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Effects of banana blossom supplementation on the nutritional value, antioxidant activity, and sensory quality of fresh egg noodles

Paponpat Pattarathitiwat[1]
Nattapas Yousawang[2]
Pornpachen Chuchird[3]
Apidech Pongprajak[4]
Teerapap Panklai[5+]

[1,3,4,5]*Department of Food and Nutrition, Faculty of Home Economics Technology, Rajamangala University of Technology Thanyaburi, Pathum Thani, 12110, Thailand.*
[1]*Email: Paponpat_p@rmutt.ac.th*
[3]*Email: Pornpachen_c@rmutt.ac.th*
[4]*Email: Apidech_p@rmutt.ac.th*
[5]*Email: Teerapap.pan@cra.ac.th*
[2]*Chulabhorn Hospital, Chulabhorn Royal Academy, Bangkok, 10210, Thailand.*
[2]*Email: Nattapas.you@cra.ac.th*
[5]*Medical and Health Food Technology Program, Faculty of Food and Nutrition Innovation, Chulabhorn Royal Academy, Bangkok, 10210, Thailand.*


(+ Corresponding author)

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ABSTRACT

Banana blossom is a nutrient-rich edible byproduct containing dietary fiber and bioactive compounds with potential health-promoting properties. This study aimed to evaluate the effects of banana blossom supplementation on the physicochemical properties, nutritional value, antioxidant activity, bioactive compounds, and sensory acceptance of fresh egg noodles. Egg noodles were supplemented with banana blossom at 25%, 50%, and 75%, and their color, water activity, texture, sensory attributes, nutritional composition, DPPH radical-scavenging activity, total polyphenol content, and total flavonoid content were evaluated. Nutritional values were calculated using the INMUCAL-Nutrients V.4 program, while antioxidant and bioactive compounds were determined before and after boiling. Increasing banana blossom supplementation reduced energy, carbohydrate, protein, fat, sugar, cholesterol, and saturated fatty acid contents while increasing dietary fiber, calcium, potassium, and vitamin C. Antioxidant activity, total polyphenol content, and total flavonoid content also increased significantly with banana blossom supplementation, although boiling reduced these values. Physicochemical analysis showed formulation-dependent changes in color and selected texture parameters, whereas most textural properties after boiling were not significantly affected by supplementation level. Sensory evaluation identified the 50% banana blossom formulation as the most acceptable, and subsequent consumer testing confirmed moderate-to-high acceptance. These findings demonstrate that banana blossom can be effectively incorporated into fresh egg noodles as a functional ingredient, with 50% supplementation providing a favorable balance between enhanced nutritional and antioxidant properties and consumer acceptability.

Contribution/Originality: This study contributes to the existing literature by being one of very few studies that have investigated the incorporation of banana blossom into fresh egg noodles, demonstrating its effects on nutritional value, antioxidant activity, and sensory quality, and identifying an optimal supplementation level for consumer acceptance.

1. INTRODUCTION

Noncommunicable diseases (NCDs) comprise cardiovascular diseases (e.g., heart disease and stroke), chronic respiratory diseases (e.g., chronic obstructive pulmonary disease and asthma), diabetes, and cancer. These conditions cause approximately 41 million deaths annually, accounting for 74% of all global deaths (Teerapap & Sangwanna, 2024). The risk factors for NCDs can be broadly classified into three categories: behavioral risk factors, including tobacco use (and exposure to secondhand smoke), unhealthy diets high in salt, sugar, and fat, excessive alcohol consumption, and insufficient physical activity; metabolic risk factors, such as high blood pressure (including chronic hypertension), overweight and obesity, elevated blood glucose levels (including diabetes), and abnormal blood lipid profiles (including high cholesterol); and environmental risk factors, which contribute to the development of NCDs, with indoor and outdoor air pollution being among the most significant contributors (World Health Organization, 2024). Therefore, adopting a healthy diet is an important factor in reducing the risk of developing chronic noncommunicable diseases.

Bananas, widely consumed around the world, are an essential food crop. Asian countries produce the highest quantity of bananas (Panyayong & Srikaeo, 2022). Bananas are a perennial crop widely grown throughout various areas in Thailand due to favorable weather conditions, fast growth, and quick production (Jai-aree, 2023). Hence, Thailand ranks as the second-largest banana exporter among the Association of Southeast Asian Nations (ASEAN) countries. Local Thai cuisine often incorporates various parts of bananas as components in dishes, and bananas are also used as raw materials for other economic products (Samarakoon et al., 2024). Every part of a banana can be used for multiple purposes, including as food, in ceremonies, and as medicine. This includes the leaves, leaf sheaths, banana blossoms (BB), and fruits (Jai-aree, 2023). Banana leaves are commonly used to wrap traditional Thai food and desserts. In contrast, BB, one of the edible byproducts, is an essential food ingredient in Asian cuisines, particularly in India, Sri Lanka, Indonesia, Malaysia, and Thailand. It is found in traditional Thai dishes such as Pad Thai, Hua Plee soup, and Tod Mun Hua Plee (Esterik, 2008; Panyayong & Srikaeo, 2022; Termpitipong, 2021). BB contains many phytochemicals, such as phenolics, flavonoids, dietary fibers, tannins, saponins, and vitamins, which have various beneficial properties for human health, such as antioxidant, anti-hyperglycemic, anti-inflammatory, anti-carcinogenic, and antimicrobial effects (Chowdary, Rana, & Ghosh, 2022; Govindaraj et al., 2022; Sarker et al., 2022; Suffi, Mohamed, Camalxaman, Rambely, & Haron, 2021). Previous studies have developed various products using BB as an ingredient to create new functional foods with therapeutic health benefits and higher nutritional value. These products include vegan tofu meatballs, tuna floss, cupcakes, pork burgers, sausages, plain cakes, nut chocolate, nuggets, biscuits, and dark chocolate (Elaveniya & Jayamuthunagai, 2014; Hardoko et al., 2022; Kartikaningsih et al., 2021; Kraithong & Issara, 2021; Panklai, Srangsriwong, Deewo, & Reanaree, 2021; Tariga, Quitan, & De Vera, 2022).

Asian noodles have a long history and are made from various raw materials, such as wheat flour, rice flour, and different starches. They come in multiple types and forms to suit local tastes and extend shelf life. The differences in raw materials result in distinct processing methods for wheat flour noodles versus rice- and starch-based noodles. Ensuring high-quality raw materials and consistent production is crucial for the industry. Continuous efforts are made to use functional ingredients and new technologies to enhance shelf life, improve quality, and create new noodle products (Hou, 2020). Egg noodles are the second most popular food after rice and bread in the ASEAN region, including Thailand, Vietnam, Laos, Myanmar, Malaysia, and Singapore. Many studies have focused on adding ingredients to improve the properties and nutritional values of egg noodles, providing consumers with more options (Jirukkakul, 2021), such as green seaweed powder (Chang & Wu, 2008), banana pulp and peel flour (Jirukkakul, 2021), seaweed and cuttlefish paste (Chang, Chen, & Hu, 2011), Basella alba L. leaf powder (Soriano et al., 2020), and durian seed flour (Waritchon, Kunlaporn, & Jiraporn, 2019).

We have not seen any products that mix egg noodles with BB. This study is, therefore, intriguing because egg noodles are composed mainly of carbohydrates and have low nutritional value. Mixing BB into egg noodles can increase their nutritional value, promote health for consumers, and provide a new healthy alternative product for those who enjoy eating egg noodles. In addition, the development of noodle products supplemented with BB as an ingredient has the potential to support industrial-scale production and to promote farmer groups in the production of noodles for both consumption and commercial distribution. This approach may enhance the value of BB while reducing post-harvest losses and disposal-related costs. Thus, this study aims to determine the amount of BB that can be supplemented in egg noodles and to analyze the physicochemical properties, total flavonoid and total polyphenol content, antioxidant activity, nutritional values, and sensory evaluation.

2. MATERIALS AND METHODS

2.1. Materials

All-purpose flour, bread flour, duck eggs, chicken eggs, limewater, baking soda, vegetable oil, salt, and BB were purchased from a local market in Pathum Thani Province, Thailand. Ethanol, methanol, sodium hydroxide (NaOH), sodium acetate (CH_3COONa), sodium carbonate (Na_2CO_3), aluminum chloride ($AlCl_3$), quercetin, gallic acid, Folin–Ciocalteu reagent, and 1,1-diphenyl-2-picrylhydrazyl (DPPH) were obtained from Sigma-Aldrich (St. Louis, MO, USA).

2.2. Preparation of Egg Noodles Supplemented with Banana Blossom

2.2.1. Preparation of Basic Formulas

The basic formula for the egg noodles was obtained by sensory evaluation of three formulas. All ingredients include all-purpose flour, bread flour, duck egg, chicken egg, limewater, baking soda, vegetable oil, salt, and water (Table 1).

2.2.2. Preparation of Banana Blossom

The outer red peel of the banana blossom was removed, leaving only the white flesh. The flesh was cleaned and boiled in water until soft, then the excess water was squeezed out. It was cut into small pieces and blended with the other ingredients.

2.2.3. Process of making Egg Noodles Supplemented with Banana Blossom

The basic formula for egg noodles obtained from 2.2.1 was used to determine the appropriate percentages of BB supplemented in egg noodles at 25, 50, and 75% of the total weight, respectively. The procedure for making egg noodles is to mix and knead them together, then leave them to rest for 30 minutes. Later, the dough was rolled into thin sheets and cut using a dough-rolling machine.

2.3. Physicochemical Properties

The ColorFlex EZ Spectrophotometer measured the color values (L^*, a^*, and b^*). An AquaLab Lite was used to measure water activity (a_w). A texture analyzer (LLOYD Instruments, TA Plus Ametek, UK) was used to measure the texture profile. All measurements were repeated three times to produce average values.

2.4. Sensory Evaluation

Sensory evaluation was carried out using a 9-point hedonic scale. The panelists evaluated the appearance, color, flavor, odor, and overall acceptance. The panelists scored different parameters, with a maximum score of 9 for like extremely, 8-like very good, 7-like good, 6-like moderately, 5-neither like nor dislike, 4-dislike moderately, 3-dislike fairly, 2-dislike very much, and 1-dislike extremely.

2.5. Nutritional Values

Nutritional values were determined using the INMUCAL-Nutrients V.4 program (Institute of Nutrition & Mahidol University, 2018) to calculate energy, carbohydrates, protein, fat, vitamins, and minerals.

2.6. DPPH Radical Scavenging Activity

The antioxidant activity of egg noodles supplemented with BB was determined using a modified DPPH (2,2-diphenyl-1-picrylhydrazyl) radical-scavenging activity assay based on the method described by Panklai et al. (2025). Briefly, two grams of noodles before and after boiling were extracted with 10 mL of methanol and sonicated for 30 min. Then, 0.1 mL of the extract was added to 0.8 mL of the DPPH solution, and the mixture was mixed thoroughly. The scavenging capacity was assessed by measuring absorbance at 490 nm using a microplate reader (model ELx800, BioTek, USA) after 1 h at room temperature. The percentage of DPPH radical inhibition was calculated using the following equation.

$$\text{Radical scavenging activity (\%)} = (1 - (A_{sample} / A_{control})) \times 100 \quad (1)$$

2.7. Total Flavonoid Content

The total flavonoid content (TFC) was determined using a modified spectrophotometric colorimetry method based on (Panklai et al., 2025). Briefly, two grams of noodles before and after boiling were extracted with 10 mL of methanol and sonicated for 30 min. The 0.2 mL of extract was mixed with 0.1 mL of 5% CH_3COONa and left to stand for 6 min. After adding 0.1 mL of 10% $AlCl_3$ and letting it stand for another 6 min, 0.8 mL of 4% NaOH was added and reacted for 15 min. The absorbance was measured at 405 nm using a microplate reader (model ELx800, BioTek, USA). A calibration curve with rutin was used to express the results in mg of quercetin equivalents per mg of sample.

2.8. Total Polyphenol Content

The total polyphenol content (TPC) was determined using a modified Folin–Ciocalteu method based on (Panklai et al., 2025). Briefly, two grams of noodles before and after boiling were extracted with 10 mL of methanol and sonicated for 30 min. 0.2 mL of the extract was mixed with diluted Folin–Ciocalteu reagent and Na_2CO_3, incubated for 1 h at room temperature in the dark, and analyzed at 630 nm using a microplate reader (model ELx800, BioTek, USA). A calibration curve with gallic acid was used to express the results as mg of gallic acid equivalents per mg of sample.

2.9. Statistical Analysis

All experiments were repeated three times, and the data are expressed as the mean ± standard deviation (SD). Significant differences in the results were assessed using one-way analysis of variance (ANOVA) with Duncan's multiple range test ($p < 0.05$) using SPSS statistical software.

Table 1. Three basic formulas of egg noodles.

Raw materials (%)	Formula 1	Formula 2	Formula 3
All-purpose flour	65.57	-	52.24
Bread flour	-	62.11	-
Whole egg	19.67	24.84	-
Duck egg yolk	-	-	7.46
Chicken egg yolk	-	-	7.46
Egg white	-	-	14.93
Limewater	4.92	-	-
Baking soda	-	-	0.75
Vegetable oil	-	2.07	6.72
Salts	-	0.62	-
Water (ml)	9.84	10.35	10.45

3. RESULTS AND DISCUSSION

3.1. Sensory Evaluation and Physicochemical Properties of Basic Formulas

Three basic formulas were evaluated for sensory attributes to determine the most acceptable one for the panelists. Formula 1 received the highest scores in color, odor, flavor, texture, and overall acceptance. The scores for the three formulas ranged as follows: color (6.92-7.40), odor (6.72-7.26), flavor (6.66-7.22), texture (6.86-7.38), and overall acceptance (7.02-7.54) (Figure 1). As a result, formula 1 was selected for further development into egg noodles supplemented with BB. In examining the physicochemical properties of the three formulas (Table 2), formula 1 was found to have the highest lightness ($L*$) values, both before and after boiling, at 59.00 and 50.30, respectively. Formula 2 exhibited the highest yellowness ($b*$) values before and after boiling, while formula 3 had the highest redness ($a*$) values before and after boiling. The water activity (a_w) values showed no difference before and after boiling, ranging from 0.92 to 0.96. The textural analysis of egg noodles showed significant variations among the formulas both before and after boiling. Before boiling, formula 3 was identified as markedly different from formulas 1 and 2, exhibiting the lowest values for hardness, cohesiveness, gumminess, and chewiness, while demonstrating the highest level of springiness. In contrast, the after-boiling analysis indicated that formula 2 differed significantly from formulas 1 and 3, with the highest values for hardness, cohesiveness, springiness, gumminess, and chewiness.

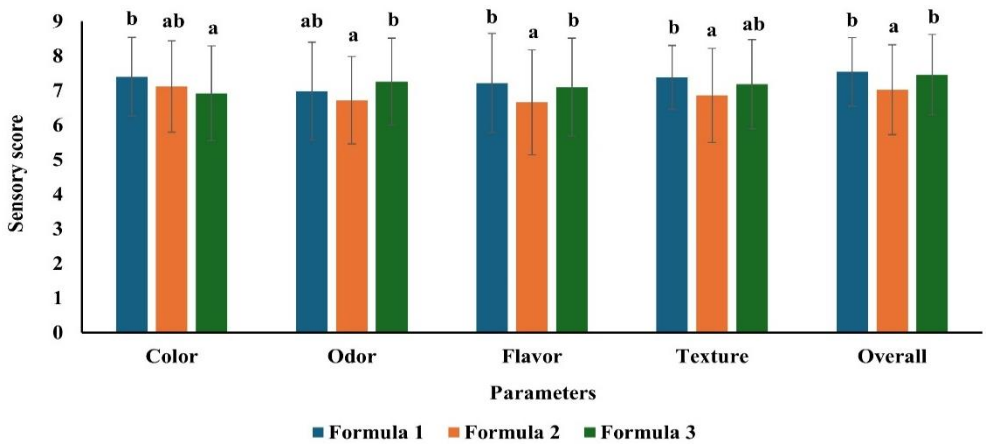


Figure 1. Sensory evaluation of three basic formulas.

Note: Mean values with different superscripts are significantly different ($p<0.05$).

Table 2. Physicochemical properties of three basic formulas.

Parameters	Formula 1	Formula 2	Formula 3
Before boiling			
Color			
L*	59.00 ± 1.71^{b}	47.80 ± 1.73^{a}	51.70 ± 1.37^{a}
a*	30.17 ± 1.50^{b}	25.40 ± 1.56^{a}	30.83 ± 1.32^{b}
b*	8.70 ± 1.01^{b}	24.43 ± 1.62^{c}	1.77 ± 0.38^{a}
a_w ^{ns}	0.95 ± 0.02	0.92 ± 0.02	0.92 ± 0.01
Texture analysis			
Hardness (N)	0.69 ± 0.13^{c}	0.39 ± 0.16^{b}	0.19 ± 0.06^{a}
Cohesiveness	0.11 ± 0.01^{b}	0.17 ± 0.02^{c}	0.07 ± 0.01^{a}
Springiness	2.36 ± 0.27^{a}	3.20 ± 0.22^{ab}	6.04 ± 2.57^{c}
Gumminess (g)	0.07 ± 0.02^{b}	0.07 ± 0.03^{b}	0.01 ± 0.00^{a}
Chewiness (g)	0.17 ± 0.04^{ab}	0.23 ± 0.12^{b}	0.08 ± 0.04^{a}
Adhesiveness (N/s)	0.04 ± 0.01^{b}	0.01 ± 0.00^{a}	0.01 ± 0.00^{a}
After boiling			
Color			
L*	50.30 ± 3.95^{c}	32.63 ± 1.68^{a}	41.03 ± 1.31^{b}
a*	32.90 ± 2.76^{b}	20.17 ± 1.53^{a}	48.53 ± 2.36^{c}
b*	6.57 ± 2.46^{a}	11.63 ± 2.14^{b}	3.47 ± 0.25^{a}
a_w ^{ns}	0.95 ± 0.01	0.95 ± 0.02	0.96 ± 0.01
Texture analysis			
Hardness (N)	0.38 ± 0.01^{a}	0.57 ± 0.08^{c}	0.47 ± 0.05^{b}

Parameters	Formula 1	Formula 2	Formula 3
Cohesiveness	0.31 ± 0.01^{a}	0.36 ± 0.02^{b}	0.35 ± 0.02^{b}
Springiness	7.17 ± 0.45^{a}	7.77 ± 0.26^{b}	7.49 ± 0.28^{ab}
Gumminess	0.12 ± 0.01^{a}	0.21 ± 0.04^{c}	0.16 ± 0.01^{b}
Chewiness	0.84 ± 0.08^{a}	1.64 ± 0.36^{b}	1.22 ± 0.14^{ab}
Adhesiveness (N/s)^{ns}	0.05 ± 0.01	0.07 ± 0.03	0.05 ± 0.00

Note: Mean values with different superscripts in the same row (a, b, c) are significantly different ($p<0.05$). ns = not significantly different.

3.2. Sensory Evaluation and Physicochemical Properties of Egg Noodles Supplemented with Different Levels of Banana Blossom

Egg noodles supplemented with BB at levels of 25%, 50%, and 75% (Figure 3) were evaluated for sensory qualities to determine which was most acceptable to the panelists. Before boiling, the color, odor, and overall acceptance did not differ significantly among the samples, but the appearance of the egg noodles supplemented with 25% BB received the highest score (7.14). After boiling, there were no significant differences in color, odor, flavor, or texture, but the appearance of the egg noodles supplemented with 50% BB received the highest score (7.52) (Figure 2). The physicochemical properties (Table 3) indicated that, before boiling, egg noodles supplemented with 25% BB had the highest lightness ($L*$), redness ($a*$), and yellowness ($b*$) values, at 45.37, 31.40, and 9.77, respectively. After boiling, there were no differences in lightness ($L*$) and yellowness ($b*$) values among the samples. These results indicated that increasing the percentage of BB added resulted in a decrease in the $L*$ and $a*$ values before boiling. In contrast, the $a*$ value showed an increasing trend after boiling. These findings align with trends observed in prior research on incorporating BB into food products. For example, Tasnim, Das, Begum, Nupur, and Mazumder (2020), in research on adding BB to plain cakes, reported a decrease in the $L*$ and $b*$ values and an increase in the $a*$ value. Similarly, research by Chaiwongsa, Charoenvitayavorakul, Pakasap, and Khuenpet (2021) revealed that adding BB to meatballs caused a reduction in the $L*$ value and increased the $a*$ and $b*$ values. Furthermore, Elaveniya and Jayamuthunagai (2014) observed that biscuits containing BB powder exhibited a higher $L*$ value compared to biscuits without the powder, although $a*$ and $b*$ values were not significantly different. The differences in color parameters across these studies are likely due to variations in the preparation methods of BB and the unique ingredient compositions of each product. The water activity (a_w) values showed no difference before and after boiling, ranging from 0.93 to 0.96. The textural analysis of egg noodles supplemented with banana blossom, conducted before boiling, demonstrated that an increased percentage of banana blossom in the formulation significantly elevated gumminess and chewiness values. However, this modification did not exert a measurable impact on the hardness, cohesiveness, or springiness of the noodles. Conversely, the after-boiling textural analysis indicated no statistically significant differences in the noodles, irrespective of the quantity of banana blossom added. This study's findings are consistent with those of Chaiwongsa et al. (2021), who observed that increasing the percentage of BB in meatball formulations corresponds to higher values of hardness, chewiness, and gumminess.

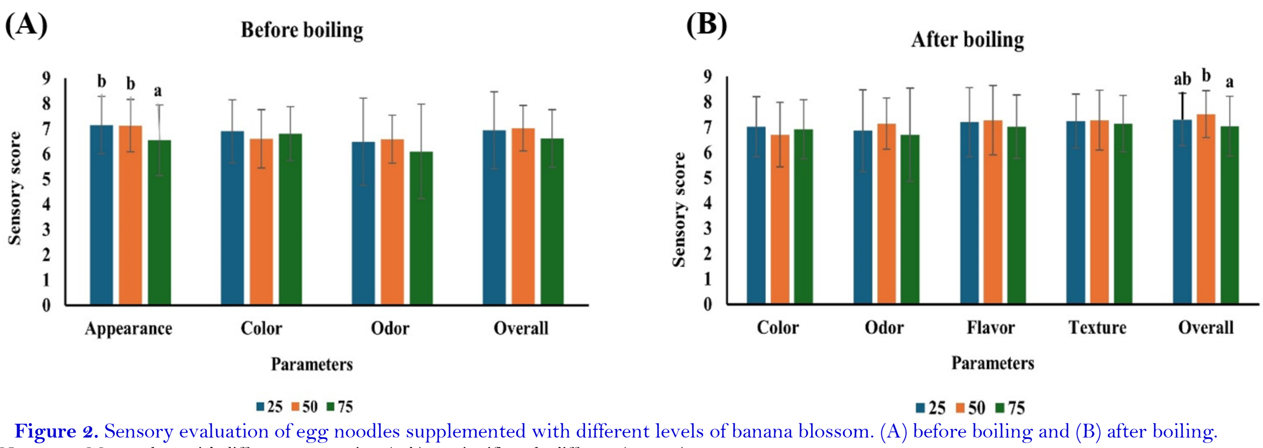


Figure 2. Sensory evaluation of egg noodles supplemented with different levels of banana blossom. (A) before boiling and (B) after boiling.

Note: Mean values with different superscripts (a, b) are significantly different ($p<0.05$).
The absence of a superscript indicates no significant difference.

Table 3. Physicochemical properties of egg noodles supplemented with different levels of banana blossom.

Parameters	Percentage of banana blossom		
	25	50	75
Before boiling			
Color			
L^*	45.37 ± 2.95^b	45.07 ± 2.31^b	33.10 ± 2.07^a
a^*	31.40 ± 9.68^b	17.30 ± 3.48^a	14.87 ± 1.07^a
$b^{*\ ns}$	9.77 ± 3.11	9.27 ± 1.45	9.43 ± 1.12
a_w	0.96 ± 0.01^b	0.94 ± 0.01^{ab}	0.93 ± 0.02^a
Texture analysis			
Hardness (N) ^{ns}	0.21 ± 0.06	0.40 ± 0.12	0.54 ± 0.18
Cohesiveness ^{ns}	0.10 ± 0.00	0.11 ± 0.01	0.10 ± 0.02
Springiness ^{ns}	2.23 ± 0.13	2.36 ± 0.19	2.29 ± 0.26
Gumminess	0.02 ± 0.01^a	0.04 ± 0.02^{ab}	0.05 ± 0.01^b
Chewiness	0.05 ± 0.01^a	0.10 ± 0.05^{ab}	0.12 ± 0.01^b
Adhesiveness (N/s)	0.01 ± 0.01^a	0.03 ± 0.01^{ab}	0.04 ± 0.02^b
After boiling			
Color			
$L^{*\ ns}$	33.43 ± 1.68	31.93 ± 1.62	35.03 ± 0.65
a^*	9.87 ± 1.19^a	17.10 ± 1.50^b	17.70 ± 1.40^b
$b^{*\ ns}$	8.53 ± 0.95	6.00 ± 2.21	8.97 ± 0.93
a_w ^{ns}	0.95 ± 0.01	0.96 ± 0.01	0.95 ± 0.02
Texture analysis			
Hardness (N) ^{ns}	0.45 ± 0.10	0.35 ± 0.04	0.30 ± 0.11
Cohesiveness ^{ns}	0.37 ± 0.03	0.37 ± 0.03	0.34 ± 0.01
Springiness ^{ns}	7.50 ± 0.43	7.64 ± 0.27	7.63 ± 0.28
Gumminess ^{ns}	0.16 ± 0.02	0.13 ± 0.03	0.10 ± 0.03
Chewiness ^{ns}	1.22 ± 0.13	1.02 ± 0.25	0.78 ± 0.29
Adhesiveness (N/s) ^{ns}	0.07 ± 0.03	0.04 ± 0.01	0.03 ± 0.01

Note: Mean values with different superscripts in the same row (a, b) are significantly different ($p<0.05$). ns = not significantly different.

3.3. Nutritional Values, Antioxidant Activity, Total Flavonoid Content, and Total Polyphenol Content

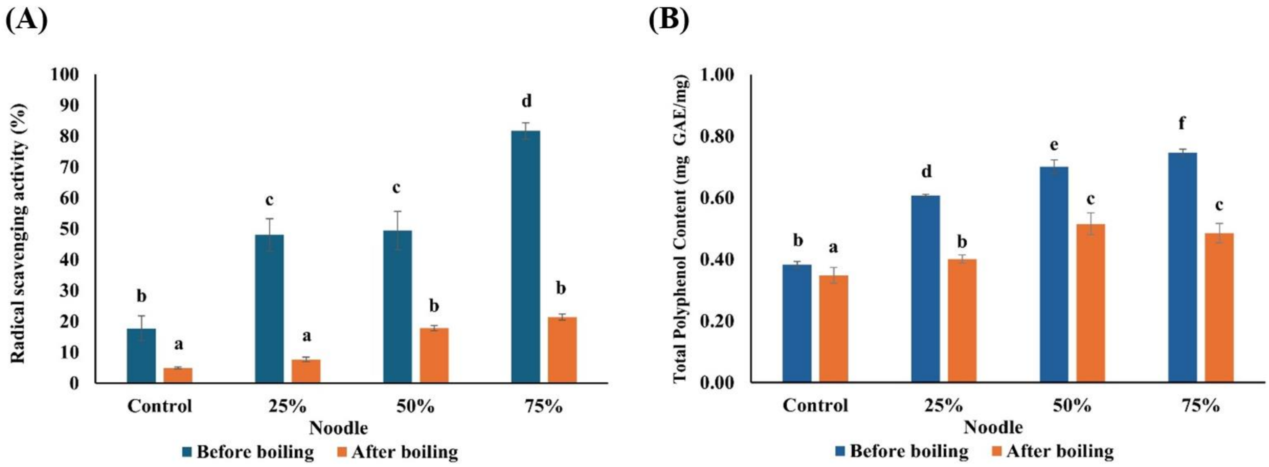
The nutritional analysis (Table 4) of egg noodles supplemented with different levels of BB showed decreases in energy, carbohydrates, protein, fat, sugar, cholesterol, total saturated fatty acids, minerals, and vitamins. Conversely, the levels of potassium, calcium, vitamin C, and dietary fiber increased compared to those in egg noodles without BB supplementation. This finding indicates that supplementing egg noodles with different levels of BB significantly enhances their nutritional profile. BB is characterized as a low-calorie, low-fat ingredient that serves as a good source of protein, dietary fiber, vitamins, and minerals (Institute of Nutrition & Mahidol University, 2015; Thagunna, Kandel, & Lamichhane, 2023). Additionally, BB supplementation led to statistically significant enhancements in antioxidant activity, total polyphenol content, and total flavonoid content, both before and after boiling, compared with egg noodles not supplemented with BB. However, the findings also showed that boiling resulted in statistically significant reductions in antioxidant activity, total polyphenol content, and total flavonoid content relative to their pre-boiling state. These results suggest that thermal processing negatively impacts the antioxidant properties and bioactive compound content of egg noodles supplemented with BB (Figure 4). In contrast, the study by Novidiyanto, Enardi, Devriany, Pratiwi, and Airuni (2020) demonstrated that increasing the percentage of BB in shredded chicken products was linked to a decrease in antioxidant activity. Several studies have demonstrated that BB contains flavonoids and polyphenols and exhibits antioxidant activity. These bioactive compounds and antioxidant properties may contribute to health promotion, reduce risk factors, and help prevent the development of non-communicable diseases (NCDs) (Elaveniya & Jayamuthunagai, 2014; Kraithong & Issara, 2021; Sarker et al., 2022; Suffi et al., 2021; Thagunna et al., 2023; Thaweesang, 2019).

Table 4. Nutritional values of 100 grams of egg noodles supplemented with different levels of banana blossom.

Nutrients	Percentage of banana blossom			
	0	25	50	75
Energy (kcal)	259.22	214.52	184.55	163.06
Carbohydrate (g)	50.28	41.49	35.61	31.39
Protein (g)	9.35	7.82	6.79	6.05
Fat (g)	2.30	1.92	1.66	1.48
Calcium (mg)	19.55	19.64	19.70	19.74
Iron (mg)	1.03	0.92	0.85	0.79
Vitamin A (μg RAE)	46.23	38.91	34.01	30.49
Thiamin (mg)	0.10	0.08	0.07	0.06
Riboflavin (mg)	0.09	0.08	0.07	0.07
Vitamin C (mg)	0.00	3.26	5.44	7.01
Niacin (mg)	0.83	0.80	0.77	0.75
Sodium (mg)	28.33	23.28	19.90	17.48
Potassium (mg)	95.67	165.08	211.62	244.98
Sugars (g)	0.30	0.24	0.20	0.17
Dietary fiber (g)	1.77	2.26	2.59	2.82
Cholesterol (mg)	77.05	61.84	51.65	44.34
Total saturated fatty acid (g)	0.68	0.57	0.50	0.45
Energy distribution (Carbohydrate:Protein:Fat)	78:14:8	77:15:8	77:15:8	77:15:8

Source: Calculated from INMUCAL-Nutrients V.4 Program.

Figure 3. The egg noodles were supplemented with different levels of banana blossom **(A)** before and **(B)** after boiling.



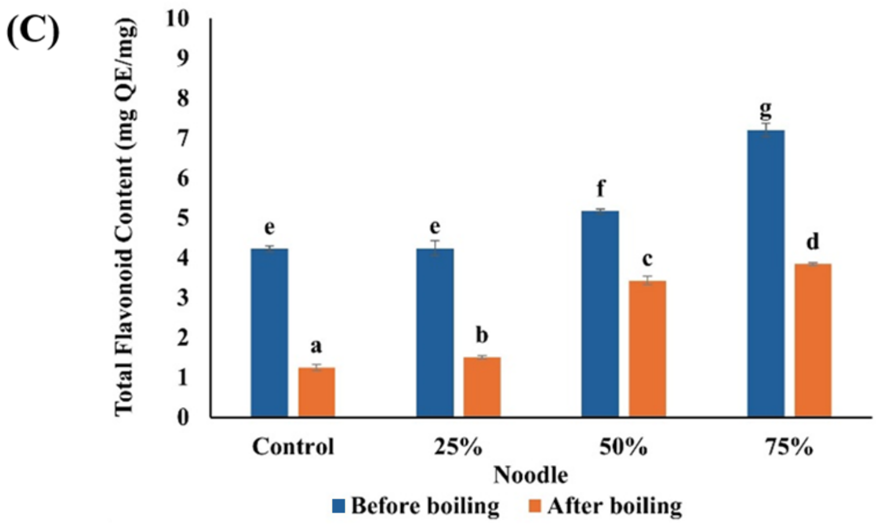


Figure 4. The antioxidant activity (A), total polyphenol content (B), and total flavonoid content (C) of egg noodles supplemented with different levels of banana blossom before and after boiling.

Note: Mean values with different superscripts (a, b, c, d, e, f, g) are significantly different ($p<0.05$).

3.4. Consumer Acceptance of Egg Noodles Supplemented with 50% Banana Blossom

Egg noodles supplemented with 50% banana blossom achieved the highest sensory evaluation score and were subsequently subjected to a consumer acceptance assessment involving 100 participants. Analysis of demographic data indicated that the majority of respondents were female (68.0%), predominantly aged between 16 and 25 years (87.0%), and primarily undergraduate students (87.0%). Examination of consumption behavior revealed that a substantial proportion of participants reported enjoying egg noodles (83.0%), consuming them 1–3 times per week (74.0%), and purchasing them predominantly from markets (54.0%). Additionally, 64.0% of consumers expressed a preference for the original variant of egg noodles, with personal preference being identified as the primary motivation for consumption (66.0%). Consumer acceptance ratings for attributes such as color, odor, flavor, texture, and overall quality were evaluated to range from moderate to high levels, as shown in Figure 5. Adding a higher proportion of BB leads to lower flavor scores among consumers due to increased astringency in the product (Panklai et al., 2021).

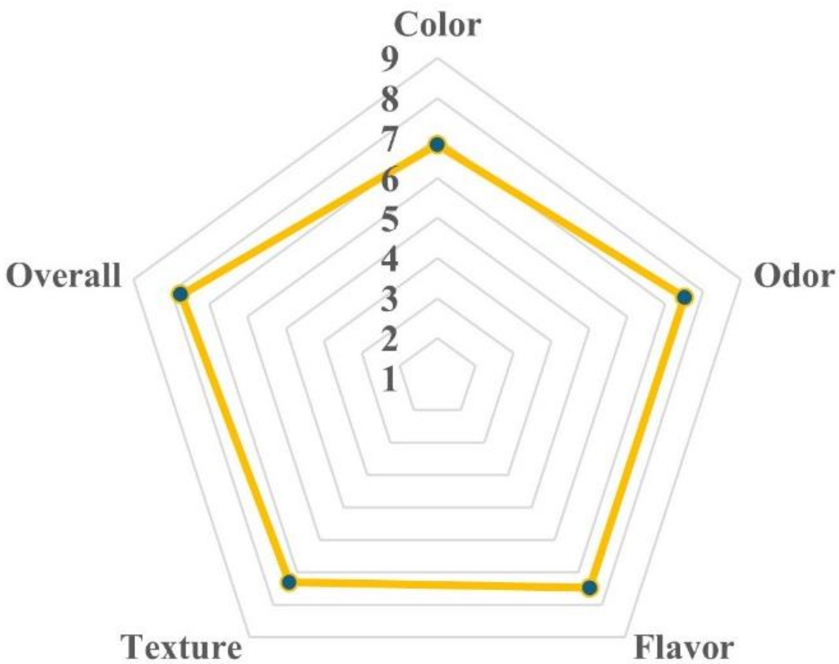


Figure 5. Consumer acceptance of egg noodles supplemented with 50% banana blossom (n=100).

4. CONCLUSION

This study shows that supplementing BB with fresh egg noodles significantly enhances their nutritional values, antioxidant properties, and health benefits. The supplementation of BB increased dietary fiber, calcium, potassium, and vitamin C contents, while decreasing energy, carbohydrate, protein, fat, sugar, and cholesterol levels. Moreover, antioxidant activity, total polyphenol content, and total flavonoid content were enhanced, thereby supporting the classification of the noodles as a functional food with health benefits. Sensory evaluation indicated that noodles supplemented with 50% BB achieved the highest overall acceptability, reflecting an optimal balance between nutritional enhancement and desirable texture, flavor, and appearance. In contrast, higher supplementation levels (75%) adversely affected sensory attributes, suggesting that excessive supplementation with BB may reduce consumer acceptance. These findings show the promise of BB as a valuable functional ingredient for improving the nutritional quality of egg noodles. However, the study has limitations, including reliance on calculated nutritional values rather than direct measurements and the absence of glycemic index, shelf-life, and microbiological assessments. Future research will address these limitations.

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Institutional Review Board Statement: The sensory evaluation was a non-invasive consumer acceptance test with no health interventions; therefore, formal ethics approval was not required under institutional guidelines. Participants were informed about the study, participated voluntarily, provided verbal informed consent, and the study followed ethical principles for human research.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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