overall liking scores among the sugar substitutes, with no significant difference in consumer acceptance compared to the sucrose control ($p > 0.05$).

Regarding product stability, the shelf-life of the developed stevia-based Yentafo sauce was evaluated under accelerated storage conditions (45 °C and 55 °C) and predicted using the Q_{10} approach. The results indicated a shelf-life of approximately 44 days at an ambient temperature of 30 °C. The primary factor limiting the shelf-life was temperature-driven pigment degradation, which caused a significant decrease in the redness (a^* value) and an increase in lightness (L^* value) over time. This color deterioration occurred more rapidly at higher temperatures, leading to a loss of the characteristic pink/red appearance of Yentafo sauce. While this stevia-based formulation offers a viable healthier alternative, future work should focus on optimizing thermal processing or packaging conditions to prevent color degradation and further extend the commercial shelf-life.

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