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Effect of pickling process by using Rosella powder-tea proportion on Pidan yolk color, proximate value, pH, and vitamin A content

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ABSTRACT

Pidan (fermented salted eggs) is preservation method using alkaline and tea-based pickling solutions to extend the egg shelf life and develop unique sensory properties. Nutritional facts showed that pidan has benefit for eyes health due to its vitamin A content. This study aimed to get more insight the effect of rosella powder–tea (RP-T) proportion in the pickling process toward yolk color, proximate value, pH, and Vitamin A content of the Pidan. Samples are made by soaking a number of duck eggs for 40 days into the pickling solution containing various percentages (0,25,50, 75, and 100) of roselle powder toward tea portion. The results showed the proportion of RP-T significantly influenced the pidan yolk color, proximate value, and vitamin A content. Single portion of tea or roselle treatment showed a similar lightness on the pidan yolk, while various proportion RP-T reduced the lightness ($P < 0.05$). The presence of roselle decreased the redness and yellowness yolk ($P < 0.05$). There was no effect of RP-T proportion to proximate value except protein content that was getting higher caused by roselle presence ($P < 0.05$). The Optimum level of pidan vitamin A was reached by 75% roselle ($P < 0.05$). These findings highlight the potential of roselle as a functional ingredient in pidan production, supporting the development of nutritionally enriched traditional foods

Introduction

Pidan, or fermented salted eggs, is a traditional Asian food product with cultural value and a distinctive flavor Xiao *et al*., 2019). The process of preserving eggs by soaking them in alkali, salt, or certain natural ingredients, generally tea, aims to extend their shelf life while also producing unique sensory characteristics in the egg whites and yolks (Xue *et al*., 2022). Pidan yolks typically exhibit a darker color, an oily texture, and a distinctive aroma due to chemical and biochemical reactions during the preservation process (Novia *et al*., 2024). However, these changes also have the potential to affect nutritional content, including proximate values, pH, and vitamin content.

With the increasing interest in functional foods and natural bioactive sources, various efforts have been made to modify the pidan production process to not only maintain sensory quality but also enhance nutritional value (Hou *et al*., 2023). One potential natural ingredient is the roselle flower (*Hibiscus sabdariffa* L.). Roselle is known to be rich in anthocyanin pigments, vitamins, and bioactive compounds that act as antioxidants (Izquierdo-Vega *et al*., 2020; Nguyen *et al*., 2022) The use of roselle powder in the egg soaking process is expected to influence the color of the pidan yolk, maintain vitamin A stability, and modulate other chemical characteristics such as water, protein, fat, and pH content.

Research on the utilization of roselle in the pidan-making process is still relatively limited, particularly regarding the effect of the roselle powder-tea ratio on egg yolk quality. Therefore, this study aimed to get more insight into the effects of various proportions of roselle powder and tea (RP-T) in the pidan pickling process on yolk color, proximate value, pH, and vitamin A content. The results of this study are expected to contribute to the development of innovative fermented egg products based on natural ingredients with better nutritional and sensory qualities.

Materials and methods

Ingredient preparation

A number of eggs for pidan production were collected from the nearby farm. Sodium Hydroxide (NaOH), salt, and mineral water were purchased from the chemical store in the city while tea and rosella powder were brought in from the herbal market of suburb area. Eggs were selected based on the weight (70-75 g) and washed in order to remove the impurities. Other materials were measured according to the indicated percentage (Table .1). All ingredients were packaged and stored at room temperature for later use in the pidan production.

Table 1. Composition of Pickling solution for Pidan production.

Stuff	Rosella Powder Proportion (%)*				
	0	25	50	75	100
Sodium Hydroxide (g)	50	50	50	50	50
Salt (g)	50	50	50	50	50
Tea Powder (g)	25	18.75	12.5	6.25	0
Rosella Powder (g)	0	6.25	12.5	18.75	25
Mineral Water (L)	1	1	1	1	1

*Note: Percentage of rosella powder proportion is part of the tea powder total weight.

Pidan production

The curing solution was prepared by brewing black tea leaves in hot water, followed by the addition of NaCl, NaOH, and roselle powder in accordance with the treatment ratios (0, 25, 50, 75, and 100% substitution of tea by roselle). The mixture was stirred until homogeneous. Cleaned duck eggs were then fully immersed in the respective solutions inside airtight containers wrapped in black plastic to prevent light exposure. Eggs were kept at ambient temperature (25–30°C) for 10 days. After curing, the eggs were removed, coated with melted beeswax to prevent moisture loss and microbial contamination, and allowed to ripen at room temperature for an additional 30 days. The total preservation period was therefore 40 days, in line with established pidan production practices (Evanuarini *et al*., 2017; Hou *et al*., 2023).

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Parameter Analysis

Identification of Pidan Yolk Color

The yolk color was determined using a Konica Minolta spectrophotometer (Japan), measuring the CIELAB parameters: lightness (L*), redness (a*), and yellowness (b*). These values were used to assess the influence of roselle substitution on pigmentation, as yolk color is a critical sensory attribute for consumer acceptance (Spada *et al*., 2016; Asare *et al*., 2024).

Determination of Pidan Proximate Value

The proximate analysis of yolk samples was carried out in triplicate following AOAC-recommended methods. Moisture was determined by oven drying at 105°C until constant weight, ash content by incineration at 550°C, protein by the Kjeldahl method, and fat by Soxhlet extraction using n-hexane as a solvent. Carbohydrates were calculated by difference. These methods are standard for nutritional characterization of eggs and egg-based products (Azizah *et al*., 2017; Rosaini *et al*., 2017).

Measurement of Pidan pH

The pH of homogenized yolk samples was measured using a calibrated digital pH meter. Measurements were performed at room temperature to determine the acidity–alkalinity balance, which plays a role in the textural stability and microbial safety of pidan (Spada *et al*., 2016).

Determination of Pidan Vitamin A content

Vitamin A content in pidan yolk was determined using UV-Vis spectrophotometry following the method of Aberásturi *et al*., (2001) and Miao *et al*., (2023). About 5 g of homogenized yolk was saponified with 10% ethanolic KOH at 60°C for 30 minutes under nitrogen to release retinol and provitamin A carotenoids, followed by triple extraction with n-hexane. The combined extracts were washed to neutrality, dried with anhydrous sodium sulfate, evaporated under reduced pressure, and re-dissolved in n-hexane. Absorbance was measured at 325 nm against standard retinol solutions, and results were expressed as µg vitamin A per g (µg/g) of yolk. All analyses were conducted in triplicate to ensure accuracy and reproducibility.

Statistical analysis

All data was analyzed statically by Analysis of Varian (ANOVA) to determine the effect of the treatment ($P < 0.05$). Duncan's multiple range test (DMRT) was performed to determine significant differences among treatments between the treatment when the ANOVA obtained the significant influence (Ganesan *et al*., 2014; Hou *et al*., 2023).

Results

Pidan yolk color

Various proportions of RP-T in the pidan pickling process significantly affected the appearance of the color of the pidan yolk (Table. 2). Rosella powder with a proportion of 25-75% (Fig. 1) toward tea significantly produced a lower yolk brightness level (L*) compared to a proportion of 0% (only tea). Meanwhile, 100% rosella powder (without tea) produced the same yolk brightness (Fig. 2) level as 100% tea (without rosella powder). The presence of rosella powder in the pickling solution composition significantly produced lower red (a*) and yellow (b*) color intensity of the yolk wherein the proportion of 25% rosella powder toward tea produced the lowest yellow color intensity among other proportion variations.

Table 2. Color of Pidan Yolk with Various Proportions of Rosella Powder in the Pickling Process.

Color Intensity	Rosella Powder Proportion (%)				
	0	25	50	75	100
L*	66.56±6.74^{a}	53.51±4.21^{b}	56.95±6.29^{b}	53.38±6.74^{b}	62.83±6.74^{a}
a*	10.52±7.22^{a}	3.63±0.23^{b}	6.05±0.38^{b}	5.95±0.28^{b}	6.33±0.42^{b}
b*	39.81±8.05^{a}	23.36±6.14^{b}	28.72±5.17^{c}	30.30±7.11^{c}	31.78±6.14^{c}

Note: The percentage of rosella powder proportion is part of the tea powder total weight. Data were expressed as Mean±SD which different superscripts in the same line are significantly different ($P < 0.05$) among the various proportion.

Fig. 1. Yolk color appearance of pidan resulted from the pickling process using the proportion of RP-T in 25-75%.

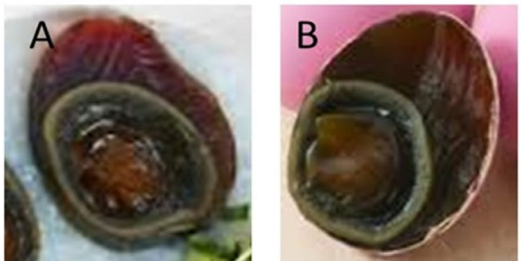

Fig. 2. Yolk color appearance of pidan resulted from the pickling process by using 100% tea (A) or 100% roselle (B) containing solution.

Table 3. Proximate value of pidan yolk with various proportions of rosella powder in the pickling process.

Proximate Parameters	Rosella Powder Proportion (%)				
	0	25	50	75	100
Moisture (%)	2.66±0.21	2.88±0.45	3.15±0.19	2.33±0.14	2.49±0.11
Ash Content (%)	6.51±0.31	6.57±0.25	6.58±0.18	6.58±0.18	6.63±0.22
Carbohydrate Content (%)	5.21±0.61	5.50±0.14	5.71±0.17	6.11±0.17	5.41±0.14
Protein Content (%)	41.27±8.41^{a}	42.35±9.75^{a}	40.34±6.75^{a}	44.59±5.75^{b}	45.25±8.75^{b}
Fat Content (%)	23.99±3.78	21.61±4.75	22.67±3.25	21.89±7.15	22.82±4.75

Note: The percentage of rosella powder proportion is part of the tea powder total weight. Data were expressed as Mean±SD which different superscripts in the same line are significantly different ($P < 0.05$) among the various proportion.

pH and Proximate Value of Pidan

Various proportion of RP-T in the pidan pickling process had no effect on the pH (Fig. 3) and proximate value except on the protein content (Table 3). The presence of rosella 75-100% toward tea in pickling solution composition significantly increased the pidan protein content.

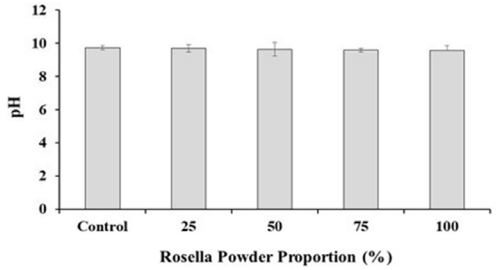

Fig. 3. pH of Pidan with Various Proportion of Rosella Powder in the Pickling Process. Percentage of rosella powder proportion is part of tea powder total weight. Data were expressed as Mean±SD.

Pidan Vitamin A content

Various proportion of RP-T in the pidan pickling process significantly influenced the pidan vitamin A content (Fig. 4). Proportion of 75% RP-T showed the highest vitamin A level among the others ($P < 0.05$). The presence of 100% rosella in the pidan pickling solution resulted the lower vitamin A content ($P < 0.05$).

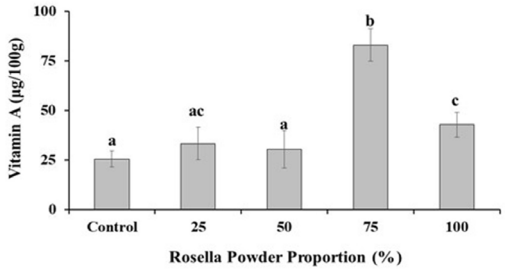

Fig. 4. Vitamin A content of Pidan with Various Proportion of Rosella Powder in the Pickling Process. Percentage of rosella powder proportion is part of tea powder total weight. Data were expressed as Mean±SD. Different superscripts above bar chart showed significantly different among the various proportion ($P < 0.05$).

Discussion

The results of this study demonstrated that the proportion of rosella powder–tea (RP-T) in the pickling solution significantly influenced the color characteristics of pidan yolk. According to the Table 2, the decrease in yolk brightness (L*) observed at the 25–75% RP-T levels compared with the 0% treatment (only tea) indicates that rosella powder contributes to darker pigmentation in the yolk (Fig. 1). This effect may be attributed to the presence of anthocyanin pigments in rosella, which are known to impart deep red to purple hues and can undergo structural changes become blue-green during alkaline conditions in the pickling process, thereby reducing the lightness of the yolk or yolk appeared become brownness to dark hues (Kljak *et al*., 2021a) Interestingly, the 100% rosella powder treatment resulted in a yolk brightness level comparable to the 100% tea treatment (Table. 2). The similar yolk brightness level due to the presence rosella or tea as a single agent in the pickling solution is shown in Fig. 2 of this study. This finding suggests that, although rosella powder has strong pigmentation, its contribution to yolk brightness may reach a saturation point or interact differently with yolk components in the absence of tea polyphenols (Luo *et al*., 2024)

In terms of color intensity, the presence of rosella powder significantly reduced both the red (a*) and yellow (b*) values of pidan yolk. The reduction in redness and yellowness might be linked to the degradation or transformation of anthocyanins during alkaline pickling, which can lead to pigment instability and a muted color profile (Kljak, *et al*., 2021a). Among all variations, the 25% RP-T proportion generated the lowest yellowness (b*), indicating that small amounts of rosella powder are sufficient to interfere with carotenoid stability or visibility in the yolk (Kljak, *et al*., 2021a; Kljak, *et al*., 2021b). This interaction suggests a competitive effect between rosella anthocyanins and natural yolk pigments, where the former may dominate or mask the latter.

Overall, the findings highlight that the incorporation of rosella powder into the traditional tea-based pickling solution modifies the yolk color profile of pidan, with proportion-dependent effects. These results provide new insights into the potential of rosella powder as a natural additive for diversifying pidan product characteristics, while also raising questions regarding pigment stability and interactions in alkaline pickling environments.

In the other hand, the application of various proportions of rosella powder–tea (RP-T) in the pickling process did not influence the pH of pidan (Fig. 3). This finding suggests that the acidic or alkaline balance of the pickling solution remained relatively stable despite the substitution of tea with rosella powder. Similar stability in pH during pickling has been reported in previous studies, where the buffering capacity of the solution and the protein-lipid interactions in the egg matrix contributed to maintaining a consistent pH (Yang *et al*., 2023; Widyawati *et al*., 2025)

In terms of proximate composition, most parameters including moisture, fat, ash, and carbohydrate contents were not significantly affected by the proportion of RP-T in the pickling solution (Table 3). This implies that the substitution of tea with rosella powder did not alter the overall nutrient distribution in pidan, except in the case of protein. Interestingly, the incorporation of rosella at 75–100% replacement levels significantly increased the protein content of pidan. The increase in protein may be attributed to the bioactive compounds in rosella, particularly organic acids and anthocyanins, which could enhance protein retention or reduce protein denaturation during the pickling process (Pame *et al*., 2023). Additionally, rosella may promote protein cross-linking or binding with polyphenols, thereby improving measurable protein concentration (Pame *et al*., 2023; Sun *et al*., 2022)

The enhancement of protein content by rosella is of particular importance from both nutritional and functional perspectives. Higher protein levels could increase the nutritional value of pidan, making it more beneficial for consumers. Moreover, the interaction of rosella-derived compounds with egg proteins may also contribute to the unique textural and sensory properties of pidan, which could be further explored in future studies.

Overall, while the substitution of tea with rosella powder in the pickling solution did not affect pH or most proximate values, the significant increase in protein content at higher rosella proportions highlights the potential of rosella as a functional ingredient to improve the nutritional quality of pidan.

Moreover, this study also demonstrates that the proportion of rosella powder-tea (RP-T) in the pidan pickling process had a significant effect on the vitamin A content of pidan yolk (Fig. 4). Specifically, the use of 75% RP-T yielded the highest vitamin A concentration, indicating that this proportion provided an optimal balance of conditions for vitamin A retention during the pickling process. The possible explanation is that the moderate presence of rosella contributed antioxidant compounds, such as polyphenols and anthocyanins, which may have protected vitamin A from oxidative degradation. Besides that, rosella also contains 1.13 mg/g of vitamin A and 0.23 µg/g of β-carotene (Grune *et al*., 2010; Zhang *et al*., 2022) which allows to contribute the pidan vitamin A stability. In contrast, the use of 100% rosella in the pickling solution resulted in a lower vitamin A content. This finding suggests that excessive concentrations of rosella may exert a pro-oxidant effect or cause interactions between anthocyanins and vitamin A that reduce its stability. Previous studies have shown

that high concentrations of certain polyphenolic compounds can lead to degradation of sensitive nutrients due to pH alterations or complex formation (Xiao, 2022; Zembyla *et al*., 2019) Therefore, while rosella possesses beneficial bioactive compounds, its proportion in the pickling medium must be carefully optimized to prevent nutrient losses.

Overall, these results highlight that 75% RP-T is the most favorable proportion for preserving vitamin A in pidan, while higher levels of rosella, particularly at 100%, may negatively affect its stability. This finding provides valuable insights for developing functional pidan products with improved nutritional quality.

Conclusion

The incorporation of rosella in the pickling process modified yolk brightness and intensity in a proportion-dependent manner, reflecting the role of anthocyanins in pigment transformation under alkaline conditions. Notably, higher proportions of rosella (75–100%) enhanced protein content, indicating its potential as a functional additive to improve pidan's nutritional value. In terms of micronutrients, the 75% rosella–tea proportion was most effective in preserving vitamin A, suggesting a protective role of rosella-derived antioxidants at moderate levels, whereas excessive use (100%) may compromise nutrient stability. Collectively, these findings highlight rosella powder as a promising natural ingredient for diversifying pidan characteristics and enhancing its functional properties, with optimal benefits achieved at balanced substitution levels.

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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