

## Research article

# Impact of Herbal Mixed Tisanes on Antioxidant Property and Sensory Emotion of Relaxation and Calmness

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## Abstract

Traditional tisanes have gained more interest as functional dietary sources of antioxidants and represent a class of bioactive compounds. This research aimed to develop mixed herbal tisanes with high antioxidant activity and impact on consumer acceptance and emotions (relaxation and calmness). The study explored the antioxidant properties of five herbal mixtures; lavender (*Lavandula angustifolia* Mill.), mimosa (*Mimosa pudica* Linn.), stevia (*Stevia rebaudiana* Bertoni), chamomile (*Chamaemelum nobile* (L.) All.) and rose (*Rosa damascene*). The analysis of raw materials found stevia exhibited the highest total phenolic content ( $768.92 \pm 30.19$   $\mu\text{mol GE}/100\text{g}$ ) and highest nitric oxide scavenging ( $54.63 \pm 1.37\%$ ), followed by chamomile and mimosa. Sensory emotions, measured on a 5-point scale, indicated moderate to high levels of relaxation ( $3.94 \pm 0.69$ ) and calmness ( $3.62 \pm 0.67$ ). The mixture design employed varying proportions of three herbs: lavender (10-30%), mimosa (10-35%), and stevia (5-20%), with chamomile (30%) and rose (20%) as fixed components. Regression models demonstrated that various formulations of the herbs significantly affected consumer acceptance, calmness emotion and total flavonoid content ( $p < 0.05$ ). The optimized formulation of 23% lavender, 10% mimosa, and 17% stevia exhibited high consumer acceptance, emotions and antioxidant activities. The optimized herbal tea was analyzed for amino acid profile, and contained phenylalanine ( $86.13 \pm 0.08$   $\mu\text{g}/\text{mL}$ ), tyrosine ( $7.67 \pm 0.04$   $\mu\text{g}/\text{mL}$ ), serine ( $13.47 \pm 0.02$   $\mu\text{g}/\text{mL}$ ), glutamic acid ( $8.36 \pm 0.21$   $\mu\text{g}/\text{mL}$ ), all of which contributed to mood regulation and calmness. The phenolic compounds identified in tisanes were as follows; chlorogenic acid, catechin, ferulic acid, myricetin, and quercetin at  $2967.66 \pm 46.19$ ;  $2089.45 \pm 0.68$ ,  $1025.35 \pm 1.87$ ,  $987.06 \pm 19.16$ , and  $470.69 \pm 0.98$  ( $\mu\text{g}/\text{g}$ ), respectively, which may support relaxation and mental well-being. These findings highlight the promising role of herbal tisanes as a natural, functional beverage for oxidative stress reduction and emotional balance, with potential applications in the health and wellness industries.

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**Keywords:** antioxidant; adaptogen; calmness; herbal infusion; relaxation; sensory emotion; tisanes

## 1. Introduction

Herbal tisanes have been used for centuries for their medicinal properties, particularly in promoting relaxation and calmness, reducing stress, and promoting sleep. Chamomile and lavender are most commonly used for insomnia (Zick et al., 2011; Özderin, 2022), to improve sleep problems (Batiha et al., 2023). Herbal teas, such as chamomile tea, are typically served as hot functional beverages (Gupta et al., 2023; USDA, 2024). Herbal teas made from various plants can serve as natural and healthy alternatives to traditional tea and caffeine-free drinks (Srivastava et al., 2010; Chang & Chen, 2016; Poswal et al., 2019; Liu et al., 2023). Moreover, tisanes have been categorized as functional foods. Diet, nutrition, and/or sleep quality are categories of lifestyle medicine (LM), which promote good health, reduce the risks of physical, mental, or chronic diseases, and improve the quality of life, as mentioned by Phrommin et al. (2024). Many chronic diseases are caused by risk behaviors (CDC, 2024; WHO, 2024). The prevention of non-communicable diseases (NCDs) is a global challenge with priority recognition by the World Health Organization (Seyedsadjadi & Grant, 2021), as NCDs have a significant impact on health and hinder economic and social development (WHO, 2024). Although mental illness and insomnia are not classified as NCDs directly, they are closely associated with the progression and management of NCDs due to their strong links with chronic physical conditions and lifestyle factors (Javaheri & Redline, 2017; WHO, 2018; Georgiev et al., 2025). NCDs are considered the leading cause of death both globally and in Thailand (Babazadeh et al., 2016; Kaewtha et al., 2020; WHO, 2024). Although mental illness and insomnia are not directly classified as NCDs, sleep disorders can affect overall health, safety, and the quality of life (Stein et al., 2019). Insomnia is a prevalent issue that often accompanies both mental health disorders and NCDs (Stein et al., 2019). Chronic insomnia has been identified as a risk factor for several NCDs and contributes to increased stress, inflammation, and other physiological disturbances that may worsen the prognosis of these diseases. Monitoring oxidative stress and inflammation may serve as a preventive strategy, as NCDs typically develop over an extended period (Seyedsadjadi & Grant, 2021).

The use of herbal infusions aids in sleep and promotes physical or emotional well-being. It has been part of traditional medicine for centuries; the demand targeting stress relief and relaxation has increased, prompting scientific interest in the development of tisanes specifically formulated for these purposes. Traditional tisanes have long been brewed to ease stress, improve sleep, and enhance overall well-being, and demand for such relaxation-targeted blends continues to grow (Srivastava et al., 2010; Chang & Chen, 2016; Liu et al., 2023). Lavender (*Lavandula angustifolia*) contains the terpenes linalool and linalyl acetate, which deliver anxiolytic, sedative, and neuroprotective effects, also (Lis-Balchin & Hart, 1999; Koulivand et al., 2013; Batiha et al., 2023). Lavender has shown efficacy as an aromatherapy agent for depression and anxiety (Basch et al., 2004; Anonymous, 2025). Lavender has also been used in aromatherapy as a holistic relaxant and anti-insomnia agent (Kageyama et al., 2012; Ebrahimi et al., 2021; Kim et al., 2021; Batiha et al., 2023), and as therapeutic efficacy in neurological disorders (Koulivand et al., 2013). Chamomile (*Matricaria chamomilla*) supplies the flavone apigenin and the sesquiterpene  $\alpha$ -bisabolol, both associated with anti-inflammatory action and improved sleep latency (Srivastava et al., 2010). Rose (*Rosa damascena*) petals are rich in geraniol, citronellol, and quercetin-type flavonoids that uplift mood and attenuate oxidative

stress and have been used from ancient times to cure many infectious disorders, such as anti-inflammatory, antimutagenic, and antidepressant agents (Boskabady et al., 2011; Nayebi et al., 2017; Iqbal et al., 2020). Stevia (*Stevia rebaudiana*) contributes antioxidant phenolic acids alongside sweet steviol glycosides, offering glycaemic control and anti-inflammatory activity (Chatsudhipong & Muanprasat, 2009; Goyal et al., 2009). *Mimosa pudica* provides flavonoids, alkaloids, and tannins that show anxiolytic and antidepressant-like effects in pre-clinical studies (Rajendran & Sundararajan, 2010; Ahmad et al., 2012; Muhammad et al., 2016; Majeed et al., 2021). Even limited data, mimosa shows potential roles in neuroprotection and cancer chemoprevention (Bharati & Tiwari, 2025). Collectively, these bioactive profiles furnish antioxidant, anti-inflammatory, and neuromodulatory actions. Additionally, in China, mimosa is a rich source of natural antioxidants. The whole part of the mimosa has been used in traditional medicine for the treatment of neurasthenia, insomnia, traumatic injuries, and pulmonary tuberculosis. Mimosa is being studied for its phytochemicals and flavonoids, phenols, and other compounds, including two new C-glycosylflavones, have been discovered (Zhang et al., 2011). Such synergy offers a robust scientific basis for formulating a functional tisane that promotes relaxation, enhances mood, and may help mitigate long-term NCD risk. Traditional medicine highlights its anticonvulsant properties and uses in reducing depression symptoms (Muhammad et al., 2016; Phrommin et al., 2024). Despite its therapeutic potential, the use of mimosa in modern tisane formulations, particularly in the form of bath decoctions for insomnia, remains underexplored or limited (Singh, 2004; Bharati & Tiwari, 2025). Stevia, commonly valued for its natural sweetening properties, enhances the sensory experience of tisanes without adding calories. Chamomile, used in fixed proportions, is well-known for its sedative and anti-anxiety effects due to apigenin's binding to GABA receptors (Srivastava et al., 2010; Salehi et al., 2019). It has also been found to improve sleep quality by reducing nighttime awakenings (Kazemi et al., 2024).

Rose provides stress-reducing and mood-enhancing benefits, attributable to its bioactive compounds, which help manage anxiety and promote mental well-being (Boskabady et al., 2011; Mahboubi et al., 2015). Trendafilova et al. (2023) reported that the remarkable bioactive properties of rose extracts could be promising candidates for innovative applications in the cosmetic, food, and pharmaceutical industries. The role of traditional and complementary medicine has been emphasized in combating diabetes, relieving stress, and treating skin conditions (Konsue & Talubmook, 2018; Panyadee, 2023). The combination of lavender, mimosa, stevia, chamomile, and rose in herbal tisanes offers a synergistic effect for promoting relaxation, calmness, and sleep. This blend provides antioxidant, anti-inflammatory, and neuroprotective properties, contributing to mental well-being and the prevention of NCDs. While lavender and chamomile are extensively studied for their calming effects, mimosa's unique therapeutic contributions remain underexplored, making it a novel addition to tisane formulations. This study aimed to verify the impact of mixed herbal tisanes on consumer sensory emotions regarding the growing demand of consumers for natural remedies.

This study investigated the potential of a herbal tisane formulation comprising five herbs: lavender, mimosa, stevia, chamomile, and rose, using a mixture design approach. The focus was to optimize the ratio of lavender, mimosa, and stevia while maintaining fixed proportions of chamomile and rose. Key attributes, including sensory properties (relaxation, calmness, aroma, and flavor), antioxidant content, and emotional calming effects, were evaluated. Regression models were developed to quantify the contribution of each herb to these attributes, providing insights into their individual and combined effects on relaxation and wellness.

## 2. Materials and Methods

### 2.1 Materials and chemicals

#### 2.1.1 Research design

This research was conducted following the Helsinki declaration and was approved by the Ethics Committee of Chiang Mai University Research Ethics Committee (CMUREC No. 67/194; COA no. 170/67 approved date 3 September 2024). Informed consent was received for human studies. A baseline survey of the standard formulation was conducted (Phrommin et al., 2024). A mixture design, D-optimal, was then applied to develop tisane formulations, focusing on sensory acceptance (Singh et al., 2023a,b), emotional responses and antioxidant activities. Response surface methodology (RSM) (Khuri & Cornell, 2018) was used to optimize the final tisanes formulation, followed by validation. Each sample was measured in triplicate. Both the raw materials and the developed tisane formulations were analyzed for their physicochemical properties. The optimized tisanes were further evaluated for their amino acid and phenolic content profiles.

#### 2.1.2 Properties of raw materials

An herbal tea blend was developed using five dry plants, including chamomile (*Chamaemelum nobile* (L.) All.), lavender (*Lavandula angustifolia* Mill.), mimosa (*Mimosa pudica* Linn.), rose (*Rosa damascena*), and stevia (*Stevia rebaudiana* Bertoni). The plants were harvested in 2024 from royal projects at the Inthanon branch, Chiang Mai, Thailand. The quality of the herbs was controlled by moisture content (MC) of less than 10%, water activity,  $a_w$  value of less than 0.6, and the numbers of bacteria, yeast and mold and heavy metal levels in accordance with the regulations for herbs and tea as stated in the announcement of the Ministry of Public Health (No. 426) (Ministry of Public Health, 2021). Each tisane (Tea) sachet (1 g) was weighed and steeped in 200 mL of water at  $96^\circ\text{C}\pm 1^\circ\text{C}$  for 7 min. Tea infusion was modified from McAlpine and Ward (2016), Cleverdon et al. (2018), and Phrommin et al. (2022), as shown in Figure 1, which shows how to prepare tisanes in this study. The color of herbs either in powder or tisane forms was determined by color value using Minolta CR-400 colorimeter (Konica Minolta sensing Japan) and the CIE  $L^* a^* b^*$  system, which expresses color as follows:  $L^*$  is lightness and  $a^*$  is green (if-) or red (if+) and  $b^*$  is blue (if-) or yellow (if+).

#### 2.1.3 Chemicals

The Folin-Ciocalteu reagent, gallic acid, sodium carbonate solution ( $\text{Na}_2\text{CO}_3$ ), aluminum chloride ( $\text{AlCl}_3$ , 10% solution), quercetin, sodium nitrite ( $\text{NaNO}_2$ , 5%) and sodium hydroxide ( $\text{NaOH}$ , 1M solution) were acquired from RCI Lab Scan Limited (Bangkok, Thailand). The NO scavenging assay employed sodium nitroprusside (SNP), with Griess reagent, which included a mixture of sulfanilamide and N-(1-Naphthyl) ethylenediamine dihydrochloride (NED) in phosphate-buffered saline (PBS, pH 7.4). The ABTS (2,2'-Azino-bis (3-



**Figure 1.** The preparation of tisanes,  $95\pm 1^\circ\text{C}$ , 7 mins

ethylbenzothiazoline-6-sulfonic acid, potassium persulfate ( $\text{K}_2\text{S}_2\text{O}_8$ ), and Trolox as the standard for curve preparation were procured from Sigma-Aldrich (St. Louis, MO, USA), while potassium persulfate ( $\text{K}_2\text{S}_2\text{O}_8$ ), ferrous sulfate ( $\text{FeSO}_4$ ), hydrochloric acid (HCl), sodium carbonate ( $\text{Na}_2\text{CO}_3$ ), sodium acetate ( $\text{CH}_3\text{COONa}$ ), and acetic acid ( $\text{CH}_3\text{COOH}$ ) were provided from RCI Labscan Co., Ltd. (Bangkok, Thailand). Additionally, SNP and NED were obtained from Union Science (Chiang Mai, Thailand).

## 2.2 Development of tisane formulations

Herbal tea product formulas: chamomile (30%), lavender (20%), mimosa (20%), rose (20%), stevia (10%) were derived from standard tea formulas of Phrommin Thai Traditional Medicine Clinic (Phrommin et al., 2022). A D-optimum mixture design was used to assess the effects of varying proportions of five different herbs. The mixture design experiment was conducted to optimize the development of a tisane formulation (Table 1), focusing on physicochemical properties, sensory acceptance characteristics, and emotional impact. The herbal blend's mixture design composition included varying proportions of lavender (10-30%), mimosa (10-35%), and stevia (5-20%), collectively comprising 50% of the total formulation across eight treatments. The rose (20%) and chamomile (30%) remained constant throughout the study.

**Table 1.** Formation of mixed tisanes ( $T_1$ - $T_8$ ) using D-optimum mixture design

Treatments	A: X1 Lavender (%)	B: X2 Mimosa (%)	C: X3 Stevia (%)
$T_1$	20	18	12
$T_2$	30	15	5
$T_3$	10	35	5
$T_4$	10	27.5	12.5
$T_5$	10	20	20
$T_6$	20	10	20
$T_7$	30	10	10
$T_8$	10	35	5

Note: Total is 50%.

### 2.3 Physicochemical analysis

Physical and chemical properties of raw materials and herbal tea formulations were analyzed including color ( $L^*$ ,  $a^*$ ,  $b^*$ ), the values were measured with a color meter (CR-400, Konica Minolta, Japan). Water activity was determined using AQUA LAB (USA); moisture content followed the AOAC (2000).

### 2.4 Nitric oxide (NO) scavenging activity

Nitric oxide (NO) activity was assessed using a microplate reader (TECAN, Spark, Switzerland). The assay involved mixing 50  $\mu\text{L}$  of tisane decoction (prepared by steeping) with 50  $\mu\text{L}$  of freshly prepared 10 mM sodium nitroprusside (SNP) in phosphate-buffered saline (PBS, pH 7.4). The SNP solution was allowed to stand for 2 h in the dark before use. After mixing, Griess reagent 100  $\mu\text{L}$  was added, and the solution was left to stand at room temperature for 30 min. Absorbance was measured at 540 nm to determine NO inhibition, following a modified method of Marcocci et al. (1994) and Kantawong et al. (2017). The percentage of inhibition was calculated using a standard formula (equation 1):

$$\% \text{ inhibition} = [1 - A_1/A_0] \times 100 \quad (1)$$

$A_1$  was the absorbance of the extract or standard, and  $A_0$  was the absorbance of the control (ethanol/DMSO/water). In this study, sodium nitrite (1  $\mu\text{g}/\text{mL}$ ) was used as the standard curve, weighing 0.0010 g (1000  $\mu\text{g}/\text{mL}$ ). Stock solution of sodium nitrite, from working standards, was prepared at various concentrations, including 1  $\mu\text{g}/\text{mL}$ , a standard curve of series, 1-20  $\mu\text{Molar}$ .

### 2.5 Total phenolic content (TPC)

The TPC was conducted using a modified method by Cleverdon et al. (2018). The tisane steeped decoctions (20  $\mu\text{L}$ ) were mixed with Folin-Ciocalteu reagent (80  $\mu\text{L}$ ) in a 96-well plate and allowed to react for 5 min. Subsequently, 80  $\mu\text{L}$  of sodium carbonate solution (7.5% w/v) was added, and the volume was adjusted to 200  $\mu\text{L}$  with distilled water. The solution was then incubated at room temperature for 2 h. The absorbance was measured at 730 nm using a microplate reader (TECAN, Spark). Gallic acid (0.001 to 0.01 mg/mL) was used as a standard, and the TPC was calculated as gallic acid equivalent (GAE) based on the standard curve. Additionally, the phenolic profile was analyzed following a modified method from Liaudanskas et al. (2014).

### 2.6 ABTS assay

The ABTS radical scavenging activity was determined using a modified method from Salee et al. (2024). Briefly, 3 mL of 2.45 mM potassium persulfate ( $\text{K}_2\text{S}_2\text{O}_8$ ) solution was mixed with 3 mL of 7 mM ABTS solution and incubated in the dark for 12-16 h before use. The ABTS solution was then diluted with water until its absorbance reached  $0.700 \pm 0.002$  at 734 nm. For the assay, 180  $\mu\text{L}$  of the prepared ABTS solution was added to 20  $\mu\text{L}$  of a 0.02 mg/mL extract solution in a 96-well plate, followed by incubation in the dark at room temperature for 6 min. The absorbance of the mixture was measured at 734 nm using a microplate reader (TECAN, Spark). A standard curve of 6-rolox was constructed for quantification.

## 2.7 Total flavonoid content (TFC)

TFC assay was explored following a modified method from Chuensun et al. (2020). Briefly, 1 mL of decoction of the tisane sample was mixed with 0.1 mL of 10% aluminum chloride, 0.1 mL of 1M potassium acetate, and 2.8 mL of distilled water. The mixture was then vortexed for 30 s and then incubated at room temperature for 30 min. The absorbance was measured at 415 nm.

## 2.8 Amino acid profile analysis

The amino acid profile of the final tisane sample was analyzed using HPLC with a post-column method, as described by Kageyama et al. (2015) and Somjai et al. (2022). A Na-type sulfone group column, Shim-pack AMINO-NA (100 mm length × 6.0 mm I.D.) with a 5 µm particle size (P/N: 228–18837-91, Shimadzu, Japan), was utilized along with an RF-20A fluorescence detector (Shimadzu, Japan).

## 2.9 Sensory emotion and acceptance

This study evaluated the sensory emotions and acceptance of eight tisane formulations (T1-T8) among experienced panelists. The evaluation process was structured into a clear five-step process: 1) Panelist selection and demographic data. The study involved 53 participants from the Faculty of Agro-Industry, Chiang Mai, Thailand. The demographic details included gender, age group, and allergic history. The participant group comprised 83% females and 17% males, aged 20-65 years. 2) Evaluation process; the assessment consisted of two parts: Sensory emotion test: participants rated their emotional responses (e.g., relaxation and calmness) using a 5-point scale: 1 = Weak feeling, 2 = Mild feeling, 3 = Moderate feeling, 4 = Very much feeling, 5 = Extremely feeling, then following with an acceptance test; participants evaluated their acceptance of each tisane formulation using a 9-point hedonic scale: 1 = Dislike extremely, 5 = Neither like nor dislike, 9 = Like extremely. 3) Sensory attributes, the sensory evaluation focused on the following attributes, adapted from Phrommin et al. (2024); color, clearness, total aroma, sweet aroma, spices aroma, sweetness, total flavors, astringency, aftertaste, and overall liking. 4) Sample evaluation; each participant was served 20 mL of the tea formulations in clear plastic cups. The tea temperature was meticulously maintained between 60-65°C to ensure consistency acceptance. Samples were coded with three-digit random numbers and presented sequentially to avoid bias. 5) Testing environment: the evaluations were conducted in a controlled laboratory environment with a constant temperature of 25°C. This controlled setup ensured reliable and consistent results for both sensory emotions and acceptance testing. By systematically following this approach, the study effectively captured panelists' emotional feeling responses (e.g., relaxation and calmness) and their sensory preferences for each tisane formulation. Mineral water and plain crackers were provided for rinsing the palate between samples.

## 2.10 Statistical analysis

Data were expressed as mean±standard deviation. Analysis of variance (ANOVA) was performed using SPSS (version 17.0) with a significance level of  $p \leq 0.05$ , followed by Tukey's post hoc test. Regression analysis for mixture design modeling was conducted using Design-Expert software (version 6.0.10, Minneapolis, USA). Preference and

acceptance tests were also analyzed. Models with  $R^2$  values between 65% and 70% were considered acceptable.

### 3. Results and Discussion

#### 3.1 Color and physicochemical properties of the five raw materials and their tisanes (herbs blended)

The physicochemical properties and antioxidant activities of the raw materials used in the study are presented in Table 2. Significant differences were observed in the MC,  $a_w$ , color values, and antioxidant properties across the five herbal samples ( $p < 0.05$ ). Lavender showed the highest moisture content ( $7.29 \pm 0.08\%$ ), while mimosa had the lowest ( $4.80 \pm 0.07\%$ ). Water activity ranged from  $0.29 \pm 0.02$  in rose to  $0.34 \pm 0.005$  in lavender and mimosa. For powder samples, chamomile exhibited the highest degree of lightness ( $L^* = 58.2 \pm 0.34$ ) and the most neutral  $a^*$  value ( $-3.6 \pm 0.49$ ). Stevia displayed the darkest color ( $L^* = 49.2 \pm 0.46$ ) with a greenish hue ( $a^* = -4.78 \pm 0.14$ ). Among the tisane forms (herb decoctions); chamomile retained the brightest color ( $L^* = 28.35 \pm 0.00$ ), while stevia showed the lowest brightness ( $L^* = 26.87 \pm 0.04$ ). Rose had the most reddish hue in its tisane form ( $a^* = 16.62 \pm 0.34$ ).

The herbal tisanes' antioxidant activity varied notably, with stevia showing the highest total phenolic content ( $768.92 \pm 30.19 \mu\text{mol GE}/100\text{g}$ ) and NO scavenging assay (% inhibition) ( $54.63 \pm 1.37\%$ ) (Table 2), followed by rose ( $547.23 \pm 20.36 \mu\text{mol GE}/100\text{g}$ ). Also, stevia had the highest ABTS radical scavenging activity ( $433.88 \pm 0.51 \mu\text{mol TE}/100\text{g}$ ) demonstrating its strong antioxidant potential. Rose also showed high flavonoid content (TFC =  $24.52 \pm 0.26 \mu\text{mol QE}/100\text{g}$ ), comparable to stevia (TFC =  $24.37 \pm 0.10 \mu\text{mol QE}/100\text{g}$ ).

Color properties in raw material and blended herbs (tisanes) were shown in lightness. Table 2 summarizes the physicochemical and color characteristics of chamomile, lavender, mimosa, rose, and stevia in both raw powders and their corresponding tisanes. Among the raw powders, chamomile exhibited the highest lightness ( $L^* = 58.20 \pm 0.34$ ), indicating the brightest appearance, followed by mimosa ( $54.80 \pm 0.51$ ) and stevia ( $49.20 \pm 0.46$ ). Rose presented the lowest  $L^*$  value ( $46.10 \pm 0.46$ ), confirming its darker tone, while lavender ( $46.80 \pm 0.21$ ) was slightly lighter than rose. The  $a^*$  (red–green) axis revealed a wide variation: rose powder showed the most intense positive  $a^*$  value ( $16.62 \pm 0.34$ ), reflecting a strong red hue, whereas stevia and chamomile displayed negative  $a^*$  values ( $-4.78 \pm 0.14$  and  $-3.60 \pm 0.49$ , respectively), indicating a greener appearance. For  $b^*$  (yellow–blue), chamomile had the highest yellowness ( $27.21 \pm 1.20$ ), while lavender recorded the lowest  $b^*$  ( $7.62 \pm 0.51$ ).

After infusion (tisanes),  $L^*$  values decreased for all samples, indicating a darker liquor compared with the dry powders. Chamomile maintained the highest brightness ( $28.35 \pm 0.00$ ), whereas stevia tea was the darkest ( $26.87 \pm 0.04$ ). Negative  $a^*$  values for all tisanes suggest a shift toward greenish tones, with stevia ( $-2.62 \pm 0.07$ ) showing the strongest green hue. The  $b^*$  values of the tisanes were markedly reduced compared with the powders; stevia ( $8.71 \pm 0.04$ ) retained the greatest yellowness, while rose remained the least yellow ( $4.89 \pm 0.35$ ). Regarding chemical composition, stevia showed the highest total phenolic content (TPC,  $768.92 \pm 30.19 \mu\text{mol GE}/100 \text{g}$ ) and total flavonoid content (TFC,  $24.37 \pm 0.10 \mu\text{mol QE}/100 \text{g}$ ), which corresponded with its strongest antioxidant capacity (ABTS  $433.88 \pm 0.51 \mu\text{mol TE}/100 \text{g}$ ; NO inhibition  $54.63 \pm 1.37 \%$ ). Rose also exhibited high TPC ( $547.23 \pm 20.36 \mu\text{mol GE}/100 \text{g}$ ) and TFC ( $24.52 \pm 0.26 \mu\text{mol QE}/100 \text{g}$ ), supporting its

notable antioxidant activity. Lavender recorded the lowest TPC and relatively low antioxidant indices. These results indicate that the color attributes, particularly the  $a^*$  and  $b^*$  values are closely associated with phenolic and flavonoid concentrations, which is in agreement with previous findings that phenolic pigments contribute to both color expression and antioxidant properties in herbal infusions (Muzolf-Panek & Waśkiewicz, 2022). A comparison between the powders of all herbs and their corresponding tisanes reveals distinct color differences. The dry herbs were brighter, as indicated by higher  $L^*$  values, and exhibited more intense yellow tones, which were reflected in higher  $b^*$  values. In contrast, the tisanes displayed darker tones (lower  $L^*$  values) with reduced yellow intensity (lower  $b^*$  values). Among the herbs, chamomile consistently appeared the lightest and most yellowish in both forms, while rose and stevia were darker with more muted colors compared to the other materials. Chamomile, which had the highest  $L^*$  value, also had a moderate moisture content (MC:  $6.17 \pm 0.11$ ;  $a_w$ :  $0.29 \pm 0.01$ ) as shown in Table 2.

For antioxidant properties, stevia recorded the highest total phenolic content (TPC=  $768.92 \pm 30.19$   $\mu\text{mol GE}/100\text{g}$ ), total flavonoid content (TFC=  $24.37 \pm 0.10$   $\mu\text{mol QE}/100\text{g}$ ), ABTS radical scavenging activity ( $433.88 \pm 0.51$   $\mu\text{mol TE}/100\text{g}$ ), and nitric oxide (NO) scavenging activity ( $54.63 \pm 1.37\%$ ). Rose followed with high TPC ( $547.23 \pm 20.36$   $\mu\text{mol GE}/100\text{g}$ ) and TFC ( $24.52 \pm 0.26$   $\mu\text{mol QE}/100\text{g}$ ). A report from Jin et al. (2016) showed high antioxidants in rose tea. Chamomile and mimosa showed moderate antioxidant activities, which were similar to McKay and Blumberg's (2006), while lavender exhibited the lowest values across most antioxidant parameters. The teas (tisanes) made from chamomile, lavender, and mimosa had comparable lightness and yellowish tones, with stevia and mimosa showing the most yellow among the tisanes, as shown in Table 2. Antioxidant properties of raw materials in this study showed that TPC and ABTS values were highest in stevia and mimosa, suggesting that darker raw materials (lower  $L^*$ ) may correlate with higher antioxidant properties (Table 2).

Color is one of the important sensory perception-related characteristics of tea and corresponds to the levels of antioxidant components. Color is often correlated with antioxidant activity in herbs (Jin et al., 2016). In addition, drying techniques can affect the color and nutritional properties of herbs, and up to 50% may be lost depending on herb storage temperature (Jiménez-Zamora et al., 2016). Stevia's high antioxidant properties align with the findings of Chan et al. (2012), who reported that the antioxidant activity of *Stevia rebaudiana* tea was comparable to that of oolong and/or black teas, which had stronger antioxidant activity than teas of *C. sinensis*. High antioxidant activity of stevia was also reported by Shukla et al. (2012) and Sytar et al. (2023). Additionally, stevia demonstrated anti-inflammatory properties via sativoside inhibition (Kasti et al., 2022). An important note was that herbal teas with darker colors tend to have higher antioxidant activity (Jin et al., 2016). Chamomile powder exhibited the highest lightness value ( $L^*$ ) at  $58.2 \pm 0.34$ , whereas its tisane showed a significant reduction in lightness ( $28.35 \pm 0.00$ ). Similarly, the  $a^*$  value shifted from a negative range ( $-3.6 \pm 0.49$ ) in the powder to  $-1.58 \pm 0.01$  in the tisane, indicating a diminished green hue. The  $b^*$  value, which denotes the yellow component, decreased from  $27.21 \pm 1.20$  in the powder to  $4.87 \pm 0.05$  in the tisane. This reduction in color intensity during tisane preparation was likely attributed to the dissolution and extraction processes, which affected pigment content, as supported by studies on herbal infusion color degradation (Phrommin et al., 2024). Lavender powder had relatively low lightness ( $L^*$ ) at  $46.8 \pm 0.21$ , with the value further decreasing in the tisane form ( $27.47 \pm 0.18$ ). The  $a^*$  values remained positive, indicating a reddish hue ( $1.7 \pm 0.15$  in powder,  $-1.11 \pm 0.03$  in tisane), while the yellow ( $b^*$ ) parameter showed a slight decrease

**Table 2.** Physicochemical properties of five raw materials

Raw Material	Moisture Content (MC)	Water Activity ( $A_w$ )	Color Value (powder)			Color Value (Tisanes)			TPC ( $\mu\text{mol GE}/100\text{g}$ )	TFC ( $\mu\text{mol QE}/100\text{g}$ )	Antioxidant Property	
			L*	a*	b*	L*	a*	b*			ABTS ( $\mu\text{mol TE}/100\text{g}$ )	NO (%) inhibition
Chamomile	6.17±0.11 <sup>c</sup>	0.29±0.01 <sup>b</sup>	<b>58.20±0.34<sup>a</sup></b>	-3.60±0.49 <sup>d</sup>	<b>27.21±1.20<sup>a</sup></b>	<b>28.35±0.00<sup>a</sup></b>	-1.58±0.01 <sup>d</sup>	4.87±0.05 <sup>c</sup>	312.87±15.23 <sup>b</sup>	12.19±0.07 <sup>b</sup>	400.97±3.42 <sup>b</sup>	<b>51.25±2.74<sup>ab</sup></b>
Lavender	<b>7.29±0.08<sup>a</sup></b>	<b>0.34±0.01<sup>a</sup></b>	46.80±0.21 <sup>d</sup>	1.70±0.15 <sup>b</sup>	7.62±0.51 <sup>c</sup>	27.47±0.18 <sup>c</sup>	-1.11±0.03 <sup>b</sup>	4.92±0.03 <sup>c</sup>	208.55±8.65 <sup>c</sup>	14.76±0.42 <sup>b</sup>	218.08±8.62 <sup>c</sup>	44.76±1.52 <sup>c</sup>
Mimosa	4.80±0.07 <sup>e</sup>	0.34±0.00 <sup>a</sup>	54.80±0.51 <sup>b</sup>	-2.55±0.00 <sup>c</sup>	17.31±0.16 <sup>b</sup>	27.85±0.01 <sup>b</sup>	-1.15±0.03 <sup>c</sup>	6.25±0.06 <sup>b</sup>	299.63±10.45 <sup>b</sup>	6.20±0.05 <sup>c</sup>	395.23±2.76 <sup>b</sup>	50.05±0.99 <sup>b</sup>
Rose	5.19±0.06 <sup>d</sup>	0.29±0.02 <sup>b</sup>	46.10±0.46 <sup>e</sup>	<b>16.62±0.34<sup>a</sup></b>	1.51±0.14 <sup>d</sup>	27.29±0.07 <sup>d</sup>	<b>-0.48±0.02<sup>a</sup></b>	4.89±0.35 <sup>c</sup>	<b>547.23±20.36<sup>a</sup></b>	<b>24.52±0.26<sup>a</sup></b>	347.89±3.51 <sup>b</sup>	47.83±1.95 <sup>b</sup>
Stevia	7.03±0.10 <sup>b</sup>	<b>0.32±0.01<sup>ab</sup></b>	49.20±0.46 <sup>c</sup>	-4.78±0.14 <sup>e</sup>	16.37±0.18 <sup>b</sup>	26.87±0.04 <sup>e</sup>	-2.62±0.07 <sup>b</sup>	<b>8.71±0.04<sup>a</sup></b>	<b>768.92±30.19<sup>a</sup></b>	<b>24.37±0.10<sup>a</sup></b>	<b>433.88±0.51<sup>a</sup></b>	<b>54.63±1.37<sup>a</sup></b>

Note: Data are expressed as mean±standard deviation. Different superscript letters in the same columns indicate significant differences ( $p \leq 0.05$ ), while ns indicates non-significant differences ( $p > 0.05$ ). Bold values indicate the highest score in each property. TPC= Total phenolic content, TFC= total flavonoid content, ABTS= ABTS radical scavenging assay, NO= Nitric oxide scavenging assay. The color parameters are represented by the L\* (lightness), a\* (green to red), and b\* (blue to yellow) values. Abbreviation; Gallic acid eq= GE, Quercetin eq=QE, Trolox eq=TE

from  $7.62 \pm 0.51$  to  $4.92 \pm 0.03$ . The changes of tea polyphenol (TP) in infusions may be due to heat exposure and polyphenolic degradation. With an increase in temperature, the TP solutions became darker and less green, but deeper yellow in color (Zeng et al., 2017). For mimosa, the  $L^*$  value of the powder was moderately high ( $54.8 \pm 0.51$ ) but dropped to  $27.85 \pm 0.01$  in the tisane form. The  $a^*$  value shifted slightly from  $-2.55 \pm 0.00$  in powder to  $-1.15 \pm 0.06$  in tisane, indicating a slight loss of greenness. Similarly, the  $b^*$  value decreased significantly from  $17.31 \pm 0.16$  to  $6.25 \pm 0.10$ , consistent with pigment solubility and oxidation during the steeping process (Kanatt et al., 2014; Lu et al., 2023; Kaveh et al., 2025). Rose powder exhibited one of the lowest lightness values ( $L^*$ ) at  $46.1 \pm 0.46$ , with a further reduction to  $27.29 \pm 0.07$  in the tisane. The  $a^*$  value remained close to neutral ( $0.34 \pm 0.34$  in powder,  $-0.48 \pm 0.02$  in tisane), while the yellow hue ( $b^*$ ) dropped dramatically from  $1.51 \pm 0.14$  to  $4.89 \pm 0.35$  which was due to an unstable  $b^*$  value caused by dissolution/oxidation of pigments (Lantano et al., 2015). Similar results were reported by McKay and Blumberg (2006), who observed that rose infusions lost vibrancy as their flavonoid compounds degraded during extraction. Stevia demonstrated moderate lightness ( $L^*$ ) values in powder ( $49.2 \pm 0.46$ ) and tisane ( $26.87 \pm 0.04$ ), with its  $a^*$  value shifting from  $-4.78 \pm 0.14$  to  $-2.62 \pm 0.07$ , maintaining a slight green hue. The yellow component ( $b^*$ ) declined from  $16.37 \pm 0.18$  in powder to  $8.71 \pm 0.04$  in the tisane.

These findings were consistent with earlier studies of stevia leaves, where chlorophyll and carotenoid breakdown during hot-water extraction caused color loss and pigment declined (Yang et al., 2022; Roohinejad et al., 2025). Overall, these changes in  $L^*$ ,  $a^*$ , and  $b^*$  values across all the herbs can be attributed to the steeping process, which induces pigment dissolution, oxidation, and thermal degradation. These color variations provide insights into the extraction efficiency and stability of bioactive compounds, which are essential for sensory evaluation and antioxidant retention in herbal tisanes (Jin et al., 2016; McAlpine & Ward, 2016; Yang et al., 2022; Roohinejad et al., 2025).

### 3.2 Development of tisanes

The formulation of herbal tisanes was standardized to maximize consumer acceptance, emotion and antioxidant activities utilizing the response surface model. A mixture design was employed to determine the composition of lavender, mimosa, and stevia with fixed rose and chamomile. The herbal tisanes were analyzed for moisture content,  $a_w$ , color, antioxidant activities, sensory and emotional evaluations.

#### 3.2.1 Antioxidant properties of tisanes formulation

Antioxidant properties of the tisane formulas (T1-T8, Table 1) are shown in Table 3. The highest values of TPC, TFC and ABTS were found in T7 ( $511.47 \pm 19.00$   $\mu\text{mol GE}/100\text{g}$ ,  $19.08 \pm 0.46$   $\mu\text{mol QE}/100\text{g}$ ,  $381.86 \pm 4.34$   $\mu\text{mol TE}/100\text{g}$ , respectively), followed by the TPC values in T6 and T1 with  $380.11 \pm 4.99$ ,  $363.51 \pm 20.49$   $\mu\text{mol GE}/100\text{g}$ , respectively. The NO scavenging assay showed the highest value of % inhibition in T4, T1, T8, T7 ( $59.82 \pm 0.40$ ,  $57.34 \pm 0.66$ ,  $57.22 \pm 0.40$ , and  $56.40 \pm 1.50$ ), respectively. As shown in Table 3, the main effects observed in formulations T1, T4, T7, and T8 were largely influenced by the proportions of lavender, mimosa, and stevia. The physicochemical results (Tables 2 and 3) show that blending tisanes enhanced both TPC/TFC and antioxidant capacity compared to most single ingredients. Among the formulas, T7 (rich in stevia and rose) achieved the highest TPC ( $511.47 \pm 19.00$   $\mu\text{mol GE}/100\text{g}$ ) and strong NO inhibition ( $56.40 \pm 1.50\%$ ), while T4 (mimosa dominant) recorded the top NO inhibition ( $59.82 \pm 0.40\%$ ), highlighting the

positive association between herbal composition and antioxidant activity. This indicates potential anti-inflammatory benefits, aligning with the herbs' properties. Although we did not find another study of mixed tisane properties shown in other research, the results in this work aligned with other studies of mimosa, stevia or lavender (Chan et al., 2012; Patro et al., 2016; Donelli et al., 2019; Fasiha et al., 2020; Abdela et al., 2021; Gupta et al., 2023).

### 3.2.2 Sensory and emotional evaluation

The sensory and emotional responses in this study was conducted in all formulations (T1-T8) with 53 participants from Faculty of Agro-industry, Chiang Mai University, Thailand, 83% of whom were female and 17% were male, aged 20-65. The results of acceptance and emotional responses are presented in Table 4. T1 demonstrated the highest scores in relaxation ( $3.57 \pm 0.84$ ) and calmness ( $3.30 \pm 0.90$ ). It also received the highest overall liking score ( $6.91 \pm 1.43$ ). The lowest score of astringency was observed in T8 ( $6.31 \pm 1.63$ ). The highest scores of total flavors were found in T6, and T7, and for total aroma, T6 had the highest score ( $6.91 \pm 1.36$ ,  $7.33 \pm 1.06$ ), respectively (Table 4).

### 3.3 Optimization of tisane formulation

The optimization result found an impact of formula variation on eight attributes (Table 5), which were categorized into 3 main parts: 1) calmness, 2) consumer acceptance, and 3) total flavonoid content. The regression model results demonstrated that the mixture design incorporates lavender (10-30%), mimosa (10-35%), and stevia (5-20%), with fixed levels of chamomile (30%) and rose (20%). These relationships were further supported by the R-squared ( $R^2$ ) values, which explained the proportion of variability in the response variables. The attributes with significant R-square values were calmness ( $R^2=0.68$ ), color ( $R^2=0.72$ ), total aroma ( $R^2=0.97$ ), and sweet aroma ( $R^2=0.94$ ). Stevia contributed significantly to aroma and flavor, while lavender enhanced flavonoid content ( $R^2=0.90$ ), reinforcing its antioxidant potential (Shukla et al., 2011; 2012). Mimosa's contribution to relaxation and calmness aligned with its traditional usage (Khare, 2004; Kumar, 2021) and played a crucial role in sensory sweetness and flavor.

#### 3.3.1 The effect of formula variation on emotional calmness

The regression model for calmness is shown in Table 5. It indicates that stevia had the strongest positive effect (0.07), followed by lavender (0.06) and mimosa (0.06). The  $R^2$  in this regression of calmness was 0.68, which indicated that the proportions of these three herbs were able to explain 68% of the variation in emotional calmness. The researcher found the ingesting data of the effect of increasing/decreasing factors as follows by Phrommin et al. (2024); 1) Increasing stevia concentration enhances emotional calmness to the greatest degree, either flavors or an aroma as shown in a regression model (Table 5). This finding aligned with previous studies demonstrating that *Stevia rebaudiana* contained antioxidant compounds, which may reduce stress and promote relaxation (Gupta et al., 2023; Fasiha et al., 2020; Khakpai et al., 2023). This may show that people themselves perceive that sweet taste can alter mood, e.g. feel "better" or emotionally uplifted under sweetness conditions (Kampov-Polevoy et al., 2006). Zushi et al. (2023) suggested emotional state influences how much sweet taste is felt/enjoyed; this implies that in relaxed states, sweetness might "feel sweeter" and may promote more pleasure/calm.

**Table 3.** Physicochemical properties of developed tea formulas

Tea Formulas	Moisture Content (MC)	Water Activity (A <sub>w</sub> )	Color Value (Powder)			Color Value (Tisanes)			TPC (μmol GE/100g)	TFC (μmol QE/100g)	Antioxidant Property	
			L*	a*	b*	L*	a*	b*			ABTS (μmol TE/100g)	NO (% inhibition)
T <sub>1</sub>	7.17±0.09	0.39±0.01	51.86±0.86	0.49±0.13	16.11±0.16	27.32±0.34	-1.62±0.05	6.49±0.68	363.51±20.49 <sup>bc</sup>	12.13±.28 <sup>b</sup>	329.67±12.68 <sup>cd</sup>	<b>57.34±0.66<sup>ab</sup></b>
T <sub>2</sub>	8.16±0.19	0.48±0.02	51.62±0.19	0.97±0.22	15.75±0.18	27.53±0.26	-1.41±0.07	6.54±0.61	349.81±15.56 <sup>c</sup>	11.98±.12 <sup>a</sup>	296.85±8.73 <sup>g</sup>	<b>55.62±0.48<sup>abc</sup></b>
T <sub>3</sub>	7.44±0.05	0.51±0.01	52.79±0.40	0.45±0.14	17.31±0.16	27.64±0.19	-1.51±0.05	6.53±0.46	318.76±7.10 <sup>d</sup>	15.17±.07 <sup>c</sup>	319.76±8.46 <sup>de</sup>	55.22±5.47 <sup>c</sup>
T <sub>4</sub>	7.31±0.08	0.47±0.03	52.65±0.36	-1.02±0.22	17.85±0.28	27.53±0.20	-1.65±0.06	7.17±0.36	338.93± 11.28 <sup>cd</sup>	13.75±.82 <sup>d</sup>	310.03±5.08 <sup>e</sup>	<b>59.82±0.40<sup>a</sup></b>
T <sub>5</sub>	7.31±0.06	0.48±0.03	51.70±0.59	-0.42±0.44	16.64±0.62	27.53±0.10	-1.69±0.02	6.44±0.35	360.49±19.07 <sup>bc</sup>	15.34±.79 <sup>c</sup>	339.19±2.06 <sup>bc</sup>	50.01±0.76 <sup>d</sup>
T <sub>6</sub>	7.87±0.14	0.51±0.01	51.16±0.44	-0.41±0.25	16.09±0.24	27.5±0.13	-1.81±0.03	7.23±0.39	380.11±4.99 <sup>b</sup>	16.28±0.24 <sup>b</sup>	350.30±5.93 <sup>b</sup>	52.34±2.06 <sup>cd</sup>
T <sub>7</sub>	7.78±0.15	0.49±0.03	50.65±0.40	1.14±0.24	15.16±0.27	27.27±0.23	-1.58±0.04	6.93±0.51	<b>511.47±19.00<sup>a</sup></b>	<b>19.08±.46<sup>a</sup></b>	<b>381.86±4.34<sup>a</sup></b>	56.40±1.50 <sup>abc</sup>
T <sub>8</sub>	7.22±0.14	0.54±0.02	52.70±0.56	0.13±0.30	16.31±0.57	27.62±0.13	-1.61±0.04	6.51±0.39	139.97±3.14 <sup>e</sup>	13.00±.30 <sup>d</sup>	291.57±9.21 <sup>g</sup>	<b>57.22±0.40<sup>ab</sup></b>

Note: Data are expressed as mean ± standard deviation. Different superscript letters in the same columns indicate significant differences (p≤0.05), while ns indicates non-significant differences (p>0.05). Bold values indicate the highest score in each property. TPC=Total phenolic content, TFC Total Flavonoid content, ABTS ABTS radical scavenging assay, NO = Nitric oxide assay. The color parameters are represented by the L\* (lightness), a\* (green to red), and b\* (blue to yellow) values. Abbreviation; Gallic acid eq= GE, Quercetin eq=QE, Trolox eq=TE. The formulations T1–T8 are described in Table 1. Bold values indicate the highest score in each property.

**Table 4.** Sensory and emotional acceptance properties of developed tea formulas (N=53)

Attributes	Nine-point hedonic scores							
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>6</sub>	T <sub>7</sub>	T <sub>8</sub>
Color <sup>ns</sup>	7.31±1.13	6.98±1.49	7.00±1.40	7.22±1.11	7.28±1.12	7.28±1.25	7.22±1.16	7.07±1.33
Clearness <sup>ns</sup>	7.56±1.27	7.41±1.46	7.63±1.39	7.56±1.00	7.46±1.28	7.46±1.09	7.37±1.29	7.46±1.24
Total aroma	7.09±1.20 <sup>ab</sup>	6.81±1.18 <sup>abc</sup>	6.63±1.60 <sup>bc</sup>	6.89±1.19 <sup>abc</sup>	<b>7.06±1.26<sup>ab</sup></b>	7.33±1.06 <sup>a</sup>	<b>7.20±1.17<sup>a</sup></b>	6.46 ±1.34 <sup>c</sup>
Sweet aroma	7.04±1.30 <sup>ab</sup>	6.59±1.29 <sup>bc</sup>	6.44±1.94 <sup>c</sup>	6.72±1.22 <sup>bc</sup>	6.76±1.30 <sup>abc</sup>	7.04±1.03 <sup>ab</sup>	<b>7.30±1.16<sup>a</sup></b>	6.24 ±1.44 <sup>c</sup>
Spices' aroma	<b>6.74±1.39<sup>a</sup></b>	<b>6.41±1.31<sup>ab</sup></b>	<b>6.24±1.75<sup>ab</sup></b>	<b>6.46±1.25<sup>ab</sup></b>	<b>6.44±1.41<sup>ab</sup></b>	<b>6.72±0.99<sup>a</sup></b>	<b>6.54±1.24<sup>ab</sup></b>	6.06±1.43 <sup>b</sup>
Sweetness <sup>ns</sup>	6.52±1.58	6.44±1.41	6.43±1.87	6.26±1.73	6.24±1.47	6.33±1.64	6.35±1.66	6.22±1.70
Total flavors <sup>ns</sup>	6.89±1.38	6.83±1.06	6.35±1.51	6.85±1.35	6.72±1.16	6.91±1.36	6.91±1.39	6.41±1.41
Astringency <sup>ns</sup>	6.70±1.50	6.57±1.25	6.65±1.48	6.54±1.30	6.81±1.35	6.7±1.37	6.85±1.43	6.31±1.63
Aftertaste <sup>ns</sup>	6.69±1.41	6.85±1.11	6.76±1.48	6.54±1.33	6.63±1.54	6.59±1.54	6.59±1.47	6.39 ±1.40
Overall liking <sup>ns</sup>	6.91±1.43	6.87±1.30	6.87±1.37	6.78±1.30	6.74±1.29	6.7±1.35	6.85±1.31	6.41±1.43
Relaxation	<b>3.57±0.84<sup>a</sup></b>	<b>3.33±0.87<sup>ab</sup></b>	<b>3.22±1.12<sup>ab</sup></b>	<b>3.30±0.84<sup>ab</sup></b>	<b>3.33±0.85<sup>ab</sup></b>	<b>3.37±0.92<sup>ab</sup></b>	<b>3.37±0.98<sup>ab</sup></b>	<b>3.02±0.81<sup>b</sup></b>
Calmness <sup>ns</sup>	3.30±0.90	3.11±0.90	3.09±1.14	3.02±0.90	3.26±0.87	3.30±0.86	3.24±0.97	3.04±0.82

Note: Data are expressed as mean ± standard deviation. Different superscript letters in the same columns indicate significant differences (p ≤ 0.05), while ns indicates non-significant differences (p > 0.05). Bold values indicate the highest score in each property. The liking scores were evaluated on a nine-point hedonic scale with; 1=Dislike extremely, 9=Like extremely. The formulations T1–T8 are described in Table 1.

**Table 5.** Regression model of the tea formulas (n=53)

Variable	Regression Models	R <sup>2</sup>
Calmness	$0.06X_1 + 0.06X_2 + 0.07X_3$	0.68
Color	$0.14X_1 + 0.14X_2 + 0.16X_3$	0.72
Total aroma	$0.13X_1 + 0.12X_2 + 0.10X_3 + 2.89 \times 10^{-3}X_1X_3 + 1.88 \times 10^{-3}X_2X_3$	0.97
Sweet aroma	$0.12X_1 + 0.11X_2 - 7.82 \times 10^{-3}X_3 + 6.75 \times 10^{-3}X_1X_3 + 5.13 \times 10^{-3}X_2X_3$	0.94
Spices aroma	$0.13X_1 + 0.12X_2 + 0.14X_3$	0.71
Total flavors	$0.14X_1 + 0.11X_2 + 0.07X_3 + 2.48 \times 10^{-3}X_1X_3 + 3.27 \times 10^{-3}X_2X_3$	0.93
Color of Tea (a*)	$-0.03X_1 - 0.03X_2 - 0.05X_3$	0.77
TFC	$0.94X_1 + 0.72X_2 + 0.16X_3 - 0.06X_1X_2$	0.90

Note: X<sub>1</sub>; lavender, X<sub>2</sub>; mimosa, X<sub>3</sub>; stevia. R<sup>2</sup> > 0.65 indicates acceptable model fit.

The mechanism by which stevia assisting in controlling blood pressure is due to artery relaxation (Mlambo et al., 2022). Stevia affects relaxation and calmness indirectly by reducing oxidative stress and anti-inflammatory effects (Nikam et al., 2023). 2) Lavender contributes moderately to calmness, which is consistent with its known sedative effects due to linalool and linalyl acetate, which interact with the nervous system to reduce anxiety (Cavanagh & Wilkinson, 2002). 3) Mimosa had the least impact but still contributed positively, potentially due to the anxiolytic, calming, and antidepressant properties of its flavonoids (Ahmad et al., 2012; Shalini & Mirunaleni, 2021; Adurosakinn et al., 2023). Mimosa was previously shown to be a promising pharmacological anticonvulsant and antidepressant agent. The herb has been used in traditional treatment (Ahmad et al., 2012; Barati et al., 2016; Majeed et al., 2021; Gupta et al., 2023).

### 3.3.2 The effect of formula variation on consumer acceptance

The regression model analyzed key parameters for consumer acceptance, including color, total aroma, sweet aroma, spices aroma, and total flavors, with the key variables of color, as shown in Table 5. The results show that stevia had the greatest effect (0.16), enhancing visual appeal, which aligned with the findings that sweetness influenced sensory perceptions (Wang et al., 2019; Phrommin et al., 2024), linking the results of sweet taste intensity and hedonic liking in a positive relationship between sweet hedonic liking and intake (Kampov-Polevoy et al., 2006; Jayasinghe et al., 2017; Zushi et al., 2023). The results of the total aroma showed that stevia again had the strongest positive impact (0.16), followed by lavender and mimosa. Aroma, as a significant driver of consumer liking, reflects the contributions of these herbs' aromatic compounds (Jayasinghe et al., 2017; Zushi et al., 2023). The third parameter was sweet aroma, and stevia's high impact (0.15) was attributed to its inherent sweetness and volatile compounds, which enhanced the sweet aroma perception (Muenprasitvej et al., 2022; Phrommin et al., 2024). Sytar et al. (2023) reported that adding stevia to herbal tea had a relatively good aroma and improved the overall evaluation of the product with higher points, and improved aroma perception. Especially, combining stevia with green tea significantly improved the perception of the

product. The fourth factor, spices aroma and total flavors both showed strong  $R^2$  values (0.71 and 0.93, respectively), with stevia dominating, followed by lavender and mimosa, both lavender and mimosa showing astringency or spicy taste, as bitter, astringent, and slightly acrid leaves and roots are known for a bitter and astringent taste, which is a key indicator of its medicinal properties in traditional practice (Kumar, 2021; Havaladar et al., 2022; Chauhan, 2025). Sensory perception of taste was more bitter, cooling, and astringent (Patro et al., 2016). The aroma flavor of lavender was shown to be dominated by spicy top notes and spicy or herbal odors (Norman, 2015; Guo & Wang, 2020). Therefore, increasing the levels of stevia improved multiple sensory attributes, including color, aroma, and flavor, leading to higher consumer acceptance and gaining positive acceptance of sensory attributes (Tondare & Hembade, 2019; Muenprasitivej et al., 2022). The findings regarding the contributions of lavender and mimosa were also in alignment with earlier research on herbal tisanes and their sensory properties. The strong  $R^2$  values (e.g., 97.0% for Total aroma, 94% for sweet aroma) confirmed the robustness of these relationships.

### 3.3.3 The effect of formula variation on TFC

The regression model for total flavonoid content is shown in Table 5. Lavender had the highest positive effect (0.93502), followed by mimosa (0.71661). Stevia contributed minimally (0.15863). The negative interaction term for lavender and mimosa (-0.060584) indicated that increasing both together slightly reduced the flavonoid content. The effect of increasing/decreasing factors was found when increasing the levels of lavender significantly boosted total flavonoid content due to its high phenolic compounds, such as ferulic acid, vanillic acid, rosmarinic acid and flavonoids (Lopes et al., 2018; Özderin, 2022). Mimosa, known for its flavonoid-rich flowers and leaves, also increased flavonoid content (Khare, 2004; Singh, 2004; Ahmad et al., 2012; Patro et al., 2016). Stevia contributed less to flavonoid enhancement, likely because its primary bioactive compounds were glycosides rather than phenolics. High total flavonoid content is associated with strong antioxidant potential, contributing to health benefits like reduced oxidative stress and inflammation (Dai & Mumper, 2010; Panche et al., 2016). Previous studies confirmed that lavender and mimosa exhibited robust flavonoid content, supporting their medicinal and functional roles in tisanes (Ahmad et al., 2012; Mbomo et al., 2012; Patro et al., 2016). Therefore, increasing stevia level had the strongest positive effect on calmness ( $R^2 = 0.6757$ ), followed by lavender and mimosa. Consumer acceptance in terms of sensory attributes such as color, aroma, and flavors was significantly improved by increasing stevia, with strong  $R^2$  values (up to 0.9200). Lavender and mimosa contributed positively, but to a lesser extent. For total flavonoid content, increasing lavender and mimosa significantly enhanced flavonoid content ( $R^2 = 0.8987$ ), while their combination slightly reduced it. These findings align with earlier research demonstrating the functional benefits and sensory appeal of herbal components like lavender, mimosa, and stevia in mixed tisanes.

These findings highlight the importance of stevia in sensory acceptance and lavender in functional properties like flavonoid content. Increasing stevia, which added sweetness without affecting flavonoid content, positively influenced sensory ratings (Cabanac, 1979; Ashwell, 2015; Abdela et al., 2021). Herbal tea brewed with stevia in the right formulation resulted in the highest antioxidant content and sensory acceptability. The optimized blend demonstrated moderate to high relaxation effects, which was in agreement with previous studies on herbal tea's emotional benefits (Cabanac, 1979; Srivastava et al., 2010; Long et al., 2023). According to Phrommin et al. (2024), the sweetness attribute was found to elevate the overall preference score. Specifically, for each 1-point increase in the

hedonic score for sweet flavor, the chance of purchasing increased by 88%. The regression model presented accounted for 95.2% ( $R^2$ ) in purchase intention. The likelihood of purchase was significantly affected by sweetness, indicating the critical factor in consumer acceptance. The sensory and emotional survey on tisanes/herbal tea revealed significant insights into how its ingredients impact consumers' senses and emotions, providing compelling evidence of their positive effects, especially sweetness perception (Wei et al., 2025). The marketing probability of purchasing was significantly influenced by sweetness and aftertaste, and with each 1-point increase in the hedonic score for sweet flavor, the chance of purchasing increased by 88%. Similarly, a 1-point increase in the aftertaste was associated with an increased chance of purchasing by ~150% (Phrommin et al., 2024). The final tisane formulation showed a high positive of relaxation and calmness and a high score of acceptance in each attribution (Tables 3 and 4).

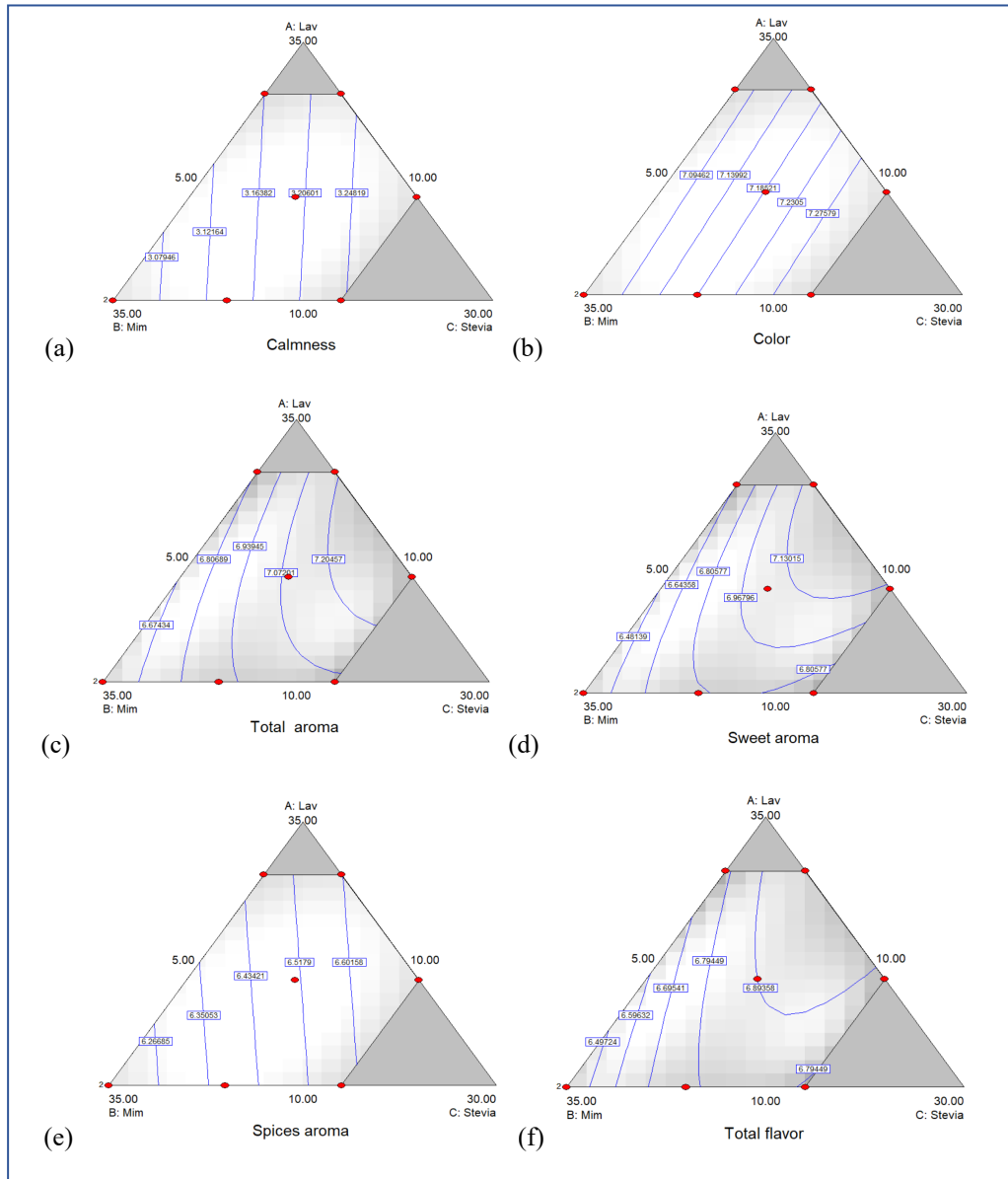
### 3.4 Optimization

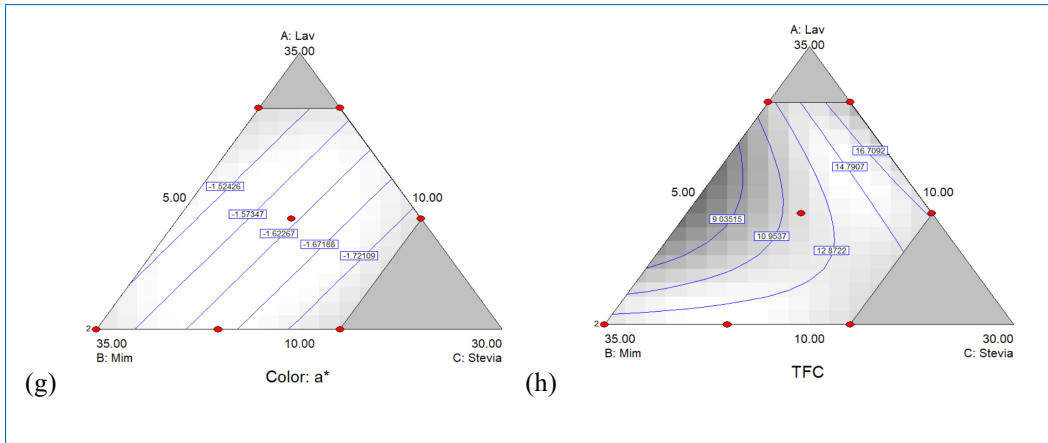
The results of regression data (Table 5) and the response area diagrams (Figures 2a-h) illustrate the impact of significant factors ( $p \leq 0.5$ ): calmness, color, total aroma, sweet aroma, spices aroma, total flavor, tea color ( $a^*$ ), and total flavonoid content. From factors  $X_1$  (lavender),  $X_2$  (mimosa) and  $X_3$  (stevia), the optimized-tisane formulas are shown in Figure 3, and the final formulation from the mixture design was predicted to be lavender 23%, mimosa 10%, and stevia 17%, indicated by the red star in Figure 3, which was the optimum point.

### 3.5 Validation and future directions

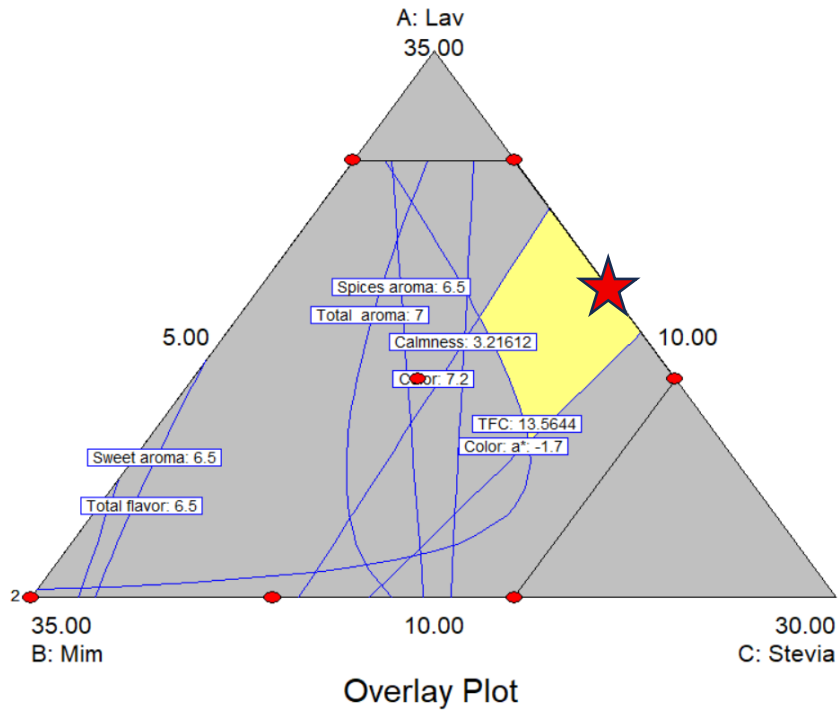
The optimized tisane showed moisture content of  $8.70 \pm 0.11\%$  and water activity ( $a_w$ ) of  $0.54 \pm 0.00$ , ensuring good dry tea stability. Its tea powder color ( $L^*$ ,  $a^*$ ,  $b^*$ ) was  $51.51 \pm 0.62$ ,  $1.54 \pm 0.16$ ,  $14.89 \pm 0.62$ , while the infused tisane measured  $28.04 \pm 0.05$ ,  $-1.56 \pm 0.21$ ,  $5.76 \pm 0.21$ . The tisane contained a high total phenolic content ( $212.66 \pm 8.54 \mu\text{mol GE}/100 \text{ g}$ ). It also showed strong antioxidant activity with ABTS capacity of  $243.87 \pm 8.50 \mu\text{mol QE}/100 \text{ g}$ . These properties indicate its potential as a functional beverage with antioxidant benefits. These results highlighted the herbal mixture's potential for neutralizing oxidative agents, which may be potential for brain disease protection and promotion of cellular health and longevity (Fu et al., 2011; Zhang et al., 2022). Minor variations in color ( $a^*$  value) in the tisane samples were also observed, highlighting the formulation's aesthetic appeal and likely influence on sensory acceptance (Delgado-Vargas et al., 2000; Pathare et al., 2013). The overlay plot as the program predicted, is shown in Figure 3. The data, which show validation between predicted vs actual values with errors less than 10%, are shown in Table 6. The results for color of the final optimized formulation of tisanes values were  $L^*$ ,  $a^*$ ,  $b^*$  ( $28.04 \pm 0.04$ ,  $-1.56 \pm 0.05$ , and  $5.76 \pm 0.17$ ), respectively. The negative  $a^*$  values suggest a subtle green tint, consistent with herbal ingredients such as lavender and chamomile, which yield muted colors due to natural pigmentation. Color is an important quality attribute in the food and bioprocess industries, and it influences consumers' choices and preferences (Pathare et al., 2013). The consistency between predicted and observed  $a^*$  value indicates stability, contributing to consumer appeal (Delgado-Vargas et al., 2000). The tisane moisture content was  $8.7 \pm 0.11\%$  and  $a_w$  was  $0.54 \pm 0.00$ . This analysis helps prioritize chamomile and mimosa for light, visually appealing blends, while stevia and rose may contribute depth and stronger antioxidant functionality. The antioxidant properties of the optimized tisane formula as expressed as TPC ( $\mu\text{mol GE}/100\text{g}$ ), TFC ( $\mu\text{mol QE}/100\text{g}$ ),

ABTS ( $\mu\text{mol TE}/100\text{g}$ ), and NO scavenging assay (% inhibition), were  $212.66\pm 8.54$ ,  $16.234\pm 0.70$ ,  $243.87\pm 8.5$ , and  $43.80\pm 0.24$ , respectively. The sensory acceptance of the final formulation was moderate to high. The lowest score was found for spice aroma ( $7.28\pm 1.18$ ), and the highest was for overall liking ( $7.75\pm 0.85$ ). The emotional sensory of the tea formula was moderate to high relaxation ( $3.94\pm 0.69$ ), and calmness ( $3.62\pm 0.97$ ) (Table 4).





**Figure 2.** Contour plot of the response values from the study (a) Calmness (b) Color (c) Total aroma (d) Sweet aroma (e) Spices aroma (f) Total flavor (g) color a\* of tisanes (h) Total flavonoid content (TFC).



**Figure 3.** The overlay plot of the optimized tisane formulation, X1= lavender (23%), X2= mimosa (10%), and X3= stevia (17%)

The formulation's validation (Table 6) from the D-optimal mixture design software revealed that the predicted and observed values had percentage errors ranging from 3.96% to 9.74% (Table 6), indicating accurate formulation prediction. This validation supports the mixture design's reliability in producing reproducible sensory and physicochemical properties. Furthermore, the experimental errors indicated that the fitted model of mixed tisane values was satisfactory and reliable. Future research should investigate the long-term effects of these herbal tisanes, especially mimosa's effects on stress reduction and acute toxicity assessment to ensure safe consumption.

**Table 6.** Validation of the final developed formulation (N=53)

Parameters	Predicted Value	Observed Value	Percentage of Error (%)
Calmness	3.28	3.62±0.67	9.39
Color	7.28	7.60±1.00	4.21
Total aroma	7.35	7.79±0.95	5.65
Sweet aroma	7.27	7.57±1.01	3.96
Spices aroma	6.68	7.28±1.18	8.24
Total flavor	6.95	7.70±0.97	9.74
Color (a*)	-1.68	-1.55±0.05	8.39
TFC	17.43	16.23±0.70	7.37

Note: Data are expressed as mean±standard deviation. %error = [Predicted Value-Observed value] / Observed value x 100

### 3.6 Amino acid and phenolic profile

#### 3.6.1 Amino acid and phenolic profile contributions to health and mental health

The amino acid content and antioxidant properties of the optimized tisane (Table 7), including phenylalanine (86.13±0.08 µg/mL) and glycine, support neurotransmitter function. Phenylalanine is an essential amino acid that serves as a precursor for several key neurotransmitters involved in mood regulation and brain function. Through its conversion to tyrosine, it supports the synthesis of dopamine and norepinephrine, while it also contributes indirectly to serotonin production, neurochemicals that are critical for mood stability and synaptic plasticity. Addition, histidine is metabolized to histamine, another neurotransmitter that modulates neuronal activity and emotional responses (Fernstrom, 1983; He & Wu, 2020). Glycine's role as an inhibitory neurotransmitter enhances calmness and improves sleep quality (Wirthgen et al., 2018). These findings underscore the tisane's potential in supporting emotional and physiological well-being through a blend of sensory and bioactive properties. Mental health and noncommunicable diseases (NCDs) are indirectly linked through shared pathways such as chronic stress, inflammation, and metabolic imbalance. Dietary patterns and phytonutrient intake have emerged as important preventive factors that may help reduce the risk of both mental health disorders and NCDs (Chatsudthipong & Muanprasat, 2009; Periche et al., 2014; Long et al., 2023; WHO, 2024). The herbal blend contains significant amino acids that may support metabolic health and inflammation control, which is essential in NCD prevention. Glutamic acid, a key precursor to the antioxidant glutathione, is essential for neural health, defending against oxidative

damage (Bains & Shaw, 1997; Amores-Sánchez & Medina, 1999; Forman et al., 2009). Histidine's anti-inflammatory effects contribute to improved metabolic function, particularly in individuals with metabolic syndrome (Kumada et al., 2003), while proline supports collagen synthesis, cardiovascular health (Wu et al., 2011), cell signaling, stress protection, and energy production (Christgen & Becker, 2019). These amino acids provide an added layer of health benefits in the herbal tisane's formulation, suggesting potential therapeutic roles for NCD protection factor (Poswal et al., 2019; Krawczyk et al., 2023). Studies of amino acid intake consisting of serine, alanine, glutamate, aspartate, and tyrosine have been shown to contribute to maintaining proper motivation and cognitive function of regulating mental health, memory, and liver disease (Lee & Kim, 2019; Chen et al., 2024). The analysis of the phenolic profile of this final tea formulation revealed that chlorogenic acid, catechin, ferulic acid, myricetin, and quercetin were present at concentrations of  $2967.66 \pm 46.19$ ;  $2089.45 \pm 68$ ;  $1025.35 \pm 1.87$ ;  $987.06 \pm 19.16$ , and  $470.69 \pm 0.98$  (mg/g dry weight), respectively (Table 7). Chlorogenic acid (CGA) plays therapeutic or preventive roles and demonstrates antioxidative and anti-inflammatory properties (Li et al., 2024) and can be a potent treatment for gastrointestinal disease. CGA on intestinal development has been shown to improve immune defense and suppress excessive apoptosis of intestinal epithelial cells in animal studies (Chen et al., 2018). Chlorogenic acid reduces glucose levels, aiding in Type 2 diabetes prevention and cardiovascular health. The development of this as a novel medication for the prevention and treatment of DM requires improvement in stability, solubility, and oral absolute bioavailability (Yan et al., 2020). Additionally, its neuroprotective role enhances mental clarity and mood stabilization (Tajik et al., 2017; Naveed et al., 2018), exhibits hepato-protective effects (Naveed et al., 2018), and cardioprotective and neuroprotective agents (Singh et al., 2023). Catechin modulates GABA neurotransmitter activity, reducing stress and promoting calmness. Catechins are reactive oxygen species (ROS) scavengers and metal ion chelators. They inhibit LDL oxidation, minimizing cardiovascular risks. Catechins also improve cognitive function and protect neural pathways, contributing to mental health benefits (Bernatoniene & Kopustinskiene, 2018; Khan & Mukhtar, 2018). Oxidative stress and ROS are implicated in aging and related dysfunctions (Bernatoniene & Kopustinskiene, 2018). Ferulic acid (FA) found in this tisane is a phytochemical commonly found in fruits and vegetables. Ferulic acid's potent antioxidant effects combat oxidative stress and inflammation, where FA works well in herbal antioxidant formulas, vitamins, and herbal health supplements (Srinivasan et al., 2007). FA exhibits a wide range of therapeutic properties like anti-inflammatory, antiatherogenic, antidiabetic, antiaging, neuroprotective, radioprotective, and hepatoprotective effects (Srinivasan et al., 2007). Myricetin is a flavonoid that protects neurons by reducing oxidative stress and inflammation. It lowers blood sugar levels, mitigating the risk of diabetes and cardiovascular disease. Myricetin also exhibits potential to enhance memory and prevent neurodegeneration, improving overall mental health (Semwal et al., 2016). The health benefits offered by myricetin are related to its impact on various cellular processes, including apoptosis, glycolysis, and energy balance. Additionally, myricetin is a crucial nutritional component of a diet that promotes immunological protection and is beneficial to overall health (Imran et al., 2021). Quercetin is a powerful antioxidant that reduces inflammation and cortisol levels, promoting a calming effect (Alharbi et al., 2025). It protects against hypertension and supports cardiovascular health. Quercetin's neuroprotective properties help in stress resilience and mental fatigue reduction. It also has biological properties that may improve mental/physical performance (Chiang et al., 2023; Alharbi et al., 2025).

**Table 7.** Amino acid and total phenolic profile in the final formulation

<b>Properties</b>	<b>Values</b>
<b>Amino acid values (µg/mL)</b>	
Aspartic acid	2.06±0.07
Threonine	18.17±0.21
Aspartic acid	2.06±0.07
Threonine	18.17±0.21
Serine	13.47±0.02
Glutamic acid	8.36±0.21
Proline	13.20±0.28
Glycine	0.90±0.00
Alanine and cysteine	13.26±0.19
Valine	4.55±0.00
Methionine	0.51±0.00
Isoleucine	5.33±0.16
Leucine	1.53±0.21
Tyrosine	7.67±0.04
Phenylalanine	86.13±0.08
Histidine	14.03±0.28
Lysine	4.39±0.03
Arginine	1.50±0.09
<b>Phenolic profile (µg/g sample)</b>	
Gallic acid	112.62±0.67
Theobromine	0.00
p-Hydroxybenzoic acid	0.00
Catechin	2089.45±.68
Chlorogenic acid	2967.66±46.19
Caffeine	0.00
Vanillic acid	317.18±1.63
Caffeic acid	0.00
Syringic acid	297.05±
Epicatechin	44.13±
Vanillin	12.90±
p-Coumaric acid	0.00
Ferulic acid	1025.35±1.87
Sinapic acid	106.96±2.09
Rutin	285.66±0.93
Myricetin	987.06±19.16
Quercetin	470.69±0.98
Trans-cinnamic acid	0.00

Note: Data are expressed as mean±standard deviation.

In the optimized formula, these phenolic compounds synergistically support relaxation and mental well-being by targeting oxidative stress and inflammation, which are key contributors to NCDs. Their combined benefits extend to both physical and mental health. The phenolic compounds play a critical role in protecting against neuro dysfunction, promoting relaxation and providing a calming effect by reducing oxidative stress and inflammation while supporting neurotransmitter balance, in the prevention of cancer, diabetes, cardiovascular and neurological diseases (Srinivasan et al., 2007; Tajik et al., 2017; Khan & Mukhtar, 2018).

### 3.6.2 Antioxidant for health and mental health benefits

The provided data ( $\mu\text{g/g}$  sample) (Table 7) list includes several phenolic compounds that are critical for mental health and relaxation. The summary in Table 8 provides a comparison of the levels of these phenolic compounds with levels in known food sources in USDA (2024). The tisane demonstrates a robust phenolic profile that would seem to align with mental wellness benefits, including enhanced relaxation and reduced anxiety. The concentrations of catechin and chlorogenic acid, particularly in supporting relaxation and neuroprotection, are due to an anti-inflammation activity (Li et al., 2024). Future optimization may be explored by adding herbs to incorporate missing profiles (e.g., caffeic acid sources). Our developed tisane displays catechin levels comparable to cocoa (2000-4000  $\mu\text{g/g}$ ), suggesting strong potential for relaxation and mental wellness (USDA, 2025). The tisanes' antioxidant properties and NO scavenging ability are associated with decreased oxidative stress, which is a factor in NCDs like cardiovascular disease (Król & Kepinska, 2020). Regular consumption could mitigate oxidative stress, supporting cardiovascular health (Roy et al., 2023). The presence of lavender, mimosa, and chamomile further aids relaxation, with compounds like linalool and apigenin supporting sleep and stress relief (McKay et al., 2006; Donelli et al., 2019). Stevia's gut microbiome benefits, including alpha diversity enhancement, add to the tisanes's health value (Kasti et al., 2022). This research identified the bioactive compounds (Tables 1, 2, 6) in the selected herbs, and in the blended tisanes and their roles in mental health enhancement, especially those roles of amino acid and total phenolic profiles (Table 7). This shows potential for mental health or brain promotion (Zhang et al., 2022). Lavender, for instance, is rich in linalool and linalyl acetate, which modulate GABAergic activity and contribute to anxiolytic and antidepressant effects (Koulivand et al., 2013). Seol et al. (2010) reported the mechanism of the modulation of dopamine activity in rats. So, lavender can be an efficacious complementary treatment for depression using either aroma oil or tea (Firoozeei et al., 2021). Bazrafshan et al. (2020) studied the effect of lavender herbal tea on anxiety and depression in the elderly, and lavender tea was found to reduce depression scores. Chamomile apigenin binds to benzodiazepine receptors, inducing calmness and acting as a sedative for the treatment of anxiety and insomnia, and anxiety disorders (Srivastava et al., 2010; Saadatmand et al., 2024). A study of Awad et al (2007) showed significant inhibition of GAD activity which is traditionally used as anxiolytic botanicals on enzymes of the gamma-aminobutyric acid (GABA) system. Amsterdam et al. (2009) conducted a controlled clinical trial of chamomile extract for patients with general anxiety disorder (GAD). The results suggested that chamomile had modest anxiolytic activity in patients with mild to moderate GAD. Mimosa contains quercetin and rutin, providing antioxidant and neuroprotective properties to assist in stress management and mental health support (Adhale et al., 2012). *Mimosa pudica* was shown to possess anxiolytic-like and antipyretic activity (Bum, 2011). The experiment confirmed the traditional treatment use of the villagers. Using the traditional Thai herbal formulas from *Mimosa pudica* (MAI-YA-LAP) and

*A. indicum* (KHOB-FUN-SRI) can treat diabetes, prevent complications caused by diabetes and improve blood biochemistry in experimental mice. These findings aligned with the traditional uses of mimosa, which showed sedation and hypnosis in animal studies, supporting its use in alleviating stress and mental distress (Sajid et al., 2013; Ittiyavirah & Pullochal, 2014). These findings suggest that mimosa, in particular, can modulate the central nervous system, presenting it as a potential therapeutic for neurocognitive concerns.

Therefore, due to the phenolic acids, flavonoids and amino acid components found in mixed tisanes, we would recommend the production of mixed tisanes as functional foods with medicinal properties. The decoction and steeped extracts from these herbal mixed samples showed strong antioxidant activity *in vitro* and impact on emotions compared to food sources, as shown in Table 8.

**Table 8.** Comparison of phenolic content with food range and their roles in mental health wellness

Phenolic Compound	Tisanes (µg/g)	USDA Food (range in µg/g)	Food Sources	Role in Mental Promotion
Chlorogenic Acid	2967.66±46.19	500–3000	Coffee, berries	Neuroprotection, relaxation, and reduction of neuroinflammation
Catechin	2089.45±0.68	800–5000	Green tea, cocoa, apples, and berries.	Promoting relaxation: Modulates stress response pathways, supports neural plasticity, and antioxidant protection. Calming effects: Reduces oxidative stress and improves mood stability.
Ferulic acid	1025.35±1.87	50–600	Cereal grains, vegetables	Reduces oxidative stress in the brain; supports mood
Myricetin	987.06±19.16	100–500	Berries, tea	Modulates anxiety pathways; it is an anti-depressant.
Quercetin	470.69±0.98	200–1000	Onions, apples	Anti-anxiety; reduces cortisol

Source: USDA (2025)

The bioactive compounds, such as flavonoids and phenolic compounds in these herbs (Tables 2, 3, 7), also offer protective effects against NCDs like cardiovascular diseases and diabetes. The researchers highlighted mimosa, which was challenging to study, as it showed anti-depressant and memory-enhancing activities in mice in earlier research (Patro et al., 2016). Mimosa was first recorded as a medicinal plant in the Qing dynasty in Sheng Cao Yao Xin Bei Yao, which can decrease insomnia and has immunostimulatory effects with low toxicity (Cheng, 1993; Rizwan et al., 2022). Stevia, which contains flavonoids like kaempferol and quercetin, shows antioxidant properties that may mitigate oxidative stress and aid in blood glucose regulation, thereby potentially reducing chronic disease risk (Chatsudthipong & Muanprasat, 2009; Periche et al., 2014). Chamomile's antioxidants, apigenin and quercetin, are noted for their anti-inflammatory and cardioprotective effects, while rose combats oxidative stress through its potent anti-inflammatory actions (McKay & Blumberg, 2006; Boskabady et al., 2011; Krawczyk et al.,

2023). These properties align with the findings of Delgado-Vargas et al. (2000), who reported that regular intake of flavonoid-rich herbs could serve as a protective strategy against NCD progression. Emotional survey of tisanes in the Thai traditional field by Phrommin et al. (2024) revealed significant insights into herbs' ingredients' impact on emotions, providing compelling evidence of their positive effects, especially consumers' desired herbal tea that promotes relaxation, sleep, and decreases stress. We highlighted the mental wellness desires of adaptogenic or nervine herbs like chamomile, lavender, and mimosa (Panossian & Wikman, 2010; Semalty et al., 2012; Ittiyavirah & Pullochal, 2014). Adaptogens can fight fatigue, increase mental performance, and relieve depression and anxiety. Chamomile is considered an adaptogen herb and is used to promote relaxation and sleep. It is in a group of herbs called Nervine (Herb Pharm, 2022; Kępińska-Pacelik & Biel, 2025).

Mixture designs are indeed effective for optimizing herbal formulations, particularly because they allow for the evaluation of interactions between different components. The interactions among these ingredients can significantly influence both antioxidant and sensory properties. The interactions of various compounds in an optimal mixture of different antioxidants, including polyphenols, may work synergistically to enhance their effects. This synergy of all antioxidants in beverages, spices, and herbs could contribute to better mental health outcomes by promoting overall well-being (Carlsen et al., 2010). The balance of flavors from stevia (which is sweet) and the floral notes from lavender and rose can create a more palatable and appealing formulation. Additionally, the aromatic compounds in these herbs can interact to produce a more complex and desirable scent profile. Herbal teas provide a cost-effective and enjoyable therapeutic option (Poswel et al., 2019).

This study is the first scientific investigation of mimosa tisanes (blended tea), establishing a foundational contribution to the field of Thai traditional medicine and local wisdom. It emphasizes the innovative use of mimosa, blended with adaptogenic or nervine herbs, to develop tisanes that not only enhance sensory experiences but also promote emotional well-being and shown low toxicity in animals (Panossian & Wikman, 2010; Patro et al., 2016; Ugenyi et al., 2018). In addition, Patro et al. (2016) reported that mimosa may exert antidepressant effects by modulating monoaminergic systems. These neurotransmitters are closely associated with mood regulation and are often targeted by antidepressant therapies.

#### 4. Conclusions

The regression model showed that lavender, mimosa, and stevia each contributed to the calming effect, but with different levels of influence. The model coefficients indicated the strength of each herb's contribution, revealing that stevia exerted the greatest impact, followed by lavender and then mimosa. Importantly, the observed relaxation effect arose from the synergistic interaction of all herbs within the mixed tisane rather than from any single ingredient alone. The study demonstrates that the herbal blend (tisanes) could provide antioxidant benefits while supporting the sensory emotions of the study, which were relaxation and calmness. They had adaptogenic qualities, supporting the nervous system by balancing cortisol, modulating neurotransmitters, reducing oxidative stress, and promoting neuroplasticity. The remarkable bioactive properties of these tisanes represented a promising opportunity for innovative applications in the functional food and mental health industries. This tisane formulation's high antioxidant capacity and soothing sensory profile make it a promising functional beverage for reducing oxidative stress and

potentially aiding in the prevention of NCDs. The study highlighted the tisane's antioxidant properties and potential neuroprotective effects, including its mental health benefits. The overall findings support the concept that emotional benefits from herbal beverages arise from the integration of sensory pleasure, aroma-volatile chemistry, and bioactive function.

However, the sensory emotional survey in this study was limited by the subjective variability of individual perceptions, which may be influenced by factors such as mood, expectation, and prior experience. Moreover, emotional states like relaxation and calmness are inherently complex and difficult to measure objectively. Emotional effects were evaluated over a short-term period without long-term follow-up. These limitations pose significant challenges that will be addressed in future research in collaboration with a subdistrict study in the community and the Ministry of Mental Health to promote mental well-being.

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## 6. Authors' Contributions

Preechaya Phrommin conceived the conceptualization, performed the experiments, data curation, and drafted the manuscript. Niramom Utama-ang supervised the work and provided critical revisions, data curation, methodology, project administration, as well as research implementation and participation in design. Siraphat Taesuwan and Ponjan Walter provided critical revisions. Kanjana Singh and Fahsai Kantawong assisted with data collection, experiment analysis, manuscript preparation, as well as contributions in writing, review & editing.

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## 7. Conflicts of Interest

There are no conflicts of interest in this research.

## 8. AI Declaration

The preparation of this manuscript by Grammarly and CiteFast to correct grammar and recheck APA 7<sup>th</sup> edition was reviewed and edited as needed by Preechaya Phrommin and Kanjana Singh. The authors take full responsibility for the content of the publication.

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