

# Edible Origami Paper Innovation to Increase Daily Vegetables Intake

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## ABSTRACT

Indonesia has a low level of vegetable consumption, especially among children, even though this type of food is essential for growth and health. According to data from the Basic Health Research (Riskesdas), around 30.8% of toddlers in Indonesia experience stunted growth, and about 10.2% suffer from malnutrition. This condition increases the risk of child mortality up to 11.6 times higher compared to children with adequate growth and nutrition. Children tend to dislike vegetables due to their taste, texture, and early habits of consuming fast food. The proposed innovation of edible origami paper serves as a fun, educational, and nutritious approach that is both creative and contextually appropriate, particularly for promoting early nutrition awareness. The innovative formulation in this folding paper utilizes green spinach, purple cabbage, and pumpkin with the addition of a binding agent. Proximate analysis was conducted to determine the main nutritional components, including moisture, ash, protein, fat, carbohydrates, and dietary fiber, and the results were compared with those of fresh vegetables. The analysis showed that the edible origami paper has a higher nutrient density than the fresh materials due to the drying process, which reduces moisture content and increases nutrient concentration. The product also exhibited good physical properties such as high folding strength, allowing it to be folded like conventional origami. This innovation is expected to serve as a creative and contextual approach to enhancing children's nutrition awareness from an early age through an enjoyable, educational, and nutritious medium.

**KEYWORDS:** *Folding paper, Vegetables, Stunted growth, Nutrition education, Proximate analysis*

## Introduction

Indonesia has a low vegetable consumption rate, particularly among children, despite vegetables being an essential food group for growth and health. According to the 2018 Basic Health Research (Riskesdas) data, approximately 30.8% of Indonesian children under five years old experience stunted growth, and around 10.2% suffer from malnutrition. The same report indicated an increase in the proportion of children under five consuming vegetables, from 93.5% to 95.5%. However, this level of vegetable intake still does not meet the standards recommended by the World Health Organization (WHO). Children aged 6–9 years old were recorded as the age group with the highest percentage of inadequate vegetable consumption, reaching 96.9% (Nurwahidah *et al.*, 2023). Such nutritional deficiencies can elevate the risk of mortality by 11.6 times compared to children with sufficient nutrition. Early school-age years are a critical stage for shaping dietary habits, and promoting vegetable intake at this age can foster healthier, long-term eating behaviors (Sari & Rovendra, 2023).

According to WHO (2003), children are encouraged to consume approximately 400 grams of vegetables daily—equivalent to five servings across all age groups (Israeli *et al.*, 2021). However, national surveys indicate that this goal remains unmet. The 2013

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Riskesdas reported that 96.4% of West Java residents aged over ten failed to meet this requirement, while the 2014 National Socio-Economic Survey (Susenas) revealed that 83.64% of school-age children still lacked adequate vegetable consumption (Sari & Rovendra, 2023). Additionally, 2014 National Socio-Economic Survey (Susenas) data showed that 83.64% of school-aged children had not yet met the recommended vegetable intake. Children tend to choose foods they are familiar with, and their daily eating patterns strongly influence their food preferences. Therefore, efforts to change children's vegetable consumption behavior must include increasing their awareness of the importance of eating vegetables (Osman *et al.*, 2021).

Vegetables are among the food types that offer positive health benefits for preschool-aged children. Vegetable intake in this age group is influenced by several factors, including their level of knowledge about the importance of consuming vegetables (Putri *et al.*, 2017). As a natural source of nutrients, vegetables play a vital role in fulfilling the body's nutritional needs. However, many individuals across all age groups, especially children, tend to dislike eating vegetables. Low vegetable intake can lead to deficiencies in nutrients such as vitamins, minerals, and fiber, as well as disturb the body's acid-base balance, potentially triggering various health issues. Children are more inclined to eat instant foods or snacks rather than vegetables, necessitating innovative approaches to boost their interest in consuming vegetables (Sartika *et al.*, 2022). One approach is through nutrition education using attractive learning media, such as edible origami paper. This medium can help enhance children's knowledge and promote better vegetable consumption behaviors. Several types of vegetables known for their high nutritional value include green spinach, purple cabbage, and pumpkin.

Each type of vegetable used contains essential nutrients to support children's health and growth. For every 100 grams, green spinach contains approximately 3.50 mg of iron, 41 mg of vitamin C, 3.7 grams of protein, 166 mg of calcium, 76 mg of phosphorus, and 130 mcg of copper. The iron and vitamin C content in spinach play a vital role in increasing haemoglobin levels by stimulating red blood cell production. Additionally, spinach helps control high blood pressure due to its high potassium and low sodium content, which supports electrolyte balance in the body (Simanjuntak, 2025). Purple cabbage is known to be rich in antioxidants, which help enhance the immune system and protect body cells from damage caused by free radicals (Suriani *et al.*, 2013). Pumpkin (*Cucurbita moschata*) contains abundant beta-carotene a precursor of vitamin A essential for maintaining vision, immunity, and bone health (Baidowi *et al.*, 2021).

The general reluctance of children to eat vegetables stems largely from taste preferences, visual appearance, and early exposure to instant foods (Vega, 2024). To overcome this, innovative strategies are needed to introduce vegetables in fun and appealing forms. The concept of *edible origami paper* presents a promising solution: a foldable, edible sheet made from vegetables that can serve both as a creative food wrapper and as an educational medium. The use of binding agents, such as carrageenan, ensures elasticity and prevents breakage (Saidi & Wulandari, 2019). This approach not only increases vegetable intake but also introduces a novel, interactive method of food education. Through its playful design and nutritional value, edible origami paper can encourage children to consume more vegetables and develop healthier eating (Janowicz, 2023).

## Material and Method

### Material

The main materials used in this study consisted of three types of vegetables: green spinach (*Amaranthus hybridus* L.), purple cabbage (*Brassica oleracea* var. *capitata* f. *rubra*), and pumpkin (*Cucurbita moschata*). Additional materials included baking paper and multilayer plastic, which were used for the drying and packaging processes.

The equipment utilized in this study included a blender, knife, spatula, cutting board, basin, food scale, saucepan, stove, measuring cup, scissors, microwave, and vacuum packaging machine. All materials were sourced from a local traditional market in Salatiga City, Central Java, to ensure freshness and availability.

The selection of vegetables was conducted manually based on quality indicators such as natural color, firm texture, and the absence of physical damage or signs of spoilage, in accordance with functional food quality standards.

Fresh green spinach with bright green leaves and intact structure was used, weighing approximately 635 g before cutting and 450 g after cleaning and trimming. Purple cabbage with uniformly purple leaves and compact structure weighed 230 g before and 206 g after trimming, while pumpkin with bright orange flesh and clean surface maintained a constant weight of 200 g before and after cutting.

These three vegetables were selected not only for their high nutritional value but also for their easy local availability and affordability, supporting the potential development of edible origami paper as a market-oriented product. A commercial fiber-based binder was used to enhance the structural integrity and flexibility of the sheets. This fiber material contained no added coloring or flavoring agents, allowing the natural color and taste of each vegetable to dominate the final product. Moreover, all ingredients were safe for general consumption, including children, aligning with the study's objective to develop an educational and nutritious medium in the form of edible origami paper.

### Preparation of Edible Origami Paper from Spinach

Approximately  $\pm 450$  g of green spinach (*Amaranthus hybridus* L.) was thoroughly washed under running water to remove any dirt or impurities. The spinach leaves were then blanched in hot water at  $90 \pm 2^\circ\text{C}$  for 5 minutes, drained, and immediately immersed in ice water for 2 minutes to halt enzymatic activity. The blanched spinach was blended with the addition of 200 mL of water until a smooth spinach puree was obtained. The puree was then mixed with 15 g of a commercial binding agent to form a slightly viscous dough. The dough was evenly spread on a baking tray lined with parchment paper to a thickness of 1–2 mm. Drying was carried out using a microwave at medium power (approximately 600 W) for 30 minutes, followed by low power (approximately 200 W) for 10 minutes. The dried sheets were cut into  $15 \times 15$  cm pieces, each weighing approximately 11 g, and then vacuum-packed using multilayer plastic.

### Preparation of Edible Origami Paper from Pumpkin

Approximately  $\pm 200$  g of pumpkin (*Cucurbita moschata*) was peeled and thoroughly washed under running water to remove any dirt or impurities. The pumpkin pieces were then steamed at  $100 \pm 2^\circ\text{C}$  for 10 minutes until soft texture. The cooked pumpkin was blended to obtain a smooth puree. The pumpkin puree was then mixed with 15 g of a commercial binding agent to form a slightly viscous dough. The dough was evenly spread on a baking tray lined with parchment paper to a thickness of 1–2 mm. Drying was carried out using a microwave at medium power (approximately 600 W) for 25 minutes, followed by low power (approximately 200 W) for 5 minutes. The dried sheets were cut into  $15 \times 15$

cm pieces, each weighing approximately 16 g, and then vacuum-packed using multilayer plastic.

### Preparation of Edible Origami Paper from Purple Cabbage

Approximately  $\pm 230$  g of purple cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) was thoroughly washed under running water to remove any dirt or impurities. The cabbage was then chopped into small pieces and blended to obtain a smooth purple cabbage puree. The puree was mixed with 15 g of a commercial binding agent to form a slightly viscous dough. The dough was evenly spread on a baking tray lined with parchment paper to a thickness of 1–2 mm. Drying was performed using a microwave at medium power (approximately 600 W) for 30 minutes, followed by low power (approximately 200 W) for 40 minutes. The dried sheets were then cut into 15 × 15 cm pieces, each weighing approximately 11 g, and vacuum-packed using multilayer plastic.

### Proximate Analysis

The parameters analyzed included ash content, moisture content, protein, fat, carbohydrate, and dietary fiber. Ash and moisture contents were analyzed according to the SNI 01-2891-1992 method. Protein content (Total-N) was determined using the semi-micro Kjeldahl method, while fat content was measured by direct extraction using a Soxhlet apparatus. Carbohydrate content was determined using the phenol-sulfuric acid spectrophotometric method, and dietary fiber was analyzed using the gravimetric method. All analyses were conducted quantitatively in triplicate. The results are presented as mean values and compared with the nutrient composition of the corresponding fresh vegetable materials. The nutrient composition analysis results are shown in Table 1.

### Results and Discussion

Proximate analysis was conducted to determine the basic nutritional content of the edible origami paper made from three types of vegetables: spinach, purple cabbage, and pumpkin. Fresh vegetables of spinach, purple cabbage, and pumpkin were used as control samples to compare the nutrient composition before and after processing. Each proximate analysis was conducted in triplicate to ensure the accuracy and reliability of the data. The parameters analyzed included ash, moisture, protein, fat, carbohydrate, and dietary fiber contents. The analysis results are presented in Table 1 below.

**Table 1.** Proximate analysis results on vegetable samples.

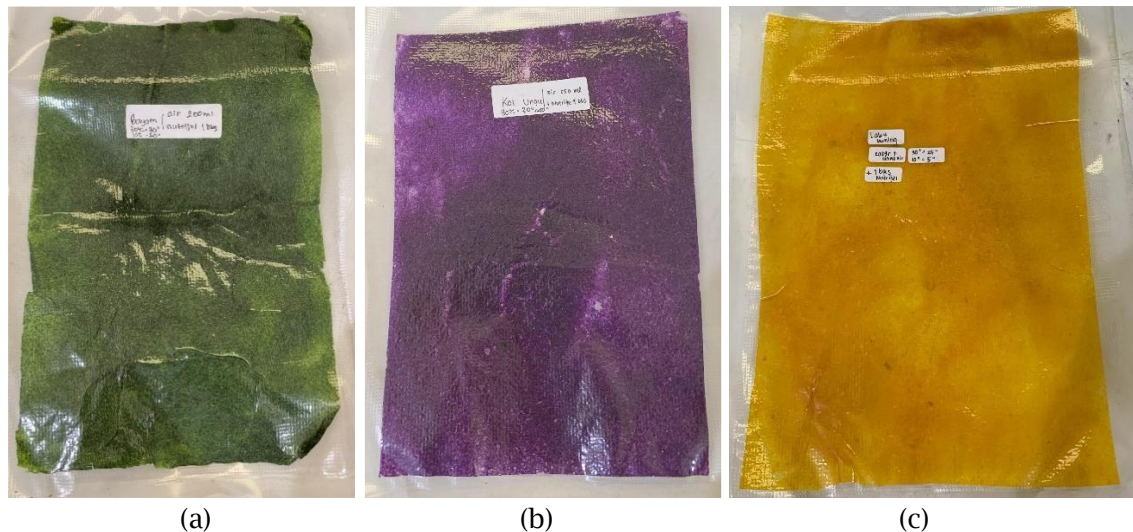
Proximate Analysis Results						
Parameter	Spinach Sample	Original Green Spinach*	Pumpkin Sample	Original Pumpkin*	Purple Cabbage Sample	Original Purple Cabbage*
Ash	12.28	1.3	9.81	0.56	6.70	0.9
Water	26.09	94.5	20.14	90.48	7.35	92.4
N-total Protein	24.01	0.9	14.32	1.56	7.50	1.4
Fat	0.30	0.4	0.34	0.07	1.67	0.2
Carbohydrate	67.89	2.9	66.46	7.32	62.39	5.3
Fiber	74.34	0.7	61.59	4.94	26.60	1.9

Note: \*Reference Table of Indonesian Food Composition 2020

The proximate results indicate that the nutritional density of the edible origami paper was considerably higher than that of the corresponding fresh vegetables. This pattern was consistently observed across all three variants—spinach, pumpkin, and purple cabbage.

The increase in macronutrient concentration was primarily attributed to the drying process, which drastically reduced the moisture level, thereby concentrating other nutrients per 100 weight (Saidi & Wulandari, 2019). In the spinach-based edible origami paper, the moisture content was significantly reduced to 26.09%, compared to 94.5% in fresh spinach. As a result, the concentration of other nutrients increased considerably, with protein rising from 0.9% to 24.01%, carbohydrates from 2.9% to 67.89%, dietary fiber from 0.7% to 74.34%, and ash content from 1.3% to 12.28%. Fat content also increased slightly, from 0.30% to 0.50%. This high nutrient concentration demonstrates that the processing method not only retains but also enhances the nutritional value per unit weight of the product. In the case of purple cabbage, the edible origami paper showed a decrease in moisture content to only 7.35%, down from 92.4% in its fresh form. Significant increases were observed in dietary fiber (from 1.9% to 26.60%), protein (from 1.4% to 7.5%), and carbohydrates (from 5.3% to 62.39%). Ash content reached 6.70%, and fat rose to 1.67%. These findings corroborate previous research that highlights the ability of controlled heat drying to preserve nutrient solids and enhance their density in final products (Natumanya *et al.*, 2021). The decline in moisture not only improves nutrient concentration but also contributes to the edible origami paper's physical properties, such as flexibility and extended shelf life. Reduced water activity hinders microbial growth, allowing the product to remain stable over longer periods. Therefore, the drying process not only improves nutritional composition but also functional characteristics, enhancing both usability and safety (Deden *et al.*, 2020).

The physical appearance and mechanical properties of each variant are illustrated in Figure 1, which shows the distinct color and texture differences among spinach, cabbage, and pumpkin-based sheets. The spinach-based sheet displayed a strong, compact texture with high tensile strength and tear resistance, although it was slightly less pliable than the others. This rigidity can be linked to the high fiber content of spinach, which provides structure but reduces elasticity (Arisyida *et al.*, 2024). In contrast, the purple cabbage variant exhibited excellent flexibility and was easy to fold without tearing. This quality can be attributed to its anthocyanin pigments and fine fiber composition, which enhance matrix formation and improve elasticity. Anthocyanins also contribute to the product's vibrant purple coloration while reinforcing its tensile properties (Sitanggang *et al.*, 2020). The pumpkin-based edible paper demonstrated the best foldability and softness among the three samples. This was largely due to its natural pectin and the presence of carrageenan as a binding agent, which work synergistically to form an elastic gel structure. The hydrophilic nature of pumpkin pectin and the gel-forming ability of carrageenan play critical roles in improving flexibility and durability. This observation aligns with the findings of Scarton *et al.* (2021), who emphasized carrageenan's effectiveness in enhancing the mechanical strength and foldability of edible films. Overall, the proximate data and physical characterization confirm that the edible origami paper developed from spinach, cabbage, and pumpkin retains significant nutritional value while offering desirable handling properties. The reduced water content not only enriches the macronutrient concentration but also enhances product stability, making it suitable for storage and consumption as an innovative educational food medium.



**Figure 1.** Edible Origami Paper Green Spinach, (B) Edible Origami Paper Purple Cabbage, (C), Edible Origami Paper Pumpkin. Each sheet was produced following the method described in the text, using vegetable puree and 15 g of commercial binder per batch. The mixture was evenly spread (1–2 mm thickness) and dried using a microwave at 600 W for 25–30 minutes followed by 200 W for 5–10 minutes. All samples were cut into 15 × 15 cm sheets and vacuum-packed in multilayer plastic. Visual evaluation included color uniformity, surface smoothness, and flexibility. Scale bar = 5 cm.

## Conclusion

Based on the results of the proximate analysis, it can be concluded that the edible origami paper developed from green spinach, purple cabbage, and pumpkin maintains a favorable macronutrient composition, making it a promising candidate for daily dietary consumption. The drying process, in combination with the use of a binding agent, effectively minimized nutrient degradation typically associated with thermal exposure. The product can be folded and shaped similarly to traditional origami, highlighting its potential as both a functional food and an educational medium to encourage higher vegetable intake among children. This innovation is expected to bridge the gap between nutrition education and vegetable consumption behaviors in early childhood through an enjoyable and interactive approach. The physical characteristics of the vegetable-based edible origami paper were influenced by the type of vegetable, base formulation, and the inclusion of carrageenan as a binder, which played a crucial role in determining the product's flexibility, strength, and foldability. However, sensory and acceptance evaluations involving children were not conducted due to time constraints during the research period. Future studies are recommended to include sensory assessments with children to provide deeper insights into product acceptance, preference, and its potential effectiveness in promoting healthy eating habits through playful, food-based learning activities. In addition, future research should include microbial stability testing to confirm that low moisture content indeed enhances product safety and shelf stability.

## Supporting Information

Due to time constraints during the preparation phase, the analysis was limited to macronutrient content only. Future studies should include micronutrient analysis to strengthen the nutritional data and further support the product's role as a daily dietary supplement.

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### Conflicts of Interest

The research team and academic supervisors declare that there is no conflict of interest with any parties in the execution of this study.

### Author Contributions

Femyta Anindya Putri conducted the experiments and analysed the data. Amelia Putri Nuladhani and Rachel Abelyana also performed the experiments and contributed to the writing. All authors have read and approved the final version of this paper.

### Ethical Statement

This study did not involve any materials or procedures that required ethical approval from a research ethics committee.

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